KINGDOM OF SAUDI ARABIA

MINISTRY OF COMMUNICATIONS

GENERAL SPECIFICATIONS

FOR

ROAD AND BRIDGE CONSTRUCTION

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PART ONE

GENERAL

PART ONE: GENERAL

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PART ONE: GENERAL

SECTION 1.01 - ABBREVIATIONS AND DEFINITIONS OF TERMS

1.01.1 ABBREVIATIONS. Whenever the following abbreviations are used in the specifications or on the plans, they are to be construed the same as the respective expressions represented.

AASHTO	-	American Association of State Highway and Transportation Officials
ACI	-	American Concrete Institute
ACPA	-	American Concrete Pavement Association
ADM	-	Arrow Diagram Method
AGC	-	American General Contractors of America
AISC	-	American Institute of Steel Construction
AI	-	Asphalt Institute
AISI	-	American Iron and Steel Institute
ANSI	-	American National Standards Institute
ASHRAE	-	American Society of Heating, Refrigeration and Air Conditioning Engineers
ASME	-	American Society of Mechanical Engineers
ASTM	-	American Society for Testing and Materials
AWS	-	American Welding Society
BSI	-	British Standards Institution
BTU	-	British Thermal Unit
CIRIA	-	Construction Industry Research and Information Association
CPM-PS	-	Critical Path Method - Project Schedule
CRSI	-	Concrete Reinforcing Steel Institute
DIN	-	German National Standards Organization
FHWA	-	Federal Highway Administration
FSS	-	Federal Specifications and Standards
HCM	-	Highway Construction Manual (M.O.C.)
HDM	-	Highway Design Manual (M.O.C.)
HI	-	Hydraulic Institute
HMM	-	Highway Maintenance Manual (M.O.C.)
IEC	-	International Electrotechnical Commission
IEEE	-	Institute of Electrical and Electronic Engineers, Inc.
IES	-	Illuminating Engineering Society
ISSA	-	International Slurry Seal Association
ISO	-	International Standards Organization
ITE	-	Institute of Transportation Engineers
LSL	-	Lower Specification Limit
MIL	-	Military Specifications
MOC	-	Ministry of Communications
MRDMM	-	Materials and Research Department, Materials Manual (MOC)
MRDTM	-	Materials and Research Department, Standard Method of Test
MUTCD	-	Manual on Uniform Traffic Control Devices
NEMA	-	National Electrical Manufacturers Association

NFPA	-	National Fire Protection Association
NIST	-	National Institute of Standards and Technology
PAS	-	Preliminary Activity Schedule
PCA	-	Portland Cement Association
PCI	-	Prestressed Concrete Institute
PS&E	-	Plans, Specifications and Estimate
PTI	-	Post-Tensioning Institute
SASO	-	Saudi Arabian Standards Organization
SI	-	International System of Units
SSPC	-	Steel Structures Painting Council
USL	-	Upper Specification Limit
USC	-	United States Code
VDE	-	Verband Deutscher Electotechiker, e.V.

1.01.2 DEFINITIONS. Whenever in the specifications or in other Contract Documents the following terms or pronouns in place of them are used, the intent and meaning shall be interpreted as follows:

Admixture (additive) - A substance added to a mixture to impart a specific characteristic, such as pozzolith in concrete, antistripping agents in bituminous mixes, calcium chloride or sodium chloride to clay, etc.

Addendum - A written amendment or revision to the Contract Documents or plans issued to bidders subsequent to the date of advertisement and prior to the final date and time for submission of Tenders indicated in the "Instructions to Tenderer."

Acceptable Quality Level (AQL) - The level of Lot percent defective at/or below which the work is considered to be satisfactory.

Acceptance Program - All factors comprise the agency's determination of the degree of compliance with contract requirements and value of a product. These factors include agency or agency supervised sampling, testing, measuring, and inspection. These factors should also include validated results of contractor sampling and testing.

Advertisement - The public announcement, inviting Tenders for the Work.

Aggregates - Mineral particles consisting of sand, crushed or uncrushed gravel, crushed stone or similar materials, usually of controlled gradation, ranging in size from seventy-five (75) millimeters to seventy-five thousandths (0.075) millimeter. Coarse aggregates are those retained on the 4.75 millimeter (No. 4) sieve; fine aggregates are those passing the 4.75 millimeter (No. 4) sieve.

Air Entraining Agent - An admixture used in Portland cement concrete to entrain air in the mixture.

As-Built Plans - Plans prepared at the site during or immediately after construction representing the exact executed work.

Asphalt - A dark brown to black cementitious material; solid, semi-solid, or liquid in consistency; in which the predominating constituents are bitumens which occur in nature as such or which are obtained as residue in refining petroleum.

Asphalt Cement - A fluxed or unfluxed asphalt especially prepared as to quality and consistency for direct use in bituminous pavements.

Asphalt Concrete - See Bituminous Concrete.

Asphalt Emulsion - See Emulsified Asphalt.

Asphaltic Material - See Bituminous Material.

Award - The official acceptance by the Ministry of the Tender submitted by the Bidder selected to be the Contractor.

Backfill - Material used to replace, or the act of replacing, material removed during construction; also denotes material placed, or the act of placing, material adjacent to structures.

Backslope - In cuts, the slope from the bottom of the ditch to the top of cut.

Balance - A highway or section of highway where the available excavation material is equal to the necessary volume of embankment without borrow or waste.

Balled - Plant transplanted with roots in a ball of earth.

Bareroot - Plant transplanted with no soil on the roots.

Base Course - The layer or layers, of specified or selected aggregate materials of designed thickness placed on a subbase or a subgrade to support the remainder of the pavement structure.

Bedrock - Solid rock of indefinite thickness in its native location.

Bench Mark - A permanent or semi-permanent marker of known coordinates and elevation relative to a datum plane.

Berm - (1) A raised and elongated area of earth intended to direct the flow of water, screen headlight glare, or redirect out-of-control vehicles. (2) Embankment widening to provide lateral support for the roadway.

Bid - See Tender.

Bidder (tenderer) - An individual, firm or corporation submitting a Tender for the Work.

Bill of Quantities - That portion of the Contract Documents showing all items of Work as well as estimated quantities and contract unit prices for those items.

Binder - Material used to stabilize or bind together loose soil or aggregates.

Bitumen - See Asphalt Cement.

Bituminous Concrete - A combination of mineral aggregates and asphalt cement, mixed in a central plant which is usually mixed, laid and compacted while hot.

Bituminous Material - A general term encompassing asphalt cements, cutbacks and emulsified asphalt.

Bituminous Pavement - A pavement composed predominantly of aggregates cemented together with bituminous material.

Bituminous Surface Treatment - The application of thin layers of bituminous material with or without aggregate to an existing road surface.

Bleeding (Asphalt) - The flushing to the pavement surface of excess bituminous material, caused by heat or the use of excessive quantities of bituminous material.

Bleeding (Concrete) - The flow of water to the surface of freshly placed concrete or mortar.

Borrow - That material necessary to construct the embankment which is not available from the staked excavation.

Boulder - A rock fragment, usually rounded by weathering or abrasion, which will be retained on a seventy-five (75) millimeter sieve.

Breakaway (Yielding) Supports - A support for a roadside device which yields or collapses readily when struck by a vehicle.

Bridge - A structure exceeding six (6) meters clear span measured along the centerline of the roadway, which carries traffic over a watercourse, other roadways or opening.

Buyer's Risk - The probability that an acceptance plan will erroneously accept a Lot that is truly rejectable.

Calendar Day - Every day shown on the Hegira calendar.

Calibrate - (1) To determine settings of the plant which will provide correct proportions of the components of plant-mixed materials. (2) To compare with a standard or check the graduations of a gauge or other measuring devices.

Camber - A slight arch designed or built into a structure to compensate for the natural deflection after loading.

Centerline - The defined and surveyed line shown on the plans from which the highway construction is controlled.

Certificate of Guarantee - A signed statement by a person having legal authority to bind a company or supplier to its product. Such certificate shall state that the material specifications and test results are in compliance with the specified requirements of the pertinent AASHTO, ASTM and/or other designations.

Compaction - The active or mechanical consolidation of a mass by rolling, tamping or other similar means.

Consecutive Days - Two or more calendar days, one following the other.

Consolidation - The densification of a mass by compaction, vibration, passive loading or other means.

Contract and Contract Documents - The written agreement between the MOC and the Contractor setting forth the obligations of the parties thereunder, including, but not limited to, the performance of the Work, the furnishing of labor and materials, and the basis of payment. The contract documents include the invitation for tenders, instructions to tenderers, the tender, notice of award, form of contract, contract bond, general conditions and special conditions, general specifications, supplemental specifications, special specifications, bill of quantities, plans, addenda, directives, change orders, and supplemental agreements that are required to complete the Work, all of which constitute one instrument.

Contract Item (Item of Work) - A specifically described unit of Work for which a unit price is provided in the Contract Documents.

Change Order - A written order to the Contractor, approved by the Ministry, issued by the Engineer authorizing additions, deletions or revisions in the Work. The Change Order will set forth force account or negotiated unit prices, and any adjustments in the contract price and/or contract time as appropriate to the variation in the Work.

Contract Time - The time allowed for completion of the contract, including authorized time extensions. When a calendar date of completion is shown in the Tender, in lieu of the number of working or calendar days, the contract time is the period between the Process Verbal for Handing Over the Site to the date of completion.

Contractor - The individual, firm or corporation contracting with the MOC for performance of the Work described in the Contract Documents.

Contractor Process Quality Control - All contractor activities that have to do with making the quality of a system what it should be, including sampling and testing.

The Quality Control activities include, but are not limited to, all operational techniques and activities that are used to fulfill the contract requirements.

Creep - The slow movement of a material under stress usually imperceptible except to the observations of long duration.

Cross Section - A transverse cutaway view of a highway, roadway or structure showing horizontal and vertical dimensions, elevations, and/or other details.

Cross Slope - The transverse slope of the surface of the traveled way expressed as the vertical rise or fall as a percent of the horizontal distance.

Crown - (1) The high point at the center of the cross section of the surface of the traveled way, usually on a tangent alignment. (2) The condition where there is uniform cross slope down and away from the center of the traveled way toward both sides.

Cutback Asphalt - A mixture of asphalt cement and a petroleum diluent blended to provide viscosity suitable for spraying at relatively low temperatures.

Cut Section - A section of roadway where the bottom of the excavation or subgrade is lower in elevation than the original ground.

Date - Day, month and year reckoned according to the Hegira calendar and the applicable date corresponding to the Gregorian calendar.

Deck - The surface layer of concrete and reinforcing steel on a bridge.

Dense Graded - A well graded aggregate with sufficient fine material to nearly fill all voids.

Density - The mass per unit volume of material, usually expressed in kilograms per cubic meter or grams per unit centimeter.

Design Mix - See Job Mix.

Design Load - The maximum anticipated loads that must be supported by a structure.

Detour - (1) A temporary rerouting of traffic. (2) The route of the temporary rerouting.

Directive - An official written communication, having contractual status, from the Engineer to the Contractor with respect to any or all phases of the Contract and Work including, but not limited to, progress, approvals, rejections, procedures, methods, safety, etc.

Divided Highway - A highway with separated roadways for traffic in opposite directions.

Drawings - See Plans.

Dust Palliative - Any material used to control dust.

Elevation - Height above sea level or other datum.

Embankment - A raised earth structure on which the roadway pavement structure is placed.

Embankment Foundation - The original ground on which any embankment is constructed.

Emulsified Asphalt - A mixture of processed asphalt cement and water mixed with an emulsifying agent.

Engineer - The duly authorized representative of the Ministry at the project site, acting directly or through his duly authorized representatives, who is responsible for engineering supervision of the Work.

Equipment - All machinery and equipment, together with the necessary supplies for upkeep and maintenance; also tools and apparatus necessary for the proper construction and acceptable completion of the Work.

Extra Work - Additional or new work not provided for in the Contract as awarded but subsequently ordered by the Ministry for the satisfactory completion of a project within its intended scope.

Feasts and Holidays - All recognized feasts, holidays, days of rest, and other religious customs officially recognized by the Kingdom.

Fill Section - A section of roadway where the subgrade is higher in elevation than the original ground.

Fill Slope - In fills, the slope from the top of the subgrade to the toe or bottom of fill.

Final Handover - The final acceptance of the Work, by the MOC, as authorized by the General Conditions of the Contract.

Fines - (1) **Aggregates** - Portion finer than the 4.75 mm (No. 4) sieve.
(2) **Soils** - Portion of a soil finer than a 0.075 mm (No. 200) sieve.

Flushing - See Bleeding (Asphalt).

Force Majeure - An unexpected and disruptive event which may operate to excuse a party from a contract or part thereof.

Foreslope - The slope from the top of the surfaced shoulder to the top of the subgrade, or the bottom of the ditch in cuts.

Free Water - Water in aggregate or soil in excess of that absorbed into the surface of the particles.

Gap-Graded - An aggregate gradation of predominantly two sizes with little or no in-between sizes.

Grade - (1) The profile of the center of the roadway, or its rate of ascent or descent. (2) To shape or reshape an earth road by means of cutting or filling. (3) To arrange according to size. (4) Elevation.

Grade Line, Grade Profile - See Profile Grade.

Grading - (1) Construction of the earthwork portion of the highway. (2) Planing or smoothing the surface of various parts of the road by means of a motor grader.

Gravel - Aggregate deposited naturally by water.

Ground Water - Free water contained in the zone below the water table.

Grout - Mortar, composed of sand, cement, and water of such consistency that it can easily be placed by pouring or pumping if necessary.

Guarantor - A bank approved by the Government of Saudi Arabia, which provides the guarantees called for in the Contract Documents.

Guardrail - A protective cable or rail device placed along the roadway edge for the purpose of redirecting vehicles which have left the roadway at a point of hazard.

Hardpan - Layer of extremely dense soil.

Headwall - A wall, at the end of a culvert to prevent earth from spilling into the channel.

Highway, Street or Road - General terms denoting a public way for purposes of vehicular travel.

Impact Attenuator - A device placed in front of a fixed object in or near the roadway for the purpose of stopping a vehicle at a controlled rate.

Inspector - The Engineer's authorized representative assigned to make detailed inspections of the Work.

Item of Work - See Contract Item.

Job-Mix (job-mix formula, design-mix) - The exact proportions of all components of a bituminous or other type mix, determined by laboratory tests.

Kingdom - the Kingdom of Saudi Arabia.

Laboratory - The field testing facility or other testing facility which may be designated by the Engineer.

Ledge Rock - A layer of stone in a quarry.

Leveling Course - The layer of material placed on an existing surface to eliminate irregularities prior to placing an overlaying course.

Limit (USL, LSL) - Upper and lower specification limits outside of which the material or work is defined to be defective.

Liquid Asphalt - Cutbacks or emulsified asphalt.

Lot - A discrete quantity of material or work to which an acceptance procedure is applied.

Median - The portion of a divided highway separating the traveled ways for traffic in opposite directions.

Median Barrier - A longitudinal system used to prevent a vehicle from crossing the median of a divided highway.

Ministry - The Ministry of Communications of the Kingdom of Saudi Arabia.

Minor Concrete - Nonstructural concrete as designated on the plans or in the specifications.

Moisture Content - The percentage, by weight, of water contained in soil or other material, usually based on the dry weight.

Muck - An organic or saturated soil of very soil or liquid consistency.

Open-graded Aggregate - A graded aggregate, containing little or no fines, with a high percentage of aggregate voids.

Overburden - The mass of soil which overlies a source of rock, gravel or other road material. This material is removed before the materials are quarried to avoid contamination.

Pavement Structure - The combination of subbase, base course, and surface courses placed on a subgrade to support the traffic load and distribute it to the roadbed.

Percent Defective - Percentage of the Lot falling outside specification limits, may refer to either the population value or the sample estimate of the population value.

Performance Guarantee - The approved form of security, executed by the Contractor and his Surety or Sureties, guaranteeing complete execution of the Contract and all supplemental agreements pertaining thereto, and the payment of, all legal debts pertaining to the construction of the project.

Period of Maintenance - Period of maintenance shall mean the period of Contractor maintenance named in the Contract, calculated from the date of completion of the Work as certified by the Provisional Handover Committee.

Pit - A natural deposit of gravel or other type of soil which has been, or may be, excavated.

Plans (Drawings) - The approved plans (drawings), profiles, typical cross sections, working drawings, and supplemental drawings, or exact reproductions thereof, which show the location, character, dimensions, and details of the Work.

Plating - The covering or confining of unstable fills with a suitable, stable material.

Point - To fill the outside part of a joint in masonry with mortar.

Preconstruction Conference - A conference arranged by the Engineer between himself and representatives of the Contractor before Work begins to discuss schedule of progress and contract administration requirements.

Prime Coat - The application of a low viscosity liquid asphalt to an absorbent surface, preparatory to any subsequent treatment, for the purpose of hardening or toughening the surface and providing a transition between it and the succeeding bituminous construction.

Process-Verbal - Any written statement of record concerning the Works of the Contract signed by the Engineer and the Contractor.

Producer's Risk - The probability that an acceptance plan will erroneously reject a Lot that is truly acceptable.

Profile Grade - The trace of a vertical plane intersecting the top surface of the proposed wearing surface, along a defined point on the roadway typical section or the longitudinal centerline of the roadway.

Program of Work - A work schedule prepared and submitted by the Contractor to the Engineer for his approval prior to the commencement of the Work. The Program shall show the equipment, the order of procedure, and methods which the Contractor proposes to use to carry out the Work.

Project - An undertaking to construct a particular portion of a highway.

Provisional Handover - A conditional acceptance, by the Ministry, of a partial or total completion of the Work as authorized in the General Conditions of the Contract.

Quality Assurance - All those planned and systematic actions necessary to provide adequate confidence that a product or service will satisfy given requirements for quality.

Quality Assurance Procedures - Specific sampling, testing, measuring, and evaluation procedures for determining the degree of conformance to the quality and quantity requirements of the Specifications.

Quality Index (Q) - A statistic computed when applying the variables acceptance procedures to estimate the level of quality actually achieved.

Random - Without bias or regularity.

Random Sample - A sample selected in such a way that every element of the population has an equally likely opportunity to be included in the sample.

Ravelling - The progressive loosening of the aggregate in the surface course of a road.

Rejectable Quality Level (RQL) - The level of Lot percent defective at/or above which the work is considered to be unacceptable.

Right-of-Way - The publicly owned land, acquired for and devoted to the highway and its appurtenances.

Riprap - A protective covering of graded boulders, pieces of concrete or stone, with or without mortar, to prevent erosion.

Road (Highway) - A general term denoting a public way for purposes of vehicular travel, including the entire area within the right-of-way.

Roadbed - The graded portion of a road or highway, usually considered as the area between the intersection of top and side slopes, upon which the base course, surface course, shoulders, and median are constructed. The top of the subgrade.

Roadway - (1) The portion of a highway, including shoulders, for vehicular use; a divided highway has two or more roadways. (2) During construction the portion of a highway within the limits of construction.

Screed - A mechanical device to strike off, smooth and (at least partially) consolidate a newly placed concrete or bituminous surface.

Segregation - Separation of portions of a mixture from the mass or the localization of sizes or portions within a mixture or mass.

Shoulder - The portion of roadway contiguous with the traveled way for accommodation of stopped vehicles for emergency use, and for lateral support of base and surface courses.

Silt - Material passing the 0.075 mm (No. 200) sieve that is non-plastic or very slightly plastic, and exhibits little or no strength when air dried.

Site - The lands and other places provided by the Ministry for the execution of the Work.

Site Engineer - The on-site representative of the Contractor duly authorized to receive and execute all instructions of the Engineer and to supervise and direct all of the Contractor's construction operations in all phases of the Work.

Special Specifications - Additions and revisions to the General and Supplemental Specifications covering conditions peculiar to an individual project.

Specifications - The formal directions, provisions, and requirements which outline the Work to be done, the way in which it is to be done, the character of materials and mixtures to be used, or the results to be obtained.

Specified Completion Date - The calendar date on which the Work is specified to be completed.

Spur Dike - An earth embankment projecting into the flood plain to guide water flow into a bridge opening or culvert. Dikes may be armored by riprap to protect them from erosion.

Station - (1) A measure of distance used for highways and railroads. In Saudi Arabia a station is equal to one (1) kilometer. (2) A precise location along a survey line.

Statistically Based Acceptance - The analysis of all test results collectively and statistically by quality level analysis to determine the total estimated percent defective for acceptance.

Stone - Rock material produced from bedrock, i.e., non-gravel material.

Street or Highway - A public way that is open to the movement of vehicular traffic, pedestrians, and transportation by other means or conveyances. The entire width between the right-of-way lines of any way open to public traffic.

Stripped - Peeled off, as asphalt from aggregate or forms from concrete.

Subcontractor - An individual, firm or corporation to whom the Contractor sublets part of the Work.

Subbase - The layer or layers of specified or selected aggregate materials of designed thickness placed on a subgrade to support a base course.

Subgrade - A defined layer thickness of select material (normally thirty (30) centimeters) on which the pavement structure, including shoulders, is constructed.

Substructure - All of that part of the structure below the bearings of simple and continuous spans, skewbacks of arches and tops of footings of rigid frames, together with the backwalls, wingwalls and wing protection railings.

Superelevation - The increasing of the cross slope on a curve to partially offset the centrifugal force generated when a vehicle rounds the curve.

Superstructure - The entire structure except for the substructure.

Supplemental Agreement - A written proposal and agreement, executed by the Ministry and the Contractor, covering Work not included in the original contract. Prices for such Work, and extension of contract time, will be determined by good faith negotiation.

Supplemental Specifications - Additions and revisions to the General Specifications that are adopted subsequent to issuances of the printed book.

Surety - The corporation, partnership, or individual other than the Contractor, executing a Tender Guarantee furnished by the Contractor.

Surface Treatment - See Bituminous Surface Treatment.

Tack Coat - An application of bituminous material to an existing surface to provide bond with the succeeding bituminous course.

Tender - The bid or offer made by a bidder, on the prescribed form, to perform the Work and to furnish the labor and materials at the prices quoted.

Tender Documents - The approved form on which the Ministry requires Tenders to be prepared and submitted for the Work.

Tender Guarantee - The security furnished with a Tender to guarantee that the bidder will enter into contract if his Tender is accepted, and includes the specified forms on which the Contractor shall furnish required information as to his ability to perform and finance the Work.

Tenderer - See Bidder.

Toe of Slope - The intersection of a roadway embankment side slope with the original ground surface.

Topsoil - Naturally occurring surface soil, usually containing organic matter.

Traffic Control Devices - Signs, signals, markings, and devices placed, erected, or authorized by proper authority having jurisdiction, for the purpose of regulating, warning, or guiding traffic.

Traffic Lane - That portion of the traveled way for the movement of a single line of vehicles.

Traveled Way - The portion of the roadway for the movement of vehicles, exclusive of shoulders and auxiliary lanes.

Typical Section - A transverse section of a proposed highway showing the lateral slopes, horizontal and vertical dimensions and functional and structural elements of the highway.

Underdrain - Porous or perforated pipe, or graded aggregate installed under a roadway or shoulder to provide sub-surface drainage.

Uniformly Graded - Aggregate with a uniform gradation from coarse to fine.

Visual Inspection - Inspection for defects which can be seen.

Wadi - A stream or watercourse that is dry except during periods of rainfall.

Water-Cement Ratio - The ratio of the amount of water, exclusive of that absorbed by the aggregates, to the amount of cement in a concrete or mortar mixture; preferably stated as a decimal by mass.

Weephole - A hole through an abutment or retaining wall to relieve hydrostatic pressure from groundwater.

Well Graded - Aggregate material of varying particle sizes which produce maximum density when mixed.

Windrow - Material deposited or manipulated into a continuous uniform row along the roadbed.

Work - The Work shall mean the furnishing of all labor, materials, equipment, and other incidentals necessary or convenient to the successful completion of the project and the carrying out of all the duties and obligations imposed by the contract.

Working Day - A working day shall be any day upon which the Contractor can physically and legally prosecute the Work.

Working Drawings - Stress sheets, shop drawings, erection plans, falsework plans, framework plans, cofferdam plans, bending diagrams for reinforcing steel, or any other supplementary plans or similar data which the Contractor is required to submit to the Engineer for approval.

1.01.3 FORMAT AND REFERENCES.

1.01.3.1 Part. This book of General Specifications is divided into Parts, with each Part designated by a one digit numerical figure and an upper case alphabetical title as follows:

PART 2
EARTHWORK

1.01.3.2 Section. Each Part is divided into Sections with each Section designated by a three digit numerical figure and an upper case alphabetical title as follows:

Section 2.01
CLEARING AND GRUBBING

1.01.3.3 Subsection. Each Section is divided into Subsections with each Subsection designated by a four digit numerical figure and an upper case title as follows:

Subsection 2.01.1 MATERIALS

1.01.3.4 Paragraph. Each Subsection may or may not be divided into a series of subordinate Paragraphs with each Paragraph designated by a five digit numerical figure and a lower case title as follows:

Paragraph 2.01.1.2 Aggregates

1.01.3.5 Subparagraph. Each paragraph may or may not be further divided into a series of subordinate subparagraphs designated by a six digit numerical figure or a combination of six digits and alphabetical letters and a lower case title as follows:

Subparagraph 2.01.1.2.a. Fine Aggregate
Subparagraph 2.01.1.2.1. Fine Aggregate

1.01.3.6 References. The specifications for any Item of Work in the Bill of Quantities are included in the Section corresponding to the number of that Item of Work. All provisions of that Section, including corresponding Supplemental Specifications and Special Specifications, shall be construed as specifications for the Item of Work, except those provisions clearly inapplicable in the context in which they appear or unless they are waived or modified by the Supplemental Specifications, Special Specifications, Notes on the Plans, or by Change Order. In addition, the Plans or Specifications may contain cross references to other Sections, Subsections, Paragraphs, etc., which shall likewise be construed as specifications for the Item of Work.

1.01.4 MEANINGS OF "SHALL," "SHOULD" AND "MAY." In these General Specifications the words "shall," "should" and "may" are used to describe specific conditions concerning various requirements. To clarify the meanings intended in these General Specifications by the use of these words, the following definitions apply:

1. SHALL - a *mandatory* condition. Where certain requirements in the construction or application are described with the "shall" stipulation, it is mandatory that these requirements be met.

2. SHOULD - an *advisory* condition. Where the word "should" is used it is considered to be advisable usage, recommended but not mandatory.

3. MAY - a *permissive* condition. No specific requirement for construction or application is intended.

SECTION 1.02 - SCOPE OF WORK

1.02.1 INTENT OF CONTRACT. The intent of the Contract is to provide for the construction and completion in every detail of the Work described. The Contractor shall furnish all labor, materials, equipment, tools, transportation and supplies required to complete the Work in accordance with the plan, specifications, and terms of the Contract Documents.

1.02.2 ADDITIONAL PLANS. The Contract plans may be supplemented, from time to time, by the Engineer, with additional plans to illustrate particular or special parts of the Work. These additional plans shall be considered as having the same effect as the contract plans in the control and execution of the Contract. These additional plans will not change the Work of the Contract but will explain it.

1.02.3 SPECIAL WORK. Special Work refers to that part of the Work which is not satisfactorily covered by the General Specifications or Supplemental Specifications and for which Special Specifications have been prepared. Such Special Work shall be considered a part of the Contract.

1.02.4 ADDITIONS, DELETIONS AND REVISIONS IN THE WORK. The Ministry reserves the right to make, at any time during the progress of the Work, such increases or decreases in quantities and such alterations in the details of construction, including alterations in the grade or alignment of the road or structures or both, as may be found to be necessary or desirable. Such increases or decreases and alterations shall not invalidate the Contract nor release the Surety, and the Contractor agrees to accept the Work as altered, the same as if it had been a part of the original Contract. See Article 7-1 of the Conditions of Contract.

The Engineer will, upon determination of a significant change in plan quantities, notify the Contractor in writing of the anticipated change. The Contractor shall acknowledge this notification and perform the altered Work accordingly. Unless such alterations and increases or decreases materially change the character of the Work to be performed or the cost thereof, the altered Work shall be paid for at the same contract unit prices as other parts of the Work. If, however, the character of the Work, or the contract unit cost(s) thereof are materially changed, an adjustment will be made on such basis as may have been mutually agreed to by Change Order, or in case no such basis can be agreed upon in advance, then an adjustment shall be made, either for or against the Contractor, in such amount as the Ministry may determine to be fair and equitable. See Article 7-3 of the Conditions of Contract.

No claims shall be made by the Contractor for any loss of anticipated profits because of any such alteration, or by reason of any variation between the approximate quantities and the quantities of Work as done.

Payment for Work occasioned by changes or alterations will be made in accordance with the provisions set forth under Subsection 1.07.3, "Compensation for Altered Quantities" in these General Specifications.

If the altered or added Work is of sufficient magnitude as to require additional time in which to complete the project, such time adjustment may be made in accordance with the provisions of Section 1.06, "Prosecution and Progress" in these General Specifications.

Should the Contractor encounter, or the Engineer discover during the progress of the Work, subsurface or latent physical conditions at the site differing materially from those indicated, or unknown physical conditions at the site of an unusual nature, differing materially from those ordinarily encountered and generally recognized as inherent in Work of the character provided for in the Contract, the Engineer shall be promptly notified in writing of such conditions before they are disturbed. The Engineer will thereupon promptly investigate the conditions and if he finds they do so materially differ and cause an increase or decrease in the cost of, or the time required for performance of the Contract, an equitable adjustment will be recommended and, with the concurrence of the Ministry, the contract will be modified by Change Order or Supplemental Agreement.

1.02.4.1 Authorization for Variations and Adjustments. Variations or adjustments to the Work will be authorized by one of the following methods (see Article 7-2 of the Conditions of Contract):

1.02.4.1.1 Directive. There are two types of Directives - written orders issued to the Contractor by the Engineer. Type I implements the Contract by providing an order, notification, confirmation, or approval related to prosecution of the Work in the Contract. Type II authorizes minor additions, deletions, or revisions in the Work for which the basis of payment has been established in the Bill of Quantities and which do not increase the total Contract Price or extend the Period of the Contract. Type III Directives must be approved by the Ministry before they are issued. Type I Directives may be issued without advance Ministry approval.

1.02.4.1.2 Change Order. A written order, approved by the Ministry, issued to the Contractor by the Engineer, supplementing the Contract and authorizing additions, deletions, revisions or material changes in the Work which they are considered to be within the original scope of the Contract, but which increase the total Contract Price, extend the Period of the Contract, or include items of Work for which no basis of payment has been established in the Tender. The Change Order will set forth all adjustments in the Contract price or unit prices based on negotiations with the Contractor or cost estimates approved by the Engineer. The Change Order may authorize some or all of the Work to be performed on a Force Account basis if contract unit price(s) are deemed by the Engineer to be inappropriate. The Change Order will also set forth any adjustment in the Period of the Contract as appropriate to the variation in the Work.

1.02.4.1.3 Supplemental Agreement. A written mutual agreement between the Contractor and the Ministry modifying the scope of the Contract. The Supplemental Agreement will set forth any adjustments in the Contract price or unit prices. The Supplemental Agreement may authorize some or all of the Work to be performed on a Force Account basis if contract unit price(s) are deemed inappropriate.

The Supplemental Agreement will also set forth any adjustment in the Period of the Contract appropriate to the Work authorized.

1.02.4.1.4 Force Account. If the Ministry elects, or if a Supplemental Agreement between the Ministry and the Contractor cannot be reached, the Ministry may direct Extra Work to be performed on a force account or day-work basis as provided in Subsection 1.07.5, "Extra and Force Account Work" in these General Specifications. See Article 7-4 of the Conditions of Contract.

1.02.4.2 Materially Changed Work. Unless increases and decreases in quantities and alterations in plans materially change the character of the Work, or the cost thereof, the altered Work shall be performed as a part of the Contract and will be paid for at the same contract unit price(s) as for other parts of the Work. The term "materially change," for purposes of intent under the Contract, shall be construed to apply only to the following circumstances:

1.02.4.2.1 Character of the Work. When, in the opinion of the Engineer, the character of any of the Work as altered differs in kind or nature from that involved or encountered in the original proposed construction.

1.02.4.2.2 Amount of Increase or Decrease. When the total amount of the increase or decrease exceeds twenty percent (20%) of the total estimated value of the Contract.

If the character of the Work or the unit costs thereof are "materially changed" as above defined, an allowance will be made on such basis as may have been provided by Change Order or Supplemental Agreement in advance of the performance of the Work involved or, in case no such basis has been previously agreed upon, an equitable adjustment in the Contract Unit Price will be made.

1.02.4.3 Value Engineering.

1.02.4.3.1 Intent. The intent of value engineering is to provide an incentive to the Contractor to initiate, develop, and present to the Engineer for consideration, any cost reduction proposals conceived by him, involving changes in the drawings, designs, specifications, or other requirements of the contract. These provisions do not apply unless the proposal submitted is specifically identified by the Contractor as being presented for consideration as a value engineering proposal.

The cost reduction proposals contemplated are those that would require a change order modifying the contract and would produce a savings to the Ministry by providing less costly items or methods than those specified in the contract, and/or reducing future maintenance costs, without impairing essential functions and characteristics such as service life, reliability, economy of operation, ease of maintenance and necessary standardized features.

1.02.4.3.2 Proposal by Contractor. Value engineering proposals will be processed in the same manner as prescribed for any other alterations of the contract

that would require a change order or supplemental agreement. As a minimum, the following information shall be submitted by the Contractor with each proposal:

1. A statement that the proposal is submitted as a value engineering proposal.

2. A description of the proposal.

3. An itemization of the requirements of the contract which must be changed and a recommendation of how to make each change.

4. An estimate of the reduction in performance costs that will result from adoption of the proposal.

5. A prediction of any effects the proposed changes would have on other costs to the Ministry.

6. A statement of the time by which an agreement for adoption of the proposal must be executed to obtain the maximum cost reduction during the remainder of the contract and the reasoning for this time schedule.

7. A statement as to the effect the proposal would have on time for completion of the project.

1.02.4.3.3 Review and Approval. The Ministry shall not be liable for any delay in acting upon any proposal submitted. The Contractor may withdraw in whole or in part, any value engineering proposal not accepted within the period specified in his proposal. The decision of the Engineer as to the acceptance or rejection of value engineering proposals shall be final and shall not be subjected to the provisions of Subsection 1.03.15, "Claims for Adjustments and Disputes." The Contractor will be notified in writing of the Ministry's decision to accept or reject each value engineering proposal submitted under the provisions in these General Specifications.

1.02.4.3.4 Contract Modifications and Payment. If a proposal is accepted, the necessary contract modifications will be effected by execution of a change order, which will provide for equitable price adjustments giving the Contractor and the Ministry proportionate shares in net savings resulting therefrom. Unless and until a proposal is effected by such contract modification, the Contractor shall remain obligated to perform in accordance with the terms of the existing contract.

The change order effecting the necessary contract modifications shall establish the net savings agreed upon and shall provide for such adjustment in the contract price as will divide the net savings equally between the Contractor and the Ministry. All reasonably incurred costs developing the cost reduction proposal and implementing the changes, including any increased costs to the Ministry resulting from its application, will be deducted from the total estimated decrease in the Contractor's cost of performance to arrive at the net savings. The Ministry reserves the right to include in the agreement any conditions it deems appropriate for consideration, approval, and implementation of the cost reduction proposal. The Contractor's forty percent (40%) share of the net

savings shall constitute full compensation to him for effecting all changes pursuant to the agreement. Upon acceptance of a cost reduction proposal, any restrictions imposed by the Contractor on its use or disclosure of the information submitted shall be void, and the Ministry shall thereafter have the right to use, duplicate, and disclose in whole or in part any data necessary to utilization of the proposal on this project or other Ministry projects.

1.02.4.3.5 Contract Time. Any time savings realized by implementation of value engineering proposals will result in a corresponding adjustment in the contract completion time.

All time savings from any approved value engineering proposal will be to the benefit of the Ministry.

1.02.5 CONSTRUCTION AND MAINTENANCE OF DETOURS. The Contractor will be required to establish, construct and maintain temporary detour roads over or through construction or to build and maintain temporary structures around or in place of bridges in accordance with Part Nine, "Traffic Control Devices and Work Zones" in these General Specifications. The Contractor will be required to build and maintain suitable temporary structures around or over culverts to serve the residents living on or traffic originating on the section of road under contract. All detour routes shall be signed, striped, and maintained by the Contractor including traffic control devices as shown in the Traffic Control Plan for the project and the M.O.C. Manual of Uniform Traffic Control Devices (MUTCD). If the project plans do not detail a Traffic Control Plan (TCP) the Contractor shall submit in writing to the Engineer all details of his proposed Traffic Control Plan including all detours, layouts, geometrics, pavement construction, drainage, lighting, signing, traffic control devices including pavement marking and existing marking removal, crashworthy safety barriers according to the M.O.C. Road Services Department Work Zone Traffic Control Handbook and MUTCD for approval.

Payment for detour construction, maintenance costs, signs, barricades, and other traffic control devices will be made in accordance with Section 9.02, "Control of Traffic Through Work Zones" in these General Specifications.

1.02.6 REMOVAL AND DISPOSAL OF STRUCTURES AND OBSTRUCTIONS. The Contractor shall remove any and all materials not suitable for use in the Work. This includes obstructions, fences, existing culverts, bridges, and all other structures or parts of structures within the highway right-of-way, which are to be replaced or interfere with the new construction, in accordance with Section 2.02, "Removal of Structures and Obstructions" in these General Specifications, unless otherwise specifically provided on the plans or in the Special Specifications. The Contractor shall also remove and dispose of all foundations, debris, trash, and remains left after the previous removal by others of vacated dwelling houses or other buildings as detailed in Section 2.02 "Removal of Structures and Obstructions" in these General Specifications. Such removal shall be performed at the Contractor's expense and is considered subsidiary Work included in other items of Work performed, unless a separate item is included in the Bill of Quantities for this Work.

1.02.7 RIGHTS IN AND USE OF MATERIALS FOUND ON THE WORK. The Contractor, with the approval of the Engineer, may use on the project such stone, gravel, sand, or other material determined suitable by the Engineer, as may be found in the authorized excavation and will be paid both for the excavation of such materials at the corresponding contract unit price and for the pay item for which the excavated material is used. He shall replace at his own expense with other acceptable material all of that portion of the excavation material so removed and used which was needed for use in the embankments, backfills, approaches or otherwise. No charge for the materials so used will be made against the Contractor.

The Contractor shall not excavate or remove any material from within the right-of-way which is not within the grading limits, as indicated by the slope and grade lines, without written authorization from the Engineer.

Unless otherwise provided, the material from any existing old structure may be used temporarily by the Contractor in the erection of the new structure. Such material shall not be cut or otherwise damaged except with the approval of the Engineer.

1.02.8 FLOODING. The Contractor bears all costs and expenses for the protection of the Works which he executes from rains and flooding including the construction of all temporary diversion banks, sumps, channels, pipes, well points and pumps, etc. The Contractor is also responsible for insuring that all rain and flood water is discharged at locations and in such a way as to cause no inconvenience to any third parties.

The Contractor shall submit details to the Engineer of his arrangements for keeping the working area free from rain and flood water and of the equipment and methods he proposes to use to dispose of any rain or flood water from the site.

It should be especially noted that much of the construction of the underpasses is expected to be below the existing water table.

1.02.9 ELECTRICITY SUPPLY. The Contractor shall, at his own expense, make arrangements for the supply of electricity required for the execution of the Work.

1.02.10 WATER SUPPLY. The Contractor shall, at his own expense, make his own arrangements for the supply of water required for execution of the Work and shall coordinate with the concerned authorities in this respect. All water shall be obtained from a source approved by the Engineer.

1.02.11 OTHER CONTRACTORS. The Contractor's attention is drawn to the fact that there may be other Contractors working in the area during the course of this Contract and that his prices shall include for any disturbance or interference to his work, in this respect.

1.02.12 CONSTRUCTION RECORDS. The Contractor shall submit at his expense each month photographs of twenty (20) different subjects as agreed by the Engineer. For each subject, the Contractor shall supply three (3) color prints (glossy finish) size twenty (20) centimeter x twenty-five (25) centimeters plus negatives and, in addition, color transparencies. Negative and transparency should be exposed and as far as possible, should show identical scenes. Each print and transparency shall be titled and referenced to a suitable key plan. Prints and negatives should also be suitably cross-referenced. Video film of unique construction operations and innovative procedures shall also be provided by the Contractor.

The furnishing of all photographic records will not be paid for separately but will be considered subsidiary to other items in the Bill of Quantities.

1.02.13 FINAL CLEAN UP. Upon the completion of the Work and before provisional and final handover, the Contractor, at his own expense, shall clean the roadway and adjacent property defaced or occupied by him in connection with the Work, of all rubbish, weeds, brush, excess materials, falsework, temporary structures, and equipment. All parts of all types of the Work shall be left in a neat and presentable condition and as approved by the Engineer.

1.02.14 FINAL CERTIFICATE. The Contractor shall comply with the M.O.C. Circular No. 8404 dated 16-09/1411 (H) regarding instructions and documents that must be attached with the final certificate.

SECTION 1.03 - CONTROL OF WORK

1.03.1 AUTHORITY OF THE ENGINEER. The Engineer, as the duly authorized representative of the Ministry, will decide all questions which may arise as to the quality and acceptability of materials furnished and Work performed and as to the rate of progress of the Work; specifications compliance; and all questions as to the acceptable fulfillment of the Contract on the part of the Contractor. See Articles 2 and 3-4 of the Conditions of Contract.

The Engineer will have the authority to suspend the Work wholly or in part due to the failure of the Contractor to correct conditions unsafe for the workmen or the general public; for failure to carry out provisions of the Contract; for failure to carry out orders; for such periods as he may deem necessary due to unsuitable weather; for conditions considered unsuitable for the prosecution of the Work or for any other condition or reason deemed to be in the interest of the Ministry.

In order to provide for the protection of the Work, for the protection of the public, for the most advantageous movement of public traffic, and to assure early completion of the Work when more than one Contractor is involved, the Engineer shall have the right to require the early completion or the delay of portions of the Work and to determine the order in which the Work shall be prosecuted. His decision shall be final and he shall have executive authority to enforce and make effective such decisions and orders that the Contractor fails to carry out promptly.

Any Directives or written instructions to the Contractor which may be required may be served on said Contractor or his representative, either personally or by mailing to the address given in the Contract, or by leaving the same at said address.

1.03.2 PLANS AND WORKING DRAWINGS. The plans will show details of all traffic control plans, lines, grades, typical cross sections of the roadway, location, and design of all structures and a summary of items appearing on the Bill of Quantities. Only general features will be shown for steel bridges. The Contractor shall keep one set of plans available at the Work Site at all times.

The plans will be supplemented by such working drawings as are necessary to adequately control the Work. Working drawings for structures shall be furnished by the Contractor and shall consist of such detailed plans as may be required to adequately control the Work and which are not included in the plans furnished by the Ministry. They shall include stress sheets, shop drawings, erection plans, falsework plans, cofferdam plans, bending diagrams for reinforcing steel, or any other supplementary plans or similar data required of the Contractor. Working drawings for traffic control through work zones (Traffic Control Plans) shall be furnished by the Contractor when they are not included in the plans. These working drawings shall include Geometrics and cross section detour layouts, signs and other traffic control device locations and traffic handling schemes. All working drawings must be approved in writing by the Engineer and such approval shall not operate to relieve the Contractor of any of his responsibility under the Contract for the successful completion of the Work. No related Work may proceed until approval is obtained from the Engineer. Deviations from the working drawings may likewise be approved in writing. Deviations without previous approval may be cause for rejection of the Work involved. The Contract price shall include the cost of furnishing all working drawings.

1.03.3 CONFORMITY WITH THE PLANS AND SPECIFICATIONS. All Work performed and all materials furnished shall be in conformity with the lines, grades, cross sections, dimensions, and material requirements, including tolerances, shown on the plans or indicated in the specifications.

In the event the Engineer finds the materials or the finished product in which the materials are used or the Work performed are not in conformity with the plans and specifications and have resulted in an inferior or unsatisfactory product, the Work, or materials shall be removed and replaced or otherwise corrected by and at the expense of the Contractor.

1.03.4 COORDINATION OF PLANS, GENERAL SPECIFICATIONS AND SPECIAL SPECIFICATIONS. These General Specifications, the Plans, and the Special Specifications, and all supplementary documents are essential parts of the Contract, and a requirement occurring in one is as binding as though occurring in all. They are intended to be complementary and to describe and provide for a complete Work. In case of discrepancy, conflict, or error, the Contract Documents shall be given precedence in the order stipulated in the Form of Contract.

The provisions of the Form of Contract, General Conditions of Contract, and the Saudi Arabian Tender Regulations shall take precedence over the provisions or stipulations in these General Specifications. In the plans, calculated dimensions will govern scaled dimensions. In case of discordance between the Arabic and English versions of the Contract Documents, the Arabic version shall govern all of the Contract Documents including the Conditions of Contract, except for the General Specifications, Supplemental Specifications, Bill of Quantities, Special Specifications, and the Project Plans, in which cases the English version shall govern. If no English version exists, then the Arabic version shall govern.

The Contractor shall take no advantage of any apparent error or omission in the plans or specifications. In the event the Contractor discovers such an error or omission, he shall immediately notify the Engineer. The Engineer will then make such corrections and interpretations as may be deemed necessary for fulfilling the intent of the plans and specifications.

1.03.5 SILENCE OF SPECIFICATIONS. The apparent silence of the specifications, plans, or other contract documents as to any detail or the apparent omission from them of a detailed description concerning any point, shall be regarded as meaning that only the best generally accepted practice is to be used. All interpretations of the specifications will be made by the Engineer on this basis.

1.03.6 COOPERATION OF CONTRACTOR. In order to coordinate the efforts of the Contractor or the several Contractors with those of the Engineer; to facilitate the movement of traffic; and to insure the early completion of all phases of the Work; the

Contractor shall, prior to beginning the Work, confer with the Engineer to arrange for a satisfactory Program of Work. See Article 3.5 of the Conditions of Contract.

Whenever work being done by other Contractors is contiguous or related to the Work included in this Contract, the sequence of handling the Work shall be such that the least delay possible will result to each Contractor and such sequence may be designated by the Engineer. The respective rights of the various interests involved shall be established by the Engineer, in order to secure the completion of the various portions of the Work in general harmony.

The Contractor shall have available on the Work at all times one copy of the plans and specifications. He shall give the Work the constant attention necessary to facilitate the progress thereof and shall cooperate with the Engineer and other Contractors in every way possible. The Contractor shall at all times have a competent, English speaking, Site Engineer capable of reading and thoroughly understanding the plans and specifications, as his agent on the Work, who shall receive instructions from the Engineer or his authorized representatives. The Site Engineer shall have full authority to execute the orders or directions of the Engineer without delay and to supply promptly such materials, tools, plant equipment, and labor as may be required. The Site Engineer shall be furnished irrespective of the amount of Work sublet. Whenever the Contractor or his Site Engineer is not present on any part of the Work where the Engineer may desire to give orders or directions, they shall be received and obeyed by the Foreman or person in charge of the particular Work.

1.03.7 COOPERATION WITH UTILITIES. Notwithstanding anything to the contrary in the Contract Documents, the Contractor shall coordinate with the Local Authorities and Utility Owners concerning identification, new construction, relocationing, adjustment or removal of utilities including any temporary work or lines. He shall execute such works as directed, and perform the same in full cooperation with the Local Authorities and Utility Owners.

It is understood that the Contractor has considered in his Tender all of the permanent and temporary utility appurtenances in their present and relocated positions as shown on the plans. The Contractor shall cooperate fully with the utility owners and schedule his work so as to minimize any potential delays, inconveniences, or damages to the Work that may result from utility interferences or the operations of moving them.

1.03.8 CONSTRUCTION STAKES, LINES AND GRADES. The Engineer will furnish the Contractor with the location of points of intersection, a list of coordinates of all the points of tangents intersection and benchmark information. The plans indicate the properties of horizontal and vertical curves, together with rates of superelevation where required. The Contractor shall set construction stakes establishing lines, slopes, and continuous profile grade in road work, and centerline and benchmarks for bridge work, culvert work, protective and accessory structures, and appurtenances as he may deem necessary and will furnish the Engineer with the original copy of the field notes together with all necessary information relating to lines, slopes and grades. These stakes and marks shall constitute the field control by and in accordance with which the Contractor shall establish other necessary controls and perform the Work. See Article 3-7 of the Conditions of Contract.

The Contractor shall, prior to any stakeout Work, submit to the Engineer for his approval a planned method of operations for the staking-out of the project. The plan shall include minimum accuracy of stakes, the positions of the various types of stakes, the method of marking stakes, the methods to be used for protecting stakes, etc. No staking shall proceed prior to the Engineer's approval of the Contractor's staking plan.

At least twenty-four (24) hours before he intends to stakeout any portion of the Work, the Contractor shall submit written notice to the Engineer. Such notice shall include the time, location, and type of Work to be staked.

The Contractor will stakeout the Work and secure the Engineer's approval of his stakeout during the preparation period before proceeding with construction. If, in the opinion of the Engineer, modification of the line or grade is advisable, before or after stakeout, the Engineer will issue detailed instructions to the Contractor for such modifications and the Contractor will revise the stakeout for further approval. No changes in the contract unit price(s) of the affected items of Work will be made for such modifications.

The profiles and cross sections on the plans indicate the elevation of the top of road surface or as otherwise noted on the plans. Coordinates and elevations shown on the Drawings are in meters and are based upon an approved coordinate system.

The Contractor shall be held responsible for the preservation of all stakes and marks. If any of the construction stakes or marks have been destroyed or disturbed, the Contractor will replace them at his own expense. Certain established Bench Marks are located in the vicinity of the Works and the Contractor shall ensure that they are not damaged or disturbed by his operations.

The Contractor shall be responsible for the accuracy of all lines, slopes, grades and other survey Work.

1.03.9 DUTIES OF THE INSPECTOR. Inspectors, employed by the Engineer, will be authorized to inspect all Work done and materials furnished. Such inspection may extend to all or any part of the Work and to the preparation, fabrication, or manufacture of the materials to be used. The Inspector will not be authorized to alter or waive the provisions of the specifications. The Inspector will not be authorized to issue instructions contrary to the plans and specifications, or to act as foreman for the Contractor.

1.03.10 INSPECTION OF WORK. All materials and each part or detail of the Work shall be subject to inspection by the Engineer. The Engineer, or any persons authorized by him, shall at all times have access to the Work and all workshops and places where Work is being prepared, or where materials, manufactured articles, or machinery are being obtained for the Work. The Contractor shall afford every facility for and every assistance in obtaining the right to such access.

The Contractor shall submit a written request for inspection of any portion of the Work at least twenty-four (24) hours before such Work is to be performed. The request

shall include the date, time, location and type of Work to be performed. When approved by the Engineer, a method of communication other than a written request may be used.

At any time before acceptance of the Work, the Contractor shall remove or uncover such portions of the finished and previously inspected Work as may be directed by the Engineer. After examination, the Contractor shall restore said portions of the Work to the standard required by the specifications. Should the Work thus exposed or examined prove acceptable, the uncovering, or removing, and the replacing of the covering or making good of the parts removed, will be paid for by the Ministry; but should the Work so exposed or examined prove unacceptable, the uncovering, or removing and the replacing of the covering or making good of the parts removed will be at the Contractor's expense.

Any Work done or materials used without inspection by the Engineer may be ordered removed and replaced at the Contractor's expense unless the Engineer failed to inspect after having been given reasonable notice in writing that the Work was to be performed.

The inspection function shall in no way be replaced by the sampling and testing program used to determine the estimated percent defective and resultant value of work.

1.03.11 TEMPLATES AND STRAIGHTEDGES. The Contractor shall provide a sufficient number of metal templates to be used by the Contractor and the Engineer to control and check the correct shaping of finished surfaces of the Work. The templates shall be the dimensions shown on the plans or as directed by the Engineer.

In addition, the Contractor shall provide a sufficient number of metal straightedges, as required by the specifications and the Engineer, for control of the longitudinal and transverse dimensions of the Work.

Samples of the templates and straightedges shall be submitted to the Engineer for approval.

The templates and straightedges shall be maintained in good condition at all times. They will be checked from time to time by the Engineer and, if necessary, repaired, corrected or replaced by the Contractor as directed by the Engineer.

No separate payment for templates and straightedges will be made. The cost of these items is considered to be included in other items in the Bill of Quantities.

1.03.12 REMOVAL OF UNACCEPTABLE AND UNAUTHORIZED WORK. All work which, as determined by the Engineer, does not conform to the requirements of the Contract and results in an inferior or unsatisfactory product, will be considered unacceptable. Unacceptable Work, whether the result of poor workmanship, use of defective materials, damage through carelessness or any other cause, found to exist prior to the final acceptance of the Work, shall be removed or replaced at the Contractor's expense.

No work shall be done without lines and grades having been approved by the Engineer. Work done contrary to the instructions of the Engineer, Work done beyond the lines shown on the plans, or as given, except as herein specified, or any extra work done without authority, will be considered as unauthorized and will not be paid for under the provisions of the Contract. Work so done may be ordered removed or replaced at the Contractor's expense.

Upon failure on the part of the Contractor to comply forthwith with any order of the Engineer, made under the provisions of this article, the Engineer will have authority to cause unacceptable Work to be remedied or removed and replaced and unauthorized Work to be removed and to deduct the costs from any moneys due or to become due the Contractor.

See Articles 3-4 and 6-2 of the Conditions of Contract.

1.03.13 LOAD RESTRICTIONS. The Contractor shall comply with legal load restrictions in the hauling of materials on public roads beyond the limits of the project. The Contractor shall use every reasonable means to prevent any of the highways or bridges intersecting with or on the routes to the Site from being damaged or injured by any traffic of the Contractor or any of his Subcontractors, and in particular shall select routes, choose and use vehicles, and restrict loads so that any such extraordinary traffic as will inevitably arise from the moving of plant and materials from and to the Site shall be limited as far as reasonably possible and so that no unnecessary damage or injury may be caused to such highways and bridges.

Should it be found necessary for the Contractor to move one or more loads of construction plant machinery or pre-constructed units, or parts of units of Work, over part of a highway or bridge, the moving of which is likely to damage any highway or bridge unless special protection or strengthening is carried out, then the Contractor shall, before moving the load onto such highway or bridge, give notice to the Engineer of the weight and other particulars of the load to be moved and his proposals for protecting or strengthening the said highway or bridge. Unless within fourteen (14) days of the receipt of such notice the Engineer shall by counter-notice direct that such protection or strengthening is unnecessary, then the Contractor will carry out at his own expense such proposals or any modification thereof that the Engineer shall require.

The Contractor shall bear all responsibility and liability for damages or injury resulting from his failure to abide by these provisions except when such transport or passage is done by special written permission of the Ministry. The Contractor shall be responsible for all damage caused by his hauling within the limits of the Work.

Any type of equipment of such weight or so loaded as to cause damage to drainage structures of any kind, or to any other type of construction, either being constructed or previously constructed, will not be permitted to operate in any location where damage would be caused. No loads shall be permitted on a pavement or base before the expiration of the curing period.

The Contractor shall prepare proposals for routes to be taken by heavy construction traffic, particularly for hauling in fill material for use on the site. These routes should,

where possible, avoid existing roads and built-up areas. The Contractor shall provide and maintain signs to direct construction traffic onto haul routes. Details of haul routes and signing shall be submitted to the Engineer for approval within one (1) month of the commencement of the Contract and the signs shall be erected within a further one (1) month.

One-way traffic systems shall be operated on haul routes where required by the Engineer. The Engineer may, at any time, withdraw his approval to the use of any route until such strengthening or repair work as he considers necessary has been carried out on that route by the Contractor.

Where it is necessary for Contractor's plant or vehicles to cross public highways, and where required by the Engineer, all such crossings shall be equipped with manual-controlled traffic lights. During brief stoppages of crossings by Contractor's plant, the traffic signals shall be set to show "green" to the Public Highway. During extended period when the Contractor's plant is not using the crossing, the traffic signals shall be switched off, turned away from the carriageway and the advance warning signs obscured.

Stationary vehicles, equipment, huts, heaps of materials, etc. shall be kept clear of the crossing point so that all those using the highway and the haul road shall have a clear view.

See Article 3-14 of the Conditions of Contract.

1.03.14 PROTECTION AND MAINTENANCE OF THE WORKS DURING CONSTRUCTION. The Contractor shall protect and maintain the Work throughout the Contract Period and until the Final Handover of the project. This protection and maintenance shall be done with adequate equipment and forces to the end that the roadway and structures are kept in satisfactory condition, as determined by the Engineer, at all times.

In the case of a requirement for the placing of a course upon a course or subgrade previously constructed, the Contractor shall maintain the previous course or subgrade during all construction operations.

All cost of protection and maintenance Work during the Contract Period and until the project is accepted shall be included in the contract unit price(s) on the various pay items in the Bill of Quantities and the Contractor will not be paid an additional amount for such Work.

1.03.15 CLAIMS FOR ADJUSTMENTS AND DISPUTES. If, in any case, the Contractor deems that additional compensation is due him for Work or material not clearly covered in the Contract or not ordered by the Engineer as Extra Work, as defined herein, the Contractor shall notify the Engineer in writing of his intention to make claim for such additional compensation before he begins the Work on which he bases the claim. If such notification is not given, and the Engineer is not afforded proper facilities by the Contractor for keeping strict account of actual cost as required, then the Contractor thereby agrees to waive any claim for such additional

compensation. Such notice by the Contractor, and the fact that the Engineer has kept account of the cost as aforesaid, shall not in any way be construed as proving or substantiating the validity of the claim. If the claim, after consideration by the Engineer, is found to be just, it will be paid as Extra Work as provided herein for force account Work. Nothing in this Paragraph shall be construed as establishing a claim contrary to the terms of Section 1.02, "Scope of Work" in these General Specifications.

1.03.16 SETTLEMENT OF DIFFERENCES. Any difference or dispute between the Ministry and the Contractor shall be reviewed by a Committee of two representatives of the Ministry and two of the Contractor. The purpose of this Committee shall be to help arrive at a mutual understanding between the Ministry and the Contractor. If it fails to do so within a period of twenty-eight (28) days from the date the difference is referred to the Committee, the matter shall be referred to the Grievance Council in Saudi Arabia, and the decision of the Grievance Council then shall be final and binding. See Article 12 of the Conditions of Contract.

1.03.17 ACCEPTANCE. The Provisional Handover and Final Handover of the Work will be made by the procedures authorized in the General Conditions of Contract. The Provisional Handover procedures require that the physical tests performed on the Works will be reviewed by a Committee designated by the Ministry. The Contractor will be assessed deductions based on the results of these tests if the results indicate deviations from the Specifications. The Contractor shall understand that these and other tests required or performed by the Handover Committee, some of which may be taken on in-situ material, sometime after construction, may yield slightly different results than tests on the same material during construction. It is therefore important that all Works are clearly sampled and tested during construction in compliance with these specifications.

See Articles 5-7 and 6-4 of the Conditions of Contract.

1.03.18 SIGN BOARDS. The Contractor shall, within sixty (60) days of signing of the Contract, provide and install two (2) metal project sign boards, written in Arabic and English. Each board shall conform to the construction, erection and message details shown on the Project Sign Standard Detail Drawing in the plans.

Each sign board is to be erected in a prominent and approved position, one at each end of the length of road included in the Contract. The sign boards shall be maintained in good order, for the duration of the Contract, by the Contractor, and at his own expense. No separate payment will be made for the construction, erection and maintenance or any other costs thereof of the sign boards. The costs shall be considered as included in the prices of other items in the Bill of Quantities. At the end of the maintenance period, the project sign boards and supports shall be dismantled and removed from the site by the Contractor.

1.03.19 MONUMENTS. The Contractor shall be responsible for supplying a monument in a location selected by the local Municipality where the monument is to be placed, to the Specifications and Drawings prepared by an artist and approved by the Local Municipality and the Ministry. This Work is considered subsidiary to project laboratory and office items as per the Bill of Quantities.

1.03.20 WATER WELLS. The Contractor shall make sure that Water Wells are drilled and maintained in accordance with the specification of the Ministry of Agriculture and Water. These water wells are to be handed over to the Ministry of Agriculture and Water upon the completion of the project and the Contractor must attach the handing over certificate within the final certificate.

SECTION 1.04 - CONTROL OF MATERIALS

1.04.1 SOURCES OF SUPPLY AND QUALITY REQUIREMENTS. All materials, manufactured articles, and machinery incorporated in the permanent Work shall meet all quality requirements of the Contract. They must, in all cases, be approved by the Engineer prior to their inclusion in the Work.

In order to expedite the Work, the Contractor shall, before placing any purchase order for materials, manufactured articles, and machinery to be a part of the permanent works, submit for the approval of the Engineer, a complete description of such items, the names of the firms from which he proposes to obtain such items, together with copies of all test records proving compliance with Contract provisions. No materials, manufactured articles, or machinery shall be ordered from any firm without the written approval of the Engineer. When directed by the Engineer or otherwise specified in the Contract, the Contractor shall submit samples for approval.

If it is found after trial that sources of supply for previously approved materials, manufactured articles, or machinery do not produce specified products, the Contractor shall replace the defective items and furnish the items from other sources approved by the Engineer and without additional compensation.

See Article 4 of the Conditions of Contract.

1.04.2 LOCAL MATERIAL SOURCES. When material deposits are not designated on the plans or described in the Special Specifications, the Contractor shall locate and provide materials that meet the contract requirements.

When sources of local materials are designated on the plans and/or described in the Special Specifications, the quality of materials in such deposits is considered to be acceptable in general, but the Contractor shall determine for himself the quality and the amount of equipment and work required to produce a material conforming to the specifications. The designation of a source of material in no way relieves the Contractor of his responsibility to produce materials conforming to the specifications.

It shall be understood that it is not feasible to ascertain from the samples the limits for an entire deposit, and that variations shall be considered as usual and are to be expected. The Engineer may order procurement of material from any portion of a deposit and may reject other portions of the deposits as unacceptable.

When sources of local materials are not designated on the plans and/or described in the Special Specifications, the Contractor shall be totally responsible for locating and producing materials meeting the specifications. The exploring, testing of samples, and developing of such material sources and the costs thereof are the responsibility of the Contractor.

No material, regardless of its source, shall be incorporated in the Work until representative samples taken and tested in an approved laboratory by or in the

presence of the Engineer, have been approved and written authority is issued by the Engineer for the use thereof.

1.04.3 SAMPLING, TESTING AND CITED SPECIFICATIONS. All materials shall be presented to the Engineer for inspection, testing and acceptance before incorporation into the Work. All materials being used are subject to inspection, testing or rejection at any time prior to incorporation into the Work.

Any Work in which untested and unaccepted materials are used without written approval of the Engineer shall be performed at the Contractor's risk and may be considered unacceptable, unauthorized and may not be paid for.

1.04.3.1 Sampling. All sampling shall be in accordance with standard AASHTO procedures. Unless otherwise stated in the Special Specifications, materials subject to statistical based acceptance shall be sampled randomly which provides that all units being produced have an equal chance of being selected for sampling and testing.

When sampling a material for statistical acceptance, the samples must be selected using an approved random number selection procedure detailed in the following paragraph or other random number selection procedure approved by the Engineer. At least five (5) random samples from a lot of material are needed to make an acceptable statistical evaluation.

1.04.3.2 Random Sampling. All published sampling tables are prepared on the assumption that samples are drawn at random; i.e., at any one time each of the remaining uninspected units of product has an equal chance of being the next unit selected for the sample. To conduct random sampling requires that (1) random numbers be generated and (2) these random numbers be applied to the product at hand.

Random numbers are available in prefabricated form in tables of random numbers such as Table 1.04-1. One uses such a table by entering it at random (without "looking") and then proceeding in some chosen direction (up, right, left, etc.) to obtain random numbers for use. Numbers which cannot be applied to the product arrangement are discarded.

Random numbers may also be generated by various devices. These include:

1.04.3.2.1 Calculators or computers: Many calculators are available with random number routines built in. Computers are, of course, an excellent source of random numbers. Statistical software often has random numbers built in.

1.04.3.2.2 A bowl of numbered chips or marbles: After mixing, one is withdrawn and the number recorded. It is then replaced and the bowl is again mixed before the next number is withdrawn.

1.04.3.2.3 Random number dice: One form is the icosahedron (20-sided) dice. There are three of these, each of a different color, one for units, one for

tens, and one for hundreds. (Each die has the numbers from 0 to 9 appearing twice.) Hence one throw of the three dice displays a random number within 000 to 999.

Random sampling shall be used for selecting when or where to take a sample. In large lots, the method recommended by the Ministry is stratified (proportional) random sampling because it prevents groupings of samples by using sublots and spreading the sampling over the entire lot. Following are two (2) examples on how to determine and use stratified random numbers for sample selection.

1.04.3.3 Use of Random Numbers to Select a Sample. The use of a table of random digits by a numerical example will be illustrated based on Table 1.04-1. Assume that it is desired to select a sample of 15 from a lot of 750 items. Each item in the lot is identified by a number from 1 to 750. Therefore, it is necessary to select 15 random three-digit numbers from 001 to 750.

First it is necessary to determine a starting point in the table. Table 1.04-1 contains 50 rows and 10 columns of digits listed in groups of four. Assume that a pencil point is placed at random in the table and the first two-digit number to the right from 1 to 50 determines the row to be selected. The procedure is repeated to determine which of the 10 columns is the starting column. Assume the 40th row and the 8th column are chosen. Assume that the decision was made in advance that the starting digit chosen will be the first three digits of the four-digit number read to the right and that succeeding numbers will be read down the column or columns. The following numbers are obtained. (Numbers that are not between 001 and 750 must be discarded; these are shown in parentheses. A number that has already occurred must also be discarded; there are no such numbers in this example.)

482, (858), 601, 623, (953), 703, 723, 094, 582, 337, 163 (904), 187, (782), 590, (923), 544, 146, 120, 030

The selection of the sample is simplified if the 15 numbers between 001 and 750 are rearranged in order of increasing size as follows:

030, 094, 120, 146, 163, 187, 337, 482, 544, 582, 590, 601, 623, 703, 723

1.04.3.4 Application Example. Assume a bituminous concrete pavement is being produced and it is going to be statistically sampled and tested for acceptance. The total quantity in the Bill of Quantities is thirty-eight thousand (38,000) square meters and the Special Specifications state that one (1) test will be taken for every lot of five thousand (5,000) square meters placed even though these General Specifications require five (5) tests per lot.

The contract plans show the roadbed width as eight (8) meters and the depth of pavement as a one (1) fifty (50) millimeter lift. The contractor indicates that pavement will be placed in four (4) meter lane widths because of traffic.

Therefore, the sampling frequency can be established as one (1) test for every one thousand two hundred fifty (1,250) meters.

Divide the total quantity square meters in the lot thirty-eight thousand (38,000) square meters by the sampling frequency five thousand (5,000) square meters specified. This calculation (38,000 divided by 5,000 = 7.6) indicates that there will be eight (8) sublots and eight (8) tests.

One sublot - one test: Two (2) sets of eight (8) random numbers will be needed. Eight (8) random numbers to determine the centerline station and eight (8) numbers to determine the offset distance from the outside pavement shoulder at each centerline location to each sampling site. Each set of eight (8) random numbers between 001 and 1250 will be chosen using the procedure outlined above.

The random numbers are then multiplied by the total number of units (1250 in this example) in each sublot and converted to longitudinal distance and offset distance. This procedure stratifies or spreads out the samples over the entire lot by random selecting one (1) test site per sublot.

This same procedure can also be used to statistically determine sample locations for taking density tests of embankment, aggregate base, and subbase lifts, and thickness measurement tests of bituminous concrete pavements, etc.

1.04.3.5 Quality or Source Approval Samples and Tests. All source approval samples shall be taken by the Contractor with notice given to the Engineer and opportunity afforded the Engineer to observe the sampling procedure. All source approval tests shall be performed under the supervision of the Engineer or, when specified, by an independent laboratory approved by the Ministry and engauged and paid by the Contractor.

Once a source of materials has been approved, the Contractor shall develop and produce from the source only to the extent that material is represented by the source approval samples. The expansion of the source or the changing of sources shall necessitate additional source approval samples and tests.

The Engineer shall periodically order new testing of previously approved sources to verify that they continue to comply with the specifications. The Engineer may order the new testing to be performed at the same or at a different laboratory from the laboratory performing the original source approval tests. If new testing indicates that a previously approved source no longer complies with the specification requirements, the Contractor shall immediately cease production. He shall perform additional tests as ordered by the Engineer to ascertain the magnitude of the problem. No source shall continue to be used which does not comply with the specifications. Stockpiles of materials not complying with specifications shall not be incorporated into the Work.

1.04.3.6 Contractor Quality Control Samples and Tests. Contractor quality control tests (process control) are those tests performed by the Contractor during construction to ascertain specification compliance prior to submitting the material to the Engineer for acceptance. The Contractor is totally responsible for sampling and testing for process control. The Contractor shall advise the Engineer of the details of his quality control testing program and cooperate in any review of that program requested by the Engineer. While the Engineer will not normally specify the details of the Contractor's process control testing, he may declare the program unacceptable if there are chronic rejections of nonspecification Work as determined by the Project Acceptance Tests (see below). The Contractor may then be ordered to improve process control procedures, including increasing the frequency of tests and modifying construction procedures as necessary.

1.04.3.7 Project Acceptance Samples and Tests. All project acceptance samples shall be taken in a random manner and jointly by the Engineer and the Contractor after the Contractor has notified the Engineer that the material is ready for testing. These tests shall be performed in the Project Laboratory, or in-situ as appropriate, under the supervision of the Engineer. The Engineer may order the retesting of any material when there has been a significant delay in the construction operations or when he believes the material may have deteriorated since its original acceptance. Material which does not comply with the specifications as determined by project control tests shall be rejected and removed from the Work and replaced, or corrected at the expense of the Contractor. The Engineer may order additional testing to ascertain the extent of non-specification material.

1.04.3.8 Split Samples and Tests. Split samples are a split part of a job-control or acceptance sample taken by project personnel and delivered to the Materials and Research Department Laboratory to verify the testing results of the field job control or acceptance tests. The sample data sheet accompanying the split sample shall show the job control or acceptance sample number and the project test results for comparing the results obtained by both laboratories.

1.04.3.9 Check Samples and Tests. The Engineer will perform or supervise the performance program of quality and acceptance check sampling and testing to verify the quality of materials being incorporated into the work and the sampling, testing and equipment. The Engineer may direct that the check tests be performed by persons other than those normally responsible for project control testing, or he may direct the sample be transported to the MOC Central Laboratory or to an MOC approved independent laboratory for testing. The Contractor shall be responsible for the costs of testing in an independent laboratory.

The cost of all materials taken as samples for testing shall be borne by the Contractor. The Contractor, at his own expense, shall supply the Engineer with all necessary test report forms and such expendable materials as may be removed to perform the required tests. Copies of all test results will be furnished to the Contractor or his representative.

All references to test methods or specifications designated by MRDTM shall be construed to mean the Materials and Research Department Test Method specified in the most recent edition of the Ministry of Communications' Highway Materials Manual published prior to the date of the Contract. In case of conflict between MRDTM test methods and specifications and corresponding, equivalent AASHTO or ASTM test methods or specifications, the MRDTM test methods or specifications shall govern. In case of conflict between the AASHTO and equivalent ASTM specifications and methods of sampling and testing, AASHTO shall govern. In case of conflict between MRDTM, AASHTO, ASTM or other test methods and specifications and corresponding, equivalent Saudi Arabian Standards Organization (SASO) test methods and specifications, the SASO test methods of specifications will govern. If the specified test or specification clearly indicates a standard of performance or quality higher than SASO, then the specified test or specification shall govern.

Unless otherwise specified, all references to methods of test or specifications of AASHTO, ASTM, SASO and others shall be construed to mean those methods of test or specifications which have been most recently adopted and published prior to the date of the Contract.

1.04.3.10 Contractor Minimum Sampling and Testing Schedule. Sampling and testing frequencies shall be in accordance with the M.O.C. Highway Materials Manual - Pages I-25 - I-35 unless superseded by these General Specifications or the Special Specifications. Table 1.08.3 contains the minimum schedule for materials subject to statistically based acceptance under Subsection 1.08.5 of these General Specifications.

Contractor process quality control sampling and testing requirements are listed under the "Contractor Quality Control Procedures" Subsections in each Section of these General Specifications.

For all other materials, unless otherwise specified in the Special Specifications, AASHTO methods of sampling and testing shall govern. In the absence of such sampling and testing methods in the AASHTO Standard, the ASTM methods shall govern.

In the event that there are items of Work in the Bill of Quantities for which there are no testing frequencies listed in the Materials Manual, General Specifications or in the Special Specifications, the Engineer will establish minimum frequencies based on the character of the materials and the specification requirements.

TABLE 1.04-1

1306	1189	5731	3968	5606	5084	8947	3897	1636	7810
0422	2431	0649	8085	5053	4722	6598	5044	9040	5121
6597	2202	6168	5060	8656	6733	6364	7649	1871	4328
7965	6541	5645	6243	7658	6903	9911	5740	7824	8520
7695	6937	0406	8894	0441	8135	9797	7285	5905	9539
5160	7851	8464	6789	3938	4197	6511	0407	9239	2232
2961	0551	0539	8288	7478	7565	5581	5771	5442	8761
1428	4183	4312	5445	4854	9157	9158	5218	1464	3634
3666	5642	4539	1561	7849	7520	2547	0756	1206	2033
6543	6799	7454	9052	6689	1948	2574	9386	0304	7945
9975	6080	7423	3175	9377	6951	6519	8287	8994	5532
4868	0956	7545	7723	8085	4948	2228	9583	4415	7065
8239	7068	6694	5168	3117	1586	0237	6160	9585	1133
8722	9191	3386	3443	0434	4586	4150	1224	6204	0937
1330	9120	8785	8382	2929	7089	3109	6742	2468	7025
2296	2952	4764	9070	6356	9192	4012	0618	2219	1109
3582	7052	3132	4519	9250	2486	0830	8472	2160	7046
5872	9207	7222	6494	8973	3545	6967	8490	5264	9821
1134	6324	6201	3792	5651	0538	4676	2064	0584	7996
1403	4497	7390	8503	8239	4236	8022	2914	4368	4529
3393	7025	3381	3553	2128	1021	8353	6413	5161	8583
1137	7896	3602	0060	7850	7626	0854	6565	4260	6220
7437	5198	8772	6927	8527	6851	2709	5992	7383	1071
8414	8820	3917	7238	9821	6073	6658	1280	9643	7761
8398	5224	2749	7311	5740	9771	7826	9533	3800	4553
0995	8935	2939	3092	2496	0359	0318	4697	7181	4035
6657	0755	9685	4017	6581	7292	5643	5064	1142	1297
8875	8369	7868	0190	9278	1709	4253	9346	4335	3769
8399	6702	0586	6423	7985	2979	4513	1970	1989	3105
6703	1024	2064	0393	6815	8502	1375	4171	6970	1201
4730	1653	0932	0955	0957	7366	0325	5178	7958	5371
8400	6834	3187	8688	1079	1480	6776	9888	7585	9998
3647	8002	6726	0877	4552	3238	7542	7804	3933	9475
6789	5197	8037	2354	9262	5497	0005	3986	1767	7981
2630	2721	2810	2185	6323	5679	4931	8336	6662	3566
1374	8625	1644	3342	1587	0762	6057	8011	2666	3759
1572	7625	9110	4409	0239	7059	3415	5537	2250	7292
9678	2877	7579	4935	0449	8119	6969	5383	1717	6719
0882	6781	3538	4090	3092	2365	6001	3446	9985	6007
0006	4205	2389	4365	1981	8158	7784	6256	3842	5603
4661	9861	7916	9305	2074	9462	0254	4827	9198	3974
1093	3784	4190	6332	1175	8599	9735	8584	6581	7194
3374	3545	6865	8819	3342	1676	2264	6014	5012	2458
3650	9676	1436	4374	4716	5548	8276	6235	6742	2154
7292	5749	7877	7602	9205	3599	3880	9537	4423	2330
2353	8319	2850	4026	3027	1708	3518	7034	7132	6903
1094	2009	8919	5676	7283	4982	9642	7235	8167	3366
0568	4002	0587	7165	1094	2006	7471	0940	4366	9554
5608	4070	5233	4339	6543	6695	5799	5821	3953	9458
8285	7537	1181	2300	5294	6892	1627	3372	1952	3028

1.04.4 QUALITY CONTROL CHARTS. The quality of materials and construction shall be controlled using control charts based on statistical techniques. The control charts shall be prepared and kept current daily by the Contractor. These charts shall be submitted to the Engineer every month for review and approval. The charts shall be drawn in the form of graphs with property characteristics on the vertical axis and test numbers on the horizontal axis.

Target line, upper and lower control and warning limits shall be drawn as directed by the Engineer. The Engineer will divide the work and the materials into lots. Each lot will be evaluated separately.

The Engineer may apply quality level analysis to determine the pay factor for the monthly certificates based on the standard deviations and quality indices.

See Article 5-7 of the Conditions of Contract.

1.04.5 PLANT INSPECTION. The Engineer may undertake the inspection of materials at the production plant.

In the event plant inspection is undertaken, the following conditions shall be met: (1) the Engineer shall have the cooperation and assistance of the Contractor and/or the producer with whom he has contracted for materials; (2) the Engineer shall have full entry at all times to such parts of the plant as may concern the manufacture or production of the materials being furnished; and (3) adequate safety measures are to be provided and maintained.

It is understood that the Engineer reserves the right to retest all materials which have been tested and accepted at the source of supply after delivery to the site and prior to incorporation into the Work and to reject all materials which are obviously defective or, when retested, do not meet the requirements of the specifications.

1.04.6 STORAGE OF MATERIALS. Materials shall be so stored as to assure the preservation of their quality and fitness for the Work. Stored materials, even though approved before storage, may again be located so as to facilitate their prompt inspection. Materials shall not be stored on the right-of-way except where and as permitted by the Engineer. Stockpiling of aggregate material within the right-of-way shall be confined to such authorized areas as may be approved by the Engineer. Where stockpiling is done outside the roadway on Government or private property, the site shall be abandoned immediately upon completion of the utilization of the stockpiled material and the natural surface shall then be restored as nearly as possible to the original condition by the Contractor at his own expense and to the satisfaction of the Engineer. Any costs for the use of privately-owned land for storage and/or for the placing of the Contractor's plant and equipment shall be borne by the Contractor. Private property shall not be used for storage purposes without written permission and release of the owner or lessee, and a copy of such written permission and release shall be furnished to the Engineer prior to any use of the land by the Contractor.

Explosives shall be stored in a secure manner marked clearly in Arabic and English "Danger Explosives." Storage shall be in compliance with Ministry of the Interior/Public

Security regulations as directed in Section 2.04, "Controlled and Production Blasting" in these General Specifications.

Where no local laws or ordinances apply, storage shall be to the satisfaction of the Engineer and, in general, not closer than three hundred (300) meters from the road or from any building or camping area. In no case shall the Contractor store explosives on the site without prior approval of the local authorities or the Engineer.

The Contractor shall keep a current inventory of all explosives and explosive devices and submit a monthly report to the Engineer, detailing the usage of all explosives by date and location.

1.04.7 HANDLING MATERIALS. All materials shall be handled in such manner as to preserve their quality and fitness for the Work. Aggregates shall be transported from the storage site to the Work in tight vehicles so constructed as to prevent loss or segregation of materials after loading and measuring in order that there may be no inconsistencies in the quantities and qualities of materials intended for incorporation in the Work as loaded, and in the quantities and qualities as actually received at the place of operations.

1.04.8 UNACCEPTABLE MATERIALS. All materials not conforming to the requirements of the specifications at the time they are used shall be considered as unacceptable and all such materials will be rejected and shall be removed immediately from the site of the Work unless otherwise instructed by the Engineer. No rejected material, the defects of which have been corrected, shall be used until approval has been given.

1.04.9 MINISTRY-FURNISHED MATERIAL. The Contractor shall furnish all materials required to complete the Work, except those specified to be furnished by the Ministry.

Material furnished by the Ministry will be delivered or made available to the Contractor and shall be considered as included in the contract price for the item in connection with which they are to be used.

The cost of handling and placing all materials after they are delivered to the Contractor shall be considered included in the contract price for the item in connection with which they are to be used.

The Contractor will be held responsible for all material delivered to him, and deductions will be made from any moneys due him to make good any shortages and deficiencies, from any cause whatsoever, and for any damage which may occur after such delivery, and for any demurrage charges.

SECTION 1.05 - LEGAL RELATIONS AND RESPONSIBILITY TO THE PUBLIC

1.05.1 LAWS TO BE OBSERVED. The Contractor shall keep fully informed of all Government laws, all local ordinances, and regulations, and all orders and decrees of bodies or tribunals having any jurisdiction or authority, which in any manner affect those engaged or employed on the Work, or which in any way affect the conduct of the Work.

He shall at all times observe and comply with all such laws, bylaws, ordinances, regulations, orders, and decrees; and shall protect and indemnify the Government and/or Ministry and its representatives against any claim or liability arising from or based on the violation of any such law, bylaws, ordinance, regulation, order, or decree, whether by himself, his employees, or his subcontractors.

1.05.2 PERMITS, LICENSES AND TAXES. The Contractor shall procure all permits and licenses, pay all charges, fees, and taxes, and give all notices necessary and incidental to the due and lawful prosecution of the Work.

1.05.3 PATENTED DEVICES, MATERIALS AND PROCESSES. If the Contractor employs any design, device, material, or process covered by letter of patent or copyright, he shall provide for such use by suitable legal agreement with the patentee or owner. The Contractor and his Surety shall indemnify and save harmless the Government and/or the Ministry, any affected third party, or political subdivision from any and all claim for infringement by reason of the use of any such patented design, device, material or process, or any trademark or copyright, and shall indemnify the Government and/or Ministry for any costs, expenses, and damages which it may be obliged to pay by reason of any infringement, at any time during the prosecution or after the completion of the Work. See Article 3-12 of the Conditions of Contract.

1.05.4 ROYALTIES. The Contractor shall be responsible for all compensation and royalties due in respect to quarried materials. No special payment will be made for the compensation of royalties; the costs shall be subsidiary to all other items listed in the Bill of Quantities. See Article 3-12 of the Conditions of Contract.

1.05.5 RESTORATION OF SURFACES OPENED BY PERMIT. Any individual, firm, or corporation wishing to make an opening in the highway must secure a permit from and will be required to deposit a security with the Ministry in a suitable amount to cover the cost of making the necessary repairs, and the Contractor shall not allow any person or persons to make an opening unless a duly authorized permit by the Ministry is presented. All permits before becoming effective must receive the approval of the Engineer. Until the acceptance of the Work performed under the Contract, the Contractor shall make all necessary repairs, within the time indicated in writing by the Engineer and in an acceptable manner, at the point or points in the roadway where openings have been made by authority of the Ministry. Such repair Work will be paid for by the Ministry as Extra Work and said Work shall be subject to the same conditions as the original Work performed. Should the Contractor refuse or neglect to make said repairs at such point or points within the time specified, the Engineer shall have the authority to cause such repairs to be made, in which case the Contractor shall not be relieved in any way from his responsibility for the Work performed by him.

1.05.6 RELATIONS BETWEEN CONTRACTOR AND HIS EMPLOYEES AND HIS SUBCONTRACTOR'S EMPLOYEES. The Contractor shall provide adequate housing for his and his subcontractor employees, including sanitary facilities, in accordance with the Public Health Codes and Regulations, in especially as related to contagious diseases without creating undue pressure on local public utilities and facilities. Violation of this provision is punishable by fine in accordance with the law of public utilities protection. The Contractor, in his relations with his employees, shall comply with the regulations in force regarding compensation, medical treatment, securities, and transportation needed, as well as other benefits specified by the Saudi Labor Code as a minimum. The Contractor shall provide, at no profit to himself, a constant supply of food for his employees without creating a monopoly for himself or restricting their freedom to secure food from other sources.

The Ministry will not be liable for any damages or compensation payable at Law in respect or in consequence of any accident or injury to any employee of the Contractor and the Contractor shall meet all claims, demands, proceedings, costs, charges, and expenses whatsoever in respect thereof or in relation thereto. See Article 3-10 of the Conditions of Contract.

1.05.7 INSURANCE. The Contractor shall secure and maintain such insurance from an insurance company authorized to write casualty insurance in the Kingdom of Saudi Arabia as will protect himself, his Subcontractors, the Engineer and the Ministry from claims for bodily injury, death, or property damage which may arise from operations under this Contract. Bodily injury and death insurance shall provide coverage for all persons of any age. The Contractor shall not commence the Work under this Contract until he has obtained all insurance required under this provision and shall have filed the certificate of insurance or the certified copy of the insurance policy with both the Engineer and the Ministry. Each insurance policy shall contain a clause providing that it shall not be cancelled by the insurance company without ten (10) days written notice to both the Engineer and the Ministry of the intention to cancel. The amounts of such insurance shall be not less than that called for in the General Conditions of the Contract. The Contractor is directed to the relevant stipulation listed in the Conditions of Contract regarding insurance.

1.05.8 SAFETY AND ACCIDENT PREVENTION REQUIREMENTS. In performance of the Contract, the Contractor shall comply with all applicable laws and codes governing safety, health and sanitation. The Contractor shall provide all safeguards, safety devices, and protective equipment, and take any other needed actions, on his own responsibility or as the Ministry may determine, reasonably necessary to protect the life and health of employees on the job and the safety of the public and to protect property in connection with the performance of the Work covered by the Contract. See Article 3-10 of the Conditions of Contract.

1.05.9 PUBLIC CONVENIENCE AND SAFETY. The Contractor shall at all times so conduct the Work as to insure the least practicable obstruction to public traffic. The safety and convenience of the general public and the residents along the highway and the protection of persons and property are of prime importance and shall be provided for by the Contractor in an adequate and satisfactory manner. When it is necessary for residents living along the project to use a portion of the road under construction, the Contractor shall maintain, within the limits of the specifications, that portion of the road in a suitable condition for vehicular traffic.

When it is indicated on the plans or provided in the specifications that traffic shall be carried through construction, a suitable width shall be maintained level and smooth to provide satisfactory passage. The width shall be periodically watered or treated with dust control agents as directed to prevent dust nuisance. Traffic shall be maintained over or around structures and culverts.

Materials stored upon the highway shall be placed so as to cause minimum obstruction and danger to the traveling public.

The Contractor shall provide, and maintain in a safe condition, temporary approaches to and crossing of intersecting highways, railroads, private entrances, and approaches to partly constructed Work. See Article 3-13 of the Conditions of Contract.

1.05.10 HANDLING TRAFFIC THROUGH WORK ZONES. All features of the work zone traffic control shall be in accordance with Section 9.02, "Traffic Control Through Work Zones" in these General Specifications, and the Kingdom's Manual of Uniform Traffic Control Devices.

The Contractor shall use every precaution to safeguard the persons and property of the traveling public who must move through or across the work zone. The failure of the Engineer to notify the Contractor to maintain barriers, lights, signals, or flagmen shall not operate to relieve the Contractor from his responsibility. When the plans specifically provide that traffic be carried through the construction, the Contractor shall not route traffic on a longer or more arduous route without the permission of the Engineer. If the plans do not detail a Traffic Control Plan (TCP) the contractor shall be responsible for the development and submittal of a traffic control plan for handling of the traffic safely during the Period of Contract.

This traffic detour plan shall be approved in advance by M.O.C. Road Safety Department, Traffic Police Department and the local Municipality before implementation. All detour construction and maintenance costs, including temporary signs, lights, barricades, signals and all other devices for the maintenance and safe regulation of traffic are included in the Section 9.02, "Traffic Control through Work Zones," except where it is shown to be subsidiary in the Special Specifications. The Engineer shall require additional barricades, lights, flagmen, or watchmen at any time or at any place that, in his opinion, it is necessary for proper protection of traffic, but approval by the Engineer of the Contractor's method of operation shall not relieve the Contractor of the responsibility of protecting the traffic.

When necessary to permit only one-way traffic, the Contractor shall station figures to direct traffic safety through or around the Work.

Where it is necessary for residents or businesses along the road to use the road, suitable means shall be provided for their entrance or exit.

The Contractor's responsibility for the maintenance of traffic control devices on any individual portion of the Work included in the Contract shall continue through the duration of the Contract.

Payment for all barricades, warning signs, lights, flagmen, and pilot car operators and equipment, and other protective devices will be in accordance with Section 9.02, "Traffic Control through Work Zones" in these General Specifications except where it is shown to be subsidiary in the Special Specifications.

1.05.11 FOSSILS, ANTIQUITIES, ETC. All fossils, coins, articles of value or antiquity and structures or other remains or things of geological or archeological interest discovered on the site of the Work shall be considered the exclusive property of the Ministry. The Contractor shall take reasonable precautions to prevent his workmen or any other persons from removing or damaging such article or thing; and shall, upon discovery of such items or things, notify the Engineer thereof within not more than twenty-four (24) hours of such discovery, and shall carry out the Engineer's instructions concerning special requirements to salvage such items, at the expense of the Ministry. No interference shall occur with historical locations and buildings. The Contractor and his subcontractors shall abide by all Royal Decrees regarding Historical Building regulations. See Article 3-11 of the Conditions of Contract.

1.05.12 ALCOHOLIC DRINKS, NARCOTICS, ARMS AND AMMUNITION AND DISCIPLINE. The Contractor shall not import, sell, give, barter, or otherwise handle any alcoholic drinks or narcotics, or permit or connive such importation, sale, distribution as gifts, barter, or use by his employees or by the employees of his Subcontractors. See Article 3-10 of the Conditions of Contract.

1.05.13 USE OF EXPLOSIVES. When the use of explosives is necessary for the prosecution of the Work, the Contractor shall exercise the utmost care not to endanger life or property, including new Work. The Contractor shall be responsible for any and all damage resulting from the use of explosives.

The Contractor shall comply with all the requirements of Section 1.04, "Control of Materials" in these General Specifications and Section 2.04, "Controlled and Production Blasting" complying with all laws, regulations, and ordinances concerning the use of explosives.

1.05.14 PROTECTION AND RESTORATION OF PROPERTY AND LANDSCAPE. The Contractor shall be responsible for the preservation of all public and private property and shall protect carefully from disturbance or damage all land monuments and property marks until the Engineer has witnessed or otherwise referenced their location and shall not move them until directed.

The Contractor shall be responsible for all damage or injury to property of any character, during the prosecution of the Work, resulting from any act, omission, neglect, or misconduct in his manner or method of executing the Work, or at any time due to defective work or materials, and said responsibility will not be released until the project is completed and accepted.

When or where any direct or indirect damage or injury is done to public or private property by or on account of any act, omission, neglect, or misconduct in the execution of the Work, or in consequence of the nonexecution thereof by the Contractor, he shall restore, at his own expense, such property to a condition similar or equal to that existing before such damage or injury was done, by repairing, rebuilding, or otherwise restoring as may be directed, or he shall make good such damage or injury in an acceptable manner.

1.05.15 FURNISHING RIGHTS-OF-WAY. The Ministry will be responsible for the securing of all necessary permanent rights-of-way for the Work in advance of construction. However, the Contractor shall bear all expenses and charges for temporary access or ownership required by him in connection with access to the Work Site, material sources, materials, or equipment storage, or other construction operations outside of the permanent highway right-of-way. Any exception will be indicated in the Contract Documents.

1.05.16 RESPONSIBILITY FOR DAMAGE CLAIMS. The Contractor shall assume all risk and liability for accidents and damages that may occur to persons or property during the prosecution of the Work, by reason of negligence or carelessness by himself, his agents or employees, and shall assume also all direct or indirect damage that may be suffered on account of any such construction or improvement, during the time thereof and until the Work is accepted.

Where the Work of the Contractor injures or damages the property of others, the Contractor shall negotiate with the party so damaged and pay for such damage, leaving the Ministry of Communications free of liability. This shall, among other things, include damage to crops, trees, bushes, and disturbance of irrigation, water sources, etc. The Contractor shall maintain and repair damage due to his construction equipment traffic, at his own expense, on any public road used to, from, and through the project for construction and hauling. The acceptability of this maintenance will be as determined by the Engineer. See Article 3-8 of the Conditions of Contract.

1.05.17 OPENING OF SECTIONS TO TRAFFIC. Opening of sections of the Work to traffic prior to completion of the entire Contract may be desirable from a traffic service standpoint, or may be necessary due to conditions inherent in the Work, or by changes in the Contractor's work schedule, and may be necessary due to conditions or events unforeseen at the time of signing the Contract. Such openings as may be necessary due to any of the foregoing conditions shall be made when so ordered by the Engineer. When a section of the Work is ordered opened, the Contractor shall expedite the completion of all permanent traffic control devices and safety measures. Such devices and measures shall be completed by the time required to open the section to traffic. Under no condition shall such openings constitute acceptance of the Work or a part thereof, or a waiver of any provisions of the Contract.

If the Contractor is dilatory in completing shoulders, drainage structures, or other features of the Work, the Engineer will so notify him in writing and establish therein a reasonable period of time in which the Work shall be completed. If the Contractor fails to make a reasonable effort toward completion in this period of time, the Engineer may then order all or a portion of the project opened to traffic. On such sections which are so ordered to be opened, the Contractor shall conduct the remainder of his construction operations so as to cause the least obstruction to traffic and shall not receive any added compensation due to the added cost of the Work by reason of opening such section to traffic.

1.05.18 CONTRACTOR'S RESPONSIBILITY FOR THE WORK. Until final written acceptance (Final Handover) of the project by the Ministry, the Contractor shall have the charge and care thereof and shall take every precaution against injury or damage to any part of the project. Should any injury or damage occur due to construction or maintenance deficiencies during the guarantee period or due to the fault or negligence of the Contractor in fulfilling any of the explicit or implicit obligations assigned to him under the contract arising from the execution or from the nonexecution of the Work, he shall rebuild, repair, restore, and make good all injuries or damages to any portion of the Work before final acceptance at his expense. However, in the case of Force Majeure where the injury or damage to the Work is due to unforeseeable causes beyond the control of and without the fault or negligence of the Contractor, or arising from the action of others (third party), the Contractor shall not bear the involved repair costs but shall immediately inform the client of the injury or the damages and their causes. The client may ask the Contractor to carry out the repair works as per the unit prices incorporated into the contract.

Any amount to be collected from culpable parties as compensation with respect to damage to the Work because of traffic accidents during the construction/maintenance period or the warranty period, shall become the property of the Government. The Contractor shall have no right to claim for such amounts, whether in whole or in part. The Contractor shall rebuild, repair, restore, and make good all damages to any portion of the Work occasioned by any traffic accident before final acceptance, and shall bear the expense thereof.

An "Act of God" means an earthquake, flood, cloudburst, tornado, or other phenomena of nature beyond the power of the Contractor to foresee or to make preparation in defense against. A rainstorm, windstorm, or other natural phenomenon within the range of normal intensity, based on weather records and reports for the particular locality and for the particular season of the year in which the Work is being prosecuted, shall not be construed as an "Act of God" and the Contractor shall bear the expense of repairing damages therefrom and no extension of time will be granted for the consequent delay or suspension. No extension of time will be granted for any delay

or suspension of the Work due to the fault of the Contractor. No extension of time on account of a delay due to unforeseen causes will be granted if written application therefore is not filed by the Contractor with the Engineer setting forth the reasons which he believes will justify the approval of his request.

If the Contractor files a request for an extension of time, the Engineer will notify the Contractor, in writing, whether or not an extension has been recommended and, if recommended, include the recommended amount of such extension. If the Ministry approves of the Engineer's recommendation, the extended date for completion shall be considered as in effect the same as if it were the original date for completion.

In case of suspension of Work from any cause whatever, the Contractor shall be responsible for the project and shall take such precautions as may be necessary to prevent damage to the project, provide for normal drainage and shall erect any necessary temporary structures, signs, or other facilities at his expense. See Article 3-9 of the Conditions of Contract.

1.05.19 CONTRACTOR'S RESPONSIBILITY FOR UTILITY PROPERTY AND SERVICES. At points where the Contractor's operations are adjacent to properties of railway, telegraph, telephone, and power agencies or companies, or are adjacent to other property, damage to which might result in considerable expense, loss or inconvenience, the Work shall not be commenced until all arrangements necessary for the protection thereof have been made.

The Contractor shall cooperate with the owners of any underground or overhead utility lines in their removal and rearrangement operations in order that these operations may progress in a reasonable manner and that duplication of rearrangement work may be reduced to a minimum and that services rendered by those parties will not be unnecessarily interrupted. The Contractor must consult Services Authorities prior to the realignment of utilities. The concerned Authorities shall either instruct the Contractor to carry out the Work under their supervision or carry out all or part of the Work themselves. In all cases, the Contractor shall be reimbursed at the contract unit price rate in the Bill of Quantities. The Contractor shall be responsible for settling all expenses incurred by the Authority which executed the relocation of the Work.

The Contractor must investigate the site for underground utilities before commencement of the Works. Any damage to utilities shall make the Contractor liable to repair and penalties enforced by the Authorities at that time.

The Contractor shall exercise special care as to the clearance required at locations where the alignment of any type of road or highway crosses in plan the alignment of overhead power lines. The minimum clearances at such locations, measured vertically from the top of the wearing course to the point of maximum deflection of the nearest conductor, shall be as follows:

1. For power lines with voltage ranging from 13.8 KV up to 131 KV, the clearance shall be not less that twelve (12) meters.

2. For power lines with voltage ranging from 132 KV up to 380 KV, the clearance shall be not less than fifteen (15) meters.

The foregoing clearances are applicable at the maximum temperature of the conductors, eighty degrees Celsius (80 C), without wind load.

In the event that the specified clearances cannot be accommodated, the Contractor shall notify the Engineer in writing accordingly, and shall assist the Engineer in the preparation of sketches and taking of all measurements necessary for resolution. No Work related to substandard clearances, as above, shall start, until an approved set of plans is issued to the Contractor by the Engineer.

In the event of interruption to water or utility services as a result of accidental breakage, or as a result of being exposed or unsupported, the Contractor shall promptly notify the proper authority and shall cooperate with the said authority in the restoration of service. If essential public utility service is interrupted, repair work shall be continuous until the service is restored. No Work shall be undertaken around fire hydrants until provisions for continued service have been approved by the local fire authority.

1.05.20 PERSONAL LIABILITY OF PUBLIC OFFICIALS. In carrying out any of the above provisions or in exercising any power or authority granted to him by his Contract, there shall be no liability upon said Engineer or his authorized assistants, either personally or as an official of the Ministry, it being understood that in such matters he acts as the agent and representative of the Ministry.

1.05.21 ENVIRONMENTAL PROTECTION

1.05.21.1 General. The Contractor shall comply with all Ministry and Municipality laws and regulations regarding protection against pollution of the environment.

1.05.21.2 Pre-Construction Requirements. Prior to the start of project construction, the Contractor shall contact the Ministry or Municipality responsible for air, noise, and water quality control regulations to determine the standards which shall be adhered to during construction operations.

1.05.21.3 Noise Abatement. In urban or populated rural areas where quiet conditions normally prevail, no equipment which emits noise above seventy (70) DBA (decibels, A-scale) measured at a distance of 16 m, shall be operated between the hours of 6:00 P.M. and 7:00 A.M. except under emergency conditions or specific authorization from the Engineer. Local requirements shall apply if they are more stringent than the requirements in these specifications.

1.05.21.4 Bituminous Mixing Plants. The following performance standards will apply to all stationary bituminous mixing plants:

(1) Particulate matter emissions shall be limited to the maximum number of milligrams per cubic meter at standard conditions established by the responsible regulatory Ministry or Municipality.

(2) An existing stationary bituminous mixing plant will be subject to the performance standards only if a physical change to the plant or change in the method of operating the plant causes an increase in the amount of air pollutants emitted. Routine maintenance, repair, and replacement, relocation of a portable plant, change of aggregate, and transfer of ownership are not considered modifications which will require an existing plant to comply with the standards.

1.05.21.5 Construction Requirements. The Contractor shall perform construction activities in a manner so as to prevent damage to the environment as the result of burning, drilling, blasting, production of materials, hauling, or any other necessary construction operations of any kind in conformity with the regulations issued by the responsible Kingdom Ministry.

All drilling, grinding, and sawing of rock, shale, concrete, and other similar dust-producing materials shall be performed by equipment provided with water sprays, fabric filtered collection systems, or other suitable devices to prevent excessive dust from becoming airborne and becoming fugitive dust.

No construction operations shall be performed without an approved Fugitive Dust and Erosion Control Plan developed and approved in accordance with Paragraph 2.05.3.7 "Fugitive Dust and Erosion Control Plan" in these General Specifications.

When concrete and steel surfaces are designated to be blast cleaned, the blast cleaning may be performed by either wet sandblasting, high pressure water blasting, blasting grits, shrouded dry sandblasting with dust collectors or other methods approved by the Engineer. The method used shall be performed so as to conform to air and water pollution regulations applicable to the site of work and to also conform to applicable safety and health regulations. Any method which does not consistently provide satisfactory work and conform to the above requirements shall be discontinued and replaced by an acceptable method. All debris of every type, including dirty water, resulting from the blast cleaning operation shall be reasonably confined during the performance of the blast cleaning work and shall be immediately and thoroughly cleaned from the blast cleaned surfaces and all other areas where any escaped debris may have accumulated.

In reconstruction areas, the old roadway asphalt will be left undisturbed, placed at least 305 mm below the finished roadbed or sideslope, recycled, stockpiled for future use, as specified in the contract. This material shall not be disposed of outside the roadway subgrade without placement in an approved landfill or approved burial area.

1.05.21.6 Disposal of Unsuitable Materials. Items indicated for removal without salvage, unsuitable construction materials and debris from clearing and grubbing are to be placed in an environmentally suitable disposal site decided upon and coordinated with appropriate regulatory agencies by the Contractor.

Borrow material, rock waste and vegetative debris, etc., cannot be placed in wetlands or areas that will impact endangered species or archaeological resources.

Application of prime coat, tack coat and soil sterilants in roadway surfacing must avoid soils outside the roadway prism. Contamination must be carefully avoided in wadis, irrigation supplies, wetlands, irrigation supplies, water impoundments and live streams.

1.05.21.7 Water Quality. All work in the vicinity of live streams, water impoundments, wetlands or irrigation supplies must minimize vegetation removal, soil disturbance and erosion. Crossings with heavy equipment shall be minimal. Equipment maintenance such as refueling and cement dumping is prohibited. The Contractor is responsible for compliance with Paragraph 2.05.3.7, "Fugitive Dust and Soil Erosion Control Plan," in these General Specifications.

1.05.21.8 Hazardous Waste Materials. The Contractor shall be responsible for reporting and cleanup of spills associated with project construction and shall report and respond to spills of hazardous materials such as gasoline, diesel, motor oils, solvents, chemicals, toxic and corrosive substances, etc., that may be a threat to public health or the environment. The Contractor shall be responsible for reporting discoveries of past spills and of current spills not associated with construction. Reports shall be made immediately to the Ministry Construction Department.

1.05.21.9 Fugitive Dust. The Contractor shall take all steps necessary to minimize the fugitive dust and other deleterious materials from entering the air from construction operations in accordance with Paragraph 2.05.3.7, "Fugitive Dust and Soil Erosion Control Plan," in these General Specifications.

1.05.22 NO WAIVER OF LEGAL RIGHTS. Upon completion of the Work, the Ministry will expeditiously make final inspection and notify the Contractor of acceptance. Such final acceptance, however, shall not preclude or stop the Ministry from correcting any measurement, estimate, or certificate made before or after the completion of the Work, nor shall the Ministry be precluded or stopped from recovering from the Contractor or his Surety, or both, such overpayment as it may sustain, or by failure on the part of the Contractor to fulfill his obligations under the Contract. A waiver on the part of the Ministry of any breach of any part of the Contract shall not be held to be a waiver of any other or subsequent breach.

The Contractor, without prejudice to the terms of the Contract, shall be liable to the Ministry for latent defects, fraud, or such gross mistakes as may amount to fraud, or as regards the Ministry's rights under any warranty or guarantee.

SECTION 1.06 - PROSECUTION AND PROGRESS

1.06.1 SUBLETTING OF CONTRACT. The Contractor shall not sublet, sell, transfer, assign, or otherwise dispose of the Contract or Contracts or any portion thereof, or of his right, title, or interest therein, without written consent of the Ministry. In case such consent is given, the Contractor will be permitted to sublet a portion thereof, but shall perform with his own organization Work amounting to not less than fifty percent (50%) of the total Contract cost, except that any items designated in the Contract as "specialty items" may be performed by subcontract and the cost of any such specialty items so performed by subcontract may be deducted from the total cost before computing the amount of Work required to be performed by the Contractor within his own organization. No subcontracts, or transfer of Contract, shall in any case release the Contractor of his liability under the Contract and bonds. See Article 3-2A of the Conditions of Contract.

1.06.2 PROGRAM AND SCHEDULE OF WORK.

1.06.2.1 Contract Time. Contract Time shall begin on the date of the first Process-Verbal for the Handover of the site issued by the Engineer to the Contractor, or twenty-eight (28) days after signing of the Contract, unless otherwise stipulated in the General Conditions. See Article 5-1 of the Conditions of Contract.

No work shall be performed until the issuance of the Process-Verbal to the Contractor by the Engineer. The Process-Verbal will state the date when the Work may proceed and the areas in which the Contractor may perform Work. The Work shall be diligently prosecuted at such a rate and in such manner as is necessary for completion within the Contract Time. Additional Process-Verbals may be issued before completion of Work already underway if, in the opinion of the Engineer, it is necessary to expedite other parts of the project or to allow for completion before seasonal limitations.

1.06.2.2 Construction Equipment. The Contractor shall plan, schedule and supply equipment of the type and number necessary to assure timely completion of the Works in accordance with these General Specifications, the Special Specifications, and his CPM Project Schedule.

1.06.2.3 Preconstruction Conference. After the Contract is signed and before any Work is performed, the Engineer will call a Preconstruction Conference between himself, as representative of the Ministry, and representatives of the Contractor. The Engineer may furnish the Contractor an agenda in advance of the conference. The Contractor shall be prepared to discuss his Program and Schedule of Work, proposed construction procedures, and other items on the agenda.

1.06.2.4 Conduct and Coordination. The Contractor shall at all times conduct the Work in such manner and in such sequence as will insure the least practicable interference with private traffic and he shall have due regard to the necessity for convenient detours. He shall not open up Work to the prejudice of

Work already started and the Engineer may require the Contractor to finish a section on which Work is in progress before it is started on any additional section.

The Contractor shall coordinate his Work and dispose of his materials so as not to interfere with the operations of other Contractors engaged upon adjacent Work, shall coordinate his Work with that of others in a cooperative manner, and perform his Work in the proper sequence in relation to that of other Contractors, as may be directed by the Engineer.

Each Contractor shall be responsible for any damage done by him or his agent to the Work performed by another Contractor. Each Contractor shall so conduct his operations and maintain the Work in such condition that adequate drainage shall be in effect at all times.

1.06.2.5 Preparation Period. Due to the importance of planning and preparation before the start of the project, the Contractor shall carry out during the preparation period (first 90 days after the site is handed over to the Contractor or as proposed and approved in the CPM-Project Schedule) the following steps:

1. Review of Contract Drawings and related documents.

2. Execute all necessary survey works including the following:

(1) Locate roadway centerline and fix bench marks.

(2) Execute cross-sections for natural ground.

(3) Prepare necessary drawings shown actual natural ground elevations and obtain approval. All survey work shall be carried out and contoured as three dimensional X, Y, Z and produced on floppy diskettes readable on one of the approved computer systems.

(4) Locate areas of cut and fill along the entire roadway alignment.

(5) Locate stations for concrete structures.

(6) Identify all obstructions and structures which interfere, within the Right-of-Way, in preparation for finding adequate solutions in coordination with concerned parties, if any.

3. Prepare a detailed Work Program for all work items to be accomplished under the Preliminary Activity Schedule (PAS).

4. Prepare a site workshop location and provide the minimum number of necessary equipment.

5. Prepare Engineer's Offices and Supervision Staff Compound during the specified period in the Contract and according to Contract Conditions.

6. Locate borrow sources and obtain approval for adequate pits sources as well as obtain written approval of Owners or concerned agencies.

7. Conduct all laboratory tests required for materials obtained from borrow sources.

8. Identify location of crusher, install crusher and conduct necessary test trials for crusher materials whether for concrete or asphalt paving. These locations must be approved before erection.

9. Commence preparation of concrete and asphalt mix designs according to Specifications and relevant Circulars and Special Specifications.

10. Prepare the necessary materials needed for the project including materials list showing all necessary materials such as highway road studs, barriers, etc. and other incidental items and obtain necessary approvals for the type, brand and sources of supply.

11. Prepare a Preliminary Activity Schedule (PAS) for the preparation period taking into account what is mentioned above and means of executing various items accordingly.

12. Prepare necessary traffic detours schemes and obtain approvals from concerned agencies.

13. Submit qualifications for all proposed technical staff and Subcontractors for approval prior to start of work.

14. Prepare necessary forms for monthly certificates, related report forms for monthly laboratory tests, request forms for approval, and other reports which will be utilized during the construction including all necessary items.

1.06.2.6 Schedule of Work.

1.06.2.6.1 General Format and Purpose of the Progress Schedule of Work.

1. The progress schedule of work to be prepared by the Contractor pursuant to this Subsection shall employ a Network Analysis System (NAS) as described below. The Contractor shall provide information and input required for development of the NAS for the Work in accordance with the requirements of this provision and other related Contract provisions. The purpose of the NAS shall be to: (1) assure the Contractor adequately plans, schedules, and executes the Work to achieve timely completion; (2) assure coordination of the Work of the Contractor and all subcontractors; (3) assist the Contractor and Ministry in identifying and resolving obstacles to successful completion of the Work and evaluating proposed changes to the Contract and the NAS; and (4) assist the Engineer and the Contractor in the preparation and evaluation of the monthly and final certificates.

2. The Contractor-prepared NAS system shall employ the Critical Path Method (CPM) to satisfy time, cost and resource applications and shall be called the Critical Path Method Project Schedule (CPM-PS). It shall be provided and operated by onsite Contractor personnel at terminals located in the Contractor's onsite office. The system selected shall be written for an independent personal computer or small business type computer (IBM or IBM compatible) using the latest version of Primavera Project Planner software or approved equal. The Contractor shall provide the necessary computer hardware capability to support the project scheduling requirements. Onsite management personnel shall have the expertise to operate the software and/or the computer to address all project activities and resources on a real time or interactive basis and be capable of rapidly evaluating alternative scenarios to optimize project management. Evidence of technical expertise of the onsite personnel with the system selected shall be submitted for the Engineer's approval within fifteen (15) calendar days after the site is handed over to the Contractor.

The Contractor shall use the "activity-on-arrow" format for the arrow diagrams or the "activity-on-node" format for precedence diagrams. The principles used herein shall be as set forth in the Associated General Construction Managers of America (AGC) publication, "The Use of CPM in Construction, a Manual for General Construction Managers and the Construction Industry," Copyright 1976.

3. All costs incurred by the Contractor in preparing all versions, revisions and updates of the CPM-PS, as required herein, shall be reimbursed under the lump sum item as defined in this proposal at Subsection 1.06.15 "Payment" in these General Specifications.

4. No construction work on the project (other than mobilization and traffic control) is allowed without an approved Preliminary Activity Schedule (PAS). No progress payments will be made until the initial CPM-PS has been approved.

5. Should the prosecution of the Work be discontinued for any reason, the Contractor shall notify the Engineer at least twenty-four (24) hours in advance of resuming operations.

1.06.2.6.2 Contractor's NAS Representatives.

1. Before the Site is handed over to the Contractor, the Contractor shall designate in writing an individual in the Contractor's organization who shall be the Contractor's on-site full time authorized Planning and Scheduling Representative and who shall be responsible for the preparation, updating, and revision of the NAS. The Representative shall review and report progress of the project with the Contractor's Project Manager and to the Engineer. This Representative shall have a minimum of two (2) years experience on a multi-year project of complexity similar to this project. At least one additional full-time scheduling or construction management engineer shall be assigned to the authorized Representative to monitor progress and daily update the NAS in accordance with the requirements of Subparagraph 1.06.2.6.8 "Contractor's Daily Log" below.

2. The Contractor's Representative shall be delegated in writing the authority to act on behalf of the Contractor in filling the NAS requirements. This authority should not be interrupted throughout the duration of the project unless approved in writing by the Engineer.

1.06.2.6.3 Preliminary Activity Schedule (PAS).

1. Requirement to Submit - No later than five (5) days after the Site is handed over to the Contractor, the Contractor shall submit a ninety (90) Day Preliminary Activity Schedule (PAS) to the Engineer for review and approval.

2. Form

(1) The PAS shall be in the form of a written narrative and will provide a detailed breakdown of all contract activities scheduled for the preparation period. (90 calendar days after the site is handed over to the Contractor).

(2) The PAS shall include mobilization, all shop drawing and sample submittals, and the fabrication and delivery of key and long-lead procurement activities. The PAS shall indicate intended submittal dates and realistic delivery dates for fabrication and delivery items. The PAS shall provide sufficient time, in accordance with Subparagraph (3) below for the Engineer to review, approve and dispatch each shop drawing or submittal after its receipt with the required information.

(3) Review and Approval of the PAS - The Engineer will respond in seven (7) calendar days to the PAS submission and either approve the PAS or request revisions. The Contractor shall provide the requested revisions in seven (7) calendar days. The Engineer shall approve the PAS unless it does not reflect the requirements of the Contract.

(4) Effect of the PAS - The Contractor's submission and use of an approved PAS does not relieve the Contractor from his contractual requirement to provide and implement an approved CPM-PS.

1.06.2.6.4 Initial CPM Project Schedule (Initial CPM-PS). Within sixty (60) calendar days after Award of the Contract, the Contractor shall develop a proposed CPM-PS and submit four (4) copies of all CPM-PS documents and one backup diskette to the Engineer for review. The following requirements shall apply to all versions, updates, and revisions of the CPM-PS; including all related documents, as required herein:

1. General

(1) The CPM-PS shall consist of a schedule diagram and related documents - including a written narrative, a list of proposed submittals and drawings, duration and productivity assumptions.

(2) The CPM-PS will cover all activities required by the Contract - including both construction and non-construction. To the extent feasible, an activity (or groups of activities) shall be defined and related to discrete pay items.

(3) The Engineer may agree with the Contractor to limit the number of activities on the CPM-PS diagram, or the Engineer may require that unreflected items be added to it, based on what the Engineer considers to be reasonable for a project of this scope and complexity.

(4) Failure by the Contractor to include in the CPM-PS any element of work required for performance of the Contract shall not excuse the Contractor from completing all elements of work required for performance of the contract by the contract completion date.

(5) The Contractor shall prepare all schedule diagrams required by this subsection using the Arrow Diagram Method (ADM) or Precedence Diagram Method (PDM). The schedule diagram shall depict the order and interdependence of all activities and the sequence of the work that is to be accomplished by the Contractor in coordination with its subcontractors. The diagram shall be followed to show how the completion of preceding activities restrict the start of following activities.

2. CPM-PS Diagram. The CPM-PS diagram shall include the following:

(1) Construction activities shall have durations of whole working days, with a maximum duration of twenty-five (25) working days each, unless otherwise directed by the Engineer. Activities with longer durations shall be divided into subgroups of activities not exceeding twenty-five (25) working days in duration.

(2) Procurement and submittal activities may have durations exceeding twenty-five (25) working days. Procurement and submittal activities include mobilization, all shop drawing and sample submittals, and the fabrication and delivery of <u>key</u> and <u>long-lead</u> procurement activities. The diagram shall indicate intended submittal dates and realistic delivery dates for fabrication and delivery activities. CPM-PS diagram shall provide the times for review, approval, and dispatch for each shop drawing or submittal as required by the plans, specifications and Special Contract

Requirements. Where no times are specified in the contract plans, specifications or Special Contract Specifications, the CPM-PS diagram shall provide fourteen (14) calendar days for the Engineer to review, approve and dispatch each shop drawing or submittal after its receipt by the Engineer, unless otherwise directed or approved by the Engineer.

(3) The CPM-PS diagram shall include all activities covered by the PAS.

(4) The CPM-PS diagram shall include a concise description of the Work represented by each activity, which shall be placed at or near the event node for each activity. If the project is of sufficient complexity that the concise description cannot be legibly placed on the diagram, the Contractor shall submit a tabulation of all activities by their event node numbering.

(5) The CPM-PS diagram shall indicate the total number of anticipated working days to complete each activity of work required under contract. The CPM-PS diagram shall reflect a Saturday through Thursday work week, and no work on religious holidays.

(6) The Late Finish as shown on the proposed CPM-PS diagram, must equal the contract completion date as set forth in the Contract Documents. Early finish date schedules will not be accepted.

3. Supporting Documents. The Contractor shall submit a list of all drawing and sample submittals required for the entire contract period. This list shall include the following information for each item:

(1) Item Number

(2) Item Description

(3) Related Activity ID Number and Description from the CPM Schedule

(4) Planned Date of Initial Submittal

(5) Actual Date(s) of Initial (and all Subsequent) Submittals

(6) Planned Date of Engineer's Initial Response

(7) Actual Date(s) of Engineer's Initial (and Subsequent) Responses

(8) Status of Engineer's Initial (and Subsequent) Response(s) - i.e. Approved, Rejected, Approved As Noted, etc.

(9) Comments

This list shall be updated whenever the CPM-PS is updated.

4. Narrative. The Contractor shall provide a written narrative along with the proposed CPM-PS diagram describing the rationale and assumptions utilized in the development of the proposed CPM-PS diagram. The narrative will serve, in conjunction with the diagram, as the basis for the Engineer's review and approval of the CPM-PS.

The written narrative shall include, at a minimum:

(1) A description of the planned critical path and the general sequence of work.

(2) Information and references to adequately define the scope of work included in each major activity type (i.e., unclassified excavation, aggregate base course). This would include such information as station numbers, location, etc.

(3) A description of the means and methods the Contractor plans to use in the performance of the Work for each major activity type. This would include such information as subcontractors involved, types and numbers of labor utilized, equipment to be employed, etc.

(4) A description of the basis for the calculation of the duration for all activities, including planned weekly output, work accomplishment quantities (e.g., cubic meters of excavation), equipment, etc., used to calculate how long an activity will take to perform.

(5) A description of the assumptions used in converting working days to calendar days; including anticipated holidays or non-work days.

(6) A description of any organizational constraints such as resource limitations and subcontractor commitments which limit scheduling flexibility.

(7) It is the Contractor's responsibility to ensure that there is no conflict between the diagram and the narrative. The Engineer's approval of the CPM-PS does not waive this responsibility.

5. Review and Approval of the Initial CPM-PS

(1) Within twenty-one (21) calendar days of the receipt of the proposed CPM-PS, the Engineer will either approve the proposed CPM-PS or convene a Joint Review Conference at which the Engineer and the Contractor will discuss corrections and adjustments to the proposed CPM-PS. If any corrections or adjustments to the proposed CPM-PS are agreed upon or directed by the Engineer based on this review, they shall be made and the adjusted Schedule submitted by the Contractor to the Engineer for review and approval within fourteen (14) calendar days after the date of this meeting.

(2) If after the second submission the Engineer determines that the Schedule is still not acceptable because it is inconsistent with the physical or

Contractual requirements or the constraints of the project, then the approval process will continue as per paragraph (3)a above.

(3) When the proposed CPM-PS receives the final approval of the Engineer, the Contractor shall, within seven (7) calendar days, sign on the face of two sets of the CPM-PS, indicating the Contractor's express agreement that the CPM-PS truly represents and includes all of the Work of the Contract. After the Contractor's signing of the CPM-PS, the Engineer will also sign on the CPM-PS, indicating his acceptance, which is qualified as stated herein.

(4) When the Engineer approves the CPM-PS, that document will thereupon become the CPM-PS of Record. It is then converted to a Base Line Schedule. Thereafter, the Contractor shall be responsible for implementing and executing the Work under the contract in accordance with that Schedule, unless a Revision to that Schedule is approved by the Engineer in accordance with the procedures below. An approved revised or updated CPM-PS of Record becomes the current CPM-PS of Record. The current CPM-PS of Record will be considered the Contractor's work plan for completing the entire contract as set forth in the contract documents.

(5) The Engineer's review and approval of the Contractor's Schedule, at any stage, is for conformance to the requirements of this Section only. Review and approval by the Engineer of the Contractor's Schedule or narratives at any stage does not relieve the Contractor of any of its responsibility whatsoever for the accuracy or feasibility of the Project Schedule, or of the Contractor's ability to meet the Contract Completion Date and other contractual requirements, nor does such review and approval warrant, acknowledge or admit the reasonableness of the logic, durations, labor, or equipment loading of the Contractor's Schedule.

1.06.2.6.5 CPM-PS Updates and CPM-PS Revisions.

1. Timing of updates and revisions

Job Site Monthly Update progress meetings shall be held on a date mutually agreed to by the Engineer and the Contractor.

Presence of Subcontractors during the progress meeting is optional unless required by the Engineer. The Contractor is required to submit actual Activity Start and Finish dates on the CPM-PS turnaround document along with identification of obstacles to timely completion for each monthly progress meeting. The preliminary Update information will be submitted to the Engineer three (3) days prior to the meeting date. Proposed revisions to the CPM-PS shall be submitted in writing with the update or as they are determined necessary by either party. It is the Contractor's responsibility to propose a revision to the CPM-PS whenever a deviation from the CPM-PS of Record is proposed, planned, or when directed by the Engineer. The proposed revision to the CPM-PS shall include a Time Impact Analysis in accordance with below.

2. CPM-PS Updates. CPM-PS updates shall contain complete information on and be reviewed to verify:

(1) Actual finish dates for completed activities.

(2) Remaining duration, required to complete each activity started, or scheduled to start, but not completed.

(3) Logic, time and cost data for contract modifications and supplemental agreements that are to be incorporated into the Arrow diagram. Changes in activity sequence and durations which have been approved pursuant to the provisions of CPM-PS Revisions.

(4) Percentage for completed and partially completed activities.

(5) Logic and duration revisions required by this Section of the specifications.

The Contractor shall submit a narrative report as a part of his monthly Update Progress Meeting and full Update, in a form agreed upon by the Contractor and the Engineer. The narrative report shall include a description of problem areas; current and anticipated delaying factors and their estimated impact on performance of other activities and completion dates; and an explanation of corrective action taken or proposed.

After each monthly update, the Contractor shall submit within seven (7) calendar days to the Engineer four (4) copies of a revised complete CPM -PS diagram showing all completed and partially completed activities, contract changes and logic changes agreed to by the Engineer on the subject update. This shall become the CPM-PS of Record.

The monthly updating of the CPM-PS is necessary to verify the certificate upon which progress payments will be made. If the Contractor fails to provide sufficient information for the Engineer to approve a Progress Update or Revision of the CPM -PS, the Contractor shall not be entitled to progress payments until the necessary information is furnished and the Engineer's approval is obtained.

3. CPM-PS Revisions. A Revised CPM-PS reflects a change to the logic or some other modification to the schedule of planned work.

Requirements for Submitting and Executing a Proposed Revision to the CPM-PS are as follows:

(1) Form of a Proposal to Revise the CPM-PS

1) All proposals to revise the CPM-PS shall include a written narrative describing the changes to the critical path and any logic revisions or modifications to the schedule, including, but not limited to, changes in the method or manner of the work, changes in Specifications, extra work, changes in

duration, the addition or deletion of work, increased or decreased quantities, defective work, and acceleration of the work.

2) When any delays or disruptions have occurred, or are occurring, which impact current or future activities, the extent of these impacts shall be depicted on the proposed CPM-PS diagram. Delays and disruptions which are ongoing and of uncertain duration as of the date of the proposed revision shall be so identified. In addition, if the Contractor alleges any Ministry-caused or excusable delays during the current period for which the schedule update is made, a Time Impact Analysis must be submitted in accordance with Subparagraph 1.06.2.6.6, "Time Impact Analysis For Proposed Time Extensions" below.

3) When any delays or disruptions have occurred which are the contractual responsibility of the Contractor - i.e. which do not entitle the Contractor to a time extension under the terms of the Contract - the Contractor shall advise the Engineer of the Contractor's proposed efforts to return the project to a schedule consistent with the terms of the Contract - including the commitment of additional resources or other appropriate action.

If the Contractor deems this not to be possible, the Engineer shall be advised of the extent to which completion dates or other terms of the Contract will not be met so that the Government may evaluate its options under the terms of the Contract.

(2) Execution of a Proposed Revision to the CPM-PS

When the parties agree to a proposed revision to the CPM-PS, the Contractor shall submit four (4) copies of the revised CPM-PS within seven (7) days after the parties reach agreement. The revised CPM-PS shall include all of the items required by Subparagraph 1.06.2.6.4, "Initial CPM Protect Schedule (Initial CPM-PS)," above, plus a narrative description of the basis for the approved revisions to the CPM-PS. The revised CPM-PS shall be executed in accordance with Subparagraph 1.06.2.6.4.5 "Review and Approval of the Initial CPM-PS."

(3) Effect of the Submission of a Revised or Update Schedule

Submission of an updated or revised CPM-PS Schedule shall not in itself be considered to be Notice to the Engineer of a delay or disruption, or of any other basis for a change under the Contract.

1.06.2.6.6 Time Impact Analysis for Proposed Time Extensions.

1. General - When Contract Modifications are initiated, delays are experienced, or the Contractor desires to revise the Project Schedule, the Contractor shall submit to the Engineer a written Time Impact Analysis as specified below.

The activities and event times in the Time Impact Analysis shall be those included in the current CPM-PS of Record, except as the Contractor is proposing they are affected by the situation in question.

Once any Time Impact Analysis is approved by the Engineer both parties agree to waive any rights to re-evaluate the impacts, evaluated therein, at a later date.

2. Ministry Requested Contract Modifications - When requested by the Ministry in connection with a proposed Contract Modification, the Contractor shall prepare a proposed revision to the CPM-PS with a Time Impact Analysis reflecting, in detail, the anticipated impact of the Contract Modification. This revised CPM-PS will be used as a basis to grant any additional contract time resulting from the Contract Modification.

3. Delays, Disruptions, or Notification of a Contractor Proposed Contract Modification.

(1) When delays and disruptions occur, or notification of a Contractor proposed contract modification is given, which the Contractor deems to warrant a time extension under the terms of the Contract, such events shall be identified and the Engineer given written notice within seven (7) calendar days after the commencement of an alleged delay or notification. This notice shall detail the contractual basis of the extension to which the Contractor alleges entitlement.

(2) When the Contractor submits the Contractor-proposed contract modification or within fourteen (14) calendar days after the end of a delay and/or disruption event which the Contractor has given notice of in accordance with (a) above, the Contractor must submit to the Engineer a Time Impact Analysis which reflects and analyzes the alleged delay and/or disruption event or contract modification which the Contractor deems to warrant a time extension under the terms of the Contract.

In cases where the Contractor does not submit a Time Impact Analysis as required above, it is mutually agreed that the particular contract modification, delay or Contractor request does not require an extension of time to the interim milestone date or the Contract Completion Date, and the Contractor hereby waives its right to subsequently request a time extension.

4. Format of a Time Impact Analysis - Each Time Impact Analysis shall include, at a minimum, the following documents or information:

(1) The current CPM-PS of Record.

(2) A Narrative Impact Analysis - A detailed narrative description of each alleged impact event shall be provided. The alleged impact to each and every specifically affected activity in the Current CPM-PS shall be described in detail, including how each activity referenced in the Time Impact Analysis reflects the alleged impact.

This narrative shall describe, at a minimum, 1) the cause of the impact, 2) the start date of the impact, 3) the duration of the impact, specifically describing how Contractor caused delays were deleted from the analysis, 4) the

activities affected, and 5) whatever methods the Contractor can employ, at no or minimal cost to the Ministry, to re-sequence or reschedule the work to mitigate the delay.

(3) Fragmentary Network Diagram (Fragnet) - The alleged impact to each and every specifically affected activity in the Current CPM-PS shall be drawn on the Fragmentary Network Diagram (Fragnet) which consists of only that portion of the CPM-PS Arrow Diagram which is affected by the alleged impact.

(4) As-Properly Impacted Schedule - The Current CPM-PS of Record shall be revised to show the impact of the activities identified above (including any re-sequencing which would mitigate the delay). If any interim or Contract completion date is delayed, the amount of the requested time extension shall be noted as a request for a delay to that date.

Each Time Impact Analysis shall be consecutively numbered.

5. Analysis of a Request for an Extension of Time

(1) General

1) Any request for an extension of the contract time will be determined by the Engineer's review of the Time Impact Analysis' effect on the current CPM-PS of Record.

2) Activity delays shall not automatically mean that an extension of the Interim or Final Contract Completion Date is warranted or due the Contractor. A delay may not affect existing critical activities or cause non-critical activities to become critical, but may result in only absorbing a part of the available total float that may exist within an activity chain of the Network, thereby not causing any effect on any interim completion date or the Final Contract Completion Date.

3) Only delays to activities which affect interim completion dates or contract completion dates will be considered for a time extension. The extension of the specified Contract Completion Date will be based upon the actual number of calendar days the Contract Completion Date is adjusted.

4) Extensions of time to interim completion dates and the Contract Completion Date will be granted only if requested in writing by the Contractor within the applicable notice period.

(2) Float - No extensions of the specified Interim or Contract Completion Dates will be issued for work performed on activities with available float. Float is defined as the amount of time between an activity "can start" (the early start) and when an activity "must start" (the late start). Float is a shared commodity, not for the exclusive use or benefit of either party. Either party has the full use of the float until it is depleted. Float may be consumed by the Contractor through routine operational considerations; by the Ministry through Contract Modifications, or other actions which are its responsibility; or by unusually severe weather, strikes or other actions which are

the responsibility of neither the Contractor nor the Government. Each updated or revised Schedule shall depict float as it is currently projected. Once all or part of this float has been consumed, it will no longer be an issue with respect to subsequent events.

(3) Contractor's Duty to Mitigate - It is the Contractor's duty to attempt to mitigate delay. The Contractor shall, in its analysis, discuss what measures it plans to take to mitigate delay. These shall include, at least, those items of no cost to the Ministry.

Any measures which are alleged to increase cost, such as additional staffing or equipment, shall be accompanied by corresponding Rationale and Assumptions which analyzes the additional requirements. In addition, any Time Impact Analysis which does not include a discussion of the feasibility of re-sequencing future work to mitigate delay at no cost to the Ministry shall be rejected.

6. Extensions to Contract Dates - The Ministry desires all contract work (including all work associated with an approved Time Impact Analysis) to be completed by the Contract Completion Date. Therefore, no time extensions to any contract completion date will be granted unless agreed to by the Engineer.

7. Review and Execution of the Time Impact Analysis - The Engineer will review the request for an extension of time in accordance with the provisions of this Paragraph, and will respond, within twenty-one (21) calendar days after receipt unless subsequent meetings and negotiations are necessary by either acknowledging responsibility for the delay, or by denying responsibility and instructing the Contractor to take appropriate action to return the project to an acceptable schedule. Following the Engineer's review, a copy of the Time Impact Analysis, signed by the Engineer, will be returned to the Contractor, and approved logic changes or time extensions will be incorporated into the CPM-PS by the Contractor by or before the next monthly meeting.

1.06.2.6.7 Responsibility for Completion.

The Contractor shall furnish sufficient forces, offices, facilities and equipment, and shall work such hours including night shift and overtime operations, as necessary to ensure the prosecution of the Work in accordance with the current monthly Project Schedule Update. If the Contractor falls behind in meeting the Project Schedule as presented in the current monthly Schedule Update due to staffing or equipping the project with fewer resources than shown on the CPM-PS Schedule of Record or his rate of productivity falls below that planned, the Contractor shall take such steps as may be necessary to improve its progress. The Engineer may require it to increase the hours of work, the number of shifts, overtime operations and/or the amount of construction plant and equipment.

Failure of the Contractor to comply with the requirements of the above paragraph shall be a basis for determination by the Engineer that the Contractor is not prosecuting the Work with such diligence as will ensure completion within the Contract Completion Date. If the Schedule shows completion beyond the Contract Completion Date, or if the Contractor's actual progress is less than that required by the Contractor's

currently approved Schedule in order to complete by the Contract Completion Date, there will be ten percent (10%) of the amount of all progress payments withheld until completion or until progress is improved so as to permit completion by the Contract Completion Date. If the Contractor fails to improve progress so as to permit completion by the Contract Completion Date, the Ministry may exercise its rights Subsection 1.06.9, "Forfeiture of Contract and Conditions Thereof" in these General Specifications.

1.06.2.6.8 Contractors Daily Log.

The Contractor shall document, on a daily basis, progress on each scheduled activity contained in the Contract Schedule. For the purpose of this subsection, scheduled activity shall mean those activities contained in the latest approved CPM schedule update which has in fact started, should start or can start on the subject day according to the actual start or the calculated early start designation. The elements of the daily documentation for each scheduled activity shall consist of the following:

1. **Whether any work was actually performed on that activity.**
2. **If work was performed, a brief description of the work performed.**
3. **Man power expended on that activity by craft or subcontractor.**
4. **Equipment resources expended by equipment type and equipment number.**
5. **Deliveries of materials having an individual value in excess of SR 10,000.**
6. **The actual start and/or the actual completion date, if applicable.**
7. **Percentage of total work deemed complete for that day.**
8. **If no work was performed, a brief explanation as to why work was not performed.**

Within two (2) hours of the start of the first shift of the following workday, the Contractor shall deliver to the Engineer a printed report containing the above information.

Daily recording of the schedule activity progress shall continue until the activity is determined by the Engineer to be one hundred percent (100%) complete. This data shall be collected on a 5.25 inch or 3.5 inch MSDOS-compatible electronic floppy disk media using the DBF format. Each month, the Contractor shall furnish to the Owner, the progressed daily documentation data disk along with the monthly CPM update and the monthly progress payment estimate. The current percentage complete for each activity shall exactly match the percentage complete shown in CPM Schedule Update reports. Compliance may be achieved through the use of Daily Log or equal.

Failure to submit these complete printed reports or the required electronic data by the date specified will be considered cause for withholding any progress payments otherwise due under the Contract. Furthermore, failure to submit the CPM Schedule Update and Daily reports will result in costs to the Ministry; therefore, at the option of the Ministry, the Contractor shall pay the Ministry SR 5,000 for the first day the submittal is late and SR 1,000 per day for each late thereafter. This amount shall be deducted from any amount otherwise due the Contractor.

1.06.2.6.9 As-Built Progress Documentation.

Prior to provisional handover, the Contractor shall provide the Engineer with a complete and fully progressed daily documentation data disk, including all the data elements specified above. The level of detail shall be such as to enable the preparation of as-built schedule fully synchronized with the project CPM and capable of showing progress (or no progress) as the daily level of detail.

1.06.3 NIGHT WORK. Part Five, "Concrete, Steel and Structures" in these General Specifications permits night concrete Work during periods with high daytime temperatures. Otherwise, if the Work is not specifically specified in the Contract Documents to be performed both day and night, the Contractor must request permission to Work by night as well as by day. The Ministry may grant such permission but the Contractor shall not be entitled to any additional payment for so doing. Such permission will not be denied the Contractor unless there is an equivalent practicable method of expediting the progress of the Work. All Work at night shall be performed without unreasonable noise and disturbance and the Contractor shall reimburse and indemnify the Ministry for and against any damage resulting from the noise and disturbance during the progress of the Work or because of it, as well as for all claims, demands, costs, charges, and expenses whatsoever in regard to or in relation to such liability. See Article 5-4 of the Conditions of Contract.

Whenever Work is being done by the Contractor in other than daylight hours, he shall provide suitable lighting equipment, approved by the Engineer, so that the Work can be carried on in the same manner as during the daylight hours. When public traffic is routed through or adjacent to the Work, additional traffic control devices may be required to maintain safety during night Work.

1.06.4 CHARACTER OF WORKMEN: METHODS AND EQUIPMENT.

1.06.4.1 Work Force. The Contractor shall at all times employ sufficient labor and equipment for prosecuting the several classes of the Work to full completion in the manner and time required by the specifications.

The Contractor shall make all necessary arrangements for employing the laborers required for the execution of the Work. Priority should be given, however, to citizens of the area who have the required qualifications. The Ministry may provide the Contractor with up to fifteen percent (15%) of the laborers required for performing the Work, and the Contractor shall be compelled to hire them for Work suitable to their qualifications, at the rates prevailing for similar laborers, provided that this will not waive the responsibility of the Contractor and his obligations toward these laborers regarding

setting their salaries in accordance with the regulations in force and the employment agreement signed with them. All workmen shall have sufficient skill and experience to perform properly the Work assigned to them. Workmen engauged in special Work or skilled Work shall have sufficient experience in such Work and the operation of the equipment required to perform all Work properly and satisfactorily.

Any person employed by the Contractor or by any Subcontractor who, in the opinion of the Engineer, does not perform his Work in a proper and skillful manner, or is intemperate or disorderly shall, at the written request of the Engineer, be removed forthwith by the Contractor or Subcontractor employing such person, and shall not be employed again in any portion of the Work without the approval of the Engineer.

Should the Contractor fail to remove such person or persons as required above, or fail to furnish suitable and sufficient personnel for the proper prosecution of the Work, the Engineer may suspend the Work by written notice until such orders are complied with. These orders shall have no effect on Contract Time.

See Article 3-10 of the Conditions of Contract.

1.06.4.2 Construction Methods. All equipment which is proposed to be used on the Work shall be of sufficient size and in such mechanical condition as to meet requirements of the Work and to produce satisfactory quality of Work. Equipment used on any portion of the project shall be such that no injury to the roadway, adjacent property, or other highways will result from its use.

When the Contract specifies that the construction be performed by the use of certain methods and equipment, such methods and equipment shall be used unless others are authorized by the Engineer. If the Contractor desires to use a method or type of equipment other than those specified in the Contract, he may request authority from the Engineer to do so. The request shall be in writing and shall include a full description of the methods and equipment proposed to be used and an explanation of the reasons for desiring to make the change. If approval is given, it will be on the condition that the Contractor will be fully responsible for producing Work in conformity with Contract requirements. If, after trial use of the substituted methods or equipment, the Engineer determines that the Work produced does not meet Contract requirements, the Contractor shall discontinue the use of the substitute method or equipment and shall complete the remaining construction with the specified methods and equipment. The Contractor shall remove the deficient Work and replace it with Work of specified quality, or take such other corrective action as the Engineer may direct. No change will be made in basis of payment for the construction items involved nor in Contract Time as a result of authorizing a change in methods or equipment under these provisions.

1.06.5 TEMPORARY SUSPENSION OF WORK. The Ministry shall have the authority to suspend the Work wholly or in part for such reasonable time period or periods as it may deem necessary, due to unsuitable weather or such other conditions of the Work, for which suspension is provided for in the Contract, or for such time as it is necessary due to the failure on the part of the Contractor to carry out orders given or to perform any or all provisions of the Contract. If it should become necessary to stop the Work for an indefinite period, the Contractor shall store all materials in such manner

that they will not obstruct or impede the traveling public unnecessarily nor become damaged in any way, and he shall take every precaution to prevent damage or deterioration of the Work performed, erect temporary structures where necessary, and provide suitable drainage of the roadway by opening ditches, shoulder drains, etc. The Contractor shall not suspend Work without written authority. See Article 4-5 of the Conditions of Contract.

1.06.6 DEFECTS AND DEFAULTS.

1.06.6.1 Removal of Defective Work or Materials. The Engineer shall have power during the progress of the Work to give verbal orders, which shall be confirmed later in writing, for the following:

Removal of any materials from the site which, in the opinion of the Engineer, are not in accordance with the Contract.

Substitution of proper and suitable materials for the unsuitable materials. Removal and proper reconstruction of any Work which, in the opinion of the Engineer, is not in accordance with the Contract in respect to materials or workmanship.

1.06.6.2 Contractor's Failure to Comply with Ministry Orders. In case of failure by the Contractor to carry out a removal order issued to him by the Ministry, the Ministry shall have the right to employ and pay other persons to carry out the Work involved in the order. All expenses consequent thereto and incidental thereto shall be borne by the Contractor and shall be recoverable from him by the Ministry by deduction from any monies due to him or from any monies which may become due to him.

See Article 4-4 of the Conditions of Contract.

1.06.7 DETERMINATION AND EXTENSION OF CONTRACT TIME. The time for completion of the Work will be specified in the Tender and the Form of Contract and the completion of the Work within the Contract Time specified is an essential part of the Contract.

Contract Time shall begin on the date of the first Process-Verbal for the Handover of the site issued by the Engineer to the Contractor, or twenty-eight (28) days after the date of signing of the Contract.

Work which will require inspection of the Engineer will not be permitted on Fridays, legal holidays, or Holy Days except that which may be necessary to preserve and protect the Work.

The above provision relative to Friday and holiday Work may be waived but only with the written approval of the Ministry. The above provisions relative to Fridays, holidays, and Holy Day work do not preclude the repairing of equipment or the performing of other minor Work which requires no inspection of the Engineer.

Additional working days may be granted for Work added to the Contract. Such additional working days will be computed by the Engineer with due regard to the nature of the additional Work.

Additional working days may be granted to compensate for working days lost due to causes entirely beyond the Contractor's control or for partial Contract Time lost due to causes that hampered the normal prosecution of the Work and that were entirely beyond the Contractor's control, provided that the following provisions are complied with:

The Contractor shall, as soon as practicable after such delays occur, and prior to the expiration of the Contract Time period, make written request to the Engineer for an extension in the number of working days, stating the number of working days lost or the amount of partial Contract Time lost due causes beyond his control, together with sufficient proof to establish his claim.

Additional working days, if authorized, will be computed by the Engineer for the Contract as a whole and not proportioned for separate Work divisions. See Article 5-3 of the Conditions of Contract.

1.06.8 DELAY PENALTY. If the Contractor does not complete the Work within the Contract Time, plus any approved extensions of the Contract Time, he shall be liable for such penalty as may be called for in the Contract and the General Conditions of Contract.

The penalty shall be computed on the basis of the final total sum of the whole Contract if, in the opinion of the Ministry, the unfinished part makes it impossible to safely receive full benefits from use the completed Work within the time specified, hampers the use of any other facility, or affects directly the completed Work.

In order to receive full benefit from the completed Work, all remaining Work must be accomplished from the shoulder with traffic control in accordance with Section 9.02, "Traffic Control through Work Zones" in these General Specifications. If the unfinished part does not make it impossible to safely receive full benefit from the executed Work within the time specified, does not hamper the use of any other facility, or does not affect directly the executed Work, the penalty shall be computed on the basis of cost of the unfinished part of the delayed Work only.

Notwithstanding any other provision of the Contract, all costs of inspection for all Work performed after the expiration of the stipulated Contract Time shall be borne by the Contractor, and the Engineer's normal charges to the Ministry shall be deducted from the Monthly Certificate therefor. See Article 5-6 of the Conditions of Contract.

1.06.9 FORFEITURE OF CONTRACT AND CONDITIONS THEREOF. The Ministry shall have the right to take over the Work from the Contractor in any of the following occurrences:

1. If the Contractor has failed to pay his creditors or has become bankrupt or presented his petition of bankruptcy or has made an engagement with, or agreed to carry out the Contract under the direction of a committee of his creditors, or

2. If the Contractor, being a corporation, shall go into liquidation or voluntary liquidation for the purpose of amalgamation or reconstruction, and the Ministry does not find it in the interest of the Work to continue under such new arrangement, or

3. If, without any reasonable excuse, the Contractor has failed to commence the Work or has slowed down the progress of the Work to the extent that leads the Ministry to believe the Work would not be completed as scheduled, or has suspended the Work for a period that exceeds thirty (30) days after receiving from the Engineer, written notice to proceed, or

4. If the Contractor has failed to remove materials from the site or demolish and replace any portion of the Work within thirty (30) days after receiving written notice from the Engineer specifying materials to be removed or Work to be demolished and replaced, and reasons thereof, or

5. If the Contractor has committed a breach of Contract or neglected to carry out any of his obligations under the Contract, or

6. If the Contractor has committed any act of fraud, personally or through any of his agents or employees, or

7. If the Contractor has assigned the whole Work of any part thereof of any of the monies due him, without the previous written consent of the Ministry.

The Ministry will take over the Work twenty (28) days after a notice is served upon the Contractor and the following shall take place:

(1) The Ministry will take possession of the Performance Guarantee already submitted by the Contractor, without having to prove damages suffered. Such action shall not prejudice the right of the Ministry to charge and obtain from the Contractor any compensation for damages suffered.

(2) Not relieving the Contractor from his liabilities and obligations under the Contract, and on his own account and responsiblity, the Ministry will execute the unfinished Work or contract with another Contractor to do so through public or local tender, negotiation, or by any other way the Ministry deems fit.

(3) If, for the portion or portions of the Work that the Contractor failed to complete and the Ministry executed as in the previous manner, the cost therefor exceeds those of the Contract, the Contractor shall bear such excess costs, but any savings in cost shall be the right of the Ministry.

1.06.10 METHOD OF ACTION IN CASE OF FORFEITURE. The Engineer, will, in the presence of the Contractor, or a representative of his, prepare a report covering the Work completed and equipment available at the site. Materials already supplied for use

shall not be accepted until after they have been inspected and tested by the Engineer, provided that such materials are suitable for use and in quantities that do not exceed those quantities required for completion of the Work. The Contractor shall not remove any of his or his subcontractor's equipment from the site.

The Engineer will make calculations of the Work executed on the account of the Contractor as stated above, and the Contractor shall pay the Ministry any losses suffered due to unfinished portions of the Work or any other damages in accordance with the provisions of the Contract. However, if the Ministry concludes that failure of the Contractor to complete the Work was not due to any of his fault, or due to carelessness, or lack of good administration on his part (on condition that the Contractor informs the Ministry in due time of the case and the actual reasons that caused such failure), the Ministry may, but shall not be bound to do so, relieve the Contractor from the rights due, or part thereof.

The Ministry shall have the right to confiscate all or part of the equipment, instruments, and materials supplied by the Contractor and used by him for the completion of the Work, but shall not be responsible to the Contractor, or to anyone else, for any rent charges or expenses. The Ministry shall have the right to retain such items until after the Final Handover.

1.06.11 PAYMENT AFTER FORFEITURE. After forfeiture, the Ministry will not pay to the Contractor any portion of the monies due him for completed Work, or for equipment and materials that will be used in completing the unfinished portion or portions of the Work, until the expiry of the Period of Maintenance.

However, the Period of Maintenance shall not start for any of the completed Work until after the Provisional Handover for the whole Work, including the completion of the delayed portions of the Work.

1.06.12 URGENT REPAIRS. If by reason of an accident or failure, or other event occurring to, in, or in connection with the Work or any part thereof, either during the execution of the Work or during the Period of Maintenance, any remedial or other Work or repair shall in the opinion of the Engineer be urgently necessary for safety or security, and the Contractor is unable or unwilling at once to perform such Work or repair, the Ministry may by his own or other workmen perform such Work or repair as the Engineer may consider necessary. If the Work or repair so performed by the Ministry is Work, which, in the opinion of the Engineer, the Contractor was liable to do at his own expense under the Contract, then all costs and charges properly incurred by the Ministry in so doing shall, on demand, be paid by the Contractor to the Ministry, or may be deducted by the Ministry from any monies due or which may become due to the Contractor; provided always that the Engineer shall, as soon after the occurrence of such emergency as may be reasonably practical, notify the Contractor thereof in writing. See Article 11-2 of the Conditions of Contract.

1.06.13 TERMINATION OF CONTRACTOR'S RESPONSIBILITY. The Contractor shall be released from further Work on the project upon receiving a written Process-Verbal from the Ministry notifying the Contractor of the approval of the Final Handover. See Article 6-4 of the Conditions of Contractor.

1.06.14 METHOD OF MEASUREMENT. "Construction Schedule" will include all materials, computer equipment, labor, supervision, maintenance, support and incidental items required by this Section. The lump sum price for this Work will be all inclusive for all versions of the construction schedule specified, developed, submitted, updated, revised and maintained to the satisfaction of the Engineer in accordance with the requirements of this Section.

1.06.15 PAYMENT.

1.06.15.1 Regular Payment Schedule. The Initial Approved CPM-PS, Preliminary Activity Schedule, CPM-PS Revisions, and all CPM-PS Updates thereto for maintaining the schedules, will be paid for at the lump sum price bid for Pay Item No. 10601- Construction Schedule. Twenty-five percent (25%) of the lump sum price bid for the CPM-PS and PAS (except when the price bid exceeds one-half (1/2) of one percent (1%) of the total contract price bid) will be paid upon approval of the initial CPM-PS with the balance paid upon a monthly prorated sum based upon the specified contract duration.

1.06.15.2 Special Payment Schedule. When the price bid for the CPM-PS exceeds one-half (1/2) of one percent (1%) of the total contract price bid, the following shall prevail; the total progress payments for the Approved CPM-PS will be limited to one-half (1/2) of one percent (1%) of the total contract price as bid by the Contractor and will be paid in accordance with the above. Any remaining balance (over one-half (1/2) of one percent 1%) of the total contract price bid) will be paid upon final contract payment.

1.06.15.3 Scope of Payment. The items of Work, measured as provided above will be paid at the contract unit price(s) for each item as specified in the Bill of Quantities, which price(s) shall be full compensation for furnishing all material and furnishing, for all labor, equipment, tools, supplies and all other items necessary for completion of the Work as specified in Subsection 1.07.2 "Scope of Payment."

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO.	PAY ITEM	PAY UNIT
10601	Construction Schedule	Lump Sum

SECTION 1.07 - MEASUREMENT AND PAYMENT

1.07.1 MEASUREMENT OF QUANTITIES.

1.07.1.1 General. All Work completed under the Contract shall be measured according to the Metric System.

The method of measurement and computations to be used in determination of quantities of material furnished and of Work performed under the Contract shall be those methods generally recognized as conforming to good engineering practice and current MOC circulars. All methods shall be as approved or directed by the Engineer.

All field measurements shall be made by the Contractor in the presence of the Engineer, including measurements for monthly pay certificate quantities and for final quantities. Original copies of the field measurement notes, signed by the Contractor, will be retained by the Engineer.

Quantities shall be computed by the Contractor and will be checked by the Engineer. Copies of the quantity computations, including cross sections, shall be delivered to the Engineer at least five (5) days prior to the date set by the Engineer for his submittal of the pay certificate.

If the Contractor fails to or refuses to measure items of Work, the Engineer may, at his discretion, estimate quantities for the monthly pay certificate or make no payment certificate for the items of Work not measured and quantities not computed. See Articles 9-1 and 9-2 of the Conditions of Contract.

1.07.1.2 Measurements. Unless otherwise specified, longitudinal measurements for area computations shall be made horizontally, and no deductions will be made for fixtures (manholes, etc.) having an area of one (1) square meter or less. Unless otherwise specified, transverse measurements for area computations shall be the neat dimensions shown on the plans or ordered in writing by the Engineer.

Structures shall be measured according to neat lines shown on the plans or as altered by direction of the Engineer to meet field conditions.

All items which are measured by the linear meter, such as pipe culverts, guardrail, underdrains, etc., shall be measured parallel to the base or foundation upon which such structures are placed, unless otherwise shown on the plans. Pipe culverts shall be measured parallel to the centerline of the pipe.

1.07.1. 3 Earthwork. In computing volumes of earthwork, the average end area method shall be used in computing quantities, except where the error exceeds plus or minus five percent (5%) as compared with the prismoidal formula, in which case the Engineer will direct the use of the more accurate method. However, the Contractor shall request such direction before he submits his quantities for approval. He will not be allowed to ask for review of quantities previously approved in order to revise them,

if they have been submitted on the average end area basis, without prior permission to use a more accurate method.

The quantities of excavation which will be paid for under contract unit price(s) shall be limited to the lines shown on the plans, drawings, or standard drawings, and will be indicated on approved cross sections. Excavation beyond lines shown on approved cross sections will not be paid for except that ordered in writing by the Engineer. The Engineer will adjust the angle of slopes for cuts and fills as the Work proceeds, and make his determination of the advisable rate of slope in accordance with his evaluation of the soil conditions. The actual lines of the cuts as made shall be duly measured and recorded by the Contractor. The Engineer will check these records and, where he finds them as ordered, will approve the measurement as a basis for payment. Excavation in excess of approved cross section will not be paid for, except unsuitable excavation ordered removed by the Engineer in writing. These areas shall be backfilled with approved materials as directed by the Engineer. Areas of unauthorized over-excavation shall be backfilled at the Contractor's expense.

Within sixty (60) days of the date of field staking, the Contractor shall submit to the Engineer for his approval, the plots of the original and final earthwork cross sections together with the area and volumetric earthwork computations. The Contractor's cross sections shall be on transparent cross section sheets for print reproductions. All sheets shall have a title block and be of size designated by the Engineer. On final approval of the Contractor's cross sections, the Contractor shall give the Engineer the original transparent tracings and three (3) prints of the same. If the Contractor fails or refuses to submit cross sections within the specified time, the Engineer may withhold payment for all or any part of the earthwork quantities specified.

In case of any variations from the approved plans, the Contractor shall give the Engineer the original and two (2) copies of cross sections and profiles of the graphical record and the notes and computations of his stake-out, as required by the Engineer. The Contractor shall take cross sections at twenty-five (25) meter centerline intervals, and at other locations as may be directed by the Engineer. At his option, he may submit cross sections intermediate to these locations. The Engineer will indicate, on one (1) copy, his approval of the proposed lines of the Work or his revision thereof and return it to the Contractor. The Contractor shall resubmit for approval any cross sections the Engineer may revise.

The Contractor may, as an alternate method for earthwork computations, submit to the Ministry for approval, a proposal for the use of an electronic computer. Such proposal shall include details of the computer hardware, the earthwork program or programs, the input, the output, and a complete summary of the methods and procedures to be used. The Contractor may use the electronic computer method only with the prior approval of the Ministry, and continuance of such approval is contingent on satisfactory results. If results from the computer are not as represented or are otherwise deemed unsatisfactory, the Contractor shall recompute the earthwork computations by the cross sectional method.

The Engineer may direct the Contractor to use a specific approved earthwork program. In this case, the Contractor shall make this software program available to the Engineer to be used in checking the earthwork calculations.

1.07.1.4 Gauge Designations. The term gauge when used in connection with the measurement of plates, will mean the U.S. Standard Gauge, except that when reference is made to the measurements of galvanized sheets used in the manufacture of corrugated metal pipe, metal plate pipe culverts and arches, and metal cribbing, the term gauge will mean that specified in AASHTO M 36 or AASHTO M 167.

When the term gauge refers to the measurement of wire, it shall mean the wire gauge specified in AASHTO M 32.

1.07.1.5 Weight. The term ton or tonne shall mean the metric ton consisting of one thousand (1,000) kilograms (2204.623 pounds avoirdupois). All materials which are measured or proportioned by weight shall be weighed on accurate and approved scales by competent and qualified personnel, at locations designated or approved by the Engineer. If material is shipped by rail, the car weight may be accepted provided the actual weight of material only will be paid for. However, car weights will not be acceptable for material to be passed through mixing plants. Trucks used to haul material being paid for by weight shall be weighed empty daily at such times as the Engineer directs, and each truck shall bear a legible identification mark.

1.07.1.6 Volume. Materials to be measured by volume in the hauling vehicle shall be hauled in approved vehicles and measured therein at the point of delivery. Vehicles for this purpose may be of any size or type acceptable to the Engineer, provided that the body is of such shape that the actual contents may be readily and accurately determined. All vehicles shall be loaded to their level capacity and the Engineer may require loads to be releveled when the vehicles arrive at the point of delivery.

When requested by the Contractor and approved by the Engineer in writing, material specified to be measured by the cubic meter may be weighed and such weights will be converted to cubic meter for payment purposes. Factor for conversion from weight measurement to volume measurement will be determined by the Engineer and shall be agreed to by the Contractor before such method of measurement of pay quantities is used.

1.07.1.7 Bituminous Materials. Net certified scale weights or weights based on certified volumes in the case of rail shipments shall be used as basis of measurement, subject to correction when bituminous material has been lost from the car or the distributor, wasted, or otherwise not incorporated in the Work.

When bituminous materials are shipped by truck or transport, net certified weights or volumes, subject to correction for loss or foaming, may be used for computing quantities.

When bituminous materials are transported directly from the refinery to the Work, measurement at the refinery may be made with temperature compensating meters in lieu of weighing.

1.07.1.8 Cement. Cement shall be measured by the sack. The term sack shall mean fifty (50) kilograms of cement.

1.07.1.9 Lump Sum. The term "lump sum," when used for an Item of Work, shall include all labor, equipment, and materials necessary to complete the Work.

1.07.1.10 Fittings and Accessories. When any Item of Work is shown on the plans as requiring miscellaneous fittings and accessories for which no separate payment is provided, the unit (lump sum or otherwise) shall be construed to include those fittings and accessories.

1.07.1.11 Rental Equipment. Rental of equipment shall be measured in hours of actual working time and necessary traveling time of the equipment within the limits of the project unless special equipment has been ordered by the Engineer in connection with force account work, in which case travel and transportation to the project shall be measured.

1.07.1.12 Manufactured Items. When standard manufactured items are specified such as fence, wire, plates, rolled shapes, pipe conduit, etc., and these items are identified by gauge, unit weight, section dimensions, etc., such identification shall be considered to be nominal weights or dimensions. Unless more stringently controlled by tolerances in cited specifications, manufacturing tolerances established by the industries involved will be accepted.

1.07.2 SCOPE OF PAYMENT. The Contractor shall receive and accept compensation provided for in the Contract as full payment for all labor, material, job organizational costs, overhead, profit, royalties payment to others for land or use of land or damage to property of others, incidental Work, where herein specified for the proper completion of the Work, which is not paid for separately but is subsidiary to the Work of payment items, including drainage to protect the Work during construction, haulage, tools, placement of material where specified herein or directed, sheeting, shoring, centering and supports, laboratory equipment and personnel for testing, housing for his personnel and all other costs necessary or usual to the proper completion of the Work.

1.07.3 COMPENSATION FOR ALTERED QUANTITIES. When the accepted quantities of Work vary from the Bill of Quantities, the Contractor shall accept as payment in full, at the original contract unit price(s) for the accepted quantities of Work done. No allowance, except as provided in Section 1.02, "Scope of Work" in these General Specifications will be made for any increased expense, loss of expected reimbursement, or loss of anticipated profits suffered or claimed by the Contractor resulting either directly from such alternations or indirectly from unbalanced allocation among the Contract items of overhead expense and subsequent loss of expected reimbursement therefore or from any other cause. See Article 7-3 of the Conditions of Contract.

1.07.4 ELIMINATED ITEMS. Should any items contained in the Tender be found unnecessary for the proper completion of the Work, the Engineer may, upon written order to the Contractor, eliminate such items from the Contract, and such action shall in no way invalidate the Contract. When a Contractor is notified of the elimination of items, he may make written claim for actual Work done and all costs incurred, including mobilization of materials and equipment prior to said notification. He will be reimbursed by Change Order for all such costs deemed valid by the Ministry.

1.07.5 EXTRA AND FORCE ACCOUNT WORK. Extra Work performed in accordance with the requirements and provisions of Section 1.02, "Scope of Work" in these General Specifications will be paid for at the contract unit price(s) or lump sum stipulated in the Change Order authorizing the Work, or the Ministry may require the Contractor to do such Work on force account (Day Work) basis, to be compensated according to the scheduled rates submitted by the Contractor in his Tender in the "Appendix to Bill of Quantities." Such rates include overhead and profit and all other costs of whatever nature necessary and incidental to the performance of force account Work and whenever ordered.

In respect to all Work executed on a force account basis, the Contractor shall, during the continuance of such Work, deliver each day to the Engineer an exact list, in duplicate, of the name, occupation, and time of each workman employed in such Work and a statement, also in duplicate, giving the description and quantity of all materials and plant used thereon or therefor (other than plant which is included in the percentage addition in accordance with the "Appendix to Bill of Quantities" hereinbefore referred to).

One copy of each list and statement will, if correct or when agreed to, be signed by the Engineer and returned to the Contractor. At the end of each month the Contractor shall deliver to the Engineer a price statement based on the previous daily approved lists of the labor, material, and plant (except as aforesaid).

1.07.6 UNAUTHORIZED WORK. Any Work performed in excess of the requirements of the plans and specifications such as overdepth excavation, extra thickness of base or surface courses, extra thickness or depth of concrete, extra depth of riprap, and similar items will not be paid for as Extra Work and will not be considered as a basis for claim for compensation for Extra Work performed unless such Extra Work was authorized by the Engineer either by Directive or Change Order. Knowledge of the Engineer or his representative that such excess Work is being performed will not constitute authorization.

1.07.7 SET PRICE ITEMS. Before the opening of Tenders, where it is impossible or impracticable to determine the amount or kind of some of the items that may be encountered or needed to complete the Work properly, and where the Ministry has reason to believe these items may be encountered or needed, it may set a price upon said items in the Tender, and the prices so set shall become the unit prices for those items, should the Contract be awarded.

1.07.8 SUPPLEMENTAL AGREEMENT. The Ministry may enter into a Supplemental Agreement with the Contractor to do Special or Extra Work or certain

other Work, not included in original Tender, at the contract unit price(s) specified in the Supplemental Agreement.

Such an agreement when executed shall immediately become a part of the original Contract and shall be subject to all General, Supplemental, or Special Specifications governing it.

1.07.9 TEMPORARY PAYMENTS. The Ministry may make temporary (partial) payments to the Contractor within the limits of seventy-five percent (75%) of the specified cost of certain materials supplied by the Contractor for use in the permanent Work, provided that the materials are in accordance with the specifications, and have been tentatively approved by the Engineer and, where applicable, upon receipt of the Certificate of Guarantee stating that the material meets all requirements of the specifications. The Contractor shall furnish proof of ownership and shall be totally responsible for the storage of these materials and shall maintain them in safe and sound condition as long as they are being stored, and until such time as they are incorporated into the Work.

The amounts of temporary payments will be determined on the basis of the relevant contract unit prices for the materials in the Bill of Quantities. If there is no contract unit price for such materials in the Bill of Quantities, the cost of these materials shall be determined on the basis of purchase invoices that are certified and legalized by the Chambers of Commerce. Temporary payments for materials will be deducted from the current Monthly Payments after the Contractor incorporates the materials into the final Work.

Temporary payments may only be made for the following materials which are actually imported to the site according to seventy-five percent (75%) of the market price or seventy-five percent (75%) of the contract unit price as appropriate.

Cement
Reinforcing Steel, Prestressing Steel
Road Paint, Bearing Devices, Expansion Joints and Electrical Materials
Structural Steel and Miscellaneous Metals, including Guardrails, Delineators and Signs, and Gabion Baskets.

When a temporary payment for an item or quantity of material has been received by the Contractor, that material shall become the property of the Ministry. The Contractor shall be responsible for the proper storage, condition, and security of the materials regardless of ownership.

The Ministry reserves the right to refuse to make temporary (partial) payments for justifiable reasons such as lack of progress, unacceptable procedures by the Contractor, Royal Decrees or any similar reasons. There presently exists a Royal Decree against making these temporary payments.

1.07.10 PREPARATION OF MONTHLY CERTIFICATES OF WORK; AND THE MANNER OF PAYMENT THEREOF. At the end of each Hegira month, the Engineer and the representative of the Contractor shall prepare a certificate of Work completed from the beginning of the Contract until the end of such Hegira month.

The monthly certificates shall be signed by the representative of the Contractor and by the Engineer, and shall be delivered to the Ministry before the end of the tenth day of the following month.

The Ministry will check the certificate and, if it is found to be accurate and in compliance with the Contract, the Ministry will deduct the following items:

The total sum paid for previous monthly certificates.

The installment for the repayment of the advance payment.

Any other deductions for taxes and charges required by Law or the Contract, or any other requirements.

Any probable delay penalty according to provisions of the Contract Documents.

Other miscellaneous deductions that the Contractor may owe according to provisions of the Contract Documents.

The Ministry will then, within a reasonable period from the date the monthly certificate is received, pay the net sum to the Contractor by a pay-order payable by the Ministry of Finance and National Economy.

By payment of the provisional monthly certificate, all of the Work paid for shall be property of the Ministry and shall be in the custody of the Contractor until the Contract is completed.

If, due to any reason, the certificate is defective, or if some of the items are objected to by the Ministry, it will be returned to the Engineer for correction.

All of the quantities stipulated in the monthly certificates and the payments made are provisional only and final and are considered to be on-account. Any mistake in measurement and computation in the monthly certificates or in the final certificate shall be corrected and made good. If such errors are discovered after payment of a monthly certificate, corrections shall be made on the following monthly certificate by increasing or decreasing the quantities as appropriate. See Article 10-2 of the Conditions of Contract.

1.07.11 FINAL CERTIFICATE. As soon as the Provisional Handover of the completed Work has taken place, the Engineer and the representative of the Contractor shall together take measurements and prepare the Final Certificate for the Work performed. The Contractor shall provide all instruments, materials, and personnel required for measurements and preparation of the Final Certificate. The quantities and figures that are given in the Final Certificate are final; whether or not there are

discrepancies between these figures and the quantities and figures which were stated in the monthly certificates.

The Final Certificate, with attachments and computations, will be forwarded to the Contractor. If the Contractor has objections they shall be submitted, in writing, to the Engineer within ten (10) days from the date of the receipt of the Certificate. The Contractor shall state his reasons fully, and document his objection(s) to the Final Certificate with adequate and accurate data and records, for use by the Engineer in investigating and determining the validity of the Contractor's objection(s). If the Contractor does not object to the Final Certificate within the ten (10) days stipulated, it will be considered as Final. See Article 10-4 of the Conditions of Contract.

SECTION 1.08 - ACCEPTANCE OF WORK

1.08.1 GENERAL. The references to standard test methods of AASHTO, ASTM and other recognized standards authorities refer to the methods in effect on the date of solicitation for bids.

All shall be performed according to the contract requirements. All work lines, grades, cross-sections, dimensions and processes or materials shall be as shown on the plans or specified in the contract.

Plan dimensions and contract specification values are the values to be strived for and complied with as the design values from which any deviations are allowed. Work is to be performed and material that is uniform in character and reasonably close to the prescribed value or within the specified tolerance range is to be provided. The purpose of a tolerance range is to accommodate occasional minor variations from the median zone that are unavoidable for practical reasons.

The Ministry may inspect, sample or test all work at any time before final acceptance of the project. When the Ministry tests work, copies of test reports are furnished to the Contractor upon request. Ministry tests may or may not be performed at the work site. The Contractor shall not rely on the availability of Ministry test results for process control.

Acceptable work conforming to the contract will be paid for at the contract unit price. Four methods of determining conformity and accepting work are described in the following Subsections 1.08.2 to 1.08.5 inclusive. The primary method of acceptance is specified in each Section of work. However, work may be rejected at any time it is found by any of the methods not to comply with the contract.

Work that does not conform to the contract, or to prevailing industry standards where no specific contract requirements are noted, shall be removed and replaced at no cost to the Ministry.

As an alternative to removal and replacement, the Contractor may submit a written request to:

1. Have the Work accepted at a reduced price, or
2. Be given permission to perform corrective measures to bring the Work into conformity.

The request shall contain supporting reasons and documentation for his request. This shall include references or data justifying the proposal based on an evaluation of test results, effect on service life, value of material or work, quality, and other tangible engineering basis. The Engineer will determine disposition of the non-conforming work.

When standard manufactured items are specified, (such as fence, wire, plates, rolled shapes, pipe conduits, etc. that are identified by gauge, unit weight, section dimensions, etc.) the identification will be considered to be nominal weights or

dimensions. Unless specific contract tolerances are noted, established manufacturing tolerances will be accepted.

1.08.2 VISUAL INSPECTION. Where appropriate Acceptance may be based on visual inspection of the work for compliance with the contract and prevailing industry standards.

1.08.3 CERTIFICATION OF COMPLIANCE. Acceptance is based on a Certificate of Guarantee from a manufacturer based on an effective internal testing and inspection system or a test certificate from an approved independent testing laboratory or service. The independent laboratory shall be approved by the Engineer before any materials are submitted for tests. The manufacturer shall furnish documentation of the testing and inspection system with a Certificate of Guarantee that states the Work complies with the specific contract requirements.

The manufacturer shall be required to furnish a "*product certification*" for material commercially produced to a standard specification. The manufacturer shall clearly mark the material or package with a unique product identification. One *"product certification"* may apply to all the Work incorporated into the project.

The manufacturer shall be required to furnish a *"product certification"* for material that:

1. **Is specifically produced or fabricated for the project, or**
2. **Is produced or shipped in bulk and therefore not readily identifiable as to manufacturer and product, or**
3. **Has a specific contract requirement.**

A *"product certification"* shall accompany each shipment of material and shall identify the date and place of manufacturer as well as the lot number or other means of cross referencing to the inspection and testing system. The Contractor shall furnish specific test results on material from the same lot upon request.

However, all materials delivered to the site are subject to additional laboratory testing when requested by the Engineer, even though the materials are accompanied by a Certificate of Guarantee or laboratory test certificate. All costs in connection with Certificates of Guarantee and/or laboratory tests and certificates shall be borne by the Contractor.

The issuance of a Certificate of Guarantee without having recently performed the required tests on representative samples of the material in question shall render the Certificate invalid.

The issuance of an invalid or erroneous Certificate of Guarantee shall be just cause for rejection of the materials without further testing and all cost of transportation and handling of the rejected materials shall be the sole responsibility of the Contractor.

1.08.4 MEASURED OR TESTED CONFORMANCE. Acceptance shall be based on all necessary production and processing of the Work and control performance of the Work so that all of the work complies with the contract requirements.

Results from inspection or testing shall be used to support acceptance of the work incorporated into the project with values within the specified tolerances or specification limits. When no tolerance values are identified in the contract, the Work will be accepted based on customary manufacturing and construction tolerances.

1.08.5 STATISTICAL EVALUATION OF WORK FOR ACCEPTANCE AND DETERMINATION OF PAY FACTOR (Value of Work). Statistical evaluation of work is a method of analyzing inspection or test results to determine conformity with the contract requirements. When the specifications provide for material to be sampled and tested on a statistical basis, the material will be evaluated for acceptance in accordance with this Subsection as follows:

1.08.5.1 General. For work accepted based on statistical evaluation of random sampling, both the Ministry and Contractor assume some risk.

The Ministry's risk is the probability that work of a rejectable quality level (RQL) is accepted. The Contractor's risk is the probability that work produced at an acceptable quality level (AQL) is rejected or accepted at a reduced contract price.

Acceptable quality level is the highest percentage of work outside the specification limits that is considered acceptable for payment at contract price. There are two (2) acceptance categories. Category I (for major characteristics) is based on an AQL of five percent defective (5%). Category II (for minor characteristics) is based on AQL of ten percent defective (10%). In both cases, the Contractor's risk is five percent (5%).

The Contractor is encouraged to produce superior work yielding the highest quality level (AQL) to offset the Contractor's risk. The final maximum obtainable pay factor for each lot will never be greater than 1.00.

The measured characteristics to be evaluated, lot size, acceptance sampling frequency, acceptance sampling location, test methods, specification limits and category are as follows:

1.08.5.1.1 Quality and Quantity Characteristics. The quality and quantity characteristics to be measured and evaluated are listed in Table 1.08-3.

1.08.5.1.2 Lot Size. A lot size is a discrete quantity of work to which the statistical acceptance procedure is applied. The General or Special Specifications shall specify the lot size in terms of unit quantities (eg. tons, cubic meters or square meters).

1.08.5.1.3 Acceptance Sampling Frequency. The frequency of sampling is listed in Table 1.08-3. The frequency rate shown normally results in a minimum of five (5) samples per lot which is the minimum number required to perform a statistical evaluation. The maximum obtainable measured characteristic pay factor with five (5) samples is one and one hundredths (1.01). A minimum of eight (8) samples are required to obtain a one and five-hundredths (1.05) characteristic pay factor.

If the sampling frequencies and quantity of work would otherwise result in fewer than five (5) samples, a written request is required to increase the sampling frequency to provide for a minimum of five (5) samples. The request to increase the sampling frequency shall be submitted at least forty-eight (48) hours before beginning production. An increase in the sampling frequency may result in a different pay factor.

1.08.5.1.4 Acceptance Sampling Location. The point of sampling is listed in Table 1.08-3. The exact location of sampling will be based on random sampling in accordance with Paragraph 1.04.3.8 "Random Numbers" in these General Specifications.

1.08.5.1.5 Test Methods. The test methods used to test the sample are listed in Table 1.08-3.

1.08.5.1.6 Specification Limits. The specification limits for the quality characteristics are listed in the General Specifications or Special Specifications for the work in question.

1.08.5.1.7 Category. The category for the quality characteristics to be analyzed are listed in Table 1.08-3.

1.08.5.2 Acceptance. The Work in the lot will be accepted and paid for at a final pay factor when all inspection or test results are completed and evaluated.

A grand or total pay item quantity lot will be used if specified in the Special Specifications. The concept of a grand lot is based on letting the grand lot accumulate the stream of homogenous sublots while they are exhibiting a certain level of quality. The homogeneity can be defined by the quality level of the inspected lots in terms of AQL. The level of homogeneity would be a minimum of fifteen percent (15%) for an AQL that has to be maintained for consecutive sublots to be allowed to aggregate as a grand lot. In other words, the grand lot will be allowed to agglomerate provided the current pay factor does not fall below ninety hundredths (0.90). If the current pay factor of a lot falls below ninety hundredths (0.90), terminate production. Production may resume after effective actions to improve the quality of the production are taken by the Contractor and the actions taken are approved. The Contract may state when the accumulative lot is exhausted in terms of maximum number of samples.

A lot containing an unsatisfactory percentage of nonspecification material (less than 1.00 pay factor) is accepted provided the pay factor is at least seventy-five hundredths (0.75) and there are no isolated defects identified by the Engineer.

A lot containing an unsatisfactory percentage of nonspecification material that fails to obtain at least seventy-five hundredths (0.75) pay factor will be rejected by the Engineer. All of the rejected material shall be removed from the Work.

When approved, it is permissible to voluntarily remove defective material and replace it with new material to avoid or minimize a pay factor of less than 1.00. New material will be sampled, tested and evaluated for acceptance according to this Subsection.

Any quantity of material that is determined to be defective may be rejected on visual inspection or test results. Do not incorporate rejected material in the Work. The results of tests run on rejected material will be excluded from the lot of acceptable tests, if the rejected material is removed from the Work.

1.08.5.3 Statistical Evaluation. The Variability-Unknown/Standard Deviation Method will be used to determine the estimated percentage of the lot that is outside specification limits.

The number of significant figures used in the calculations will be according to AASHTO R-11, Absolute Method.

The estimated percentage of work that is outside of the specification limits for each quality characteristic will be determined in accordance with the following steps:

1. Calculate the arithmetic mean (X) of the test values: $X = \frac{\Sigma x}{n}$

   Where: Σ_x = summation of individual test values

   n = total number of test values

2. Calculate the sample standard deviation(s):

   $$s = \sqrt{\frac{n\Sigma(x^2) - (\Sigma x)^2}{n(n-1)}}$$

   Where: $\Sigma(x^2)$ = summation of the squares of individual test values
   $(\Sigma x)^2$ = summation of the individual test values squared

3. Calculate the upper quality index (Q_u): $Q_u = \frac{USL - X}{s}$

   Where: USL = Upper Specification Limit

   Note: The USL is equal to the contract specification limit or the target value plus the allowable deviation.

4. Calculate the lower quality index (Q_L): $Q_L = \frac{X - LSL}{s}$

   Where: LSL = Lower Specification Limit

   Note: The LSL is equal to the contract specification limit or the target value minus the allowable deviation.

5. From Table 1.08-1, determine P_u (the estimated percentage of work outside the USL which corresponds to a given $Q_{u)}$. If a USL is not specified, P_u is O.

6. From Table 1.08-1, determine P_L (the estimated percentage of work within the lot outside the LSL). P_L corresponds to a given Q_L. If an LSL is not specified, P_L is O.

7. Calculate the total estimated percentage of work outside the USL and LSL (percent defective).

Percent Defective = $P_u + P_L$

8. Repeat steps 1 through 7 for each quality characteristic listed for acceptance.

1.08.5.4 Pay Factor Determination (Value of the Work). The pay factor for a lot will be determined in accordance with the following steps:

1. From Table 1.08-2, determine the pay factor for each quality and quantity characteristic using the total number of test values and the total estimated percentage of work outside the specification limits from step (7) above.

2. When the measured characteristics tested for a lot are all quality characteristics, the lot pay factor will be the lowest single pay factor for all the quality characteristics. The maximum obtainable quality pay factor is 1.00.

3. When the measured characteristics for a lot are all quantity characteristics, the lot pay factor will be the lowest single pay factor for all the quantity characteristics. The maximum obtainable quantity pay factor is 1.00.

4. When the measured characteristics for a lot are both quality and quantity, the lot pay factors will be based on the following:

(1) When any quality characteristics are less than 1.00, the lot quality pay factor will be the lowest single pay factor for all quality characteristics. The maximum obtainable pay quality factor is 1.00.

(2) When any quantity characteristics are less than 1.00, the lot quantity pay factor will be the lowest single pay factor for any quantity characteristic.

5. Adjusted payment for material in a lot will be made at a price determined by multiplying the contract unit price by the lowest quality and quantity pay factor or pay factors as determined above.

Table 1.08-1
Estimated Percent of Work Outside Specification Limits

Estimated Percent Outside Specification Limits (P_U and/or P_L)	Upper Quality Index Q_U or Lower Quality Index Q_L						
	n=5	n=6	n=7	n=8	n=9	n=10 to n=11	n=12 to n=14
0	1.72	1.88	1.98	2.07	2.13	2.20	2.28
1	1.64	1.75	1.82	1.98	1.91	1.96	2.01
2	1.58	1.66	1.72	1.75	1.76	1.81	1.84
3	1.52	1.59	1.63	1.66	1.68	1.71	1.73
4	1.47	1.52	1.56	1.58	1.60	1.62	1.64
5	1.42	1.47	1.49	1.51	1.52	1.54	1.55
6	1.36	1.41	1.43	1.46	1.46	1.47	1.48
7	1.33	1.36	1.38	1.39	1.40	1.41	1.41
8	1.28	1.31	1.33	1.33	1.34	1.35	1.35
9	1.26	1.27	1.28	1.28	1.29	1.28	1.30
10	1.21	1.23	1.23	1.24	1.24	1.24	1.26
11	1.18	1.18	1.19	1.19	1.18	1.19	1.20
12	1.14	1.14	1.15	1.16	1.15	1.15	1.15
13	1.10	1.10	1.10	1.10	1.10	1.10	1.11
14	1.07	1.07	1.07	1.06	1.06	1.06	1.06
15	1.03	1.03	1.03	1.03	1.02	1.02	1.02
16	1.00	0.99	0.99	0.99	0.99	0.98	0.98
17	0.97	0.96	0.96	0.95	0.95	0.96	0.94
18	0.93	0.92	0.92	0.92	0.91	0.91	0.91
19	0.90	0.88	0.89	0.88	0.88	0.87	0.87
20	0.87	0.86	0.86	0.85	0.84	0.84	0.84
21	0.84	0.82	0.82	0.81	0.81	0.81	0.80
22	0.81	0.79	0.79	0.76	0.76	0.77	0.77
23	0.77	0.76	0.76	0.75	0.74	0.74	0.74
24	0.74	0.73	0.72	0.72	0.71	0.71	0.70
25	0.71	0.70	0.69	0.69	0.68	0.68	0.67
26	0.68	0.67	0.67	0.66	0.66	0.66	0.64
27	0.65	0.64	0.63	0.62	0.62	0.62	0.61
28	0.62	0.61	0.60	0.58	0.59	0.59	0.58
29	0.59	0.58	0.57	0.57	0.56	0.56	0.56
30	0.56	0.55	0.54	0.54	0.53	0.53	0.55
31	0.53	0.52	0.51	0.51	0.50	0.50	0.50
32	0.50	0.49	0.48	0.48	0.48	0.47	0.47
33	0.47	0.46	0.45	0.45	0.46	0.44	0.44
34	0.45	0.43	0.43	0.42	0.42	0.42	0.41
35	0.42	0.40	0.40	0.39	0.38	0.39	0.38
36	0.38	0.38	0.37	0.37	0.36	0.36	0.36
37	0.36	0.36	0.34	0.34	0.34	0.33	0.33
38	0.33	0.32	0.32	0.31	0.31	0.31	0.30
39	0.30	0.30	0.28	0.28	0.28	0.28	0.28
40	0.38	0.26	0.26	0.26	0.26	0.26	0.25
41	0.26	0.23	0.23	0.23	0.23	0.23	0.23
42	0.23	0.20	0.20	0.20	0.20	0.20	0.20
43	0.18	0.18	0.18	0.18	0.18	0.18	0.18
44	0.16	0.15	0.16	0.16	0.16	0.16	0.16
45	0.13	0.13	0.13	0.13	0.13	0.13	0.13
46	0.10	0.10	0.10	0.10	0.10	0.10	0.10
47	0.08	0.08	0.08	0.08	0.08	0.08	0.08
48	0.06	0.06	0.06	0.06	0.06	0.06	0.06
49	0.03	0.03	0.03	0.03	0.03	0.03	0.03
50	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Note: If the Value of Q_u or Q_L does not correspond to a value in the table, use the next lower value. If Q_u or Q_L are negative values, P_u or P_L is equal to 100 minus the table value for P_u or P_L.

Table 1.08-1
Estimated Percent of Work Outside Specification Limits

Estimated Percent Outside Specification Limits (P_U and/or P_L)	Upper Quality Index Q_U or Lower Quality Index Q_L					
	n=15 to n=17	n=18 to n=22	n=23 to n=29	n=30 to n=42	n=43 to n=66	n=67 ton=00
0	2.34	2.30	2.44	2.48	2.51	2.54
1	2.04	2.07	2.09	2.12	2.14	2.16
2	1.87	1.88	1.91	1.83	1.84	1.96
3	1.75	1.76	1.76	1.79	1.80	1.91
4	1.65	1.66	1.67	1.65	1.68	1.70
5	1.56	1.57	1.58	1.59	1.59	1.60
6	1.49	1.50	1.60	1.61	1.51	1.52
7	1.42	1.43	1.43	1.44	1.44	1.44
8	1.36	1.36	1.37	1.37	1.37	1.38
9	1.30	1.30	1.31	1.31	1.31	1.31
10	1.26	1.26	1.26	1.26	1.26	1.26
11	1.20	1.20	1.20	1.20	1.20	1.20
12	1.15	1.15	1.15	1.15	1.15	1.15
13	1.11	1.11	1.11	1.11	1.11	1.11
14	1.06	1.06	1.06	1.06	1.06	1.06
15	1.02	1.02	1.02	1.02	1.02	1.02
16	0.98	0.98	0.98	0.98	0.98	0.98
17	0.94	0.94	0.94	0.94	0.94	0.94
18	0.91	0.90	0.90	0.90	0.90	0.90
19	0.87	0.87	0.87	0.87	0.87	0.87
20	0.83	0.83	0.83	0.83	0.83	0.83
21	0.80	0.80	0.80	0.90	0.80	0.78
8822	0.77	0.76	0.76	0.76	0.76	0.76
23	0.73	0.73	0.73	0.73	0.73	0.73
24	0.70	0.70	0.70	0.70	0.70	0.70
25	0.67	0.67	0.67	0.67	0.67	0.66
26	0.64	0.64	0.64	0.64	0.64	0.63
27	0.61	0.61	0.61	0.61	0.61	0.60
28	0.58	0.58	0.58	0.58	0.58	0.57
29	0.55	0.55	0.55	0.55	0.56	0.54
30	0.52	0.52	0.52	0.52	0.52	0.52
31	0.49	0.49	0.48	0.49	0.48	0.49
32	0.47	0.46	0.46	0.46	0.46	0.46
33	0.44	0.44	0.43	0.43	0.43	0.43
34	0.41	0.41	0.41	0.41	0.41	0.40
35	0.38	0.38	0.38	0.38	0.38	0.38
36	0.36	0.36	0.36	0.36	0.36	0.36
37	0.33	0.33	0.33	0.33	0.33	0.32
38	0.30	0.30	0.30	0.30	0.30	0.30
39	0.28	0.28	0.28	0.28	0.28	0.28
40	0.26	0.26	0.26	0.26	0.26	0.26
41	0.23	0.23	0.23	0.23	0.23	0.23
42	0.20	0.20	0.20	0.20	0.20	0.20
43	0.18	0.18	0.18	0.18	0.18	0.18
44	0.15	0.15	0.15	0.16	0.15	0.16
45	0.13	0.13	0.13	0.13	0.13	0.13
46	0.10	0.10	0.10	0.10	0.10	0.10
47	0.08	0.08	0.08	0.06	0.08	0.08
48	0.05	0.05	0.06	0.05	0.05	0.06
49	0.03	0.03	0.03	0.03	0.03	0.03
50	0.00	0.00	0.00	0.00	0.00	0.00

Note: If the Value of Q_u or Q_L does not correspond to a value in the table, use the next lower value. If Q_u or Q_L are negative values, P_u or P_L is equal to 100 minus the table value for P_u or P_L .

Table 1.08-2 Pay Factors

PAY FACTOR		Maximum Allowable Percent of Work Outside Specification Limits for a Given Pay Factor ($P_U + P_L$)												
Category														
I	II	n=5	n=6	n=7	n=8	n=9	n=10 to n=11	n=12 to n=14	n=15 to n=17	n=18 to n=22	n=23 to n=29	n=30 to n=42	n=43 to n=66	n=67 to 00
1.05					0	0	0	0	0	0	0	0	0	0
1.04				0	1	3	5	4	4	4	3	3	3	3
1.03			0	2	4	6	8	7	7	6	5	5	4	4
1.02			1	3	6	9	11	10	9	8	7	7	6	6
1.01		0	2	5	8	11	13	12	11	10	9	8	8	7
1.00		22	20	18	17	16	15	14	13	12	11	10	9	8
0.99		24	22	20	19	18	17	16	15	14	13	11	10	9
0.98		26	24	22	21	20	19	18	16	15	14	13	12	10
0.97		28	26	24	23	22	21	19	18	17	16	14	13	12
0.96		30	28	26	25	24	22	21	19	18	17	16	14	13
0.95	1.00	32	29	28	26	25	24	22	21	20	18	17	16	14
0.94	0.99	33	31	29	28	27	25	24	22	21	20	18	17	15
0.93	0.98	35	33	31	29	28	27	25	24	22	21	20	18	16
0.92	0.97	37	34	32	31	30	28	27	25	24	22	21	19	18
0.91	0.96	38	36	34	32	31	30	28	26	25	24	22	21	19
0.90	0.95	39	37	35	34	33	31	29	28	26	25	23	22	20
0.89	0.94	41	38	37	35	34	32	31	29	28	26	25	23	21
0.88	0.93	42	40	38	36	35	34	32	30	29	27	26	24	22
0.87	0.92	43	41	39	38	37	35	33	32	30	29	27	25	23
0.86	0.91	45	42	41	39	38	36	34	33	31	30	28	26	24

Note: To obtain a pay factor when the estimated percent outside specifications limits from Table 1.08-1 does not correspond to a value in the table, use the next larger value (continued).

Table 1.08-2 Pay Factors (continued)

PAY FACTOR		Maximum Allowable Percent of Work Outside Specification Limits for a Given Pay Factor ($P_U + P_L$)												
Category														
I	II	n=5	n=6	n=7	n=8	n=9	n=10 to n=11	n=12 to n=14	n=15 to n=17	n=18 to n=22	n=23 to n=29	n=30 to n=42	n=43 to n=66	n=67 to 00
0.85	0.90	46	44	42	40	39	38	36	34	33	31	29	28	25
0.84	0.89	47	45	43	42	40	39	37	35	34	32	30	29	27
0.83	0.88	49	46	44	43	42	40	38	36	35	33	31	30	28
0.82	0.87	50	47	46	44	43	41	39	38	36	34	33	31	29
0.81	0.86	51	49	47	45	44	42	41	39	37	36	34	32	30
0.80	0.85	52	50	48	46	45	44	42	40	38	37	35	33	31
0.79	0.84	54	51	49	48	46	45	43	41	39	38	36	34	32
0.78	0.83	55	52	50	49	48	46	44	42	41	39	37	35	33
0.77	0.82	56	54	52	50	49	47	45	43	42	40	38	36	34
0.76	0.81	57	55	53	51	50	48	46	44	43	41	39	37	35
0.75	0.80	58	56	54	52	51	49	47	46	44	42	40	38	36
	0.79	60	57	55	53	52	51	48	47	45	43	41	40	37
	0.78	61	58	56	55	53	52	50	48	46	44	43	41	38
	0.77	62	59	57	56	54	53	51	49	47	45	44	42	39
REJECT	0.76	63	61	58	57	55	54	52	50	48	47	45	43	40
	0.75	64	62	60	58	57	55	53	51	49	48	46	44	41
	REJECT	Values Greater Than Those Shown Above												

Note: To obtain a pay factor when the estimated percent outside specifications limits from Table 1.08-1 does not correspond to a value in the table, use the next larger value.

Table 1.08-3 Materials Subject to Statistical Based Acceptance

Section	Material	Characteristics	Characteristic Type	Test Method	Sampling Frequency	Point of Sampling
2.02	Embankment	Compaction	Quality	MRDTM 215 or MRDTM 218	Minimum of 8 nuclear gage or 5 cone density tests on each embankment lift or portion of lift up to a maximum of 10,000 cubic meters lot	In-place after compaction
2.06 2.07 2.08	Untreated Subgrade Lime Treated Subgrade Cement Treated Subgrade	Compaction	Quality	MRDTM 215 or MRDTM 218	Minimum of 8 nuclear gage or 5 sand cone density tests on each 5,000 square meter lot for each layer constructed.	In-place after compaction.
		Thickness	Quantity	Dig Test Holes	Minimum 5 test holes per lot	In-place after compaction
3.02 3.03 3.04	Aggregate Subbases Aggregate Bases Cement Treated Bases	Aggregate Gradation(1)- Tables 3.02-1, 3.03-1 All Sieves(5), Sand Equivalent and Plasticity Index	Quality	MRDTM 204 MRDTM 313 MRDTM 208	Minimum of five (5) samples per 10,000 square meter lot for each layer constructed	From the windrow or roadbed after processing
		Thickness	Quantity	Dig Test Holes	Minimum of (5) test holes per lot	In place after compaction
		Compaction	Quality	MRDTM 215 or 218	Minimum 8 nuclear gage or 5 sand cone density tests per lot	In place after compaction
4.04	Bituminous emulsion treated base course	Aggregate Gradation(1)- Table 4.40-1 All Sieves(5)	Quality	MRDTM 419	Minimum of 5 samples per 10,000 square meter lot for each layer constructed	Behind laydown machine or from roadway after mixing and placement
		Thickness	Quantity	ASTM D-3549	Minimum 5 core depths per lot	In place after compaction
		Compaction	Quality	ASTM D-2041 or D-2726	Minimum 5 core or 10 nuclear gage density tests per lot	In place after compaction
4.05 4.06	Bituminous concrete pavement Hot-mix recycled bituminous concrete pavement	Bituminous material content Aggregate Gradation(1) - Table 4.05-1, All Sieves(5)	Quality Quality	MRDTM 418 MRDTM 419	Minimum of 5 samples per 10,000 square meter lot for each layer constructed	Behind laydown machine before rolling
		Compaction	Quality	ASTM D-2726 or ASTM D-2041	Minimum 5 cores or 10 nuclear gage density tests per lot	In place after compaction
		Thickness	Quantity	ASTM D-3549	Minimum of 5 core depths per lot	In place after compaction
		Smoothness(3)	Quality	Paragraph 4.05.8.4	Paragraph 4.05.8.4	Paragraph 4.05.8.4

Table 1.08-3 Materials Subject to Statistical Based Acceptance (continued)

Section	Material	Characteristics	Characteristic Type	Test Method	Sampling Frequency	Point of Sampling
4.07	Bituminous concrete friction course	Bituminous material content Aggregate Gradation[1] Table 4.07-1, All Sieves[5] Thickness	Quality Quality Quantity	MRDTM 418 MRDTM 419 ASTM D-3549	Minimum of 5 samples per 5,000 square meter per lot Minimum 5 core depths per lot	Hopper of laydown machine after discharge from plant In-place after compaction
4.09	Cold Mix Recycled Bituminous Base	Aggregate Gradation Table 3.03-1 or 4.04-1, All Sieves[5] Compaction Thickness	Quality Quality Quantity	MRDTM 419 ASTM D-2726 or ASTM D-2041 ASTM D-2726	Minimum (5) samples per 10,000 square meter per lot for each layer constructed Minimum of (5) cores or 10 nuclear gage density tests per lot Minimum 5 core depths per lot	From the roadway after mixing and placement In place after compaction In place after compaction
4.12	Surface Recycled Bituminous Pavement	Thickness Compaction	Quantity Quality	ASTM D-3549 ASTM D-2041 or D-2726	Minimum 5 core depths per 10,000 square meter lot Minimum 5 core or 10 nuclear gage density tests per lot	In place after compaction In place after compaction
5.02	Structural concrete	Compressive strength	Quality	MRDTM 528 and 523	1 set of 6 cylinders per 50 cubic meters but not less than 1 set per day	Discharge stream at point of placement

(1) Uses only sieves indicated for the specific gradation. Do not use maximum or nominal maximum size sieve.
(2) Characteristic applies to surface course aggregate only.
(3) Applies only to an item used as a surface course.
(4) Thickness is not a statistically based acceptance parameter unless payment is by the square meter.
(5) Category I (Major characteristics) sieves for all materials are the 0.075 mm (No. 200) and the 4.75 mm (No. 4) sieves. In addition, the 9.5 mm (3/8 inch) sieve is a Category I (major characteristic) sieve for all aggregate subbase and base materials. Also, the 0.425 mm (No. 40) sieve is a Category I (major characteristic) sieve for all bituminous aggregate materials. All other sieves are Category (minor characteristic) sieves.

1.08.6 INSPECTION AT THE PLANT. Work may be inspected at the point of production or fabrication. Manufacturing plants may be inspected for compliance with specified manufacturing methods. Material samples may be obtained for laboratory testing for compliance with quality requirements. Allow full entry at all times to the parts of the plant producing the Work.

1.08.7 PARTIAL AND FINAL ACCEPTANCE. The Contractor shall maintain the Work during construction and guarantee period until the project is accepted.

1.08.7.1 Partial Acceptance. When a separate portion of the project is completed, a final inspection of that portion may be requested. If the portion is complete and in compliance with the contract, it will be accepted and the Contractor will be relieved of all responsibility except for maintenance of the completed portion. Partial acceptance does not void or alter any of the terms of the contract.

When public traffic is accommodated through construction and begins using sections of the roadway as they are completed, continue maintenance of such sections until final acceptance.

1.08.7.2 Final Acceptance. When notified that the entire project is complete, an inspection will be scheduled. If all work is determined complete, the inspection will constitute the final inspection, and the Contractor will be notified in writing of final acceptance as of the date of the final inspection. Final acceptance relieves the Contractor of all responsibility except for the maintenance of the project throughout the guarantee period.

If the inspection discloses any unsatisfactory work, the Contractor will receive a list of the Work that is incomplete or requires correction. He shall immediately complete or correct the Work and furnish notification when the Work has been completed.

SECTION 1.09 - SUPERVISION STAFF FACILITIES

1.09.1 DESCRIPTION. The supervision staff facilities shall include the Engineer's Offices, Project Laboratory, Dormitory (Rest House), Family Houses, Mess and Kitchen, Ancillary Structures, computers and survey equipment constructed and furnished to the requirements of the standard drawings and these specifications. All aspects of the facilities shall conform to national and local ordinances and regulations with respect to sanitation, segregation of facilities, and other details.

Items in Bill of Quantities
Supervision Staff Compound
Supervision Staff Compound (Temporary)
Project Laboratory
Computers and Survey Equipment

1.09.2 GENERAL REQUIREMENTS. The Supervision Staff facilities shall be located as approved by the Engineer and the local municipality, adjacent to the Project, outside the boundaries of towns and villages. The area chosen shall not be subject to flooding or other foreseeable natural damage and shall be away from areas where there is a health risk. The minimum area of land required for the Supervision Staff facilities is three thousand five hundred (3,500) square meters. The Contractor shall be responsible for all costs involved in the development of the land which shall be included in the lump sum items for the various supervision staff facilities unless provided for otherwise in the Special Specifications.

Unless the Supervision Staff facilities is specified as "Temporary" in the Bill of Quantities or Special Specifications, all land, buildings and specified stationary equipment shall become the property of the Ministry at the time of one hundred percent (100%) completion and shall be maintained by the Contractor in good condition to the final handing over of the project.

Living accommodations in the Dormitory and Family Housing shall be Type A, Type B or modified as specified in the Special Specifications depending on the anticipated size and character of the supervision staff.

The deduction for noncompletion of the Supervision Staff facilities within one hundred eighty (180) days of the handing over of the location of the facilities shall be at the rate of two thousand Saudi Riyals (SR 2000) per day of delay except that if the Supervision Staff facilities are specified as "Temporary," the penalty for noncompletion within one hundred twenty (120) days of the signing of the contract shall be at the rate of five hundred Saudi Riyals (SR 500) per day of delay.

The facilities plans are not presented as a complete set of construction plans, but rather as a set of definitive plans. Complete details for the electrical system, plumbing, water supply, sewers, etc., are not included and shall be the responsibility of the Contractor.

The facilities and equipment, as specified, are for a basic inspection team. If the operations of the Contractor are such that additions to the Engineer's staff are required, the Contractor shall provide additional facilities and equipment as directed by the Engineer. The cost of the additional facilities and equipment shall be the responsibility of the Contractor and shall be considered subsidiary to all other pay items listed in the Bill of Quantities.

During the period between the beginning of the Contractor's Work and the completion of the Supervision Staff facilities, the Contractor shall furnish and maintain approved mobile or special temporary facilities for the supervision staff depending on the nature of the Work in progress and the required inspection and testing. The minimum accommodations during this period shall be for four (4) men. No Contractor's Work may proceed or be paid on monthly certificates unless adequate facilities are provided for the Supervision Staff to inspect and test that Work.

1.09.3 CONSTRUCTION DETAILS.

1.09.3.1 Permanent Buildings. Unless the Supervision Staff facilities are specified as "Temporary" in the Bill of Quantities or Special Specifications, all buildings shall be permanent in construction conforming to the standard drawings and the requirements specified herein. Details not specified shall be in accordance with standard building construction practices and performed to the satisfaction of the Engineer.

1.09.3.1.1 Foundations. Building footings shall extend a minimum of sixty (60) centimeters below the surrounding ground elevations. Footings shall be constructed on soil of an approved bearing capacity, compacted to ninety-five percent (95%) of maximum density as determined by MRD Test 212. Necessary excavation and backfill shall be in accordance with procedures in Paragraph 2.09.2.3, "Structural Excavation for Culverts and Miscellaneous Structures" in these General Specifications. Buildings shall be constructed such that the finished floor elevations are a minimum of sixty (60) centimeters above the surrounding ground elevations.

1.09.3.1.2 Concrete. Concrete shall conform to the requirements of Section 5.01, "Portland Cement Concrete." Slabs, footings, and other nonstructural concrete shall conform to Class B. Columns, girders and other structural concrete shall conform to Class C and shall be constructed in accordance with Section 5.03, "Concrete Structures" in these General Specifications. Reinforced concrete wall columns shall be constructed at wall intersections and building corners with ground beam and roof beam connectors. Column reinforcement shall be four (4) - fourteen (14) millimeter diameter vertical bars with ten (10) millimeter closed stirrups at fifty (50) centimeters centers.

1.09.3.1.3 Roofs. Roofs shall be of reinforced concrete with an overhang of one (1) meter to the face of the outside wall. All roofs shall be constructed to a fall of two percent (2%) with a uniform slab thickness and adequate scuppers along the low side. The low side of each roof shall be on the side that faces the perimeter of the compound. The upper surfaces of all roofs shall be waterproofed using materials and methods approved by the Engineer.

1.09.3.1.4 Walls.

1. Masonry Work. Walls shall be constructed of hollow concrete masonry blocks of size twenty (20) by twenty (20) by forty (40) centimeters or similar approved material. Lintels may be precast or cast-in-place.

Mortar for masonry shall conform to the requirements of Subparagraph 5.01.3.1.2, "Mortar." All masonry Work shall be constructed plumb, square and with level courses all carried together. No portion of any wall shall be extended more than one and one-half (1 1/2) meters above adjacent Work, and, in every case, shall be racked back to insure proper connection of subsequent Work.

Each masonry unit shall be shoved into a full bed of unfurrowed mortar and all joints filled, leaving no voids. Joints shall be struck flush. Special care shall be used in laying masonry units to keep mortar off the face of units and out of wall cavities. Mortar that falls and is trapped between scaffold members and walls shall be removed daily. Upon completion of the Work, exposed joints shall be pointed and the wall face cleaned down.

Masonry Units shall have uniform joints, not more than fourteen (14) millimeters thick. Units shall be laid in common bond. Units shall be properly bonded at corners, connections, and intersections. Concrete brick shall be used for bearing courses to maintain proper coursing and where standard size block units cannot be used. All joints shall be struck flush. Where masonry units must be cut to accommodate pipe, conduit, electrical switches or convenience outlets, and adjoining materials, all cuts shall be made with carborundum masonry saws. Space around all pipes extending through walls and partitions shall be tightly caulked.

Vertical joints, where masonry abuts concrete columns and walls, shall be plumb with blocks carefully sawed on ends and joints raked out and caulked.

All anchors, ties and flashings shall be built-in at the proper locations as the Work progresses. Not less than three (3) anchors per jamb for door frames shall be provided. All voids around door and window frames, and voids in masonry units where shown or required for anchorage of surface mounted items, shall be filled in solid with mortar. The mason shall protect the Work of other trades from damage, shall provide openings in walls for pipes, conduits, and electrical fixtures, and shall be jointly responsible with such trades to see that the masonry walls are properly constructed and finished. He shall consult other trades in advance and make provisions for installation of their Work in order to avoid cutting and patching. Built-in Work specified under other sections of the specifications shall be installed as the Work progresses. Steel lintels shall be set in beds of mortar. Spaces behind metal window and door frames shall be filled with mortar. Space around perimeter of frames shall be filled with plastic caulking.

2. Plastering. Internal wall surfaces shall be plastered to a smooth, fair finish. Minimum thickness of plaster shall be fourteen (14) millimeters, including both scratch and finish coats. Plaster materials shall be standard products approved by the Engineer, applied or installed in accordance with the manufacturer's instructions.

Surfaces shall be prepared for application of bond plaster in strict accordance with recommendations of the bond plaster manufacturer. A temperature of not less than ten degrees Celsius (10°C) shall be maintained in all areas during application of plaster and until plaster has completely dried. After plaster has set hard, free circulation of air shall be provided.

Scratch coat shall be doubled back, straightened to a true surface with rod or darby, and left rough to receive finish coat.

Gypsum Plaster Finish shall be applied only after scratch coat has set and seasoned. Scratch coat shall be evenly dampened by use of fog spray prior to application of finish coat. Finish coat shall be first coated to a true and even surface, then troweled, leaving the surface burnished smooth, free of rough areas, trowel marks, or other blemishes. Mortar around trim and other Work shall be pointed up. Defective and damaged plaster shall be cut out and patched. Patching of plaster shall match existing Work in texture and finish and shall finish flush and smooth at joints with previously applied Work.

3. Ceramic Tiles. Bathroom walls shall be tiled with ceramic tiles all around to a height of two (2) meters from floor level. Joints shall be straight, level, perpendicular and of even width. Vertical joints shall be maintained plumb for the entire height of the tile Work. Tiles that are out of true plane or misplaced shall be removed and reset. Damaged or defective tile shall be replaced.

Joints in ceramic mosaic wall tile, after the edges of tiles have been thoroughly wet, shall be grouted full with a plastic mix of neat, white, waterproofed Portland cement immediately after a suitable area of tile has been set and the dry set mortar has cured sufficiently to maintain the tile in place. The joints shall be tooled slightly concave and the excess mortar shall be cut off and wiped from the face of the tile. Interstices or depressions in the mortar joints after the grout has been cleaned from the surface shall be roughened at once and filled to the spring line of the cushion edge before the mortar begins to harden.

Immediately after the grout has taken its initial set, wall surfaces shall be given a protective coat of noncorrosive soap or other approved material and joints damp cured for a minimum of seventy-two (72) hours.

Upon completion, wall and floor tile shall be thoroughly cleaned in such a manner so as to not scratch or damage the surface. Acid shall not be used in the cleaning of ceramic tile.

4. Exterior Surfaces. External walls shall be finished with a white tyrolean finish.

1.09.3.1.5 Floors. With the exception of the laboratory, all floors shall be terrazzo tiles with a ten (10) centimeter kicking tile to the skirting. Samples of tile shall be submitted to the Engineer for approval of quality, color, finish and texture prior to placing orders for material.

Patterns shall be laid out to permit setting of tile with a minimum of cutting. Floors shall be laid out from one side and end, with adjustments made at opposite walls. Dimensions shall be controlled to avoid setting tile smaller than one-half (1/2) size.

Floor tile shall be installed according to well-established practices. For all floor tile areas, straightedges shall be set to the lines established and reset at suitable intervals to keep the joints parallel over the entire area. Tile shall be laid to the straightedges. The tile layout shall eliminate cut tile to the greatest extent possible. Factional changes in dimensions without varying the uniformity of joint widths will be permitted. Where required, tile shall be cut with a suitable cutting tool and rough edges shall be rubbed smooth. Cut tile misfits shall be replaced with properly cut tile.

Grouting of floor tile shall not be done until setting bed has hardened sufficiently. The joints shall be completely filled with grout by screeding and brushing grout over the tile until joints are thoroughly filled. All excess grout shall be removed. Not less than forty-eight (48) hours shall elapse before ordinary foot traffic is permitted on the floor. Grout shall be a thick, soupy mix of neat waterproofed Portland cement.

Before foot traffic is permitted over finished tile floors, the floors shall be covered with building paper. Board walkways shall be laid on floors to be continuously used as passageways by workmen. Tile floor areas to be trucked over shall have suitable constructed continuous plank runways of required width installed over the building paper. Cracked, broken, or damaged tile shall be removed and replaced.

1.09.3.1.6 Ceilings. With the exception of bathrooms and kitchens, all rooms of all buildings shall have a false internal ceiling of acoustic tiles and insulation material, strongly fixed to the concrete roof by a system of battens and hangers as specified by the tile manufacturer. The ceiling shall be level, installed at a minimum height of two and one-half (2.5) meters above the floor.

Acoustical Tile shall be nominal two (2) centimeters by thirty (30) centimeters by thirty (30) centimeters finely fissured surface, mineral tile units, with noise reduction coefficients within the ranges of seven-tenths (0.7) to eight-tenths (0.8) for suspended application. Units shall have square edges and a white factory finish. Units shall be kerfed for concealed splines.

Insulation shall be a minimum of seven and one-half (7.5) centimeters thick, fiberglass batt or blanket with paper vapor barrier.

Acoustical units shall be laid out in a square pattern symmetrical about the centerlines of each room space, or panel, unless otherwise shown on the plans. During erection, the joints around electric outlets, ducts, pipes, and other Work extending through the acoustical treatment shall be sealed tight with plastic caulking compound.

Following completion of the acoustical treatment, joints shall be straight and true to line, and the exposed surfaces shall be flush and level. Wood molding shall be used at intersections of units with walls and beams. All wood components exposed in the finished installation shall be painted white. The suspension system for installation of acoustical units shall be as shown on the plans. Insulation material shall be stapled or tacked to the upper side of the suspension system prior to the installation of the ceiling tile.

Following installation, all dirty or discolored surfaces of the acoustical panels shall be cleaned and left free from defects. Panels which are damaged or improperly installed shall be removed and replaced as directed by the Engineer.

1.09.3.1.7 Fixtures and Fittings.

1. Windows. The size of windows shall normally be one and three tenths (1.3) by one and two tenths (1.2) meters and they shall be located in the positions shown on the drawings dependent on the location and opening size required for the air conditioning units. They shall be of the aluminum type, opening internally or slide opening, with satisfactory seals providing a complete barrier to the ingress of dust when closed. External fine mesh fly screens and locking devices shall be fitted as standard by the manufacturer. Internally, all windows shall have fitted venetian blinds and curtains with the exception of bathrooms which shall have translucent "nonsee" glass.

2. Doors. External doors shall be of the aluminum type opening internally and be complete with all lock furniture and fittings. They shall be fitted with satisfactory seals to provide a complete barrier to the ingress of dust when closed. External doors shall also be fitted with an additional outside screen door of a standard type made of wood with fine mesh which shall be complete with all necessary fittings and a silent automatic closing device.

Internal doors shall be of the wooden type complete with wood frame and surround lock furniture. One (1) coat primer and two (2) coats gloss finish paint shall be applied to each wooden door. Locks to bedroom doors shall be mortise locks of the cylinder barrel type or similar of equal security.

3. Electrical Plug Sockets. All rooms shall have a minimum of two (2) double plug sockets. Offices shall have a minimum of three (3) double sockets. The laboratory shall have a minimum of ten (10) double sockets. These numbers are in excess of those sockets required on separate circuits for air conditioning, ventilation units, and required major appliances.

Sockets shall be fitted in the corridor areas and communal rooms in the places indicated by the Engineer. They shall be of an approved standard type fully insulated and with provision for earthing. In the case of socket units installed into bathrooms, they shall also be fully waterproofed and steam resistant. Electrical plugs shall be provided as required by the Engineer.

4. Ventilation Units. The main kitchen shall be fitted with two (2) exhaust fans of adequate size suitably placed to the Engineer's satisfaction. Exhaust fans shall

also be fitted at the end of the corridor in the Dormitory Building and where required in the Laboratory. Family houses shall have one exhaust fan fitted in the kitchen.

5. Lighting. Overhead lighting units shall be of the fluorescent tube type, flush fitting where there is a false ceiling, of a number and location to the satisfaction of the Engineer. External floodlighting shall be provided for the Compound at such locations that the entire area is adequately lit. Switch units shall be located in suitable places.

6. Cabinetwork. All items of built-in cabinetwork, including cabinets, cases, casework, bookcases, counters, lockers, shelving, and miscellaneous cabinetwork items shall be constructed of approved materials and as detailed on the plans. Drawers shall have solid stock facing and frames with tongue and groove or dove-tailed joints. Bottom of drawers shall be plywood or pressed wood inserted in closely fitting grooves and tacked in place. Drawers shall be provided with rabbetted sides to slide on hardwood cleats. Surfaces designated to receive laminated plastic shall be covered with nominal one and five-tenths (1.5) millimeter thick general purpose acid resistant alcohol-proof, wear resistant laminated plastic of the manufacturer's standard pattern and color as selected by the Engineer. Plastic coating shall be cemented in place with waterproof cement in accordance with the manufacturer's recommendations and good trade practices. Plastic trim and splash backs shall be provided for edges and openings in counters receiving plastic protection tops. Sink openings shall be neatly cut in countertops and shall conform to dimensions required by plumbing fixtures to be installed.

7. Miscellaneous Fittings and Trim. The Contractor shall furnish and install all miscellaneous items, fittings, and running and standing trim in accordance with room finish schedule and details. This item shall include all trim, moldings, shelves, stops, etc., required to complete the installation as detailed.

8. Hardware. The Contractor shall furnish and install all rough and finish hardware required for the completion of the structure. Rough hardware shall consist of all nails, bolts, anchors, and inserts necessary to complete the building. Finish hardware shall consist of hinges, latches, catches, locks, closers, pulls, door stops, and other miscellaneous manufactured items regularly listed for doors and built-in millwork. All hardware shall be approved by the Engineer.

1.09.3.1.8 Painting.

1. Paint Materials. All paint shall be approved by the Engineer and shall be products of reputable manufacturers. All paint shall be ready-mixed and delivered to the site in manufacturer's sealed containers. Thinning shall be done only in accordance with directions of the manufacturer. Job mixing or job tinting will not be permitted.

Colors will be selected by the Engineer. The Contractor shall submit job samples of the different kinds of finishes and colors and, after the samples have been approved, all Work shall be finished to match the approved samples.

2. General Requirements. Paint shall be spread on evenly and brushed out. Enamel Work shall be spread on evenly and show no sags and runs. During painting operations, all surrounding surfaces shall be adequately protected from splattering and dripping of paint; any damage occurring to other Work shall be promptly repaired. Paint shall not be applied when conditions are such that windblown dust, dirt, debris, or insects will collect to adhere to the freshly applied paint or finished surfaces.

Hardware, accessories, plates, lighting fixtures, and similar items shall be removed before painting to provide ample protection of such items. The above items shall be replaced upon completion of each space. Doors shall be removed, if necessary, to seal bottom edges.

3. Woodwork. All finish carpentry and millwork shall receive one (1) coat primer and two (2) finish coats of semigloss enamel, except work items in closets and storage rooms shall receive one (1) coat primer and two (2) coats of flat oil paint or as otherwise required to match adjacent surfaces.

4. Plaster. First coat shall be limeproof sealer; the second and third coats in toilet rooms and kitchen shall be semi-gloss enamel paint. In other areas, the second and third coats shall be flat latex base paint.

5. Concrete. Concrete shall be primed with one (1) coat of limeproof sealer and finished with two (2) coats of flat latex base paint.

1.09.3.2 Temporary Buildings. When the "Supervision Staff Compound" is designated in the Special Specifications or the Bill of Quantities as "Temporary," all buildings shall meet the general geometric and utilitarian requirements of the plans and specifications for permanent buildings. However, the construction material and structural system(s) used may conform to recognized standards for prefabricated or temporary buildings approved by the Engineer.

1.09.3.3 Building Keys. The Contractor shall turn over all keys to all locks to the Engineer upon completion of the buildings. Keys shall be supplied in the minimum quantity of two (2) keys for each lock.

1.09.3.4 Utilities and Services.

1.09.3.4.1 Electricity.

1. General. Electricity shall, until notified by the Engineer at the completion of the Work and the Engineer's Work, be provided by the Contractor twenty-four (24) hours per day for the duration of the Contract and shall be one hundred twenty (120)/two hundred forty (240) volt, sixty (60) cycle, single phase.

2. Power Supply. In order to provide continuous service, and in case of emergency, the Contractor shall provide, maintain, and operate two (2) generators, as specified in the list of equipment on the plans or in the Special Specifications. The generators shall be housed in a separate building outside of the Engineer's compound wall, and shall be used solely for the Engineer's facilities.

3. System. Within fifteen (15) days after signing the Contract, the Contractor shall submit to the Engineer for approval, plans and details for the electrical system of the camp. The plans must include supply, circuitry, fusing, wire size and type, grounds, etc., necessary to provide for the basic electrical services as detailed on the plans and for the equipment listed in the Special Specifications.

4. Voltage Requirements. Air conditioners (except desert coolers), space heaters and hot water heaters shall be operated on a two hundred forty (240) volt, sixty (60) cycle system. All other electrical equipment and outlets, except as otherwise specified, shall be operated on a one hundred twenty (120) volt, sixty (60) cycle system. The laboratory shall operate on a system compatible with the electrically operated testing equipment purchased by the Contractor.

5. Concealed Conduit. All wiring below ceiling level shall be placed in conduit embedded in the wall. Conduit shall run in a direct line with bends as long as possible, unless otherwise directed by the Engineer.

6. Telephone and Facsimile (FAX). Communication lines for telephones in each office and FAX in one office of the office and laboratory buildings shall be provided.

7. Joints and Splices. All joints and splices shall be made in junction boxes. Wire size to eight (8) AWG shall be made mechanically secure with vinyl jacketed pressure spin connectors, or by twisting conductors together and soldering. Solder joints, if used, shall not be made with acid-core solder. Joints and splices for conductors larger than eight (8) AWG shall be made with split bolt or crimped connector applied with a tool. All joints and splices shall be fully insulated.

1.09.3.4.2 Water Supply and Plumbing.

1. General. The Contractor, shall, until notified by the Engineer at the completion of the Work and the Engineer's Work, provide and maintain an adequate and continuous supply of pure filtered water for the Engineer's facilities. Prior to its use, the source of water proposed by the Contractor must be tested for purity and approved by the Ministry of Health. The Engineer may, at any time he deems necessary, direct the Contractor to retest the water source. The testing of the water source shall be at the Contractor's expense.

2. Storage. The Contractor shall construct an approved elevated storage tank having a minimum capacity of ten thousand (10,000) liters. The elevation of the storage tank shall be set to provide the distribution system with an operating pressure of one (1) kilogram per square centimeter. In addition, the Contractor shall provide, for the kitchen, an emergency water supply consisting of two (2) water tanks. Each tank shall have a capacity of one thousand five hundred (1,500) liters and be set at roof height (but not directly on the roof). The emergency system shall have valves and bypasses so it may be divorced from the main distribution system in case of a contamination emergency. Each of the storage facilities shall have an electrical pump and riser for filling.

3. Distribution System. Within fifteen (15) days after signing the Contract, the Contractor shall submit to the Engineer for his approval, plans and details for the water distribution system for the Engineer's facilities. The plans shall include details of the storage tank, piping diagrams, pipe sizes, etc., and meet the following minimum basic criteria:

- The main supply line from the water tower to the building area shall have a minimum inside diameter of seventy-five (75) millimeters.
- The supply system within the building area shall have a minimum inside diameter of fifty (50) millimeters.
- Water lines shall not be placed within five (5) meters of a sewer line and under no circumstances shall a water line cross above or below a sewer line.

4. Testing. The water distribution system shall be tested for acceptance under the supervision of the Engineer. The test procedure is as follows:

- The Contractor shall place the system under a pressure equal to the ultimate operational pressure for a period of eight (8) hours.

- All leaks shall be repaired and the system retested. Tests for acceptance may be conducted on each of the individual parts of the system and need not necessarily include the entire system at one time. Tests shall be conducted prior to the plastering over or otherwise covering up of the piping to be tested. Untested piping which has been covered up shall be re-exposed for testing.

5. Plumbing and Fixtures. Plumbing shall be done in a neat, workmanlike manner. Fixtures shall be of high quality and of the size and type designated in the drawings and specifications. Fixtures shall be approved by the Engineer prior to their installation. Fixtures broken or damaged during installation shall be replaced. On completion of the plumbing Work, the Contractor shall clean all fixtures to the satisfaction of the Engineer.

1.09.3.4.3 Waste Disposal.

1. General. The Contractor shall, until notified by the Engineer at the completion of the Work and the Engineer's Work, provide and maintain adequate septic tanks and sewage disposal systems. He shall also provide garbage and trash removal service at least once daily.

2. Septic Tanks. The Contractor shall construct three (3) septic tanks located at least sixty (60) meters from the Compound. One (1) each for the laboratory building and the kitchen and one (1) for the living quarters buildings. The service quarters shall be connected to the kitchen tank. The septic tanks shall be dual chamber structures with an internal wall forming a high level weir overflow separating the two (2) chambers. Access to each chamber shall be provided by airtight inspection covers. Inlet pipes shall be into the first chamber opposite to the overflow weir wall and the outlet shall be at a high level at the opposite end of the second chamber. The outlet shall be a three (3) meter pipe, diameter twenty (20) centimeters, leading into an

excavated soakaway pit which shall be filled with rock and contain no fine material. The septic tanks shall be emptied as required.

The Contractor shall be responsible for cleaning the septic tanks when, in the opinion of the Engineer, it is necessary. Outfall laterals shall be installed as noted on the plans. Tanks and lateral systems shall be plainly marked in order to keep vehicles from driving over them.

3. Sewer System. Within fifteen (15) days after signing the Contract, the Contractor shall submit to the Engineer, for his approval, plans and details for an adequate sewer system. The plans shall include piping diagrams, cleanout locations, venting, traps, etc., and shall meet the following minimum basic criteria:

- Horizontal sewer lines within the buildings shall be minimum fifteen (15) centimeters inside diameter, cast iron soil pipe and have a slope of between one (1) percent minimum and three percent (3%) maximum. The lines shall be supported or anchored at intervals not to exceed three (3) meters.
- Horizontal sewer lines outside the buildings shall be a minimum fifteen (15) centimeters inside diameter pipe and have a slope of between six-tenths percent (0.6%) minimum and two percent (2%) maximum.

- Outfall laterals shall be minimum fifteen (15) centimeters inside diameter perforated pipe and have a slope of between two-tenths percent (0.2%) minimum and four-tenths percent (0.4%) maximum. Outfall laterals shall be installed as shown on the plans.
- Adequate vents and cleanouts shall be included in the system.
- All drains and fixtures shall be adequately trapped from sewer gas.
- Sewer lines shall be joined by "Y" connections. "T" connections shall not be used.

4. Testing. The sewer system shall be tested for acceptance under the supervision of the Engineer. The test procedure is as follows:

- The Contractor shall place the sewer lines system under one (1) meter of head above the highest drain for a minimum period of four (4) hours.

- Any leaks shall be repaired and the system retested for approval. The encasement of a leaking joint in concrete shall not be accepted as repair. Tests for acceptance may be conducted on each of the individual parts of the system and need not necessarily include the entire system at one time. Test shall be conducted prior to the covering up of any portion of the system. Untested piping which has been covered up shall be re-exposed for testing.

1.09.3.5 Ancillary Structures. Within the compound shall be erected the following ancillary structures:

1.09.3.5.1 Carport. The structure shall be ten (10) centimeter posts set in concrete with corrugated sheet roof fixed to suitable steel lathes and rails. The height of the carport shall be specified by the Engineer. There shall be space for at least sixteen (16) cars.

1.09.3.5.2 Radio Antenna. The radio antenna shall be constructed to the standard drawings, complete with all necessary wires and connections to the office.

1.09.3.5.3 Perimeter Fence. The Compound shall be surrounded by a fence of at least two (2) meters in height. It shall be four (4) centimeter mesh wire fixed on steel "T" section posts all painted one (1) coat primer and one (1) coat gloss paint. Vehicular access gates shall be provided together with a single person access gate. Gate locations shall be indicated by the Engineer. The bottom three (3) centimeters of the perimeter fence shall extend a minimum of six (6) centimeters below ground elevation and shall be cast for the full length of the perimeter fence, except at the gate locations.

1.09.3.5.4 Clothes Line. Close to the Service Quarters a five (5) strand clothes line of adequate size shall be erected. Sufficient pegs shall be provided.

1.09.3.6 Ground Improvements.

1.09.3.6.1 Concrete Walks. Concrete Walks shall be constructed at locations shown on the plans. Fourteen (14) millimeter thick expansion joints shall be placed where walks about buildings and at distances not to exceed twenty (20) meters in straight runs. The surface of walks shall be divided into squares by means of contraction joints formed in the fresh concrete. Finish shall be by wood float followed by a stiff brush or broom as required to insure nonslip characteristics. Concrete for walks must be cured for a minimum of three (3) days or as directed by the Engineer.

1.09.3.6.2 Gravel Surfaces. Gravel Surfaces shall be screened or natural gravel, as approved by the Engineer, and placed in the locations noted on the drawings. The thickness of the surfacing shall be that required to eliminate dust conditions for the particular camp site selected. Minimum thickness shall in no case be less than fifteen (15) centimeters.

1.09.3.6.3 Concrete Bumper Posts. Concrete Bumper Posts shall be precast to the dimensions shown on the plans and installed in the manner and location shown on the plans. In lieu of concrete posts, the Contractor may substitute wooden bumper posts with the approval of the Engineer.

1.09.3.6.4 Grading. The site of construction shall be graded to uniform slopes, conforming to existing adjacent contours; properly drained without ponding; and presenting a neat and finished appearance. All excess and unsuitable materials shall be removed from the site and all ruts, holes, and depressions caused by construction activities shall be filled and graded to match adjacent surfaces. During construction, the

Contractor shall control grading in the vicinity of the building so the ground surface is properly pitched to prevent water from running into excavated areas. Water entering excavated areas shall be removed, excavations dried out, and subgrade recompacted to its proper bearing capacity.

1.09.4 BUILDING FURNISHINGS. The buildings within the compound shall be provided with the following permanent and temporary furnishings. Permanent furnishing shall remain a part of permanent buildings when they are turned over to the Ministry. Temporary furnishings shall be removed from permanent building prior to turning the building over to the Ministry. All furnishings shall be removed as a part of the temporary building removal.

1.09.4.1 Dormitory Building.

1.09.4.1.1 Bathrooms. Permanent - European toilet, bidet, paper holder, shower unit (minimum head height - two (2) meters), sunken shower basin, shower curtain rail, soap dish, large hand wash basin, mirror, shelf, towel rail, light, razor socket, fifty (50) liter electrical water heater with waterproof switch.

1.09.4.1.2 Bedrooms. Permanent - wall mirror, coat hook on door. Temporary - twelve thousand (12,000) BTU air conditioner.

1.09.4.2 Office Building.

1.09.4.2.1 Resident Engineer's Office. Permanent - shelves, bell to kitchen, wall board. Temporary - eighteen thousand (18,000) BTU air conditioner.

1.09.4.2.2 Surveyor's Office. Permanent - lockable cupboard, long bench for plans, shelves, wall board. Temporary - fourteen thousand (14,000) BTU air conditioner.

1.09.4.2.3 Civil Engineer's, Material Engineer's and Bridge Engineer's Offices. Permanent (each) - lockable cupboard, shelves, wall board. Temporary (each) - eighteen thousand (18,000) BTU air conditioner.

1.09.4.2.4 Administrative Assistant's Office. Permanent - lockable cupboard, shelves, wall board. Temporary - fourteen thousand (14,000) BTU air conditioner.

1.09.4.2.5 Corridor. Permanent - wall board.

1.09.4.2.6 Toilet. Permanent - European toilet, hand wash basin, towel rail.

1.09.4.2.7 Storeroom. Permanent - shelves.

1.09.4.3 Kitchen and Mess Building.

1.09.4.3.1 Kitchen. Permanent - sarge cupboard, shelves, two hundred (200) liter water heater, double stainless steel sink, working table with marble slab, foot hutch with sliding opening to dining room. Temporary - gas or electric stove with oven to cater for at least twenty (20) people, minimum six tenths (0.6) cubic meter refrigerator, minimum six-tenths (0.6) cubic meter freezer, two (2) twenty-four thousand (24,000) BTU air conditioners.

1.09.4.3.2 Storeroom. Permanent - shelves. Temporary - minimum six-tenths (0.6) cubic meter refrigerator, twelve thousand (12,000) BTU air conditioner.

1.09.4.3.3 Dining Room. Temporary - minimum of ninety and four-tenths (90.4) cubic meter refrigerator, two (2) - twenty-four thousand (24,000) BTU air conditioners.

1.09.4.3.4 Lounge. Permanent - shelves. Temporary - two (2) twenty-four thousand (24,000) BTU air conditioners.

1.09.4.3.5 Toilet. Permanent - European toilet, two (2) hand wash basins, two (2) towel rails.

1.09.4.4 Service Quarters.

1.09.4.4.1 Bedrooms. Permanent - two (2) wall mirrors, two (2) coat hooks. Temporary - two (2) single beds each with mattress, two (2) pillows, two (2) pairs sheets, four (4) pillow cases, two (2) blankets, two (2) towels, two (2) wardrobes with drawers, waste basket, table with chairs, twelve thousand (12,000) BTU air conditioner.

1.09.4.4.2 Bathroom. Permanent - Arabic toilet, hand wash basin, shower, twenty (20) liter electric water heater.

1.09.4.4.3 Laundry Room. Permanent - shelves, counter, large sink. Temporary - heavy duty electric washing machine, ironing table, two (2) electric irons, two hundred (200) liter electric water heater, twelve thousand (12,000) BTU air conditioner.

1.09.4.5 Family Houses.

1.09.4.5.1 Bathrooms - Same as bathrooms for dormitory buildings.

1.09.4.5.2 Bedrooms - Same as bedrooms for dormitory buildings.

1.09.4.5.3 Kitchen - Permanent - cupboard, shelves, two hundred (200) liter electric water heater, double sink, working table with marble slab. Temporary - gas or electric stove with oven to cater for at least four (4) people, three-tenths (0.3) cubic meter refrigerator, twelve thousand (12,000) BTU air conditioner, electric washing machine.

1.09.4.5.4 Living/Dining Room. Temporary - sixteen thousand (16,000) BTU air conditioner.

1.09.4.5.5 Outside. Permanent - clothes line with steel post and three (3) strands nylon line.

1.09.4.6 Laboratory.

Permanent - acid/alcohol resistant plastic counters, two (2) large stainless steel basins. Temporary - two (2) eighteen thousand (18,000) BTU air conditioners. In addition, the Contractor shall furnish all field and laboratory testing equipment required or implied by the Highway Materials Manual for the tests designated to be performed onsite in Section 1.04, "Control of Materials." The Contractor shall furnish spare parts and/or repair capabilities for all equipment. The inability to accurately test highway material for acceptance due to improper or defective equipment may result in the suspension of operations or the withholding of payment for certain materials until testing can be completed.

The Contractor shall submit to the Engineer for his approval, and within fifteen (15) days after signing of the Contract, a complete listing of the equipment, apparatus, and supplies he proposes to furnish for the laboratory. The list shall include the manufacturer's name, capacity, and descriptive literature for each piece of equipment.

1.09.4.7 General.

1.09.4.7.1 Fire Equipment. Temporary - all buildings shall be provided with a minimum of three (3) fire extinguishers which shall be maintained ready for use at all times. They shall be of the type suitable for all types of fires. Within each kitchen shall be installed a fire blanket and wall mounted bracket.

1.09.4.7.2 Weather Instruments. The Contractor shall furnish and maintain in good working order for the duration of the Contract, instruments and their necessary appurtenances to be used by the Engineer in recording weather data. The instruments shall be installed at a location designated by the Engineer in accordance with the manufacturer's instructions. All instruments shall be of professional or paraprofessional quality approved by the Engineer and accompanied by the manufacturer's operating instructions. The instruments required are:

- One rain gauge
- One recording anemometer
- One recording thermometer
- One wet-bulb thermometer for measuring relative humidity

If the Contractor cannot replace or repair the above equipment in one (1) week or less, he shall provide spares or replacement parts as needed.

1.09.5 PROJECT LABORATORY.

1.09.5.1 General. The Contractor shall provide and maintain for the duration of the Works a laboratory in good working condition with all utility services, furniture, equipment, apparatus and fittings. The laboratory, fittings and equipment shall be suitable for their purpose to the approval of the Engineer, and shall be operated by the Contractor under the supervision and direction of the Engineer.

1.09.5.2 Technicians, Laborers and Drivers. The Contractor shall provide at no cost to the Engineer, technicians, laborers, drivers, etc. in the number deemed necessary, and approved by the Engineer, to operate the laboratory as required by the Contractor's proposed Programme of Works. Personnel once assigned to the laboratory shall not be removed by the Contractor unless at the direction of, or with approval of, the Engineer.

1.09.5.3 Air Conditioning. The laboratory shall be fully air-conditioned in an approved manner, such that the temperature within the buildings does not exceed twenty-two degrees Celsius (22° C).

1.09.5.4 Ownership. On completion of the Works, the laboratory complete with all fittings and utility services, furniture, equipment and apparatus shall become the property of the Contractor.

1.09.5.5 Testing Equipment, Tests and Specifications. All shall be in accordance with the Ministry of Communication's Materials Manual, Volume I, Page 37 - 40. The Marshall Compactor shall be automatic.

1.09.5.6 Manuals and Standards. A complete set of the relevant ASTM, AASHTO, BS and other Standards, Construction and Materials Manuals and Codes of Practice referred to in this Contract, or relevant thereto, shall be provided by the Contractor for use by the Engineer.

All copies of Manuals and Standards shall become the property of the Contractor at the end of the Project.

1.09.6 SURVEY EQUIPMENT. The Contractor shall supply and maintain in full working order and shall replace, whenever directed by the Engineer during the progress of the Work, the surveying and other equipment scheduled below and shall provide chainmen and other like labor in the number required from time to time in connection with the Work. All surveying equipment shall remain the property of the Contractor.

The list below is the minimum requirement. The Contractor is to provide any other equipment necessary for the execution of the Work as directed by the Engineer and specified herewith. All equipment must be approved by the Engineer.

2 Complete sets of Electronic Distance Measuring Instruments with single and triple prisms, tripod, etc.
2 Automatic Levels complete with tripods.
4 Illuminated Targets with tripods.
2 Hand Levels (Spirit) (Water)
3 4m Levelling Staffs
2 50m Steel Tapes with extra length before zero point.
2 30m Steel Tapes with extra length before zero point.
4 Steel Pocket Tapes, 5m long
4 Surveying Umbrellas
20 Ranging Rods 2.5m long
20 Level Books
20 Field Books
6 Scientific Calculators (10 digits) with all mathematical functions.
4 Plumb Bobs
1 Optical Plumb
2 Approved Programmable Electronic Calculators with peripheral storage and printing facilities.
1 Drafting Table
1 Precise attachment for the level with direct reading to 0.1mm.

Adequate supplies of pencils, ink, scales, drawing paper, stationery, pegs, brushes, paint, etc., and all other expendable materials to be provided as and when required by the Engineer.

1.09.7 COMPUTER EQUIPMENT. The Contractor shall supply and maintain in full working order during the progress of the Work, Computer Software together with a computer and compatible accessories with an adequate specification for running the software packages provided by the Contractor.

1.09.7.1 Software. Copies of the Computer Software packages, identical to those used by the Contractor, shall be supplied to the Ministry and to the Engineer for the use of his staff. All computer software packages to be supplied must be approved by the Engineer.

In choosing the software packages to be used, the Contractor must coordinate with any adjacent Contractors to insure that the software packages used on both contracts are the same and are compatible with software currently being used by the Ministry.

Software packages must be supplied for the following operations:

- Word Processing.
- Spreadsheet.
- Project Programming and Resource Allocation
- Quantities Calculations

1.09.7.2 Hardware. The hardware provided must be capable of handling all of the software packages provided without unreasonable processing delay. The absolute minimum specification shall be as below:

- Pentium II processor at 400 MHz.
- On Board 128 MByte RAM and Internal Built-in 100 Mbyte Zip Drive With disk.
- 10 GByte Hard Disk Drive and CD-ROM Drive 32X
- 56 K Fax & Modem
- 1.44 MByte (high density) 3.5 inch Floppy Disk Drive
- Keyboard 101 Key; English /Arabic
- Display: 15" Dimension VGA, Colored.
- Printer/plotter: 24 pin dot matrix printer capable of printing at 240 cps with graphics capability and an A4 cut sheet feeder and a tractor for US wide standard paper.
- A AO/A1 plotter is required to output project program charts. The Contractor must make sure that the Engineer's staff have reasonable access, at the Contractor's expense, to a plotting facility.

1.09.7.3 Modem Links. Modem links should be provided to link the Contractor's Computer to the Engineer's and the Ministry's Computers. The Contractor shall supply compatible equipment for the Engineer and the Ministry and shall arrange for the supply of a dedicated telephone line for the use of the modem to the Engineer's office.

1.09.8 MAINTENANCE AND SERVICE.

1.09.8.1 Maintenance. The Contractor shall provide full and continuing maintenance of the Supervision Staff facilities throughout the period of the Construction Works, and shall include the costs of this maintenance in the item lump sum rate.

1.09.8.2 Service. The Contractor shall provide one (1) full-time twenty-four hour (24 hour) service staff and one (1) driver for the daily running of the Supervision Staff Compound. Accommodation for the permanent staff shall be provided within the Supervision Staff Compound in accordance with the drawings and the Special Specifications. All costs necessary for the provision and upkeep of the above mentioned personnel shall be inclusive in the lump sum rate for the Supervision Staff Compound.

1.09.9 METHOD OF MEASUREMENT. "Supervision Staff Compound" and "Supervision Staff Compound (Temporary)" will include all materials, equipment, construction, labor, maintenance, and incidental items required by this section. The lump sum price for this Work will be all inclusive for the compound specified, constructed, and maintained to the satisfaction of the Engineer.

All items described in Subparagraphs: Project Laboratory and Computers and Survey Equipment Items which are provided for the use of the Engineer's staff only shall be measured at the lump sum price and paid for in installments as described below for which payments shall be full compensation for all Project laboratory, construction, renovation, repainting, furnishing, refurbishing, maintenance and all other work described including the supply and maintenance (including replacements where necessary) of all furniture, equipment, fixtures, fittings, manuals, standards including connections to and supply of utility services including telephones. It shall also include for the provision of laboratory technicians, drivers and laborers as required by the Work Programme and the maintenance and supply of fuel (for generators, gas for laboratory, etc.), water, electricity, etc...and for the supply of all laboratory and computer consumables. Unless otherwise specified in the Special Specifications, all equipment shall be returned to the Contractor at the completion of the Final Handover.

1.09.10 PAYMENT. Payment for "Supervision Staff Compound," "Laboratory," "Survey and Computer Equipment" and "Vehicles" as described above shall be paid for in installments of the bid price as follows:

- 40% Upon completion of the required Works to bring into full use as specified or the provision and commissioning of the Supervision Staff Compound, Laboratory, the Survey Equipment and the Computer Equipment as outlined in these General Specifications.

- **10% Upon completion of every 20% of the Contract Value thereafter, except that the final 10% payment shall be made with the final certificate. Payment shall be conditional upon proper and satisfactory operation and maintenance of the facilities as specified and approved by the Engineer.**

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO.	PAY ITEM	PAY UNIT
10901	Supervision Staff Compound	Lump Sum
10902	Supervision Staff Compound (Temporary)	Lump Sum
10903	Project Laboratory	Lump Sum
10904	Computers and Survey Equipment	Lump Sum

KINGDOM OF SAUDI ARABIA

MINISTRY OF COMMUNICATIONS

GENERAL SPECIFICATIONS
FOR
ROAD AND BRIDGE CONSTRUCTION

November 1998

PART TWO

EARTHWORK

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PART TWO: EARTHWORK

SECTION 2.01 - CLEARING AND GRUBBING

2.01.1 Description. This work shall consist of removing all objectionable material from within the right of way, embankment and touch grade areas, easement areas for bridge construction, road approaches, channels and ditches, and such other areas as may be shown on the plans or specified in the special specifications, except objects designated to remain. It shall also include the recompaction of the cleared and grubbed areas as specified in Paragraph 2.05.3.2, "Foundation Preparation," in these General Specifications. Objects designated to remain or to be removed in accordance with other sections of the specifications, adjacent public and private property, utilities and non-highway facilities shall be protected from injury or damage resulting from the Contractors operations. Clearing and grubbing shall be performed in advance of grading operations and in accordance with these specifications.

ITEMS IN BILL OF QUANTITIES
Clearing and Grubbing
Individual Tree Removal

2.01.2 Construction. The Contractor, as soon as the site or part thereof has been handed over, before commencing the clearing and grubbing shall resurvey together with the Engineer the whole centerline of the alignment, locating the centerline at the ground and taking cross sections along the alignment at a maximum longitudinal spacing of twenty five (25) meters.

In case it clarifies that levels for the natural ground in a certain area differ remarkably from what is established on the plans, the Contractor shall notify the Engineer thereof and obtain his approval to commence with the work prior to causing a change in the natural ground levels.

Within sixty (60) days of the date of field staking the Contractor shall submit to the Engineer for his approval plots of the original and staked survey cross sections together with the corresponding plots as detailed in Paragraph 1.07.13 "Earthwork" in these General Specifications.

Unless otherwise shown on the plans or specified in the special specifications, the Contractor shall clear the entire length of fill and touch grade sections of the project to the following staked widths:

1. Highway construction embankment and touch grade areas, including structures, frontage roads, ramps, interchange loops, approaches, channels, ditches, and other accessory roads and connections that are to be constructed. Such areas are to extend to a width two (2) meters outside of structures and excavation and embankment slope lines, including slope rounding.

2. Borrow sites within the right of way, or as shown on the plans, specified in the Special Specifications and approved by the Engineer.

Within the limits specified, the area above the natural ground surface shall be cleared of vegetation growth, such as trees, stumps, plants, brush, and all other objectionable material, except items marked by the Engineer to remain. Within the limits of clearing, the areas below the natural ground shall be grubbed to a minimum depth of twenty (20) centimeters, or as may be necessary, to remove tree stumps, roots and other objectionable material.

2.01.3 Disposal of Removed Material. Cleared and grubbed material shall not be left in or under embankments or other constructed facility. All removed materials shall be disposed of at locations outside the right-of-way and not visible from the roadway.

Burning shall be done in accordance with applicable laws and safety practices, under the constant care of competent watchmen and at such times and in a manner that anything designated to remain and adjacent property will not be jeopardized. Residue and the effects from burning shall also be removed outside the right-of-way and view from the roadway.

Disposal of removed materials at public and private sites away from the right of way shall be done at the Contractors sole expense, in accordance with all laws and regulations, after an agreement with the property owner or public agency has been fully executed. The Engineer shall be given fifteen (I5) days prior notice and a written release from the property owner or public agency on whose property the materials are to be placed.

All sellable timber in the clearing area which has not been removed from the right of way prior to the beginning of construction, shall become the property of the Ministry, unless otherwise provided.

2.01.4 Method of Measurement. Clearing and Grubbing will be measured for payment on a unit price basis by the square meter for the work within the limits specified or approved by the Engineer. Measurement shall be to the nearest tenth of a square meter along a horizontal plane and include all clearing and grubbing of vegetation up to a tree diameter of one hundred fifty (1 50) millimeters.

Individual tree removal will be measured by the unit based upon the number of individual trees removed. Trees less than one hundred fifty (150) millimeters in average diameter at the cutoff will not be measured.

No measurement will be made when there is no item for Clearing and Grubbing or Individual Tree Removal listed in the Bill of Quantities.

2.01.5 Payment. When the Bill of Quantities includes items for Clearing and Grubbing and/or Individual Tree Removal with payment on a contract unit price basis, payment will be made at the contract unit price per square meter and unit for work actually completed as specified. Such payment shall be full compensation for furnishing labor, equipment, tools and incidentals and performing all work as specified for clearing and grubbing, disposing of removed materials and recompacting the disturbed areas and all other elements necessary for the proper

completion of the Work as specified in Subsection 1.07.2, "Scope of Payment," in these General Specifications.

When the Bill of Quantities does not include items for Clearing and Grubbing or Individual Tree Removal, such work shall be considered as subsidiary to other items of work and all costs shall be included in the contract unit price(s) for other items of work.

PAYMENT WILL BE MADE UNDER THE FOLLOWING:

ITEM NO,	PAY ITEM	PAY UNIT
20101	Clearing and Grubbing	Square Meter
20102	Individual Tree Removal Unit	

SECTION 2.02 - REMOVAL OF STRUCTURES AND OBSTRUCTIONS

2.02.1 Description. **This work shall consist of the removal and salvage or disposal, wholly or in part, of all buildings and foundations, structures, all types of walls, fences, gates, wells, septic tanks, abandoned utility lines, manholes, catch basins, poles, pylons, pipe culverts, bridges, bridge components, bridge parapets and railings, existing roadways, sidewalks, curbs, gutters, guard rails, impact attenuators, signs, sign supports, traffic signals, slope protection, traffic paint lines, raised and ceramic pavement markers, glare screens, rumble strips, delineators, sign post bases, scrap yards, rubbish dumps and any other obstructions which are not designated or permitted to remain, except for the obstructions to be removed and/or disposed of under any other items specified in the Bill of Quantities. It shall also include the backfilling the resulting trenches, holes, depressions and pits.**

ITEMS IN BILL OF QUANTITIES

Removal of Existing Building
Removal of Boundary Wall, including Gate
Removal of Bridge Structure
Removal of Bridge Component
Removal of Box Culvert & Pipe Culvert End Section
Removal of Metal Bearing Device
Removal of Elastomeric Bearing Device
Removal of Expansion Joint
Removal of Aluminum Bridge Railing
Removal of Steel Bridge Railing
Removal of Concrete Bridge Parapet
Removal of Structural Steel or Precast Concrete Member
Removal of Underground Utility Lines
Removal of Aerial Utility Lines and Poles
Removal of Curb
Removal of Combined Curb & Gutter
Removal of Gutter
Removal of Septic Tank
Removal of Catch Basin, Manhole and Inlet
Removal of Well
Removal of Riprap, Wire-Enclosed Riprap & Gabion Slope Protection
Removal of Concrete, Paving Tile & Shotcrete Slope Protection
Removal of Pipe Culvert
Removal of Fence, including Gate
Removal of Dumped Rubbish
Removal of Sidewalk & Median Paving
Removal of Guardrail, Complete
Removal of Guardrail Terminal
Removal of New Jersey Concrete Barrier
Removal of Impact Attenuator
Removal of Steel Safety Railing
Removal of Bituminous and Cement Concrete Pavement
Removal of Traffic Paint Line & Control Marking
Removal of Ceramic & Retroreflective Raised Pavement Marker

Removal of Traffic Signal & Controller
Removal of Rumble Strip or Speed Bump
Removal of Sign Post Base
Removal of Sign (Any Type)
Removal of Breakaway Sign Post
Removal of Overhead Sign Support
Removal of Glare Screen
Removal of Delineator
Removal of Telephone Cabinet

2.02.2 Preservation of Property. Existing facilities which are designated or allowed to remain shall be protected from damage. Facilities which are damaged or destroyed as a result of the Contractors operations shall be repaired or replaced by the Contractor at his own expense.

Trenches, holes, depressions and pits caused by the removal of structures and obstructions, which remain after completion of roadway excavation, shall be backfilled with embankment material as specified in Section 2.05, "Embankment Construction," in these General Specifications. When trenches, holes, depressions and pits are in surfaced areas which are designated to remain undisturbed, they shall initially be backfilled with embankment materials up to the elevation of the bottom of the surfacing materials. The removed surfacing materials shall be replaced with equal or better quality surfacing materials of the same layer thickness and degree of compaction.

2.02.3 Construction.

2.02.3.1 Miscellaneous Structures and Obstructions. These facilities include but are not limited to, buildings and foundations, gates walls, fences, septic tanks, manholes, catch basins, utility lines, poles, rubbish dumps, drainage pipe and box culverts, bridge railings and parapets, pipe for water supply and sewer services, signs, signals, traffic control devices, detour roads and other facilities shown on the plans, except bituminous and cement concrete pavements, wells and bridges which are provided for in following Paragraphs 2.02.3.2, 2.02.3.3, 2.02.3.4 in these General Specifications.

Miscellaneous structures and obstructions within the area to be cleared and grubbed, or as may be designated on the plans, except utilities and facilities which are specified elsewhere to be removed or reconstructed, shall be removed to a depth not less than sixty (60) cm bellow the bottom of subgrade.

Immediately after receiving the site, and within the time frame specified hereinafter, the Contractor shall identify any obstacles within the site, above- or underground, which may interfere with the progress of the Work. These obstacles, whether shown on the plans or not, shall be land-surveyed and described in detail in a report. This report shall be entitled "Report on Existing Obstructions" and, along with the survey diagrams, shall be submitted in triplicate to the Engineer for the project records.

Survey work, preparation of the report and submission thereof, removal in whole or in part as required, and salvaging or disposal of these obstacles in an approved location, together with any temporary work required, shall be completed during the mobilization period of the work. This requirement may be waived by the Engineer for specific portions of the work.

Material designated to be removed shall be removed, transported, salvaged and stored or disposed of at places shown on the plans, as specified, or as approved by the Engineer.

In the process of the removal work, the Contractor shall transport, clean, package, and store the removed reusable, as identified by the Engineer, elements in an approved storage yard. All reusable materials shall be cleaned of dirt, asphalt or other deleterious coatings, using detergents, mineral spirits or other approved cleaning materials. Packages shall be clearly labeled as to their contents' types, sizes and numbers, and shall be accompanied by inventory lists approved by the Engineer.

The elements so salvaged shall become the property of the Ministry. Elements damaged due to the Contractor's negligence, as determined by the Engineer, shall be declared damaged elements. All elements to be salvaged which are damaged in removal to impair their future use, will, unless otherwise specifically provided in Subsection 2.02.5, "Method of Measurement" below, be charged to the Contractor at sixty (60) percent of the current prices quoted under the respective pay items for new work, as applicable, and for an equal quantity. This amount of money shall be deducted from any money due or to become due to the Contractor. Alternatively, when practical and when approved by the Engineer, the Contractor may choose to substitute the damaged elements with an equal quantity of new elements of the same or better quality. In such a case, no deduction will be made for those damaged elements that were successfully substituted as specified and as approved by the Engineer.

To minimize the environmental impact of the work by controlling dust, noise or vibration, or to minimize disturbance to people or livestock, the plans may indicate that concrete be removed using high-pressure water as a demolition tool. This work shall be carried out using equipment specifically designed for the intended purpose, consisting of a high-pressure water pump, water tank, filter, feed pump, fuel tank, remote-controlled, tire-mounted, high-pressure nozzle, and all necessary piping and accessories.

When shown on the plans or approved by the Engineer, other methods may be used, such chemical splitting, diamond disc saw cutting or wire cutting, or thermit lance, provided that the work will be carried out by specialized crews with demonstrable experience in the applicable methods. Microwave demolition methods shall not be used.

Salvaged pipe culverts and other material shall be handled with care and protected from damage until stored as specified. Salvaged materials and equipment belonging to other agencies shall be handed over to their owners via a Process-Verbal before payment for removal is made to the Contractor.

Culverts and drainage facilities at locations used by traffic shall not be removed, or their operation interrupted, before satisfactory arrangements have been made to accommodate public traffic.

Fences enclosing farm land, or providing security to any property, shall remain in place until the Contractor has given reasonable advance notification to property owners of the intent to remove the fence. Temporary fencing required to separate construction operations from public use shall be identified in the Special Specifications. Temporary fencing shall be removed after permanent fencing is complete.

2.02.3.2 Existing Bituminous and Cement Concrete Pavement. Unless otherwise specified in the Special Specifications, the Contractor, at his option, may remove, pulverize, crush, blend and process existing bituminous and cement concrete pavement (including sidewalks, curbs, gutters and stairs) which are specified to be removed, and use such materials in the new construction, or dispose of the materials as specified in Subsection 2.02.4, 'Disposal of Removed Material," in these General Specifications. All such salvaged pavement, proposed for use in new construction, shall be processed to conform to all specified gradation and quality requirements for the material to be placed in the new construction.

Unless bituminous surface courses are specifically designated for milling or recycling, full-depth removal and disposal of all bituminous surface courses irrespective of thickness, including treated base courses and bituminous plant mix materials, shall be as specified herein.

2.02.3.3 Wells. Existing whether active or inactive, and abandoned wells within the area to be cleared and grubbed, shall be dismantled, sealed and backfilled as specified, required by law or as approved by the Engineer. The Contractor shall remove, transport and store all salvaged materials and equipment as specified in Paragraph 2.02.3.1 "Miscellaneous Structures and Obstructions" in these General Specifications.

Wells shall be backfilled as specified in Paragraph 2.05.3.2 'Preparation of Original Ground" in these General Specifications.

2.02.3.4 Bridge Structures. Steel and timber bridges shall be removed, members marked with identification numbers and letters and salvaged as specified in Paragraph 2.02.3.1 "Miscellaneous Structures and Obstructions" in these General Specifications.

Reinforced concrete and masonry bridge structures shall be removed and the removed materials salvaged at the Contractor's option or disposed of as specified in Subsection 2.02.4, "Disposal of Removed Material," in these General Specifications.

Substructures shall be removed to a depth one and half (1 -1 /2) meters below the bottom of subgrade and thirty (30) centimeters below the streambed elevation, unless otherwise specified. When portions of substructure interfere with construction of a new structure, they shall be removed as may be necessary to permit satisfactory construction of the new structures.

Blasting or other operations necessary for the removal of structures and obstructions, which may damage new construction, shall be performed before new construction commences.

Bridge structures in use by traffic, shall not be removed, or their operation interrupted, until satisfactory arrangements have been made to accommodate traffic.

2.02.3.5 Guardrails and Concrete Barriers. This Work shall consist of removal of beams, cables, posts, anchor terminal sections or concrete barriers of any size, shape or type; salvaging or disposal as directed; and backfilling of the resulting holes. Removal of concrete base shall be excluded and when required shall be carried out and paid for separately under Pay Item No. 20237 - Removal of Sign Post Base.

2.02.3.6 Impact Altenuators. This Work shall consist of removal of impact attenuators of any size or type with minimum damage and salvaging or disposal as directed. Removal of concrete base shall be excluded and when required shall be carried out and paid for separately under Pay Item No. 20237 - Removal of Sign Post Base.

Removal of all other elements listed herein shall be carried out in accordance with the requirements of this section and as detailed on the plans and approved by the Engineer.

2.02.3.7 Traffic Marking. This Work shall consist of removal of existing traffic paint lines and traffic control markings, which are not designated or permitted to remain.

Equipment for removal of traffic paint lines and traffic control marking shall consist of pickup trucks, wet sandblasting machine, air compressor, and all necessary hand tools, such as chisels, hand hammers, and brooms. When suitably qualified crews are available as determined by the Engineer, equipment may include commercially available excess-oxygen-system gear as specified in the HMM, Part 5-Highway and Bridge Maintenance, Section B-Traffic Control and Safety Devices, Paragraph 8.03. E Pavement Marking, Stripe Removal.

All striping and other traffic marking designated or directed, shall be removed to the fullest extent possible using an approved method, as specified below, that does not damage the surface or texture of the pavement. Over-painting no longer appropriate markings with black paint and/or bituminous solutions will not be permitted. The removal pattern shall be in an irregular shape that does not perpetuate the outline of the removed marking. Any damage to the pavement surface in connection with such removal work shall be repaired by the Contractor at his own expense to the satisfaction of the Engineer.

When wet sandblasting is used, removal of pavement markings will result to a barely noticeable scar, as determined by the Engineer. Sand and debris deposited on the pavement shall be removed as the work progresses, to prevent accumulations which might interfere with drainage or constitute a traffic hazard.

When the excess oxygen method is used, traffic marking removal shall be carried out in more than one passes to ensure rapid progression and to permit less heat to be transferred to the pavement. After the first passage of the burner, the hot flame melts the existing paint, which shall be removed with a straight hoe. Subsequently, the residual marking shall be re-burned in multiple passes as directed and the burned ash residue shall be brushed away each time it appears across the marking area, until only a slight indication is left of where the marking had been. This indication shall be as slight as possible so as to ensure that it will disappear with traffic wear, as approved by the Engineer.

2.02.3.8 Pavement Markers. This Work shall consist of removal of reflective raised pavement markers (cat-eyes) and/or of ceramic pavement markers, of any size, including disposal or cleaning and salvaging of reusable markers, and restoration of the pavement surface. Equipment for removal of pavement markers shall consist of pickup trucks, grinding power tools, and all necessary hand tools. When approved by the Engineer, compressor with an air hammer and chipping blade may be used. The markers shall be removed carefully with hammer and chisel and any residual adhesive on the road surface shall be ground smooth. All marker surfaces shall be cleaned with suitable mineral spirits or with kerosene. Light abrasives may be used on the exposed surfaces of markers only as approved by the Engineer. The bottom surface of the markers shall be ground to remove any adhesive and shall then be sanded off to a rough texture, free of gloss.

2.02.3.9 Rumble Strips or Speed Bumps. This Work shall consist of removal of bituminous rumble strips or speed bumps and restoration of the pavement to a flat, smooth surface. Materials shall conform to the requirements of Section 4.05, 'Bituminous Concrete Pavement' in these General Specification for Bituminous Concrete Wearing Course, Class C. Equipment shall consist of pickup truck, dump truck, air compressor, jack hammer with cuffing tool and tamper, and all necessary hand tools.

Rumble strip or speed bump materials delineated for removal by the Engineer shall be removed to full depth using a jack hammer with a spade bit, and all failed and loose material shall be disposed of. The cut out area shall then be restored as described in Subsection 4.05.9, "Minor Bituminous Concrete" in these General Specifications.

2.02.3.10 Sign Post Bases. This Work shall consist of removal of sign post bases of any size or type, along with anchor bolts and plates, disposal thereof, and backfilling and compacting of the resulting holes to the level of the surrounding ground using the same type of materials which are adjacent to the holes as directed.

2.02.3.11 Signs. This Work shall consist of removal of highway signs of any size, shape or type. Signs shall be carefully detached with minimum damage and salvaged or disposed of as directed.

2.02.3.12 Breakaway Sign Posts and Kilometer Posts. This Work shall consist of removal of breakaway single sign posts of any size or type or of kilometer posts of any size or type, including posts, sheet metal and reflectorized sheeting. Posts shall be removed by dismantling the bolts at the breakaway connection to the concrete base with minimum damage and salvaged or disposed of as directed.

2.02.3.13 Overhead Sign Supports. This Work shall consist of removal of overhead sign supports in whole or in part, and of any size or type. Sign supports shall be removed by dismantling the various members without unnecessary damage. Members shall be match marked, unless such match marking is waived by the Engineer. Materials so removed shall be salvaged or disposed of as directed.

2.02.3.14 Delineators. This Work shall consist of removal of delineator; salvaging or disposal, as directed; and backfilling of the resulting holes. Removal of concrete base shall be excluded and when required shall be carried out and paid for separately under Pay Item No. 20237 - Removal of Sign Post Base.

2.02.4 Disposal of Removed Material. All materials removed shall be disposed of at locations not visible from the roadway. Removed materials shall not be left in or under embankments or other constructed facility. Burning shall be done in accordance with applicable laws and safe practices, under the constant care of competent watchmen and at such times and in a manner that anything designated to remain or adjacent property is not jeopardized. Residue and other effects from burning shall be removed and disposed of outside the view from the roadway.

Burying removed materials within the right of way shall be done in such a manner that the removed materials are covered by at least one (1) meter of cover. The cover material shall not erode by wind or water. The contours of the finished area shall blend with the adjacent terrain.

Disposal of material at public and private sites away from the right of way shall be done at the Contractor's expense in accordance with all laws and regulations, after an agreement with the property owner has been fully executed. The Engineer shall be given fifteen (15) days prior notice and a written release from the property owner on whose property the materials are to be placed.

2.02.5 Method of Measurement. The quantities of the various removal items, as accepted, shall be measured for payment according to the plans and specifications for the several pay items appearing in the Bill of Quantities, and in terms of the prescribed units provided for the several pay items. Only accepted Work shall be included and the dimensions shall be those shown on the plans, measured on site or ordered in writing by the Engineer.

Removal of existing buildings shall be measured by the square meter, based on external ground floor dimensions, multiplied by the number of storeys, regardless of type of the building.

Removal of boundary walls or gates shall be measured by the linear meter, based on centerline plan dimensions, irrespective of type, height or thickness.

Removal of entire bridge structures shall be measured by the square meter, based on measured plan dimensions as authorized by the Engineer, regardless of height of the structure. No separate measurement shall be made of reinforcement and/or of embedded steel items.

Removal of major bridge components, such as decks, superstructure or substructure; concrete approach slabs; and associated wingwalls; shall be measured by the cubic meter, based on measured dimensions as authorized by the Engineer, regardless of height of the structure. No separate measurement shall be made of reinforcement and/or of embedded steel items.

Removal of box culverts; pipe culvert end sections; loose or grouted stone riprap; wire-enclosed riprap; gabions; shall be measured by the cubic meter of each respective pay item as authorized by the Engineer, regardless of height or depth. No separate measurement shall be made of reinforcement and/or of embedded steel items.

Removal of bearing devices shall be measured by the number of units of the various types removed as specified.

Removal of expansion joints, aluminum and steel railing for bridges, underground and aerial utility lines and poles, and concrete bridge parapet shall be measured by the linear meter.

Removal of structural steel shall be measured by the metric ton, to the nearest kilogram, as determined from the Engineers computed weights made in accordance with Section 5.05, "Steel Structures and Miscellaneous Metalwork" in these General Specifications, or from accurate scaled measurements witnessed by the Engineer. For purpose of payment, all metal parts removed from a structure in connection with this Work, such as railings, anchor bolts and nuts, expansion dams, plates and shapes for pier protection, and similar metal items, shall, unless otherwise specified, be measured for payment under this item.

Removal of precast concrete members shall be measured by the metric ton, to the nearest kilogram, as determined from the Engineers computed weights (volumetric computation times two and forty five hundredths (2.45) tons per cubic meter) or from accurate scaled measurements witnessed by the Engineer.

Removal of glare screens; steel safety railings; curbs, gutters or combination curband-gutter; pipe culvert barrels; and fences; shall be measured by the linear meter of each respective pay item as authorized by the Engineer.

Removal of guardrail shall be measured by the linear meter of accepted work. Removal of guardrail terminal sections shall be measured by the number of units removed as shown or directed. The pay limits for guardrail removal and anchor terminal sections removal shall be as specified in the Ministry's Standard Drawings, Series TB-4 and TB-5. Damaged metal beams or cables shall be charged to the Contractor at sixty (60) percent of the prices quoted under the respective pay items for new work.

Removal of New Jersey concrete barrier shall be measured by the linear meter along the front face, including the terminal tapered segments, which shall not be measured separately.

Removal of impact attenuators shall be measured by the number of units authorized by the Engineer, regardless of type, height or depth.

Removal of concrete, paving tile or shotcrete slope protection; and sidewalk and median paving; shall be measured by the square meter of each respective pay item as authorized by the Engineer, regardless of thickness, height or depth.

Removal of traffic paint lines or traffic marking shall be measured by the square meter of theoretical area of successfully removed traffic marking, accepted as specified.

Removal of reflective raised or of ceramic pavement markers shall be measured by the number of units of the various types removed as specified above irrespective of size or color.

Removal of rumble strips and speed bumps shall be measured by the square meter of removed material as accepted. This item shall include. the removal of existing rumble strips/speed bumps and the restoration of the pavement with hot plant bituminous mix material. No separate measurement shall be made of the restoration materials or work.

Removal of sign post base shall be measured by the cubic meter of concrete removed and accepted, which shall include all excavation and backfilling, concrete, reinforcement, anchor bolts, embedded metal items, anchor plates, and all incidentals in connection with these items.

Removal of signs shall be measured by the face area to the nearest one-one hundredth (1/100) square meter for each sign and to the nearest one-tenth (1/10) square meter for the total as specified in the Bill of Quantities. The area of each sign shall be that of the smallest rectangular, circular, triangular, trapezoidal, or other standard Ministry sign shape that will encompass the sign panel. No measurement shall be made of stiffeners, that is, those needed to support smaller signs on to larger ones, as they are considered subsidiary to the pay item of signs removal appearing in the Bill of Quantities.

Removal of single breakaway sign post, regardless of type, shall be measured by the number of units removed and accepted, which shall include the sign post, hinged as required, brackets, coupling bolts, breakaway couplings, nuts, etc., or the threaded reducer when a threaded collar detail is applicable. Removal of kilometer posts shall be measured under the same item as single breakaway sign post, by the number of units removed and accepted, which shall include the sign plate(s) regardless of size, the post, the threaded reducer and all incidentals in connection with these items.

Removal of overhead sign supports shall be measured by the metric ton as specified in the Bill of Quantities, as determined by weighing in the presence of the

Engineer on an approved, accurate set of scales, including all steel items in connection with walkways on overhead signs, rails, brackets and fasteners onto the tubular support, gratings and all incidentals thereof.

Removal of delineators shall be measured by the number of units removed and accepted, irrespective of type or color.

Removal of traffic signals (head and controller) and telephone cabinets as specified, shall be measured on unit basis.

Bituminous and cement concrete pavements, sidewalks, stairways, and other bituminous and cement concrete surfaces which are shown on the plans or identified in the Special Specifications and actually removed, shall be measured in square meters within the lines delineated on the plans or ordered by the Engineer.

Wells, septic tanks, manholes, catch basins, and inlets which are removed and backfilled or sealed as specified shall be measured on a unit basis.

Incidental excavation in connection with the foregoing items, as specified herein, shown on the plans or authorized by the Engineer, shall be measured for payment under Pay Item No. 20301 - Roadway Excavation.

When the bill of Quantities does not contain separate items for the removal of structures and obstructions, no measurements will be made. Damaged elements shall be measured for deduction as specified and deduction(s) may be applied at any time after such damage is discovered.

2.02.6 Payment. When the Bill of Quantities lists items specified for removal, such items which are actually removed and measured as specified in Subsection 2.02.5, "Method of Measurement," in these General Specifications will be paid for at the Contract price per unit of measurement.

Such payment shall be full compensation for furnishing all labor, equipment, tools and incidentals necessary for removing, handling, salvaging, transporting, storing and disposing of structures and obstructions and filling trenches, holes, depressions and pits and all other -items necessary for proper completion of the Work as specified in Subsection 1.07.2, 'Scope of Payment,' in these General Specifications.

When the Bill of Quantities does not list items specified in this section, no payment will be allowed for the removal of various structures and obstructions. All costs for removal, handling, transporting, storing and disposing of structures and obstructions shall be subsidiary to the work and all costs shall be included in contract unit prices for other items listed in the Bill of Quantities.

PAYMENT WILL BE MADE UNDER THE FOLLOWING:

ITEM No.	PAY ITEM	PAY UNIT
20201	Removal of Existing Building	Square Meter
20202	Removal of Boundary Wall, including Gate	Linear Meter
20203	Removal of Bridge Structure	Square Meter
20204	Removal of Bridge Component	Cubic Meter
20205	Removal of Box Culvert & Pipe Culvert End Section	Cubic Meter
20206	Removal of Metal Bearing Device	Unit
20207	Removal of Elastomeric Bearing Device	Unit
20208	Removal of Expansion Joint	Linear Meter
20209	Removal of Aluminum Bridge Railing	Linear Meter
20210	Removal of Steel Bridge Railing	Linear Meter
20211	Removal of Concrete Bridge Parapet	Linear Meter
20212	Removal of Structural Steel or Precast Concrete Member	Ton
20213	Removal of Underground Utility Lines	Linear Meter
2021301	Removal of Underground Utility Lines, Water	Linear Meter
2021302	Removal of Underground Utility Lines, Electrical	Linear Meter
2021303	Removal of Underground Utility Lines, Storm Drain	Linear Meter
2021304	Removal of Underground Utility Lines, Sanitary Sewer	Linear Meter
2021305	Removal of Underground Utility Lines, Telephone	Linear Meter
20214	Removal of Aerial Utility Lines and Poles	Linear Meter
2021401	Removal of Aerial Utility Lines and Poles, Electrical	Linear Meter
2021402	Removal of Aerial Utility Lines and Poles, Telephone	Linear Meter
20215	Removal of Curb	Linear Meter
20216	Removal of Combined Curb & Gutter	Linear Meter
20217	Removal of Gutter	Linear Meter
20218	Removal of Septic Tank	Unit
20219	Removal of Catch Basin, Manhole and Inlet	Unit
20220	Removal of Well	Unit
20221	Removal of Riprap, Wire-Enclosed Riprap & Gabion Slope Protection	Cubic Meter
20222	Removal of Concrete, Paving Tile & Shotcrete Slope Protection	Square Meter
20223	Removal of Pipe Culvert	Linear Meter
20224	Removal of Fence, including Gate	Linear Meter
20225	Removal of Dumped Rubbish	Cubic Meter
20226	Removal of Sidewalk & Median Paving	Square Meter
20227	Removal of Guardrail, Complete	Linear Meter
20228	Removal of Guardrail Terminal	Unit
20229	Removal of New Jersey Concrete Barrier	Linear Meter
20230	Removal of Impact Attenuator	Unit
20231	Removal of Steel Safety Railing	Linear Meter
20232	Removal of Bituminous and Cement Concrete Pavement	Square Meter
20233	Removal of Traffic Paint Line & Control Marking	Square Meter
20234	Removal of Ceramic & Retroreflective Raised Pavement Marker	Unit
20235	Removal of Traffic Signal & Controller	Unit

20236	**Removal of Rumble Strip or Speed Bump**	**Square Meter**
20237	**Removal of Sign Post Base**	**Cubic Meter**
20238	**Removal of Sign (Any Type)**	**Square Meter**
20239	**Removal of Breakaway Sign Post**	**Unit**
20240	**Removal of Overhead Sign Support**	**Ton**
20241	**Removal of Glare Screen**	**Linear Meter**
20242	**Removal of Delineator**	**Unit**
20243	**Removal of Telephone Cabinet**	**Unit**

SECTION 2.03 - EXCAVATION

2.03.1 Description. Excavation, regardless of the nature or characteristics of the materials encountered, shall consist of all excavation necessary for the construction of roadways, tunnels, intersections, approaches, slope rounding, benching, channels and ditches and finishing the excavation slopes in accordance with the lines, grades and cross sections shown on the Plans or established by the Engineer and as specified in the Special Specifications. The work also includes the removal or disposal of unsuitable or otherwise surplus materials taken from within the limits of work. All excavation shall be treated as a separate item for measurement and payment purposes. Embankments and subgrades shall be constructed as specified in Section 2.05, "Embankment," and Section 2.06, "Untreated Subgrade," in these General Specifications and shall be treated as separate items for measurement and payment purposes.

The Contractor shall visit the site prior to making his tender and shall determine the nature of the earth and rock, its quantity, location and suitability to meet the specified embankment and subgrade requirements. He shall base his bid prices solely on his own determination of soil. conditions. After Award of Contract, no claim for revision of contract unit prices based on alleged misrepresentation of subsurface information will be entertained.

Any information concerning properties of the soils and other subsurface conditions which may be shown on the plans, or obtained through discussion with the Engineer or others, shall be considered gratis and shall not be a basis for the Contractors determination of his prices. Engineering geological information, including the anticipated shrink or swell of materials after compaction, from which the quantities are estimated, is based on studies made in the field for purposes of design, and represents the best information available to the Ministry. However, it is recognized that in highway construction, there is often substantial variation in the character and quantities of subsurface materials.

2.03.2 Classification of Excavation. Excavation will be classified by the Engineer in one (1) or more of the following categories:

ITEMS IN THE BILL OF QUANTITIES:
Roadway Excavation
Tunnel Excavation
Tunnel Excavation - Main Line
Tunnel Excavation - Cross Passage

The Engineer will identify and determine the quantities of the different classifications of excavation as are listed in the Bill of Quantities while the Work is in progress and upon completion of the total Work.

2.03.2.1 Roadway Excavation. Roadway excavation shall include all materials excavated from within the staked construction limits except as covered in Section 2.08, "Structural Excavation and Backfill," in these General Specifications. Roadway Excavation - includes all material encountered regardless of its nature or characteristics.

2.03.2.2 Roadway Excavation - Unsuitable Material. Unsuitable material shall include:

1. Material classified as A-7 or A-6 according to MRDTM 21 0.

2. Unstable materials incapable of being compacted to the specified density at optimum moisture content using ordinary compaction methods for the equipment being used for compaction. Such materials may include, but not be limited to, cohesionless sand, silt, organic and highly compressible soil and sod.

3. Material too wet to be compacted and circumstances prevent suitable in-place drying prior to incorporation into the Work. Such materials may include muck from tide flats and coastal marshes.

4. Materials which are otherwise unsuitable for use in or under the planned embankment. Such materials may best be characterized as having CBR values less than three (3) as described in Paragraph 2.05.3.2, "Foundation Preparation," in these General Specifications.

5. Dune sand shall be considered as unsuitable material for subgrade, plating and capping.

Material specified or directed by the Engineer as unsuitable shall be classified as Roadway Excavation.

2.03.2.3 Roadway Excavation - Channel and Ditch. Channel and ditch excavation shall include the excavation of all natural and man-made materials necessary for the construction of drainage facilities, including riprap and slope protection, stream widening or relocation and all other channels within the limits and cross sections shown on the plans, specified in the Special Specifications, or as directed by the Engineer. Materials removed during channel and ditch excavation shall be classified by the Engineer as Roadway Excavation.

2.03.2.4 Tunnel Excavation. Tunnel excavation shall consist of the excavation and removal of rock, weathered or decomposed rock and/or soil within the limits of the tunnel cross section. This work shall be done in conformity with the tunnel grades, lines and stations shown on the Plans as established by the Engineer. Materials removed during tunnel excavation shall be classified by the Engineer as Tunnel Excavation.

2.03.3 Construction.

2.03.3.1 Utilization of Excavated Materials In Rural Areas. All suitable materials removed from the excavation shall be used in the formation of the embankment, subgrade, shoulders, slopes, bedding and backfill for structures and for other purposes shown on the Plans or disposed of in a manner complying with these General Specifications. However, the Contractor is not required to use all of the suitable excavated materials in the construction of embankments provided the materials which are not used in the construction of embankments are disposed of as specified and the Contractor replaces the wasted excavation materials with borrow material of equal or better quality at his own expense. Excavated materials which the Contractor elects to waste shall be disposed of in accordance with the requirements specified in Subsection 2.03.4, "Disposal of Surplus and Unsuitable Materials," in these General Specifications. It is the Contractors responsibility to determine if sufficient material is available for the completion of the embankments before wasting any of the excavated materials.

2.03.3.2 Utilization of Excavated Materials in Municipalities (Urban Areas). All suitable materials removed from the excavation shall be used in the formation of the embankments, subgrade, shoulders, slopes, bedding and backfill for structures and for other purposes shown on the Plans. If it is found there is excess quantities of excavated materials, the Contractor shall dispose of the excess materials at suitable locations subject to the approval of the Engineer and competent governmental authorizes such as the Municipality. The disposal of such materials shall not cause damage to any of the public or private properties, valleys and tributaries and in accordance with the requirements specified in Subsection 2.03.4 "Disposal of Surplus and Unsuitable Materials" in these General Specifications. The cost of transporting to and disposal of the excess excavated materials at approved waste locations shall be considered subsidiary to the Roadway Excavation pay item and no separate payment and measurement will be made for this Work.

2.03.3.3 Roadway Excavation. This work shall consist of excavating materials identified and defined by the Engineer as Roadway Excavation - or the lines and grades shown on the plans or staked by the Engineer. It shall also include excavating below grade, removing slide material, trimming slopes, slope rounding, stockpiling designated materials for future use and removing and disposing of surplus and unsuitable materials.

Material outside the planned excavation limits, which is determined by the Engineer, to be a potential slide and material which has come into the planned excavation limits shall be excavated to lines and slopes directed by the Engineer. Such excavated materials which are not declared by the Engineer to be unsuitable may be used in embankment construction.

All areas of roadway excavation, during the entire period of construction operations, shall be thoroughly drained. The excavated surfaces shall be kept smooth and sloped to side ditches until the subgrade is finished. Side ditches emptying from excavation to embankment shall be kept clean at all times and constructed to protect excavation and embankment from erosion. Damage to the

work attributable to wetting through failure of the Contractor to provide adequate drainage shall be immediately repaired by the Contractor at his expense.

Excavation slopes shall be constructed in accordance with the lines and grades shown on the plans and as staked by the Engineer. All loose or overhanging material along the slopes, considered to be hazardous, shall be removed as directed by the Engineer. The plans may designate certain materials, such as specific quantities and/or ledges of rock or quantities of existing surfacing or other materials to be excavated and stockpiled for a specific purpose of future use. Such materials shall be carefully excavated and handled to exclude contamination. The stockpiles shall be neatly and compactly constructed in an approved manner.

The Contractor shall take care not to break down, loosen or damage rock below the grade shown on the plans and specified. The Contractor shall be responsible for his methods and any damage his rock excavation methods and operations may cause. All blasting shall be performed in accordance with the requirements specified in Section 2.04, "Controlled and Production Blasting," in these General Specifications.

2.03.3.4 Roadway Excavation - Unsuitable Material. When unsuitable material, as identified and the limits defined by the Engineer, is encountered it shall be excavated to the lines, grades and depths directed by the Engineer and disposed of as specified in Subsection 2.03.4, "Disposal of Surplus and Unsuitable Materials," in these General Specifications. The excavated areas below or outside planned grades shall be backfilled as specified in Section 2.05, "Embankment," in these General Specifications.

2.03.3.5 Roadway Excavation - Channel and Ditch. Before beginning excavation, the Contractor shall establish the lines, grades and cross sections required to determine how much material will be excavated, present the information to the Engineer and receive approval from the Engineer to proceed.

The Contractor shall utilize equipment, tools and methods necessary to complete the work in accordance with the plans and specifications or as approved by the Engineer.

2.03.3.6 Designated Materials Selected From Roadway Excavation. When the plans or specifications designate that materials from excavation are to be stockpiled for specific future use, such materials shall be handled in a manner that precludes contamination with undesirable material. The location of stockpiles shall be identified in the Special Specifications or on the Plans.

When practical, and processing is not specified, such designated materials shall be taken directly from excavation to the specified point of use.

2.03.3.7 Roadway Excavation in Cut Sections. In all areas of roadway excavation in cut areas, rock and other materials in the planned subgrade layer (bottom thirty (30) centimeters of the completed excavation) that do not conform to the requirements specified in the Subsection 2.05.2, "Materials," in these General Specifications, shall be excavated to a depth of thirty (30) centimeters or as may be specified. The excavated materials shall be defined as Roadway Excavation and shall be incorporated into the Embankment or disposed of as specified in Subsection 2.03.4, "Disposal of Surplus and Unsuitable Materials," in these General Specifications.

In case of earth cut in sand dunes, requiring confinement for stabilization purpose, the roadway foreslope and backslope steeper than six horizontal to one vertical (6 H to 1 V) shall be constructed using soils of AASHTO Class A-1 -a, A-1 -b, A-2-4 having Plasticity Index of four (4) minimum, as specified in AASHTO M145 (MRDTM 21 0) to the size and dimensions shown in the plans, or as directed by the Engineer. Obtaining, handling, transporting and placing of these materials shall be considered subsidiary to roadway Excavation" so that no measurement or payment will be made for them on a separate basis.

2.03.3.8 Tunnel Excavation - General. The Contractor shall use excavation methods that minimize excavation outside the limits of the excavation lines as defined on the Plans. Excavation outside the excavation lines (overbreak) is the responsibility of the Contractor. Enlargements of any underground opening for the convenience of the Contractor will not be allowed without prior written approval of the Engineer.

As the excavation proceeds, the Contractor shall check the crown and walls over the unsupported lengths of tunnel after each advance, and scale all loose and shattered material. He shall also carry out similar checks on previously excavated sections that have not been covered with shotcrete at the end of each shift until stability can reasonably be assumed in the opinion of the Engineer. He shall provide the Engineer with access to crown and sidewalls in these areas at least once per shift.

The Contractor shall maintain neat working conditions at all times inside the tunnels and remove all muck, unusable materials and any other material not required for the work.

Explosive excavation (blasting) shall be done in a manner to minimize air overpressure and ground vibrations at nearby structures in accordance with Section 2.04, "Controlled and Production Blasting," in these General Specifications. The Contractor shall use blasting procedures and curtains to provide effective suppression of vibrations and employ other abatement measures necessary for protection of both employees and the public. Compliance with this section will not relieve the Contractor from responsibility for compliance with local ordinances, regulations and other Sections.

Overbreak areas will need backfilling with shotcrete and/or cast-in-place concrete as indicated herein and/or indicated in the plans. This extra support is

considered corrective and backfilling overbreak areas with shotcrete and/or cast-in place concrete shall be at the Contractors expense.

Permits and Licenses. The Contractor shall be responsible for obtaining all applicable blasting permits and licenses required by the Ministry of Interior/Public Security officials.

The Contractor is responsible for control of water in the tunnel during construction and shall take any means necessary for such control. Control of water shall include, but not limited to, furnishing, installing, operating, and maintaining pumps and other equipment; constructing temporary drains and keeping ditches free to carry all water quickly to sediment basins or other disposal areas; and disposal of all water draining or pumped from the tunnel.

Tunnel drainage water shall be treated in conformance with the Kingdom and local jurisdiction's water quality criteria before discharging water into the natural drainage channel or stream. Petroleum residues shall be removed by oil soaks to the satisfaction of the Engineer.

All products and materials used for rock excavation, either explosive or nonexplosive, are subject to approval by the Engineer. Only explosives, explosive components, and detonators commercially manufactured within the previous two (2) years or the shelf life of the product, whichever is less, shall be used.

At all times, the Contractor shall keep sufficient materials (rock bolts, shotcrete, etc.) near the tunnel excavation heading to provide a secure tunnel face.

The Contractor shall install and maintain twenty (20) meter station intervals in each tunnel with a sign with numerals at least fifty (50) millimeters tall.

Work shall be performed in a manner to minimize hazards to construction personnel. Safety in excavating shall be the responsibility of the Contractor.

2.03.4 Disposal of Surplus and Unsuitable Materials. Excavated materials which are designated by the Engineer to be surplus or unsuitable for use in the embankment and excavated materials wasted by the Contractor for his own convenience shall be disposed of in borrow pits, trenches, natural depressions or at other locations outside any town approved by the Engineer. Materials disposed of at locations outside the right of way may be compacted to the degree desired by the Contractor or as required by the public agency or private individual who owns the property and shall not cause any damage to abutting property. Excess rock and other excavated materials may be placed in waste banks or spread and leveled to present a neat appearance only with the approval of the property owner and the Engineer and outside the view of the highway traveler. All disposal areas shall be finished with a neat appearance with lines, grades and contours that conform to and blend with adjacent terrain and all edges shall be trimmed to a slope no steeper than one vertical to four horizontal (1 V to 4 H).

2.03.5 Quality Assurance Procedures. The total quantity of roadway excavation shall be evaluated and accepted in accordance with Subsection 1.08.4, "Measured or Tested Conformance," in these General Specifications. The Engineer shall perform or supervise the performance of all quality assurance measuring and testing. Quality assurance measuring or testing shall involve verification that the roadway excavation conforms to the lines, grades and typical cross sections shown on the plans or established by the Engineer within the following tolerances.

1. Slopes. Slopes shall be uniformly finished and no point on the slope shall deviate from the staked slope by more than fifteen (15) centimeters when measured at right angles except in rock excavation where no point shall deviate more than thirty (30) centimeters measured along any line perpendicular to the staked slope.

2. Width. The total width between the ditch lines shall not be deficient by more than thirty (30) centimeters from the deviations shown on the plans at any location.

3. Bottom of Excavation. The bottom of excavation shall be completed to within plus one (1) centimeter of the designated grade except that in rock, the tolerance shall be plus two (2) centimeters.

The Contractor shall be responsible for the payment of any claims from property owners for excavation quantities removed from beyond the staked slope and right-of-way (R.O.W.) lines.

2.03.6 Method of Measurement. When roadway and tunnel excavation pay items are shown in the Bill of Quantities, all survey data, staking notes and computations of the quantities of the various classes of excavation shall be checked and attested to by the Engineer.

2.03.6.1 Roadway Excavation. - When the Bill of Quantities lists payment for Roadway Excavation, specific Measurements will be made as follows:

1. Slope Stake Basis. Unless otherwise provided, the slope stake basis of measurement will be used to determine the roadway excavation quantities as follows:

Original cross-sections shall be taken before completion of clearing and grubbing. Slope stake notes developed from the typical sections in the plans set by the Contractor prior to construction will be used provided the Engineer has determined that the work has been acceptably completed in conformity to the staked lines and slopes.

If the Engineer determines that any portion of the work is acceptable but has not been completed in conformity to the staked lines and slopes, the quantities will be measured in accordance with method (2) below.

2. Remeasurement Basis. When the remeasurement basis of measurement is used, quantities actually excavated and accepted will be determined in accordance with the following:

Original ground cross sections supplemented by field measurements shall be taken of the ground surface after clearing and grubbing. Final cross sections or comparable measurements will be taken of the completed and accepted work. No payment will be made for unauthorized excavation or overbreakage outside the slope lines as staked.

3. Alternative Methods of Measurement. Where it is impractical to measure material by the cross section method due to the erratic location of isolated deposits, acceptable methods involving three (3) dimensional measurements, including hauling vehicle measurements, may be used.

Any materials excavated before the original cross sections are taken and approved by the Engineer shall not be measured for payment.

The total volume of unclassified roadway excavation shall be computed from the bottom of the staked roadway cut and ditch invert elevations as follows:

(1) The excavation of rut sections containing rock within the subgrade zone shall be staked and measured to the bottom of the subgrade zone.

(2) The excavation of cut sections containing unsuitable materials (i.e. Dune Sand, A-7 and A-6 material) within the subgrade zone shall be staked and measured to a minimum of thirty (30) centimeters below the bottom of the subgrade zone. It may be increased in additional increments of thirty (30) centimeters at the direction of the Engineer.

(3) The excavation of cut sections containing material that is not rock or not unsuitable shall be staked and measured to the top of the subgrade zone.

4. Computation of Roadway Excavation Volumes.

Roadway excavation will include the following volumes:

(1) Roadway prism excavation as defined in the above paragraphs (1), (2) and (3) and shall include the following:
1) Rock material excavated and disposed of down to the bottom of subgrade.
2) Unsuitable earth material excavated and disposed of from within and below the bottom of subgrade as specified above.
3) Excavation material, which is neither rock nor unsuitable shall be measured up to the top of subgrade.

(2) Unsuitable material from beneath embankment areas, if top thirty (30) cm of the original ground does not meet the requirements for

"Embankment Materials' in Paragraph 2.05.2.1 in these General Specifications or if there is excessive moisture present.

(3) Channels and ditches.

(4) Loose scattered rocks removed and placed as required within the roadway.

(5) Slide slipout material not attributable to the Contractors method of operation.

(6) Embankment benching greater than two (2) meters wide when ordered by the Engineer.

Roadway excavation will not include the following:

1) Material from borrow sources.
2) Overbreakage from the backslope in rock excavation.
3) Roadbed material scarified in place and not removed.
4) Material excavated when rounding cut slopes.
5) Preparing foundations for embankment construction.
6) Embankment benches up to two (2) meters in width.
7) Slide or slipout material attributable to the Contractors method of operation.
8) Material temporarily stockpiled at the option of the Contractor.
9) Material excavated outside the established slope limits.

The original ground and the volumes of staked excavation and unsuitable materials removed as directed by the Engineer shall be computed from modified original ground, cross sections and staking data using the Average End Area Method. The volume of unsuitable material shall be listed separately for excavation and embankment.

2.03.6.2 Tunnel Excavation. When the Bill of Quantities lists payment for Tunnel Excavation in Cubic Meters, the volumetric measurements shall be taken as follows:

The volume will be computed to the theoretical excavation lines including shotcrete leveling, concrete lining, road pavement and subgrade layers and drainage channels. Utility duct excavation below the bottom of the subgrade zone will not be included in the tunnel excavation quantity. It will be considered part of the utility Bill of Quantities item. Excavation beyond the theoretical excavation lines (over break) is the responsibility of the Contractor. Partial payments of the Tunnel Excavation will be based upon actual cross sections of acceptably completed excavation.

2.03.7 Payment. **When Roadway Excavation is listed in the Bill of Quantities, the pay quantity shall be measured as specified in Paragraph 2.03.6.1, "Roadway Embankment" in these General Specifications and payment made at the contract – unit price for accepted quantities of Roadway Excavation on a cubic meter basis.**

When Tunnel Excavation is listed in the Bill of Quantities, the pay quantity shall be measured as specified above in Paragraph 2.03.6.2, "Tunnel Excavation" in these General Specifications, and payment made at the contract unit price for accepted quantities of Tunnel Excavation on a cubic meter basis.

Payment shall be full compensation for furnishing all labor, materials, equipment, tools and incidentals used to perform all work involved in completing roadway and tunnel excavation as shown on the plans, specified in these General Specifications and the Special Specifications and as directed by the Engineer. Payment shall also include compensation for all materials, labor, equipment and incidentals used in the disposal of surplus and unsuitable materials and the stockpiling of specified materials for future use, cleaning up the site and performing all surveys and computations and all other items necessary for the proper completion of the work as specified in Subsection 1.07.2, "Scope of Payment," in these General Specifications.

PAYMENT WILL BE MADE UNDER THE FOLLOWING:

ITEM NO.	PAY ITEM	PAY UNIT
20301	Roadway Excavation	Cubic Meter
20302	Tunnel Excavation	Cubic Meter
2030201	Tunnel Excavation - Main Line	Cubic Meter
2030302	Tunnel Excavation, Cross Passage	Cubic Meter

SECTION 2.04 - CONTROLLED AND PRODUCTION BLASTING

2.04.1 Description. This work shall consist of all blasting operations in quarries, roadway excavation, demolition of structures and obstructions and all other work associated with construction.

All rock excavation where excavation slopes are one horizontal to two vertical (1 H to 2 V) or steeper shall incorporate controlled blasting unless otherwise ordered by the Engineer. Controlled blasting shall be defined as the controlled use of explosives in carefully located and aligned drill holes to establish a free surface or shear plane in the rock at the specified excavation backslope. Production blasting refers to rock fragmentation blasts resulting from more widely spaced production holes throughout the main excavation area next to the controlled blast line. Controlled blasting techniques include presplitting and cushion (trim) blasting. These techniques @are required to minimize blast damage to the designated rock backslope and to improve the longterm stability of the slope. The Contractor shall carefully design and control all blasting operations using criteria and methods that are acceptable to the Engineer and in keeping moth good blasting practice to preserve the rock beyond the excavation limits in the soundest possible condition and to complete the rock excavation work to the lines, grades, slopes and cross section shown on the plans or staked by the Engineer.

2.04.2 Use of Explosives. All blasting operations, including the storage and handling of explosives and blasting agents, shall be performed in accordance with the applicable provisions of these General Specifications and all Kingdom Ministry of Interior regulations.

Explosives, blasting agents and detonators shall be stored on Ministry of Interior/Public Security or approved local property, conforming to all Ministry of Interior laws governing explosives storage. The Contractor is required to obtain and use copies of all Ministry of Interior/Public Security requirements applicable to explosive storage, and will familiarize himself with their requirements.

2.04.3 Product Specifications. The delay elements in blasting caps are known to deteriorate with age. For this reason, it is required that all blasting caps shall be used before the expiry dates coded on the caps.

Explosives are also known to age and deliver much less than the rated energy. For this reason, it is required that all explosives be used before their expiry date coded on the explosives. No blasting product will be brought to the job site if the date codes are missing.

Bulk explosives, such as ammonium nitrate and fuel oil, may not contain the proper amount of diesel oil, due to evaporation or improper mixing. Low diesel oil drastically reduces the energy content of the explosive and commonly produces reddish brown or yellow fumes upon detonation even in dry blastholes. Products that do not meet manufacturers specifications will not be used on the project.

All explosive manufacturers shall have a quality control system in effect as required by the Ministry of Interior. This system shall include inspection, sampling and testing. If product performance or composition deviates by more than ten percent (10%) in any manner from the manufacturers data sheet, that lot number will be rejected.

2.04.4 Blasting Plan. Not less than thirty (30) days before beginning any drilling or blasting operations, or at any time that substantial changes are made to the drilling or blasting methods, the Contractor shall submit a Blasting Plan to the Engineer for review. This Blasting Plan shall contain full details of the drilling and blasting procedures and controls the Contractor proposes to use for both the controlled and production blasting. This Blasting Plan shall contain, at the least, the following information:

1. **Maximum dimensions for width, length, and depth of any shot.**

2. **A typical drill pattern diagram for controlled blasting and fragmentation holes showing hole diameters, depths, spacings, and inclinations, including tolerances on hole alignment.**

3. **Loading pattern diagram showing the location and amount of each type of explosive in each hole, including primers, initiators, initiation methods, delay methods, delay times, and overall powder factor.**

4. **Location, type, and depth of stemming and depth of subdrilling, if any.**

5. **Manufacturers data sheets for all explosives, primers, initiators, and other blasting devices to be employed.**

6. **Operational procedures and safety precautions for storing, transporting, and handling explosives and for executing a blast in accordance with Subsection 2.04.6 "Safety" in these General Specifications.**

7. **Proposed Blasting Schedule. The drilling and blasting plan will be reviewed by the Engineer for completeness and acceptability.**

2.04.5 Traffic Interruption Notification. When blasting operations will require traffic to be interrupted on adjacent roads, the Contractor shall secure the approval from local authorities for the interruption. Before commencing blasting operations, the Contractor shall notify the Engineer that approval of the proper authorities has been obtained.

2.04.6 Safety Procedures. The Contractor shall take all reasonable and necessary steps to insure the protection of persons, property and the Work. Such protection shall be provided for adjacent or left in place trees, shrubbery, pole lines and all objects of an aesthetic, historic or archaeological value. The purpose of all protection is to prevent damage rather than to control damage. The following safety procedures shall be addressed in the Blasting Plan and adhered to throughout the length of the project.

2.04.6.1 Type of Explosive Materials. Explosive materials include, but are not necessarily limited to, dynamite and other high explosives, slurries, water gels, emulsions, blasting agents, initiating explosives, detonators and detonating cord. The Contractor shall comply with all Kingdom Ministry of Interior regulations that pertain to the purchase, transportation, storage and use of explosive materials.

2.04.6.2 Blaster-in-Charge. A person with the necessary experience and qualifications shall be designated in writing by the Contractor as Blaster-in-Charge. The Blaster-in-Charge shall have the authority and responsibility for the transportation, security, safety, and use of all explosive materials - including the obtaining, storing, distributing, loading, finding, disposing, and any other related activity. The Blaster-in-Charge shall prepare and/or approve all the safety provisions within the Contractors Blasting Plan and ensure they are strictly followed for any blasting crew used to assist with explosive activities, including transportation and security.

2.04.6.3 Initial Safety Procedures Submittal. At least thirty (30) days prior to delivery or use of any explosive materials, the Contractor shall submit the following:

2.04.6.3.1 Blaster-in-Charge Qualifications:

1. Proof of a valid Blaster's license issued by Public Security officials.

2. Resume with current references showing not less than three (3) years of active involvement as Blaster-in-Charge on projects with blasting work similar in scope to this contract.

3. Blasting Crew Qualifications. Knowledge and reliability in the safe use of explosive materials acceptable to the Blaster-in-Charge and Ministry of Interior/Public Security officials.

4. Permits and Licenses. Copies or other proof of all applicable permits and licenses.

5. Blasting Plan. The Blaster-in-Charge shall sign the plan to signify his full agreement with all its safety provisions. As a minimum, the safety aspects of the Plan shall address:

   (1) Transportation. All applicable Ministry of Interior/Public Security regulations including proposed methods for compliance.

   (2) Storage and Magazines. All applicable Ministry of Interior/Public Security regulations including proposed methods for compliance.

   (3) Blast Site Preparations. All applicable Ministry of Interior/Public Security regulations including proposed methods for compliance such as: description of explosive

materials and quantities kept at blast sites; drilling and initiating systems and equipment; methods to prevent drilling in bootlegs or within fifteen (15) meters of any loaded hole; loading plan with details of stemming and tamping; firing plan; pre-blast and post-blast inspections; handling misfires; removal and disposal of excess explosive materials, etc.

(4) Area Security. All applicable Ministry of Interior/Public Security regulations including proposed methods for compliance.

Protection. Personnel safety shall be the controlling consideration in decisions involving the use of explosive materials. The Contractor shall exercise the utmost care not to endanger life and property. Blasting mats and other protective devices shall be used where necessary to prevent damage to all landscape features and historical or archaeological structures, including those under construction. Should any damage occur, the Contractor shall make restoration as required by the Engineer at no additional cost to the Kingdom.

Explosive System. The Contractor shall use explosive materials that components commercially manufactured within the past year or the shelf-life of the product, whichever is less. All explosive material shall be properly identified in accordance with applicable requirements. The date of manufacture shall be clearly stamped on the product container or made available from the manufacturer's dateshift code or shipping paper.

The principal explosive shall not be a nitroglycerin based product-unless the type of work requires otherwise, and is fully detailed in the Blasting Plan.

The use of "safety" fuse and fuse type blasting cap initiation is prohibited.

All-electric initiation systems are permissible only when the protection against extraneous electricity (power lines, radio-transmissions, electrical storms, etc.) is shown in the Blasting Plan. Series blasting circuits shall be used for all-electric initiation unless the use of parallel-series circuits are described in the Blasting Plan.

Electricity from light, power circuits or batteries shall not be used for initiation except internal batteries for capacitor discharge blasting machines.

2.04.6.4 Check for Misfires. The Contractor and Public Security officer shall observe the entire blast area for a minimum of five (5) minutes following a blast to guard against rock fall before commencing work in the cut. The five minute delay between blasting and allowing anyone but the blaster and Public Security officer to enter the area is needed to make sure that no misfires have occurred.

During the delay period, all holes should be checked to make sure that they have detonated. If any holes have not fired, these misfires will be handled before others enter the work area.

The Engineer shall, at all times, have the authority to prohibit or halt the Contractors blasting operations if it is apparent that, through the methods being employed, the required slopes are not being obtained in a stable condition or the safety and convenience of the traveling public is being jeopardized.

2.04.6.5 Misfire Handling Procedures. Should a visual inspection indicate that complete detonation of all charges did not take place, the following procedures will be followed:

1. If the system was energized and no charges fired for electrical systems, the lead wire will be tested for continuity prior to inspection of the remainder of the blast. For nonelectric systems, the lead in or tube will be checked to make sure that detonation has entered the blast area.

2. Should an inspection of the electrical leadline or lead in tubing-line indicate that there is a break in the line or if the tubing did not fire, then the system will be repaired and the blast refired. If the inspection indicates that the leadline has fired and misfired charges remain, the blaster will do the following:

    (1) The blaster will exclude all employees except those necessary to rectify the problem.

    (2) Traffic will be closed if a premature explosion could be a hazard to traffic on nearby roads.

    (3) The blaster will correct the misfire in a safe manner. If the misfire poses problems that cannot be safely corrected by the blaster, a consultant or an explosive company representative skilled in the art of correcting misfires, will be called to rectify the problem.

2.04.6.6 Lightning Protection. The Contractor shall furnish, maintain and operate lightning detection equipment during the entire period of blasting operations and/or during the periods that explosives are at the site. Equipment shall be similar or equal to the Thomas Instruments S250 Storm Alert as manufactured by D.L. Thomas Equipment, Keene, New Hampshire, U.S.A or the VS1 12 Lightning Forecast System manufactured by NITRO NOBEL of Sweden. When the lightning detection device indicates a blasting hazard potential, personnel shall be evacuated from all areas where explosives are present. When a lightning detector indicates a blasting hazard, the following shall be performed:

1. Clear the blasting area of all personnel.

2. Notify the Project Engineer of the potential hazards and precautions to be taken.

3. Terminate the loading of holes and return the unused explosives to the day storage area.

4. **If blastholes are loaded and would pose a hazard to traffic if detonated, roads will be closed until the lightning hazard has passed.**

5. **When the hazard dissipates, inform the Project Engineer that production blasting will continue.**

2.04.7 Execution.

2.04.7.1 Time Restrictions. Blasting shall be restricted to the times permitted by local authorities or the Engineer.

2.04.7.2 Pre-Blast Report. In addition to the Blasting Plan, a pre-blast report shall be prepared for each specific blast. This pre-blast report shall be presented to the Engineer prior to the commencement of drilling of holes for that blast and will describe the location and geometry of the blast, and all specific loading and firing details required in items one (1) through four (4) of the Blasting Plan. This pre-blast report shall also include the surveyed location and elevation of the collar of each presplit or cushion blast hole. Any modifications made during the actual drilling, loading, and filing of the blast shall be reported to the Engineer prior to firing the shot. As soon as sufficient material has been removed from the cut face, a visual inspection and an assessment of the success of the blast shall be carried out prior to the loading of the next blast and prior to the drilling of any other future blasts. If, in the judgement of the Engineer, changes appear necessary, drilling and blasting operations shall be suspended and revised blasting procedures shall be developed. All necessary changes shall be incorporated in the next pre-blast report. If the changes are significant, a revised Blasting Plan shall be submitted.

Submittal of the Blasting Plan and pre-blast reports are for quality assurance and recordkeeping purposes. The Contractor shall adopt rational blast design and observation and documentation methods which will refine and optimize fragmentation and controlled blasting procedures. The Contractor shall also adapt these procedures to the changing rock conditions. Review of the Blasting Plan and the blast reports by the Engineer shall not relieve the Contractor of his responsibility for the accuracy and adequacy of the plan when implemented in the field, nor for the safety and damage to personnel and property caused by toxic substances, flyrock, noise, or vibration associated with the blasts.

The Engineer shall, at all times, have the authority to prohibit or halt the Contractors blasting operations, if smooth and stable slopes Within the required dimensional tolerances and a minimum of backslope damage are not achieved, or the safety and convenience of the public is being jeopardized or property or natural features are being endangered.

2.04.7.3 Test Blasts. Prior to commencing full-scale blasting operations, the Contractor shall demonstrate the adequacy of the proposed blast plan by drilling, blasting and excavating short test sections, up to thirty (30) meters in length, to determine which combination of method, hole spacing and charge works best. When field conditions warrant, as determined by the Engineer, the Contractor may be ordered to use test section lengths less than thirty (30) meters.

Unless otherwise allowed by the Engineer, the Contractor shall begin the controlled blasting tests with the presplit blastholes spaced between eight hundred (800) millimeters and one (1) meter apart, then adjust if needed until the Engineer approves the spacing to be used for full-scale blasting operations.

Requirements for controlled and production blasting operations covered elsewhere in this specification shall also apply to the blasting carried out in conjunction with the test shots.

The Contractor will not be allowed to drill ahead of the test shot area until the test section has been excavated and the results evaluated by the Engineer. If the results of the test shot(s), in the opinion of the Engineer, are unsatisfactory, then notwithstanding the Engineer's prior review of such methods, the Contractor shall adopt such methods as are necessary to achieve the required results. Unsatisfactory test shot results include an excessive amount of fragmentation beyond the indicated lines and grade, excessive flyrock, or violation of other requirements within these specifications. All costs incurred by the Contractor in adopting revised blasting methods necessary to produce an acceptable test shot shall be considered incidental to the contract unit prices for roadway excavation and controlled blasting.

2.04.7.4 Production Blasting. All production blasting, including that carried out in conjunction with the blasting test section requirements of Paragraph 2.04.3.5 'Test Blasts" in these General Specifications, shall be performed in accordance with the following general requirements:

Production blastholes shall be drilled on the patterns submitted by the Contractor and approved by the Engineer. The production blastholes shall be drilled within two (2) blasthole diameters of the staked collar location. If more than five percent (5%) of the holes are drilled outside of this tolerance, at the option of the Engineer, the Contractor may be required to refill these holes with crushed stone and redrill them at the proper location.

If the blastholes are plugged or unable to be fully loaded, at the option of the Engineer, the Contractor may be required to deepen or clean-out these holes. The blastholes should all be checked and measured before any explosives are loaded into any of the holes to eliminate any safety hazard resulting from drilling near loaded holes.

All blastholes should reach their desired depth. If more than five percent (5%) of the holes are short before loading, the Contractor may be required by the Engineer to redrill the short holes to proper grade at the Contractors expense.

Blastholes will be covered to keep overburden from falling into the holes after drilling.

The row of production blastholes immediately adjacent to the controlled blast line shall be drilled on a plane approximately parallel to the controlled blast line. Production blastholes shall not be drilled closer than two (2) meters to the controlled blast line, unless approved by the Engineer. The bottom of the production holes shall not be lower than the bottom of the controlled blastholes. By approval of the Engineer, the bottom of the production hole may be lower than the controlled blastholes by the amount of subdrilling used on the production holes. Detonation of production holes shall be on a delay sequence toward a free face. Stemming material used in production holes shall be sand or other dry angular granular material, all of which passes a 9.5 mm (3/8 inch) sieve.

It is the Contractors responsibility to take all necessary precautions in the production blasting so as to minimize blast damage to the rock backslope.

Payment for the production blasting shall be incidental to the contract unit price for roadway excavation.

Production blasting shall break up the rock to dimensions of approximately two thirds (2/3) the lift thickness specified for rock lifts in the embankment. Any material outside the authorized cross sections which becomes shattered or loosened by the production blasting shall be removed during excavation at the Contractors expense. If controlled blasting is not used, slopes shall be drilled and blasted to create a neat and uniform surface, free from hollows or protrusions or loose or overhanging rocks. Undercut slopes are not to be created by the drilling and blasting.

2.04.7.5 Presplitting. The Contractor shall completely remove all overburden soil and weathered rock longitudinally along the slope lines for a distance of at least ten (1 0) meters beyond the drilling limits, or to the end of the excavation, whichever is less, before drilling the presplitting holes. Particular care and attention shall be directed to the beginning and the end of excavations to ensure complete removal of all overburden soil and weathered rock and to expose rock to an elevation equal to the bottom of the adjacent lift of the presplitting holes being drilled. This will allow observation of the rock profile and permit proper design of the drilling and charging configuration for holes located at the extremity of the blast.

Presplitting holes not less than twenty-five (25) millimeters nor greater than seventy-five (75) millimeters in diameter shall be drilled along the proposed excavation line at the spacing shown in the Blasting Plan. For the initial test blast, this spacing shall not exceed one (1) meter. The spacing of presplit holes shall be maximum that will ensure a general continuity of stress relief fractures between adjacent holes, so as to expose the half-barrels. The Contractor shall stake the location of presplitting holes for review by the Engineer prior to drilling.

The Contractor shall control his drilling operations by use of proper equipment and experienced personnel so that no presplit hole shall deviate from the plane of the staked slope by more than three hundred (300) millimeters either parallel or normal to the slope. If more than ten percent (10%) of the presplit holes are outside this tolerance, drilling length and lift height shall be reduced on subsequent blasts to the point where the drilling meets this tolerance.

Maximum lift heights greater than ten (1 0) meters or less than four (4) meters will not be allowed unless the Contractor can demonstrate he can stay within the above tolerances and still produce a uniform and stable slope. The presplitting holes on subsequent lifts shall be drilled as close to the final face as possible, but in no case more than six hundred (600) millimeters from the face of the previous lift. Drilling direction on subsequent lifts shall be adjusted to compensate for the actual number of lifts and offset distances so that the toe of the final slope occurs within three hundred (300) millimeters of the planned location.

Presplit faces shall be drilled and blasted prior to production blasting designed to expose these faces. Presplitting shall not extend more than ten (1 0) meters ahead of the zone of production blasting at any time. If a presplit line ahead of a production blast is shot with that production blast, all production holes shall be delayed at least one hundred (100) milliseconds more than the last presplit detonation.

Only standard cartridge explosives prepared and packaged by explosive manufacturing firms will be permitted for use in presplit holes. These may consist of fractional portions of standard cartridges to be attached to detonating cord in the field or continuous column explosives joined and attached to detonating cord or as recommended by the manufacturer.

The maximum diameter of standard explosives used in presplit holes shall be approximately one-half (1/2) the diameter of the presplit hole.

If fractional portions of standard explosive cartridges are used, the cartridges shall be firmly attached to a length of detonating cord equal to the depth of the drill hole so that the cartridges will not slip down the detonating cord nor cock across the hole and bridge the flow of stemming material. Spacing of cartridges shall not exceed two-hundred fifty (250) millimeters and shall be adjusted to give the desired result.

If a continuous column type of explosive is used, the column shall be assembled and affixed to the detonating cord in accordance with the explosive manufacturer's instructions, a copy of which shall be included with the submitted Blasting Plan.

The bottom charge of a presplit hole may be larger than the line charges but shall not be large enough to cause overt>reak. The top charge of the presplitting hole shall be placed far enough below the collar to avoid overbreaking the surface, flyrock, or premature venting.

Only standard explosives manufactured especially for presplitting shall be used in presplit holes, unless approved in writing by the Engineer.

Before placing the charge, the Contractor shall determine that the hole is free of obstructions for its entire depth. All necessary precautions shall be exercised so that the placing of the charge will not cause caving of material from the walls of the hole.

If the Blasting Plan so indicates, unloaded and unstemmed relief holes may be drilled between loaded controlled blasting holes.

2.04.7.6 Cushion (Trim) Blasting. Where the horizontal distance from the cut face to the existing rock face is less than five (5) meters, the Contractor may cushion blast in lieu of presplitting. Cushion blasting is similar to presplitting except that the detonation along the cut face shall be performed after the detonation of all production holes.

Difference in delay time between the trim line and the nearest production row shall not be greater than seventy (75) milliseconds nor less than twenty-five (25) milliseconds. With the exception of this timing criterion, all requirements for presplitting shall also apply to cushion blasting.

2.04.7.7 Scaling and Stabilization. All rock on the cut face that is loose, hanging, or creating a dangerous situation shall be removed or stabilized, to the Engineer's satisfaction, during or upon completion of the excavation in each lift. Drilling of the next lift will not be allowed until this work has been completed. Scaling shall be performed by approved methods, including handscaling with a suitable steel mine scaling rod, barring, wedging, and light blasting, as necessary. Localized and minor irregularities or surface variations which do not impair the facility or create a hazard will be permitted to remain in place.

The slopes shall be scaled throughout the span of the contract and at such frequency as required to remove all hazardous loose rock or overhangs. Payment for scaling shall be incidental to the contract unit price for roadway excavation.

Any damage to the face which results from the Contractors blasting operations shall be repaired or stabilized at the Contractors expense. This corrective work may take the form of removal or rock bolting the unstable material or with shotcrete, structural concrete, rockbolts, or other techniques ordered by the Engineer. A plan for this stabilization shall be submitted to and approved by the Engineer before beginning the corrective work.

All rockbolts, dowels, shotcrete, and other mechanical stabilization necessary to assure the stability of each life shall be installed before blasting or removing subsequent lifts. Shotcrete and grout shall be allowed to gain sufficient strength to assure that these items will not be damaged by subsequent excavation.

2.04.8 Special Requirements.

2.04.8.1 Blasting Consultant. When called for in the contract special provisions, the Contractor shall retain a recognized blasting consultant to assist in the blast design. The blast design shall include both the controlled and production blasting. The consultant shall be an expert in the field of drilling and blasting who derives his primary source of income from providing specialized blasting and/or blasting consulting services. The consultant shall not be an employee of the Contractor, explosives manufacturer, or explosives distributor.

Not later than the preconstruction conference, the Contractor shall submit a resume of the credentials of the proposed blasting consultant. The resume shall include a list of at least 5 highway rock excavation projects on which the blasting consultant has worked. The list shall contain a description of the projects, details of the blast plans, and modifications made during the project. The list shall also contain the names and telephone numbers of project owners with sufficient knowledge of the projects to verify the submitted information. The blasting consultant must be approved by the Engineer prior to the beginning of any drilling and blasting work.

2.04.8.2 Pro-Blast Condition Survey. When blasting near buildings, structures or utilities, the Contractor shall arrange for a pre-blast survey of any nearby buildings, structures, or utilities which may potentially be at risk from blasting damage. The survey method used shall be acceptable to the Contractors insurance company. The Contractor shall be responsible for any damage resulting from blasting. The preblast survey records shall be made available to the Engineer for review. Occupants of local buildings shall be notified by the Contractor prior to the commencement of blasting.

2.04.8.3 Vibration Control Monitoring. When blasting near buildings, structures or utilities which may be subject to damage from blast induced ground vibrations, the ground vibrations shall be controlled by the use of properly designed delay sequences and allowable charge weights per delay. Allowable charge weights per delay shall be based on vibration levels which will not cause damage. The allowable charge weights per delay shall be established by carrying out trial blasts and measuring vibration levels.

When blasting is closer than three hundred (300) meters from bridges or buildings, a risk assessment is to be done prior to actual blasting operation. Structures and buildings are to be inspected and existing cracks and damage recorded. The radius inside which blast vibration monitoring will be done will be determined and a detailed vibration monitoring program will be designed and submitted to the Engineer for approval. After blasting works, a second inspection is to be done and the damage caused by blasting to be reviewed and the injured parties compensated by the Contractor.

The trial blasts shall be carried out in conformance with the blasting test section requirements of Paragraph 2.04.7.4, "Production Blasting," in these General Specifications, modified as required to limit ground vibrations to a level which will not cause damage. Whenever vibration damage to adjacent structures is possible, the

Contractor shall monitor each blast with an approved seismograph located, as approved, between the blast area and the closest structure subject to blast damage. The seismograph used shall be capable of recording particle velocity for three mutually perpendicular components of vibration in the range generally found with controlled blasting.

The Contractors vibration monitoring program is to be formulated assuring the peak particle velocity of each component not exceeding the safe limits contained in Table 2.04-1 and Table 2.04-2. The Contractor shall employ a qualified vibration specialist to measure the vibration velocities and also interpret the seismograph records to insure that the seismograph data shall be effectively utilized in the control of the blasting operations with respect to the existing structures. The vibration specialist used shall be subject to the Engineer's approval.

Data recorded for each shot shall be furnished to the Engineer prior to the next blast and shall include the following:

1. **Identification of instrument used.**
2. **Name of qualified observer and interpreter.**
3. **Distance and direction of recording station from blast area.**
4. **Type of ground at receiving station and material on which the instrument is sifting.**
5. **Maximum particle velocity in each component.**
6. **A dated and signed copy of seismograph readings record.**

Specifics of vibration monitoring plan for the blast monitoring zones specified below shall be submitted prior to the start of any blasting and shall include the proposed device(s) and manufacturers' literature for each device to be used.

- ***Blast Monitoring Equipment.*** **Equipment for seismic and air overpressure monitoring shall be equal to the four (4) channel (one (1) overpressure and three (3) seismic channels) equipment shall be capable of providing a permanent photographic record of the particle velocity and overpressure traces. The equipment shall also have frequency response of four (4) to two hundred (200) Hz and two (2) and two hundred (200) Hz for particle velocity and air overpressure, respectively.**

- ***Blast Monitoring.*** **Mandatory blast monitoring of every test blast will be required within the distances of all structures shown in Table 2.04-2 for the type of foundation materials involved to establish the decay of air overpressure and ground vibrations with distance from the blast, for various explosive weights per delay. The decay function will be established as the scaled range. If the test blast vibrations produce peak particles greater than seventy-five percent (75%) of those contained in Table 2.04-1, then all blasts shall be monitored.**

The Contractor shall propose specific monitoring points for each structure for the Engineer's review.

- ***Blast Vibrations.*** **Blasting patterns shall be maintained so peak particle velocity does not exceed those contained in Table 2.04-2 and also in Table 2.04-1 at frequencies greater than forty (40) Hz or one-half (1/2) of the peak particle velocities in Table 2.04-1 at frequencies less than forty (40) Hz at the subject structures.**

The Engineer will review measurements to determine if the Contractors operations are exceeding the peak particle velocity contained in Table 2.04-1 or Table 2.04-2.

If the data indicates that the peak particle velocity limitations are not being met, measures shall be taken to reduce particle velocity or overpressure to the specified . levels, including such measures as reducing the size of charge, increasing the number of delay intervals.

TABLE 2.04-1

STRUCTURE TYPE	MAXIMUM PPF (MILLIMETERS PER SECOND)
Frame Construction Timber, Frame, Brick and Concrete Buildings	50
Reinforced Concrete Structures	100
Steel Structures	100
Buried Utilities	50
Wells & Aquifers	50
Green Concrete (less than 7 days)	25

Older residential structures or utilities and structures housing computers or other sensitive equipment and founded on different materials may require lower peak particle velocity limits, as shown below in Table 2.04-2. Also, buried pipelines owned by private utility companies or bridge structures owned by other agencies are sometimes subject to lower limiting values imposed by the owner.

TABLE 2.04-2

Table 2.04-2. Permitted peak particle velocity (vertical component) as a function of distance for structures and buildings founded on different materials. (The structural coefficient is based on residential homes.)

Distance Meters (m)	Soft moraine Sand Clay	Moraine Slate Soft limestone Soft sandstone	Granite Gneiss Quartz Hard sandstone Hard limestone
Wave velocities c.	1000-1 500 m/s	2000-3000 m/s	4500-6000 m/s
PERMITTED PEAK PARTICLE VELOCITY V_1 (mm/s)			
1	18	35	140
5	18	35	85
10	18	35	70
20	15	28	55
30	14	25	45
50	12	21	38
100	10	17	28
200	9	14	22
500	7	11	15
1000	6	9	12
2000	5	7	9

2.04.8.4 Flyrock Control. Before the firing of any blast in areas where flying rock may result in personal injury or unacceptable damage to property or the work, the rock to be blasted shall be covered with approved blasting mats, soil, or other equally serviceable material, to prevent flyrock.

If flyrock leaves the construction site and lands on private property all blasting operations will cease until a qualified blasting consultant, hired by the Contractor, reviews the site and determines the cause and solution to the flyrock problem. Before blasting proceeds, a written report will be submitted to the Engineer for his approval.

2.04.8.5 Public Meetings. The Contractor shall make his qualified vibration specialist and blasting consultant available for one (1) day if requested by the Engineer to prepare for and participate in a public meeting conducted by the Engineer to better inform the public about anticipated drilling and blasting operations. The specialists shall be prepared to answer any questions dealing with the magnitude of seismic motion, and flyrock expected to impact on the public.

2.04.9 Recordkeeping.

2.04.9.1 Daily Explosive Material Consumption. The Contractor shall keep a daily record of transactions to be maintained at each storage magazine. Inventory records shall be updated at the close of every business day. The records shall show the class and quantities received and issued and total remaining on hand at the end of each day. Remaining explosive inventory shall be checked each day and any discrepancies that would indicate a theft or loss of explosive material would be immediately reported.

2.04.9.2 Report of Loss. Should a loss or theft of explosives occur, all circumstances and details of the loss or theft will be immediately reported to the nearest Department of the Interior office as well as to the local law enforcement authorities and Contractors offices representative.

2.04.9.3 Daily Blasting Logs. The Contractor shall provide the contracting officer, on a weekly basis, a daily log of blasting operations. The log shall be updated at the close of each business day. The log shall include the number of blasts, times and dates of blasts. The blasting locations and patterns and all information shown below:

1. Station limits of the shot.
2. Plan and section views of drill pattern including free face, burden, blasthole spacing, blasthole diameters, blasthole angles, lift height, and subdrill depth.
3. Loading diagram showing type and amount of explosive, primers, initiators and location and depth of stemming.
4. Initiators sequence of blastholes including delay times and delay system in each blasthole.
5. Trade names and sizes of all explosives, primers and initiators to be employed.
6. Signature of the blaster-in-charge.

The blasting logs are for quality control and recordkeeping purposes. Review of the blast log by the Engineer shall not relieve the Contractor of his responsibility for the accuracy and adequacy of the blasting log.

2.04.9.4 Video Recording of Blasts. If blasting problems develop and Public Security officials' permission is obtained, video tape recordings will be taken of several blasts. The tapes or sections of tapes will be indexed in a manner to properly identify each blast. Copies of the video tapes of blast shall be furnished to the Engineer.

2.04.10 Method of Measurement. When controlled blastholes is specified as a pay item in the bid schedule, measurement shall be per linear meter of controlled blasthole. The lineal meters of controlled blastholes to be paid for shall be the plan length computed from hole collar elevations to a depth of six hundred (600) millimeters below finished ditch grade. Holes whose alignment is in excess of three hundred (300) millimeters shall not be measured for payment.

2.04.11 Payment. **The contract unit price per linear meter for controlled blasting shall be full pay for all materials, explosives, labor, tools, equipment, and all other items necessary for proper completion of the Work as specified in Subsection 1.07.2, "Scope of Payment," in these General Specifications. Quantities shown in the plans are based on eight hundred (800) millimeter hole spacing. Actual accepted quantities will depend on field conditions, the results from test sections and the Contractors drill control. All production blasting costs are subsidiary to the Roadway Excavation Pay Item.**

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO.	PAY ITEM	PAY UNIT
20401	Controlled Blastholes	Linear Meter

SECTION 2.05 - EMBANKMENT

2.05.1 Description. This work shall consist of preparing ft original ground on which embankment is to be constructed; loading, handling, transporting and placing acceptable materials excavated from the roadway or imported from borrow sites in horizontal layers of uniform thickness for the full width of the embankment; compacting each layer, and finishing the top of the embankment in accordance with specified tolerances. It shall also cc>nsist of maintaining and draining the embankment layers, trimming embankment slopes, all as shown on the plans, specified in these specifications and the special specifications or established by the Engineer. It shall also include the placing and compacting of embankment materials in natural depressions within the roadway area and where unsuitable material has been excavated. R shall also include the construction of working platforms, plating layers, edge berms and capping of embankment made of dune sand, all in accordance with these Specifications. All embankment shall be constructed as specified herein and shall be treated as a separate item for measurement and payment purposes. Excavation shall be completed as specified in Section 2.03, "Excavation," in these General Specifications, and shall be treated as a separate item for measurement and payment purposes.

ITEMS IN BILL OF QUANTITIES
Embankment

2.05.2 Materials. Materials from roadway excavation, tunnel excavation or imported borrow meeting the appropriate specification requirements shall be used to construct embankments in accordance with the typical sections contained in the plans or as staked by the Engineer.

2.05.2.1 Embankment Materials. Embankment materials shall meet the following requirements:

1. **Material classified by MRDTM 21 0 as A-5 or better.**

2. **In areas subject to flood and prolonged inundation of the embankment, such as at bridge sites, the material used in the embankment, unless rock, shall be classified by MRDTM 21 0 as A-1 -a(O), A-1 -b(O) or A-2-4(0).**

No material described in Paragraph 2.03.2.2, "Roadway Excavation Unsuitable Material" in these General Specifications, shall be used in any embankment.

2.05.3 Construction.

2.05.3.1 Equipment. The Contractor shall provide all types, sizes and numbers of equipment which are necessary for loading, hauling, spreading, mixing, watering, compacting and finishing material to form the embankment in accordance with the plans, the special specifications, this specification and as directed by- the Engineer. Compacting operations shall include adequate blading with motor graders to insure uniformity of the layers of embankments being compacted. The number of blades and rollers in use shall be sufficient to blade and compact adequately all materials being delivered to the embankment. The Engineer shall have full authority to

suspend the delivery of materials to the embankment until previously delivered materials are properly placed and satisfactorily compacted. When construction of rock embankment is required, one (1) or more of the following additional items of equipment shall be furnished:

1. Vibratory Rollers. Minimum eighteen thousand (18,000) kilogram impact per vibration and minimum one thousand (1 000) vibrations per minute.

2. For Dune Sand Embankment construction, the additional equipment furnished by the Contractor shall include vibratory rollers with minimum fourteen thousand (14,000) kilogram impact per vibration and minimum one hundred (100) vibrations per minute.

3. The Contractor shall limit the speed of compression rollers to a maximum of six and one-half (6.5) kilometers per hour and shall limit the speed of vibratory rollers to a maximum of two and one-half (2.5) kilometers per hour (kph).

2.05.3.2 Foundation Preparation. The foundation shall have been cleared and grubbed and recompacted as specified in Section 2.01, "Clearing and Grubbing," in these General Specifications, before the foundation is prepared to receive the embankment. The surface upon which the embankment is to be placed shall be scarified to a minimum depth of twenty (20) centimeters, brought to a uniform moisture content within the specified range, and compacted to the density specified for the overlying embankment.

Up to a depth of twenty (20) centimeters, the sod and vegetation removal is considered subsidiary to other items. Sod and vegetable matter removal in excess of the twenty (20) centimeter depth, as well as the removal of other noncompactible material, will be measured for payment as roadway excavation only when ordered in writing by the Engineer. The underlying soil shall be scarified, brought to a uniform moisture content within the specified range, and compacted to the density specified for the overlying embankment.

When the embankment height is less than sixty (60) centimeters, the original ground shall be scarified to a depth of twenty (20) centimeters, watered or dried to obtain uniform moisture content and compacted to Type 95 density if the top thirty (30) centimeters of original ground meets the requirements for "Embankment Materials" in Paragraph 2.05.2.1, in these General Specifications. If the top thirty (30) centimeters of original ground does not meet these requirements or there is excessive moisture present, the top thirty (30) centimeters shall be removed and replaced with material meeting these requirements. This material shall be compacted to Type 95 density after the top twenty (20) centimeters of the underlying material is scarified, watered and compacted to Type 90 density.

When embankment is to be placed and compacted on hillsides or where new embankment is to be compacted against existing embankments, or where embankment is built part width at a time, the slopes that are steeper than one horizontal to three vertical (1 H to 3 V) when measured at right angles to the roadway shall be continuously benched over those areas where it is required as the Work is brought up in layers. Benching shall be of sufficient width to permit

operations of placing and compacting equipment and/or as directed by the Engineer. Each horizontal cut shall begin at the intersection of the original ground and the vertical sides of the previous cuts. Material thus cut out shall be recompacted along with the new embankment material at the Contractors expense, unless the width of the excavation required and ordered by the Engineer exceeds two (2) meters, in which .case the excavated material for bench widths in excess of two (2) meters will be measured and paid for as roadway excavation. Payment will include full compensation for all labor, equipment, tools and incidentals used to bench hillsides using greater than two (2) meter bench widths.

If the original surface upon which embankment is to be placed is an old roadbed, the surface shall be plowed, scarified, or broken up to a depth of twenty (20) centimeters and recompacted to the density specified for the overlying embankment. No separate payment will be made for this work as it is considered subsidiary to the various items in the Bill of Quantities.

2.05.3.3 Imported Borrow Material. Imported Borrow Material shall be utilized to supplement roadway excavation as may be required to complete the layers of embankment to the lines, grades and cross sections shown on the plans, specified in the Special Specifications and as staked by the Engineer.

Imported borrow material includes material taken from borrow sites, whether or not shown on the plans or described in the Special Specifications and from the widening of cuts when said widening is approved by the Engineer in writing.

Borrow sites shall not be located so that any edge is closer than three hundred (300) meters from embankment toe of slope unless otherwise shown on the plans, specified in the Special Specifications or approved by the Engineer.

Imported borrow material shall not be taken from any area within five hundred (500) meters downstream of a drainage structure unless approved by the Engineer in writing. Such borrow sites shall be backfilled and compacted, as directed by the Engineer, at the Contractors expense.

Imported borrow material shall not be taken from flat or depressed areas or areas that would become pits or depressions as a result of the borrow excavation, regardless of the areas' location. All imported borrow material shall be cut from the hills or areas with elevations higher than the surrounding existing ground level. After the removal of the borrow material the areas excavated shall still have elevations higher than the surrounding ground level. The excavation shall be done in a neat and workman-like manner and the competed excavation shall be finished and restored to a naturally appearing elevation and cross section condition acceptable to the Engineer and the owners of the lands in accordance with the approved Site Excavation, Regrading and Restoration Plan.

If the Contractor desires to borrow from locations within the right of way, he shall submit a request to the Engineer with the locations and the quantity of borrow to be removed along with a Site Excavation, Regrading and Restoration Plan for each site. The Engineer shall review each site and site Excavation, Regarding and Restoration Plan and when satisfied with the Plan forward the request to the

concerned municipality. The Municipality shall select the acceptable borrow excavation sites within the right of way, determine the quantity of materials to be removed and approve each Site Excavation, Regrading and Restoration Plan. If the Contractor desires to import borrow materials from sites away from the right of way, he shall submit a similar request and Site Excavation, Regrading and Restoration Plan to the Engineer and obtain similar approvals for such imported borrow from the Engineer and the owners of the lands at his sole and exclusive cost.

The Contractor shall obtain prior approval, in writing, from the Engineer and the owners of the lands or the concerned Municipality for each borrow site, quantity to be removed, and each Site Excavation, Regrading and Restoration Plan. Should the Contractor fail to comply with this requirement he shall be solely responsible for complete backfilling and reestablishing these excavations including native vegetation.

The Contractor shall perform preliminary testing of all proposed sources of imported material for embankment. The preliminary testing shall consist of test pits and/or borings and testing of samples. This testing shall include, at the minimum, the following tests for each soil or rock strata in each proposed source:

1. **Classification - MRDTM 210 (All Required Tests)**

2. **Proctor - MRDTM 212 or MRDTM 214 if appropriate**

3. **California Bearing Ration (CBR) - MRDTM 213**

The Contractor shall furnish all test data to the Engineer at least two (2) weeks prior to taking material from the site and request preliminary approval from the Engineer to use the borrow, site. The Engineer shall review the test information and accept or reject the Contractors request in writing. Final approval of the material shall be based on acceptance samples taken from each layer of embankment.

Before abandoning any borrow site located on public or private property, the Contractor shall, at his sole expense, clean and trim the borrow site, haul roads and all areas occupied during the work, in accordance with the approved Site Excavation, Regrading and Restoration Plan, all to the satisfaction of the Engineer and property owner.

2.05.3.4 Placement of Materials. Logs, trees, stumps, seeds, heavy grass, frozen soil, or other undesirable materials, shall not be placed in the layers of embankment.

When an embankment surface is to be constructed over an area previously occupied by a building basement, cellar, irrigation canal, well, any previous excavation, or other such construction that will not permit the use of normal compaction equipment, the embankment construction shall conform to the backfilling requirements specified in Subsection 2.09.4.5, "Backfilling Structures," in these General Specifications, until the normal compaction equipment can be used. The material shall be compacted to the density specified for the adjacent embankments.

The Contractor shall have in operation a sufficient number of motor graders to properly smooth and maintain the surface of each layer of freshly placed embankment prior to and during rolling and compacting operations.

When it is feasible, trucks, scrapers, tractors, or other heavy hauling equipment shall be routed over the fill in such a manner as to take advantage of the compaction afforded thereby. The Engineer shall have full authority to require at any time, the suspension of delivery of material to the embankment until previously delivered materials have been satisfactorily spread and uniformly compacted to the specified density.

Embankments shall not be constructed by means of a dragline except with the special permission of the Engineer and when special provisions are made to keep the layers uniform and the embankment level well-drained at all times.

Materials of widely divergent characteristics shall not be mixed within the embankment limits to produce a mixture meeting the requirements of Paragraph 2.05.2.1, "Embankment Materials" in these General Specifications. Such widely divergent materials may be mixed, sampled and tested outside the embankment limits and the mixture may be used as a proposed source of imported material for embankment as outlined in Paragraph 2.05.3.3, "Imported Borrow Material" in these General Specifications. Obtaining, handling, mixing, transporting, placing and compacting of these materials shall not be a basis for additional payment except as provided in the Section 2.05, "Embankment," in these General Specifications.

Where embankments are constructed across marshlands, tidal flats, or wet ground which is soft and compressible and will not support the weight and forces of hauling and compacting equipment, the lower part of the embankment may be constructed by dumping successive loads in a uniformly distributed layer (bridging lift) of a thickness not greater than necessary to support equipment hauling, and the placing and compacting of subsequent layers. Such supporting layers shall not be subjected to the compaction requirements specified in Subsection 2.05.4, "Lift Thickness and Compaction Requirements," in these General Specifications. The remainder of the embankment shall be constructed in layers as specified in this specification.

When the roadway profile is so low that the construction of the lower part of the embankment using a "bridging lift" will not permit the placement and compaction of sixty (60) centimeters of acceptable embankment material, the following procedure shall be followed:

1. The Contractor will excavate the soft and compressible material to the minimum depth required to permit the placement of one (1) or more bridging lifts and sixty (60) centimeters of embankment material placed and compacted in accordance with Paragraph 2.05.4.3, "Earth Embankment Lift Thickness and Compaction Requirements," in these General Specifications.

2. The Contractor will construct the bridging and regular embankment lifts and complete the embankment to the specified density and finishing tolerances.

Boulders and rock fragments larger than twenty (20) centimeters in maximum dimension shall not be placed in the embankment any closer than sixty (60) centimeters from the staked top of the embankment.

Rocks, broken concrete and other solid material having a diameter greater than ten (1 0) centimeters shall not be placed in embankment where piling is to be installed by driving or drilling.

When an embankment settlement period is specified in the special specifications, the embankment shall remain in place for the required settlement period before placing the 30 cm thick subgrade layer, excavating for abutments, wing walls or retaining wall foundations or installing foundation piles at each location.

When embankment surcharge is to be placed as specified in the special specifications, it shall be placed in layers of uniform thickness, using tractor equipment compaction and shall remain in place for the full settlement period specified. The surcharge shall be removed and disposed of at the toe of slope along both sides of the embankment, used to construct embankment elsewhere or at locations approved by the Engineer. When surcharge material is placed at the toe of slope it shall be placed alternately along both sides of the embankment, to equal elevations and compacted as specified in Subsection 2.05.4, "Compaction Requirements," in these General Specifications.

Settlement platforms and heave stakes shall be furnished, installed and monitored as provided in the special specifications.

2.05.3.5 Embankment Drainage and Slope Stability. When constructed next to a hillside, the embankment surface shall slope away from or parallel to the hillside in one (1) or more directions until such time as the subgrade is finished. At the end of each day's operations, the Contractor shall shape and compact the embankment surface to a uniform enough cross section that will allow water to drain and eliminate all ruts and spots that could hold water. Dikes and slope drains shall be constructed and maintained along the embankment edges to prevent water from spilling over the edge and eroding the side slopes.

The Contractor shall be responsible for the stability of all embankments and surcharges and shall replace all sections of same which, in the opinion of the Engineer, have been damaged or displaced (slumped or slid) due to carelessness or neglect on the part of the Contractor, or due to normally occurring natural causes, such as erosion caused by wind or water, and not due to the unavoidable movement of the natural ground upon which the embankment is made. When unacceptable material has been placed in the embankment, its removal shall be at the expense of the Contractor.

2.05.3.6 Dune Sand Embankment. Construction of embankments with dune sand shall be accomplished as shown on the plans, specified in the special specifications and this specification and as directed by the Engineer. Construction of embankment with dune sand shall be accomplished in a series of operations as follows:

1. Edge berms shall first be constructed along both sides of the staked embankment, except where the embankment is to be constructed against hillsides or existing embankment, using Class A-1 or A-2 soils from roadway excavation or borrow which resist erosion by wind and water and are approved by the Engineer. Edge berms shall be constructed with an external side slope as shown on the plans or specified in the special specifications, but not steeper than one (1) vertical to six (6) horizontal. Edge berms shall be constructed not more than forty (40) centimeters in height and not less than two (2) meters wide at the top. The materials shall be placed and spread in layers as specified in this specification and compacted as required by Subsection 2.05.4, "Lift Thickness and Compaction Requirements," in these General Specifications.

When the embankment is constructed against hillsides other than sand dunes or existing embankment, the hillside and existing embankment shall be benched as specified in Paragraph 2.05.3.2, "Foundation Preparation" in these General Specifications.

2. Dune sand shall be excavated, hauled, deposited and spread within the edge berms to the full height of the edge berms using any means other than hydraulic sluicing.

The above series of operations shall be repeated until the embankment is completed to an elevation thirty (30) centimeters below the staked top of embankment. Material equal to that used to construct edge berms shall be placed and compacted to finish the embankment. The thirty (30) centimeters thick subgrade on top of the embankment shall be completed as specified in Section 2.06, "Untreated Subgrade," in these General Specifications.

The dune sand at all points along the side slopes of the embankment shall be covered with a minimum two (2) meter thickness of compacted Class A-1 or A-2 soils which will resist erosion caused by wind and water.

2.05.3.7 Fugitive Dust and Soil Erosion Control Plan.

2.05.3.7.1 General. Prior to start of work the Contractor shall furnish the Engineer a fugitive dust and soil erosion control plan. The plan shall detail the proposed coordination for minimizing fugitive dust and accomplishing the temporary and permanent erosion control work in a timely and appropriate manner. No work shall be started until the plan has been approved and the necessary controls installed as required for the particular operation to be in progress.

The Contractor will be directed to provide immediate fugitive dust and permanent or temporary erosion control measures to prevent fugitive dust and soil erosion that will adversely affect public traffic, damage adjacent properties, or cause

contamination of adjacent watercourses, ponds or other areas of water impoundment. Such work may involve the construction of temporary berms, dikes, dams, sediment basins, slope drains and use of temporary mulches, mats, seeding or other control devices or methods as necessary to control erosion. Such work may also involve water mist over dusty construction operations, tarps over hauling trailers, chemical suppressants, wheel washing, flushing and mechanical sweeping of paved surfaces, and installation of gravel buffer zones to minimize fugitive dust.

The Contractor shall incorporate all permanent erosion control features into the project at the earliest practicable time as outlined in the accepted schedule to minimize the need for temporary erosion control measures. If the Engineer determines that the Contractor is not in compliance with the approved fugitive dust and erosion control plan or field conditions warrant changes in the plan, the Contractor shall submit a revised schedule for performing fugitive dust and erosion control work and no work contingent upon the revised schedule shall be continued or started until the revised plan has been approved.

Grubbing operations shall be so scheduled and performed that grading operations and permanent erosion control features can follow immediately thereafter if the project conditions permit; otherwise, temporary erosion control measures may be required between successive construction stages.

Excavation, borrow, and embankment operations shall also be scheduled and performed to permit permanent erosion control features to follow immediately thereafter if project conditions permit; otherwise, temporary erosion control measures may be required. Under no conditions shall the surface area of erodible earth material exposed at one time by excavation, borrow, or fill exceed 70,000 square meters without the written approval of the Engineer.

The Engineer will limit the area of grubbing, excavation, borrow and embankment operations in progress commensurate with the Contractor's capability and progress in keeping the finish grading, surface ditching mulching, seeding and other such permanent erosion and pollution control measures current in accordance with the accepted schedule.

In the event that temporary erosion and fugitive dust control measures are required due to the Contractor's negligence, carelessness or failure to install permanent controls as a part of the work as scheduled or as ordered by the Engineer, such work shall be performed by the Contractor at no cost to the Ministry.

Temporary erosion and fugitive dust control may include construction work outside the right-of-way where such work is necessary as a result of road construction such as borrow pit operations, haul road construction and maintenance and equipment storage sites.

The erosion control features installed by the Contractor shall be operated and maintained by the Contractor in an acceptable functional condition.

2.05.3.7.2 Erosion Check Dams. Erosion checks, constructed with riprap or sand bags shall be staked in place as shown on the plans or where ordered installed by the Engineer to act as erosion filters and barriers at the toe of fills, in ditches, at pipe inlets and outlets, or for other uses as directed.

2.05.3.7.3 Sediment Containment Structures. Settling ponds, basins, dikes, dams or other such containment structures shall be constructed in accordance with the details specified in the contract or designated by the Engineer.

2.05.3.7.4 Diversion Channels. Temporary diversion channels for diverting water around an area where a culvert is to be installed shall be lined with plastic film sheeting. The diversion channel shall be excavated to a depth and width adequate to accommodate stream flow during the period of culvert installation. The channel shall be reasonably smooth and free of sharp rocks, stones, roots or other projections that may puncture the plastic liner. No longitudinal seams will be permitted. Transverse seams shall be lapped a minimum of 1 meter in the direction of flow. The liner shall be anchored in place using clean rock, gravel, or other methods approved by the Engineer.

2.05.3.7.5 Earth Berms. Temporary earth berms shall be used for diverting or channeling runoff waters to slope drains, waterways, diversion ditches, sediment traps, or other uses as directed. Earth berms shall be constructed to the dimensions shown on the plans and at the locations established by the Engineer. Material shall be reasonably nonporous and shall contain no frozen material, roots, sod or other deleterious materials.

2.05.3.7.6 Slope Drains. Temporary slope drains shall be constructed at the intervals and locations designated by the Engineer for channeling runoff waters down embankment slopes.

Temporary slope drains shall be adequately anchored to the slopes and their outlets constructed or anchored to prevent erosion.

2.05.3.7.7 Turf Establishment. When it is not practical or not permitted to perform permanent turf establishment work temporary seeding, fertilizing, liming, and mulching shall be applied. The applicable rates and types of materials for temporary turf establishment shall be as specified in the Special Specifications and established by the Engineer.

2.05.3.7.8 Cleanup. After the temporary erosion and fugitive dust control installations are no longer required, the Contractor shall remove and dispose of all materials and restore the areas to their original appearance in a manner acceptable to the Engineer.

2.05.3.7.9 Method of Measurement. When the Special Specifications and Bill of Quantities contain pay items including estimated quantities for soil erosion and pollution control items of work on a unit price basis, the applicable measurements will be made as follows:

(1) Quantities to be measured on an each basis will be the actual number and kind of units ordered installed and accepted.

(2) Linear meter quantities will be measured along the line and grade of the installation end-to-end as ordered installed and accepted.

(3) Square meter quantities will be measured on the ground surface of the installation as ordered installed and accepted.

(4) Area quantities based on acres and fractions thereof will be determined with horizontal measurements.

(5) Quantities to be measured on a weight basis will be measured by the kilogram or ton, as applicable.

Commercially furnished products may be accepted based on the weight as packaged by the manufacturer.

(6) Station or kilometer quantities will be measured horizontally along the centerline of the roadbed.

(7) Quantities measured on a cubic meter basis will be measured in the hauling vehicle at point of delivery.

2.05.3.7.10 Basis of Payment. The accepted quantities, determined as provided above, will be paid for at the contract price per unit of measurement, respectively, for each of the particular pay items that are shown in the Bill of Quantities, which prices and payments will be full contract compensation for the work prescribed in this Section.

No additional payments will be made for any adjustments, cleanout and disposal of accumulated sediments or other such maintenance work on previously installed erosion and pollution control facilities.

No direct payment will be made for furnishing, installing, and subsequently removing and disposing of temporary drainage structures, such as culvert pipe or polyethylene sheeting, used for diverting of live streams around or through work areas, but such work will be considered as a subsidiary obligation of the Contractor.

When the Special Specifications and Bill of Quantities do not contain estimated quantities for soil erosion and pollution control work, the work will not be paid for directly but will be considered as a subsidiary obligation of the Contractor under other contract items.

2.05.4 Lift Thickness and Compaction Requirements.

2.05.4.1 Description. This Work shall consist of the placement and compaction of embankment by rolling or tamping or any combination of these methods in accordance with the requirements specified for the Moisture Content Range and Type of compaction designated on the plans, in the Special Specifications or. ordered by the Engineer.

2.05.4.2 Testing Methods.

1. Moisture Density Test. A Moisture Density Test (MRDTM 212) and preliminary study will be made of each type of soil to be used in the construction of the Work to determine the Maximum Density, the Optimum Moisture content and the Moisture Content Range required of the soil for satisfactory compaction. The Field Density and actual Moisture Content of the compacted embankment shall be determined by field tests according to MRDTM 215. The Maximum Dry Density as determined by MRDTM 212 shall be adjusted by AASHTO T 244 to compensate for differing percentages of coarse particles on the 4.75 millimeter (No. 4) Sieve in the Field Density Test Sample.

(1) Maximum Density. The Maximum Dry Density as determined by the Moisture-Density Test shall be the density to which the Field Density is referred for comparison or percentage for each type of soil used in the Work.

(2) Optimum Moisture. The Optimum Moisture shall be the moisture content corresponding to the Maximum Density on the Moisture-Density curve.

(3) Moisture Content Range. The Moisture Content Range shall be limits of moisture content of each 4" of soil with the Optimum as a reference.

(4) Field Density. The Field Density shall be the density of the compacted embankment determined by the Field Density test.

(5) Moisture Content. The Moisture Content shall be the actual content of the soil in the compacted embankment at the time of compaction.

2. Relative Density Test. For cohesionless free-draining soils for which impact compaction will not produce a well-defined moisture density relationship curve and the maximum density, the Test for the Relative Density of Cohesionless Soils (MRDTM 214) shall be used to determine the relative density.

Relative density is defined as the state of compactness of a soil with respect to the loosest and densest state at which it can be placed by the laboratory procedures described in the MTDTM 214. The Field Density and actual Moisture Content of the compacted embankment shall be determined by field tests according to MRDTM 215 and 216, or by the nuclear method MRDTM 218.

(1) Relative Density. The Relative Density as determined by the Relative Density Test shall be the standard to which the Field Density is referred for comparison for each type of cohesionless soil used in the Work.

(2) Field Density. The Field Density shall be the density of the compacted embankment determined by the Field Density test.

(3) Moisture Content. The Moisture Content shall be the actual content of the soil in the compacted embankment at the time of compaction.

3. Borderline Materials. In cases where borderline materials are encountered, both methods will be utilized and the method which results in the higher laboratory maximum density shall be used as the standard to which the field density is compacted.

4. Plate Load Test. In addition to the Moisture-Density Test and the Relative Density Test, the compaction of earthwork may also be checked by a Plate Load Test (German Method for Roads). This method is described in MRDTM 237A. The Test shall be applicable for all soils but not rockfill. Use of the Plate Load Test for the Dune Sand, A-3(0), shall be encouraged.

2.05.4.3 Earth Embankment Lift Thickness and Compaction Requirement. The top sixty (60) centimeters of all embankments and all embankment layers not meeting the Paragraph 2.05.4.4, "Rock Embankment Lift Thickness and Compaction Requirements," for rock fill shall be constructed, controlled and compacted as earth embankment. Earth embankment layers shall be placed in horizontal lifts not exceeding twenty (20) centimeters (loose measurement) and shall be compacted as specified and accepted by the Engineer before the next layer is placed. Horizontal layers in excess of twenty (20) centimeters (loose measurement) and up to the depths shown below may be approved by the Engineer if compaction trial sections verify that the required density can be uniformly attained. Effective spreading equipment shall be used on each layer to obtain uniform thickness prior to compacting. As the compaction of each layer progresses, continuous leveling and manipulating will be required to assure uniform density. Proper moisture content shall be established in order to obtain and maintain the required density. Construction equipment shall be routed uniformly over the entire surface of each layer. A motor grader shall be used on the embankment at all times during the placing and compacting of the earth material.

The compaction requirements as controlled by the methods of testing specified in Paragraph 2.05.4.2, 'Testing Methods," in these General Specifications are as follows:

1. Type 98. Compacted density of the soil shall be equal or greater than ninety eight percent (98%) of Maximum Density or seventy-six percent (76%) of Relative Density.

2. Type 95. Compacted density of the soil shall be equal or greater than ninety-five percent (95%) of Maximum Density or seventy-four percent (74%) of Relative Density.

3. Type 90. Compacted density of the soil shall be equal or greater than ninety percent (90%) of Maximum Density or seventy percent (70%) of Relative Density.

4. Special Compaction. Where specified on the plans or in the Special Specifications, the embankment shall, in addition to meeting the requirements of a specified type of compaction, be formed of a material and compacted to meet a specified CBR (California Bearing Ratio) requirement. The material and methods of compaction shall be as determined from tests in accordance with AASHTO T 193.

5. Specific Compaction Requirements are as follows:

Subgrade-Expressways and Major Link Roads	Type 98
Subgrade-Agricultural Roads and Links	Type 95
Top 60 cm of Embankment	Type 95
Bottom Portion of Embankment	Type 90
Agricultural Roads and Links Embankment	Type 90
Natural Ground	Same type compaction requirement as embankment layer above the Natural Ground.
Natural Ground-Touch Grade	Compaction Requirement type 5% less than the compaction requirement type for subgrade.

6. Special Loose Lift Thickness Maximums subject to Verified Uniform Density during test sections and special quality requirements:

For the top sixty (60) cm of the Embankment thirty (30) cm Lifts may be attempted subject to verified uniform density throughout the full depth of the lift. However, A-3, A-6, and A-7 material are not permitted.

For the remaining portion of the Embankment:

MATERIAL TYPE PERMITTED .	LIFT THICKNESS
A-1 -a, A-1 -b, and A-2-4	30 cm.
A-4 and A-5	20 cm.
A-3 (0)	50 cm.

2.05.4.4 Rock Embankment Lift Thickness and Compaction Requirements. The following criteria should also be followed in the acceptance of rockfill:

1. Material.

(1) The material used for rockfill embankments shall consist predominantly of rock fragments of such size that the material can be placed in layers of the thickness prescribed, conforming to the following requirements:

Table 2,05-1

Maximum particle size... 2/3 loose layer thickness
Passing 0.6 mm (No. 30 Sieve).25% maximum
Uniformity coefficient, Cu 5 minimum, where
Cu = D60/D10
D60 = the particle size at which 60% passes
D10 = the particle size at which 1 0% passes

(2) Rockfill material shall be obtained from roadway, underground structures excavation or quarry and shall be sound, dense, hard and durable rock capable of being placed and compacted as specified. Individual pieces are to be clean and angular. It shall be the Contractors responsibility to excavate material from rock cuts whether by blasting or other manner, so that all excavated materials are of suitable size; large size materials will not be paid for as waste, but shall be disposed of in an approved manner without additional compensation.

(3) The maximum permitted layer thickness shall be related to the unit weight of the vibratory roller used for compaction as given in Table 2.05-2 below, and shall not exceed one hundred (1 00) centimeters loose measurement.

Table 2,05-2

Maximum Thickness of Layer (Loose Measurement) Centimeters	Minimum Roller Mass on Drum (kilogram/unit width,)
40	2300-2900
60	2900-3600
80	3600-4300
100	4300-5000

** For multiple roller, this shall be assessed on the high axle load.

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(4) Rockfill materials shall be placed in such a manner that the larger rocks are well distributed and the voids are filled to the maximum practical extent by smaller particles, each layer shall be bladed into a neat and homogenous mass prior to compaction. Any rocks found protruding from the leveled surface shall be removed and replaced in by smaller particles. Initial breakdown compaction shall

be performed with heavy bulldozers. After compaction each layer must be approved by the Engineer before the next layer is placed.

(5) Depending on the type of rockfill material, water may be added as required and approved by the Engineer to achieve a maximum compaction.

(6) Rockfill shall not be used in the top sixty (60) centimeters of the embankment (below the bottom of the subgrade), nor shall it be used to within five (5) meters of a structural element (next to bridge abutments, footings, etc.). The side slopes of rockfill embankments shall be thoroughly blanketed with A-2-4 or better material placed perpendicular to the slope in twenty (20) centimeters thickness and compacted to "Type 95" to seal the surface.

(7) Rockfill shall not be used for sixty (60) centimeters on top and bottom of Box and Pipe Culverts. Subgrade or trench backfill material compacted to "Type 95" requirements shall be used in these areas up to the width excavated for structures.

2. Compaction

(1) To ensure proper compaction of rockfill embankments, the Contractor shall be required to conduct compaction tests using equipment and materials available in the presence of the Engineer to develop compaction control criteria. To conduct compaction control test the following steps shall be followed:

1) A rockfill test section shall be placed on a firm surface approved by the Engineer, the material and layer thickness conforming @o the requirements of Tables 2.05-1 and 2.05-2.

2) The test section shall be of sufficient dimensions to permit the establishment of at least twenty (20) leveling points on a five (5) meters square (5 sq.m.) grid, and no fewer than three (3) points on any line and no point less than three (3) meters from the edge of the layer.

3) Compaction shall then commence with a minimum of three passes of a vibratory roller conforming to the requirements of Table 2.05-2, leveling points are then established. Short lengths of painted steel bars hammered flush with the surface of the rockfill have been found suitable for this purpose. A level reading is taken at each leveling point on top of a moveable thirty (30) centimeters square flat steel plate. A hole drilled in the center of the plate will enable a visual check to be made that the plate is located centrally over the bar each time.

4) Further readings are then taken at the leveling points. After two (2) additional passes with the roller, if the average settlement is less than one percent (1 %) of the average compacted layer thickness, or as determined by the Engineer, the rockfill compaction test is completed.

5) If the average settlement is more than one percent (1 %), two (2) additional passes of the roller are required and the leveling procedure is

repeated. If the average settlement is now less than one percent (1 %), the test is completed. If not, this step is then repeated.

6) The total number of passes of the rolling equipment necessary to obtain the required result will establish the minimum number of passes to be used on the rock embankments. The Contractor shall then use this verified procedure, that is, the equipment, rolling pattern, and number of passes, during the construction of rock embankments. However, in no case shall the number of passes be less than five (5).

(2) This verification procedure shall be conducted for each change of material and at least once each week during the initial stages of construction until reliable rolling pattern is established. The frequency then can be reduced as approved by the Engineer.

(3) Documentation of the rockfill compaction test shall be maintained in the project records.

3. Preparation of Natural Ground. All surfaces to receive rockfill are to be prepared as specified in Paragraph 2.05.3.2, "Foundation Preparation" in these General Specifications. Soil surfaces are to be scarified and recompacted to at least ninety percent (90%) of maximum dry density as determined by AASHTO T180 (Method D.) Compaction is to be to a depth of at least twenty (20) centimeters below ground surface. Hard or smooth surfaces are to be roughened before filling is placed. Existing road surfaces and the like are to be broken up and removed.

4. Approval of Material for Rockfill. Individual pieces are to be neither elongated nor flat, the longest dimension not exceeding twice the shortest dimension. At least seventy-five percent (75%) of the material shall be greater than twenty (20) centimeters.

5. Monitoring Settlement. On completion of the embankment, the Contractor shall carry out precise leveling of the crest of the embankment. This shall consist of leveling transverse sections (a minimum of five (5) points) at a maximum spacing of thirty (30) meters along the embankment. These shall be referenced to a stable approved datum. Leveling shall be carried out at suitable time intervals until the average rate of settlement over a period of one (1) month does not exceed 0.05 mm per day. No permanent pavement construction will be permitted until the specific criteria is achieved.

6. Tamping. Whenever embankments are placed adjacent to structures or at locations where it is not practicable to use a roller, the embankment materials shall be tamped by the use of mechanical rammers or tampers. Each layer shall be compacted to a density to or greater than obtained under the above rolling procedure for the type of compaction designated. Each successive layer shall contain only that amount of material which will insure proper compaction but in no instance shall any layer be greater than twenty (20) centimeters (loose measurement) in depth. Each layer must be approved by the Engineer before the next layer is placed. When the quantity of Work is small, a hand tamper may be used with the permission of the Engineer.

7. **Special Provisions for Other Rollers.** When special heavy rollers are used, the loose thickness of the layer may be increased when approved by the Engineer as long as ninety percent (90%) Maximum Density or seventy percent (70%) of Relative Density is achieved. Satisfactory compaction is defined as compaction which results in a uniform density throughout the entire depth of the layer equal to or in excess of the specified density. The maximum compacted thickness of the layer shall be established by the Engineer for each type of heavy roller used and for the various types of soil encountered. The Engineer reserves the right to vary the compacted thickness of the layer as the Work progresses to insure adequate compaction or to rescind approval of the heavy rollers.

2.05.5 Moisture Content Control Requirements. The moisture content of the soil at the time of compaction shall be such that the soil can be compacted to the requirements of the type of compaction designated on the plans or ordered by the Engineer. The Moisture Content Range shall be determined by the Engineer during the Compaction Trials.

The Moisture Content Requirements required when the compaction is under the methods of testing specified in Paragraph 2.06.2.2, "Relative Density Test," in these General Specifications shall be the Moisture Content Range directed by the Engineer as determined during the Compaction Trials.

When the moisture content of the soil does not fall within the required moisture range, water shall be added and thoroughly mixed into the soil, by approved methods or the material shall be aerated, whichever is needed to adjust the soil to the proper moisture content.

The amount of water to be added shall be only that amount that will, as determined by the Engineer by field tests, provide a moisture content in the soil within the required range plus a reasonable amount to compensate for evaporation and other unavoidable losses. Water added in excess of this amount shall be considered as excess water and must be removed by aeration or other suitable means as directed by the Engineer. Satisfactory methods and sufficient equipment shall be used for the furnishing and handling of the water so that there will be no undue loss due to evaporating or waste. If water is added to cut areas or borrow pits, the surfaces of the areas or pits shall be maintained in such a manner that will prevent undue loss of moisture.

From other than the results of the Moisture Content test, the moisture content of the soil being compacted shall be considered as being too high to insure compaction when, after repeated rollings with the sheepsfoot roller, the roller continues to pick up excessive amounts of soil and refuses to "build up" so that the tamping foot eventually ride the compacted surface.

When other types of rollers are used, the moisture content of the soil shall be considered as excessive when "bridging" or "building up" of the soil occurs in front of, or behind the rear wheels of such rollers, and/or when earth hauling equipment produces excessive ruts in the rolled surfaces.

2.05.6 Compaction Test Sections. Prior to the commencement of embankment construction, the Contractor shall make compaction test sections as directed by the Engineer. The compaction equipment to be used shall be the one (1) specified in the Contractors detailed program of work and approved by the Engineer. The object of these trials is to determine the relationship between the layer thickness, field molding moisture content of the material, field density, and the number of compaction passes.

The Engineer may order additional compaction test sections when he deems them necessary.

2.05.7 Quality Assurance Procedures. Embankment shall be accepted by lot unless otherwise stated in the Special Specifications. The lot size will be each embankment lift or portion of lift up to a maximum of ten thousand (1 0,000) cubic meters in accordance with the lift thickness requirements specified in Subsection 2.05.4, "Lift Thickness and Compaction Requirements," in these General Specifications. The embankment shall be sampled, tested and evaluated in accordance with Section 1.08, "Acceptance," in these General Specifications. The Engineer may, during the beginning of placement of embankment, at times when test results indicate erratic characteristics and at any other time, reduce the lot size to sections of embankment with similar quality characteristics. This should facilitate the isolation and modification or replacement of low-quality materials with materials of acceptable quality to maintain the overall strength of the embankment.

The Engineer shall perform or supervise the performance of all quality assurance sampling and testing. The location of all samples and tests shall be recorded by roadway, embankment height, centerline station (kilometer) and offset. Quality assurance testing for each lot shall include:

1. Lift thickness
2. Compaction
3. Classification
4. Embankment Finishing Tolerances and Requirement
5. Acceptance

2.05.7.1 Lift Thickness. The thickness of each lift of embankment shall be measured at the beginning and periodically during the construction of the lift.

A lot will be accepted when all lift thickness measurements are no greater than those specified in Subsection 2.05.4, "Lift Thickness and Compaction Requirements," in accordance with these General Specifications.

2.05.7.2 Compaction. The compacted density for each layer of embankment shall be determined by the sand cone method, MRDTM 215, or by nuclear method, MRDTM 218 using full depth penetration, at the option of the Engineer.

When the sand cone method is used, unless otherwise stated in the Special Specifications, the tests shall be made at five (5) randomly selected locations in each lot.

When the nuclear method is used, unless otherwise stated in the Special Specifications, the tests shall be made at eight (8) randomly selected locations in each lot. Three (3) nuclear gauge readings shall be made at each test location within a radius of two (2) meters. The three (3) readings shall be averaged and the average considered to be the density for that test location.

Percent relative compaction shall be computed by comparing the average actual in-place compacted density from the eight (8) nuclear gauge or five (5) sand cone test results with the maximum density determined by MRDTM 212. For example, MRDTM 212 maximum density shall be determined from samples of embankment at a sampling frequency of one (1) test per three (3) lots. The maximum density used for determining percent compaction shall be the running average for three (3) consecutive tests.

Any lot of embankment that has a percent relative compaction below the minimum percent compaction specified in Subsection 2.05.4, "Lift Thickness and Compaction Requirements," in these General Specifications, resulting in a reduced pay factor of 0.75 or higher determined in accordance with Subsection 1.08.5, "Statistical Evaluation of Work for Acceptance and Determination of Pay Factor (Value of Work)," in these General Specifications may be accepted on the basis of a reduced payment if requested in writing by the Contractor. Otherwise the said lot shall be removed and replaced by the Contractor at his expense. Lots that have percent relative compaction resulting in a reduced pay factor less than 0.75 shall be removed and replaced by the Contractor at his expense.

2.05.7.3 Classification. Classification including gradation, plastic limit and liquid limit will be tested, and evaluated on the results of a minimum of one (1) sample per lot for the first three (3) lots and then one (1) sample for every fifth lot when changes in material properties is suspected by the Contractor or Engineer.

A lot will be accepted when all the classification tests representing that lot are as specified in Subsection 2.05.2, "Materials," in these General Specifications.

2.05.7.4 Embankment Finishing Tolerances and Requirements. Embankment Quality Assurance measuring or testing shall involve verification that the embankments are constructed, timely finished and trimmed in a neat, workmanlike manner to the lines, grades and typical cross sections shown on the plans or staked by the Engineer within the following tolerances and deadlines:

1. Embankment slopes shall be constructed in conformance with the lines and grades established by the Engineer. The completed slopes within one (1) meter of top of embankment grade shall not vary by more than fifteen (1 5) centimeters from the staked slope measured at right angles to the slope. Slopes below one (1) meter shall not vary more than thirty (30) centimeters from the staked slope, measured at right angles to the slope.

2. Median and side slopes which are on a one (1) vertical to six (6) horizontal (6:1) or flatter slope in excavation as well as embankment shall be finished in accordance with the lines and grades established by the Engineer. The completed slopes shall not vary more than one (1) centimeter from the designated slope, measured at right angles to the slope. Flowlines within medians shall be carefully graded to drain and shall not vary more than five (5) centimeters) from the grade line established by the Engineer.

3. Finished Grade of Top of Embankment. The elevation of the finished top of embankment shall be checked under the supervision of the Engineer. Each cross section shall be checked at each change in cross slope and intermediate points as directed. Cross sections shall be established at maximum intervals of twenty-five(25) meters with additional sections as directed by the Engineer. The allowable tolerance of the finished embankment above the staked elevation shall be two (2) centimeters.

4. Variations above the design elevation shall not result in the diminished thickness of any subsequent layer. The allowable tolerance of the finished embankment below the staked elevation shall be forty (40) millimeters. Isolated variations below the staked elevation shall be compensated by additional thickness of the following subgrade layer.

5. Embankment slopes shall be finished in a timely manner preferably immediately following the finishing of the roadbed. In no case, however, shall any bituminous prime coat or bituminous concrete pavement be placed before the embankment slopes are finished and accepted.

2.05.7.5 Acceptance. Embankment construction including lift thickness classification and surface tolerances shall be accepted under Subsection 1.08.4, "Measured or Tested Conformance," in these General Specifications.

Compaction will be accepted under Subsection 1.08.5, "Statistical Evaluation of work for Acceptance and Determination of Pay Factor (Value of Work)."

2.05.8 Method of Measurement. When payment is specified on a volume basis in the Bill of Quantities, quantities of "Embankment" shall be computed by the Contractor and checked by the Engineer. Quantity computations shall be based on the original ground cross sections taken by the Contractor which were observed by and attested to by the Engineer and staked elevations developed from the typical sections in the plans and based on the Contractors staking notes which were checked and attested to by the Engineer using the Average End Area Method. These shall include zero area stations at inflection points between cut and all areas. Any materials excavated or placed before these measurements have been taken and approved by the Engineer will not be paid for.

Measurements will be made for embankment materials actually used to replace unsuitable materials removed to obtain proper compaction in foundations to fillsections.

Where it is impractical to measure material by the cross section method due to the erratic location of isolated deposits, acceptable methods involving three dimensional measurements may be used, when approved by the Engineer.

Payment for preparation of foundations for embankments shall not include the removal of the top twenty (20) centimeters of sod and vegetable matter and compaction of the twenty (20) centimeters thickness which is paid for under Clearing and Grubbing, Pay Item No. 20101. Embankment bridging lifts as described in Paragraph 2.05.3.4, "Placement of Materials" in these General Specifications, will be measured for payment under Embankment, Pay Item No. 20501.

When material paid for as "Roadway Excavation" otherwise conforms to the applicable specification requirements, it may be used in the "Embankment," or any other Item of Work and also be paid under that item as provided in the specifications.

The total volume of Embankment shall be computed from the approved cross sections based on original ground elevations after the authorized excavation of one (1) unsuitable material in embankment areas, two (2) unsuitable material below subgrade in cuts, three (3) authorized undercut areas in rock cuts, and four (4) other materials ordered removed from their original position by the Engineer for replacement or compaction of underlying layers, except those materials specifically excluded from payment by the specifications. The approved cross sections shall not include the volume of embankments widened solely to accommodate the disposal of surplus materials. Embankment shall not include the volume of "Subgrade" since separate payment is provided in the Bill of Quantities for that item.

In computing the pay quantity of Embankment, the volume occupied by multiple barrel reinforced concrete box culverts shall be deducted from the total volume of embankment. No deduction shall be made for the volume occupied by pipe culverts or single barrel reinforced box culverts. No adjustments in pay quantities based on the natural expansion or contraction of earthwork volumes as they are excavated and compacted in embankments will be made. Estimates shown in the plans based on assumed expansion or contraction are for information only.

There will be no adjustment in contract unit prices nor will claims for additional payment be considered based on erroneous assumptions or representations to the contraction of excavated or imported materials, or the suitability of those materials for use in the embankment, regardless whether the assumptions or representations were made by the Ministry, its representatives, or any other responsible persons.

There will be no separate payment for foundation treatment or compaction of materials in their original position or for Work specifically included for payment under other items of Work.

2.05.9 Payment. The amount of authorized, completed and accepted Work, measured as provided above, will be paid for at the contract unit price per cubic meter for Embankment, as shown in the Bill of Quantities, which price(s) shall be full compensation for all materials, labor, equipment, tools, and all other items necessary for the proper completion of the Work including all surveying and quantity computations as specified in Subsection 1.07.2, "Scope of Payment," in these General Specifications. A ten percent (10%) retent will be held by the Engineer on each section of Embankment until the roadbed and slopes have been finished, trimmed and compacted.

PAYMENT WILL BE MADE UNDER:

ITEM NO.	PAY ITEM	PAY UNIT
20501	Embankment	Cubic Meter

SECTION 2.06 - UNTREATED SUBGRADE

2.06.1 Description. This work shall consist of blending, mixing, loading, transporting and placing acceptable materials excavated from the roadway or imported from borrow sites in horizontal lifts of uniform thickness for the full width of the subgrade; compacting each layer, and finishing the top of the untreated subgrade layer to specified tolerances. This work shall also consist of preparation of existing subgrade layers, consisting of removal and replacement of the top layer of the existing material, scarification, moisture adjustment, and compaction, and finishing the top of the untreated subgrade layer to the specified tolerances. It shall also consist of maintaining and draining the untreated subgrade layers, trimming the untreated subgrade slopes, all as shown on the plans, specified in these specifications and the special specifications or established by the Engineer. Untreated subgrade layers shall be constructed as specified herein and shall be treated as a separate item for measurement and payment purposes. Excavation shall be completed as specified in Section 2.03, "Excavation," in these General Specifications, and shall be treated as a separate item for measurement and payment purposes. Embankment shall be completed as specified in Section 2.05 "Embankment" in these General Specifications, and shall be treated as a separate item for measurement and payment purposes. For the remainder of the Section and for simplification purposes, Untreated Subgrade will be referred to as Subgrade.

ITEMS IN BILL OF QUANTITIES
Subgrade
Subgrade Preparation

2.06.2 Materials. Materials from roadway excavation, tunnel excavation or imported borrow meeting the appropriate quality requirements shall be used to construct subgrade in accordance with the typical sections contained in the plans or as staked by the Engineer.

Subgrade layer materials shall be a minimum of thirty (30) centimeter thick after compaction in both embankment and cut areas using materials meeting the following requirements:

1. Material classified by MRDTM 21 0 as A-1 -a(O), A-1 -b(O) and A-2-4(0) having
no rock fragments larger than ten (1 0) centimeters.

2. Material having a minimum soaked California Bearing Ratio (CBR) of twenty five (25) (MRDTM 213) at maximum specified density.

3. Material being reasonably well-graded with sufficient fines to permit compaction and compaction testing.

2.06.3 Construction.

2.06.3.1 Equipment. The Contractor shall provide all types, sizes and numbers of equipment which are necessary for handling, mixing, loading, hauling, spreading, watering, compacting and finishing material to form the subgrade layer in accordance with the plans, the special specifications, this specification and as directed by the Engineer.

2.06.3.2 Imported Borrow Material. The Contractor may use imported borrow material to complete the subgrade layer to the lines, grades and cross sections shown on the plans, specified in the Special Specifications and as staked by the Engineer.

Imported borrow material includes material taken from borrow sites, whether or not shown on the plans or described in the Special Specifications and from the widening of cuts when said widening is approved by the Engineer in writing.

Borrow sites shall not be located so that any edge is closer than three hundred (300) meters from embankment toe of slope unless otherwise shown on the plans, specified in the Special Specifications or approved by the Engineer.

Borrow material shall not be taken from any site within five hundred (500) meters downstream of a drainage structure unless approved by the Engineer in writing. Such borrow sites shall be backfilled and compacted, as directed by the Engineer, at the Contractors expense.

The Contractor may only import borrow materials from sites outside the right of way. All such imported borrow shall be arranged by the Contractor at his sole and exclusive cost. When the Contractor proposes to import borrow material from public or private property he shall obtain the consent of the public agency or private owners and present said consent agreement to the Engineer prior to beginning removal.

The Contractor shall perform preliminary testing of all proposed sources of imported material for subgrade. The preliminary testing shall consist of test pits and/or borings and testing of samples. This testing shall include, at the minimum, the following tests for each soil or rock strata in each proposed source:

1. Classification - MRDTM 21 0 (All Required Tests)

2. Proctor - MRDTM 212 or MRDTM 214 if appropriate

3. California Bearing Ration (CBR) - MRDTM 213

The Contractor shall furnish all test data to the Engineer at least two (2) weeks prior to taking material from the site and request preliminary approval from the Engineer to use the borrow site. The Engineer shall review the test information and accept or reject the Contractors request in writing. Final approval of the material shall be based on acceptance samples taken from each layer of subgrade.

Before abandoning any borrow site located on public or private property, the Contractor shall, at his sole expense, clean and trim the borrow site, haul roads and all areas occupied during the work, all to the satisfaction of the Engineer and property owner. Borrow sites shall present a neat and workmanlike natural appearance and all edges shall be trimmed to slope no steeper than one vertical to four horizontal (1 V to 4 H).

2.06.3.3 Placement of Materials. The Contractor shall have in operation a sufficient number of motor graders or tractors to properly smooth and maintain the surface of each layer of freshly placed subgrade prior to and during rolling and compacting operations.

When it is feasible, trucks, scrapers, tractors or other heavy hauling equipment shall be routed over the subgrade in such a manner to take advantage of the compaction afforded thereby. The Engineer shall have full authority to require at any time, the suspension of delivery of subgrade material until previously delivered materials are properly placed and preceding layers are satisfactorily smooth, uniformly compacted, and tested.

2.06.3.4 Subgrade Drainage and Slope Stability. At the end of each day's operation, the Contractor will shape and compact to a uniform enough cross section that will allow the surface of the subgrade allow water to drain. Dikes and slope drains shall be constructed and maintained along the subgrade edges to prevent water from spilling over the edge and eroding the side slopes.

The Contractor shall be responsible for the stability of all subgrade lifts and shall replace all sections of same which, in the opinion of the Engineer, have been damaged or displaced (slumped or slid) due to carelessness or neglect on the part of the Contractor, or due to normally occurring natural causes, such as erosion caused by wind or water, and not due to the unavoidable movement of the embankment upon which the subgrade is placed. When unacceptable material has been placed in the subgrade, its removal shall be at the expense of the Contractor.

2.06.3.5 Subgrade on Existing Road Surfaces. When an existing road surface is shown on the plans, or directed by the Engineer, to be used as subgrade, the adjustment of the elevation on which the subbase or base is to be placed shall be made by a bituminous concrete leveling course constructed in accordance with the details shown on the plans or as directed by the Engineer and complying with Section 4.05, "Bituminous Concrete Pavement," in these General Specifications.

When the width of the subgrade of that road under construction is greater than the surface width of the existing roadway, that part of the subgrade which falls on the surface of the existing road surface shall be constructed according to this subparagraph, and that part of the subgrade which falls outside the limits of the existing road surface shall be constructed as new construction and shall meet all the requirements thereof.

2.06.3.6 Subgrade In Earth Cuts. The depth of subgrade in earth cuts shall be thirty (30) centimeters. The material shall be Class A-1 -a(O), A-1 -b(O), or A-2-a(O) as determined by MRDTM 21 0, and shall meet a minimum soaked CBR of twenty-five (25) as determined by MRDTM 213 when compacted to the specified density. If the natural material in the cut meets these requirements, then the top fifteen (1 5) centimeters shall be removed. The bottom fifteen (15) centimeters shall be scarified, brought to a uniform moisture content within the specified range, and compacted to ninety-eight percent (98%) of maximum dry density. The top fifteen (1 5) centimeters shall be replaced with the same or equivalent material, brought to a uniform moisture content within the specified range, and compacted to the specified density.

If the natural material in the cut does not meet the above requirements for subgrade, then the subgrade shall be subexcavated to a depth of thirty (30) centimeters unless additional excavation is ordered by the Engineer. The twenty (20) centimeters below the excavated area shall be scarified, brought to a uniform moisture content within the specified range, and compacted to Type 95 density. The excavated material shall be replaced with material meeting the requirements of Class A-1 -1 (0), A-1 -b(O), or A-2-4(0), with a minimum soaked CBR of twenty-five (25) at the maximum specified density. The replacement material shall be brought to uniform moisture content within the specified range and compacted in two (2) approximately equal layers to ninety-eight percent (98%) of maximum dry density.

2.06.3.7 Subgrade in Rock Cuts. When a cut area is identified by the Engineer as rock for purposes of subgrade preparation, the area shall be undercut to a depth of thirty (30) centimeters below top of subgrade. The material excavated shall be placed in embankments or disposed of as approved by the Engineer if there is a surplus of embankment material. Care shall be taken that undrained pockets shall not be left in the surface of the rock. Coarse aggregate material complying with the requirements of AASHTO M43 - Sizes of Aggregates for Road and Bridge Construction - Size numbers one (1) through four hundred sixty-seven (467) shall be placed in the pockets or in the undercut rock surface and consolidated. After consolidation, the undercut subgrade surface shall be in substantial compliance with the grade and typical section shown on the plans. Placement and consolidation of the coarse aggregate is required to fill the voids and irregularities left in the subgrade from the Contractors excavation operation. This operation will be considered subsidiary to the Excavation Item and the Contractor shall not receive additional compensation for this Work.

The excavated material shall be replaced with material meeting the requirements of Class A-1 -1 (0), A-1 -b(O), or A-2-4(0), with a minimum soaked CBR of twenty-five (25) at the maximum specified density. The material shall be brought to uniform moisture content within the specified range and compacted in two (2) approximately equal layers to ninety-eight percent (98%) of maximum dry density.

2.06.3.8 Subgrade on Embankments (including Sand Duns Areas). The thirty (30) centimeters of material placed on the embankment to form the subgrade layer shall meet the requirements of Class A-1 -a(O), A-1 -b(O), or A-24 as determined by MRDTM 21 0, with a minimum soaked CBR of twenty-five (25) as determined by MRDTM 213 when compacted to ninety-eight percent (98%) of maximum dry density. The entire thirty (30) centimeters shall be compacted to the specified density in two (2) approximately equal layers.

2.06.3.9 Preparation of Existing Subgrade. This work, whether in cut or in fill sections, shall be carried out as specified in Paragraph 2.06.3.6 - "Subgrade in Earth Cuts," in these General Specifications.

2.06.4 Quality Assurance Procedures. Subgrade shall be accepted by lot unless otherwise stated in the Special Specifications. The lot shall consist of five thousand (5,000) square meters constructed in accordance with the lift thickness requirements specified in Subsection 2.05.4, "Lift Thickness and Compaction Requirements," in these General Specifications. The subgrade shall be sampled, tested and evaluated in accordance with Section 1.08, "Acceptance," in these General Specifications. The Engineer may, during the beginning of placement of subgrade, at times when test results indicate erratic characteristics and at any other time, reduce the lot size to sections of embankment with similar quality characteristics. This should facilitate the isolation and modification or replacement of low-quality materials with materials of acceptable quality to maintain the overall strength of the subgrade.

The Engineer shall perform or supervise the performance of all quality assurance sampling and testing. The location of all samples and tests shall be recorded by roadway, embankment height, centerline station (kilometer) and offset. Quality assurance testing for each lot shall include:

1. Thickness
2. Compaction
3. Classification Maximum Particle Size and CBR
4. Subgrade Finishing Tolerances and Requirements
5. Acceptance

2.06.4.1 Thickness. The thickness of each lot of subgrade complete as placed and compacted, shall be measured from test holes obtained at a minimum of five (5) random locations within the lot. The thickness of each hole shall be determined after it is determined that the compacted density is acceptable. The average of the test hole thickness shall be reported as the thickness of the lot.

A lot shall be accepted when the average total thickness is not less than the Plan thickness.

Any lot of subgrade with an average thickness less than the Plan thickness but resulting in a reduced pay factor of 0.75 or higher determined in accordance with Subsection 1.08.5, "Statistical Evaluation of Work for Acceptance and Determination of Pay Factor (Value of Work)," in these General Specifications may be accepted on the basis of reduced payment if requested in writing by the Contractor. Otherwise, the said lot thickness shall be increased as specified in the following paragraph.

When the average thickness of a lot of subgrade is less than the plan thickness by an amount resulting in a reduced pay factor below 0.75 the Contractor, at his own expense, shall place and remix additional subgrade material with the original subgrade material and recompact before new test holes are dug.

2.06.4.2 Compaction. Subgrade materials shall be compacted to the percent of maximum density detailed in Subsection 2.05.4, "Lift Thickness and Compaction Requirements," in these General Specifications.

The compacted density for each layer of subgrade shall be determined by the sand cone method, MRDTM 215, or by nuclear method, MRDTM 218, using full depth penetration, at the option of the Engineer.

When the sand cone method is used, unless otherwise stated in the Special Specifications, the tests shall be made at a minimum of five (5) randomly selected locations in each lot.

When the nuclear method is used, unless otherwise stated in the Special Specifications, the test shall be made at a minimum of eight (8) randomly selected locations in each lot. Three (3) nuclear gauge readings shall be made at each test location within a radius of two (2) meters. The three (3) readings shall be averaged and the average considered to be the density for that test location.

Percent relative compaction shall be computed by comparing the average actual in-place compacted density from the nuclear gauge or sand cone test results with the maximum density determined by MRDTM 212. For example, MRDTM 212 maximum density shall be determined from samples of embankment at a sampling frequency of one (1) test per three (3) lots. The maximum density used for determining percent compaction shall be the running average for three (3) consecutive tests.

Any lot of subgrade that has a percent relative compaction below the minimum percent compaction specified in Subsection 2.05.4 "Lift Thickness and Compaction Requirements" in these General Specifications, resulting in a reduced pay factor of 0.75 or higher may be accepted on the basis of a reduced payment if requested in writing by the Contractor. Otherwise the said lot shall be removed and replaced by the Contractor at his expense. Lots that have percent relative compaction resulting in a reduced pay factor less than 0.75 shall be removed and replaced by the Contractor at his expense.

2.06.4.3 Classification, Maximum Particle Size and CBR. Classification and CBR including gradation, plastic limit and liquid limit will be sampled, tested, and evaluated on the results of a minimum of one (1) test result per lot for the first three (3) lots and then one (1) test result for every fifth lot when changes in the material properties are suspected by the Contractor or the Engineer. Maximum particle size shall be determined by screening the entire sample as received over a ten (1 0) centimeter square screen. The weight retained on the ten (1 0) centimeter screen shall be recorded.

A lot will be accepted when all the classifications and maximum particle size tests representing that lot are as specified in Subsection 2.06.2, "Materials," in these General Specifications.

2.06.4.4 Finishing Tolerances and Requirements. Quality Assurance measuring or testing shall involve verification that the subgrade is constructed, timely finished and trimmed in a neat, workmanlike manner to the lines, grades and typical cross sections shown on the Plans or staked by the Engineer within the following tolerances and deadlines:

1. Subgrade slopes shall be constructed in conformance with the lines and grades established by the Engineer. The completed slopes shall not vary more than one (1) centimeter from the designated slope measured at right angles to the slope.

2. Finished Grade of Subgrade. The elevation of the top of subgrade surface shall be checked under the supervision of the Engineer. Each cross section shall be checked at each change in cross slope and intermediate points as directed. Cross sections shall be established at maximum intervals of twenty-five (25) meters with additional sections as directed by the Engineer. The allowable tolerances for the finished grade of the top of subgrade are as follows:

(1) When bituminous concrete or bituminous concrete base is to directly be placed on the subgrade, the finished top of subgrade at any point shall not vary more than one (1) centimeter above or below the grade established by the Engineer.

(2) When subbase or base material (other than bituminous concrete base) is to be placed on the subgrade, the finished top of subgrade at any point shall not vary more than two (2) centimeters above or below the grade established by the Engineer.

2.06.4.5 Acceptance. Subgrade construction including classification, maximum particle size, California Bearing Ratio and finishing tolerances and requirements shall be accepted under Subsection 1.08.4, "Measured or Tested Conformance," in these General Specifications.

Compaction and thickness will be accepted under Subsection 1.08.5, "Statistical Evaluation of Work for Acceptance and Determination of Pay Factor (Value of Work)," in two (2) stages as follows: The first stage shall be the selection of the pay factor for the quality of the subgrade relating to compaction. The second stage involves the selection of a quantity pay factor based on the thickness of the subgrade. The reduced thickness pay factor for the lower courses of multiple layer courses will be applied provisionally based on the results of the depths of the holes dug in the lower layers. Additional holes will be dug in the total depth of all subgrade layers within the lot represented by lower layer reduced thickness pay factors. If the total thickness depths show that the increased upper level layer thickness has resulted in total thickness acceptability, the lower level layer reduced thickness pay factor will be adjusted accordingly. The second stage thickness quantity pay factor will be applied to all the individual course lots in addition to the first stage quality pay factor.

2.06.5 Maintenance and Protection. Following construction of the subgrade, the compacted course shall be maintained by the Contractor at his own expense. The Contractor shall blade, broom, and otherwise maintain the course, keeping it free from raveling and other defects that result in lost density until such time as the next element of the pavement structure is placed. Water shall be applied at such times and in such quantities as directed by the Engineer, and the Engineer shall have full authority to require the suspension of all other work on the project to insure the proper maintenance of previously compacted material.

The Engineer shall determine when the surface of the subgrade is in the proper condition to permit the bituminous prime and/or surfacing to be applied. The Contractor must continue to maintain the surface of the subgrade, including the application of the necessary water, at his own expense until such time as the bituminous prime and/or surfacing is applied. Any additional expense incurred by the Contractor t>ecause of delay in applying the bituminous prime and/or surfacing when so permitted by the Engineer will not be considered as the basis for a claim for additional compensation.

2.06.6 Method of Measurement. When payment is specified on a volume basis in the Bill of Quantities, quantities of "Subgrade" shall be computed by the Contractor and checked by the Engineer. The total volume of "Subgrade" shall be computed from the approved cross sections and shall include the volume of material in the subgrade zone which is required to be placed, removed and replaced, or removed, returned, and compacted, or even scarified, watered, rolled and generally left in its original location. The total volume of "Subgrade" shall include the subgrade layer constructed in earth cuts, rock cuts, and on embankments including all roadways, frontage and service roads, interchanges, ramps and other incidental roads. The volume shall not include material below the subgrade zone which is scarified, watered, rolled, or otherwise generally left in its original location. The lateral limits of the subgrade zone shall be those shown on the typical section or ordered in writing by the Engineer.

Where it is impractical to measure material by the cross section method due. to the erratic location of isolated deposits, acceptable methods involving three dimensional measurements may be used, when approved by the Engineer.

When material paid for as Roadway Excavation otherwise conforms to the applicable specification requirements, it may be used in the Subgrade or any other Item of Work and also be paid under that Item as provided in these General Specifications.

Subgrade preparation will be measured by the square meter of completed and accepted work, on the basis of approved cross-sections and as authorized and directed by the Engineer. Measurement shall be to the nearest tenth of a square meter along the longitudinal profile of the road. No measurement shall be made of unauthorized areas, as specified in Subsection 1.07.6 "Unauthorized work" in these General Specifications.

There will be no adjustment in contract unit price(s) nor will claims for additional payment be considered based on erroneous assumptions or representations to the contraction of excavated or imported materials, or the suitability of those materials for use in the subgrade, regardless whether the assumptions or representations were made by the Ministry, its representatives, or any other responsible persons.

2.06.7 Payment. The amount of authorized, completed, and accepted subgrade Work, measured as provided above, will be paid for at the contract unit price(s) per cubic meter for Subgrade as shown in the Bill of Quantities, which price(s) shall be full compensation for all loading, hauling and the proper formation of subgrade, trimming of slopes, cleanup, preparation, compaction and completion of subgrade including shoulder areas, except as otherwise provided, and all other items necessary for the proper completion of the Work as specified in Subsection 1.07.2, "Scope of Payment," in these General Specifications, including all surveying and quantity computations.

The amount of completed and accepted Work for Subgrade Preparation, measured as provided above, will be paid for at the unit price bid per square meter for such item, appearing in the Bill of Quantities, which price shall be full compensation for all that is necessary for proper completion as specified in subsection 1.07.2 'Scope of Payment' in these General Specifications.

PAYMENT WILL BE MADE UNDER:

ITEM NO.	PAY ITEM	PAY UNIT
20601	Subgrade	Cubic Meter
20602	Subgrade Preparation	Square Meter

SECTION 2.07 - LIME TREATED SUBGRADE

2.07.1 Description. This work shall consist of preparing roadbed for lime treatment, furnishing and applying lime, mixing lime and water with in-place material, and spreading, compacting, curing and sealing the mixture, to the lines, grades and dimensions shown on the plans and as specified.

ITEMS IN BILL OF QUANTITIES
Lime Treated Subgrade
Lime

2.07.2 Equipment. The Contractor shall submit to the Engineer, a list of equipment which he intends to use, at least fourteen (14) days prior to beginning lime treated construction operations. The list shall include, but not be limited to:

1. Scarifying Equipment that is capable of loosening the subgrade soil to the depths shown on the plans or specified in the Special Specifications.

2. Pulverizing Equipment that is capable of reducing the soil clods to facilitate adequate mixing throughout the entire depth of layer specified.

3. Lime Spreading Equipment that will spread the lime uniformly at the specified rate of application.

4. Mixing Equipment shall be traveling pugmill, or a single or multiple cross shaft mixer capable of uniformly mixing soil, lime and water to the depths shown on the plans or specified in the special specifications.

5. Watering Equipment that will apply water uniformly at measured rates.

NOTE: The requirements listed above shall not be interpreted to prohibit use of a single item of equipment that will scarify, pulverize, add water and mix to the depths specified.

6. Compacting Equipment as specified in Paragraph 2.07.4.4, "Compaction and Finishing" in these General Specifications.

7. Bituminous Material Distributor as specified in Subsection 4.02.4, "Equipment" in these General Specifications.

The Engineer shall consider the equipment proposed, approve that which will produce the results specified and require the Contractor to provide such other equipment as may be needed. At any time during construction activities, if the work performed by the Con-tractor fails to conform to specified requirements, the Engineer shall order changes in equipment, construction methods or both.

2.07.3 Materials.

2.07.3.1 Lime. Lime shall be a commercial dry hydrated lime or granular or palletized quicklime conforming to the requirements of ASTM C 51. When sampled on delivery to the project, the lime shall conform to the following gradation and quality requirements:

GRADATION

Sieve Size	Percent Passing Hydrated Lime	Quicklime
19 mm (% inch)	100	100
No. 30	95-100	-
No. 100	-	30-100
No. 200	75-100	-
Test Method	ASTM C 110 (Dry sieving only)	ASTM C 136

Hydrated lime shall contain not less than eighty-five percent (85%) calcium hydroxide $Ca(OH)2$, as determined by ASTM C 25.

Quicklime shall contain not less than ninety-four percent (94%) total available calcium oxide and magnesium oxide ($CaO + MgO$) and not less than ninety percent (90%) total available calcium oxide (CaO) as determined by ASTM C 25.

Lime from more than one (1) source or more than one (1) type of lime may be used on the same project, but the different limes shall not be mixed. The lime shall be protected from exposure to moisture until used and shall be sufficiently dry to flow freely when handled.

The supplier of lime shall provide a written Certificate of Guarantee stating that the lime conforms to the requirements of this section. A certified copy of shipping weight shall be submitted to the Engineer with each delivery of lime.

2.07.3.2 Water. Water used for mixing shall be capable of producing the specified lime treated material as confirmed by laboratory testing and shall be approved by the Engineer.

2.07.3.3 Bituminous Curing Seal. Bituminous material for curing seal shall be SS-1 h or CSS-1h conforming to the requirements specified in Section 4. 01, "Bituminous Materials" in these General Specifications.

2.07.4 Construction Requirements.

2.07.4.1 Preparation of Roadbed. In-place material to be lime treated shall be scarified and thoroughly broken up for the full roadway width. The material to be treated shall contain no rocks or clods larger than six (6) centimeters in greatest dimension. The depth to be scarified shall be as specified in the Plans or Special Specifications. The lime, water and in-place material shall be mixed and compacted

to the full scarified depth. The thickness of lime treated subgrade layer shall not be more than two (2) centimeters less than the planned and staked thickness.

If the mixing machine to be used requires that the material be windrowed, the windrows shall be of uniform cross section and limited to such size that all the material will pass through the mixer at each operation. Otherwise, the material shall be shaped to the required line, grade and cross section before application of lime and mixing.

2.07.4.2 Application of Lime. Lime shall be added to the material to be treated at a rate not varying more than ten percent (1 0%) from the rate specified in the Special Specifications. The equipment used to distribute the lime shall be capable of uniformly distributing the required amount of lime for the full width of the pass within this tolerance.

Lime or lime treated material shall not be spread or mixed when the temperature is less than five degrees Celsius (5' C) in the shade, or when conditions are such at the temperature will fall below five degrees Celsius (50 C) within twenty-four (24) hours.

The area on which the lime may be spread ahead of the mixing operation shall be limited to that which the Contractor demonstrates he is capable of thoroughly mixing by the end of the working day.

No traffic other than water trucks and mixing equipment shall be allowed on the lime treated material until after completion of all mixing.

2.07.4.3 Mixing. The soil and lime shall be uniformly mixed with approved equipment. Water shall be applied and mixed to produce a moisture content which is uniform throughout the depth being mixed within two (2) percentage points of the optimum moisture content required for compaction. The optimum moisture content shall be established by the Contractor and approved by the Engineer.

Mixing and remixing operations shall continue until the material is uniformly mixed and free of streaks or pockets of lime. The final mixture shall not contain more than five percent (5%), by dry weight, untreated soil clods larger than three (3) centimeters in diameter.

The lime treated material, after the initial mixing operations and before compaction, shall be allowed to cure for a period between twenty-four (24) to forty eight (48) hours as determined by the Engineer.

If quicklime is used for subgrade treatment, sufficient water shall be added prior to or during the initial mixing operation to slake all of the quicklime.

When lime treated subgrade is required to be reworked more than seven (7) days after original compaction is completed, an additional two percent (2%) lime shall be uniformly incorporated into the mixture.

2.07.4.4 Compaction and Finishing. The treated mixture, after curing, shall be spread to the lines, grades and thickness shown on the plans or specified in the special specifications.

The thickness of a compacted layer shall not exceed thirty (30) centimeters. When the required thickness is more than thirty (30) centimeters, the mixture shall be spread and compacted in two (2) or more layers of approximately equal thickness. Optimum moisture content shall be maintained by watering during the spreading and compacting process. Unless otherwise stated in the special specifications, the lime treated subgrade shall be compacted to a dry density not less than ninety-five percent (95%) of the maximum density determined by MRDTM 212.

Initial compaction shall be by grid, segmented or peg rollers. Final compaction shall be accomplished by a minimum of two (2) coverages with a steel drum or pneumatic roller. Areas inaccessible to rollers shall be compacted as specified by tamping using equipment selected by the Contractor and acceptable to the Engineer.

The lime treated subgrade shall be completed to the grades shown on the plans within a tolerance of +/- two (2) centimeters.

2.07.4.5 Curing. The surface of the lime treated subgrade shall be kept moist until covered by another layer of lime treated subgrade or until a bituminous curing seal is placed. The bituminous curing seal shall be applied at a rate between one half (0.5) and one (1.0) liters per square meter. The curing seal shall be applied within one (1) hour after completion of final compaction along any portion of the roadbed having a length of two hundred and fifty (250) meters. Curing seal shall be applied when air temperatures are above five degrees Celsius (5' C).

Additional applications of curing seal shall be applied as necessary to maintain a uniform, complete film of bituminous material on the lime treated subgrade for at least seventy-two (72) hours).

No equipment or traffic will be allowed on the bituminous curing seal for at least seventy-two (72) hours after application of the curing seal. Subsequent layers of subbase, base or bituminous surfacing shall be placed within ten (10) days after application of the curing seal.

2.07.4.6 Safety Requirements. The Contractor shall prepare a program for safety of construction personnel and the public and present it to the Engineer prior to the beginning of lime treatment operations. The program shall include training of construction personnel, provision of safety equipment for protection of body, eyes and nasal passages. A suitable first aid kit shall be available at the work site at all times when lime spreading and mixing is in progress. No work shall begin until the Engineer has received the safety program and approved it. During construction operations the Contractor shall enforce all safety regulations and require the use of safety equipment. When the Contractor fails to enforce all safety requirements, construction activities shall cease.

2.07.5 Quality Assurance Procedures. Lime treated subgrade shall be accepted by lot unless otherwise stated in the Special Specifications. The lot shall consist of five thousand (5,000) square meters constructed in accordance with the subgrade lift thickness requirements specified in Subsection 2.05.4, "Lift Thickness and Compaction Requirements," in these General Specifications. The lime treated subgrade shall be sampled, tested and evaluated in accordance with Section 1.08 "Acceptance" in these General Specifications. The Engineer may, during the beginning of placement of lime treated subgrade, at times when test results indicate erratic characteristics and at any other time, reduce the lot size to sections of embankment with similar quality characteristics. This should facilitate the isolation and modification or replacement of low-quality materials with materials of acceptable quality to maintain the overall strength of the subgrade.

The Engineer shall perform or supervise the performance of all quality assurance sampling and testing. The location of all samples and tests shall be recorded by roadway, embankment height, centerline station (kilometer) and offset. Quality assurance testing for each lot shall include:

1. Thickness
2. Compaction
3. Classification Maximum Particle Size and CBR
4. Finishing Tolerances and Requirements
5. Lime
6. Acceptance

2.07.5.1 Thickness. The thickness of each lot of lime treated subgrade complete as placed and compacted, shall be measured from test holes obtained at a minimum of five (5) random locations within the lot. The thickness of each hole shall be determined after it is determined that the compacted density is acceptable. The average of the test hole thickness shall be reported as the thickness of the lot.

A lot shall be accepted when the average total thickness is not less than the Plan thickness.

Any lot of lime treated subgrade with an average thickness less than the Plan thickness but resulting in a reduced pay factor of 0.75 or higher determined in accordance with Subsection 1.08.5, "Statistical Evaluation of Work for Acceptance and Determination of Pay Factor (Value of Work)," in these General Specifications may be accepted on the basis of reduced payment if requested in writing by the Contractor. Otherwise the said lot thickness shall be increased as specified in the following paragraph.

When the average thickness of a lot of subgrade is less than the plan thickness by an amount resulting in a reduced pay factor below 0.75 the Contractor, at his own expense, shall place and remix additional lime treated subgrade material with the original subgrade material and recompact before new test holes are dug.

2.07.5.2 Compaction. Lime treated subgrade materials shall be compacted to the percent of maximum density detailed in Subsection 2.05.4, "Lift Thickness and Compaction Requirements," in these General Specifications.

The compacted density for each layer of lime treated subgrade shall be determined by the sand cone method, MRDTM 215, or by nuclear method, MRDTM 218, using full depth penetration, at the option of the Engineer.

When the sand cone method is used, unless otherwise stated in the Special Specifications, the tests shall be made at a minimum of five (5) randomly selected locations in each lot.

When the nuclear method is used, unless otherwise stated in the Special Specifications, the test shall be made at a minimum of eight (8) randomly selected locations in each lot. Three (3) nuclear gauge readings shall be made at each test location within a radius of two (2) meters. The three (3) readings shall be averaged and the average considered to be the density for that test location.

Percent relative compaction shall be computed by comparing the average actual in-place compacted density from the nuclear gauge or sand cone test results with the maximum density determined by MRDTM 212. For example, MRDTM 212 maximum density shall be determined from samples of lime treated subgrade at a sampling frequency of one (1) test per three (3) lots. The maximum density used for determining percent compaction shall be the running average for three (3) consecutive tests.

Any lot of lime treated subgrade that has a percent relative compaction below the minimum percent compaction specified for subgrade in Subsection 2.05.4 "Lift Thickness and Compaction Requirements" in these General Specifications, resulting in a reduced pay factor of 0.75 or higher may be accepted on the basis of a reduced payment if requested in writing by the Contractor. Otherwise the said lot shall be removed and replaced by the Contractor at his expense. Lots that have percent relative compaction resulting in a reduced pay factor less than 0.75 shall be removed and replaced by the Contractor at his expense.

When requested, the lime treated subgrade lift may be accepted on the basis of reduced pay factor of 0.75 or higher in accordance with Subsection 1.08.5, "Statistical Evaluation of Work for Acceptance and Determination of Pay Factor (Value of Work)," in these General Specifications.

2.07.5.3 Classification, Maximum Particle Size and CBR. Classification and CBR including gradation, plastic limit and liquid limit will be sampled, tested, and evaluated on the results of a minimum of one (1) test result per lot for the first three (3) lots and then one (1) test result for every fifth lot when changes in the material properties are suspected by the Contractor or the Engineer. Maximum particle size shall be determined by screening the entire sample as received over a ten (1 0) centimeter square screen. The weight retained on the ten (1 0) centimeter screen shall be recorded.

A lot will be accepted when all the classifications and maximum particle size tests representing that lot are as specified in Subsection 2.07.2, "Materials," in these General Specifications.

2.07.5.4 Finishing Tolerances and Requirements. Quality Assurance measuring or testing shall involve verification that the lime treated subgrade is constructed, timely finished and trimmed in a neat, workmanlike manner to the lines, grades and typical cross sections shown on the Plans or staked by the Engineer within the following tolerances and deadlines:

1. Lime treated subgrade slopes shall be constructed in conformance with the lines and grades established by the Engineer. The completed slopes shall not vary more than one (1) centimeter from the designated slope measured at right angles to the slope.

2. Finished Grade of Lime Treated Subgrade. The elevation of the top of lime treated subgrade surface shall be checked under the supervision of the Engineer. Each cross section shall be checked at each change in cross slope and intermediate points as directed. Cross sections shall be established at maximum intervals of twenty-five (25) meters with additional sections as directed by the Engineer. The allowable tolerances for the finished grade of the top of subgrade are as follows:

(1) When bituminous concrete or bituminous concrete base is to directly be placed on the subgrade, the finished top of subgrade at any point shall not vary more than one (1) centimeter above or below the grade established by the Engineer.

(2) When subbase or base material (other than bituminous concrete base) is to be placed on the subgrade, the finished top of subgrade at any point shall not vary more than two (2) centimeters above or below the grade established by the Engineer.

2.07.5.5 Lime. The lime shall conform to the gradation and quality requirements in Paragraph 2.07.3.1, "Lime," in these General Specifications based upon Certificates of Compliance delivered with each load of lime.

2.07.5.6 Acceptance. Lime treated subgrade construction including classification, maximum particle size, California Bearing Ratio, lime, and finishing tolerances and requirements shall be accepted under Section 1.08.4, "Measured or Tested Conformance," in these General Specifications.

Lime shall be accepted under Subsection 1.08.3, "Certification of Compliance," in these General Specifications.

Compaction and thickness will be accepted under Subsection 1.08.5, "Statistical Evaluation of Work for Acceptance and Determination of Pay Factor (Value of Work)," in two (2) stages as follows: The first stage shall be the selection of the pay factor for the quality of the lime treated subgrade relating to Compaction. The second stage involves the selection of a quantity pay factor based on the thickness of the lime treated subgrade. The reduced thickness pay factor for the lower courses of multiple layer courses will be applied provisionally based on the

results of the depths of the holes dug in the lower layers. Additional holes will be dug in the total depth of all lime treated subgrade layers within the lot represented by lower layer reduced thickness pay factors. If the total thickness depths show that the increased upper level layer thickness has resulted in total thickness acceptability, the lower level layer reduced thickness pay factor will be adjusted accordingly. The second stage thickness quantity pay factor will be applied to all the individual course lots in addition to the first stage quality pay factor.

2.07.6 Method of Measurement. The accepted lime treated subgrade shall be measured in cubic meters based on dimensions shown on the plans or as ordered by the Engineer. The amount of Lime incorporated into the measured and accepted quantity of lime treated subgrade shall be measured in tons. No measurement shall be made for materials placed outside authorized limits.

2.07.7 Payment. Lime treated subgrade shall be paid for at the contract unit price(s) per cubic meter for Lime Treated Subgrade and per ton for Lime as listed in the Bill of Quantities.

Such payment shall be full compensation for furnishing materials, labor, equipment, tools and all incidentals necessary for the proper completion of the work as specified in Subsection 1.07.2, "Scope of Payment," in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO.	PAY ITEM	PAY UNIT
20701	Lime Treated Subgrade	Cubic Meter

SECTION 2.08 - CEMENT TREATED SUBGRADE

2.08.1 Description. This work shall consist of preparing roadbed for cement treatment, furnishing and applying cement and water, mixing cement and water with in-place material, and spreading, compacting, sealing and curing the mixture within the lines, grades, and dimensions shown on the project plans and as specified.

ITEMS IN BILL OF QUANTITIES
Cement Treated Subgrade
Cement

2.08.2 Materials.

2.08.2.1 In-Place Material. In-place material on the roadbed shall be the native material or embankment, free of plant growth and unsuitable materials, as unsuitable materials are defined in Section 2.03, "Excavation," or in these General Specifications.

2.08.2.2 Portland Cement. Portland Cement shall conform to the requirements of Paragraph 5.01.2.1 "Portland Cement" in these General Specifications.

2.08.2.3 Water. Water used for mixing shall conform to the requirements for "Water" in Paragraph 5.01.2.3 in these General Specifications.

2.08.2.4 Bituminous Cure Seal. Bituminous material for the curing seal shall be emulsified bituminous materials, grades SS-1 h or CSS-1 h, conforming to the requirements of Section 4.01, "Bituminous Materials," in these General Specifications.

2.08.2.5 Chemical Admixtures. Set retarders shall conform to the requirements specified in ASTM C 494.

2.08.3 Mix Design. The applicable design parameters will be specified in the special specifications. The Contractor shall provide a mix design having proportions of materials that, when mixed, spread and compacted as specified, the cement treated subgrade will conform to all specified requirements. When design parameters are not specified in the special specifications, the Contractor shall prepare a mix design with three and one-half percent (31/2%) percent cement by dry weight of aggregate.

At least thirty (30) days prior to the production of the mixture, the Contractor shall submit, for the Engineers approval, design mix information as follows:

1. Source of each material to be used to produce the cement treated mixture.

2. Recommended percent cement and water contents.

3. Density of the mixture at the recommended cement and water content based on MRDTM 212.

4. Retarder or other additive used in the design mix and proportions of each based on the dry weight of aggregate.

In addition, thirty (30) days prior to the production of mixture, the Contractor shall furnish the Engineer the following quantities of materials proposed for use in the mixture:

1. Aggregate One hundred (100) kilograms
2. Cement Twenty (20) kilograms
3. Retarder or other additive, if used three (3) kilograms

Should a change in materials be made by the Contractor or should verification testing performed by the Engineer indicate that the recommended mix design is unsatisfactory, the Contractor shall immediately develop a new mix design and furnish the above information prior to beginning or continuing production of cement treated mixture.

2.08.4 Weather Limitations. Cement treated material shall not be mixed or placed during rain, dust or sand storms, unless approved by the Engineer. When the air temperature is below five (5) degrees Celsius or expected to reach thirty- five (35) degrees Celsius or higher, the Contractor shall schedule his operations to place and compact the cement treated base.

2.08.5 Traffic Control. The Contractor shall take effective action to prevent traffic, other than necessary construction equipment, from using the cement treated subgrade until approved by the Engineer. When public traffic uses the roadway on which cement treated subgrade is being constructed, the Contractor shall provide all necessary signs, barricades, flagmen and pilot cars needed to allow traffic to proceed with minimum interruption.

2.08.6 Equipment. Equipment shall conform to the general requirements Section 2.06, "Lime Treated Subgrade," except that mixing and spreading equipment shall be suitable for use with cement.

2.08.7 Construction.

2.08.7.1 Preparation of Roadbed. In-place material to be cement treated shall be scarified and thoroughly broken up for the full width of treatment. The material to be treated shall contain no rocks larger than eight (8) centimeters in any dimension. When rocks larger than eight (8) centimeters are present in the subgrade to be treated, the Contractor shall remove the larger rock from the full depth to be cement treated by picking, breaking to size, raking, screening or any other means which will result in removal of oversize rock. The depth to be scarified shall be such that when compacted, the treated subgrade will conform to the specified thickness within plus or minus two (±2) centimeters.

If the mixing operation requires that the material be windrowed, the windrows shall be of uniform cross-section and limited to a size that will allow it to all pass through the mixer in each operation. Otherwise the material shall be shaped to the required line, grade, and cross-section before applying the cement and mixing.

2.08.7.2 Application of the Cement. Cement shall be added to the material to be treated at the rate specified or as determined from the approved design mix. The actual application rate shall not vary by more than ten percent (10%) of the specified rate. The equipment used to distribute the cement shall be as approved by the Engineer and it shall be capable of uniformly distributing the required amount of cement for the full width of the pass.

The area upon which cement is spread shall be limited to that which the contractor can thoroughly mix and compact by the end of each one-half (1/2) work shift.

2.08.7.3 Mixing. Mixing shall be accomplished with a traveling pugmill or a single or multiple transverse shaft mixer as approved by the Engineer. Mixers shall be equipped with a system capable of introducing water at a controlled rate during mixing and be capable of producing a completed mixture with a uniform moisture content. The moisture content of the completed mixture shall be within two percentage points of the optimum moisture content of the material being treated as determined by MRDTM 212.

The in-place material and cement shall be mixed such that cement balls are prevented from forming when water is added. Mixing shall be continued until the mixture is uniform and at the required moisture content.

2.08.7.4 Compacting and Finishing. The thickness of a compacted layer shall not exceed twenty (20) centimeters. The moisture content shall be maintained as necessary to achieve specified compaction. Unless specified otherwise, the cement treated material shall be compacted to a density of not less ninety-five percent (95%) percent of the maximum density as determined by MRDTM 212.

Initial compaction shall be accomplished with a sheepsfoot or grid rollers. Final compaction shall be accomplished with steel wheel or pneumatic tired rollers. Areas inaccessible to rollers shall be compacted to the required density as approved by the Engineer.

The cement treated subgrade shall be finished to a reasonably smooth and , uniform surface and in reasonably close conformity to the lines, grades, dimensions, and cross-sections shown on the project plans or established by the Engineer. The surface of the treated subgrade shall not vary by more than two (2) centimeters above or below the specified grade.

Damage to cement treated subgrade which occurs as a result of the Contractors activities shall be promptly repaired by the Contractor at his expense.

2.08.7.5 Operation Time Requirement. The Contractor shall furnish and operate sufficient equipment or limit the area of work in progress so that not more than one (1) hour shall elapse between the time water is added to the in-place materials and cement and the time to Completion of the final compaction after trimming, unless otherwise approved by the Engineer.

2.08.8 Curing. The surface of cement treated subgrade shall be kept moist until a curing seal is applied. Bituminous curing seal shall be applied uniformly at a rate between one-half (0.50) and one (1.0) liter per square meter of surface. The curing seal shall be applied on the same day that final compaction is performed and as soon after the final compaction as is practicable.

After the curing seal has been applied, the cement treated subgrade shall be kept free from traffic for a period of at least three (3) days.

Any damage to the curing seal or the cement treated subgrade shall be promptly repaired by the contractor, at his expense and as directed by the Engineer, until a subsequent subbase, base, or pavement course is placed over the cement treated subgrade.

2.08.9 Quality Assurance Procedures. Cement treated subgrade shall be accepted by lot. Unless otherwise stated in the Special Specifications. The lot shall consist of five thousand (5,000) square meters constructed in accordance with the lift thickness requirements specified in Subsection 2.05.4, "Lift Thickness and Compaction Requirements," in these General Specifications. The cement treated subgrade shall be sampled, tested and evaluated in accordance with Section 1.08, "Acceptance," in these General Specifications. The Engineer may, during the beginning of placement of cement treated subgrade, at times when test results indicate erratic characteristics and at any other time, reduce the lot size to sections of embankment with similar quality characteristics. This should facilitate the isolation and modification or replacement of low-quality materials with materials of acceptable quality to maintain the overall strength of the subgrade.

The Engineer shall perform or supervise the performance of all quality assurance sampling and testing. The location of all samples and tests shall be recorded by roadway, at embankment height, centerline station (kilometer) and offset. Quality assurance testing for each lot shall include:

1. **Thickness**
2. **Compaction**
3. **Classification Maximum Particle Size and CBR**
4. **Subgrade Finishing Tolerances and Requirements**
5. **Cement**
6. **Acceptance**

2.08.9.1 Thickness. The thickness of each lot of cement treated subgrade complete as placed and compacted, shall be measured from test holes obtained at a minimum five (5) random locations within the lot. The thickness of each hole shall be determined after it is determined that the compacted density is acceptable. The average of the test hole thickness shall be reported as the thickness of the lot.

A lot shall be accepted when the average total thickness is not less than the Plan thickness.

Any lot of cement treated subgrade with an average thickness less than the Plan thickness but resulting in a reduced pay factor of 0.75 or higher determined in accordance with Subsection 1.08.5, "Statistical Evaluation of Work for Acceptance and Determination of Pay Factor (Value of Work)," in these General Specifications may be accepted on the basis of reduced payment if requested in writing by the Contractor. Otherwise the lot thickness shall be increased as specified in the following paragraph.

When the average thickness of a lot of subgrade is less than the plan thickness by an amount resulting in a reduced pay factor below 0.75 the Contractor, at his own expense, shall place and remix additional subgrade material with the original subgrade material and recompact before new test holes are dug.

2.08.9.2 Compaction. Cement treated subgrade materials shall be compacted to the percent of maximum density detailed in Subsection 2.08.4, "Lift Thickness and Compaction Requirements," in these General Specifications.

The compacted density for each layer of cement treated subgrade shall be determined by the sand cone method, MRDTM 215, or by nuclear method, MRDTM 218, using full depth penetration, at the option of the Engineer.

When the sand cone method is used, unless otherwise stated in the Special Specifications, the tests shall be made at a minimum of five (5) randomly selected locations in each lot.

When the nuclear method is used, unless otherwise stated in the Special Specifications, the test shall be made at a minimum of eight (8) randomly selected locations in each lot. Three (3) nuclear gauge readings shall be made at each test location within a radius of two (2) meters. The three (3) readings shall be averaged and the average considered to be the density for that test location.

Percent compaction shall be computed by comparing the average actual in place compacted density from the nuclear gauge or sand cone test results with the maximum density determined by MRDTM 212. For example, MRDTM 212 maximum density shall be determined from samples of embankment at a sampling frequency of one (1) test per three (3) lots. The maximum density used for determining percent compaction shall be the running average for three (3) consecutive tests.

Any lot of cement treated subgrade that has a percent relative compaction below the minimum percent compaction specified in Subsection 2.05.4, "Lift Thickness and Compaction Requirements," in these General Specifications, resulting

in a reduced pay factor of 0.75 or higher may be accepted on the basis of a reduced payment if requested in writing by the Contractor. Otherwise the said lot shall be removed and replaced by the Contractor at his expense. Lots that have percent relative compaction resulting in a reduced pay factor less than 0.75 shall be removed and replaced by the Contractor at his expense.

When requested, the cement treated subgrade lift may be accepted on the basis of reduced pay factor of 0.75 or higher in accordance with Subsection 1.08.5, "Statistical Evaluation of Work for Acceptance and Determination of Pay Factor (Value of Work)," in these General Specifications.

2.08.9.3 Classification, Maximum Particle Size and CBR. Classification and CBR including gradation, plastic limit and liquid limit will be sampled, tested, and evaluated on the results of a minimum of one (1) test result per lot for the first three (3) lots and then one (1) test result for every fifth lot when changes in the material properties are suspected by the Contractor or the Engineer. Maximum particle size shall be determined by screening the entire sample as received over a ten (1 0) centimeter square screen. The weight retained on the ten (1 0) centimeter screen shall be recorded.

A lot will be accepted when all the classifications and maximum particle size tests representing that lot are as specified in Subsection 2.08.2 "Materials" in these General Specifications.

2.08.9.4 Finishing Tolerances and Requirements. Quality Assurance measuring or testing shall involve verification that the cement treated subgrade is constructed, timely finished and trimmed in a neat, workmanlike manner to the lines, grades and typical cross sections shown on the Plans or staked by the Engineer within the following tolerances and deadlines:

1. Cement treated subgrade slopes shall be constructed in conformance with the lines and grades established by the Engineer. The completed slopes shall not vary more than one (1) centimeter from the designated slope measured at right angles to the slope.

2. Finished Grade of Cement Treated Subgrade. The elevation of the top of cement treated subgrade surface shall be checked under the supervision of the Engineer. Each cross section shall be checked at each change in cross slope and intermediate points as directed. Cross sections shall be established at maximum intervals of twenty-five (25) meters with additional sections as directed by the Engineer. The allowable tolerances for the finished grade of the top of subgrade are as follows:

(1) When bituminous concrete or bituminous concrete base is to directly be placed on the subgrade, the finished top of subgrade at any point shall not vary more than one (1) centimeter above or below the grade established by the Engineer.

(2) When subbase or base material (other than bituminous concrete base) is to be placed on the subgrade, the finished top of subgrade at any point shall

not vary more than two (2) centimeters above or below the grade established by the Engineer.

2.08.9.5 Cement. The cement and other miscellaneous materials shall conform to the requirements in Subsection 2.08.2, "Materials," in these General Specifications based upon Certificates of Compliance delivered with each shipment.

2.08.9.6 Acceptance. Cement treated subgrade construction including classification, maximum particle size, California Bearing Ratio and finishing tolerances and requirements shall be accepted under Subsection 1.08.4, "Measured or Tested Conformance," in these General Specifications.

Cement shall be accepted under Subsection 1.08.3, "Certification of Compliance," in these General Specifications.

Compaction and thickness will be accepted under Subsection 1.08.5, "Statistical Evaluation of Work for Acceptance and Determination of Pay Factor (Value of Work)," in two (2) stages as follows: The first stage shall be the selection of the pay factor for the quality of the cement treated subgrade relating to compaction. The second stage involves the selection of a quantity pay factor based on the thickness of the cement treated subgrade. The reduced thickness pay factor for the lower courses of multiple layer courses will be applied provisionally based on the results of the depths of the holes dug in the lower layers. Additional holes will be dug in the total depth of all cement treated subgrade layers within the lot represented by lower layer reduced thickness pay factors. If the total thickness depths show that the increased upper level layer thickness has resulted in total thickness acceptability, the lower level layer reduced thickness pay factor will be adjusted accordingly. The second stage thickness quantity pay factor will be applied to all the individual course lots in addition to the first stage quality pay factor.

2.08.10 Method of Measurement. Cement treated subgrade will be measured by the cubic meter, as placed and compacted to the specified thickness and within the lines and grades shown on the plans or as directed by the Engineer. The amount of cement incorporated into the measured and accepted quantities of cement treated subgrade shall be measured in tons. No measurement shall be made for material placed outside authorized limits.

2.08.11 Payment. **The accepted quantity of cement treated subgrade, measured as provided above, will be paid for at the contract unit price per cubic meter for Cement Treated Subgrade and per ton for Cement as listed in the Bill of Quantities.**

Said price and payment shall cover and be full compensation for furnishing all equipment, labor, materials, tools and incidentals necessary for the proper completion of the cement treated subgrade as specified in Subsection 1.07.2, "Scope of Payment," in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO.	PAY ITEM	PAY UNIT
20801	Cement Treated Subgrade	Cubic Meter
20802	Cement	Ton

SECTION 2.09 - STRUCTURAL EXCAVATION AND BACKFILL

2.09.1 Description. This work shall consist of all excavation for foundations for bridges and other structures including reinforced concrete box culverts, headwalls, wingwalls, energy dissipators, crib walls, sign supports and retaining walls. This work shall include necessary bailing, drainage, pumping, sheeting, and the necessary construction of cofferdams or c-ribs, and their subsequent removal and placing of all necessary backfill. This work includes the disposal of all material obtained from such excavation and backfilling with the suitable material to the level of the original ground. It shall include the furnishing and placing of approved foundation fill material to replace unsuitable material encountered below the foundation elevation of structures.

Temporary Shoring and Cribbing shall consist of such shoring and cribbing required to support roadways or other public or private structures within five (5) meters of the excavation for the duration of the excavation operations.

ITEMS IN BILL OF QUANTITIES
Structural Excavation
Structural Excavation - Bridges
Structural Excavation - Other Structures
Temporary Shoring and Cribbing

The Contractor shall visit the site and evaluate the geological make-up of the area for himself and base his bid prices solely on his own determination of geological conditions. Variations in the actual volume or character of structural excavation quantities shall not be a basis for a claim for additional money or revision of bid price by the Contractor. No allowance will be made for the classification of materials regardless of their physical properties.

2.09.2 Construction.

2.09.2.1 General. The Contractor shall notify the Engineer a sufficient time in advance of the beginning of any excavation for structures which constitute a pay item in the Bill of Quantities so that the Engineer may observe the cross-sectional elevations and measurements taken of the existing ground in the area of the structure. Any materials removed or excavated before these measurements have been taken and approved by the Engineer will not be paid for.

The Contractor shall minimize, to the extent possible, the length of time that excavated areas are open. He shall be solely responsible for damages due to weather, equipment, accidents, or other causes when excavation is left open.

In areas where the excavation is adjacent to public roads and walkways, the Contractor shall erect all barricades, barriers, enclosed walkways, and warning signs necessary to restrict the exposure of the public to the excavation. Special precautions shall be taken in areas where children may play. The adequacy of all such safety measures shall be subject to the approval of the Engineer.

The Contractor shall take necessary precautions, including cofferdams and other shoring, to protect employees in the excavation and on the ground above. The Engineer will not enter excavated areas to approve the foundation and further work unless the area is considered safe.

2.09.2.2 Structural Excavation for Bridges. The foundations for bridges shall be excavated according to the outlines of the footings as shown on the plans and shall be of sufficient size to permit the placing of the full width and lengths of the footings shown with full horizontal beds. Rounded or undercut corners and edges of footings will not be permitted.

Borings and soil tests, including chloride and sulphate content if applicable, made prior to execution of this work, were carried out for purposes of establishing tentative soil conditions and bearing capacity at the locations of bridge foundations for the sake of the bridge design. The Contractor shall be responsible to conduct his own additional geotechnical investigations, as may be required, to verify the subsurface soil conditions, in order to ensure safe foundations for the structures. Such additional geotechnical investigations shall not be paid for directly but shall be considered as subsidiary to the pay item of this section.

The excavation shall be carried to the elevation shown on the plans or as established by the Engineer. Excavation depths for bridge footing foundations shall be only as directed by the Engineer. Borings and soil tests, made during design, and actual investigation of the completed foundation excavation will be used to determine final depth. No concrete shall be placed prior to the approval by the Engineer of the excavation pit. Excavation shall be carried to a depth so that the bottom of excavation is approximately one hundred (100) millimeters above the formation level of foundation (level of bottom of Blinding Concrete). No further excavation shall be carried out until the Engineer has examined the excavation and certified that at the level of excavation, the design bearing pressure stated in the drawings can safely be attained. After permission to proceed with the excavation is given, the Contractor shall excavate to the formation level and place the blinding concrete immediately. K after excavation to formation level, the placing of blinding concrete is delayed whereby the material at formation level becomes unsuitable, then additional excavation and backfilling with concrete shall be carried out as directed by the Engineer. If the depth of the additional excavation is less than five (500) millimeters, the concrete used for the backfilling shall be the same class as the concrete specified for the footing. If the depth of the additional excavation exceeds five hundred (500) millimeters, the concrete used for the backfilling shall be either no Fines Concrete or Cyclopean concrete in accordance with Section 5.01, "Portland Cement Concrete," in these General Specifications. The plan dimensions of the such additional excavation shall be increased to allow for the spreading of load from the footing at forty-five (45) degrees in all directions to the formation. When unsuitable material is encountered below the level specified for bridge footings, the Contractor at the direction of the Engineer, shall excavate such unsuitable material and backfill with concrete. The additional excavation and backfilling shall be as described above in this paragraph.

No payment will be made for unauthorized overdepth and overwidth excavation and the concrete backfill-shall be at the Contractors expense. Where excavation to rock foundation is required, the excavation shall be done in such manner as to allow the solid rock to be exposed and prepared in horizontal beds or properly serrated for receiving the concrete. All loose and disintegrated rock and thin strata shall be removed.

All blasting necessary in any one (1) pier or abutment shall be performed prior to placing any concrete. Where rock is encountered in the toe wall excavation for concrete box culverts or concrete headwalls for pipe culverts and the rock is such quality that will prevent erosion, part of the toe wall may be eliminated in the rock strata as directed, but the toe wall shall be keyed into the rock strata.

Where foundation piles are used, the excavation of each pit shall be completed before the piles are driven. All the foundation piling shall be driven in any pier abutment before concrete is placed in any column of that pier or abutment.

2.09.2.3 Structural Excavation for Culverts and Miscellaneous Structures. Excavation for culverts and miscellaneous structures shall be performed to the limits required for construction and to the depth required for bedding material or removal of unsuitable material.

When unsuitable material is encountered below foundation elevation for reinforced concrete box structures or pipe culverts, the Contractor, at the direction of the Engineer, shall excavate such unsuitable material and replace with suitable and stable backfill material. The foundation stabilization, including the degree of instability of the existing material, necessary depth of excavation, and suitability of the proposed backfill material, shall be approved by the Engineer prior to beginning the excavation.

The foundation material supporting the bedding or structure shall be Class A-1 a(O), A-1 -b(O), or A-2-4 material compacted to Type 95 compaction. If the natural material does not meet the classification requirements, it shall be subexcavated a depth of thirty (30) centimeters and replaced with material meeting the requirements contained in Subsection 2.09.3, "Materials," in these General Specifications. Any rock or hardened material within fifteen (1 5) centimeters of the bottom of the structure shall be similarly subexcavated and replaced with material meeting the classification requirements.

If no special bedding is required, the foundation for precast and prefabricated culverts shall be shaped to the shape of the culvert, including all protrusions. The shaping shall extend to twenty-five percent (25%) of the normal height of the culvert.

2.09.2.4 Foundation Pits. When no piles are used and structures are to rest on an excavated surface other than rock, the following shall apply:

The Contractor may excavate in open pits when:

1. Worker safety is assured.
2. Footings can be placed in dry material away from flowing water.
3. The integrity of the structure and its surroundings, including existing pavement is not reduced.

Care shall be taken during excavation to prevent disturbing the foundation. If ground water is encountered during excavation and a concrete seal course is not to be used, dewatering shall be commenced and shall proceed in advance of or concurrently with further excavation. The foundation shall be free of water at the time footing concrete is placed, and water control shall continue as necessary to prevent damage to the work.

All dewatering shall be performed at the Contractors sole expense and shall be considered as included in the contract unit price(s) for the facility being constructed. The sides of excavations may be sloped as required by soil conditions to stabilize the sides for safe working conditions. The quantities of excavation for said sloping will not be measured for payment and backfilling shall be done with suitable materials, approved by the Engineer, at the Contractors expense.

If suitable foundation material has been disturbed by the Contractors operations, has been damaged by the water or has been removed for the Contractors convenience in dewatering the foundation, the foundation shall be restored by the Contractor at his expense, to a condition at least equal to the undisturbed foundation as determined by the Engineer.

When undisturbed original material at the planned grade of the excavation does not meet the foundation material requirements as defined in Section 2.09.3.2, "Foundation Material" or in these General Specifications, the Engineer shall order that the unsuitable material be removed and replaced with suitable material.

When footings or masonry are to rest upon rock, the rock shall be fully uncovered and the surface thereof shall be removed to a depth sufficient to expose sound rock. The rock shall be leveled to cut to steps and roughened. Seams shall be grouted under pressure or treated as the Engineer may direct.

Where rock, in either ledge or boulder formation, or other unyielding material is encountered in one (1) portion of foundation for a concrete box culvert and a yielding material is encountered in an adjacent are of the foundation excavation for the same box culvert, such unyielding material shall be removed for a minimum depth of sixty (60) centimeters and backrilled with structure backfill.

2.09.2.5 Pile Foundations. When footings are to be supported on piles, excavations shall be completed to the bottom of footings before any piles are drilled or driven therein. When swell or subsidence results from driving piles, the Contractor shall at his expense, excavate, or backfill with suitable material, the footing area to the grade of the bottom of footing as shown on the plans. If material under footings is such that it would mix into the concrete during placement or would not support the weight of the fluid concrete, the Contractor shall, at his expense, replace the material with suitable material, install soffit forms or otherwise provide a suitable platform on which to cast the footing.

2.09.2.6 Cofferdams. All foundation excavation within five (5) meters of the traveled way and two (2) meters or more in depth shall be shored, cribbed, or protected by cofferdams. All other excavation shall be shored, cribbed or protected by cofferdams except those that meet the requirements of Paragraph 2.09.2.4, "Foundation Pits," in these General Specifications.

Cofferdams shall be used in all excavation that is under water or affected by ground water. A cofferdam is any water tight enclosure, sealed at the bottom, that surrounds the excavated area of a structure.

The Contractor shall submit to the Engineer, not less than fourteen (14) days in advance of beginning excavation requiring shoring, cribbing or cofferdams, plans showing proposed methods and construction details of shoring, cribbing and cofferdams. The Contractor shall not begin construction until the Engineer has approved the plans. The Contractor shall remain responsible for satisfactory results.

Cofferdams shall be constructed in a manner capable of resisting earth and water pressures without appreciable displacement. Cofferdams shall be sunk to a depth that will prevent material from flowing into the excavation. A clear space of sixty (60) centimeters shall be provided on all sides between the footing, as shown on the plans, and the cofferdam. Cofferdams shall not be used as a form for footings. Cofferdams may be used as a form for concrete seal courses. Bracing for cofferdams and shoring shall not be encased in the concrete of the structure,

At locations where concrete seal courses are shown on the plans or when the bottom of the foundation excavation is of porous material which will not, in the opinion of the Engineer, permit the footing to be satisfactorily constructed, concrete seal courses shall be placed. Concrete seal courses shall consist of concrete, conforming to the requirements for Class B concrete in Section 5.01, "Portland Cement Concrete," in these General Specifications, placed using underwater placement techniques and of sufficient thickness, approved by the Engineer, to permit the cofferdam to be pumped dry.

The Contractor shall furnish and operate sufficient dewatering pumps to keep the cofferdam dry.

If, in the opinion of the Engineer, the need for a concrete seal course is due to improper construction of the cofferdam, he may order the reconstruction of the cofferdam, or the placement of a concrete seal course at the Contractors expense.

After the concrete seal course has set, the cofferdam shall be cleared of water and construction of the structure completed in the dry.

All materials used in the construction and bracing of shoring, cribbing and cofferdams shall be removed to the natural bed of the waterway or one (1) meter below finished ground line.

2.09.2.7 Scheduling Excavation for Structures. The Contractor shall so schedule the work that no excavation will be left in an exposed condition for a period greater than thirty (30) days unless otherwise approved by the Engineer. If the Contractor fails to meet this requirements, the Engineer will order the Contractor to suspend further structural excavation until the Contractors progress enables him to meet the requirement.

In areas where the excavation is adjacent to public roads and walkways, no excavation shall be scheduled to be left in an exposed condition more than fourteen (14) days unless otherwise approved by the Engineer.

The Contractor shall schedule roadway excavation and embankment work and drainage work so that they complement each other. If the Contractors earth work progress exceeds the progress of the drainage work to the point where the roadway becomes a dam to cross drainage, the Engineer will order the Contractor to open adequate waterways through the roadway at the locations where drainage structures are to be installed. Any damage to the roadway caused by water passing through these openings shall be repaired at the Contractors expense.

2.09.3 Materials.

2.09.3.1 General. When the foundation material under Structures other than Bridges is of an unstable nature, the Engineer may direct in writing that the foundation be improved by excavating below the required elevation, and backfilling with gravel or crushed stone, slurry cement, combinations of stone and slurry cement or other suitable material approved by the Engineer.

Completed structures shall be backfilled with material free from spongy or vegetable substances and rock or broken concrete over eight (8) centimeters in the greatest dimension. When pervious backfill is shown on the plans or specified, backfill material shall conform to the requirements in this section. Slurry cement backfill may be placed to backfill structures when requested by the Contractor and approved by the Engineer. No additional compensation shall be allowed when slurry cement backfill is requested by the Contractor and placed in lieu of other acceptable backfill material.

2.09.3.2 Foundation Material. Material excavated from the roadway, borrow pits, structure foundation or produced by processing shall be used in preparing the foundation for structures when it conforms to the following requirements:

1. Material classified by AASHTO M-145 as A-1-a(O), A-1-b(O) or A-2-4(0) and no rock fragment larger than eight (8) centimeters.

2. Aggregate subbase or base materials conforming to the requirements in Sections 3.02, "Aggregate Subbases," and 3.03, "Aggregate Bases," in these General Specifications.

3. Slurry Cement. When shown on the plans, specified in the Special Specifications or requested by the Contractor and approved by the Engineer, slurry cement may be used in preparing the foundation for structures when it conforms to the following requirements:

(1) Aggregate.

Sieve Size	Percentage Passing
62.5 mm (1 ½ inch)	100
50 mm (1 inch)	80-100
19 mm (% inch)	60-100
9.5 mm (3/a inch)	50-100
4.75 mm (No. 4)	35-70
0. 1 50 mm (No. 100)	5-20

(2) Cement. Cement shall be Portland cement.

(3) Water. Water shall be free from oils, salts or other impurities which would have an adverse effect on the quality of the slurry cement material.

(4) Proportions. Proportioning may be done by weight or volume. The cement content shall not be less than one hundred ten (110) kilograms per cubic meter. The water content shall be sufficient to produce a fluid, workable mix that will flow and can be pumped without segregation of the aggregate while being placed. Materials for slurry cement shall be thoroughly machine mixed until cement and water are dispersed throughout the material. Slurry cement shall be placed within forty-five (45) minutes after mixing.

4. Portland Cement Concrete, all classes, specified in Section 5.01, "Portland Cement Concrete," in these General Specifications.

2.09.3.3 Structural Backfill Material. Material excavated from the roadway, borrow pits, structure foundation or produced by processing shall be used for structure backfilling when it conforms to the following requirements:

1. Gravel, crushed stone or slurry cement conforming to the requirements specified in Paragraph 2.09.3.2, "Foundation Treatment Material" in these General Specifications.

2. No-fines or Cyclopean Concrete conforming to the requirements specified in Section 5.01 "Portland Cement Concrete," in these General Specifications.

3. Concrete coarse aggregate as specified in Subparagraph 5.01-2.2.2, "Coarse Aggregate" in these General Specifications.

4. When pervious backfill material is called for on the plans or specified in the special specifications, gravel, crushed gravel, crushed rock, natural sands, manufactured sands or combinations thereof shall be used in backfilling structures when said material conforms to the following requirements:

Sieve Size	**Percentage Passing**
62.5 mm (21/2 inch)	**100**
0.300 mm (No. 50)	**0-100**
0. 1 50 mm (No. 100)	**0-8**
0.075 mm (No. 200)	**0-4**

Pervious material shall be uniformly graded within the specified range. At locations where pervious backfill material will be exposed to erosion by wind or water it shall be covered with at least one and one-half (1 +1/2) meters of material which resists erosion by wind and water and is approved by the Engineer.

2.09.4 Backfilling Structures. The type of material used in bedding, filling and backfilling shall conform with the details shown on the drawings or as contained in Subsection 2.09.3 "Materials" and shall be considered subsidiary to structural excavation and no additional payment will be made thereof. All earth material which has loosened or collapsed into the excavation from adjacent ground, all trash, forms, and loose rocks larger than twenty (20) centimeters in greatest dimension shall be removed from the excavation before backfill begins.

Backfill material shall be placed in uniform layers and brought up simultaneously on all sides of the structure or facility. The thickness of each layer shall not exceed thirty (30) centimeters before compaction except that when compaction is done by ponding and jetting said thickness shall not exceed one (1) meter. Backfilling shall extend to the original ground or to the top elevation of any embankment, in-place or to be placed.

Backfill material may be compacted by mechanical or pneumatic tamping devices or backfill material may be placed as a slurry. Compaction equipment or methods which will displace or cause damage to the structure shall not be used.

Structure backfill shall not be placed until the structure footings or other portion of the structure or facility have been inspected by the Engineer and approved for backfilling. No backfill material shall be deposited against the back of concrete abutments, concrete retaining walls of the outside walls of cast-in-place concrete structures until the concrete has attained a strength of not less than one hundred eighty (180) kilograms per square centimeter in compression, or until the concrete has been in place twenty eight (28) days, whichever occurs first.

Backfill at the inside of bridge wingwalls and abutments shall be placed before curbs or sidewalks are constructed over the backfill and before railings on the wingwalls are constructed.

Pervious backfill material shall be placed in layers along with and by the same methods specified for structure backfill. Pervious material at one (1) location shall be approximately the same grading.

Slurry cement backfill shall be placed in uniform horizontal layers not exceeding one (1) meter in depth. Unless otherwise approved by the Engineer, the slurry shall be compacted with internal vibrators. Backfilling over or placing any material over slurry cement shall not commence until four (4) hours after the slurry cement backfill has been placed.

The cells formed by crib members of crib walls and the space between the crib wall and the limits designated for foundation excavation, as shown on the plans or specified in the special specifications, including any material being removed outside said limits, shall be backfilled with material conforming to the following gradations, quality and placement requirements:

1. Backfill placed for crib walls shall be of such character that it will not sift or flow through openings in the wall.

2. Material classified by AASHTO M-145 as A-1-a(O), A-1-b(O) and A-2-4(0) and no rock fragment larger than eight (8) centimeters.

3. Class A Aggregate Subbase or Base materials conforming to the requirements in Sections 3.02, "Aggregate Subbases,' and 3.03, "Aggregate Bases" in these General Specifications.

4. Backfilling shall progress simultaneously with the erection of the crib wall. Backfill shall be so placed as to not disturb or damage the crib members, shall be placed in uniform layers before compaction not exceeding thirty (30) centimeters thickness and shall be compacted by hand tamping, mechanical compaction or other means approved by the Engineer.

2.09.5 Compaction of Structural Backfill. Compaction of structural backfill by ponding and jetting will be permitted when, as determined by the Engineer, the backfill material is of such character that it will be self-draining when compacted and that foundation materials will not soften or be otherwise damaged by the applied water and no damage from hydrostatic pressure will result to the structure. Ponding and jetting of the upper one and one-half (1 %) meters below finished grade will not be permitted. The work shall be performed without damage to the structure and embankment, and in such manner that water will not be impounded. Ponding and jetting methods shall be supplemented by the use of vibratory or other compaction equipment when necessary to obtain the required compaction.

Structural backfill shall be compacted to a dry density not less than ninety-five percent (95%) of the maximum density determined from MRDTM 212 when compactible material is used. When materials such as concrete coarse aggregate is used, it shall be consolidated with two (2) passes of mechanical vibratory or plate compaction equipment.

At locations where at least one and one-half (1 '1/2) meters of material resistant to erosion caused by wind or water is placed to cover pervious material, the cover material shall be compacted to a dry density not less than ninety-five percent (95%) of the maximum density determined by MRDTM 212.

2.09.6 Quality Assurance Procedures. The Contractor shall sample and test foundation treatment material, structure backfill materials, pervious backfill, concrete seal course and all other materials covered by the specifications as necessary to confirm the quality of materials entering the work. Density tests, when specified, will be performed at the rate of one (1) per compacted lift. The Contractor shall furnish the test results to the Engineer within twenty-four (24) hours after completion of the test.

The Engineer reserves the right to request, at any time, duplicate samples be obtained by the Contractor for check testing performed by the Engineer. The Engineer reserves the right to enter the work at any time and sample materials entering the work and perform density tests.

When a discrepancy occurs between test results provided by the Contractor and those completed by the Engineer, work on the structure backfill shall cease until the discrepancy has been clarified.

2.09.7 Disposal of Unsuitable and Surplus Excavation. Excavated materials which are designated by the Engineer to be surplus or unsuitable for use in backfilling structures or construction of embankment shall be disposed of as specified in Subsection 2.03.4 "Disposal of Unsuitable and Surplus Materials" in these General Specifications. No surplus or unsuitable materials shall be disposed of in or along any stream, water way, lake or other area subject to periodic water flow or storage.

2.09.8 Method of Measurement. Measurement of Structural Excavation Bridges - will be limited to excavation for foundations of bridge piers and bridge abutments.

Measurement of Structural Excavation - Other Structures - will be limited to footings or foundations for retaining walls, pipe culverts, box culverts including inlet/outlet structures and toe walls associated with box culverts and floor slabs of underpass structures. No measurement will be made of structural excavation for pipe culvert wingwalls, headwalls and aprons, or for ducts and storm sewers, catchbasins, pump houses, manholes and inlets regardless of the type of pipe or duct used or the type of material through which the excavation is made.

Excavation shown on the plans or specified in the special specifications or measured as Roadway Excavation - Channel and Ditch will not be measured as Foundation Excavation.

No measurement will be made nor compensation allowed for removal and use or disposal of material which may come into an excavation from outside designated limits or for furnishing and placing backfill material in an excavation that is below or outside designated limits.

The quantities for payment shall be determined from limits shown on the plans or specified in these specifications or the special specifications.

Structural excavation shall be measured by the cubic meter of material removed, computed by the average end area. Measurements shall be made by the Contractor, in the presence of the Engineer, in a manner approved by the Engineer. No measurement will be made for structural excavation outside the following limits.

The pay volume of structural excavation shall be that measured with a prism with limiting planes of (1) the bottom of the foundation as shown on the plans or otherwise specified by the Engineer, (2) the vertical planes shown on the plans or otherwise specified by the Engineer and (3) the upper limits as follows:

1. Fill Areas. In fill areas, the original ground surface as recorded on approved cross sections.

2. Cut Areas. In cut areas, such as roadway cut-sections, channel changes, and stream channel cleanouts, the top of cut grade such as top of subgrade or flow line of channel as shown in the plans or otherwise directed by the Engineer. The volume of excavation in the roadway cuts, channel changes, and stream cleanouts shall be measured and will be paid for as provided in Section 2.03, "Excavation," in these General Specifications.

When no excavation dimension detail appears in the plans, the limits of excavation shall be as follows:

3. Bridge Footings. Excavation from upper limit plane to the formation level- of foundation shall be limited by vertical planes three hundred (300) millimeters outside the actual footing dimensions in the plan. The formation level of foundation is defined as the underside of the blinding concrete. The upper limit plane shall be the lowest of the following:

The mean existing ground level over the plan area of the footing at the time the Contractor is given full possession of Site or the mean level of the final ground over the plan area of the footing where general excavation such as regrading or landscaping of the area is required, or from the bottom of subgrade elevation above that footing, only if the Contractor has not carried out the general excavation of the area by the time he carried out the general excavation for the footing.

In cases of high water table due to any reasons, the Contractor shall carry out the necessary technical and practical actions to construct the foundations properly. This includes getting rid of water by pumping or constructing sheet piles to dry the pit to enable concreting as per Engineer instruction. All these works are subsidiary to contract items.

4. Box Culverts. Excavation from upper limit plane to the formation level of foundation shall be limited by vertical planes three hundred (300) millimeters outside the culvert dimensions in plan. The definitions of formation level and upper limit planes shall be as defined in Sub-clause 3 of this clause. Excavations for toe walls

shall be limited to the actual depth of toe walls plus the blinding concrete and vertical planes walls three hundred (300) millimeters outside the outer faces of the toe walls.

5. Pipe Culverts. Excavation from the bottom of the pipe bedding plane to the bottom of the unsuitable foundation material excavation shall be limited by the pipe trench width limits contained in Subsection 2.09.2, "General," in these General Specifications.

6. Special Conditions. When the Contractor encounters special or unusual conditions he shall notify the Engineer who may direct special structural excavation limits where he deems them necessary. Any additional excavation because of special conditions, performed by the Contractor without prior approval of the Engineer, shall be at the Contractors expense and no subsequent measurement or payment will be made.

When included in the Bill of Quantities, "Temporary Shoring and Cribbing Structure" shall include all Work required by the plans and specifications for a specific structure, completed and accepted by the Engineer, and maintained by the Contractor for the duration of its need.

2.09.9 Payment. The amount of authorized, completed and accepted Work measured as provided in the previous Subsection will be paid at the contract unit price(s) per cubic meter for Structural Excavation - Bridges and Structural Excavation - Other Structures as they may appear on the Bill of Quantities, which price(s) shall be full compensation for all excavation, trimming, cleaning, foundation adjustment, furnishing of backfill material, backfilling, compaction, water, and the disposal of surplus materials and the furnishing of all equipment, tools, labor, and all other items necessary for the proper completion of the Work as specified in Subsection 1.07.2, "Scope of Payment," in these General Specifications.

When included in the Bill of Quantities, "Temporary Shoring and Cribbing. Structure," constructed, accepted, and maintained, based on the Plans and Special Specifications, will be paid on a lump sum basis. If significant changes to the design are ordered by the Engineer which changes the magnitude of the Temporary Shoring and Cribbing, required for a specific structure, an equitable adjustment to the contract unit price for that unit will be made. If no "Temporary Shoring and Cribbing Structure" item is included in the Bill of Quantities, then this Work, if required, will be considered subsidiary to other items of Work.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO.	PAY ITEM	PAY UNIT
20901	Structural Excavation	Cubic Meter
2090101	Structural Excavation-Bridges	Cubic Meter
2090102	Structural Excavation-Other Structures	Cubic Meter
20902	Temporary Shoring and Cribbing, Structure	Lump Sum

SECTION 2.10 - TRENCH EXCAVATION AND BACKFILL

2.10.1 Description. This work shall consist of excavation of trenches for the construction of pipe for drainage, water and sanitary sewer services or other facilities shown on the plans as pipe, the construction or installation of all facilities necessary to accomplish the work, all bailing, drainage, pumping necessary to keep the trench free of standing or flowing water, sheeting, furnishing and placing bedding material, and backfilling pipe and trench, all as shown on the plans and the special specifications or as directed by the Engineer.

The Contractor shall visit the site and evaluate the geological make-up of the area for himself and base his bid prices solely on his own determination of geological conditions. Variations in the actual volume or character of structural excavation quantities shall not be a basis for a claim for additional money or revision of bid price by the Contractor. No allowance will be made for the classification of materials regardless of their physical properties.

When unsuitable pipe foundation material is encountered below the bottom of bedding elevation as determined by the Engineer, said unsuitable material shall be removed to the depth directed by the Engineer and backfilled with suitable and stable backfill material. It shall be replaced with suitable and stable backfill material and shall be measured and paid for at the contract unit price for Unclassified Structural Excavation - Other Structures.

2.10.2 Construction.

2.10.2.1 General. Pipe for drainage, water and sewer services, or other facilities shown on the plans as pipe, shall be installed in trenches excavated into previously constructed embankment or original ground.

The Contractor shall notify the Engineer in advance of the beginning of any trench excavation below the bottom of bedding that may constitute a pay item in the Bill of Quantities so that the Engineer may observe the profile elevations and measurements taken along the center line of the trench. Any materials removed or excavated before these measurements have been taken and approved by the Engineer will not be paid for.

Where pipe is to be placed in a new embankment, the embankment shall be constructed as specified in Section 2.05, "Embankment," in these General Specifications, to a minimum height sixty (60) centimeters above the outside diameter of the pipe or subgrade surface elevation which is lowest, and for a distance each side of the pipe location equal to at least ten (10) times the outside diameter of the pipe.

Where pipe is installed in original ground, excavation shall be by open trench unless otherwise shown on the plans or specified in the special specifications.

The Contractor may request the Engineer to approve construction by tunneling or jacking any portion not so specified.

The trench within which the pipe is to be placed shall be excavated to the widths shown on the plans. When widths are not shown on the plans the trench shall be excavated such that the clearance from each side of the pipe will be as follows:

1. Pipe up to eighteen (1 8) centimeters outside diameter - fifteen (15) centimeters.

2. Pipe and pipe arches from eighteen (1 8) centimeters to not more than one and one-half (1.5) meters in outside diameter - thirty (30) centimeters.

3. Pipe and pipe arches greater than one and one-half (1.5) meters outside diameter - sixty (60) centimeters.

Trenches greater than one and one-half (1 %) meters in depth shall be excavated with sloping sides or shored and braced at the option of the Contractor. The Contractor shall submit to the Engineer, not less than seven (7) days prior to beginning trench excavation greater than one and one-half (1 1/2) meters in depth, detailed plans showing the design of side slopes, shoring or bracing proposed for use. The Contractor shall not begin trench excavation which is greater than one and one-half (1 1/2) meters in depth until the Engineer has approved the plans. The Contractor shall remain responsible for satisfactory results.

Safe and suitable ladders which project at least sixty (60) centimeters above the top of the trench shall be provided for all trenches greater than one and one-half (1.5) meters in depth. One (1) ladder shall be installed in the trench for each thirty (30) meters of open trench, or fraction thereof, and so located in the trench that workmen need not move more than fifteen (1 5) meters to a ladder.

The bottom of the trench shall be graded according to the lines, slopes and elevations shown on the plans or directed by the Engineer, and bedding material placed and compacted. If the Engineer determines that the material in the bottom of the trench is satisfactory for pipe bedding, placement of pipe bedding material will not be required providing the existing material is loosened, regraded and compacted to form a dense unyielding foundation.

2.10.2.2 Scheduling. The Contractor shall schedule roadway excavation, embankment construction and installation of pipe for drainage so that they complement each other. Embankment construction which interferes with, reduces or prevents the flow of normal or necessary drainage shall not be allowed.

Trench excavation for culvert construction shall not be left in an exposed condition for more than thirty (30) days unless approved by-the Engineer.

Trench excavation for construction of water and sewer services, subdrainage systems other than culverts, electrical conduits and other ducts shall not be more than two hundred (200) meters ahead of the pipe laying operations and shall be backfilled or covered at the end of each day. Where cast-in-place pipe construction is specified or elected by the Contractor and approved by the Engineer, the allowable maximum length of open trench at any one (1) location shall be that which is necessary to permit uninterrupted progress, but in no event, greater than five hundred (500) meters.

2.10.2.3 Trench Excavation. **The Contractor shall establish line and grade as shown on the plans and profile the original ground or embankment as directed by the Engineer.**

The Contractor shall perform all excavation of every description and of whatever materials encountered to the depth indicated on the plans or specified or ordered by the Engineer. Material excavated from trenches shall be piled on one (1) side of and adjacent to the trench and maintained so that the toe of slope of the piled material is at least sixty (60) centimeters from the edge of the trench. When material excavated from a trench is piled in or adjacent to a traveled way, it shall be located to cause a minimum of inconvenience to vehicle travel. The Contractor shall minimize the length of time that trenches are open.

The Contractor shall exercise sound engineering and construction practices in excavating the trench and maintaining it so that no damage will occur to any foundation, structure, pole line, pipe line, traffic sign or signal structure, electric cable or conduit, or other facility. No act, representation or instruction from the Engineer or his representatives shall relieve the Contractor from liability for damages or costs that result from trench excavation.

Care shall be taken not to excavate below the depth specified or ordered by the Engineer, and excavation below that depth shall be backfilled with sand bedding material at the Contractors expense.

When water is encountered during trench excavations, the Contractor shall remove the water by bailing, pumping or other means necessary to permit installation of the pipe facility in a trench without ponding or flowing water. The cost of dewatering shall be considered as subsidiary to the pipe being installed.

2.10.2.4 Unsuitable Foundation Material. **If in the opinion of the Engineer, it is necessary to adjust, correct, relocate, or in any way change the trench line and grade shown on the plans, such changes shall be made by the Contractor under the terms of these specifications.**

Where trench excavation exposes unsuitable foundation material below the bottom of bedding excavation, as determined by the Engineer, said unsuitable material shall be excavated to the depth directed by the Engineer and backfilled with suitable and stable backfill materials meeting the requirements of Paragraph 2.08.3.3, "Foundation Materials," and compacted in accordance with Subsection 2.08.5, "Backfilling Structures," both in these General Specifications.

All unsuitable material shall be loaded directly into trucks and hauled to disposal sites and disposed of as specified in Subsection 2.03.4, "Disposal of Unsuitable and Surplus Materials" in these General Specifications.

2.10.2.5 Precast Concrete Pipe Culverts. Culvert pipe shall be installed in trenches excavated in a new or existing embankment in accordance with the lines and grades shown on the plans or as directed by the Engineer as specified in Section 6.08, "Pipe Culverts," in these General Specifications.

Bedding for precast concrete pipe shall be as shown on the plans, specified in the Special Specifications or specified in Subsection 2.10.3 "Bedding Materials" in these General Specifications. The bedding material shall be placed in more than one (1) layer. The first layer shall be at least twenty (20) centimeters thick as bedding under the pipe in the bottom of the excavation. Subsequent trench backfill layers, not more than twenty (20) centimeters thick, shall be placed around the pipe and compacted.

When belled pipe are to be installed, the bedding shall be shaped to receive the bell. All adjustments to line and grade shall be made by removing or filling with bedding material and not by wedging or blocking.

Trench backfill material shall be deposited on compacted bedding material in layers not exceeding twenty (20) centimeters loose thickness. Backfill material may be placed around and over the pipe while joint mortar is still plastic. Should the joint mortar become set before backfill material is placed around and over the pipe, placement of bedding material shall not be commenced within sixteen (16) hours of jointing the pipe. Placement and compaction of successive layers shall continue to the top of the embankment or sixty (60) centimeters above the top of the pipe, whichever is greater.

All layers of bedding material and trench backfill material shall be compacted to a dry density not less than ninety percent (90%) of the maximum dry density determined from MRDTM 212.

When soil cement bedding material is placed, the bedding material placed below the springline of the pipe. The soil cement shall be compacted with internal vibrators to form a dense mass.

A dike of impervious material at least one and one-half (1 "/2) meters in length shall be placed and compacted near the intake and outlet ends of the culvert to prevent piping.

2.10.2.6 Metal Pipe Culverts. Culvert pipe shall be installed in trenches excavated in new or existing embankment in accordance with the lines and grades shown on the plans or as directed by the Engineer as specified in Section 6.08, "Pipe Culverts," in these General Specifications.

Pipe bedding material and trench backfill material shall be furnished, placed and compacted as specified in Paragraph 2.10.2.5, "Precast Concrete Pipe Culverts," in these General Specifications.

A dike of impervious material at least one and one-half (1 %) meters in length shall be placed and compacted near the intake and outlet ends of the culvert to prevent piping.

2.10.2.7 Cast in Place Concrete Pipe. Nonreinforced cast in place concrete pipe shall be cast monolithically in a prepared trench at the locations and in accordance with the lines and grades shown on the plans.

The trench shall be excavated and shaped according to the details shown on the plans and prepared to provide full, firm and uniform support over the bottom two hundred ten (210) degrees of the pipe to be constructed.

The trench walls, from a point thirty (30) centimeters above the-tope of the pipe, may be sloped as required by soil conditions to provide more stability in the trench and safer working conditions.

Backfilling cast in place concrete pipe shall not begin until the concrete has developed a compressive strength of at least one hundred fifty (1 50) kilograms per square centimeter (kg/CM^2).

The type of trench backfill material shall conform to the requirements of Paragraph 2.09.3.3, "Structural Backfill Materials" in these General Specifications.

Placement and compaction of trench backfill material shall conform to the requirements of Paragraph 2.10.2.5, "Precast Concrete Pipe Culverts," in these General Specifications.

2.10.3 Bedding Materials.

2.10.3.1 Sand Bedding. Sand shall be free from clay or organic material, suitable for the purpose intended, and shall be of such size that ninety (90) to one hundred percent (1 00%) passes a 4.75 mm (No. 4) sieve and not more than five percent (5%) passes a 0.075 mm (No. 200) sieve.

2.10.3.2 Soil Cement Bedding. When shown on the plans or specified in the special specifications, soil cement bedding to be placed under pipe shall conform to the following requirements:

1. Aggregate.

Percentage

Sieve Size	Passing
37. 5 mm (1 '1/2 inch)	100
25 mm (1 inch)	80-100
19 mm ("A inch)	60-100
9.5 mm (% inch)	50-100
4.75 mm (No. 4)	35-70
0.075 mm (No. 200)	5-20

2. Cement. Cement shall be Portland Cement, Type I or II.

3. Water. Water shall be free of oils, salts or other impurities which would have an adverse effect on the quality of the soil cement bedding material.

4. Proportions. Proportioning may be done by weight or volume. The cement content shall not be less than one hundred sixty (160) kilograms per cubic meter. The water content shall be sufficient to produce a fluid, workable mix that will flow and can be pumped without segregation of the aggregate while being placed. Materials for soil. cement bedding shall be thoroughly machine mixed until cement and water are dispersed throughout the material. Soil cement bedding shall be placed within forty-five (45) minutes after mixing.

Backfilling with earth on culverts set in soil cement bedding shall not commence until eight (8) hours after the soil cement bedding has been placed.

2.10.4 Trench Backfill Materials. Materials excavated from the roadway, borrow pits, foundations, trenches or produced by processing shall be used for pipe bedding and trench backfilling when it conforms to the following requirements:

1. Material classified by AASHTO M-1 45 as A-1 -a(O), A-1 -b(O) and A-2-4(0) and no rock fragment larger than six (6) centimeters.

2. Base material conforming to the requirements in Section 3.03, "Aggregate Bases," in these General Specifications.

3. Slurry cement conforming to the requirements in Paragraph 2.09.3.2, "Foundation Material," in these General Specifications.

4. Pervious Backfill conforming to the requirements in Paragraph 2.09.3.3, "Structural Backfill Material," in these General Specifications.

5. Other materials used in embankments construction or structure backfill as approved by the Engineer with no rock fragment larger than six (6) centimeters.

2.10.5 Quality Assurance Procedures. The Contractor shall sample trench bedding and backfill materials and other items entering the work as specified or required to assure that the items conform to special requirements. Density tests, where specified, shall be performed at the rate of one (1) per compacted lift. The results of sampling and testing shall be furnished to the Engineer within twenty four (24) hours after completion of the testing.

The Engineer reserves the right to request, at any time, that the Contractor obtain duplicate samples of materials for check testing performed by the Engineer.

The Engineer reserves the right to enter the work at any time and obtain samples and perform density tests.

When a discrepancy occurs between the test results furnished by the Contractor and results from tests completed by the Engineer, the work shall cease until the discrepancy is clarified.

2.10.6 Method of Measurement. No measurement shall be made for clearing and grubbing, removal of existing road improvements, protection of existing utilities and services, trench excavation including dewatering, bedding of the pipe, and compaction of bedding and backfill.

Removal of unsuitable foundation material as specified in Paragraph 2.10.2.4, "Unsuitable Foundation Material," in these General Specifications and replacement with pipe bedding material shall be measured in cubic meters. The horizontal limits for measuring unsuitable material excavation will be the sides of the trench specified in Paragraph 2.09.2.1, "General," in these General Specifications. Vertical distances shall be the depth of additional excavation ordered by the Engineer.

2.10.7 Payment. No separate payment will be made for clearing and grubbing, removal of existing road improvements and protection of existing utilities and services, trench excavation and backfill within the lines and grades shown on the plans, including dewatering and furnishing and placing pipe bedding and compaction of bedding and trench backfill. The costs for such work shall be considered as subsidiary to the work of constructing pipe facilities and all costs therefore shall be included in the contract unit prices listed in the Bill of Quantities for the pipe facility constructed.

Excavation of Unsuitable Foundation Material - Payment shall be made at the contract unit price per cubic meter for Structural Excavation - Other Structures, for the actual quantities measured by the Engineer, which price and payment shall be full compensation for removing unsuitable material and replacing with suitable and stable backfill material.

Said prices and payments shall be full compensation for furnishing labor, equipment, materials, tools and all incidentals necessary for the completion of the Work as specified in Subsection 1.07.2, "Scope of Payment," in these General Specifications.

KINGDOM OF SAUDI ARABIA
MINISTRY OF COMMUNICATIONS

GENERAL SPECIFICATIONS
FOR
ROAD AND BRIDGE CONSTRUCTION

November 1998

PART THREE
AGGREGATE SUBBASE AND BASE COURSES

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PART THREE: AGGREGATE SUBBASE AND BASE COURSES

SECTION 3.01 - PRODUCTION, HANDLING AND STOCKPILING AGGREGATES

3.01.1 DESCRIPTION. This work consists of producing, handling and stockpiling crushed and screened aggregates including pit run aggregates of the kind, quality and grading specified for all types of materials to be used in road and bridge and related construction.

Requirements set forth herein shall apply whether the source be ledge rock, talus, gravel, sand, or a combination thereof.

3.01.2 MATERIALS.

3.01.2.1 Sources. Materials sources may be shown on the plans, described in the special specifications, or established by the Contractor after approval by the Engineer.

The Contractor shall furnish the Engineer, not less than thirty (30) days prior to the scheduled date for beginning crushing operations, information on the source of aggregates, the method of production to be employed, types and capacity of equipment to be used and a schedule showing rates of production for the several types of aggregate to be produced.

Whether or not the materials sources are shown on the plans, specified in the special specifications, or established by the Contractor after approval by the Engineer, the Contractor shall determine for himself the types and numbers of equipment and extent of work needed to remove overburden and produce the volumes of aggregates required for the work within the contract time, and produce aggregates having the fracture, gradation and quality conforming to the specifications.

The Engineer may require procurement of aggregate from any portion of a source and may reject portions of the source as being unacceptable.

3.01.2.2 Definitions.

1. Coarse aggregate consists of particles retained on the 4.75 mm (No. 4) sieve.

2. Fine aggregate consists of particles passing the 4.75 mm (No. 4) sieve.

3. Crushed stone consists of rock and stone fragments or gravel having one (1) or more mechanically fractured faces. Every fractured face shall have a minimum dimension from edge to edge across the fractured face which is not less than one-third (1/3) the minimum dimension of the aggregate particle.

4. Gravel consists of uncrushed aggregate particles passing a seventy-five (75) millimeter (3-inch) sieve and retained on a 4.75 mm (No. 4) sieve.

5. Sand consists of aggregate particles passing a 4.75 millimeter (No. 4) sieve and retained on a 0.075 millimeter (No. 200) sieve and may be naturally occurring, manufactured or combinations thereof.

6. Material passing a 0.075 mm (No. 200) sieve may be referred to as silt or clay or dust depending on other characteristics.

3.01.3 PRODUCTION REQUIREMENTS.

3.01.3.1 Preparation of Site. The portion of the quarry or pit site to be used shall be cleared and grubbed as specified in Section 2.01, "Clearing and Grubbing" in these General Specifications.

When clearing and grubbing is completed, all surface materials which are unsatisfactory for the kind of aggregate to be produced shall be stripped and removed. Materials from clearing, grubbing and stripping which are removed as unsatisfactory for producing specified aggregates shall be disposed of at locations not visible from the roadway, in a manner that precludes erosion by wind or water and the form and contours of the finished disposal area blends with adjacent terrain.

The costs involved in preparing the site, clearing, grubbing, stripping and removing overburden and other operations shall be incidental to the production of aggregate and shall be included by the Contractor in the contract unit price for the specific aggregate produced.

3.01.3.2 Production of Aggregates. The Contractor shall, as a minimum, utilize all stone, rock fragments or boulders occurring in the source, up to and including those measuring four hundred and fifty (450) millimeters in greatest dimension, in the manufacture of crushed aggregates. The Contractor, at his option, may use stone and boulders larger than four hundred and fifty (450) millimeters in greatest dimension.

When the percent fracture and other requirements cannot be obtained by using the natural material, portions of the material may be rejected to the extent necessary to produce aggregates conforming to the requirements of the specifications.

Failure to include an aggregate scalping and rejection requirement in the specifications for any type of aggregate shall not relieve the Contractor of the responsibility for scalping and rejection of portions of the materials if such become necessary to produce aggregates conforming to the requirements of the specifications.

When scalping over a screen of specified size is required in the special specifications, the scalping screen shall be of such size and capacity that enough of the fine material will be removed to produce aggregates conforming to the requirements of the specifications.

Rejected materials may be used in other portions of the work and locations when it conforms to the specified requirements for said other portions and locations.

Surplus screenings accumulated during crushing and screening of specified aggregates shall be kept separate from materials rejected during scalping operations.

Washing of coarse and fine aggregates shall be performed as specified in the special specifications or as may be necessary to produce aggregates free from clay, loam, alkali, vegetable and other deleterious material.

Washing and reclaiming of rejected material and subsequent addition to any finished aggregate shall not be allowed unless authorized in writing by the Engineer.

When producing screened gravel or sand materials, the Contractor shall remove all oversize material by screening at the source. Operations at the source shall be such that the grading of aggregates in each hauling unit is reasonably uniform within tolerances that are specified for individual materials. The Contractor shall use the most suitable materials available at the source. He shall move his loading equipment as many times as may be necessary to fulfill these requirements.

3.01.3.3 Rejected Aggregates. All rejected materials unsatisfactory for use in other portions of the work and locations, shall be disposed of as specified in Paragraph 3.01.3.1, "Preparation of Site" in these General Specifications.

3.01.3.4 Surplus Screenings. Surplus screenings accumulated during the production of the specified aggregates at material sources established by the Contractor shall remain the property of the Contractor.

Surplus screenings accumulated during the production of the specified aggregates at materials sources shown on the plans or described in the special specifications and furnished by the Ministry shall be stockpiled at the source and become the property of the Ministry.

The stockpile area shall be prepared and constructed as specified in Subsection 3.01.5, "Stockpiling Aggregates" in these General Specifications. All costs incurred in producing, hauling and stockpiling the surplus screenings shall be incidental to the production of the specified aggregates and shall be included by the Contractor in the contract unit prices for said aggregates.

3.01.3.5 Site Cleanup. Upon completion of the Contractor's operations at any source, the quarry or pit shall be cleared of rubbish, equipment, temporary structures and other items brought to the site by the Contractor. The site shall be left in a neat and presentable condition. When the special specifications require that aggregate sources be reclaimed in accordance with an approved reclamation plan, the Contractor shall comply with such approved reclamation plan.

3.01.4 QUALITY ASSURANCE PROCEDURES

3.01.4.1 Methods and Procedures. All aggregate testing shall be performed in accordance with methods and procedures described in the specifications and Materials Manual publications issued by the Ministry of Communications, Materials and Research Department.

3.01.4.2 Preliminary Testing. The Contractor shall submit to the Engineer all results of testing as may be necessary to confirm that the source of materials, equipment and production methods to be employed by the Contractor will produce aggregates conforming to the requirements of the specifications. No installation of equipment or production shall start at any materials source until the Engineer has approved the source, and the dimensions of the area to be excavated. The equipment and methods proposed by the Contractor shall also be approved by the Engineer.

The approval of the Engineer shall not be construed as final acceptance of the aggregate to be produced.

Representative samples of materials may be obtained by the Contractor and, when requested, duplicate samples shall be furnished to the Engineer for testing and future reference.

Testing may be accomplished in the Contractor's laboratory or a commercial laboratory. The testing shall be the responsibility of the Contractor and performed at his expense.

3.01.4.3 Production Testing. The Contractor shall arrange all testing necessary to control specified aggregate fracture, gradation and quality during production as specified in Paragraphs 3.02.5.1, 3.03.5.1 and 3.04.8 all entitled "Contractor Quality Control Procedures" in these General Specifications. The results of such testing shall be promptly delivered to the Engineer. Such test results are intended to be used to guide the Contractor operations and shall not be used to infer that the aggregates being produced are acceptable and in conformance to the specifications.

3.01.4.4 Acceptance Testing. The Engineer shall sample or supervise the sampling testing and evaluation of aggregates furnished to the work as specified in Subsections 3.02.6, 3.03.6 and 3.04.9 all entitled "Quality Assurance Procedures" in these General Specifications.

3.01.5 STOCKPILING AGGREGATES

3.01.5.1 Sites. The site for constructing stockpiles shall be approved by the Engineer and located in a manner that the stockpiled materials will not be contaminated with other aggregates or altered by dust, dune sand or other natural or processed material. Stockpiling on private property shall be permitted with the written consent of the owner or lessee. The Engineer shall be afforded access to the stockpiled materials at all times.

3.01.5.2 Preparation of Stockpile Site. Before placing aggregates on the stockpile site, the site shall be cleared of vegetation, rocks and debris and the ground leveled to a smooth, firm uniform surface.

3.01.5.3 Construction of Stockpiles. The stockpiles shall be constructed on the prepared site, shall be neat and regular in shape and not more than eight (8) meters in height.

Stockpiles in excess of two hundred (200) cubic meters shall be built up in layers not more than one and one-half (1.5) meters in depth using methods and equipment approved by the Engineer. Pushing aggregate into a stockpile using dozers will not be permitted. Each layer shall be completed over the entire area of the pile before depositing aggregate in the succeeding layer. Any method of placing aggregate in a stockpile which, in the opinion of the Engineer, results in segregation, breaks, degrades or otherwise damages the aggregate will not be permitted.

Stockpiles of different kinds or sizes of aggregate shall be separated by space or suitable walls or partitions to prevent mixing. Aggregate shall not be stockpiled where vehicles will run over or through the piles and cause foreign material to become mixed with the stockpiled aggregate.

3.01.5.4 Removing Aggregate From Stockpiles. Aggregate shall be removed from the stockpiles using equipment and methods approved by the Engineer and in a manner that precludes segregation of particle sizes or adulteration with underlying or adjacent soil or foreign material.

When removing aggregate from stockpiles, the removal equipment shall be operated in such a manner as to face-load from the floor to the top of the stockpile to obtain maximum uniformity of aggregate.

The Contractor shall remove only such aggregate quantities as are necessary to complete work under the contract.

3.01.5.5 Site Cleanup. If a surplus remains in the stockpile, the Contractor shall leave said surplus in neat, regular shaped piles, free of foreign matter and equipment.

3.01.6 METHOD OF MEASUREMENT. No measurement will be made for any work or aggregate produced under this section.

3.01.7 PAYMENT. Full compensation for performing all of the work specified in this section shall be considered as subsidiary to other items of work appearing in the Bill of Quantities unless otherwise provided for in the Special Specifications and listed in the Bill of Quantities.

SECTION 3.02 - AGGREGATE SUBBASES

3.02.1 DESCRIPTION. This work shall consist of furnishing, spreading and compacting aggregate subbases to the lines and elevations shown on the plans as specified in these General Specifications and the Special Specifications.

Aggregate subbases will be designated as Aggregate Subbase Course or Aggregate Subbase Course, Grading ___. The grading(s) of aggregate subbase to be furnished shall be according to the item(s) shown in the Plans or Special Specifications and listed in the Bill of Quantities. If the grading of aggregate subbase is not specified, aggregate subbase course shall be furnished meeting one of the gradations listed in Table 3.02-1 as designated by the Engineer. The designation of the appropriate Grading shall be such that the maximum size of aggregate will not exceed two thirds (2/3) of the thickness of the subbase course layer to be constructed.

ITEMS IN BILL OF QUANTITIES:
Aggregate Subbase Course
Aggregate Subbase Course, Grading ___

3.02.2 MATERIALS. Aggregate used for aggregate subbase shall be free from vegetation matter and other deleterious substances and, when compacted under watering and rolling, form a firm, stable subbase. Coarse aggregate shall be crushed stone, crushed slag, or crushed gravel. Fine aggregate, material passing the 4.75 mm (No. 14) sieve, shall consist of natural or crushed sand and fine material particles.

The Contractor shall furnish, produce, stockpile, blend and mix all necessary materials using such equipment and procedures as will produce specified aggregate subbase. Aggregate shall conform to one of the following grading and quality requirements on the road bed after all blending and mixing and spreading and before compacting:

TABLE 3.02-1
AGGREGATE SUBBASES GRADATION REQUIREMENTS - MTDTM 204

Sieve Sizes	Grading I	Grading II
62.5 mm (2 inch)	100	
50 mm (2 inch)	90-100	100
37.5 mm (1 inch)	-	90-100
25 mm (1 inch)	-	55-85
19 mm (3/4 inch)	-	50-80
9.5 mm (inch)	-	40-70
4.75 mm (No. 4)	35-70	30-60
2.54 mm (No. 10)	-	20-50
0.425 mm (No. 40)	-	10-30
0.075 mm (No. 200)	0-15	0-15

QUALITY REQUIREMENTS	
Sand Equivalent (MRDTM 313)	25 Min.
Plasticity Index (MRDTM 208)	6 Max.
Abrasion Loss (MRDTM 309)	50 Max.
California Bearing Ratio (CBR) (MRDTM 213)	50 Min.

Aggregate for Grading III aggregate subbase shall conform to the requirements specified in the Special Specifications.

3.02.3 PROPORTIONING AGGREGATE SUBBASE MIXTURES.

3.02.3.1 Job Mix Design Proposal. A proposed Job Mix Formula (JMF) shall be formulated by the Contractor and submitted to the Engineer for approval. The JMF shall be prepared by the Contractor in precise compliance with procedures and requirements set forth in the Materials and Research Department Manual of Materials and Tests and all current letters issued by the Ministry of Communications.

The Contractor shall select his sources of aggregate and, after sufficient quantities have been stockpiled or are available for use , obtain representative samples of the materials and test to determine if they conform to the requirements of these specifications. At least thirty (30) days before producing aggregate subbase mixtures, the Contractor shall submit in writing to the Engineer detailed information for each mix which he proposes to furnish. The information shall include, but not be limited to the following:

1. The source and gradation of the aggregate for each mix to be furnished. If the aggregate (coarse, fine, supplemental fine) is separated into two (2) or more sizes, the information provided shall consist of gradations for all individual sizes, the proportions of each individual size to be used, and the mathematically combined gradation for each mix to be furnished. Such combined gradation shall meet the applicable grading requirements shown in Subsection 3.03.2, "Materials" in these General Specifications and show the percentage passing each of the specified sieve sizes.

2. Pertinent test data and a written certification that the aggregates to be furnished conform to all quality requirements shown in Subsection 3.03.2, Materials in these General Specifications.

3. The type of plant to be used for mixing each mix to be furnished.

4. The beginning date for producing aggregate subbase mixtures.

The Engineer shall be provided access to the materials sampling and testing operations at all times. The combined aggregate, including mineral additives, shall conform to the approved JMF grading within the following tolerances:

9.75 mm (3/8") and larger sieves,	11 percentage points
4.75 mm (No. 4) sieve,	10 percentage points
2.36 mm (No. 8) sieve,	9 percentage points
0.300 mm (No. 50) sieve,	8 percentage points
0.075 mm (No. 200) sieve,	8 percentage points

At the same time the above information is provided, the Contractor shall supply to the Engineer fifty (50) kilogram samples of each individual aggregate size, when used, ten (10) kilogram samples of mineral filler and chemical admixture, all representing the materials which the Contractor proposes to furnish.

3.02.3.2 Acceptance of Job Mix Formula. The Engineer shall review the JMF to determine that it contains all required information. If it does not contain all required information, it shall be returned within seven (7) days to the Contractor for further action and resubmission by the Contractor.

If the proposed JMF contains all required information but fails to meet all the requirements specified, it shall not be accepted by the Engineer and will be returned to the Contractor within fourteen (14) days. The Contractor shall prepare and submit to the Engineer a new JMF conforming to the requirements specified and propose a new date for beginning production.

When the Engineer is satisfied that the JMF proposed by the Contractor conforms to all the requirements of the specifications, he shall order the Contractor to construct a minimum two hundred (200) meter long field control strip. The Engineer shall evaluate the control strip as to its constructability and compactability and conformance to the laboratory tested JMF. Split samples of the aggregate subbase mix for and components raw material along with the field laboratory test results are to be sent to the Materials and Research Departments Central Laboratory for a one (1) point check and documentation. If the Engineer is not satisfied with the results of the control strip, he shall state his objections in writing and request a revised JMF and a new control strip.

When the Engineer is satisfied that the JMF proposed by the Contractor conforms to all requirements of the specifications and the control strip results are acceptable, he will issue written acceptance to the Contractor to begin producing the mixes proposed.

Production of aggregate subbase mixes shall not begin until the Engineer has given written acceptance of the Job Mix Formula.

Acceptance of the JMF by the Engineer does not relieve the Contractor of his obligation to produce aggregate subbase mixes conforming to all specified requirements.

3.02.3.3 Job Mix Formula Revisions. The Contractor shall not alter his methods of crushing, screening, blending, or stockpiling from that used to produce materials for the approved JMF. Changes to the JMF will not be permitted without retesting and resubmission of a proposed (revised) JMF in accordance with all the steps in Paragraph 3.02.3.1, "Job Mix Design Proposal" in these General Specifications. Significant changes may include, but not be limited to, changes in the amount or type of materials rejected or wasted, changes in the amount of materials crushed, reductions in the amount of crushed fines, changes in the amount and type of mineral filler.

Should the Contractor change his source of aggregate, he shall furnish a new job mix design proposal and samples of materials, as described in Paragraph 3.02.3.1, "Job Mix Design Proposal" in these General Specifications, as determined by the Engineer to be necessary, at least twenty-one (21) days before their intended use.

At any time after the JMF is approved the Contractor may submit a new JMF for approval by the Engineer. If the revised JMF is approved it shall become the approved JMF.

3.02.4 EQUIPMENT. The Contractor shall furnish all necessary equipment for production, stockpiling and hauling aggregate, preparing the subgrade and placing, compacting, finishing and maintaining the aggregate subbase according to the minimum type and number outlined in the contractor's detailed Program of Work as approved by the Engineer.

Blending and mixing aggregates and adjusting the moisture content as required for compaction shall be performed in a central mixing plant or on the grade by means that insure uniformity.

The blended and mixed aggregates shall be placed and spread to the width and thickness specified.

3.02.5 CONSTRUCTION.

3.02.5.1 Contractor Quality Control Procedures. Testing to control the quality of aggregate furnished for subbase shall be the responsibility of the Contractor. Copies of all test results shall be forwarded to the Engineer at the end of each working day. The Engineer shall have access to the Contractor's testing laboratory at all times and reserves the right to obtain samples of the materials at any point during construction. When requested by the Engineer, the Contractor shall obtain aggregate subbase materials and prepare duplicate samples by quartering. One (1) sample shall be delivered to the Engineer and the duplicate sample shall be tested by the Contractor.

The Contractor shall perform the following minimum types and number of tests:

1. Gradation, sand equivalent and plasticity index - One (1) test each per two thousand (2000) cubic meters of aggregates produced but no less than one (1) test per production day.

2. Abrasion Loss - One (1) test for the first, second and third five hundred (500) cubic meters of aggregate produced and one (1) test for each twenty-five hundred (2500) cubic meters thereafter.

3. CBR Value - One (1) test for each five thousand (5,000) cubic meters placed.

When test data indicate that the aggregate subbase does not conform to specified requirements, the Contractor shall take effective action to correct his production methods to assure that subbase aggregate will conform to all specified requirements. Such action shall include halting production, changing the source of aggregate supply, altering amount of aggregated scalped and rejected, increasing degree of crushing, and revising blending and handling methods. Such material if already placed, shall be removed and modified or replaced to produce material conforming to the specified requirements.

3.02.5.2 Surface Preparation. The surface to receive aggregate subbase, immediately prior to spreading aggregate subbase, shall conform to specified compaction and elevation tolerances and shall be free of loose or extraneous material.

The Contractor shall correct, at his own expense, any deviation from specified elevation and compaction in the surface to receive aggregate subbase.

When surfaces to receive aggregate subbase are lower than specified, the low areas may be filled with aggregate subbase. The volume of aggregate subbase so placed shall not be measured for payment under any item listed in the Bill of Quantities.

3.02.5.3 Placing and Spreading. Aggregate for subbase, immediately prior to spreading, shall be uniform mixtures free from pockets and streaks of coarse or fine material and shall be deposited on the subgrade in uniform layers or windrows using approved equipment.

The layers or windrows of aggregate subbase shall be shaped to such thickness that, after watering and compacting, the completed subbase layer shall conform to the required width, grade and thickness within the tolerances specified in Paragraph 3.02.4.5, "Finishing" in these General Specifications.

The material shall be handled so as to avoid segregation. Segregated materials shall be remixed until uniform. The water can either be added in the borrow pit or on a mixing platform or on the grade.

Where the subbase thickness is twenty (20) centimeters or less, the aggregate subbase may be spread and compacted in one (1) layer. Where the required thickness is more than twenty (20) cm, the aggregate subbase shall be spread in two (2) or more layers of approximately equal thickness.

3.02.5.4 Compacting. Each layer of subbase material, after being shaped to the required lines and cross section, shall be compacted to a uniform density with no individual test being less than ninety-five percent (95%) of the maximum dry unit weight determined from MRDTM 212. Each of lot of subbase material as described in

Subsection 3.02.6 "Quality Assurance Procedures" in these General Specifications shall have a percent relative compaction of no less than ninety-nine percent (99%) of the maximum dry unit weight determined from MRDTM 212. The subbase shall be watered or dried as may be necessary to obtain a moisture content suitable for compaction. Material which has dried prior to final compaction or which has dried and decompacted subsequent to final compaction shall be watered and recompacted using equipment and procedures approved by the Engineer. Should the Contractor be unable to return the material to its original or specified condition with respect to compaction, thickness, and surface tolerances, the Contractor shall remove the material and reconstruct the course on a reapproved subgrade.

When there are delays in constructing the remaining pavement structure over a granular course, the compaction of the granular course shall be reverified and deficient areas corrected or replaced to the satisfaction of the Engineer. Such corrections or replacement shall be at the Contractor's expense.

The Contractor shall plan the work and handle the various operations so that the least amount of water will be lost by evaporation from uncompleted surfaces. If the Contractor delays placing or succeeding layers of material to the extent that additional water must be applied to prevent raveling or excessive drying, the application of such water shall be at the Contractor's expense and will not be considered as the basis for a claim for additional compensation.

The material shall be compacted by means of approved compaction equipment, progressing gradually from the outside towards the center, with each succeeding pass uniformly overlapping the previous pass. Rolling shall continue until the entire thickness of each layer is thoroughly and uniformly compacted to the specified density. The final rolling of the completed course shall be done with a self-propelled roller as approved by the Engineer. Rolling shall be accompanied by sufficient blading, in a manner approved by the Engineer, to insure a smooth surface, free from ruts or ridges and having the proper section and crown. When additional water is required, it shall be added in the amount and manner approved by the Engineer. Initial layers of material must be constructed to a uniform grade and cross section and compacted by the Contractor and approved by the Engineer prior to the delivery of materials for a succeeding layer.

Prior to placing a succeeding layer of granular material, the surface of the underlayer shall be made sufficiently moist, to insure bond between the layers. The edges and edge slopes of the base course shall be bladed or otherwise dressed to conform to the lines and dimensions shown on the plans, and present straight, neat and workmanlike lines and slopes as free of loose material as practicable.

Any areas inaccessible to normal compaction equipment shall be compacted by means of portable mechanical tampers until satisfactory compaction is obtained. When the final layer is to be trimmed to final grade by an automatic grading machine, this layer shall be constructed approximately one (1) to three (3) centimeters above grade, so that the grading machine cuts continually. After the final pass of the grading machine, the subbase shall be wetted and rolled.

3.02.5.5 Finishing. All subbase material shall be placed, trimmed and finished in a neat and workmanlike manner in compliance with the lines, grades and typical cross sections shown on the plans or staked by the Engineer within the tolerances listed in Paragraph 3.02.6.5, "Surface Tolerances" in these General Specifications.

3.02.5.6 Maintenance and Protection. Following construction of the subbase course, the compacted course shall be maintained by the Contractor at his expense. The Contractor shall blade, broom, and otherwise maintain the course, keeping it free from raveling and other defects that result in lost density until such time as the next element of the pavement structure is placed. Water shall be applied at such times and in such quantities as directed by the Engineer, and the Engineer shall have full authority to require the suspension of all other work on the project to insure the proper maintenance of previously compacted material.

The Engineer shall determine when the surface of the subbase is in the proper condition to permit the placement of aggregate subbase course or the bituminous prime and/or surfacing to be applied. The Contractor must continue to maintain the surface of the base course, including the application of necessary water, at his expense until such time as the bituminous prime or the subsequent layer is applied. Any additional expense incurred by the Contractor because of delay in placing subsequent layers or applying the bituminous prime when so permitted by the Engineer will not be considered as the basis for a claim for additional compensation.

3.02.5.7 Compaction Test Trials. If directed by the Engineer, or requested by the Contractor, prior to the commencement of his subbase compaction operations, the Contractor shall construct compaction trial lengths, not to exceed one (1) kilometer. The materials used in the trials shall be that approved for use as aggregate subbase and the equipment used shall be that according to the Contractor's approved detailed Program of Work.

The object of these trials is to determine the adequacy of the Contractor's equipment, the loose depth measurements necessary to result in the specified compacted layer depths, the field moisture content, and the relationship between the number of compaction passes and the resulting density of the material.

The Contractor may proceed with aggregate subbase work only after the methods and procedures established in the compaction trial has been approved by the Engineer.

3.02.6 QUALITY ASSURANCE PROCEDURES. Aggregate subbase shall be accepted by lot. Unless otherwise stated in the Special Specifications, the lot size shall be ten thousand (10,000) square meters for each layer constructed. The aggregate subbase shall be sampled, tested and evaluated in accordance with Section 1.08 "Acceptance of Work" in these General Specifications. The Engineer may, during the beginning of placement of subbase, at times when test results indicate erratic characteristics and at any other time, reduce the lot size to sections of subbase with similar quality characteristics. This should facilitate the isolation and modification or replacement of low-quality materials with materials of acceptable quality to maintain the overall strength of the pavement structure.

The Engineer shall perform or supervise the performance of all quality assurance sampling and testing. The location of all samples and tests shall be recorded by roadway, lane and centerline station (kilometer). Quality assurance sampling and testing for each lot shall include:

1. Compaction

2. Thickness

3. Aggregate Gradation, Sand Equivalent and Plastic Limit

4. California Beating Ratio and Abrasion

5. Surface Tolerances

3.02.6.1 Compaction. The compacted density for each layer of aggregate subbase shall be determined by the sand cone method, MRDTM 215, or by nuclear method, MRDTM 218 using full depth penetration, at the option of the Engineer.

When the sand cone method is used, unless otherwise stated in the Special Specifications, the tests shall be made at a minimum of five (5) randomly selected locations in each lot.

When the nuclear method is used, unless otherwise stated in the Special Specifications, the tests shall be made at a minimum of eight (8) randomly selected locations in each lot. Three nuclear gauge readings shall be made at each test location within a radius of two (2) meters. The three (3) readings shall be averaged and the average considered to be the density for that test location.

Percent relative compaction shall be computed by comparing the average actual in-place compacted density from the nuclear gauge or sand cone test results with the maximum density determined by MRDTM 212. MRDTM 212 maximum density shall be determined from samples of aggregate subbase obtained from the roadbed at a sampling frequency of one (1) test per three (3) lots. The maximum density used for determining percent relative compaction shall be the running average for three (3) consecutive tests.

Any lot of aggregate subbase that has a percent relative compaction below the minimum percent compaction specified in Paragraph 3.02.5.4, "Compacting," in these General Specifications resulting in a reduced pay factor of 0.75 or higher determined in accordance with Subsection 1.08.5, "Statistical Evaluation of Work for Acceptance and Determination of Pay Factor (Value of Work)" in these General Specifications may be accepted on the basis of a reduced payment if requested in writing by the Contractor. Otherwise the lot shall be removed and replaced by the Contractor at his expense. Lots that have percent relative compaction resulting in a reduced pay factor less than 0.75 shall be removed and replaced by the contractor at his expense.

3.02.6.2 Thickness. The thickness of each course of aggregate subbase complete as placed and compacted, shall be measured from test holes obtained at a minimum of five (5) random locations within the lot. The thickness of each hole shall be determined after determination that the compacted density is acceptable. The average of the test hole thicknesses shall be reported as the thickness of the lot.

A lot shall be accepted when the average total thickness is not less than the planned thickness.

Any lot of aggregate subbase course with an average thickness less than shown in the plans but resulting in a reduced pay factor of 0.75 or higher determined in accordance with Subsection 1.08.5, "Statistical Evaluation of Work for Acceptance and Determination of Pay Factor (Value of Work)," in these General Specifications may be accepted on the basis of reduced payment if requested in writing by the Contractor, otherwise additional material shall be provided as specified in the preceding paragraph.

When the average thickness of a lot of aggregate subbase course is less than the planned thickness by an amount resulting in a reduced pay factor below 0.75 the Contractor, at his own expense, shall place and remix additional aggregate subbase material with the original aggregate subbase material and recompact before new test holes are dug.

3.02.6.3 Aggregate Gradation, Sand Equivalent and Plasticity Index. Aggregate subbase gradation, sand equivalent and plasticity index will be sampled, tested and evaluated based on the average of a minimum of five (5) test results per lot in accordance with the Job Mix Formula Tolerances listed in Paragraph 3.02.3.1 "Job Mix Design Proposal," and Subsection 1.08.5, "Statistical Evaluation of Work for Acceptance and Determination of Pay Factor (Value of Work), in these General Specifications.

Every sample of aggregate subbase shall be taken on a random time basis from each uncompacted lot during each one-half ( ) day of work, or portion thereof. The initial sample shall be randomly selected from within one and one-half (1) meters either side of the centerline of and weigh at least twenty-five (25) kilograms. The initial sample shall be thoroughly mixed and quartered to obtain a test sample weighing at least six (6) kilograms. The test sample shall be forwarded to the project laboratory and the aggregate gradation, and sand equivalent and plastic light determined.

When the aggregate gradation, sand equivalent or plasticity index test results for any lot produce a reduced pay factor of 0.75 or higher determined in accordance with above referenced Subsection 1.08.5, "Statistical Evaluation of Work for Acceptance and Determination of Pay Factor (Value or Work)" in these General Specifications, the lot may be accepted on the basis of a reduced pay factor if requested in writing by the Contractor. Otherwise said lot shall be removed and replaced by Contractor at his expense.

When the gradation, sand equivalent or plasticity index pay factor determined in accordance with above referenced Subsection 1.08.5, "Statistical Evaluation of Work for Acceptance and Determination of Pay Factor (Value or Work)" in these General

Specifications, for any lot whose pay factor is less than 0.75 the aggregate subbase shall be removed and replaced by the Contractor at his expense.

3.02.6.4 California Bearing Ratio and Abrasion. Random samples shall be taken and tested for California Bearing Ratio and Abrasion from the first three (3) lots and every fifth lot thereafter unless test results indicate failure to conform to the values specified in Subsection 3.02.2, "Materials" in these General Specifications. In such a case, increased sampling and testing shall be performed.

3.02.6.5 Surface Tolerances. The surface layer of the aggregate subbase shall be evaluated for compliance with the following surface tolerances:

The cross section of the finished subbase surface shall be checked by the Contractor in the presence of the Engineer at maximum intervals of twenty-five (25) meters and at intermediate points as directed by the Engineer. The deviation of the elevation of the surface above the design elevation shall be not more than twenty (20) millimeters. Deviations above the design elevation shall not result in the diminished thickness of any subsequent pavement course. The deviation of the elevation below the design elevation shall not be more than twenty (20) millimeters. Isolated deviations below the design elevation shall be compensated by additional thickness of the subsequent pavement layer. Additional cost and materials resulting from deviations from the design elevation shall be borne by the Contractor. Contractor shall furnish all devices necessary to check the surface, such as stringlines, straightedges, etc., and the labor necessary to handle the task.

3.02.6.6 Acceptance. Aggregate subbase construction including California Bearing Ratio, abrasion and surface tolerances shall be accepted under Subsection 1.08.4, "Measured or Tested Conformance" in these General Specifications.

Compaction, thickness, aggregate gradation, sand equivalent and plasticity index will be accepted under Subsection 1.08.5, "Statistical Evaluation of Work for Acceptance and Determination of Pay Factor (Value or Work)" in these General Specifications in two (2) stages as follows: The first stage shall be the selection of the lowest of the four of pay factors for the quality of the aggregate subbase relating to aggregate gradation, compaction, sand equivalent and plasticity index. The second stage involves the selection and application of a quantity pay factor based on the thickness of the aggregate subbase. The reduced thickness pay factor for the lower course lots of multiple layer courses will be applied provisionally based on the results of the depths of the holes dug in the lower layers. Additional holes will be dug in the total depth of all aggregate subbase layers within the lot represented by lower layer reduced thickness pay factors. If the total thickness depths show that the increased upper level layer thickness has resulted in total thickness acceptability, the lower level layer reduced thickness pay factor will be adjusted accordingly. The second stage thickness quantity pay factor will be applied to all the individual course lots in addition to the first stage lowest quality pay factor as determined in accordance with Subsection 1.08.5, "Statistical Evaluation of Work for Acceptance and Determination of Pay Factor (Value or Work)" in these General Specifications.

3.02.7 METHOD OF MEASUREMENT. Aggregate subbase shall be measured by the cubic meter after placement and compaction to the required density, using horizontal dimensions shown on the plans or as directed by the Engineer and thickness measurements determined as specified in this specification. No allowance for overdepth shall be permitted except as approved in writing by the Engineer prior to spreading the aggregate subbase.

3.02.8 PAYMENT. Aggregate subbase shall be paid for at the contract unit price or adjusted contract unit price per cubic meter for the aggregate subbase item(s) shown on the plans and listed in the Bill of Quantities. Such price and payment shall be full compensation for furnishing all materials, equipment, labor, tools and incidentals and all other items necessary to complete the work as specified in Subsection 1.07.2, "Scope of Payment" in these General Specifications.

When a lot of aggregate subbase course is accepted with a deficiency, the adjusted contract unit price for said lot shall be the product of the contract unit price of aggregate subbase, and the lowest quality and quantity pay factors specified in Subsection 3.02.6, "Quality Assurance Procedures," in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO.	PAY ITEM	PAY UNIT
30201	Aggregate Subbase Course	Cubic Meter
3020101	Aggregate Subbase Course, Grading I	Cubic Meter
3020102	Aggregate Subbase Course, Grading II	Cubic Meter
3020103	Aggregate Subbase Course, Grading III	Cubic Meter

SECTION 3.03 - AGGREGATE BASES

3.03.1 DESCRIPTION. This work shall consist of furnishing, spreading and compacting aggregate bases to the lines, elevations and thicknesses shown on the plans and as specified in these General Specifications and the Special Specifications.

Aggregate bases will be designated as Aggregate Base Course or Aggregate Base Course, Grading ___. The grading(s) of aggregate base to be furnished shall be according to the item(s) shown in the Plans or Special Specifications and listed in the Bill of Quantities. If the aggregate base course grading is not specified aggregate base course shall be furnished meeting one of the gradations listed in Table 3.03-1 as designated by the Engineer. The designation of the appropriate Grading shall be such that the maximum size of aggregate will not exceed two thirds (2/3) of the thickness of the aggregate base course layer to be constructed.

ITEMS IN BILL OF QUANTITIES:
Aggregate Base Course
Aggregate Base Course, Grading ___

3.03.2 MATERIALS. Aggregates used for aggregate base shall be hard durable particles or fragments free from vegetation matter and other deleterious substances and, when compacted under watering and rolling, form a firm, stable base. Aggregate shall consist of crushed stone, crushed slag, or crushed gravel.

Crushed stone aggregate shall contain not more than eight (8) percent, by weight, flat, elongated, soft, or disintegrated pieces. Aggregate retained on the 2.36 mm (No. 8) sieve shall consist of stone particles of which at least ninety percent (90%), by weight, shall have at least two (2) mechanically fractured faces.

The specified gradation shall be obtained by crushing, screening and blending processes, as necessary. The Contractor shall furnish, produce stockpile, blend and mix all necessary materials using such equipment and procedures as will produce the specified aggregate base.

If additional fine material, in excess of that already present in the base course material, is necessary for correcting the gradation properties, for satisfactory bonding of the base material, or for adjusting the material characteristics of the fraction passing the 0.425 mm (No. 40) sieve, it shall be uniformly blended and mixed with the crushed aggregates. Such mixing shall take place at the crusher, at an approved stationary proportioning and mixing plant or on a traveling plant. Reworking of the base course material in place to obtain the specified requirements shall not be permitted. The additional fine material, if any, shall be obtained from crushing stones, gravel, or slag, and shall be of a gradation as required to accomplish the specified gradation of the final mixture.

Aggregate shall conform to one of the following grading and quality requirements on the road bed after all blending and mixing and spreading and before compacting:

TABLE 3.03-1

AGGREGATE BASES
GRADING REQUIREMENTS
MRDTM 204

	PERCENTAGE PASSING		
SIEVE SIZES	Grading I	Grading II	Grading III
50 mm (2 inch)	100	-	-
37.5 mm (1 inch)	-	100	-
25 mm (1 inch)	55-85	70-95	100
19 mm (inch)	50-80	55-85	70-100
4.75 mm (No. 4)	30-60	30-60	35-65
0.425 mm (No. 40)	10-25	10-25	15-25
0.075 mm (No. 200)	3-10	3-10	3-10
The fraction passing the No. 200 sieve shall not exceed the fraction passing the 0.425 mm (No. 40) sieve.			

QUALITY REQUIREMENTS	
Sodium Sulphate Soundness (MRDTM 311), & Loss	12 Max.
Abrasion Loss (MRDTM 309)	45 Max.
Sand Equivalent (MRDTM 313)	45 Min.
Liquid Limit (MRDTM 209)	25 Max.
Plasticity Index (MRDTM 208)	6 Max.
California Bearing Ratio (MRDTM 213) Grading I	100 Min.
California Bearing Ratio (MRDTM 213) Grading II	80 Min.
California Bearing Ratio (CBR) (MRDTM 213) Grading III	65 Min.

3.03.3 PROPORTIONING AGGREGATE BASE MIXES.

3.03.3.1 Job Mix Design Proposal. A proposed Job Mix Formula (JMF) shall be formulated by the Contractor and submitted to the Engineer for approval. The JMF shall be prepared by the Contractor in precise compliance with procedures and requirements set forth in the Materials and Research Department Manual of Materials and Tests and all current letters issued by the Ministry of Communications.

The Contractor shall select his sources of aggregate and, after sufficient quantities have been stockpiled or are available for use , obtain representative samples of the materials and test to determine if they conform to the requirements of these specifications. At least thirty (30) days before producing aggregate base mixtures, the Contractor shall submit in writing to the Engineer detailed information for each mix which he proposes to furnish. The information shall include, but not be limited to the following:

1. The source and gradation of the aggregate for each mix to be furnished. If the aggregate (coarse, fine, supplemental fine) is separated into two (2) or more sizes, the information provided shall consist of gradations for all individual sizes, the proportions of each individual size to be used, and the mathematically combined gradation for each mix to be furnished. Such combined gradation shall meet the applicable grading requirements shown in Subsection 3.03.2 "Materials" in these General Specifications and show the percentage passing each of the specified sieve sizes.

2. Pertinent test data and a written certification that the aggregates to be furnished conform to all quality requirements shown in Subsection 3.03.2,"Materials" in these General Specifications.

3. The type of plant to be used for mixing each mix to be furnished.

4. The beginning date for producing aggregate base mixtures.

The Engineer shall be provided access to the materials sampling and testing operations at all times. The combined aggregate, including mineral additives, shall conform to the approved JMF grading within the following tolerances:

9.75 mm (3/8") and larger sieves,	9 percentage points
4.75 mm (No. 4) sieve,	8 percentage points
2.36 mm (No. 8) sieve,	7 percentage points
0.300 mm (No. 50 sieve,	6 percentage points
0.075 mm (No. 200) sieve,	4 percentage points

At the same time the above information is provided, the Contractor shall supply to the Engineer fifty (50) kilogram samples of each individual aggregate size, when used, ten (10) kilogram samples of mineral filler and chemical admixture, all representing the materials which the Contractor proposes to furnish.

3.03.3.2 Acceptance of Job Mix Formula. The Engineer shall review the JMF to determine that it contains all required information. If it does not contain all required information, it shall be returned within seven (7) days to the Contractor for further action and resubmission by the Contractor.

If the proposed JMF contains all required information but fails to meet all the requirements specified, it shall not be accepted by the Engineer and will be returned to the Contractor within fourteen (14) days. The Contractor shall prepare and submit to the Engineer a new JMF conforming to the requirements specified and propose a new date for beginning production.

When the Engineer is satisfied that the JMF proposed by the Contractor conforms to all the requirements of the specifications, he shall order the Contractor to construct a minimum two hundred (200) meter long field control strip. The Engineer shall evaluate the control strip as to its constructability and compactability and conformance to the laboratory tested JMF. Split samples of the aggregate base mix for and components raw material along with the field laboratory test results are to be sent to the Materials and Research Departments Central Laboratory for a one (1) point check and documentation. If the Engineer is not satisfied with the results of the control strip, he shall state his objections in writing and request a revised JMF and a new control strip.

When the Engineer is satisfied that the JMF proposed by the Contractor conforms to all requirements of the specifications and the control strip results are acceptable, he will issue written acceptance to the Contractor to begin producing the mixes proposed.

Production of aggregate base mixes shall not begin until the Engineer has given written acceptance of the Job Mix Formula.

Acceptance of the JMF by the Engineer does not relieve the Contractor of his obligation to produce aggregate base mixes conforming to all specified requirements.

3.03.3.3 Job Mix Formula Revisions. The Contractor shall not alter his methods of crushing, screening, blending, or stockpiling from that used to produce materials for the approved JMF. Changes to the JMF will not be permitted without retesting and resubmission of a proposed (revised) JMF in accordance with all the steps in Paragraph 3.03.3.1, "Job Mix Design Proposal" in these General Specifications. Significant changes may include, but not be limited to, changes in the amount or type of materials rejected or wasted, changes in the amount of materials crushed, reductions in the amount of crushed fines, changes in the amount and type of mineral filler.

Should the Contractor change his source of aggregate, he shall furnish a new job mix design proposal and samples of materials, as described in Paragraph 3.03.3.1, "Job Mix Design Proposal" in these General Specifications as determined by the Engineer to be necessary, at least twenty-one (21) days before their intended use.

At any time after the JMF is approved the Contractor may submit a new JMF for approval by the Engineer. If the revised JMF is approved it shall become the approved JMF.

3.03.4 EQUIPMENT. The Contractor shall furnish all necessary equipment for producing, stockpiling, moisture conditioning, and hauling aggregate, preparing the surface on which the aggregate base will be placed, and placing, spreading, compacting, finishing and maintaining the aggregate base in accordance with the minimum type and number outlined in the Contractor's Program of Work as approved by the Engineer. Blending and mixing aggregates and adjusting the moisture content as required for compaction shall be performed in a central mixing plant.

The blended and mixed aggregates shall be placed and spread to the width and thickness specified using approved mechanical spreading equipment. Motor graders shall not be used for spreading.

3.03.5 CONSTRUCTION.

3.03.5.1 Contractor Quality Control Procedures. Testing to control the quality of aggregate base furnished shall be the responsibility of the Contractor. Copies of all test results shall be forwarded to the Engineer at the end of each working day. The Engineer shall have access to the Contractor's testing laboratory at all times and reserves the right to obtain samples of the materials at any point during construction. When requested by the Engineer, the Contractor shall sample aggregate base materials and prepare duplicate samples, by quartering. One (1) sample shall be delivered to the Engineer and the duplicate sample shall be tested by the Contractor.

The Contractor shall perform the following minimum types and number of tests:

1. Gradation, sand equivalent and plasticity index - One (1) test each per one thousand (1000) cubic meters of aggregates produced but not less than one (1) per production day.

2. Abrasion Loss - One (1) test for first, second and third five hundred (500) cubic meters of aggregate produced and one (1) test for each twenty-five hundred (2500) cubic meters thereafter.

3. Percent Crushed Faces - One (1) test for each five hundred (500) meters of aggregate produced.

4. CBR Value - One (1) test for each five thousand (5000) cubic meters.

When test data indicate that the aggregate base does not conform to specified requirements, the Contractor shall take effective action to correct his production methods to assure that the materials produced will conform to all specified requirements. Such action shall include halting production, changing the source of aggregate supply, altering amount of aggregate scalped and rejected, increasing degree of crushing, and revising blending and handling methods.

3.03.5.2 Preparation and Maintenance. After the subgrade or subbase surface has been prepared, the Contractor shall maintain it true to cross section, grade and density. The surface of the subgrade or subbase, immediately prior to receiving the aggregate base shall conform to the specified cross section, grade and density and shall be free of any loose or extraneous material. All subgrade or subbase protection, maintenance or repair work is considered subsidiary to items in the Bill of Quantities.

3.03.5.3 Mixing. The aggregate and the water shall be thoroughly mixed in a twin shaft pugmill type mixer, unless another type of mixer is approved. The amount of water added to the aggregate shall be an amount which will provide the mixture with a satisfactory moisture content for compaction to the specified in-place density. The rate of flow of the water to the pugmill shall be controlled by valves or other devices which can be easily reset when a change in the rate of flow is desirable. The water supply system shall be equipped with a positive cut-off control which will stop the flow of water simultaneously with any stoppage in the flow of aggregate into the pugmill.

3.03.5.4 Transporting. The plant-mixed material shall be transported in such manner as to deliver the mix to the project without loss or segregation. Each truck load shall be covered with a heavy canvas sheet to reduce the loss of moisture in transit whenever the time between loading the work and spreading the moisture exceeds thirty (30) minutes.

3.03.5.5 Placing and Spreading. The mixture shall be placed on the existing roadway, approved subgrade or approved subbase, as the case may be, in a uniform layer or layers not exceeding fifteen (15) centimeters in compacted depth. Where the required thickness is greater than fifteen (15) centimeters, the material shall be placed in layers of equal thickness. However, if heavy duty vibratory compaction equipment approved by the Engineer is used, the maximum compacted layer thickness may be increased to twenty (20) centimeters provided test trial compaction tests indicate compliance with these General Specifications including the following:

1. Compaction samples are taken from the entire layer including the lower part of the increased thickness.

2. The coarse aggregates on the top of the Aggregate Base layers are not damaged or crushed.

The increased thickness approval will be rescinded by the Engineer if more than fifteen percent (15%) of the subsequent field density tests taken on the thicker layer initially fail, necessitating retesting after additional compaction.

The mixture course shall be placed on the roadbed to the required width and uncompacted thickness as follows:

1. Through an approved self-propelled spreading machine.

2. In a sized windrow from which a paving machine or travel plant will pickup and spread the aggregate base.

3. To protect the underlayer and to allow proper drainage, the spreading of the base course material shall begin along the centerline on stretches with a crowned section or on the high side of stretches with a one-way slope.

The approved spreader shall deliver the mixture in such a condition that the material will be ready for compaction without further shaping. Unless otherwise permitted by the Engineer, the aggregate shall be spread not more than two thousand (.2000) square meters ahead of the rollers. Any necessary sprinkling shall be kept within this limit.

The material shall be handled so as to avoid segregation. If the approved spreader causes segregation in the material, or leaves ridges or other objectionable marks on the surface which cannot be eliminated easily or prevented by adjustment to the spreading operation, the use of such approved spreader shall be discontinued, and it shall be replaced. All segregated material shall be removed and replaced with well-graded material. No "skin" patching shall be permitted. Only minor surface manipulation and watering to achieve the required surface tolerances shall be permitted during the compaction process.

No hauling or placement of material will be permitted when, in the judgement of the Engineer, the weather or road conditions are such that hauling operations will cause rutting of the road surface or cause contamination of the subbase or base course material. Before placing the mixture, the subgrade or previous layer shall be wetted to insure bond between the layers. The mixture shall be placed and shaped by power equipment to the lines, elevations, cross sections, depths and density specified in the following subsections.

3.03.5.6 Compacting. Each layer of aggregate base material, after being shaped to the required lines and cross section, shall be compacted to a uniform density with no individual test being less than ninety-five percent (95%) of the maximum dry unit weight determined from MRDTM 212. Each lot of base material as described in Subsection 3.03.6, "Quality Assurance Procedures" in these General Specifications shall have a percent relative compaction of no less than one hundred percent (100%) of the maximum dry unit weight determined from MRDTM 212. The aggregate base shall be watered or dried as may be necessary to obtain a moisture content suitable for compaction. Material which has dried prior to final compaction or which has dried and decompacted subsequent to final compaction shall be watered and recompacted using equipment and procedures approved by the Engineer. Should the Contractor be unable to return the material to its original or specified condition with respect to compaction, thickness, and surface tolerances, the Contractor shall remove the material and reconstruct the course on a reapproved subgrade.

When there are delays in constructing the remaining pavement structure over a granular course, the compaction of the granular course shall be reverified and deficient areas corrected or replaced to the satisfaction of the Engineer. Such corrections or replacement shall be at the Contractor's expense.

The Contractor shall plan the work and handle the various operations so that the least amount of water will be lost by evaporation from uncompleted surfaces. If the Contractor delays placing or succeeding layers of material to the extent that additional

water must be applied to prevent raveling or excessive drying, the application of such water shall be at the Contractor's expense and will not be considered as the basis for a claim for additional compensation.

The material shall be compacted by means of approved compaction equipment, progressing gradually from the outside towards the center, with each succeeding pass uniformly overlapping the previous pass. Rolling shall continue until the entire thickness of each layer is thoroughly and uniformly compacted to the specified density. The base course shall not be rolled when the underlayer is soft or yielding or when rolling causes undulation of the base course. The final rolling of the completed course shall be done with a self-propelled roller as approved by the Engineer. Rolling shall be accompanied by sufficient blading, in a manner approved by the Engineer, to insure a smooth surface, free from ruts or ridges and having the proper section and crown. When additional water is required, it shall be added in the amount and manner approved by the Engineer. Initial layers of material must be constructed to a uniform grade and cross section and compacted by the Contractor and approved by the Engineer prior to the delivery of materials for a succeeding layer.

Prior to placing a succeeding layer of granular material, the surface of the underlayer shall be made sufficiently moist, to insure bond between the layers. The edges and edge slopes of the base course shall be bladed or otherwise dressed to conform to the lines and dimensions shown on the plans, and present straight, neat and workmanlike lines and slopes as free of loose material as practicable.

Any areas inaccessible to normal compaction equipment shall be compacted by means of portable mechanical tampers until satisfactory compaction is obtained. When the final layer is to be trimmed to final grade by an automatic grading machine, this layer shall be constructed approximately one (1) to three (3) centimeters above grade, so that the grading machine cuts continually. After the final pass of the grading machine, the base shall be wetted and rolled. Excess material removed by the grading machine shall be re-used in shoulders, islands, or other areas for which Aggregate Base is specified, but not under roadway pavement. Material wasted and not re-used will be deducted from the final pay quantities.

3.03.5.7 Finishing. All aggregate base material shall be placed, trimmed and finished in a neat and workmanlike manner in compliance with the lines, grades and typical cross sections shown on the plans or staked by the Engineer.

Grade control shall be accomplished by means of grade stakes, steel pins or forms, placed in lanes parallel to the centerline of the road and at intervals sufficiently close to permit placing of string lines or straightedges for checking purposes.

3.03.5.8 Maintenance and Protection. Following construction of the aggregate base course, the compacted course shall be maintained by the Contractor at his expense. The Contractor shall blade, broom, and otherwise maintain the course, keeping it free from raveling and other defects that result in lost density until such time as the next element of the pavement structure is placed. Water shall be applied at such times and in such quantities as directed by the Engineer, and the Engineer shall have

full authority to require the suspension of all other work on the project to insure the proper maintenance of previously compacted material.

Any damage to the base course, or any layer thereof, caused from routing of construction or other equipment over completed stretches shall be repaired by the Contractor at his own expense and as approved by the Engineer.

The Engineer shall determine when the surface of the base course is in the proper condition to permit the bituminous prime and/or surfacing to be applied. The Contractor must continue to maintain the surface of the base course, including the application of necessary water, at his expense until such time as the bituminous prime and/or surfacing is applied. Any additional expense incurred by the Contractor because of delay in applying the bituminous prime and/or surfacing when so permitted by the Engineer will not be considered as the basis for a claim for additional compensation.

3.03.5.9 Compaction Test Trials. If directed by the Engineer, or requested by the Contractor, prior to the commencement of his aggregate base compaction operations, the Contractor shall construct compaction test trial lengths, not to exceed one (1) kilometer. The materials used in the trials shall be that approved for use as aggregate base and the equipment used shall be that according to the Contractor's approved detailed Program of Work.

The object of these trials is to determine the adequacy of the Contractor's equipment, the loose depth measurements necessary to result in the specified compacted layer depths, the field moisture content, and the relationship between the number of compaction passes and the resulting density of the material.

The Contractor may proceed with aggregate base Work only after the methods and procedures established in the compaction trial has been approved by the Engineer.

3.03.6 QUALITY ASSURANCE PROCEDURES. Aggregate base shall be accepted by lot. Unless otherwise stated in the Special Specifications, the lot size shall be ten thousand (10,000) square meters for each layer constructed. The aggregate base shall be sampled, tested and evaluated in accordance with Section 1.08, "Acceptance of Work" in these General Specifications. The Engineer may, during the beginning of placement of aggregate base, at times when test results indicate erratic characteristics and at any other time, reduce the lot size to sections of aggregate base with similar quality characteristics. This should facilitate the isolation and modification or replacement of low-quality materials with materials of acceptable quality to maintain the overall strength of the pavement structure.

The Engineer shall perform or supervise the performance of all quality assurance sampling and testing. The location of all samples and tests shall be recorded by roadway, lane and centerline station (kilometer). Quality assurance sampling and testing for each lot shall include:

1. **Compaction**

2. **Thickness**

3. **Aggregate Gradation, Sand Equivalent and Plasticity Index**

4. **California Bearing Ratio and Abrasion**

5. **Surface Tolerances**

3.03.6.1 Compaction. The compacted density for each layer of aggregate base shall be determined by the sand cone method, MRDTM 215, or by nuclear method, MRDTM 218 using full depth penetration, at the option of the Engineer.

When the sand cone method is used, unless otherwise stated in the Special Specifications, the tests shall be made at a minimum of five (5) randomly selected locations in each lot.

When the nuclear method is used, unless otherwise stated in the Special Specifications, the tests shall be made at a minimum of eight (8) randomly selected locations in each lot. Three nuclear gauge readings shall be made at each test location within a radius of two (2) meters. The three (3) readings shall be averaged and the average considered to be the density for that test location.

Percent relative compaction shall be computed by comparing the average actual in-place compacted density from the nuclear gauge or sand cone test results with the maximum density determined by MRDTM 212. For example, MRDTM 212 maximum density shall be determined from samples of aggregate base obtained from the roadbed at a sampling frequency of one (1) test per three (3) lots. The maximum density used for determining percent relative compaction shall be the running average for three (3) consecutive tests.

Any lot of aggregate base that has a percent relative compaction below the minimum percent compaction specified in Subsection 3.03.5.6, "Compacting," in these General Specifications, resulting in a reduced pay factor of 0.75 or higher determined in accordance with Subsection 1.08.5 "Statistical Evaluation of Work for Acceptance and Determination of Pay Factor (Value of Work)" in these General Specifications may be accepted on the basis of a reduced payment if requested in writing by the Contractor. Otherwise the lot shall be removed and replaced by the Contractor at his expense. Lots that have percent relative compaction resulting in a reduced pay factor less than 0.75 shall be removed and replaced by the contractor at his expense.

3.03.6.2 Thickness. The thickness of each course of aggregate base complete as placed and compacted, shall be measured from test holes obtained at a minimum of five (5) random locations within the lot. The thickness of each hole shall be determined after it is determined that the compacted density is acceptable. The average of the test hole thicknesses shall be reported as the thickness of the lot.

A lot shall be accepted when the average total thickness is not less than the plan thickness.

Any lot of aggregate base course with an average thickness less than the plan thickness but resulting in a reduced pay factor of 0.75 or higher determined in accordance with Subsection 1.08.5 "Statistical Evaluation of Work for Acceptance and Determination of Pay Factor (Value of Work)" in these General Specifications may be accepted on the basis of reduced payment if requested in writing by the Contractor, otherwise the lot shall be overlaid as specified in the preceding paragraph.

When the average thickness of a lot of aggregate base course is less than the plan thickness by an amount resulting in a reduced pay factor below 0.75 the Contractor, at his own expense, shall place and remix additional aggregate base material with the original aggregate base material and recompact before new test holes are dug.

3.03.6.3 Aggregate Gradation, Sand Equivalent and Plasticity Index. Aggregate base gradation, sand equivalent and plasticity index will be sampled, tested and evaluated based on the average of a minimum of five (5) test results per lot in accordance with the Job Mix Formula Tolerances listed in Paragraph 3.03.3.1, "Job Mix Design Proposal" and Subsection 1.08.5, "Statistical Evaluation of Work for Acceptance and Determination of Pay Factor (Value of Work)" in these General Specifications.

Every sample of aggregate base shall be taken on a random time basis from each uncompacted lot during each one-half ( ) day of work, or portion thereof. The initial sample shall be randomly selected from within one and one-half (1) meters either side of the centerline of and weigh at least twenty-five (25) kilograms. The initial sample shall be thoroughly mixed and quartered to obtain a test sample weighing at least six (6) kilograms. The test sample shall be forwarded to the project laboratory and the aggregate gradation, sand equivalent and plasticity index determined.

When the aggregate gradation, sand equivalent or plasticity index for any lot results in a reduced pay factor of 0.75 or higher, determined in accordance with above referenced Subsection 1.08.5, "Statistical Evaluation of Work for Acceptance and Determination of Pay Factor (Value of Work)" in these General Specifications the lot may be accepted on the basis of a reduced pay factor if requested in writing by the Contractor, otherwise said lot shall be removed and replaced by Contractor at his expenses.

When the gradation, sand equivalent or plasticity index pay factor determined in accordance with above referenced Subsection 1.08.5, "Statistical Evaluation of Work for Acceptance and Determination of Pay Factor (Value of Work)" in these General Specifications for any lot is less than 0.75 the aggregate base shall be removed and replaced by the Contractor, at his expense.

3.03.6.4 California Bearing Ratio and Abrasion. Random samples shall be taken and tested for California Bearing Ratio and Abrasion from a minimum of the first three (3) lots and every fifth lot thereafter unless test results indicate failure to conform to the quality requirements specified in Subsection 3.03.2 "Materials" in these General Specifications. In such a case, increased sampling and testing shall be performed.

3.03.6.5 Surface Tolerances. The surface layer of the aggregate base shall be evaluated for compliance with the following surface tolerances:

1. The cross section of the finished aggregate base surface shall be checked by the Contractor in the presence of the Engineer at maximum intervals of twenty-five (25) meters and at intermediate points as directed by the Engineer. The deviation of the elevation of the surface above the design elevation shall be not more than ten (10) millimeters. Deviations above the design elevation shall not result in the diminished thickness of any subsequent pavement course. The deviation of the elevation below the design elevation shall not be more than ten (10) millimeters. Isolated deviations below the design elevation shall be compensated by additional thickness of the subsequent pavement layer. Additional cost and materials resulting from deviations from the design elevation shall be borne by the Contractor.

2. The surface shall also be checked with a four (4) meter straightedge in all areas of apparent roughness as directed by the Engineer. The finished surface of the base course shall not deviate from the straightedge between any two (2) contact points more than ten (10) millimeters when the straightedge is placed parallel to centerline or twelve (12) millimeters when the straightedge is placed perpendicular to centerline. The

Contractor shall furnish all devices necessary to check the surface, such as stringlines, straightedges, etc., and the labor necessary to handle the task.

3.03.6.6 Acceptance. Aggregate base construction including California Bearing Ratio, abrasion and surface tolerances shall be accepted under Subsection 1.08.4 "Measured or Tested Conformance" in these General Specifications.

Compaction, thickness, aggregate gradation, sand equivalent and plasticity index will be accepted under Subsection 1.08.5, "Statistical Evaluation of Work for Acceptance and Determination of Pay Factor (Value of Work)" in two (2) stages as follows: The first stage shall be the selection of the lowest of the four pay factors for the quality of the aggregate base relating to aggregate gradation, compaction, sand equivalent and plasticity index. The second stage involves the selection and application of a quantity pay factor based on the thickness of the aggregate base. The reduced thickness pay factor for the lower courses of multiple layer courses will be applied provisionally based on the results of the depths of the holes dug in the lower layers. Additional holes will be dug in the total depth of all aggregate base layers within the lot represented by lower layer reduced thickness pay factors. If the total thickness depths show that the increased upper level layer thickness has resulted in total thickness acceptability, the lower level layer reduced thickness pay factor will be adjusted accordingly. The second stage thickness quantity pay factor will be applied to all the individual course lots in addition to the first stage quality pay factor as determined in accordance with Subsection 1.08.5 "Statistical Evaluation of Work for Acceptance and Determination of Pay Factor (Value of Work)" in these General Specifications.

3.03.7 METHOD OF MEASUREMENT. Aggregate base shall be measured by the cubic meter after placement and compaction to the required density, using horizontal dimensions shown on the plans or as directed by the Engineer and thickness measurements determined as specified in this specification. No allowance for overdepth shall be permitted except as approved in writing by the Engineer prior to spreading the aggregate base.

3.03.8 PAYMENT. Aggregate base shall be paid for at the contract unit price or adjusted contract unit price per cubic meter for the aggregate base item(s) shown on the plans and listed in the Bill of Quantities. Such price and payment shall be full compensation for furnishing all materials, equipment, labor, tools, incidentals and all other work necessary to complete the work as specified in Subsection 1.07.2, "Scope of Payment," in these General Specifications.

When a lot of aggregate base course is accepted with a deficiency, the adjusted contract unit price for said lot shall be the product of the contract unit price of aggregate base course and the lowest calculated quality and quantity pay factors specified in Subsection 3.03.6, "Quality Assurance Procedures," in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO.	PAY ITEM	PAY UNIT
30301	Aggregate Base Course	Cubic Meter
3030101	Aggregate Base Course, Grading I	Cubic Meter
3030102	Aggregate Base Course, Grading II	Cubic Meter
3030103	Aggregate Base Course, Grading III	Cubic Meter

SECTION 3.04 - CEMENT TREATED BASES

3.04.1 DESCRIPTION. This work shall consist of furnishing and placing one (1) or more courses of a mixture of aggregate, Portland cement and water, mixing the materials in a central plant and spreading and compacting the mixture in conformity with the lines, grades and thickness shown on the plans all as specified or approved by the Engineer.

Cement treated bases will be designated as Cement Treated Base Course or Cement Treated Base Course, Grading ___. The grading(s) of cement treated base to be furnished shall be according to the item(s) shown on the Plans or in the Special Specifications and listed in the Bill of Quantities. When the cement treated base grading is not specified it shall be furnished meeting the requirements of Grading I, Grading II, or Grading III as designated by the engineer.

ITEMS IN BILL OF QUANTITIES:
Cement Treated Base Course
Cement Treated Base Course, Grading ___

3.04.2 MATERIALS.

3.04.2.1 Portland Cement. Portland cement shall conform to the requirements of ASTMC 595 for Type IP(MS) or ASTMC 150 for Type II-M.

3.04.2.2 Aggregate. Aggregate for Grading I cement treated base shall be of such quality that when mixed with Portland cement in an amount not to exceed five percent (5%) by weight of dry aggregate and compacted at optimum moisture content in accordance with MRDTM 212, the compressive strength of the compacted mixture will not be less than fifty (50) kilograms per square centimeter after seven (7) days curing in a sealed metal container per MRDTM 528.

Aggregate for Grading II and Grading III cement treated base shall be of such quality that when mixed with Portland cement in an amount not to exceed three and one-half percent (3.5%) by weight of dry aggregate and compacted at optimum moisture content in accordance with MRDTM 212, the compressive strength of the compacted mixture will not be less than fifty (50) kilograms per square centimeter after seven (7) days curing in a sealed metal container per MRDTM 528.

The minimum cement content for both Grading I and Grading II shall be two percent (2%) by weight of dry aggregate. The minimum cement content for Grading III shall be specified in the Special Specifications.

Aggregate for cement treated base, immediately prior to mixing, shall be hard, durable, clean and free from vegetation matter and have a plasticity index no greater than six (6). The aggregate shall be graded as follows:

1. Grading I cement treated base - Aggregate gradation shall conform to the requirements for Grading I Aggregate Base as specified in Section 3.03, "Aggregate Bases, in these General Specifications.

2. Grading II cement treated base - Aggregate gradation shall conform to the requirements for Grading II Aggregate Subbase as specified in Section 3.02, "Aggregate Subbases," in these General Specifications.

3. Grading III cement treated base - Aggregate shall conform to the requirements specified in the Special Specifications.

3.04.2.3 Water. Water for mixing shall be free of injurious quantities of oil, alkali, vegetable matter and salt as determined by the Engineer. It shall be reasonably clear and shall contain not more than twenty-five hundredths percent (0.25%) total solids by weight. It shall be capable of producing the specified cement treated material strength as confirmed by laboratory testing. Water shall be tested in accordance with MRDTM 514.

3.04.2.4 Flyash and Chemical Admixtures. Flyash may be considered for incorporation into the cement treated mixture when confirmed by testing and approved by the Engineer. Set-retarders shall conform to ASTM C494.

3.04.2.5 Bituminous Curing Seal. Bituminous material for curing seal shall be SS-1h or CSS-1h conforming to Tables 4.01-3 and 4.01-4 in Section 4.01, "Bituminous Materials," in these General Specifications.

3.04.3 MIX DESIGN. The Contractor shall select his sources of aggregate and, after sufficient quantities have been stockpiled or are available for use, obtain representative samples of the aggregate and test to determine if they conform to the requirements of these specifications. At least thirty (30) days before producing cement treated base mixtures, the Contractor shall forward to the Engineer not less than fifty (50) kilograms of aggregate and five (5) kilograms Portland cement representing materials the Contractor proposes to furnish. The Contractor shall also inform the Engineer of his proposed date for beginning producing cement treated base.

The Contractor shall perform all testing required to establish the proportions of each material to be combined to produce the cement treated base mixture. Cylinders shall be molded in accordance with ASTM F134 and shall be cured in accordance with MRDTM 523. Load rate application for compression testing at twenty-eight (28) days shall be in accordance with MRDTM 528.

After completion of laboratory testing the Contractor shall submit a solid-volume mix design to the Engineer for review. The information submitted for review shall include:

1. The source of aggregate with all specified test information.

2. The brand, type, and source of cement.

3. The type admixture, if proposed for use.

4. The weights, volumes, and specific gravities of all materials to be combined.

5. The compressive strength optimum moisture content and CBR test results as they may apply.

6. Every mix design furnished by the Contractor shall be identified with a code number.

The Contractor may submit mix designs from previous or concurrent projects where the same materials were furnished.

The Contractor shall prepare trial batches of cement treated base mixture using materials, mixing equipment, procedures, and batch sizes which are the same as those to be used in the work. The number of trial batches will be established by the Engineer, who may waive the requirements for trial batches at any time.

The Contractor shall sample and test the trial batches when requested by the Engineer. When test results for samples from trial batches indicate the proposed mix will not meet the specified compressive strength or CBR requirements, the Contractor shall submit a new mix design for review.

The Contractor shall make no changes in the mix design without approval of the Engineer. A new mix design shall be submitted for the Engineer's review any time the Contractor proposes a change in materials or material proportions.

The Engineer's review of mix design and test information shall not be construed as relieving the Contractor of the responsibility to provide cement treated base conforming to the specified properties or material contents.

3.04.4 WEATHER LIMITATIONS. Cement treated base shall not be mixed or placed when the air temperature is below five (5) degrees Celsius, or during hot weather when the air temperature is expected to reach thirty-five (35) degrees Celsius or higher, or during rain, sand or dust storms, unless otherwise approved by the Engineer.

3.04.5 EQUIPMENT. The Contractor shall furnish all equipment required for producing aggregates, hauling, mixing, placing, spreading, compacting and curing the cement treated base in accordance with the minimum type and number outlined in the Contractor's detailed Program of Work as approved by the Engineer. Said equipment shall include a central plant of the batch or continuous pugmill type and self-propelled spreader boxes or finishing machines approved by the Engineer. The mixing plant shall be capable of uniformly mixing the approved cement content within a tolerance of one-half percent (0.5%) of the weight of dry aggregates.

3.04.6 CONSTRUCTION REQUIREMENTS.

3.04.6.1 Surface Preparation. The surface to receive cement treated base, immediately prior to spreading cement treated base, shall conform to specified materials quality, compaction and elevation tolerances and shall be free of loose or extraneous material. When surfaces to receive cement treated base are lower than specified, the low areas may be filled with cement treated base. The volume of cement treated base so placed shall not be measured for payment under any item listed in the Bill of Quantities.

When the surface to receive cement treated base does not conform to the specified materials quality, compaction and elevation tolerances, the Contractor shall correct all deficiencies.

3.04.6.2 Proportioning and Plant Mixing.

1. General Requirements - Aggregate and cement for cement treated base shall be proportioned and mixed in a central mixing plant. The plant shall be a batch-mixing type using revolving blades, rotary drum mixer or the continuous mixing type. The aggregate and cement may be proportioned either by weight or volume.

Water shall be proportioned by either weight or volume and there shall be a means by which the Engineer may readily verify the amount of water per batch, or the rate of flow for continuous mixers. The time of the addition of water, or the points at which it is introduced into the mixer shall be as approved by the Engineer.

The cement shall be added in such a manner that it is uniformly distributed throughout the aggregate during the mixing operation.

The charge in the batch mixer, or the rate of feed to the continuous mixer, shall not exceed that which will permit complete mixing of all materials.

2. Batch Mixing - The batch mixer shall be equipped with a sufficient number of paddles of a type and arrangement which will produce a uniformly mixed batch.

The mixer shall be equipped with a timing device accurate to within two (2) seconds which will indicate, by definite audible or visual signal, the expiration of the mixing period.

The timing of mixing a batch shall begin after all ingredients are in the mixer and shall end when the mixer is half emptied. Mixing shall continue until a homogeneous mixture of uniformly distributed and properly coated aggregate of uniform appearance is produced. The time of mixing shall not be less than thirty (30) seconds.

3. Continuous Mixing - Aggregates shall be drawn from the storage facility by a feeder or feeders which will continuously supply the correct amount of aggregate in proportion to the cement.

A control system shall be provided that will automatically halt plant operation when the material in any storage facility approaches the strike-off capacity of the feed gate. The plant will not be allowed to operate unless this automatic control is in good working condition. Storage facilities containing fine aggregate shall be equipped with a vibrating unit which will effectively vibrate the side walls of the feeder.

The feeder for the aggregate shall be mechanically or electrically driven.

The cement feeder and aggregate feeders shall be equipped with a device by which the rate of feed can be accurately determined while the plant is in full operation.

Each type of mixing plant shall be equipped with sampling facilities approved by the Engineer. The sampling facilities shall allow for the convenient and safe collection of representative samples of aggregate, cement and cement treated base mixture.

3.04.6.3 Transporting and Spreading. The cement treated base mixture shall be transported in a manner that does not cause segregation and, when required by the Engineer, shall be protected against moisture loss by approved covers. The mixture shall be deposited on the roadbed at a quantity per linear meter which will provide the compacted thickness for the width being spread without resorting to spotting, picking up or otherwise shifting the mix.

Immediately prior to depositing plant-mixed cement treated base, the surface to be covered shall be dampened and kept damp. Excessive water as evidenced by puddles or flow across the surface shall be prevented. The mixture in-place shall be free from pockets of coarse or fine material.

The mixture shall be spread on the roadbed in one (1) operation with a self-propelled mechanical spreader at a quantity per linear meter which will provide the compacted thickness without further shaping, spotting or otherwise shifting the mix. Equipment not propelled by the unloading vehicle will be considered self-propelled. The spreader shall be provided with a screen that strikes off and distributes the material to the full width being spread and to the surface tolerances specified. The screed shall be adjustable to produce the required cross section. Screed action includes any cutting, crowding, or other practical motion that produces a finished surface texture of uniform appearance.

In addition, mechanical spreader equipment used to spread and trim cement treated base shall be equipped with fully automatic screed and grade sensing controls which shall control the longitudinal grade and transverse slopes of the screed. Screed controls shall be such that compensation for differences from the slope and grade established by the Engineer will be completely automatic.

Cement treated base placed on areas inaccessible to mechanical spreading equipment may be spread in one (1) layer by methods approved by the Engineer. After spreading, the material shall be thoroughly compacted to the required lines, grades, and cross section by means of pneumatic tampers, or with other compacting equipment which consistently obtains the degree of compaction required.

The use of motor graders will not be permitted during spreading and compaction operations. Motor graders may be used to trim the edges and surface of the cement treated base after compaction in order to finish the base within the tolerances specified.

Unless traffic conditions are prohibitive, the mixed materials shall be spread in widths of not less than two (2) lanes, insofar as the width of cement treated base to be spread permits. Three (3) lane sections may be spread as a two (2) lane width and a one (1) lane width. Spread widths wider than two (2) lanes will be permitted but are not required or mandatory. Materials shall be spread either by one (1) spreader or by several spreaders operating in a staggered position across the subgrade, unless traffic conditions require that less than two (2) lanes be spread. When traffic conditions require that less than two (2) lanes be spread, construction joints shall be constructed in accordance with Subsection 3.06.6, "Construction Joints" in these General Specifications.

Longitudinal construction joints shall fall within thirty (30) centimeters of lane widths.

When cement treated base is placed in more than one (1) layer, the surface of the lower layer of compacted material shall be kept moist until covered with the next layer or with the curing seal. Curing seal shall be applied to the surface of a lower layer which has not been covered with the next layer on the same day. Full compensation for keeping lower layers moist and for furnishing and applying curing seal to the lower layers as specified will be considered as included in the contract price paid for cement treated base and no separate payment will be made therefore.

3.04.6.4 Compacting and Finishing. Initial compaction shall begin immediately after spreading. Successive passes of compaction equipment shall overlap the previous adjacent pass by at least twenty-five percent (25%) of its width. Following the initial compaction and before final compaction, the treated material shall be trimmed by blading with a motor grader or a planing machine to obtain surface in reasonable conformance to line, grade, and cross section established or shown on the plans.

The trimming equipment shall be equipped with automatic grade controls.

When the initial compaction is complete, if the surface of the cement treated base does not conform to specified finish tolerances, high spots shall be trimmed to produce the specified tolerances. All trimmed material shall be removed from the surface of the cement treated base and disposed of as approved by the Engineer. Filling low areas by drifting or hauling of trimmed material is prohibited. Following trimming, all trimmed areas shall receive a minimum of one (1) compaction pass. Additional compaction shall be performed until the entire layer of cement treated cement base conforms to the specified compaction requirements. Final compaction shall be accomplished in such a manner that no loose material remains on the surface and all tear marks are eliminated. Compaction shall proceed without interruption, except as stated above, to achieve at least ninety-five percent (95%) maximum density as determined by MRDTM 212.

The surface of the cement treated base shall be kept moist at all times until the curing seal is applied.

3.04.6.5 Operation Time Requirement. The Contractor shall furnish and operate sufficient equipment or limit the area of work in progress so that not more than two (2) hours shall elapse between the time water is added to the aggregate and cement and the time of completion of the final compaction after trimming, unless otherwise approved by the Engineer.

3.04.6.6 Construction Joints. At the end of each day's work or when cement treated base operations are delayed or stopped for more than two (2) hours, a construction joint shall be made in thoroughly compacted material. The joint shall be normal to the center line of the roadbed and have a vertical face. Additional mixture shall not be placed until the construction joint has been approved by the Engineer.

When partial-width construction of cement treated base is allowed and when the material has been finally compacted more than one (1) hour, a longitudinal joint shall be constructed by cutting back into the previously placed material to a point where it meets the proper line and grade, and trimmed to a true vertical face which is free of any loose or shattered material. Trimmed material shall be removed and disposed of at locations approved by the Engineer. The face of transverse and longitudinal construction joints shall be moistened prior to placement of the adjacent base material.

3.04.7 CURING. After final compaction, the cement treated base shall be covered with a bituminous curing seal, uniformly applied to the surface at a rate between one-half (0.50) and one (1.00) liter per square meter. The curing seal shall be applied on the same day that final compaction is achieved and as soon as practical.

After the curing seal has been applied, the cement treated base shall be kept free of general traffic for a period of at least seven (7) days. Subsequent aggregate base, or pavement course shall be placed within ten days after the curing seal is applied.

Any damage to the curing seal or the cement treated base shall be promptly repaired by the Contractor, at his expense and as directed by the Engineer

3.04.8 CONTRACTOR QUALITY CONTROL PROCEDURES. The Contractor shall sample and test materials and the cement treated base mixture throughout the period of production, placement and compaction. The results of all tests shall be delivered to the Engineer within twenty-four (24) hours after completion of testing.

Process control sampling and testing shall be by lot. A lot shall be five hundred (500) cubic meters. Contractor process control testing shall include:

1. Aggregate gradation.
2. Compressive strength or (CBR for the mixture).

3.04.9 QUALITY ASSURANCE PROCEDURES. Cement treated base shall be accepted by lot. Unless otherwise stated in the Special Specifications, the lot size shall be ten thousand (10,000) square meters for each layer constructed. The cement treated base shall be sampled, tested and evaluated in accordance with Section 1.08, "Acceptance of Work" in these General Specifications. The Engineer may, during the beginning of placement of cement treated base, at times when test results indicate erratic characteristics and at any other time, reduce the lot size to sections of cement treated base with similar quality characteristics. This should facilitate the isolation and modification or replacement of low-quality materials with materials of acceptable quality to maintain the overall strength of the pavement structure.

The Engineer shall perform or supervise the performance of all quality assurance sampling and testing. The location of all samples and tests shall be recorded by roadway, lane and centerline station (kilometer). Quality assurance sampling and testing for each lot shall include:

1. Compaction
2. Thickness
3. Aggregate Gradation, Sand Equivalent and Plasticity Index
4. California Beating Ratio or Compressive Strength
5. Surface Tolerances

3.04.9.1 Compaction. The compacted density for each layer of each course shall be determined by the sand cone method, MRDTM 215, or by nuclear method, MRDTM 218 using full depth penetration, at the option of the Engineer.

When the sand cone method is used, unless otherwise stated in the Special Specifications, the tests shall be made at a minimum of five (5) randomly selected locations in each lot.

When the nuclear method is used, unless otherwise stated in the Special Specifications, the tests shall be made at a minimum of eight (8) randomly selected locations in each lot. Three nuclear gauge readings shall be made at each test location within a radius of two (2) meters. The three (3) readings shall be averaged and the average considered to be the density for that test location.

Percent compaction shall be computed by comparing the average actual in-place compacted density from the nuclear gauge or sand cone test results with the maximum density determined by MRDTM 212. MRDTM 212 maximum density shall be determined from samples of aggregate base obtained from the roadbed at a sampling frequency of one (1) test per three (3) lots. The maximum density used for determining percent compaction shall be the running average for three (3) consecutive tests.

Any lot of cement treated base that has a percent relative compaction below the minimum percent compaction specified in Paragraph 3.03.4.6, "Compacting," in these General Specifications, resulting in a reduced pay factor of 0.75 or higher determined in accordance with Subsection 1.08.5 "Statistical Evaluation of Work for Acceptance and Determination of Pay Factor (Value of Work)" in these General Specifications may be accepted on the basis of a reduced payment if requested in writing by the Contractor. Otherwise the said lot shall be removed and replaced by the Contractor at his expense. Lots that have percent relative compaction resulting in a reduced pay factor less than 0.75 shall be removed and replaced by the contractor at his expense.

3.04.9.2 Thickness. The thickness of each course of cement treated base complete as placed and compacted, shall be measured from test holes obtained at a minimum of five (5) random locations within the lot. The thickness of each hole shall

be determined after determination that the compacted density is acceptable. The average of the test hole thicknesses shall be reported as the thickness of the lot.

A lot shall be accepted when the average total thickness is not less than the plan thickness.

Any lot of cement treated base course with an average thickness less than the plan thickness but resulting in a reduced pay factor of 0.75 or higher determined in accordance with Subsection 1.08.5, "Statistical Evaluation of Work for Acceptance and Determination of Pay Factor (Value of Work)" in these General Specifications may be accepted on the basis of reduced payment if requested in writing by the Contractor. Otherwise the said lot thickness shall be increased as specified in the following paragraph.

When the average thickness of a lot of cement treated base course is less than the planned thickness by an amount resulting in a reduced pay factor below 0.75 the Contractor, at his own expense, shall place and remix additional cement treated base material with the original cement treated base material and recompact before new test holes are dug.

3.04.9.3 Aggregate Gradation, Sand Equivalent and Plasticity Index. The cement treated base aggregate gradation, sand equivalent and plasticity index will be sampled, tested and evaluated based on the average of a minimum of five (5) samples per lot in accordance with the Job Mix Formula Tolerances listed in Paragraph 3.03.3.1, "Job Mix Design Proposal" and Subsection 1.08.5, "Statistical Evaluation of Work for Acceptance and Determination of Pay Factor (Value of Work)" in these General Specifications.

Every sample of cement treated base shall be taken on a random time basis from each uncompacted base immediately behind the spreader during each one-half ( ) day of work, or portion thereof. The initial sample shall be randomly selected from within one and one-half (1) meters either side of the centerline of and weigh at least twenty-five (25) kilograms. The initial sample shall be thoroughly mixed and quartered to obtain a test sample weighing at least six (6) kilograms. The test sample shall be forwarded to the project laboratory and the aggregate gradation, cement gradation and cement content determined.

When the aggregate gradation, sand equivalent or plasticity index for any lot results in a reduced pay factor of 0.75 or higher, determined in accordance with above referenced Subsection 1.08.5, "Statistical Evaluation of Work for Acceptance and Determination of Pay Factor (Value of Work)" in these General Specifications the lot may be accepted on the basis of a reduced pay factor if requested in writing by the Contractor, otherwise said lot shall be removed and replaced by the Contractor at his expense.

When the gradation, sand equivalent or plasticity index pay factor determined in accordance with above referenced Subsection 1.08.5, "Statistical Evaluation of Work for Acceptance and Determination of Pay Factor (Value of Work)" in these General

Specifications for any lot is less than 0.75 the aggregate base shall be removed and replaced by the Contractor at his own expense.

3.04.9.4 California Bearing Ratio or Compressive Strength. Random samples shall be taken and tested for California Bearing Ratio or compressive strength from a minimum of the first three (3) lots and every fifth lot thereafter unless test results indicate failure to conform to the values specified in Subsection 3.04.2 "Materials" in these General Specifications. In such a case, increased sampling and testing shall be performed.

3.04.9.5 Surface Tolerances. The surface layer of the cement treated base shall be evaluated for compliance with the following surface tolerances:

1. The cross section of the finished cement treated base surface shall be checked by the Contractor in the presence of the Engineer at maximum intervals of twenty-five (25) meters and at intermediate points as directed by the Engineer. The deviation of the elevation of the surface above the design elevation shall be not more than ten (10) millimeters. Deviations above the design elevation shall not result in the diminished thickness of any subsequent pavement course. The deviation of the elevation below the design elevation shall not be more than ten (10) millimeters. Isolated deviations below the design elevation shall be compensated by additional thickness of the subsequent pavement layer. Additional cost and materials resulting from deviations from the design elevation shall be borne by the Contractor.

2. The surface shall also be checked with a four (4) meter straightedge in all areas of apparent roughness as directed by the Engineer. The finished surface of the base course shall not deviate from the straightedge between any two (2) contact points more than ten (10) millimeters when the straightedge is placed parallel to centerline or twelve (12) millimeters when the straightedge is placed perpendicular to centerline. The Contractor shall furnish all devices necessary to check the surface, such as stringlines, straightedges, etc., and the labor necessary to handle the task.

3.04.9.6 Acceptance. Cement treated base construction including California Bearing Ratio, compressive strength and surface tolerances shall be accepted under Subsection 1.08.4, "Measured or Tested Conformance" in these General Specifications.

Compaction, thickness, aggregate gradation, sand equivalent and plasticity index will be accepted under Subsection 1.08.5, "Statistical Evaluation of Work for Acceptance and Determination of Pay Factor (Value of Work)" in two (2) stages as follows: The first stage shall be the selection of the lowest of the four pay factors for the quality of the cement treated base relating to aggregate gradation, compaction, sand equivalent and plasticity index. The second stage involves the selection and application of a quantity pay factor based on the thickness of the cement treated base. The reduced thickness pay factor for the lower courses of multiple layer courses will initially be applied provisionally based on the results of the depths of the holes dug in the lower layers. Additional holes will be dug in the total depth of all cement treated base layers within the lot represented by lower layer reduced thickness pay factors. If the total thickness depths show that the increased upper level layer thickness has resulted in total thickness acceptability, the lower level layer reduced thickness pay factor will be

adjusted accordingly. The second stage thickness quantity pay factor will be applied to all the individual course lots in addition to the first stage lowest quality pay factor determined in accordance with Subsection 1.08.5, "Statistical Evaluation of Work for Acceptance and Determination of Pay Factor (Value of Work)" in these General Specifications.

3.04.10 METHOD OF MEASUREMENT. Cement treated base shall be measured by the cubic meter determined as follows:

The volume to be paid for shall be calculated on the basis of the dimensions shown on the plans, adjusted by the amount of any change ordered by the Engineer. No allowance will be made for cement treated base placed outside said dimensions unless ordered by the Ministry. The quantity of cement treated base placed below the grade established by the Engineer will not be paid for.

3.04.11 PAYMENT. The accepted quantities of cement treated base, measured as provided above, shall be paid for at the contract unit price, or adjusted contract unit price, for the cement treated base Grading(s) shown on the plans and listed in the Bill of Quantities, complete in place, including bituminous curing seal when required. The price(s) shall be full compensation for furnishing all materials, labor, equipment, tools, supplies and all other items necessary for the proper completion of the Work as specified in Subsection 1.07.2, "Scope of Payment" in these General Specifications.

When a lot of cement treated base course is accepted with a deficiency, the adjusted contract unit price for said lot shall be the product of the contract unit price of cement treated base course and the lowest quality and quantity pay factors specified in Subsection 3.04.9, "Quality Assurance Procedures," in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO.	PAY ITEM	PAY UNIT
30401	Cement Treated Base Course	Cubic Meter
3040101	Cement Treated Base Course, Grading I	Cubic Meter
3040102	Cement Treated Base Course, Grading II	Cubic Meter
3040103	Cement Treated Base Course, Grading III	Cubic Meter

SECTION 3.05 - SHOULDERS AND LAYBYS

3.05.1 DESCRIPTION. This Work shall consist of constructing shoulders and laybys of the types specified hereinafter, in accordance with these specifications and in conformity to the lines, elevations, thickness and typical cross sections shown on the plans or established by the Engineer.

1. Definition of Shoulders. That portion of the completed road construction which lies above the elevation of the subgrade or base and which extends from the edge of the through travel lanes to the point of intersection with the embankment slopes on either side of the road centerline.

2. Definition of Laybys. Where shown on the plans, or where directed by the Engineer, areas adjacent to the roadway shall be constructed of the new materials and to the dimensions shown on the plans, and in the manner herein specified. These areas will be for the parking of motor vehicles off the roadway other than the space defined as shoulders. Such areas will be called "Laybys."

3. Designation of Shoulders and Laybys. Shoulders and laybys shall be designated by the type and grading of the materials used for construction. The grading(s) shall be specified in the Special Specifications and listed in the Bill of Quantities.

ITEMS IN BILL OF QUANTITIES
Earth Shoulders
Earth Laybys
Aggregate Shoulders
Aggregate Shoulders, Grading ___
Aggregate Laybys
Aggregate Laybys, Grading ___

3.05.2 EQUIPMENT. Equipment shall conform to the standards outlined in Subsection 2.05.5 "Subgrade," and Section 3.04 "Aggregate Bases, in these General Specifications and shall be according to the type and number outlined in the Contractor's detailed Program of Work as approved by the Engineer.

3.05.3 CONSTRUCTION REQUIREMENTS.

3.05.3.1 General. For the purpose of simplification throughout the remainder of the Section, when the term "shoulders" is used it shall mean "shoulders and/or laybys." Shoulders shall be constructed as soon as practicable after the construction of the base/surface course, and/or preparation of the surface area. If shoulders are part of a resurfacing project, vegetable matter shall be removed from the surface of the original shoulders and, if shown on the plans or required by the Engineer, from the adjacent foreslopes upon which the shoulders are to be constructed, and the underlying twenty (20) millimeters layer shall be scarified and recompacted to at least ninety-five percent (95%) of maximum dry density as determined by MRDTM 212.

3.05.3.2 Earth Shoulders and Laybys. The material used for Earth Shoulders and Earth Laybys shall meet the requirements of Subsection 2.05.5, "Subgrade," in the General Specifications and shall be obtained from sources approved by the Engineer. The material shall be deposited and spread in uniform layers not to exceed twenty (20) centimeters (loose measurement) in thickness and compacted to ninety-eight percent (98%) of maximum dry density as determined by MRDTM 212.

3.05.3.3 Aggregate Shoulders and Laybys. Aggregate Shoulders and Aggregate Laybys shall be constructed as shown on the plans, or as directed by the Engineer, and in conformance with the requirements specified in Section 3.04, "Aggregate Bases" in these General Specifications.

The material used for Aggregate Shoulders shall be of the grading designated on the plans and shall be in conformance with the requirements for the same grading of material used for Aggregate Bases as specified in Subsection 3.03.2, "Materials" in these General Specifications and listed in the Bill of Quantities.

3.05.3.4 Bituminous Base Shoulders and Laybys. Bituminous base course shown on the plans for use in the construction of shoulders or laybys shall be constructed as shown on the plans in conformance with the requirements specified in Section 4.05, "Bituminous Concrete Pavement" for Bituminous Base Course in these General Specifications.

3.05.3.5 Bituminous Wearing for Shoulders and Laybys. Bituminous wearing course shown on the plans for use in the construction of shoulders or laybys shall be constructed as shown on the plans in conformance with the requirements specified in Section 4.05, "Bituminous Concrete Pavement" for Bituminous Wearing Course in these General Specifications.

3.05.4 SHOULDERING AND DELINEATION. On projects that carry traffic through construction, the Contractor shall begin shouldering on the second day of the laying of the final roadway surfacing layer, unless weather conditions prevent this operation, in which case the shouldering shall begin as soon as the weather does permit. If the Contractor fails to begin the shouldering within a reasonable time after the last layer has been laid, whether the project has traffic through construction or not, the Engineer may order the Contractor to cease all other Work until the shoulder Work has begun. The shouldering shall be a continuous operation from that time on until completion, with the weather being the only delaying factor. The Contractor shall, on roads under traffic or as directed by the Engineer, delineate the edge of pavement as soon as the surfacing is begun and maintain the delineation until the shoulders are completed. The delineators shall be approved prior to use and shall be placed at the edge of the surfacing at approximately one hundred (100) meter intervals. The cost of this delineation will be considered subsidiary to other items in the Bill of Quantities and will not be paid for directly.

3.05.5 COMPACTION REQUIREMENTS. Unless otherwise specified in the Special Specifications, shoulders and laybys shall be compacted to the Type and degree specified for the materials referenced in the Paragraph 3.05.3.2 Earth Shoulders and Paragraph 3.05.3.3 Aggregate Shoulders, in these General Specifications.

The designated compaction shall be obtained at the edge of the pavement, base or surface, but extreme care shall be exercised to prevent damage to the pavement, base, or surface edges, due to the rolling operations. If deemed necessary by the Engineer, he may require planking of the edges to prevent such damage.

Only pneumatic-tired equipment will be permitted to operate on or across the pavement, base course, or other surfacing, during the construction of the shoulders. If it is necessary to cross or turn on the pavement, base or surface course, with rollers or other nonpneumatic-tired equipment, the surface at such locations shall be protected with planking or with a layer of earth of sufficient thickness to prevent damage to the surface.

When completed, the shoulders shall be smooth, compact and shall conform to the required cross section.

3.05.6 METHOD OF MEASUREMENT. Earth Shoulders, Earth Laybys, Aggregate Shoulders, and Aggregate Laybys shall be measured by the cubic meter, compacted in place but will be only measured as items for separate compensation when included in the Bill of Quantities as separate items. If they are not listed as separate items, the measured quantities will be paid for under the component materials referenced in Subsection 3.05.3, "Construction Requirements" in these General Specifications. Measurements shall be based on the dimensions as shown on the plans or as otherwise directed by the engineer.

Bituminous base and wearing course materials used in the construction of shoulders and laybys shall not be measured under Section 3.05 Shoulders and Laybys but shall be measured under Section 4.05 Bituminous Concrete Pavement in these General Specifications

No measurement will be made of unauthorized areas or for extra thickness. These items shall include the furnishing of all materials, the drying and screening of aggregates, and the mixing, placing, finishing, and compaction of the materials.

Shoulders construction shall not be considered to be complete before the final surface course has been placed and final rolling, shaping, and, if required, priming of shoulders is completed.

3.05.7 PAYMENT. The amount of completed and accepted Work, as measured above, will be paid for at the contract unit price(s) or adjusted contract unit price(s) per cubic meter for Earth Shoulders, Earth Laybys, Aggregate Shoulders, and Aggregate Laybys, according to the pay items specified in the Special Specifications and listed in the Bill of Quantities. Those price(s) shall be full compensation for furnishing all materials, for all labor, equipment, tools, supplies, and all other items necessary for the proper completion of the Work as specified in Subsection 1.07.2., "Scope of Payment" in these General Specifications.

Bituminous base and wearing course materials used in the construction of shoulders and laybys shall not be paid for under Section 3.05 Shoulders and Laybys but shall

be paid for under Section 4.05 Bituminous Concrete Pavement in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO.	PAY ITEM	PAY UNIT
30501	Earth Shoulders	Cubic Meter
30502	Earth Laybys	Cubic Meter
30503	Aggregate Shoulders	Cubic Meter
3050301	Aggregate Shoulders, Grading I	Cubic Meter
3050302	Aggregate Shoulders, Grading II	Cubic Meter
3050303	Aggregate Shoulders, Grading III	Cubic Meter
30504	Aggregate Laybys	Cubic Meter
3050401	Aggregate Laybys, Grading I	Cubic Meter
3050402	Aggregate Laybys, Grading II	Cubic Meter
3050403	Aggregate Laybys, Grading III	Cubic Meter

KINGDOM OF SAUDI ARABIA
MINISTRY OF COMMUNICATIONS

GENERAL SPECIFICATIONS
FOR
ROAD AND BRIDGE CONSTRUCTION

November 1998

PART FOUR
BITUMINOUS CONSTRUCTION

PART FOUR: BITUMINOUS CONSTRUCTION

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PART FOUR: BITUMINOUS CONSTRUCTION

SECTION 4.01 - BITUMINOUS MATERIALS

4.01.1 DESCRIPTION. Bituminous materials shall be manufactured from crude petroleum. They shall be free from any residues obtained by the artificial distillation of coal, coal tar, or paraffin and shall be homogeneous. They shall include the following types:

1. Paving grade bituminous material
2. Liquid bituminous material
3. Emulsified bituminous material
4. Latex modified emulsified bituminous materials
5. Polymer modified paving grade bituminous materials

4.01.2 GRADES.

4.01.2.1 Paving Grade Bituminous Materials. Paving grade bituminous materials shall be classified based on viscosity or penetration of original bitumen. The grades of bituminous materials shall conform to the requirements set forth in Table 4.01-1. The grade of bituminous material to be used shall be specified in these General Specifications or in the Special Specifications.

4.01.2.2 Liquid Bituminous Materials. Liquid bituminous materials shall be medium curing and rapid curing conforming to the requirements set forth in Tables 4.01-2 and 4.01-3. The grade of liquid bituminous material to be used shall be specified in these General Specifications or in the Special Specifications.

4.01.2.3 Emulsified Bituminous Materials. Emulsified bituminous materials shall be composed of a bituminous material uniformly emulsified with water and an emulsifying or stabilizing agent and shall conform to the requirements set forth in Tables 4.01-4 and 4.01-5. The grade of the emulsified bituminous material to be used shall be specified in these General Specifications or in the Special Specifications.

Use of emulsified asphalt, storage considerations and handling requirements shall be as specified in Circular No. 600, dated 12 Rabi II 1407H, issued by the Ministry.

4.01.2.4 Latex Modified Emulsified Bituminous Materials. Latex modified emulsified bituminous materials shall conform to the grade specified in the Special Specifications as set forth in Table 4.01-6.

4.01.2.5 Polymer Modified Paving Grade Bituminous Materials. Polymer modified paving grade bituminous materials shall conform to the requirements specified in the Special Specifications.

4.01.3 MANUFACTURE. Bituminous materials shall not be heated during the process of its manufacture or during construction so as to cause damage to the materials as evidenced by the formation of carbonized particles.

Rapid curing liquid bituminous materials, designated by the letters RC, shall consist of a bituminous material blended or fluxed with naphtha.

Medium curing liquid bituminous materials, designated by the letters MC, shall consist of a bituminous material blended or fluxed with kerosene.

Emulsified bituminous material shall consist of a bituminous material emulsified with an emulsifying agent and dispersed in water. The emulsified bituminous materials shall be homogeneous for a period of not less than thirty (30) days after delivery when thoroughly mixed.

4.01.4 ACCEPTANCE PROCEDURES FOR BITUMINOUS MATERIALS. Bituminous materials will be accepted under Subsection 1.08.4, "Measured or Tested Conformance," in these General Specifications subject to the following:

4.01.4.1 Shipping Container. Before loading, the manufacturer shall examine the shipping container and remove all remnants of previous cargos that may contaminate the material to be loaded.

4.01.4.2 Delivery Ticket. The manufacturer shall furnish with each shipment two (2) copies of the delivery ticket containing the following:

Consignees
Project number
Grade
Net liters
Net weight
Type and amount of antistripping agent
Identification number (truck, car tank, et.)
Destination
Date
Loadingtemperature
Specific gravity at 60 °F (15.6 °C)

4.01.4.3 Certificate of Compliance. The manufacturer shall deliver a signed Certificate of Compliance to cover the quality and quantity of material and the condition of container for each shipment. Test results shall be provided either with the shipment or within one week after shipment.

Bituminous materials may be used prior to sampling and testing when a Certificate of Compliance is furnished by the manufacturer stating that the bituminous material, at the time of loading, conformed to all specified requirements and that the shipping container was clean and contained no contaminating residue. This Certificate of Compliance shall reference the lot and identify the test numbers representing the lot.

Bituminous materials furnished without a Certificate of Compliance should not be introduced into the work until the Contractor has had sufficient time to sample and test the delivered materials.

4.01.4.4 Acceptance Sampling Procedures. The Contractor shall obtain acceptance samples of bituminous material according to AASHTO T40 at the applicable point of acceptance as follows:

1. Bituminous material used in direct application on the road. Samples shall be taken from each shipping container at the time of discharge into distributors or other conveyances on the project.

2. Bituminous material initially discharged into storage tanks on the project. Samples shall be taken from the line between the storage tank and the distributor or the mixing plant after each delivery. Samples shall be taken after a sufficient period of circulation has taken place to ensure samples are representative of the material in the storage tank.

3. The manufacturer of bituminous materials shall test all materials produced and the test results retained for reference. The Contractor, under the supervision of the Engineer, shall sample each shipment of bituminous material delivered to a bituminous concrete mixing plant, bituminous treatment production project, bituminous emulsion treated base production project or other project requiring the incorporation of bituminous materials. The samples shall be numbered consecutively and identified by project, type and grade of bituminous material, date of delivery and use. All samples shall be tested for conformance with the General and Special Specifications.

Work in which bituminous materials failed to conform to the specifications shall be rejected. Rejected bituminous materials shall be immediately removed from the work, including all portions of the work in which said rejected bituminous materials were placed, and the Contractor shall replace rejected materials with specification materials at his sole expense.

4.01.5 MEASUREMENT. Unless specified in the Special Specifications and listed in the Bill of Quantities bituminous materials shall be considered subsidiary and no measurements shall be made.

4.01.6 PAYMENT. Unless specified in the Special Specifications and listed in the Bill of Quantities, bituminous materials shall be considered as subsidiary to the work being performed and full compensation for furnishing bituminous materials shall be included in the contract unit prices and payment for the work performed in accordance with the specifications.

When specified in the Special Specifications and listed in the Bill of Quantities, payment will be made at the contract unit price per each item listed in the Bill of Quantities.

Such prices and payments shall cover and be full compensation for equipment, labor, tools and incidentals necessary for furnishing bituminous materials as specified in Subsection 1.07.2, "Scope of Payment," in these General Specifications.

TABLE 4.01-1A
SPECIFICATIONS FOR BITUMINOUS MATERIAL GRADED BY VISCOSITY

TESTS	VISCOSITY GRADE						
	AASHTO Test Method	AC-2.5	AC-5	AC-10	AC-20	AC-30	AC-40
Viscosity, 60°C(140°F.), poises	T-202	250+/-50	500 +/-100	1000 +/-200	2000 +/- 400	3000 +/- 600	4000 +/- 800
Viscosity,135°C(275°F), CS minimum	T-201	125	175	250	300	350	400
Penetration, 25°C (77°F),100g., 5 sec. Minimum	T-49	220	140	80	60	50	40
Flash Point, COC, C (F) minimum	T-48	163(325)	177(350)	219(425)	232(450)	232(450)	232(450)
Solubility in trichloroethylene, percent Minimum	T-44	99.0	99.0	99.0	99.0	99.0	99.0
Tests on residue from Thin-Film Oven Test:							
Loss on heating percent maximum (optional)	T-240		1.0	0.5	0.5	0.5	0.5
Viscosity, 60°C (140°F), poises-maximum	T-202	1000	2000	4000	8000	12000	16000
Ductiility,25°C (77°F)5cm per minute cm-minimum.	T-51	100 (Note 1)	100	75	50	40	25
Spot Test (when and as specified (see Note 2) with):							
Standard naphtha solvent	Negative for all grades						
Naphtha-xylene solvent, percent xylene	Negative for all grades						
Heptane-xylene solvent, percent xylene	Negative for all grades						

Note 1: If ductility is less than 100, material will be accepted if ductility at 15.6 C (60 F) is 100 minimum.

Note 2: The use of the spot test is optional. When it is specified, the Engineer shall indicate whether the standard naphtha solvent, the naphtha-xylene solvent, or the heptane-xylene solvent will be used in determining compliance with the requirement, and also, in the case of the xylene solvents, the percentage of xylene to be used.

TABLE 4.01-1B
SPECIFICATIONS FOR PENETRATION GRADED ASPHALT CEMENT

TESTS	AASHTO TESTMETHOD	40-50 Min.	40-50 Max.	60-70 Min.	60-70 Max.	85-100 Min.	85-100 Max.	120-150 Min.	120-150 Max.	200-300 Min.	200-300 Max.
Penetration at 25°C (77°F) 100 g, 5 sec.	T49	40	50	60	70	85	100	120	150	200	300
Penetration Ratio, percent minimum (Note 1)		25	25	25	25	25	----	----	----	----	----
Viscosity at 135° degrees C Kinematic (minimum)	T 201	240	200	170	----	---	----	----	----	----	----
Flash point, Cleveland Open Cup °F	T 48	450	----	450	----	450	----	425	----	350	----
Ductility at 25°C (77°F) 5 cm per min, cm.........	T 51	100	----	100	----	100	----	100	----	----	----
Solubility in trichloroethylene percent	T 44	99	----	99	----	99	----	99	----	99	----
Thin film oven test, 1/8 in. (3.2 mm), 163°C (325°F) 5 hour...											
Loss on bearing, percent of original		----	0.8	----	0.8	----	1.0	----	1.3	----	1.5
Penetration, of residue, percent of original		58	----	54	----	50	----	46	----	40	----
Ductility of residue at 25°C (77°F), 5 cm per Min., cm...		----	----	50	----	75	----	100	----	100	----
Spot Test (when and as specified (see Note 2) With):	T 102										
Standard naphtha solvent		Negative for all grades									
Naphtha-xylene solvent, percent xylene		Negative for all grades									
Heptane-xylene solvent, percent xylene		Negative for all grades									

Note 1: Penetration Ratio = $\dfrac{\text{Penetration at 4 degrees C, 200 gms, 60 seconds}}{\text{Penetration at 25 degrees C, 100 gms, 5 seconds}}$ X 100

Note 2: The use of the spot test is optional. When it is specified, the Engineer shall indicate whether the standard naphtha solvent, the naphtha-xylene solvent, or the heptane-xylene solvent will be used in determining compliance with the requirement, and also, in the case of the xylene solvents, the percentage of xylene to be used.

TABLE 4.01-2A
SPECIFICATIONS FOR MEDIUM CURING (MC) LIQUID ASPHALTS

TESTS	AASHTO Test Method	MC-30 Min.	MC-30 Max.	MC-70 Min.	MC-70 Max.	MC-250 Min.	MC-250 Max.	MC-800 Min.	MC-800 Max.	MC-3000 Min.	MC-3000 Max.
Kinematic Viscosity @ 60° C (140° F) - (see Note 1) centistokes	T201	30	60	70	140	250	500	800	1600	3000	6000
Flash Point (Tag, open-cup), degrees C (F)	T-79	38 (100)	...	38 (100)	...	66 (150)	...	66 (150)	...	66 (150)	...
Water Percent	T-55	...	0.2	...	0.2	...	0.2	...	0.2	...	0.2
Distillation Test: Distillate percentage by volume of total distillate to 360° C (680° F)											
To 225° C (680° F)	T-78	...	25	0	20	0	10	...	...	...	...
To 260° C (680° F)		40	70	20	60	15	55	0	35	0	15
To 315° C (680° F)		75	93	65	90	60	87	45	80	15	75
Residue from distillation to 360° C(680° F) volume percentage of sample by difference		50	...	55	...	67	...	75	...	80	...
Tests on residue from distillation: Absolute visosity @ 60° C (140° F) - (See Note 4) poises	T-49	300	1200	300	1200	300	1200	300	1200	300	1200
Ductility 5 cm/cm., cm. (See Note 2)	T-51	100	...	100	...	100	...	100	...	100	...
Solubility in Trichloroethylene, percent	T-44	99.0	...	99.0	...	99.0	...	99.0	...	99.0	...
Spot test (See Note 3) with:											
Standard naptha	T-102	Negative for all grades									
Naptha - xylene solvent, - percent xylene		Negative for all grades									
Heptane - xylene solvent, - percent xylene		Negative for all grades									

NOTE 1. As an alternate, Saybolt Furol viscosities may be specified as follows:
Grade MC-70 -- Furol viscosity @ 50° C (122° F) -- 60 to 120 sec.
Grade MC-30 -- Furol viscosity @ 25° C (77° F) -- 75 to 150 sec.
Grade MC-250 -- Furol viscosity @ 60° C (140° F) -- 125 to 250 sec.
Grade MC-800 -- Furol viscosity @ 82.2° C (180° F) -- 100 to 200 sec.
Grade MC-3000 -- Furol viscosity @ 82.2° C (180° F) -300 to 600 sec.

NOTE 2. If the ductility @ 25° C (77° F) is less than 100, the material will be acceptable if its ductility @ 15.5° C (60° F) is more than 100.

NOTE 3. The use of the spot test is optional. When specified, the Engineer shall indicate whether the standard naptha solvent, the naptha xylene solvent, or the heptane xylene solvent will be used in determining compliance with requirements, and also, in the case of the xylene solvents, the percentage of xylene to be used.

NOTE 4. In lieu of viscosity of the residue, the specifying agency, at its option, can specify penetration 100 g.; 5s @ 25° C (77° F) of 120 to 250 for Grades MC-30, MC-70,MC-250, MC-800, and MC-3000. However, in no case will both be required.

TABLE 4.01-2B
SPECIFICATIONS FOR MEDIUM-CURING (MC) LIQUID ASPHALTS

TESTS	AASHO TEST METHOD	MC-0	MC-1	MC-2	MC-3	MC-4	MC-5
		GRADES					
Flash Point (Open Tag), degrees C (F)	T 79	38+ (100+)	38+ (100+)	66+ (150+)	66+ (150+)	66+ (150+)	66+ (150+)
Furol Viscosity at 25 degrees C, seconds		75-150					
Furol Viscosity at 50 degrees C, seconds			75-150				
Furol Viscosity at 60 degrees C, seconds	T 72			100-200	250-500		
Furol Viscosity at 82.5 degrees C, seconds						125-250	300-600
Distillation:							
Distillate (percent of total) distillate to 360 degrees C:							
To 190 degrees C		0-25	0-20	0-10	0-5	0	0
To 225 degrees C	T 78	40-70	25-65	15-55	5-40	0-30	0-20
To 315.6 degrees C		75-93	70-90	60-87	55-85	40-80	20-75
Residue from distillation to 350 degrees C, volume percent by difference		50+	60+	67+	73+	78+	82+
Tests on Residue from Distillation:							
Penetration, 25 degrees C, 100 grams, 5 seconds	T 49	120-300	120-300	120-300	120-300	120-300	120-300
Ductility, 25 degrees C,[1] centimeters	T 51	100+	100+	100+	100+	100+	100+
Solubility in Carbon Tetrachloride, percent	T 44	99.5+	99.5+	99.5+	99.5+	99.5+	99.5+
Temperature for Application by Spraying, in degrees C		25-65	50-80	65-105	80-120	90-135	105-150
General Requirements	The materials shall be free from water.						

[1] If penetration of residue is more than two hundred (200) and its ductility at 25 degrees C is less than one hundred (100) the material will be acceptable if its ductility at 15.6 degrees C is one hundred plus (100+).

TABLE 4.01-3A
SPECIFICATIONS FOR RAPID CURING (RC) LIQUID ASPHALTS

TESTS	AASHTO TEST METHOD	RC-70		RC-250		RC-800		RC-3000	
		Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Kinematic Viscosity @ 60° C (140° F) - (see Note 1) centistokes	T-201	70	140	250	500	800	1600	3000	6000
Flash Point (Tag, open-cup), degrees C (F)	T-79	...	...	27 (80)	...	27 (80)	...	27 (80)	...
Water Percent	T-55	...	0.2	...	0.2	...	0.2	...	0.2
Distillation Test: Distillate percentage by volume of total distillate to 360° C (680° F)									
to 190° C (374° F)		10	...	...	...	...	...	...	...
to 225° C (680° F)		50	...	35	...	15	...	...	...
to 260° C (680° F)	T-78	70	...	60	...	45	...	25	...
to 315° C (680° F)		85	...	80	...	75	...	70	...
Residue from distillation to 360° C(680° F) volume percentage of sample by difference		55	...	65	...	75	...	80	...
Tests on residue from distillation: Absolute viscosity @ 60° C (140° F) poises - (See Note 3 AASHTO T-49)	T-202	600	2400	600	2400	600	2400	600	2400
Ductility 5 cm/min at 25° C (77° F)	T-51	100	...	100	...	100	...	100	...
Solubility in Trichloroethylene, percent	T-44	99.0	...	99.0	...	99.0	...	99.0	...
Spot test (See Note 2) with:									
Standard naphtha	T-102	Negative for all grades							
Naphtha -xylene solvent, - percent xylene		Negative for all grades							
Heptane -xylene solvent, - percent xylene		Negative for all grades							

NOTE 1. As an alternate, Saybolt Furol viscosities may be specified as follows:
Grade RC-70 -- Furol viscosity @ 50° C (122° F) -- 60 to 120 sec.
Grade RC-250 -- Furol viscosity @ 60° C (140° F) -- 125 to 250 sec.
Grade RC-800 -- Furol viscosity @ 82.2° C (180° F) -- 100 to 200 sec.
Grade RC-3000 -- Furol viscosity @ 82.2° C (180° F) -- 300 to 600 sec.

NOTE 2. The use of the spot test is optional. When specified, the Engineer shall indicate whether the standard naphtha solvent, the naphtha xylene solvent, or the heptane xylene solvent will be used in determining compliance with requirements, and also, in the case of the xylene solvents, the percentage of xylene to be used.

TABLE 4.01-3B
SPECIFICATIONS FOR RAPID-CURING (RC) LIQUID ASPHALTS

		GRADES					
TESTS	AASHO TEST METHOD	RC-0	RC-1	RC-2	RC-3	RC-4	RC-5
Flash Point (Open Tag), degrees C (F)	T 79	----	----	27+ (80+)	27+ (80+)	27+ (80+)	27+ (80+)
Furol Viscosity at 25 degrees C, seconds		75-150					
Furol Viscosity at 50 degrees C, seconds			75-150				
Furol Viscosity at 60 degrees C, seconds	T 72			100-200	250-500		
Furol Viscosity at 82.5 degrees C, seconds						125-250	300-600
Distillation:							
Distillate (percent of total) distillate to 360 degrees C:		15+	10+				
To 190 degrees C		55+	50+	40+	25+	8+	
To 225 degrees C	T 78	75+	70+	65+	55+	40+	25+
To 315.6 degrees C		90+	88+	87+	83+	80+	70+
Residue from distillation to 350 degrees C, volume percent by difference		50+	60+	67+	73+	78+	82+
Tests on Residue from Distillation:							
Penetration, 25 degrees C, 100 grams, 5 Seconds	T 49	80-120	80-120	80-120	80-120	80-120	80-120
Ductility, 25 degrees C,(1) centimeters	T 51	100+	100+	100+	100+	100+	100+
Solubility in Carbon Tetrachloride, percent	T 44	99.5+	99.5+	99.5+	99.5+	99.5+	99.5+
Temperature for Application by Spraying, in degrees C		25-50	50-80	65-105	80-95	95-120	105-135
General Requirements	The materials shall be free from water.						

TABLE 4.01-4A
SPECIFICATIONS FOR ANIONIC EMULSIFIED ASPHALT

TYPE	RAPID-SETTING			
	RS-1		RS-2	
GRADE	Min.	Max.	Min.	Max.
Tests on emulsions:				
Viscosity, Saybolt Furol @ 77 ° F (25 ° C), s	20	100	...	...
Viscosity, Saybolt Furol @ 122 ° F (50 ° C), s	...	...	75	400
Storage stability test, 24-h, %	...	1		
Demulsibility, [a] 35 ml, 0.02 N $CaCl_2$, %	60	...	60	...
Coating ability and water resistance:				
Coating, dry aggregate		...		...
Coating, after spraying		...		...
Coating, wet aggregate		...		...
Coating, after spraying		...		...
Cement mixing test, %	...		...	
Sieve test, %	...	0.1 0	...	0.10
Residue by distillation, %	55	...	63	...
Tests on residue from distillation test:				
Penetration, 77 ° F (25 ° C), 100 g, 5s	100	200	100	200
Ductility, 77 ° F (25 ° C), 5 cm/min, cm	40	...	40	...
Solubility in Trichloroethylene, %	97.5	...	97.5	...
Float test, 140 ° F (60 ° C), s	...	...	...	...
Typical Applications [b]	surface treatment, penetration macadam, sand seal coat, tack coat, mulch		surface treatment, penetration macadam, coarse aggregate seal coat (single and multiple)	

[a] The demulsibility test shall be made within 30 days from date of shipment.
[b] These typical applications are for use only as a guide for selecting and using the emulsion for pavement construction and maintenance.

TABLE 4.01-4B
SPECIFICATIONS FOR ANIONIC EMULSIFIED ASPHALT

TYPE	MEDIUM - SETTING													
GRADE	MS-1		MS-2		MS-2h		HFMS-1		HFMS-2		HFMS-2h		HFMS-2s	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Tests on emulsions:														
Viscosity, Saybold Furol @ 77°F (25° C), s	20	100	100	...	100	...	20	100	100	...	100	...	50	...
Viscosity, Saybolt Furol @ 122°F (50° C), s	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Storage stability test, 24-h, %	...	1	...	1	...	1	...	1	...	1	...	1	...	1
Demulsibility, [a] 35ml, 0.02 N $CaC1_{2}$, %	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Coating ability and water resistance:														
Coating, dry aggregate	good	good	good	good	good	good	Good	good	good	good	good	good	good	good
Coating, after spraying	fair	fair	fair	fair	fair	fair	fair	fair	fair	fair	fair	fair	fair	fair
Coating, wet aggregate	fair	fair	fair	fair	fair	fair	fair	fair	fair	fair	fair	fair	fair	fair
Coating, after spraying	fair	fair	fair	fair	fair	fair	fair	fair	fair	fair	fair	fair	fair	fair
Cement mixing test, %	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Sieve test, %	...	0.10	...	0.10	...	0.10	...	0.10	...	0.10	...	0.10	...	0.10
Residue by distillation, %	55	...	65	...	65	...	65	...	65	...	65	...	65	...
Test on residue from distillation text:														
Penetration, 77°F (25° C), 100 g, 5s	100	200	200	100	200	40	90	100	200	100	200	40	90	200
Ductility, 77°F (25° C), 5 cm/min, cm	40	...	40	...	40	...	40	...	40	...	40	...	40	...
Solubility in Trichloroethylene, %	97.5	...	97.5	...	97.5	...	97.5	...	97.5	...	97.5	...	97.5	...
Float test, 140°F (60° C), s	...	...	...	...	...	...	1200	...	1200	...	1200	...	1200	...
Typical Applications [b]	cold plant mix, road mix, sand seal coat, crack treatment, tack coat		cold plant mix, coarse aggregate seal coat (single and multiple), crack treatment, road mix, tack coat, sand seal coat		cold plant mix, hot mix, coarse aggregate seal coat (single and multiple crack treatment, road mix track coat		cold plant mix, road mix, sand seal coat, crack treatment, tack coat		cold plant mix, coarse aggregate seal coat (single and multiple), crack treatment road mix, tack coat, and seal		cold plant mix, hot plant mix, coarse aggregate seal coat (single and multiple), crack treatment road mix, tack coat		dense-graded cold plant mix and road mix stockpile mix, crack treatment, patching mix	

TABLE 4.01-4C
SPECIFICATIONS FOR ANIONIC EMULSIFIED ASPHALT

TYPE	RAPID-SETTING			
	SS-1		SS-1h	
GRADE	Min.	Max.	Min.	Max.
Tests on emulsions:				
Viscosity, Saybolt Furol @ 77 ° F (25 ° C), s	20		20	100
Viscosity, Saybolt Furol @ 120 ° F (50 ° C), s	...	...	...	...
Storage stability test, 24-h, %	...	100	...	1
Demulsibility, [a] 35 ml, 0.02 N $CaCl_2$, %	...	...	...	...
Coating ability and water resistance:				
Coating, dry aggregate		...		...
Coating, after spraying		...		...
Coating, wet aggregate	...			...
Coating, after spraying		...		...
Cement mixing test, %	...	2.0	...	2.0
Sieve test, %	...	0.10	...	0.10
Residue by distillation, %	57	...	57	...
Tests on residue from distillation test:				
Penetration, 77 ° F (25 ° C), 100 g, 5s	100	200	40	90
Ductility, 77 ° F (25 ° C), 5 cm/min, cm	40	...	40	...
Solubility in Trichloroethylene, %	97.5	...	97.5	...
Float test, 140 ° F (60 ° C), s	...	...	...	...
Typical Applications [b]	cold plant mix, road mix, slurry seal coat, tack coat, fog seal, dust layer, mulch			

[a] The demulsibility test shall be made within 30 days from date of shipment.

[b] These typical applications are for use only as a guide for selecting and using the emulsion for pavement construction and maintenance.

TABLE 4.01-5
SPECIFICATIONS FOR CATIONIC EMULSIFIED ASPHALT

TYPE	RAPID SETTING				MEDIUM SETTING				SLOW SETTING			
	CRS-1		CRS-2		CMS-2		CMS-2h		CSS-1		CSS-1h	
GRADE	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Tests on emulsions:												
Viscosity, Saybold Furol @ 77°F (25° C), s	...	...	...	...	...	...	...	...	20	100	20	100
Viscosity, Saybolt Furol @ 122°F (50° C), s	20	100	100	400	50	450	50	450	...	...	...	...
Storage stability test, 24-h, % [a]	...	1	...	1	...	1	...	1	...	1	...	1
Demulsibility 35ml, 0.8% sodium diocytl suffosucinate,%	40	...	40.	...	...	...	...	...	...	...	...	...
Classification test	Passes		Passes									
Coating ability and water resistance: Coating, dry aggregate					good		good					
Particle charge test	positive		positive		positive		positive		positive[b]		positive[b]	
Sieve test, %	...	0.10	...	0.10	...	0.10	...	0.10	...	0.10	...	0.10
Cement mixing test, % Distillation: Oil distillate, by volume of emulsion, %	...	...	...	...	...	...	...	...	...	2.0	...	2.0
Test on residue from distillation text:												
Penetration, 77°F (25° C), 100 g, 5s	100	250	100	250	100	250	40	90	100	250	40	90
Ductility, 77°F (25° C), 5 cm/min, cm	40	...	40	...	40	...	40	...	40	...	40	...
Solubility in Trichloroethylene, %	97.5	...	97.5	...	97.5	...	97.5	...	97.5	...	97.5	...
Typical Applications [c]	surface treatment, penetration macadam,		surface treatment, penetration macadam,		cold plant mix, coarse aggregate seal coat		cold plant mix, hot plant mix, coarse aggregate		cold plant mix, road mix, slurry seal coat, tack coat, fog seal, dust layer, mulch			

[a] The 24 hour storage stability test results do not necessarily predict satisfactory 5 day settlement test results.
[b] If the particle charge test result is inconclusive, material having a maximum pH value of 6.7 will be acceptable.
[c] These typical applications are for use only as a guide for selecting and using the emulsion for pavement construction and maintenance.

NOTE: The revised specification is identified as interim Specification M 208-811.

TABLE 4.01-6
LATEX MODIFIED BITUMINOUS MATERIAL

TESTS	TEST METHOD	ANIONIC LMRS-2H	ANIONIC LMRS-2	CATIONIC LMCRS-2H	CATIONIC LMCRS-2
Viscosity @ 50 ° C (122 ° F)	MRDTM 424	75-300 sec.		75-300 sec.	
Sieve	MRDTM 424	0.3% max.		0.3% max.	
Settlement, 5 Days	MRDTM 424	5% max.		5% max.	
Demulsibility	MRDTM 424	60% max.		40% max.	
Storage Stability Test (1 Day)	MRDTM 424	1% max.		1% max.	
Particle Charge	MRDTM 424	-		Positive	
Ash Content	ASTM D3723	0.2% max.		0.2% max.	
Test on Residue (by Drying):					
Percent Residue	CAL-331	65% min.		65% min.	
Penetration @ 25 ° C (77 ° F) 1009, 5 sec.	MRDTM 404	40-90	90-200	40-90	90-200
Ductility @ 25 ° C (77 ° F) 5 cm/min..	MRDTM 405	40 cm/min.		40 cm/min.	
Torsional Recovery	CAL-332	18% min.		18% min.	

NOTES:
1. The latex shall be added to either the asphalt or the emulsion at their locations of manufacture.
2. The latex may be either neoprene or a blend of butadiene and styrene.
3. Unless otherwise ordered by the Engineer, a sample of the latex modified asphaltic emulsion shall be taken by the inspector from the spray bar of the distributor truck at mid-load. The sample shall be taken in a half-gallon plastic container.
4. The latex modified asphaltic emulsion may be stored in heated circulating tanks at temperatures between
60 ° C and 80 ° C for a period not to exceed 7 days.
5. The temperature of the latex-modified asphaltic emulsion at the time of application shall be between 55 ° C and 80 ° C.

SECTION 4.02 - BITUMINOUS PRIME COAT, TACK COAT AND FOG SEAL

4.02.1 DESCRIPTION. This work consists of applying cut-back or emulsified bituminous materials on previously constructed soil, aggregate, bituminous or concrete surfaces within the lines shown on the plans, specified or established by the Engineer.

4.02.1.1 Prime Coat. A prime coat consists of applying a coat of cut-back bituminous material to the surface of an untreated soil or aggregate or other surfaces as shown on the plans and specified in the Special Specifications.

4.02.1.2 Tack Coat. A tack coat consists of applying a cut-back or emulsified bituminous material to a primed surface, to an existing bituminous or Portland cement concrete pavement to be overlaid, to the surface between layers of bituminous pavement, to bridge decks, and to vertical edges of pavement, curbs and gutters, wing walls, bridge abutments and other surfaces in contact with bituminous pavement.

4.02.1.3 Fog Seal. A fog seal consists of applying a light application of slow-setting emulsified bituminous material diluted with water to an existing bituminous surface.

ITEMS IN BILL OF QUANTITIES:
- Bituminous Prime Coat
- Bituminous Tack Coat
- Bituminous Fog Seal

4.02.2 MATERIALS. Bituminous material shall conform to the requirements in Section 4.01, "Bituminous Materials," in these General Specifications, as follows:

4.02.2.1 Prime Coat. MC-70 or MC-250 conforming to the requirements in Table 4.01-2 unless a different grade is specified in the Special Specifications.

4.02.2.2 Tack Coat. RC-70 conforming to the requirements in Table 4.01-3A, SS-1h emulsified bituminous material conforming to the requirements in Table 4.01-4C, or CSS-1h emulsified bituminous material conforming to the requirements in Table 4.01-5 unless a different grade is specified in the Special Specifications.

4.02.2.3 Fog Seal SS-1, SS-1h, CSS-1 or CSS-1h emulsified asphalt conforming to the requirements in Table 4.01-4C or Table 4.01-5 unless a different grade is specified in the Special Specifications.

4.02.2.4 Blotting Sand. Natural sand, manufactured sand, or combinations thereof that are free from organic matter or clay, having a grading consisting of one hundred percent (100%) passing the 4.75 millimeter (No. 4) sieve and not more than five percent (5%) passing the 0.150 millimeter (No. 100) sieve.

4.02.3 APPLICATION RATES. Application rates for Prime Coat, Tack Coat, Fog Seal and Blotting Sand shall be within the following ranges as approved by the Engineer:

1. Prime coat. The approved application rate shall be determined from test sections constructed using specified materials within the range 0.50 to 1.75 liters per square meter.

2. Tack coat. The approved application rate shall be within the range 0.10 to 0.30 liters per square meter for RC-70 and 0.20 to 0.50 liters per square meter, prior to dilution with additional water, for SS-1h and CSS-1h emulsified bituminous material.

3. Fog Seal. The approved undiluted application rate shall be determined from test sections constructed using specified materials with the range of 0.30 to 0.70 liters per square meter depending on the conditions of the existing surface.

4. Blotter sand. As needed to prevent bituminous material adhering to vehicle tires.

4.02.4 EQUIPMENT. The contractor shall furnish and operate sufficient equipment to complete the work within the Contract time in accordance with his Program of Work as approved by the Engineer. Said equipment shall include rotary type power brooms, aggregate spreaders, rollers, bituminous material distributors, and equipment for heating bituminous material.

Bituminous material shall be applied using a truck-mounted distributor capable of uniformly spraying bituminous material full lane widths.

Sand Spreader. Blotter sand shall be spread from a truck-mounted hopper equipped with controls to deliver the sand in a uniform application at specified rates to the surface treated with a prime coat. Sand may be spread by hand on isolated bleeding spots.

4.02.5 CONSTRUCTION.

4.02.5.1 Preparation of Surfaces. The surface to receive a prime coat, immediately prior to application of the prime coat, shall conform to the specified compaction and elevation tolerance and be free of organic and other deleterious material. When deemed necessary by the Engineer, the soil and aggregate surface shall receive a light application of water to reduce the surface tension and improve penetration of the prime into the surface.

The surface to receive a tack coat or a fog seal, immediately prior to application of the tack coat or fog seal, shall conform to all requirements of the specifications and be free of dust, organic matter and other deleterious material. Where tack coat or fog seal is applied to bridge decks, joints shall be cleaned and filled as specified in the Special Specifications.

4.02.5.2 Preparation of Bituminous Material. The bituminous material shall be uniform throughout the distributor tank and be heated to the application temperatures as follows:

MC-70, RC-70	-	50 to 80 degrees Celsius
MC-250	-	75 to 100 degrees Celsius
SS-1h, CSS-1h	-	20 to 70 degrees Celsius
SS-1, SS-1h	-	20 to 70 degrees Celsius

Prior to application, SS-1h and CSS-1h may be diluted with additional water in the proportion 1:1, or other proportions as approved by the Engineer.

4.02.5.3 Test Sections and Selection of Application Rates. The Contractor shall establish application rates for prime coat and fog seal material based on the results from test sections. A test section shall be at least three (3) meters wide by one hundred (100) meters long. Two (2) or more test sections shall be constructed for each grade of bituminous material specified for use or used and every type of material to be prime coated.

On the date scheduled or any day prior to beginning prime coating or fog sealing, the Contractor shall apply two (2) or more rates of bituminous material to consecutive test sections. When the test sections are completed, the prime coat or fog seal operation shall be halted for a minimum of four (4) hours to allow the Engineer to assess the suitability of the rates applied. Test sections receiving insufficient prime coat or fog seal shall receive an additional application of prime coat when ordered by the Engineer. Test sections receiving excess prime coat or fog seal shall be blotted with sand when ordered by the Engineer.

The prime coat or fog seal application rate will be proposed by the Contractor and approved by the Engineer.

4.02.5.4 Application of Bituminous Material. The bituminous material coverage shall be uniform without streaking or uncoated spots. When streaking occurs, as determined by the Engineer, the application of bituminous material shall cease until adjustments are made to the distributor and application procedures which will result in elimination of streaking. Uncoated spots shall be coated using the hand held nozzle.

Traffic should not be permitted on surfaces which have been primed, tacked or fogged until approved by the Engineer. Fog seal shall be allowed to penetrate undisturbed for at least two (2) hours until the emulsified asphalt breaks and is substantially absorbed into the existing surface. Remaining spots of excess asphalt shall be lightly covered with blotter sand before opening the surface to traffic.

Asphaltic emulsion shall be reheated, if necessary, but at no time after loading into a tank car or truck for transporting to the site of the work shall the temperature of the emulsion be raised above seventy degrees Celsius (70°), unless permitted by the Engineer. During all reheating operations the asphaltic emulsion shall be agitated to prevent localized overheating.

4.02.5.5 Application of Blotting Sand. When deemed necessary by the Engineer, after the bituminous material prime coat or fog seal has been applied for forty-eight (48) hours, a light application of blotting sand shall be applied to those areas which have not dried sufficiently to permit traffic to use the primed surface. Excess blotting sand shall be swept from the primed surface before placement of any bituminous course.

4.02.5.6 Maintenance of Prime Coat. The Contractor shall maintain the prime coat and coated surface until covered with a subsequent course of material. Additional prime coat material and blotting sand shall be applied when ordered by the Engineer.

4.02.5.7 Emulsified Asphalt Fog Seal. Construction requirements for emulsified asphalt applications, dilution requirements and rates of application, shall be as specified in the HMM, Part 5, Section 2.04 - Surface Maintenance Techniques; Paragraphs A - Introduction; and B - Fog Seal.

4.02.6 TRAFFIC CONTROL. While construction of a bituminous prime coat, tack coat or fog seal is in progress, the treated surface of the roadway shall not be used by the Contractor, his agents or others until the Engineer is satisfied that the treated surface will not be damaged by traffic and has given approval for traffic to use the treated surface.

The Contractor shall assure the safety and convenience of public traffic and protect the residents and property owners adjacent to the project during all bituminous prime coat, tack coat and fog seal operations. He shall erect and maintain signs, barricades and other traffic control devices and shall take effective action to exclude traffic of any description from the roadway surface for as long as may be required in the judgement of the Engineer. When traffic is restricted to a one-way basis, the Contractor shall provide such flagmen and pilot cars as deemed necessary for the protection of traffic and the treated surface. Traffic may be detoured around the construction in conformance with detailed detour plans including layout, signing, marking and other traffic control devices approved by the Engineer. Detours shall be properly constructed and maintained throughout the period traffic uses the detour. When it is necessary to provide for traffic across the prime coat before the bituminous material has been applied for forty-eighty (48) hours, the crossing shall be blotted with sand to the extent approved by the Engineer before the crossing is opened to traffic. Necessary crossings of a tack coated surface shall be retacked just prior to the construction of the subsequent layer to the satisfaction and approval of the Engineer. When traffic is permitted on a blotted prime coated surface, the Contractor shall effectively limit vehicle speeds to thirty (30) kilometers per hour for the first two (2) hours of use.

All traffic control work will be done in accordance with Section 9.02, "Traffic Control through Work Zones," in these General Specifications.

4.02.7 WEATHER LIMITATIONS. Bituminous material for prime coat, tack coat and fog seal shall not be applied to any surface until the air and surface temperatures are at least fifteen degrees Celsius (15° C.) and rising or during rain, dust or sand storms.

4.02.8 MEASUREMENT. Bituminous material for prime coat, tack coat and fog seal shall be measured in liters for the areas sealed within the limits shown on the plans, specified in the Special Specifications or ordered by the Engineer. Prime coat, tack coat and fog seal material placed outside authorized limits shall not be measured.

Sand blotter shall not be measured for payment.

4.02.9 PAYMENT. Bituminous tack coat will not be paid for directly as it is to be considered subsidiary to the pay item for the surface that is being tacked unless otherwise stated in the Special Specifications and listed in the Bill of Quantities. The amount of completed and accepted prime coat and fog seal work as measured shall be paid for at the contract unit prices, or adjusted contract unit prices, in the Bill of Quantities.

Such price and payment shall be full compensation for furnishing all materials, labor, equipment, tools and incidentals necessary for completing the work as specified in Subsection 1.07.2, "Scope of Payment," in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO.	PAY ITEM	PAY UNIT
40201	Bituminous Prime Coat	Liter
4020101	Bituminous Prime Coat, Grade MC-30, or MC-70, or MC-250	Liter
4020102	Bituminous Prime Coat, Grade MC-1, or MC-2, or MC-3	Liter
4020103	Bituminous Prime Coat, Grade RC-70, or RC-250	Liter
4020104	Bituminous Prime Coat, Grade RC-1, or RC-2, or RC-3	Liter
4020105	Bituminous Prime Coat, Grade RS-1, or RS-2	Liter
4020106	Bituminous Prime Coat, Grade SS-1 or SS-1H	Liter
4020107	Bituminous Prime Coat, Grade CRS-1 or CRS-2	Liter
4020108	Bituminous Prime Coat, Grade CMS-2 or CMS-2H	Liter
4020109	Bituminous Prime Coat, Grade CSS-1 or CSS-1H	Liter
4020110	Bituminous Prime Coat, Grade___	Liter
40202	Bituminous Tack Coat	Liter
4020201	Bituminous Tack Coat, Grade RC-70 or RC-250	Liter
4020202	Bituminous Tack Coat, Grade RC-1 or RC-2	Liter
4020203	Bituminous Tack Coat, Grade RS-1 or RS-2	Liter
4020204	Bituminous Tack Coat, Grade SS-1 or SS-1H	Liter
4020205	Bituminous Tack Coat, Grade CRS-1 or CRS-2	Liter
4020206	Bituminous Tack Coat, Grade CMS-2 or CMS-2H	Liter
4020207	Bituminous Tack Coat, Grade CSS-1 or CSS-1H	Liter
4020208	Bituminous Tack Coat, Grade ___	Liter
40203	Bituminous Fog Seal	Liter
4020301	Bituminous Fog Seal, SS-1 or SS-1H	Liter
4020302	Bituminous Fog Seal, CSS-1 or CSS-1H	Liter
4020303	Bituminous Fog Seal, Grade ___	Liter

SECTION 4.03 - BITUMINOUS SURFACE TREATMENTS

4.03.1 DESCRIPTION. This work shall consist of placing single or double applications of bituminous material and aggregate chips or screenings in accordance with the lines shown on the plans, these specifications, the Special Specifications and as directed by the Engineer.

BITUMINOUS SURFACE TREATMENTS IN THE BILL OF QUANTITIES:
Bituminous Seal Coat
Single Bituminous Surface Treatment
Double Bituminous Surface Treatment
Precoating Aggregates

The bituminous surface treatment to be applied will be shown on the plans or specified in the Special Specifications.

Bituminous Seal Coat - CM-B and CM-C, shall consist of one (1) application of bituminous material and one (1) application of aggregate screenings to an existing bituminous pavement.

Single Bituminous Surface Treatment - CM-A and CM-A-1, shall consist of one (1) or more applications of bituminous material and one (1) application of aggregate screenings to an aggregate subbase or base course.

Double Bituminous Surface Treatment shall consist of two (2) or more applications of bituminous material and two (2) applications of aggregate screenings to an aggregate subbase or base course.

4.03.2 MATERIALS.

4.03.2.1 Bituminous Material. The type and grade of bituminous material to be applied for construction of bituminous surface treatment will be shown on the plans or specified in the Special Specifications and include one (1) or more of the following:

1. Cut-back Grades. MC-70, MC-250, RC-800 conforming to the requirements in Tables 4.01-2 and 4.01-3, in Section 4.01, "Bituminous Materials," in these General Specifications.

2. Emulsified Grades. SS-1h, CSS-1h, RS-1, CRS-1, RS-2, CRS-2, conforming to the requirements in Tables 4.01-4 and 4.01-5, or latex-modified rapid set emulsions (LMRS-2H, LMRS-2, LMCRS- 2H, LMCRS-2) conforming to the requirements in Table 4.01-6, Section 4.01, "Bituminous Materials," in these General Specifications.

3. Asphalt Cement Grades and Modified Asphalt Cement. The material shall conform to the requirements in Table 4.01-1, in Section 4.01, "Bituminous Materials," in these General Specifications for the Grade(s) specified in the Special Specifications.

4.03.2.2 Changes in Grade of Bituminous Materials. At any time during the progress of the work, the Engineer may order the use of other grades of bituminous materials in substitution of the grades specified in the Special Specifications if, in his judgement, the results contemplated by the specifications will be better attained thereby.

No change in the unit price set forth in the Bill of Quantities will be permitted when such a substitution is ordered.

4.03.2.3 Aggregate. Aggregate chips or screenings to be applied for bituminous surface treatment shall be hard durable particles or fragments of crushed stone, crushed slag, or crushed gravel. The grading will be designated in the Special Specifications and listed in the Bill of Quantities and include one (1) or more of the following gradations:

Grading Designation	I	II	III	IV	V	VI
Sieve Size						
25 mm (1 inch)	100					
19.0 mm (3/4 inch)	55-85	100	100	100		
12.5 mm (1/2 inch)	0-15	45-65	90-100	90-100	100	
9.5 mm (3/8 inch)	-	10-30	30-60	-	85-100	100
4.75 mm (No. 4)	0-2	0-10	0-10	10-30	10-30	85-100
2.36 mm (No. 8)	0-3	0-3	-	0-10	10-40	
2.00 mm (No. 10)	0-3	0-5	0-10			
0.300 mm (No. 50)				0-5		

In addition to the grading requirements, the aggregate shall conform to the following:

1. Abrasion Loss, MRDTM 309, Percent - 30 Max.
2. Sodium Sulfate Soundness, MRDTM 311, Percent - 10 Max.
3. Percent Fracture, 1 Face, Min. - 90 Min.
4. Coating and Stripping, MRDTM 413, Percent - 95 Min.

Percent fracture shall be determined for the material retained on the 2.36 millimeter (No. 8) sieve. The fractured face shall have a minimum dimension from edge to edge across the fractured face which is not less than one-third (1/3) the minimum dimension of the aggregate particle.

The aggregate screenings shall be clean, uniform in quality, and free from organic and other deleterious materials. The portion of aggregate retained on the 2.36 mm (No. 8) sieve shall not have more than one tenth of one percent (0.1%) adherent material by washing.

4.03.2.4 Mineral Fillers. Mineral fillers shall be either Portland cement, blended hydraulic cement or lime conforming to the following requirements:

Materials	Requirement
Portland Cement, Type I or II	ASTM C-150
Blended Hydraulic Cement, Type IP	ASTM C-595
Lime, Type N or S	ASTM C-207

When required, the amount of mineral filler used shall be between one and two percent (1 - 2%) of the weight of the aggregate, with the exact amount to be stated in the Job Mix Formula.

4.03.2.5 Chemical Admixtures and Asphalt Modifiers. The types and amounts of chemical admixtures/asphalt modifiers used shall be limited to those listed in the Special Specifications or proposed by the Contractor and approved by the Ministry's Research and Materials Department to establish compliance with the job mix formula (JMF) requirements contained in Subsection 4.05.3, "Proportioning Bituminous Concrete Mixtures," in these General Specifications.

All chemical admixtures/asphalt modifiers including anti-stripping additives and polymers shall be thoroughly mixed and uniformly combined with the bituminous material.

4.03.2.6 Precoating Material. Materials used for precoating aggregate to promote adhesion may be either prepared material ready for use or field produced. Prepared precoating materials include bitumen based materials and oil based materials.

Bitumen based materials for precoating include medium curing cutback bitumen and special refinery prepared cutback bitument which may include an adhesion agent. Oil based materials for precoating usually comprise an adhesion agent dissolved in a petroleum oil such as distillate.

Field prepared precoating materials usually include adhesion agents which may be designed for dilution in petroleum oil such as distillate, kerosene, etc., or in water. The proportion of adhesion agent used is generally one percent (1%) by volume in both cases.

Surface active adhesion agents are generally of the amine type derived from fatty acids.

4.03.3 PROPORTIONING BITUMINOUS SURFACE TREATMENT MIXTURES.

4.03.3.1 Job Mix Design Proposal. A proposed Job Mix Formula (JMF) shall be formulated by the Contractor and submitted to the Engineer for approval. The JMF shall be prepared by the Contractor in precise compliance with procedures and requirements set forth in the MRD Test Method 425.

The Contractor shall select his sources of aggregate and bituminous material and, after sufficient quantities have been stockpiled or are available for use, obtain representative samples of the materials and test to determine if they conform to the requirements of these specifications. At least thirty (30) days before producing the bituminous surface treatment, the Contractor shall submit in writing to the Engineer detailed information for each mix which he proposes to furnish.

The information shall include, but not be limited to the following:

1. The source and gradation of the aggregate for each mix to be furnished. If the aggregate (coarse, fine, supplemental fine) is separated into two (2) or more sizes, the information provided shall consist of gradations for all individual sizes, the proportions of each individual size to be used, and the mathematically combined gradation for each mix to be furnished. Such combined gradation shall meet the applicable grading requirements shown in Paragraph 4.03.2.3, "Aggregate," in these General Specifications and show the percentage passing each of the specified sieve sizes.

2. All pertinent materials test data for triplicate test specimens and a written certification that the aggregates to be furnished conform to all of the quality requirements specified in Paragraph 4.03.2.3, "Aggregate," in these General Specifications.

3. Pertinent test data for triplicate test specimens and a written certification that the bituminous materials, mineral fillers, chemical admixtures, asphalt modifers, and precoating materials conform to the quality requirements specified in Subsection 4.03.2, "Materials," in these General Specifications.

The durability of the bitumen to be used shall be determined in accordance with the Australian Standard AS 2341.13 "Determination of Durability of Bitumen." The test results shall be included with the Contractor's Job Mix Formula (J.M.F.) submission.

The test results shall be submitted in tabular form. The information shall include the source and grade of bituminous material to be used and the recommended bituminous material content for each mix. If a mineral or chemical admixture has been used, the type and quantity shall be also stated for each mix.

The Engineer shall be provided access to the materials sampling and testing operations at all times.

At the same time that the above information is provided, the Contractor shall supply to the Engineer one hundred (100) kilogram samples of each individual aggregate size, eight (8) liters of bituminous material and, when used, sufficient quantities of mineral filler and chemical admixture, all representing the materials which the Contractor proposes to furnish.

4.03.3.2 Acceptance of Job Mix Formula. The Engineer shall review the JMF to determine that it contains all required information. If it does not contain all required information, it shall be returned within seven (7) days to the Contractor for further action and resubmission by the Contractor.

If the proposed, JMF contains all required information but fails to meet all of the requirements specified, it shall not be accepted by the Engineer and will be returned to the Contractor within fourteen (14) days. The Contractor shall prepare and submit to

the Engineer a new JMF conforming to the requirements specified and propose a new date for beginning production of the bituminous surface treatment.

When the Engineer is satisfied that the JMF proposed by the Contractor conforms to all the requirements of the specifications, he shall order the Contractor to construct a two hundred (200) meter long field control strip. The Engineer shall evaluate the control strip as to its constructability and the mix for conformance to the laboratory tested JMF. Split samples of the mix and component raw materials along with the field laboratory test results are to be sent to the Materials and Research Department's Central Laboratory for testing. If the Engineer is not satisfied with the results of the control strip, he shall state his objections in writing and request a revised JMF and a new control strip. The control strip may only be left in place if the results are satisfactory.

When the Engineer is satisfied that the JMF proposed by the Contractor conforms to all requirements of the specifications and the control strip results are acceptable, he will issue written acceptance to the Contractor to begin producing the proposed surface treatment.

Production of the bituminous surface treatment shall not begin until the Engineer has given written acceptance of the Job Mix Formula.

Acceptance of the JMF by the Engineer does not relieve the Contractor of his obligation to produce the bituminous surface treatment conforming to all specified requirements.

4.03.3.3 Job Mix Formula Revisions. The Contractor shall not alter his methods of crushing, screening, blending, or stockpiling from that used to produce materials for the approved JMF. Changes to the JMF will not be permitted without retesting and resubmission of a proposed (revised) JMF in accordance with all the steps in Paragraph 4.03.3.1, "Job Mix Design Proposal," in these General Specifications.

Should the Contractor change his source of supply of aggregate and grade of bituminous materials, he shall furnish the new information and samples of materials, as described in Paragraph 4.03.3.1, "Job Mix Design Proposal" as determined by the Engineer to be necessary, at least twenty (20) days before their intended use. The Engineer will deduct all job mix formula calculation costs for Contractor requested changes to approval or additional job mix formula calculations.

At any time after the JMF is approved the Contractor may submit a new JMF for approval by the Engineer. If the revised JMF is approved it shall become the approved JMF.

4.03.4 EQUIPMENT. The Contractor shall furnish the proper type and operate sufficient numbers of equipment to complete the work within the Contract time in accordance with his Program of Work as approved by the Engineer. Said equipment shall include rotary type power brooms, aggregate spreaders, rollers, bituminous material distributors, and equipment for heating bituminous material.

The bituminous material shall be applied using a truck-mounted distributor capable of spraying evenly heated asphalt through an adjustable full circulation spray bar up to four and six-tenths (4.6) meters wide. It shall also have positive controls including tachometer, thermometer pressure gage, volume measuring device on calibrated tank to uniformly deposit asphalt over the full width at the required rate. Prior to beginning any work specified in this section, and at all times during the performance of the work, the Contractor shall demonstrate, in the presence of the Engineer, that the distributor spray bar has been maintained and adjusted so that the nozzles provide a true triple lap without ridges or voids, that all nozzles are functioning as intended and that the distributor is capable of applying bituminous material within 0.08 liters per square meter of the specified rate.

Aggregate spreaders shall be self-propelled and capable of spreading aggregate uniformly to full lane widths.

Rollers shall be light self-propelled pneumatic-tired and two-axle smooth-drum tandem steel rollers. The light self-propelled pneumatic-tired rollers shall be constructed so that they may be loaded to provide a gross weight of at least forty (40) kilograms per centimeter of width of tire tread. The tires on the front and rear axles shall have wide smooth treads and shall be staggered to provide complete coverage of the entire area over which the roller travels. The tires shall be inflated to a pressure that has been approved by the Engineer and the pressure shall be reasonably uniform in all tires. The Contractor shall provide a suitable gauge for determining air pressure in the tires.

Two-axle tandem steel rollers shall be self-propelled and shall weigh not less than seven (7) tons or more than eleven (11) tons. The power mechanism shall be capable of propelling the roller smoothly and without jerking when starting, stopping, or reversing directions, free from backlash, loose link motion, faulty steering mechanism and worn king bolts. The steering mechanism shall have no lost motion, shall operate readily and permit the roller to be directed on the alignment desired. The faces of all rolls shall be smooth and free from defects which mar the finished road surface. Rollers shall be equipped with water tanks and sprinkling devices which shall be used for wetting the rolls to prevent adherence of the placed material. Other equipment necessary to perform the work as specified shall be furnished and operated by the Contractor.

4.03.5 APPLICATION RATES FOR BITUMINOUS MATERIAL. The exact application rates will be directed by the Engineer which, in his judgement, will provide the results contemplated by the specifications.

4.03.5.1 Bituminous Seal Coat.

		(Quantities Per Square Meter)		
Bituminous Material Type and Grade	Bituminous Finished Thickness	Material Liters	Aggregate Grading	Aggregate Screenings-Kg.
CM-B RC-800	9 mm	1.10-1.70	V	10-14
RS-2,CRS-2	9 mm	1.20-1.80	V	10-14
LMRS-2H,LMRS-2, LMCRS-2H,LMCRS-2		1.20-1.80	V	10-14

CM-CRC-800	6 mm	0.70-1.20	VI	8-11
RS-2, CRS-2	6 mm	0.80-1.30	VI	8-11
LMRS-2H, LMRS-2				
LMCRS-2H,LMCRS-12	6 mm	0.80-1.30	VI	8-11

4.03.5.2 Single Bituminous Surface Treatment.

(Quantities Per Square Meter)

Bituminous Material Type and Grade	Bituminous Finished Thickness	Material Liters	Aggregate Grading	Aggregate Screenings-Kg.
CM-A RC-800	12mm	1.50-2.00	III	14-18
RS-2,CRS-2	12mm	1.60-2.20	III	14-18
LMRS-2H, LMRS-2,				
LMCRS-2H,LMCRS-2	12mm	1.60-2.20	III	14-18
CM-A-1 RC-800	16 mm	1.80-2.30	II	20-28
RS-2, CRS-2	16 mm	2.00-2.50	II	20-28
LMRS-2H, LMRS-2,				
LMCRS-2H,LMCRS-2	16 mm	2.00-2.50	II	20-28

4.03.5.3 Double Bituminous Surface Treatment.

(Quantities Per Square Meter)

Bituminous Material Type and Grade	Bituminous Finished Thickness	Material Liters	Aggregate Grading	Aggregate Screenings-Kg.
Class A RC-800				
1st Application		1.10-1.80	I	20-28
2nd Application	25mm	1.60-2.10	IV	12-16
Class B RS-2, CRS-2, LMRS-2H, LMRS-2, LMCRS-2H,LMCRS-2				
1st Application		1.20-1.90	I	20-28
2nd Application	25mm	1.80-2.30	IV	12-16

4.03.6 WEATHER LIMITATIONS. Subject to the determination of the Engineer, bituminous material shall not be applied during sand or dust storms, rainfall, or before any imminent storms that might damage the construction. The Engineer shall have the discretion as to whether the surface and materials are dry enough. The application of any bituminous material to the prepared surface shall be restricted to the following conditions:

1. The ground temperature shall be at least fifteen degrees Celsius (15° C.) and the air temperature at least fifteen degrees Celsius (15° C.) and rising, or,

2. The air temperature shall be at least twenty degrees Celsius (20° C.) when falling and the wind shall be less than ten (10) kilometers per hour as estimated by the Engineer.

No bituminous material shall be applied which cannot be covered with aggregate screenings one hour before darkness.

The Engineer may require the Contractor to delay application of bituminous material until the atmospheric and roadway conditions are satisfactory.

4.03.7 TRAFFIC CONTROL. While construction of a bituminous surface treatment is in progress, the treated surface of the roadway shall not be used by the Contractor, his agents or others until the Engineer is satisfied that the treated surface will not be damaged by traffic and has given approval for traffic to use the treated surface.

The Contractor shall assure the safety and convenience of public traffic and protect the residents and property owners adjacent to the project during all bituminous surface treatment operations. He shall erect and maintain signs, barricades and other traffic control devices and shall take effective action to exclude traffic of any description from the roadway surface for as long as may be required in the judgement of the Engineer. When traffic is restricted to a one-way basis, the Contractor shall provide such flagmen and pilot cars as deemed necessary for the protection of traffic and the treated surface. Traffic may be detoured around the construction in conformance with detailed detour plans including layout, signing, marking and other traffic control devices approved by the Engineer. Detours shall be properly constructed and maintained throughout the period traffic uses the detour. When it is necessary to provide for traffic across the bituminous surface treatment, the crossing shall be blotted with sand to the extent approved by the Engineer before the crossing is opened to traffic. All traffic control work shall be in accordance with Section 9.02, "Traffic Control through Work Zones," in these General Specifications.

4.03.8 CONSTRUCTION REQUIREMENTS.

4.03.8.1 Preparation of Surfaces to Receive Bituminous Surface Treatments.

1. Untreated Surfaces. The surface to receive a bituminous surface treatment, immediately prior to the first application of bituminous material, shall conform to the specified compaction and surface elevation tolerance and be free of organic and other deleterious material.

A prime coat shall be applied in accordance with the requirements of Section 4.02, "Bituminous Prime Coat, Tack Coat and Fog Seal," in these General Specifications, when application of a prime coat is shown on the plans or specified in the Special Specifications, otherwise a prime coat will not be applied separately. Where a prime coat is applied it shall be allowed to cure for a minimum period of forty-eight (48) hours before proceeding with a second application of bituminous material.

2. Treated Surfaces. The existing treated surface shall be swept with a rotating broom until the surface is free from dust, dirt or other deleterious material.

Surface holes and depressions greater than two (2) centimeters in depth shall be patched using bituminous concrete wearing material. Holes two (2) centimeters in depth or less shall be patched with multiple applications of bituminous material and aggregate screenings. The holes and depressions shall be swept clean, a tack coat applied and patching completed. Patching work shall be completed at least seven (7) days prior to beginning application of the bituminous surface treatment.

When shown on the plans, specified in the Special Specifications or directed by the Engineer, reshaping the roadway cross section and reducing the depth of longitudinal sags shall be accomplished by pre-leveling with bituminous concrete wearing material in accordance with the requirements in Section 4.05, "Bituminous Concrete Pavement," in these General Specifications.

All areas patched and pre-leveled with bituminous concrete wearing course material, after completion of compaction, shall receive a fog seal, diluted with additional water as approved by the Engineer, and applied at an undiluted rate between 0.20 and 0.50 liters per square meter.

4.03.8.2 Application Temperatures For Bituminous Material. Bituminous materials shall be heated to a uniform temperature as directed by the Engineer within the following limits:

Bituminous Material	Distributor Spraying Temperature	
Type and Grade	Minimum Degrees C	Maximum Degrees C
Bituminous Cut-Back Grades		
MC, RC-800	95	125
MC, RC-250	75	105
MC, RC-70	50	80
Bituminous Emulsions		
SS-1h, CSS-1h	20	65
RS-2, CRS-2	50	85
LMRS-2H, LMRS-2, LMCRS-2H, LMCRS-2	55	85
Asphalt Cements		
All Grades	130	180 or below that at which fogging occurs

4.03.8.3 Calibration and Adjustment of the Distributor. At the beginning of each day's operations, the Contractor shall make checks, tests and calculations as necessary to confirm that the application rate is uniform and within five percent (5%) of the specified rate, at all points across the roadway width and for at least three hundred (300) meters in length. The information collected shall be reported to the Engineer in writing. The Contractor shall also calibrate the asphalt distributor spray bar height, nozzle angle and pump pressure and check contractual and transverse spread rates weekly according to ASTMD 2995.

4.03.8.4 Production Start-Up Procedures for Surface Treatment. The Contractor shall provide seven (7) calendar days advance notice before constructing all asphalt surface treatments containing aggregate. The following start-up procedures shall be repeated when resuming production after work has been terminated due to non-conformance.

On the first day of production, the contractor shall construct a one hundred fifty meter (150) long control strip that is one lane wide. The control strip shall be located on the project as designated.

The Contractor shall construct the control strip using materials, placement and compaction procedures intended for the remainder of the surface treatment. Production shall cease after construction of the control strip until the material and the control strip are evaluated and accepted.

Acceptable control strips may remain in place and will be accepted as a part of the completed surface treatment.

The control strip process shall be repeated until an acceptable control strip is produced.

4.03.8.5 Procedures for Precoating. Prepared precoating materials are supplied in drums or bulk and need no further preparation in the field. Preparation of precoating materials in the field usually involves dilution of adhesion agents in either oil or water.

For oil-soluble material the usual procedure is to mix the required quantity of adhesion agent with the appropriate amount of oil by circulating in a tank.

When the adhesion agent is either in a paste or solid form it will be necessary to melt the agent before mixing. Under cold conditions it may be necessary to warm the oil. Complete dispersion of the adhesion agent throughout the oil is essential.

For water soluble material in the mixing procedure will vary with different materials and it is most important to follow carefully the manufacturer's directions if satisfactory results are to be achieved.

Adhesion agents may be injurious to health and gloves and eye shields should be worn at all times by personnel handling these materials.

Adhesion agents may settle out after some time in solution. Containers should be checked regularly and agitated if necessary.

If precoating is to be fully effective, all aggregate particles must be completely but thinly coated. The quantity needed to obtain this result will vary with the nature of the aggregate, the efficiency of the precoating methods, the absorptive properties of the aggregates, the amount of moisture and dust present, and the type of precoating material. Generally four (4) to twelve (12) liters per cubic meter (L/m^3) will be necessary. The precoating material is usually applied as a fine spray on a moving stream of aggregate.

When aggregate is freshly precoated with oil-based materials the fluid precoating material tends to cut back the binder in contact with the aggregate and the reduction in viscosity lessens the ability of the binder to hold the aggregate. This effect, which is accentuated by over precoating, usually applies for a short time, during which instability or stripping can occur.

When cutback bitumen is used for precoating it is an advantage to allow it to dry on the aggregate before being used. To achieve this, precoating should be done at least one (1) week before use but it may be done up to about two (2) months before the aggregate is used providing that dust is not blown over the stockpile thus reducing the effectiveness of the precoating.

A small amount of moisture on the aggregate may not be detrimental to the precoating process by an excess of moisture before precoating tends to produce a thinner and less uniform film of oil reducing its effectiveness in promoting adhesion. In any case, sufficient time should be allowed for any moisture to evaporate and allow the oil to adhere to the aggregate.

If rain falls immediately after damp aggregate has been preocated and placed in a stockpile and before the precoating material has adhered properly to the aggregate the precoating material may be washed from the aggregate unless the stockpile is covered. It is good practice, where practical, to cover stockpiles of precoated aggregates which are not intended for immediate use.

Normally the aggregate will be stockpiled and checked for quantity and quality some time before being used. Immediately after the work commences a check on the aggregate should be made to see if further precoating or other treatment is necessary.

In some areas aggregate is precoated at the crushing site by running the freshly crushed and screened aggregate through a pugmill fed with a bitumen-based precoating material.

4.03.8.6 Procedures for Applying Bituminous Materials. Bituminous material shall be applied at the specified rates upon the prepared surface using distributors.

Areas missed during the application of bituminous material shall be immediately covered using the hand held nozzle and the same type and grade of bituminous material. The area covered with bituminous material shall be no larger than can be covered with aggregate within five (5) minutes from the time of application on any part of the roadway.

Unless otherwise approved by the Engineer, construction of the bituminous surface treatment shall progress towards the source of aggregate screenings being applied.

Where application of bituminous material begins at the end of a previous application of bituminous material, and when directed by the Engineer, the Contractor shall cover the full width of the end of the previous application with building paper at least eighty (80) centimeters wide. The application of bituminous material shall begin on the paper when the distributor is advancing at a speed that provides for uniform distribution of the bituminous material. The building paper shall be removed before application of aggregate screenings begins.

4.03.8.7 Procedures for Applying Aggregate Screenings. After the bituminous material has been evenly spread over the roadway surface, aggregate of the grading specified shall be evenly applied to the roadway surface by a self-propelled spreader box.

The aggregate shall be spread in one operation on one-half of the roadway in such a manner that a twenty (20) centimeters strip of bituminous material is left exposed along the center line of the roadway. Where necessary, thin or bare spots in the spread of aggregate shall be corrected by hand spreading or by other methods as may be approved by the Engineer.

As soon as the aggregate has been spread on the first one-half of the roadway, it shall be rolled as directed by the Engineer with self-propelled pneumatic-tired or smooth-drum steel rollers. The aggregate shall be rolled at speeds not in excess of seven (7) kilometers per hour (KPH) in such a manner that the aggregate surface receives three (3) complete coverages. All rolling on any area shall be completed within thirty (30) minutes after the aggregate screenings were applied.

After the application of bituminous material and aggregate to the first half of the roadway, the remaining half shall be prepared and treated in the same manner as described for the first half. Where there is an excess of aggregate, it shall be distributed evenly over the adjacent roadway or picked up by shoveling into trucks.

Where specified, subsequent applications of bituminous material and aggregate shall proceed as directed by the Engineer. When multiple applications of bituminous material and aggregates are specified, no one application of aggregate shall precede a second application of aggregate by more than two thousand (2000) meters.

When the final application of aggregate has been placed over any length of the full-width of roadway, rolled as specified and inspected by the Engineer, it shall be broomed to remove excess aggregate. When traffic is permitted to use the completed surface treatment, it shall be broomed for five days following application of the aggregate, as directed by the Engineer, to reduce the detrimental effects from free aggregate particles.

Trucks hauling aggregates shall operate in a manner, and at reduced speeds so that no damage is done to the surface treatment, as determined by the Engineer.

4.03.8.8 Adding Bituminous Material and Aggregate Screenings. If the application of bituminous material or aggregate screening, or both, placed on any portion of the roadway is insufficient for the required results, the Engineer may direct the Contractor to make additional applications of one or all materials in accordance with these specifications.

4.03.8.9 Correction of Defects. Omissions by the distributor or damage to the treated surface of any application shall be immediately repaired by hand patching. Holes which develop in the surface shall be repaired in a similar manner. All costs incurred in making said repairs shall be at the Contractor's expense.

Defects such as raveling, bleeding of bituminous material, lack of uniformity, or other imperfections caused by faulty workmanship or materials shall be corrected as directed by the Engineer and new work shall not be started until such defects and the causes of the defects have been remedied.

All improper workmanship and defective materials shall be removed from the roadway by the Contractor and replaced with approved materials and workmanship at the Contractor's expense. The removed materials shall be disposed of as specified in Subsection 2.01.3, "Disposal of Removed Material," in these General Specifications.

4.03.9 MAINTENANCE OF SURFACE. The completed surface treatment shall be maintained and all damage resulting from any cause shall be repaired by the Contractor at his expense until such time as the project or portions of the Contract have been accepted in writing by the Engineer.

4.03.10 PROGRESS OF WORK. The Contractor shall furnish and operate sufficient equipment, produce or purchase and make timely delivery of materials and organize his work so that his progress will be equivalent to at least five (5) kilometers per day of completed roadway for all classes of bituminous surface treatment. Work shall be commenced where the Engineer directs.

4.03.11 PROTECTION OF FACILITIES. All bridge handrails, curbs, road signs or other facilities shall be protected from splashing of the bituminous material. The Contractor shall immediately remove bituminous material from said facilities. Protection and cleaning shall be accomplished at the Contractor's cost.

4.03.12 QUALITY ASSURANCE PROCEDURES. Bituminous Surface Treatments shall be accepted by lot. Unless otherwise stated in the Special Specifications, the lot size shall be five thousand (5,000) square meters for each treatment constructed. The surface treatments shall be sampled, tested, and evaluated in accordance with Subsection 1.08.4, "Measured or Tested Conformance," in these General Specifications. The Engineer may, during the beginning of placement of surface treatments, at times when test results indicate erratic treatment characteristics and at any other time, reduce the lot size to sections of surface treatment with similar quality characteristics. This should facilitate the isolation and modification or replacement of low-quality materials with materials of acceptable quality to maintain the overall strength of the pavement structure.

The Engineer shall perform or supervise the performance of all quality assurance sampling and testing. The location of all samples and tests shall be recorded by roadway, lane and centerline station (kilometer). Quality assurance sampling and testing for each lot shall include:

1. Rate of application of bituminous material.
2. Bituminous material.
3. Aggregate gradation.

4.03.12.1 Rate of Application of Bituminous Material. The Contractor shall furnish test pads for the purpose of determining the uniformity and rate of application of bituminous material at locations selected by the Engineer. The test pads shall consist of three (3) pieces of building paper each thirty (30) centimeters by sixty (60) centimeters attached to plywood strips sixty (60) centimeters by ninety (90) centimeters by one and one-quarter (1.25) centimeters, or other materials as may be approved by the Engineer. The building paper shall be weighed accurately before being attached to the plywood strips.

The sixty (60) centimeter by ninety (90) centimeter plywood strips and building paper shall be placed at three (3) randomly selected roadway locations for each five thousand (5,000) square meter lot of surface treatment to be placed. The distributor shall apply bituminous material to the test pads during routine operations. Placement of screenings shall proceed as specified.

After collecting the bituminous material, the building paper shall be carefully removed from the plywood strips and weighed. The rate of application on each thirty (30) centimeter by sixty (60) centimeter test pad shall be within ninety and one hundred ten percent (90 and 110%) of the approved rate. If the rate is outside these limits, the work shall be stopped and the distributor adjusted to provide for the specified rates within said tolerances.

Any gaps left in the bituminous material application on the treated surface of the roadway shall be repaired by hand using the same type and grade of bituminous material.

4.03.12.2 Bituminous Material. Bituminous Materials utilized in bituminous surface treatment construction shall be sampled and tested in accordance with the provisions of Subsection 4.01.4, "Acceptance Procedures for Bituminous Materials," in these General Specifications.

4.03.12.3 Aggregate Gradation. Five aggregate gradation samples shall be taken from the spreader discharge at random intervals during the construction of each five thousand (5,000) square meter lot. The sample size shall not be less than twenty-five (25) kilograms of aggregate chips or screenings. The sample shall be tested immediately and the results reported to the Engineer.

4.03.12.4 Acceptance. Bituminous materials will be accepted under Subsection 1.08.3, "Certification of Compliance," in accordance with Subsection 4.01.4, "Acceptance Procedures for Bituminous Materials," in these General Specifications.

Bituminous surface treatment construction will be accepted under Subsection 1.08.4, "Measured or Tested Conformance," in these General Specifications.

Bituminous surface treatment rate of application of bituminous material and aggregate gradation will be accepted under Subsection 1.08.4, "Measured or Tested Conformance," in these General Specifications.

4.03.13 MEASUREMENT. Each type of bituminous seal coat or bituminous surface treatment specified and completed within the lines shown on the plans or ordered by the Engineer shall be measured in square meters. Seal coat or surface treatment placed outside authorized limits shall not be measured.

Prime coat, when applied, shall be considered as subsidiary to constructing single and double surface treatment and shall not be measured separately.

Precoating aggregates shall be measured by square meter and include the areas where the aggregates were acceptably precoated with asphalt cement and incorporated into the bituminous surface treatment when precoating is required by the Special Specifications and listed in the Bill of Quantities.

Mineral fillers, chemical admixtures and asphalt modifiers used by the contractor to meet the Job Mix Formula (JMF) requirements will be considered subsidiary to the construction of the bituminous seal coats and surface treatments and will not be measured separately unless specifically stated in the Special Specifications and listed in the Bill of Quantities. When they are listed in the Bill of Quantities and specified in the Special Specifications they shall be measured in liters, kilograms, or tons in accordance with Subsection 4.05.10 "Measurement" in these General Specifications.

Bituminous wearing course material furnished and placed for reshaping the roadway cross section as shown on the plans, specified or directed by the Engineer shall be measured in cubic meters in accordance with the methods described in Section 4.05, "Bituminous Concrete Pavement," in these General Specifications.

4.03.14 PAYMENT. Bituminous seal coat and bituminous surface treatment of each class completed as specified and measured shall be paid for at the contract unit price, or adjusted contract unit price, per square meter for each item listed in the Bill of Quantities.

Precoated aggregate shall be paid for at the contract unit price for each type bituminous treatment per square meter where precoating is required by the Special Specifications listed in the Bill of Quantities and measured as detailed in Section 4.03.13, "Measurement," in these General Specifications.

When a lot of bituminous surface treatment is accepted with a deficiency, the adjusted contract unit price for said lot shall be the product of the contract unit price and the lowest calculated quality and quantity pay factors specified in Subsection 4.03.11, "Quality Assurance Procedures," in these General Specifications.

Mineral fillers, chemical admixtures, and asphalt modifiers used by the contractor to meet the Job Mix Formula requirements shall be considered subsidiary to the construction of bituminous seal coats and surface treatments and shall not be paid for separately unless specifically stated in the Special Specifications and listed in the Bill of Quantities. When they are listed in the Bill of Quantities and specified in the Special Specifications they shall be paid for as provided in Subsection 4.05.11 "Payment" in these General Specifications.

No separate payment shall be allowed for adding bituminous material or aggregate screenings, for correcting defects or for maintaining the surface.

Payment for traffic control shall be in accordance with Section 9.02, "Traffic Control through Work Zones," in these General Specifications.

No separate payment shall be allowed for rolling.

No separate payment shall be allowed for furnishing and weighing test pads.

Prices and payment made under this section shall cover and be full compensation for furnishing labor, equipment, materials, tools and incidentals for completing the work as in Subsection 1.07.2, "Scope of Payment," in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO.	PAY ITEM	PAY UNIT
40301	Bituminous Seal Coat	Liter
4030101	Bituminous Seal Coat, CM-B	Liter
4030102	Bituminous Seal Coat, CM-C	Liter
40302	Single Bituminous Surface Treatment	Square Meter
4030201	Single Bituminous Surface Treatment, CM-A	Square Meter
4030202	Single Bituminous Surface Treatment, CM-A-1	Square Meter
40303	Double Bituminous Surface Treatment	Square Meter
4030301	Double Bituminous Surface Treatment, Class A, Grading I	Square Meter
4030302	Double Bituminous Surface Treatment, Class A, Grading IV	Square Meter
4030303	Double Bituminous Surface Treatment, Class B, Grading I	Square Meter
4030304	Double Bituminous Surface Treatment, Class B, Grading IV	Square Meter
40304	Precoating Aggregates	Square Meter

SECTION 4.04 - BITUMINOUS EMULSION TREATED BASES

4.04.1 DESCRIPTION. This work consists of furnishing and cold-mixing aggregate and emulsified bituminous material, hauling, spreading, compacting and finishing the bituminous emulsion treated base to the lines, grades and thickness shown on the plans, all in accordance with the specifications and as directed by the Engineer.

BITUMINOUS EMULSION TREATED BASE ITEMS IN BILL OF QUANTITIES:
Bituminous Emulsion Base Course
Type I Bituminous Emulsion Open-Graded Base Course
Type II Bituminous Emulsion Dense-Graded Base Course
Type III Bituminous Emulsion Sand Base Course

Type I bituminous emulsion treated base mixtures shall be produced at ambient temperatures only by central-mixing in a continuous mixing pugmill. Types II and III bituminous emulsion treated base mixtures shall be produced at ambient temperatures by central-mixing in a continuous mixing pugmill or screenless batch plant or by road-mixing using a travel plant at the option of the Contractor.

4.04.2 MATERIALS.

4.04.2.1 Bituminous Emulsion Material. Bituminous emulsion material for bituminous emulsion treated base shall consist of MS-2, MS-2h, CMS-2, CMS-2h, SS-1, SS-1h, CSS-1 or CSS-1h conforming to the requirements of Tables 4.01-4 and 4.01-5 in Section 4.01, "Bituminous Materials," in these General Specifications.

The type and grade of bituminous emulsion shall be specified in the Special Specifications.

4.04.2.2 Aggregate. All aggregate shall be hard durable particles or fragments of crushed stone, crushed slag, crushed gravel or sand free from decomposed materials, organic materials and other deleterious substances. The aggregate shall not contain more than one percent (1.0%) by weight of particles having a specific gravity below 1.95. Aggregate for Open-Graded Base retained on the 4.75 millimeter (No. 4) sieve shall not have more than one-tenth of one percent (0.1%) adherent material by washing.

Unless otherwise specified in the Special Specifications, the aggregate for Types I, II and III bituminous emulsion treated base, prior to the addition of bituminous emulsion material, shall conform to the following gradation and quality requirements:

AGGREGATE GRADING REQUIREMENTS - MRDTM 419

Sieve Size	Type I Open-Graded Base	Type II Dense-Graded Base	Type III Sand Base
37.5 mm (1 1/2 inch)	100	100	
25 mm (1 inch)	95-100	90-100	
12.5 mm (1/2 inch)	25-60	60-80	100
4.75 mm (No. 4)	0-10	25-60	75-100
2.36 mm (No. 8)	0-5	15-45	
0.300 mm (No. 50)	-	3-18	15-30
0.075 mm (No. 200)	0-2	1-7	5-12
Bituminous Emulsion Material Content - Percent	4.5-7.5	6.0-12.0	6.0-12.0

QUALITY REQUIREMENTS

Sand Equivalent MRDTM 313 - Percent, Min.	-	40	30
Stripping Loss MRDTM 413 - Percent, Max.	10	10	10
Abrasion Loss MRDTM - Percent, Max.	40	40	-
Percent Fracture - Min. 2 Face	75	75	-

Percent fracture shall be determined for the material retained on the 2.36 millimeter (No. 8) sieve. The fractured faces shall have a minimum dimension from edge to edge across each fractured face which is not less than one-third (1/3) the maximum dimension of the aggregate particle.

4.04.2.3 Choke Stone for Open-Graded Emulsion Base. Choke stone shall be clean sand, fine material remaining from production of the aggregate for open-graded emulsion base, or other fine material conforming to the following gradation:

Sieve Size	Percentage Passing
9.5 mm (3/8 inch)	100
4.75 mm (No. 4)	85-100
0.300 mm (No. 50)	15-45
0.075 mm (No. 200)	0-4

4.04.2.4 Portland Cement. Portland cement shall be Type I or II conforming to the requirements specified in Section 5.01, "Portland Cement Concrete," in these General Specifications.

4.04.2.5 Water. Water shall be free of matter deleterious to the quality of the bituminous emulsion treated mixture.

4.04.3 PROPORTIONING BITUMINOUS EMULSION TREATED BASE MIXTURES.

4.04.3.1 Job Mix Design Proposal. A proposed Job Mix Formula (JMF) shall be formulated by the Contractor and submitted to the Engineer for approval. The JMF shall be prepared by the Contractor in precise compliance with procedures and requirements set forth in the MRD Manual of Materials and Tests and all current circular letters issued by the Ministry of Communications.

The Contractor shall also use the Basic Asphalt Emulsion Manual," MS-19, published by the Asphalt Institute, Lexington, Kentucky, USA.

1. Type I Bituminous Emulsion Treated Base. Chapter XII Procedural Outline and Design Criteria for the Asphalt Institute Design Method for Open-Graded Mixes.

2. Types II and III Bituminous Emulsion Treated Base. Chapter XIV Marshall Method for Emulsified Asphalt-Aggregate Cold Mixture Design or, Chapter XI Modified Hveem Mix Design.

The Contractor shall select his sources of aggregate and bituminous emulsion material and, after sufficient quantities have been stockpiled or are available for use, obtain representative samples of the materials and test to determine if they conform to the requirements of these specifications.

The Contractor shall perform all testing required to establish the proportions of each material to be combined to produce the specified base (JMF).

The Contractor shall submit the Job Formula Mix (JMF) with the following information:

1. Pertinent data on the source of aggregate and test data on the fracture, gradation and other quality treatments shown in Paragraph 4.04.2.2, "Aggregate," in these General Specifications.

2. The type and grade of emulsified bituminous material to be used.

3. All laboratory trial mix test results.

4. The bituminous material content, based on total dry weight mixture. The quantity of bituminous emulsion material to be added to the mixture, based on total dry weight of material, shall be computed from the required bituminous material content and the quantity of water in the bituminous emulsion material at the time it is removed from the storage tank.

5. The percentage of Portland cement, when required, by total dry weight of mixture.

6. The percentage of additional mixing water, based on total dry weight of mixture.

7. The percentage of total fluids (bituminous material and water) at compaction, based on the total dry weight of mixture.

8. The theoretical maximum density based on ASTM D 2041 for fully cured moisture free mixtures.

9. The type and location of each plant to be used for mixing each mix to be furnished.

10. The beginning date for producing bituminous emulsion treated base mixtures.

The Engineer shall be provided access to the materials sampling and testing operations at all times.

At the same time that the above information is provided, the Contractor shall supply to the Engineer one hundred (100) kilogram samples of each individual aggregate size, eight (8) liters of bituminous material and, when used, sufficient quantities of mineral filler and chemical admixture to complete two (2) mix design checks, all representing the materials which the Contractor proposes to furnish.

4.04.3.2 Acceptance of Job Mix Formula. The Engineer shall review the JMF to determine that it contains all required information. If it does not contain all required information, it shall be returned within seven (7) days to the Contractor for further action and resubmission by the Contractor.

If the proposed JMF contains all required information but fails to meet all of the requirements specified, it shall not be accepted by the Engineer and will be returned to the Contractor within fourteen (14) days. The Contractor shall prepare and submit to the Engineer a new JMF conforming to the requirements specified and propose a new date for beginning production of the bituminous mixtures.

When the Engineer is satisfied that JMF proposed by the Contractor conforms to all the requirements of the specifications, he shall order the Contractor to construct a two hundred (200) meter long field control strip of bituminous emulsion treated base. The Engineer shall evaluate the control strip as to its constructibility and the mix for conformance to the laboratory tested JMF within the tolerances contained in Paragraph 4.04.6.1, "Contractor Process Quality Control," in these General Specifications. Split samples of the cold bituminous mix and component raw materials along with the project laboratory test results are to be sent to the Materials and Research Department Central Laboratory for a one point check and documentation purposes. If the Engineer is not satisfied with the control strip results, he shall state his objections in writing and request a revised JMF and new control strip. The control strip may only be kept in place if the results are satisfactory.

When the Engineer is satisfied that the JMF proposed by the Contractor conforms to all requirements of the specifications and the control strip results are acceptable, he will issue written acceptance to the Contractor to begin producing the mixes proposed.

Production of bituminous concrete mixtures shall not begin until the Engineer has given written acceptance of the Job Mix Formula.

Acceptance of the JMF by the Engineer does not relieve the Contractor of his obligation to produce bituminous concrete mixtures conforming to all specified requirements.

4.04.3.3 Job Mix Formula Revisions. The Contractor shall not alter his methods of crushing, screening, blending, or stockpiling from that used to produce materials for the approved JMF. Changes to the JMF will not be permitted without retesting and resubmission of a proposed (revised) JMF in accordance with all the steps in Paragraph 4.04.3.1, "Job Mix Design Proposal," in these General Specifications. Significant changes may include, but not be limited to, changes in the amount of type of materials rejected or wasted, changes in the amount of materials crushed, reductions in the amount of crushed fines, changes in the amount and type of mineral filler and mineral and chemical admixtures to be used.

Should the Contractor change his source of supply of aggregate and grade of bituminous material, he shall furnish a new information and samples of materials, as described in Paragraph 4.04.3.1, "Job Mix Design Proposal," in these General Specifications as determined by the Engineer to be necessary, at least twenty-one (21) days before their intended use.

At any time after the JMF is approved the Contractor may submit a new JMF for approval by the Engineer. If the revised JMF is approved it shall become the approved JMF.

4.04.4 EQUIPMENT. The Contractor shall supply the proper type and sufficient numbers of equipment to complete the work within the Contract time and in accordance with his Program of Work as approved by the Engineer. The equipment shall also conform to the following specific requirements:

1. Travel mixing plant shall not be used to produce open-graded base mixtures.

2. Water, when added to the mixture, shall be introduced into the mix by pumping through a volumetric rate meter, registering in liters per minute, which will accurately measure the flow of water. The flow of water shall be interlocked with the flow of aggregate, bituminous emulsion material and additives, if required.

3. Portland cement, when added to the mixture, shall be introduced into the mixture through a positive auger or belt feeder.

4. When batch plants are used for producing bituminous emulsion treated base, all screens except an oversize scalping screen shall be removed.

5. Cold-feed proportioning controls shall be used.

4.04.5 WEATHER LIMITATIONS. Bituminous emulsion treated mixtures shall not be placed on any wet or frozen surface, during dust or sand storms, or when the air temperature is less than fifteen degrees Celsius (15° C.).

4.04.6 CONSTRUCTION.

4.04.6.1 Contractor Process Quality Control. Testing to control the quality of bituminous emulsion treated base mixtures shall be the responsibility of the Contractor. Copies of all test results shall be forwarded to the Engineer at the end of each working day. The Engineer reserves the right to obtain samples of the materials at any point during the production operations for his own use.

The Contractor shall perform the following minimum testing for each type of bituminous emulsion treated base produced and each day's production.

1. Two (2) samples of combined aggregate shall be obtained from the bin discharge gate at random times during the day just prior to the addition of bituminous emulsion material and the combined aggregate tested for gradation.

2. Two (2) samples of the bituminous emulsion treated materials shall be obtained from hauling vehicles, and the water and bituminous material contents determined by oven drying and extraction testing.

Extracted aggregate shall be tested for gradation. The bituminous material content as extracted from the mixture shall conform to the requirement in the approved JMF within plus or minus four-tenths (□0.4) percentage points.

The combined aggregate, including Portland cement and other mineral additives, shall conform to the approved JMF grading within the following tolerances:

9.75 mm (3/8") and larger sieves,	± 8 percentage points
4.75 mm (No. 4) sieve,	± 7 percentage points
2.36 mm (No. 8) sieve and No. 50 sieves,	± 6 percentage points
0.300 mm (No. 50) sieve	± 4 percentage points
0.075 mm (No. 200) sieve,	± 2 percentage points

4.04.6.2 Preparation of Bituminous Emulsion Material. Bituminous emulsion material shall be stored at temperatures within the following ranges:

SS-1, SS-1h, CSS-1, CSS-1h	Minimum = 10 degrees Celsius Maximum = 60 degrees Celsius
MS-2, MS-2h, CMS-2, CMS-2h	Minimum = 50 degrees Celsius Maximum = 85 degrees Celsius

The bituminous emulsion materials shall be protected from freezing and periodically rolled or circulated to maintain uniformity. Forced air shall not be used for agitation.

4.04.6.3 Preparation of Aggregate. Aggregate shall be stockpiled and removed from stockpiles as required in Section 3.01, "Production, Handling and Stockpiling Aggregates," in these General Specifications.

4.04.6.4 Type I, Type II and Type III Bituminous Emulsion Treated Bases. Type I, Type II and Type III Bituminous Emulsion Treated Bases may be produced at centrally located mixing plant. Aggregate, bituminous emulsion material, added water, Portland cement and other additives, when required, may be proportioned by weight or by volume.

The aggregate shall be fed from storage to the mixing chamber using a belt feeder equipped with devices by which the rate of aggregate feed can be determined while the plant is in full operation. Aggregate feed and the bituminous emulsion material metering pump shall be mechanically or electrically interlocked in a manner that maintains a constant ratio of aggregate and bituminous emulsion material.

Portland cement, when required, shall be introduced into the aggregate on the belt feeder.

Mixing water, when required, shall be introduced into the aggregate through a spray bar mounted at such a point that the water is added as the aggregate enters into the mixing chamber.

The bituminous emulsion material shall be introduced into the mixing chamber through a spray bar that can be adjusted to vary mixing times between five (5) and thirty (30) seconds.

The aggregate, water and Portland cement as required, and bituminous emulsion material shall be mixed until the aggregate has been coated and a uniform and homogeneous mixture has been obtained.

Type I open-grade bituminous emulsion treated base shall be discharged directly into hauling equipment or stored in bins or silos. Type I open-graded bituminous emulsion treated base shall not be stored on the ground.

Type II and Type III bituminous emulsion treated base may be discharged directly into hauling equipment or stored. Type II and Type III base shall not be stored for periods longer than forty-eight (48) hours without prior written approval from the Engineer.

4.04.6.5 Type II and Type III bituminous emulsion treated base may be mixed on the roadway using self-propelled travel mixing plant. Travel mixing plant may be of three types:

1. A plant that moves along an appropriately sized aggregate windrow on the roadbed, picking up the aggregate in the windrow, adding and mixing bituminous emulsion material and discharging the completed mixture at the rear.

2. A plant that receives aggregate into its hopper from hauling equipment as it moves forward along the roadbed, adding and mixing bituminous emulsion material and discharging the completed mixture at the rear. The aggregate may be delivered into the hopper directly from hauling equipment or by pickup equipment from aggregate deposited into a windrow by hauling equipment.

3. A rotary type mixing plant that moves along the roadbed adding bituminous emulsion material to aggregate situated in-place on the roadbed and mixing the materials. The bituminous emulsion material may be added through a spray bar located inside the rotary mixing chamber, or spread on the aggregate immediately in advance of mixing.

Rotary mixers may be used to cut into and scarify the in-place aggregate, either old bituminous concrete pavement or new aggregate, without introduction of bituminous emulsion material. Bituminous emulsion material shall be delivered to the mixing plant from hauling equipment traveling adjacent to the mixing plant.

The travel plant shall be capable of producing a uniform, properly coated, bituminous emulsion material-aggregate mixture conforming to the requirements of the JMF. Bituminous emulsion material and aggregate proportioning devices shall be keyed to the rate of forward travel of the mixer, or interlocked to ensure a constant bituminous emulsion material-aggregate blend.

Multiple passes of the travel plant may be required for higher bituminous emulsion material contents to achieve required uniformity of mix.

4.04.6.6 Spreading and Compacting. The surface to receive bituminous emulsion treated base shall conform to the compaction and other requirements for the material involved.

When the surface to receive the bituminous emulsion treated base does not conform to compaction and other requirements for the material involved, the Contractor, at his own expense, shall correct all deviations.

When the surface to receive bituminous emulsion treated base is a soil subgrade, aggregate subbase or aggregate base, and the total thickness of the bituminous emulsion treated base and surface course is less than ten (10) centimeters, the surface shall receive a prime coat in accordance with the requirements specified in Section 4.02, "Bituminous Prime and Tack Coat," in these General Specifications. The prime coat shall be allowed to cure for at least forty-eight (48) hours before placement of bituminous emulsion treated base.

Type I open-graded bituminous emulsion treated base shall be spread using a self-propelled paving machine. The maximum thickness of one lift shall not exceed ten (10) centimeters. Immediately after spreading, each lift shall be compacted with one coverage of a steel-drum tandem roller weighing not less than ten thousand (10,000) kilograms. After the initial coverage, choke stone shall be uniformly spread across the surface of the open-grade base at a rate between seven (7) and thirteen (13) kilograms per square meter using a self-propelled spreading device conforming to the requirements specified in Section 4.02, "Bituminous Prime and Tack Coat," in these General Specifications immediately after spreading choke stone, the open-graded base shall receive three additional coverages with a steel-drum tandem roller weighing not less than ten thousand (10,000) kilograms. After completion of compaction, surplus choke stone shall be removed by sweeping. Each lift of open-graded base shall be

allowed to cure for a period not less than seventy-two (72) hours before spreading successive lifts.

Type II and Type III bituminous emulsion treated base may be spread using a self-propelled paving machine, aggregate base spreader or other device which results in a base that is smooth, has a uniform texture, conforms to planned and specified thickness and is within the lines and grade shown on the plans. The maximum thickness of one lift shall not exceed ten (10) centimeters unless otherwise approved by the Engineer. Lift thicknesses greater than ten (10) centimeters may be approved by the Engineer when sufficient Portland cement has been added to the mixture to accelerate curing and the Contractor demonstrates that curing is effective.

Each lift shall be compacted using a steel-drum tandem roller weighing not less than ten thousand (10,000) kilograms until the relative compaction of each lot of bituminous emulsion treated base as described in Subsection 4.04.8, "Quality Assurance Procedures," in these General Specifications is between ninety-one percent (91%) and ninety-four percent (94%) of the theoretical maximum density determined from ASTM D 2041.

Each lift of Type II and Type III bituminous emulsion base shall be allowed to cure for the period specified in the Special Specifications, or for three (3) to five (5) days, or, when Portland cement has been added to the mixture, for such shorter period as approved by the Engineer.

4.04.6.7 Finishing. When shown on the plans, or specified in the Special Specifications, Type I, Type II and Type III bituminous emulsion treated base courses shall be sealed with a Class C, Medium Fine, surface treatment conforming to the requirements specified in Section 4.03, "Bituminous Surface Treatment," in these General Specifications.

4.04.7 TRAFFIC CONTROL. Traffic control shall conform to the requirements specified for traffic control in Section 9.02, "Traffic Control through Work Zones," in these General Specifications.

4.04.8 QUALITY ASSURANCE PROCEDURES. The bituminous emulsion treated base shall be accepted by lot. Unless otherwise stated in the Special Specifications, the lot size shall be ten thousand (10,000) square meters for each layer constructed. The bituminous emulsion treated base shall be sampled, tested, and evaluated in accordance with Section 1.08, "Acceptance of Work," in these General Specifications. The Engineer may, during the beginning of placement of bituminous emulsion treated base, at times when test results indicate erratic characteristics, and at any other time, reduce the lot size to sections of bituminous emulsion treated base with similar quality characteristics. This should facilitate the isolation and modification or replacement of low-quality materials with materials of acceptable quality to maintain the overall strength of the pavement structure.

The Engineer shall perform or supervise the performance of all quality assurance sampling and testing. The location of all samples and tests shall be recorded by roadway, lane and centerline station (kilometer). Quality assurance sampling and testing for each lot shall include:

1. Compaction
2. Thickness
3. Aggregate Gradation and Bituminous Material Content
4. Surface Smoothness

4.04.8.1 Compaction. The specified range of acceptable compaction is between 91 and 94 percent. The bituminous emulsion treated base course compaction will be sampled, tested and evaluated as detailed in Paragraph 4.05.8.1, "Compaction," in these General Specifications.

Type I base may be accepted without density testing when the specified equipment and operating procedures are verified and documented as being utilized.

4.04.8.2 Thickness. A lot shall be accepted when the average thickness is not less than the planned thickness. The bituminous emulsion treated base course thickness will be sampled, tested and evaluated as detailed in Paragraph 4.05.8.2, "Thickness," in these General Specifications.

The Contractor shall backfill density and thickness test holes with bituminous emulsion treated base or other material approved by the Engineer.

4.04.8.3 Aggregate Gradation and Bituminous Material Content. The upper and lower specification units are the approved job-mix target values plus or minus the allowable deviations shown in Paragraph 4.04.6.1, "Contractor Process Quantity Control," in these General Specifications.

The bituminous material content of the bituminous emulsion treated base shall be determined by extraction from five (5) randomly selected sample per lot taken from the road after all mixing is complete and prior to compaction. The average bituminous material content shall not vary from the approved job mix content by more than plus or minus five-tenths percent (±0.5%). When the bituminous material content varies by more than plus or minus five-tenths percent (±0.5%) the lot shall be removed, remixed with other materials added as necessary and/or replaced with other materials approved by the Engineer.

4.04.8.4 Surface Smoothness. When a straightedge four (4) meters in length is laid on the finished surface of the base parallel with the centerline, the surface shall have no depressions greater than three (3) millimeters from the lower edge of the straightedge. When the straightedge is laid transverse to the centerline, the surface shall have no depressions greater than six (6) millimeters from the lower edge of the straightedge.

4.04.8.5 Acceptance. Bituminous materials will be accepted under Subsection 1.08.3, "Certification of Compliance," in accordance with Subsection 4.01.4, "Acceptance Procedures for Bituminous Materials," in these General Specifications.

Bituminous emulsion treated base construction including surface smoothness and bituminous material content will be accepted under Subsection 1.08.4, "Measured or Tested Conformance," in these General Specifications.

Bituminous emulsion treated base compaction, thickness and aggregate gradation, will be accepted under Subsection 1.08.5, "Statistical Evaluation of Work for Acceptance and Determination of Pay Factor (Value of Work)," in these General Specifications in two (2) stages as follows:

The first stage shall be the selection of the lowest of the two (2) pay factors for the quality of the bituminous emulsion treated base relating to aggregate gradation and density. The second stage involves the selection and application of a quantity pay factor based on the thickness of the bituminous emulsion treated base. The reduced thickness pay factor for the lower courses of multiple course pavements will initially be applied provisionally based on the results of the depths of the cores taken from the lower courses. Additional cores will be taken of the total depth of all bituminous courses within the lot represented by lower course reduced thickness pay factors. If the total thickness cores show that the increased upper level course thickness has resulted in total thickness acceptability, the lower level courses reduced thickness pay factor will be adjusted accordingly. The second stage thickness quantity pay factor will be applied to all the individual course lots in addition to the first stage lowest quality pay factor as determined in accordance with Subsection 1.08.5, "Statistical Evaluation of Work for Acceptance and Determination of Pay Factor (Value of Work)," in these General Specifications.

4.04.9 MEASUREMENT. Each Type bituminous emulsion treated base shall be measured by the cubic meter, as placed and compacted to the planned and specified thickness and within the lines and grades shown on the plans, as specified or directed by the Engineer. No measurement will be made for material placed outside authorized limits.

Mineral fillers, chemical admixtures and asphalt modifiers used by the contractor to meet the Job Mix Formula (JMF) requirements will be considered subsidiary to the construction of the bituminous emulsion base course and will not be measured separately unless specifically stated in the Special Specifications and listed in the Bill of Quantities. When they are listed in the Bill of Quantities and specified in the Special Specifications they shall be measured in liters, kilograms, or tons in accordance with Subsection 4.05.10 "Measurement" in these General Specifications.

Surface treatment shall be measured in square meters as specified in Section 4.02, "Bituminous Prime and Tack Coat," in these General Specifications.

Choke stone will be considered subsidiary to the construction of bituminous emulsion treated base and will not be measured.

4.04.10 PAYMENT. Payment shall be made at the contract unit price, or adjusted contract unit price, per cubic meter for each Type bituminous emulsion treated base measured and calculated as described above for the pay items listed below that are shown in the Bill of Quantities.

When a lot of bituminous emulsion treated base is accepted with a deficiency, the adjusted contract unit price for said lot shall be the product of the contract unit price and

the lowest quality and quantity pay factors specified in Subsection 3.04.8, "Quality Assurance Procedures," in these General Specifications.

Surface treatment shall be paid for at the contract unit price per cubic meter as measured and listed in the Bill of Quantities.

Mineral fillers, chemical admixtures, and asphalt modifiers used by the contractor to meet the Job Mix Formula requirements will be considered subsidiary to the construction of bituminous emulsion base course and shall not be paid for separately unless specifically stated in the Special Specifications and listed in the Bill of Quantities. When they are listed in the Bill of Quantities and specified in the Special Specifications they shall be paid for as provided in Subsection 4.05.11 "Payment" in these General Specifications.

Choke stone shall be considered subsidiary to the construction of Type I Bituminous Emulsion Open-Grade Base and separate payment shall not be made.

Such prices and payment shall cover and be compensation for furnishing labor, materials, equipment, tools and incidentals necessary for completing the work as specified in Subsection 1.07.2, "Scope of Payment," in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
40401	Bituminous Emulsion Base Course	Cubic Meter
4040101	Bituminous Emulsion Open Graded Base Course, Type I	Cubic Meter
4040102	Bituminous Emulsion Dense Graded Base Course, Type II	Cubic Meter
4040103	Bituminous Emulsion Sand Base Course, Type III	Cubic Meter

SECTION 4.05 - BITUMINOUS CONCRETE PAVEMENT

4.05.1 DESCRIPTION. This work shall consist of furnishing and mixing aggregate and bituminous material in a central mixing plant, hauling, spreading and compacting the mixture on a prepared surface, in one or more base, leveling or wearing courses, all as shown on the plans, specified in these General Specifications and the Special Specifications and as directed by the Engineer.

Bituminous concrete base course shall be undesignated or designated as Bituminous Grading I, Grading II or Grading III, and consist of either thirty-two (32) millimeters (1 1/4inch), twenty-two (22) millimeters (7/8 inch) or nineteen (19) millimeters (3/4 inch) nominal maximum size aggregate.

Bituminous concrete wearing course shall be undesignated or designated as Grading I, Grading II or Grading III, and consist of either sixteen (16) millimeters (5/8inch), twelve and one-half (12.5) millimeters (1/2 inch) or nine and one-half (9.5) millimeters (3/8 inch) nominal maximum size aggregate.

The grading and maximum size aggregate for bituminous concrete base course or bituminous concrete wearing course will be shown on the plans or specified in the Special Specifications. When bituminous concrete leveling course is shown on the plans, specified in the Special Specifications or listed in the Bill of Quantities, bituminous concrete wearing course of the same class and maximum size aggregate shall be furnished.

Bituminous concrete mixtures shall be produced in batch, continuous pugmill or dryer-drum mixing plant. Proportioning may be by hot or cold feed control at the option of the Contractor.

ITEMS IN THE BILL OF QUANTITIES
Bituminous Concrete Base Course
Bituminous Concrete Leveling Course
Bituminous Concrete Wearing Course
Asphalt Cement
Modified Asphalt Cement
Mineral Filler
Chemical Admixture/Asphalt Modifier
Minor Bituminous Concrete

4.05.2 MATERIALS.

4.05.2.1 Bituminous Material. Bituminous material for bituminous concrete pavement shall be a penetration or viscosity grade conforming to the requirements in Table 4.01-1, Section 4.01, "Bituminous Materials," in these General Specifications. The penetration or viscosity grade to be used shall be specified in the Special Specifications.

When penetration grade asphalt 60/70 is used, the optimum ratio between bituminous material and filler shall be so determined that the bituminous material-filler mixture will reach its softening point within the temperature range of 75-90 degrees C, when tested in accordance with MRDTM 406 (Circular No. 2401, paragraphs 3 and 6, as amended). In particular, the softening point shall be not less than 85 degrees C for heavy traffic and not less than 75 degrees C for medium or low traffic. The foregoing requirements shall be relaxed by 10 degrees C, respectively, when penetration grade asphalt 40/50 is used.

4.05.2.2 Aggregate. All aggregate shall be hard durable particles or fragments free from decomposed materials, organic materials and other deleterious substances. The aggregate shall not contain more than one percent (1.0%) by weight particles having a specific gravity below 1.95.

Coarse aggregate shall be crushed stone, crushed slag or crushed gravel retained on a 4.75 millimeter (No. 4) sieve and containing no more than ten percent (10%) thin or elongated particles which have a maximum dimension more than five (5) times the minimum dimension as determined in accordance with ASTM D 4791 Standard Test Method for Flat or Elongated Pieces.

Fine aggregate shall be material passing the 4.75 millimeter (No. 4) sieve and may be produced from crushed stone, crushed slag or crushed gravel or manufactured sand. Natural sand may not be used without the prior written approval of the Engineer. If approved, the quantity of natural sand in the aggregate shall not exceed fifteen percent (15%) of the weight passing the 4.75 millimeter (No. 4) sieve and the quantity of dune sand included shall not be more than fifty percent (50%) of the weight of natural sand authorized by the Engineer. Particular attention shall be paid to the proper control of aggregate and especially to that of natural sand. The daily timetable of the plant operations and the test results of aggregate production shall be diligently kept and updated on the Work by the Contractor. Should the Contractor fail to comply with the foregoing requirements, the Engineer will have authority to suspend the Work wholly or in part, as stipulated in Section 1.03 – "Control of Work" in these General Specifications

Supplemental fine aggregate shall be mineral filler passing the 0.600 mm (No. 30) sieve, including dust from the dust collection system. When furnished as supplemental fine aggregate, mineral filler, at the time of use, shall be dry, free flowing, without lumps or agglomerations and conform to the requirements of AASHTO M-17.

Gravel, to be crushed for use as bituminous concrete aggregate, shall be screened in such a manner that all material to be crushed is retained on a 37.5 millimeter (1 1/2 inch screen). Uncrushed material passing the screen shall be stored separately from the crushed material. Uncrushed aggregates shall not be combined with crushed aggregates.

Unless otherwise specified in the Special Specifications, the combined aggregate, prior to the addition of bituminous material, shall conform to the gradation and quality requirements contained in Table 4.05-1.

The grading limits specified are based on materials of uniform specific gravity and shall be adjusted by the Engineer to compensate for any variations in specific gravity of the individual sizes. The gradings may be varied by the Engineer on the basis of

Marshall Tests to obtain optimum stability and life of the completed Bituminous Concrete Pavement.

Aggregate gradation for heavy traffic must avoid the area defined by the following equation:

$$P = \left(\frac{d}{d\ max}\right)^{0.45} \pm T$$

Where P = Percent passing
d = Sieve opening in mm
d_{max} = The smallest sieve opening which is not allowed to retain any material (max size aggregate)
T = Vertical distance from the 0.45 power curve in %

The values of T are as follows:
For 19 mm nominal size:

d^{mm}	2.36	2.0	1.18	.6	.425	.30
T (%)	±0	±1	±3	±2	±1	±0

For greater than 19 mm nominal size

d^{mm}	4.75	2.36	2.0	1.18	.60	.425	.30
T(%)	±0	±2.0	±2.5	3.0	±2.0	±1.0	±0

TABLE 4.05-1

AGGREGATE GRADING REQUIREMENTS - MRDTM 419

BITUMINOUS BASE COURSE

Sieve Size	GRADING I 32 mm (1 1/4 In) Nominal Maximum	GRADING II 22 mm (7/8 Inch) Nominal Maximum	GRADING III 19 mm (3/4 Inch) Nominal Maximum
7.5 mm (1 1/2 inch)	100		
25 mm (1 inch)	75-90	100	100
19.0 mm (3/4 inch)	65-80	75-90	90-100
12.5 mm (1/2 inch)	55-70	65-80	78-93
9.5 mm (3/8 inch)	45-60	55-65	57-72
4.75 mm (No. 4)	31-46	35-60	43-58
2.00 mm (No. 10)	18-33	20-35	28-43
0.425 mm (No. 40)	5-18	7-20	13-28
0.180 mm (No. 80)	3-13	5-25	-
0.075 mm (No. 200)	2-9	3-7	3-7

BITUMINOUS WEARING COURSE

Sieve Size	GRADING I 16 mm (5/8 Inch) Nominal Maximum	GRADING II 12.5 mm (1/2 In) Nominal Maximum	GRADING III 9.5 mm (3/8 Inch) Nominal Maximum
19.0 mm (3/4 inch)	100	100	
12.5 mm (1/2 inch)	75-90	90-100	100
9.5 mm (3/8 inch)	64-79	78-83	90-100
4.75 mm (No. 4)	41-56	46-60	54-68
2.00 mm (No. 10)	23-37	30-42	32-46
0.425 mm (No. 40)	7-20	14-25	14-25
0.180 mm (No. 80)	5-13	8-16	8-16
0.075 mm (No. 200)	3-8	3-7	3-7

TABLE 4.05-2

QUALITY REQUIREMENTS

	Bituminous Wearing Course			Bituminous Base Course		
	Class A	Class B	Class C	Class A	Class B	Class C
Sodium Sulfate Soundness Loss, MRDTM 311-66 Percent, Max.	10	10	10	10	10	10
Abrasion Loss, MRDTM 309 - Percent, Max.	40	40	40	40	40	40
Clay and Friable Particles, MRDTM 312, Percent Max.	0.25	0.25	0.25	0.25	0.25	0.25
Sand Equivalent, MRDTM 313 - Percent, Min.	45	45	45	45	45	45

1) 75 Blow Marshall, MRDTM 410 -

Stability - Kg. min.	1000	750	500	1000	750	500
Flow - mm	2-4	2-4	2-4	2-4	2-4	2-4
Voids in Mineral Aggregate - Percent, Min.	Varies with Nominal Maximum Size per MS-2*					
Voids in Mix - Percent	4-6	4-6	3-5	5-7	5-7	5-7
Bituminous Material - Percent of Total Weight	4.0-6.0	4.0-6.0	4.0-6.0	3.0-6.0	3.0-6.0	3.0-6.0
Retained Strength - Percent, Min.	75	75	75	70	70	70

* Asphalt Institute Manual MS-2.

QUALITY REQUIREMENTS (Continued)

	Bituminous Wearing Course			Bituminous Base Course		
	Class A	Class B	Class C	Class A	Class B	Class C
2) Hveem, ASTMD 1560 -						
Stabilimeter, Minimum	40	37	35	37	35	33
Voids in Mix - Percent	4-6	4-6	3-5	5-7	5-7	5-7

Filler/Bituminous Material Softening Point	
All Mixtures	- 65 Minimum
Filler/Bituminous Material Ratio	
All Mixtures	- Between 0.5 and 1.5

Aggregate particles retained on the 2.36 mm (No. 8) sieve shall have the following minimum percentage by weight, and have two (2) faces with mechanical fracture:

Class A Base and Wearing Course	-	90 %
Class B Base and Wearing Course	-	65 %
Class C Wearing Course	-	25 %

Each fractured face shall have a minimum dimension from edge to edge across the fractured face which is not less than one-third (1/3) the maximum dimension of the aggregate particle.

4.05.2.3 Mineral Fillers. Mineral fillers shall be either Portland cement, blended hydraulic cement or lime conforming to the following requirements:

Material	Requirement
Portland Cement, Type I or II	ASTM C-150
Blended Hydraulic Cement, Type IP	ASTM C-595
Lime, Type N or S	ASTM C-207

When required, the amount of mineral filler used shall be between one and two percent (1.0 and 2.0%) of the weight of aggregate, with the exact amount to be stated in the Job Mix Formula.

4.05.2.4 Chemical Admixtures and Asphalt Modifiers. The types and amounts of chemical admixtures/asphalt modifiers used shall be limited to those listed in the Special Specifications or proposed by the Contractor and approved by the Ministry's Research and Materials Department to establish compliance with the job mix formula (JMF) requirements contained in Subsection 4.05.3, "Proportioning Bituminous Concrete Mixtures," in these General Specifications.

Should a stripping problem be determined to exist the Contractor shall add an approved antistripping agent to the mixture to meet the quality requirements.

Should the bituminous concrete mixture require improvement of the temperature susceptibility of the asphalt cement or where increased resistance to permanent deformation is required the Contractor shall add an approved polymer material to meet the job mix formula requirements in accordance with the following criteria:

1. The polymer additive shall be a commercially available product, supported by an approved mixing process, that will ensure accurate proportioning of materials and quality control of the modified asphalt cement and of the final bituminous mixture. Candidate products include styrene butadiene rubber (SBR); block copolymers; polyethylene; ethylene vinyl acetate; polypropylene; polychloroprene latex; polychloroprene solids; natural polyisoprene; ethylene propylene-diene-monomer (EDPM); and polyisobutylene.

2. The polymer material shall be fully compatible with the base asphalt cement to ensure uniform blending and shall be so stored as to prevent segregation with time.

3. When so recommended by the additive manufacturer, polymer shall be added to the asphalt mixture in the mixing plant to avoid prolonged hot storage and possible damage of the modified asphalt cement.

4. The increased viscosity of modified binders at high temperatures normally extends into the temperature range in which asphalt concrete is mixed. Therefore, it may be necessary to increase the operating temperature of the mixing plant to achieve adequate coating of aggregates and provide for satisfactory compaction of the mixture. When so recommended by the additive manufacturer, increased mixing temperature requirements shall be diligently observed.

5. An approved extraction process must exist to allow verification of the design quantity of the modified asphalt cement in the mixture. Additives must not interfere with the extraction process.

6. Readily usable, proven test methods must exist to determine the polymer content of the modified asphalt cement, even if the asphalt cement must be first extracted from the aggregate mixture.

7. The aging index of the modified asphalt cement shall not exceed that o f the base asphalt cement, as specified in ASTM D2872.

8. The polymer additive shall be capable of increasing the softening point of the base asphalt cement by at least fifteen degrees Celcius (15 C) without the addition of filler.

9. The polymer additive shall be capable of increasing the permanent deformation resistance and fatigue resistance of the modified bituminous mixture, as compared to that of a similar conventional bituminous mixture, by at least thirty (30) percent; as documented by field tests performed in Kingdom or abroad, by reputable authorities or transportation agencies and under environmental conditions closely resembling those of Saudi Arabia.

All chemical admixtures/asphalt modifiers including anti-stripping additives and polymers shall be thoroughly mixed and uniformly combined with the bituminous material.

4.05.3 PROPORTIONING BITUMINOUS CONCRETE MIXTURES.

4.05.3.1 Job Mix Design Proposal. A proposed Job Mix Formula (JMF) shall be formulated by the Contractor and submitted to the Engineer for approval. The JMF shall be prepared by the Contractor in precise compliance with procedures and requirements set forth in the MRD Manual of Materials and Tests and all current circular letters issued by the Ministry of Communications.

The Contractor shall select his sources of aggregate and bituminous material and, after sufficient quantities have been stockpiled or are available for use, obtain representative samples of the materials and test to determine if they conform to the requirements of these specifications. At least thirty (30) days before producing bituminous concrete mixtures, the Contractor shall submit in writing to the Engineer detailed information for each mix which he proposes to furnish. The information shall include, but not be limited to the following:

1. The source and gradation of the aggregate for each mix to be furnished. If the aggregate (coarse, fine, supplemental fine) is separated into two (2) or more sizes, the information provided shall consist of gradations for all individual sizes, the proportions of each individual size to be used, and the mathematically combined gradation for each mix to be furnished. Such combined gradation shall meet the applicable grading requirements shown in Paragraph 4.05.2.2, "Aggregate," in these General Specifications and show the percentage passing each of the specified sieve sizes.

2. Pertinent test data and a written certification that the aggregates to be furnished conforms to all of the quality requirements shown in Paragraph 4.05.2.2, "Aggregate," in these General Specifications.

3. Pertinent test data on the type and properties of the asphalt cement, modified asphalt cement, mineral filler, and chemical admixtures/asphalt modifiers to be furnished.

4. Marshall test data (based on seventy-five (75) blow compaction) and Hveem test data for each mix to be furnished shall include individual test results for triplicate test specimens prepared for each of at least five (5) different bituminous material contents. The test results shall be submitted in tabular form and plotted on appropriate charts. The information shall include the source and grade of bituminous material to be used

and a recommended bituminous material, mineral and chemical admixture/asphalt modifier content for each mix to be furnished.

5. The type and location of plant to be used for mixing each mix to be furnished.

6. The proposed beginning date for producing bituminous concrete mixtures.

The Engineer shall be provided access to the materials sampling and testing operations at all times.

At the same time that the above information is provided, the Contractor shall supply to the Engineer one hundred (100) kilogram samples of each individual aggregate size, eight (8) liters of bituminous material and, when used, sufficient quantities of the mineral filler and the chemical admixture/asphalt modifier to complete two (2) proposed mix design checks, all representing the materials which the Contractor proposes to furnish.

The final job mix formula shall be made by using hot-bins aggregate. The Contract may develop preliminary job mixes using stockpiled aggregate, to demonstrate their suitability for the intended purpose.

4.05.3.2 Acceptance of Job Mix Formula. The Engineer shall review the JMF to determine that it contains all required information. If it does not contain all required information, it shall be returned within seven (7) days to the Contractor for further action and resubmission by the Contractor.

If the proposed JMF contains all required information but fails to meet all of the requirements specified, it shall not be accepted by the Engineer and will be returned to the Contractor within fourteen (14) days. The Contractor shall prepare and submit to the Engineer a new JMF conforming to the requirements specified and propose a new date for beginning production of the bituminous mixtures.

When the Engineer is satisfied that the JMF proposed by the Contractor conforms to all the requirements of the specifications, he shall order the Contractor to construct a two hundred (200) meter long field control strip. The Engineer shall evaluate the control strip as to its constructability and compactability and the mix for conformance to the laboratory tested JMF within the tolerances listed in Table 4.05-4, "Job Mix Formula Tolerances," in these General Specifications. Split samples of the hot mix and components raw materials along with the field laboratory test results are to be sent to the Materials and Research Departments Central Laboratory for a one point check and documentation. If the Engineer is not satisfied with the results of the control strip, he shall state his objections in writing and request a revised JMF and a new control strip. The control strip may only be left in place if the results are satisfactory.

When the Engineer is satisfied that the JMF proposed by the Contractor conforms to all requirements of the specifications and the control strip results are acceptable, he will issue written acceptance to the Contractor to begin producing the mixes proposed.

Production of bituminous concrete mixtures shall not begin until the Engineer has given written acceptance of the Job Mix Formula.

Acceptance of the JMF by the Engineer does not relieve the Contractor of his obligation to produce bituminous concrete mixtures conforming to all specified requirements.

4.05.3.3 Job Mix Formula Revisions. The Contractor shall not alter his methods of crushing, screening, blending, or stockpiling from that used to produce materials for the approved JMF. Changes to the JMF will not be permitted without retesting and resubmission of a proposed (revised) JMF in accordance with all the steps in Paragraph 4.05.3.1, "Job Mix Design Proposal," in these General Specifications. Significant changes may include, but not be limited to, changes in the amount or type of materials rejected or wasted, changes in the amount of materials crushed, reductions in the amount of crushed fines, changes in the amount and type of mineral filler and mineral and chemical admixtures to be used.

Should the Contractor change his source of supply of aggregate and grade of bituminous material, he shall furnish a new information and samples of materials, as described in Paragraph 4.05.3.1, "Job Mix Design Proposal" as determined by the Engineer to be necessary, at least twenty-one (21) days before their intended use.

At any time after the JMF is approved the Contractor may submit a new JMF for approval by the Engineer. If the revised JMF is approved it shall become the approved JMF.

4.05.4 EQUIPMENT. The Contractor's equipment shall be of sufficient capacity and numbers to complete the paving in a timely manner as outlined in the Contractor's Program of Work as approved by the Engineer.

Equipment shall also conform to the additional requirements outlined in the MCM, Part 4 - Bituminous concrete and Surface Treatments, Section 4.3 - Bituminous Base Courses and Bituminous Wearing Courses, Paragraph B - Construction Equipment.

4.05.5 WEATHER LIMITATIONS. Bituminous concrete pavement shall not be placed on any wet or frozen surface, during dust or sand storms, when wind or other weather conditions prevent the proper handling of the bituminous mixtures or when the average surface temperatures are less than specified in the following table:

TABLE 4.05-3
SURFACE TEMPERATURE LIMITATIONS *
(Degrees Celsius)

Compacted Thickness - cm	Base and Wearing Course	Leveling Courses
Less than 3	25	20
3 to 6	20	15
6.1 to 10	Not applicable	10
More than 10	Not applicable	5

* The surface on which the bituminous mixtures are to be placed.

4.05.6 CONSTRUCTION. Construction requirements for the Work under this section shall be as specified in the MOC HCM, Part 4, Bituminous Concrete and Surface Treatment,, Section 4.3 Bituminous Base Courses and Bituminous Wearing Courses, Paragraph C - Construction Procedures and Paragraph D - Field Inspection.

4.05.6.1 Contractor Process Quality Control. Testing to control the quality of bituminous concrete mixtures produced shall be the responsibility of the Contractor. Copies of all test results shall be forwarded to the Engineer at the end of each working day. The Engineer reserves the right to obtain samples of the materials at any point during the production operations for his own use.

The Contractor shall perform the following minimum testing for each class of bituminous concrete produced and each day's production:

1. Batch-mixing. Two (2) samples of aggregate from each hot bin shall be obtained at random times during the day and tested for gradation. The results of individual sample gradations and combined gradations shall be reported.

2. Continuous Pugmill or Dryer-Drum Mixing. Two (2) samples of aggregate shall be obtained at random times during the day immediately prior to adding bituminous binder and the aggregate tested for gradation.

3. All Plant Types.

(1) One (1) sample of bituminous concrete shall be obtained from the discharge chute or hauling vehicle for bituminous material extraction testing. The bituminous material content shall be reported to one-tenth percent (0.1%) accuracy and the grading determined for the extracted aggregate.

(2) One (1) complete Marshall test, including stability, flow, compacted unit weight and percent voids in mix shall be completed on a sample obtained from the discharge gate or hauling vehicle. The theoretical maximum specific gravity (ASTM D-2041) shall be reported.

When the bituminous material content and aggregate gradation do not conform to the approved JMF within the tolerances specified in Paragraph 4.05.6.4, "Preparation of Bituminous Concrete Mixture," in these General Specifications, plant production shall cease and the plant recalibrated.

4.05.6.2 Preparation of Bituminous Materials. Bituminous materials to be used as binder for bituminous concrete shall be at a temperature not less than one hundred forty-five degrees Celsius (145° C.), nor more than one hundred eighty degrees Celsius (180° C.) when introduced into the mixing plant.

Different grades of bituminous materials shall be stored in separate tanks, transported in separate vehicles, and shall not be mixed without the approval of the Engineer.

When asphalt modifiers are used, their use shall comply with the manufacturer's recommendations as to their preparation, blending and placement.

4.05.6.3 Preparation of Aggregate. Aggregate shall be stored in separate stockpiles a minimum of ten (10) meters apart or separated by walls so that various sizes are not mixed together. Any aggregate which has been mixed together shall be removed and replaced with aggregate of specified grading.

Supplemental fine aggregate and mineral and chemical admixtures shall also be stored separately. A minimum of ten (10) meters apart or separated by walls.

Dust collected in skimmers, expansion chambers and centrifugal collectors may be returned to the aggregate without being stored separately, provided the dust is returned uniformly at a point in advance of the sampling device in batch-mix and continuous pugmill mixing plants or between the sampling device and the dryer-drum mixer in dryer-drum mixing plants and the combined aggregate gradation at the time bituminous material is added conforms to the requirements specified in Paragraph 4.05.2.2, "Aggregate," in these General Specifications.

Before being fed to the dryer, aggregate shall be separated into sizes and stored in compliance with the following:

1. When the Contractor elects to use a plant equipped with hot-feed control, aggregate for bituminous base course and Grading I and II bituminous wearing course, 19.0 millimeters (3/4 inch) and 12.5 millimeters (1/2 inch) maximum sizes, shall be separated into five (5) sizes and stored separately.

Aggregate for Grading III bituminous wearing course and Grading I and II bituminous wearing course, 9.5 millimeters (3/8 inch) maximum size, need not be separated into sizes and stored separately.

2. When the Contractor elects to use a plant equipped with cold-feed control, aggregate for bituminous base course and Grading I and II bituminous wearing course, 19.0 millimeters (3/4 inch) and 12.5 millimeters (1/2 inch) maximum sizes, shall be separated into five sizes and stored separately.

Aggregate for Grading III bituminous wearing course and Grading I and II bituminous wearing course, 9.5 millimeters (3/8 inch) maximum size, shall be separated into two (2) or more sizes and stored separately.

The various sizes of aggregate shall be fed from storage in their proper proportions, directly to a dryer or dryer-drum mixer, using mechanical feeders and at a rate to permit correct and uniform temperature control and mixing with bituminous material. Except for mixtures produced in a dryer-drum mixer, drying shall continue for a sufficient period of time and at a sufficiently high temperature that, at the time of spreading, the moisture content of the mixture shall not exceed one percent (1%). At the time of spreading, mixtures produced in a dryer-drum mixer shall not contain more than three percent (3%) moisture.

The dryer or dryer-drum mixer shall be equipped with a device which indicates the temperature of the material leaving the dryer or dryer-drum mixer. The temperature indicating device shall be accurate to the nearest five degrees Celsius (5° C.) and installed in such a manner that changes of five degrees Celsius (5° C.) will be shown within one (1) minute.

Unless otherwise approved by the Engineer, dryers and dryer-drum mixers shall be equipped with dust collectors. Dust shall be returned to the aggregate or disposed of in accordance with Subsection 2.03.4, "Disposal of Surplus and Unsuitable Materials," in these General Specifications.

3. When use of natural sand is allowed it must be fed to the dryer in a separate bin.

When dune sand is allowed, it must also be fed separately. The minimum lot size should not be less than one thousand (1000) metric tons to permit proper use of the equipment.

4.05.6.4 Preparation of Bituminous Concrete Mixture. Aggregates and bituminous material for bituminous concrete shall be proportioned in accordance with the requirements of the approved JMF and mixed using equipment that will produce a mixture conforming to these General Specifications and the Special Specifications.

When the Contractor elects to use a plant equipped with hot-feed controls, aggregate after drying shall be separated into sizes as follows:

1. Aggregate for bituminous concrete base course and Grading I and II bituminous wearing course, 19.0 millimeters (3/4 inch) and 12.5 millimeters (1/2 inch) maximum sizes, shall be separated into three (3) or more sizes and each size stored in a separate bin.

2. Aggregate for Grading III bituminous wearing course and Grading I and II bituminous wearing course, 9.5 millimeters (3/8 inch) maximum size, shall be separated into two (2) or more sizes and each size stored in a separate bin.

Supplemental fine aggregate and mineral admixtures shall each be stored in a separate bin. Chemical admixtures shall be added to the bituminous material, at a uniform rate, in the specified amount, through the bituminous material supply line using an on-line blender.

Each size aggregate, supplemental fine aggregate and mineral admixture shall be delivered from storage bins, in their proper proportion, by weight or by volume.

3. The combined aggregate, including supplemental fine aggregate and mineral admixtures and bituminous material content shall conform to the approved JMF grading within the following tolerances:

TABLE 4.05-4 JOB MIX FORMULA TOLERANCES

Parameter	JMF Tolerances			
	Wearing Courses		Base Courses	
	a	b	a	b
19.0 mm (3/4")	±4	±5	±6	± 6
12.5 mm (1/2")	± 4	5	-	-
9.75 mm (3/8")	-	-	± 6	± 8
4.75 mm (#4)	± 5	± 7	± 6	± 7
2.00 mm (#10	± 4	± 5	± 5	± 6
0.425 mm (#40)	± 3	± 4	± 3	± 4
0.180 mm (#80)	± 2	± 3	-	-
0.075 mm (#200)	± 1.5	± 2	± 1.5	± 2
% AC	± 0.40	± 0.40	± 0.40	± 0.40

[a] Job Mix Formula and Acceptance Test Result(s) Tolerances
[b] As Constructed (Final Handover) Test Result Tolerances

When discharged from the mixing plant, the temperature of the bituminous concrete shall not exceed one hundred sixty-five degrees Celsius (165° C.).

1. Proportioning for Batch-Mixing. When the Contractor elects to use batch-mixing equipment, each material storage bin shall be equipped with a suitable, safe sampling device which will provide a sample of the material discharged from the storage bin.

Aggregate and bituminous material may be manually or automatically proportioned by weight or by volume in a manner that produces a mixture conforming to the requirements specified.

An automatic plant shall not be operated manually unless the automatic circuitry is disconnected to the extent that it cannot be activated by the operation of a switch, circuit-breaker or other routine procedure.

When automatic batch mixing is required by the Special Specifications, or when the Contractor elects to use an automatic batching system, the proportioning devices shall be automatic to the extent that the only manual operation involved in proportioning all materials for one batch shall be a single operation of a switch or starter.

2. Proportioning for Continuous Pugmill and Dryer-Drum Mixing. When continuous pugmill mixing or dryer-drum mixing is used, bituminous material shall be introduced into the mixer through a meter capable of varying the rate of delivery of bituminous material.

The correct proportions of each aggregate size, supplemental fine aggregate and mineral admixture shall be drawn from storage bins by a continuous mechanical or electrical feeder which will supply the correct amount of aggregate in proportion to the bituminous material and be arranged so that each aggregate size can be adjusted separately. Aggregate feeders and the bituminous material pump shall be interlocked.

When cold feed proportioning is used with continuous pugmill or dryer-drum mixing, the bituminous material feeder, each of the aggregate feeders, the supplemental fine aggregate feeder, the mineral admixture feeder and the combined aggregate feeder shall be equipped with devices by which the rate of aggregate feed can be determined while the plant is in full operation. The combined aggregate shall be weighed using a belt scale.

A method of sampling shall be provided that will provide a representative sample for each size of aggregate or the combination of aggregates immediately prior to introduction of bituminous material. The plant shall be equipped to permit sampling of aggregates while the plant is in full operation and be such that the plant production rate may be determined.

Aggregate, supplemental fine aggregate and mineral admixtures, when used, shall be mixed uniformly and completely and coating, when tested in accordance with the requirements of AASHTO T-195, shall not be less than ninety-five percent (95%).

3. Storage of Bituminous Concrete Materials. When bituminous concrete material is stored, it shall be stored in a manner that prevents segregation of the completed mix.

Bituminous mix with hardened lumps in it shall not be used. Any storage method that results in a mixture with hardened lumps in it shall not be used.

All bituminous concrete material placed in storage shall be used before darkness on the day of mixing, except bituminous concrete material stored in approved silos may remain in storage for a period not to exceed twenty-four (24) hours.

4.05.6.5 Preparation of Surface. The following steps shall be followed to properly prepare the surface for the next layer:

1. When the bituminous mixture is placed on a prepared subgrade, and whether or not a prime coat is designated on the plans, the subgrade shall be prepared to meet the requirements provided in Section 4.02.5, "Construction," in these General Specifications.

2. When the bituminous mixture is to be placed on an aggregate base course, the surface shall be prepared as specified in Subsection 4.02.5, "Construction," and protected and maintained as specified in Paragraph 3.03.4.8, "Maintenance and Protection," in these General Specifications.

3. When the "Bituminous Concrete Wearing Course" is to be placed on a bituminous base course, all loose materials shall be removed from the surface and the surface shall be cleaned by means of approved mechanical sweepers or blowers and/or hand brooms, until it is as free from dirt as is deemed practicable. No traffic shall be permitted on the surface after it has been prepared to receive the bituminous material.

4. When the "Bituminous Concrete Wearing Course," or "Leveling Course," or "Base Course" is constructed on an existing bituminous surface, the surface shall be cleaned of all foreign material and broomed free of dust. In addition, any loose, broken, or shattered bituminous material along the edges of the existing surface shall be removed, and the exposed subgrade and a sufficient width of the shoulder adjacent to the edge of the existing surface to receive the new bituminous mixture shall be shaped, bladed, and broomed to provide a uniform firm subgrade for the new surface course. When directed by the Engineer, existing bituminous surfaces shall receive a tack coat as specified in this Section.

The existing mat, base, or subgrade shall be removed through broken, shattered, or unstable areas as shown on the plans or designated by the Engineer. The areas shall be excavated to a depth directed by the Engineer, and refilled with bituminous mixture herein described. When the Contract does not provide a patching item, the unit price for the "Bituminous Concrete Wearing Course" mixture, as specified in the Bill of Quantities, shall be used for such Work. The excavation required will not be paid for directly but will be considered subsidiary to the pay items of "Bituminous Concrete Wearing Course" as specified in the Bill of Quantities.

5. Prior to the placing of the bituminous mixture, when designated on the plans or directed by the Engineer, a prime coat shall be applied to the subgrade or surface in accordance with the standards specified in Section 4.02, "Bituminous Prime and Tack Coat," in these General Specifications.

6. Prior to the placing of the mixture, when designated or, the plans or directed by the Engineer, a tack coat as specified in Section 4.02, "Bituminous Prime and Tack Coat," in these General Specifications shall be applied to subgrade, base or existing bituminous surfaces at the rate of application not exceeding one-quarter (1/4) liters per square meter or as otherwise designated by the Engineer. When the asphaltic surface is to be constructed on a previously newly primed base, and where deemed advisable

by the Engineer, the above specified tack coat may be eliminated. No mixture will be laid on a tack coat prior to the approval of the Engineer.

4.05.6.6 Placement of Bituminous Concrete Pavement. Bituminous materials shall be placed as a base course, leveling course or surface course. The type and thickness of the individual courses will be shown on the plans. Base course is defined as a layer or layers of bituminous materials placed on a paved or unpaved surface in preparation for placing a wearing course. A leveling course is defined as a layer of bituminous material used to reshape a roadway cross section and eliminate sags and irregularities in the longitudinal grade line. Wearing course is defined as a layer to serve either as a traffic surface or a surface on which a seal coat will be placed.

The maximum and minimum depths of any layer of any course shall be in accordance with the following:

	TARGET OR DESIGN THICKNESS (CM)
Bituminous Base Course, Grading I	10
Bituminous Base Course, Grading II	7
Bituminous Base Course, Grading III	6
Bituminous Wearing Course, Grading I	5
Bituminous Wearing Course, Grading II	4
Bituminous Wearing Course, Grading III	3

The above thicknesses were developed using the formula: Target or Design Thickness equals three (3) times the nominal maximum size aggregate.

Bituminous materials may be dumped on the surface to receive the mixture or discharged directly from hauling unit into a self-propelled paving machine or other device which will produce the course as specified.

If the bituminous materials are delivered in bottom dump trucks, placed in a windrow on the surface and subsequently loaded into the paving machine, the loading equipment shall be self-supporting and not exert any vertical load on the paving machine. Substantially all of the bituminous materials shall be picked up and loaded into the paving machine.

When the bituminous materials are dumped from the hauling equipment directly into the paving machine, care shall be taken to avoid jarring the paving machine or moving it out of alignment. No vertical load shall be exerted on the paving machine by hauling equipment. Hauling equipment, while dumping into the paving machine, shall be attached firmly to the paving machine.

Sufficient quantities of bituminous materials shall be delivered in a continuous manner, using a self-propelled paving machine conforming to these General

Specifications, in a manner that the finished surface is smooth with uniform texture, no segregation is evident, planned and specified thickness is complied with and joints are tight and thoroughly sealed. The paving machine shall be operated at a uniform forward speed consistent with plant production. Stopping and starting the paving machine and folding sidewalls of the paver hopper shall be avoided.

The Contractor may propose to the Engineer and the Engineer, under certain conditions or at certain locations, may approve equipment other than self-propelled paving machines for placing base and leveling courses when such other equipment will produce the results specified.

All self-propelled paving machines used to spread bituminous material shall be equipped with automatically actuated screed controls and sensors mounted on both sides of the paver. The sensor shall be constructed to operate from a reference line or a multi-footed ski-type arrangement. The automatic screed control system shall operate at all times during spreading of bituminous materials except under conditions, or at certain locations where the Engineer deems the automatic controls impractical. Failure of the automatic controls to function properly shall be cause for suspension of placement of bituminous materials.

The Contractor shall establish all reference lines as may be necessary for the operation of automatic screed controls.

Spreading and compacting bituminous concrete wearing courses will not be permitted at night except when specified in the Special Specifications or approved by the Engineer.

4.05.6.7 Joints. Longitudinal joints for each course shall be offset thirty (30) centimeters from the joint in the immediate underlying course. Transverse joints shall be offset a minimum of sixty (60) centimeters from the joint of the immediate underlying course.

Longitudinal joints shall be located within fifteen (15) centimeters of the centerline of the roadway or within fifteen (15) centimeters of the centerline of a lane. Longitudinal joints shall be held to the minimum practical number. Longitudinal joints shall be formed by lapping the screed over the first layer placed, crowding a ridge of bituminous material at the joint and crimping the ridge of material into the joint by a compaction roller while the material is hot.

Transverse joints shall be formed by cutting back the first layer placed to the full depth of the layer, removing and wasting the material, spreading new bituminous material in sufficient quantity to create a compacted thickness equal to the thickness of the first layer. The joint shall be cross rolled with one coverage and the joint checked with a straight edge not less than four (4) meters in length. High points shall be removed and sags filled with additional bituminous material and the joint rolled a second time. The joint shall again be checked with a straight edge, humps and sags adjusted as necessary, and rolled until the joint is complete and compacted as specified.

Contact surfaces, where bituminous concrete mixtures are placed against concrete or stone curb and gutter, bridge abutments, retaining walls, drainage facilities, a cold pavement joint or metal surface, shall be tack coated as specified in Section 4.02, "Bituminous Prime Coat, Tack Coat, and Fog Seal" in these General Specifications.

4.05.6.8 Compaction of Bituminous Concrete Pavement. Unless lower temperatures are ordered by the Engineer, all courses of bituminous concrete pavement shall be spread and the initial coverage or breakdown compaction shall be performed when the temperature of the mixture is not less than one hundred forty degrees Celsius (140° C.) and all rolling shall be completed before the temperature of the mixture drops below ninety degrees Celsius (90° C.).

Longitudinal joints shall be rolled first, then rolling shall begin at the lower edge and proceed towards the highest portion, except when compacting layers that are thicker than nine (9) centimeters. Compaction of layers more than nine (9) centimeters in thickness shall begin in the middle and proceed alternately towards each edge. When the roller is within sixty (60) centimeters of either edge it shall proceed by lapping the uncompacted mixture by not more than thirty (30) centimeters per coverage.

A coverage consists of one pass of the roller over any portion of the layer being placed.

Sufficient compaction equipment shall be provided and compaction shall continue until each lot of bituminous concrete pavement as described in Subsection 4.05.8, "Quality Assurance Procedures," in these General Specifications is compacted to an in-place density within the following range when compared to the theoretical maximum density determined from ASTM D-2041:

Bituminous Concrete Base Course -	92 to 95
Bituminous Concrete Leveling Course -	92 to 95
Bituminous Concrete Wearing Course -	91 to 94

4.05.7 TRAFFIC CONTROL. The Contractor shall take effective action to prevent all traffic from using the bituminous concrete pavement until such time as the Engineer has given approval for traffic to use the pavement.

All traffic control work will be done in conformance with Section 9.02, "Traffic Control through Work Zones," in these General Specifications.

When the roadway being paved is open to traffic, the following additional requirements shall apply:

The Contractor shall keep road intersections and ramps open at all times except when a ramp is being paved or the paving operations cross the road intersection or ramp. During such time, the road intersection or ramp shall be closed for the minimum possible time period. In hot weather, the Engineer may require the Contractor to apply water to the pavement to accelerate finish rolling and opening to traffic.

Before closing a ramp or access to the roadway, warning signs shall be placed and the detour or alternate route signed.

During paving operations, temporary lane stripes shall be maintained throughout the length of project open to traffic. Temporary striping shall consist of ten (10) centimeters by thirty (30) centimeters strips of pressure sensitive tape applied to the roadway surface at eight (8) meter intervals. The temporary stripes shall be placed at the end of each day's paving operation, maintained and replaced until permanent striping is completed.

When necessary to maintain one-way traffic, the Contractor shall furnish and operate a pilot car, employ flaggers and position all signs, markings, barricades and other traffic control devices as needed to protect traffic and construction operations. All traffic control work will be done in conformance with Section 9.02, "Control of Traffic through Work Zones."

4.05.8 QUALITY ASSURANCE PROCEDURES. The bituminous base, leveling and wearing courses shall be accepted by lot. Unless otherwise stated in the Special Specifications, the lot size shall be ten thousand (10,000) square meters for each layer constructed. The bituminous base, leveling and wearing courses shall be sampled, tested, and evaluated in accordance with Section 1.08, "Acceptance of Work," in these General Specifications. The Engineer may, during the beginning of placement of bituminous base leveling and wearing courses, at times when test results indicate erratic characteristics, and at any other time, reduce the lot size to sections of bituminous base, leveling and wearing courses with similar quality characteristics. This should facilitate the isolation and modification or replacement of low quality materials with materials of acceptable quality to maintain the overall strength of the pavement structure.

The Engineer shall perform or supervise the performance of all quality assurance sampling and testing. The location of all samples and tests shall be recorded by roadway, lane and centerline station (kilometer). Quality assurance sampling and testing for each lot shall include:

1. Compaction
2. Thickness
3. Aggregate Gradation and Bituminous Material Content
4. Surface Smoothness

4.05.8.1 Compaction. The compacted density for each layer of each course shall be determined using nuclear gauge measurements in accordance with the requirements of ASTM D-2041, or from cores taken from the completed layer in accordance with the requirements of ASTM D-2726. Cores shall be not less than ten (10) centimeters in diameter obtained as described in ASTM D-979.

When testing is performed using nuclear gauges, a minimum of ten (10) randomly selected locations shall be tested in each lot. Random selection of locations shall be done in accordance with ASTM D-3665.

When coring is performed, a minimum of five (5) randomly selected locations shall be tested in each lot.

The Contractor shall backfill core holes with compacted bituminous concrete mix of the same class as placed in the lot.

The average actual in-place density from the ten (10) nuclear gauge tests or five (5) cores shall be compared with the theoretical maximum density determined by ASTM D-2041. The result shall be the percent relative compaction for the lot.

If any lot tested has a percent relative compaction outside the range specified in Paragraph 4.05.6.8, "Compaction of Bituminous Concrete Pavement," in these General Specifications, the Contractor shall be advised that he is not attaining the specified percent relative compaction and that his materials or his procedures, or both, need adjustment.

Any lot of bituminous concrete pavement that has a percent relative compaction outside the percent relative compaction range specified in Subsection 4.05.6.8, "Compaction of Bituminous Concrete Pavement," in these General Specifications resulting in a reduced pay factor of 0.75 or higher determined in accordance with Subsection 1.08.5, "Statistical Evaluation of Work for Acceptance and Determination of Pay Factor (Value of Work)," in these General Specifications may be accepted on the basis of a reduced payment if requested in writing by the Contractor. Otherwise the lot shall be removed and replaced by the Contractor at his expense. Lots that have percent relative compaction resulting in a reduced pay factor less than 0.75 shall be removed and replaced by the contractor at his expense.

4.05.8.2 Thickness of Bituminous Concrete. The thickness of each course of bituminous concrete pavement, complete as placed and compacted, shall be measured from cores obtained at five (5) random locations within the lot. The thickness of each core shall be determined, using a set of calipers, in accordance with ASTM D-3549. The average of the five core thicknesses shall be reported as the thickness of the lot.

A lot shall be accepted when the average total thickness is not less than the planned thickness.

Any lot of bituminous concrete pavement which has an average thickness less than planned but resulting in a reduced pay factor of 0.75 or higher determined in accordance with Subsection 1.08.5, "Statistical Evaluation of Work for Acceptance and Determination of Pay Factor (Value of Work)," in these General Specifications may be accepted on the basis of reduced payment if requested in writing by the Contractor. Otherwise the lot shall be overlaid as specified in the following paragraph.

When the average thickness of a lot of bituminous concrete pavement is less than the planned thickness by an amount resulting in a reduced pay factor below 0.75 the Contractor, at his expense, shall overlay the lot with a mix conforming to the requirements for bituminous concrete wearing course of the class and maximum aggregate size shown on the plans or specified in the Special Specifications. The thickness of the overlay shall be sufficient to produce the total thickness of bituminous concrete pavement as planned, but not less than four (4) centimeters.

4.05.8.3 Aggregate Gradation and Bituminous Material Content. The bituminous concrete aggregate gradation and bituminous content will be sampled, tested and evaluated based on the average of a minimum of five (5) samples per lot in accordance with the Job Mix Formula Tolerances listed in Paragraph 4.05.6.4 "Preparation of Bituminous Concrete Mixture" and Subsection 1.08.5, "Statistical Evaluation of Work for Acceptance and Determination of Pay Factor (Value of Work)," in these General Specifications.

Every sample of bituminous concrete shall be taken on a random time basis from the uncompacted pavement immediately behind the paving machine during each one-half (1/2) day of work, or portion thereof. The initial sample shall be randomly selected from within one and one-half (1/2) meters either side of the centerline of the lane being paved and weight at least twenty-five (25) kilograms. The initial sample shall be thoroughly mixed and quartered to obtain a test sample weighing at least six (6) kilograms. The test sample shall be forwarded to the project laboratory and the aggregate gradation and bituminous material content determined by extraction.

Any lot of bituminous concrete pavement that has its gradation or bituminous material content outside the tolerances specified in Subsection 4.05.6.4, "Preparation of Bituminous Concrete Mixture," in these General Specifications, resulting in a reduced pay factor of 0.75 or higher may be accepted on the basis of a reduced payment if requested in writing by the Contractor, otherwise said lot shall be removed and replaced by the Contractor at his expense. Lots that have their gradation and bituminous material content resulting in a reduced pay factor less than 0.75 shall be removed and replaced by the contractor at his expense.

4.05.8.4 Wearing Course Smoothness. The completed bituminous wearing course shall be compacted as specified, smooth, free from ruts, humps or depressions, or irregularities. Any ridges, indentations, roller checking, or other objectionable marks left in the surface, as determined by the Engineer, shall be eliminated by whatever means are necessary and approved by the Engineer. The use of any equipment that leaves ridges, indentations or other objectionable marks shall be discontinued.

When a straight edge four (4) meters in length is laid on the finished surface of the bituminous wearing course parallel with the centerline, in such a manner that both ends are in contact with the surface, the surface shall have no depressions which vary more than three (3) millimeters from the lower edge of the straight edge. When the straight edge is laid transverse to the centerline, with both ends in contact with the surface, the surface shall have no depressions which vary more than six (6) millimeters from the lower edge of the straight edge.

The wearing course smoothness will be measured by the Contractor under the supervision of the Engineer with a May's RideMeter, in accordance with MOC Test and Measurement Standards . All lots will be divided into a minimum of five (5) sublots with each sublot being a minimum of eighty (80) meters long. The May's RideMeter results will be statistically evaluated to determine the acceptability and quality of the surface smoothness.

Any lot of bituminous concrete pavement that has May's Ride Meter Reading above one hundred (100) resulting in a reduced pay factor of 0.75 or higher determined in accordance with Subsection 1.08.5, "Statistical Evaluation of Work for Acceptance and Determination of Pay Factor (Value of Work)," in these General Specifications may be accepted on the basis of a reduced pay factor if requested in writing by the Contractor. Otherwise the lot shall be removed and replaced or overlaid by Contractor at his expenses.

4.05.8.5 Acceptance. Bituminous materials will be accepted under Subsection 1.08.3, "Certification of Compliance," in accordance with Subsection 4.01.4, "Acceptance Procedures on Bituminous Materials," in these General Specifications.

Bituminous concrete pavement construction will be accepted under Subsection 1.08.4, "Measured or Tested Conformance," in these General Specifications.

Compaction, thickness, aggregate gradation, bituminous material content and wearing course smoothness will be accepted under Subsection 1.08.5, "Statistical Evaluation of Work for Acceptance and Determination of Pay Factor (Value of Work)," in these General Specifications in two (2) stages as follows:

The first stage shall be the selection of the lowest of the three (3) pay factors for the quality of the bituminous concrete pavement relating to aggregate gradation, bituminous content and density. The smoothness quality pay factor shall be the fourth quality pay factor considered as part of the first stage for bituminous concrete wearing course. The second stage involves the selection and application of a quantity pay factor based on the thickness of the bituminous concrete pavement. The reduced thickness pay factor for the lower courses of multiple course pavements will initially be applied provisionally based on the results of the depths of the cores taken from the lower courses. Additional cores will be taken of the total depth of all bituminous concrete pavement courses within the lot represented by lower course reduced thickness pay factors. If the total thickness cores show that the increased upper level course thickness has resulted in total thickness acceptability, the lower level courses reduced thickness pay factor will be adjusted accordingly. The second stage thickness quantity pay factor will be applied to all the individual course lots in addition to the first stage lowest quality pay factor as determined in accordance with Subsection 1.08.5, "Statistical Evaluation of Work for Acceptance and Determination of Pay Factor (Value of Work)," in these General Specifications.

4.05.9 MINOR BITUMINOUS CONCRETE. This work consists of constructing minor hot asphalt concrete for medians, drivepads, sidewalks, paved waterways, curbs, and other minor surfacing.

4.05.9.1 Construction Requirements.

4.05.9.1.1 Composition of Mixture (Job-Mix Formula). The Contractor shall provide a bituminous concrete mixture composed of crushed stone or gravel and asphalt cement mixed in an approved plant. The gradation and quality of the aggregate and the grade and quality of the asphalt cement shall conform to those normally used locally in the construction of highways by either Ministry or Municipality agencies.

The Contractor shall submit the strength, quality, and gradation specifications for the bituminous concrete mixture including copies of laboratory test reports that demonstrate the properties of the aggregates, asphalt cement, additives, and mixture meet the Ministry or Municipality agency specifications. He shall also submit the maximum density of the mixture as determined by AASHTO T 209.

4.05.9.1.2 Surface Preparation. The Contractor shall prepare the surface according to Paragraph 4.05.6.5, "Preparation of Surface," in these General Specifications.

4.05.9.1.3 Weather Limitations. Minor bituminous concrete shall be placed on a dry, unfrozen surface when the air temperature in the shade is at least five degrees Celsius (5° C) and rising.

4.05.9.1.4 Placing. The mixture shall be spread with a mechanical paver. In areas where mechanical spreading and finishing is impractical, each course shall be spread and finished by hand raking, screeding, or by other approved methods. The Contractor shall construct a surface that is uniform in texture and cross-section. Joints shall be constructed according to Paragraph 4.05.6.7, "Joints," in these General Specifications.

4.05.9.1.5 Compacting. Mechanically spread paving mixtures shall be compacted to a minimum of ninety percent (90%) of the maximum density determined from ASTM D-2041 by nuclear gauge.

Non-mechanically spread paving mixtures shall be compacted by rolling with a hand-operated roller weighing not less than one hundred forty (140) kilograms or with a small power roller. Areas that are not accessible to rollers shall be compacted by other approved methods.

4.05.9.2 Pavement Smoothness. The Contractor shall use a four (4) meter metal straightedge to measure smoothness at right angles and parallel to the centerline at designated sites. Defective areas are surface deviations in excess of six (6) millimeters between any two (2) contacts of the straightedge with the surface. All defective areas shall be corrected using approved methods.

4.05.9.3 Acceptance. Minor bituminous concrete mixtures will be accepted under Subsection 1.08.3, "Certifications of Conformance," in these General Specifications. Minor bituminous concrete construction work will be accepted under Subsection 1.08.4, "Measured or Tested Conformance," in these General Specifications.

4.05.10 MEASUREMENT. The quantity of each lot and course of bituminous concrete pavement shall be measured by the cubic meter, as placed and compacted to the required density, within the lines and grades and thickness shown on the plans, specified or directed by the Engineer. No measurement will be made for overdepth or areas of pavement placed outside authorized limits.

Prime coat, when placed, shall be measured as specified in Section 4.02, "Bituminous Prime and Tack Coat," in these General Specifications.

Asphalt cement and modified asphalt cement shall be considered subsidiary to the construction of each lot of bituminous concrete pavement unless specifically stated in the Special Specifications and listed in the Bill of Quantities. When they are listed separately they shall be measured in liters.

Tack coat shall not be measured.

Mineral fillers, chemical admixtures and asphalt modifiers used by the contractor to meet the Job Mix Formula (JMF) requirements will be considered subsidiary to the construction of the bituminous emulsion base course and will not be measured separately unless specifically stated in the Special Specifications and listed in the Bill of Quantities. When they are listed separately they shall be measured in liters, kilograms, or tons as specified in the Special Specifications and as listed in the Bill of Quantities.

4.05.11 PAYMENT. Payment shall be made at the contract unit price, or adjusted contract unit price, per cubic meter measured as described above for each grading and class of bituminous concrete base, leveling and wearing courses listed in the Bill of Quantities.

Prime Coat shall be paid for as specified in Section 4.01, "Bituminous Prime and Tack Coat," in these General Specifications. Tack coat shall not be measured or paid separately and shall be considered as subsidiary to the construction of Bituminous Concrete Pavement.

Asphalt cement, modified asphalt cement, mineral fillers, chemical admixtures, and asphalt modifiers shall be considered subsidiary to the construction of bituminous concrete and shall not be paid for separately unless specifically stated in the Special Specifications and listed in the Bill of Quantities. When they are listed in the Bill of Quantities and specified in the Special Specifications they shall be paid for when measured in accordance in Subsection 4.05.10 Measurement in these General Specifications.

When the asphalt or modified cement is subsidiary to the bituminous concrete pavement the payment for each lot of bituminous concrete pavement shall include the supplying, heating, mixing, placing, and compacting the bituminous material as part of the bituminous concrete pavement.

When the asphalt or modified asphalt cement is listed separately in the Bill of Quantities the payment for each liter of asphalt or modified asphalt cement shall only include the supplying of the bituminous material. The payment for each lot of bituminous concrete payment shall then still include the heating, mixing, placing, and compacting of the bituminous material as part of the bituminous concrete pavement.

When a lot of bituminous concrete base, leveling or wearing course is accepted with a deficiency, the adjusted contract unit price for said lot shall be the product of the contract unit price of bituminous concrete base, leveling or wearing course and the lowest quality and quantity pay factors specified in Subsection 4.05.8, "Quality Assurance Procedures," in these General Specifications.

The above prices and payment shall cover and be full compensation for furnishing labor, materials, equipment, tools and incidentals necessary for completing all work involved in construction of bituminous concrete pavement as specified in Subsection 1.07.2, "Scope of Payment," in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO.	PAY ITEM	PAY UNIT
40501	Bituminous Concrete Base Course	Cubic Meter
4050101	Bituminous Concrete Base Course, Grading I, Class A	Cubic Meter
4050102	Bituminous Concrete Base Course, Grading I, Class B	Cubic Meter
4050103	Bituminous Concrete Base Course, Grading II, Class A	Cubic Meter
4050104	Bituminous Concrete Base Course, Grading II, Class B	Cubic Meter
4050105	Bituminous Concrete Base Course, Grading III, Class A	Cubic Meter
4050106	Bituminous Concrete Base Course, Grading III, Class B	Cubic Meter
40502	Bituminous Concrete Leveling Course	Cubic Meter
4050201	Bituminous Concrete Leveling Course, Grading I, Class A	Cubic Meter
4050202	Bituminous Concrete Leveling Course, Grading I, Class B	Cubic Meter
4050203	Bituminous Concrete Leveling Course, Grading I, Class C	Cubic Meter
4050204	Bituminous Concrete Leveling Course, Grading II, Class A	Cubic Meter
4050205	Bituminous Concrete Leveling Course, Grading II, Class B	Cubic Meter
4050206	Bituminous Concrete Leveling Course, Grading II, Class C	Cubic Meter
4050207	Bituminous Concrete Leveling Course, Grading III, Class A	Cubic Meter
4050208	Bituminous Concrete Leveling Course, Grading III, Class B	Cubic Meter
4050209	Bituminous Concrete Leveling Course, Grading III, Class C	Cubic Meter
40503	Bituminous Concrete Wearing Course	Cubic Meter
4050301	Bituminous Concrete Wearing Course, Grading I, Class A	Cubic Meter
4050302	Bituminous Concrete Wearing Course, Grading I, Class B	Cubic Meter
4050303	Bituminous Concrete Wearing Course, Grading I, Class C	Cubic Meter
4050304	Bituminous Concrete Wearing Course, Grading II, Class A	Cubic Meter
4050305	Bituminous Concrete Wearing Course, Grading II, Class B	Cubic Meter
4050306	Bituminous Concrete Wearing Course, Grading II, Class C	Cubic Meter
4050307	Bituminous Concrete Wearing Course, Grading III, Class A	Cubic Meter
4050308	Bituminous Concrete Wearing Course, Grading III, Class B	Cubic Meter
4050309	Bituminous Concrete Wearing Course, Grading III, Class C	Cubic Meter
40504	Asphalt Cement	Liter
4050401	Asphalt Cement, Grade AC-2.5	Liter
4050402	Asphalt Cement, Grade AC-5	Liter
4050403	Asphalt Cement, Grade AC-10	Liter
4050404	Asphalt Cement, Grade AC-20	Liter
4050405	Asphalt Cement, Grade AC-30	Liter
4050406	Asphalt Cement, Grade AC-40-50	Liter
4050407	Asphalt Cement, Grade AC 60-70	Liter
4050408	Asphalt Cement, Grade AC 85-100	Liter
40505	Modified Asphalt Cement	Liter
4050501	Modified Asphalt Cement, Grade AC-2.5	Liter
4050502	Modified Asphalt Cement, Grade AC-5	Liter
4050503	Modified Asphalt Cement, Grade AC-10	Liter
4050504	Modified Asphalt Cement, Grade AC-20	Liter
4050505	Modified Asphalt Cement, Grade AC-30	Liter
4050506	Modified Asphalt Cement, Grade AC40-50	Liter
4050507	Modified Asphalt Cement, Grade AC60-70	Liter
4050508	Modified Asphalt Cement, Grade AC85-100	Liter
40506	Mineral Filler	Ton

ITEM NO.	PAY ITEM	PAY UNIT
4050601	Mineral Filler, Portland Cement	Ton
4050602	Mineral Filler, Hydraulic Cement	Ton
4050603	Mineral Filler, Lime Type N or S	Ton
40507	Chemical Admixture/Asphalt Modifier	Liter
4050701	Chemical Admixture/Asphalt Modifier, Antistrip	Liter
4050702	Chemical Admixture/Asphalt Modifier, Polymer	Liter
40508	Chemical Admixture/Asphalt Modifier	Kilogram
4050801	Chemical Admixture/Asphalt Modifier, Antistrip	Kilogram
4050802	Chemical Admixture/Asphalt Modifier, Polymer	Kilogram
4050803	Chemical Admixture/Asphalt Modifier, Latex	Kilogram
4050804	Chemical Admixture/Asphalt Modifier, Rubber	Kilogram
40509	Minor Bituminous Concrete	Ton

SECTION 4.06 - HOT-MIX RECYCLED BITUMINOUS CONCRETE

4.06.1 DESCRIPTION. This work shall consist of furnishing and mixing aggregate, pulverized bituminous concrete pavement, bituminous material and/or bituminous recycling agent, and hauling, spreading and compacting the mixture on a prepared surface, all as shown on the plans, specified in these General Specifications or the Special Specifications and as directed by the Engineer.

Pulverized bituminous concrete pavement shall be referred to in this specification as RAP (Recycled Asphalt Pavement).

Hot-mix Recycled Bituminous Concrete will be designated as Hot-mix Recycled Bituminous Concrete or Hot-mix Recycled Bituminous Concrete Type I or Type II.

Type I Hot-mix Recycled Bituminous Concrete shall consist of up to twenty percent (20%) by weight RAP blended with not less than eighty percent (80%) bituminous concrete base or wearing course materials conforming to the requirements specified in Section 4.05, "Bituminous Concrete Pavement," in these General Specifications.

Type II Hot-mix Recycled Bituminous Concrete shall consist of twenty to seventy percent (20 to 70%) RAP blended with thirty to eighty percent (30 to 80%) aggregates, bituminous material and/or hot-mix bituminous recycling agent. The proportion of RAP to new materials, aggregate grading and quality requirements and the bituminous material and/or bituminous modifying material to be furnished shall be specified in the Special Specifications.

The plans or Special Specifications will state the grading and class of base course or wearing course requirements to which the hot mix recycled bituminous concrete shall conform. When the plans or Special Specifications do not so state, the hot mix recycled bituminous concrete shall conform to the requirements for the Grading and Class of Bituminous Concrete Wearing Course designated by the Engineer from Section 4.05, "Bituminous Concrete Pavement," in these General Specifications.

Hot-mix recycled bituminous concrete may be produced in a batch-type, continuous pugmill or dryer-drum mixing plant. Central plant mix proportioning may be by hot or cold feed control at the option of the Contractor.

ITEMS IN BILL OF QUANTITIES:

Hot-Mix Recycled Bituminous Concrete Base Course
Hot-Mix Recycled Bituminous Concrete Wearing Course
Hot-Mix Recycling Agent

4.06.2 MATERIALS.

4.06.2.1 Bituminous Material. Bituminous material for hot-mix recycled bituminous concrete shall be the viscosity or penetration grade specified in the Special Specifications conforming to the requirements specified in Table 4.01-1A or 1B, Section 4.01, "Bituminous Materials," in these General Specifications.

4.06.2.2 Hot-Mix Recycling Agent. **Hot-mix recycling agent shall conform to the requirements listed in Tables 4.06-1 or 4.06-2 below or as specified in the Special Specifications.**

TABLE 4.06-1
RECYCLING OIL

		Requirement	
Property	ASTM/AASHTO Test Method	Light Grade	Medium Grade
Viscosity @ 60° C (140° F) cSt	T202	200-800	1000-4000
Flash Point, C.O.C., C(F) minimum	T48	205 (400)	219 (425)
Saturates, Wt, %	D 2007	28 Max.	30 Max.
Tests on Residue From RTFO (Note 1) or TFO Oven @ 163° C (325° F):	T240 or T179		
Wt, Change, ± %		4.0 Max.	2.0 Max.
Viscosity Ratio (See Note 2)		2.5 Max.	2.5 Max.

Notes:

1. RTFO = Rolling Thin Film-Circulating Oven

2. Viscosity Ratio = $\dfrac{\text{RTFO Residue Viscosity @ 60° C (140° F), cSt}}{\text{Viscosity of the Original Material @ 60° C (140° F), cSt}}$

TABLE 4.06-2
EMULSIFIED RECYCLING AGENT (Note 1)

Property	Test Method	Requirement
Viscosity @ 25 degrees C., SFS	ASTM D 244	15-85
Pumping Stability	G.B. Method (Note 2)	Pass
Emulsion Coarseness, %	Sieve Test ASTM D 244 (Note 3)	0.1 Max.
Sensitivity to Fines, %	Cement Mixing ASTM D 244	2.0 Max.
Particle Charge	ASTM D 244	Positive
Concentration of Oil Phase, %	ASTM D 244 (Note 4)	60 Min.

Notes:

1. Oils used for emulsions must meet specifications listed in Table 4.06-1 or as specified in the Special Specifications.

2. Pumping stability is determined by charging four hundred fifty (450) ml of emulsion into a one (1) liter beaker and circulating the emulsion through a gear pump (Roper 29.B22621) having six and three-tenths (6.3) millimeter inlet and outlet. The emulsion passes if there is no significant oil separation after circulating ten (10) minutes.

3. Test procedure identical with ASTM D 244 except that distilled water will be used in place of two percent (2%) sodium oleate solution

4. ASTM D 244 Evaporation Test for percent residue is modified by heating fifty (50) gram sample to one hundred fifty degrees Celsius (150° C.) until foaming ceases, then cooling immediately and calculating results.

Test reports and Certificates of Compliance shall be furnished with each shipment of emulsified recycling agent.

4.06.2.3 Mineral Fillers. Mineral Fillers shall be either Portland Cement, blended hydraulic cement or lime conforming to the following requirements:

Materials	Requirement
Portland Cement, Type I or II	ASTM C-150
Blended Hydraulic Cement, Type IP	ASTM C-595
Lime, Type N or S	ASTM C-207

When required, the amount of mineral filler used shall be between one and two percent (1 - 2%) of the weight of the aggregate, with the exact amount to be stated in the Job Mix Formula.

4.06.2.4 Chemical Admixtures and Asphalt Modifiers. The types and amounts of chemical admixtures/asphalt modifiers used shall be limited to those listed in the Special Specifications or proposed by the Contractor and approved by the Ministry's Research and materials Department to establish compliance with the job mix formula (JMF) requirements contained in Subsection 4.05.3, "Proportioning Bituminous Concrete Mixtures," in these General Specifications.

All chemical admixtures/asphalt modifiers including anti-stripping additives and polymers shall be thoroughly mixed and uniformly combined with the bituminous material.

4.06.2.5 Aggregate. The aggregate specified for use in Types I and II Hot-Mix Recycled Bituminous concrete shall conform to the requirements for Bituminous Concrete Pavement specified in Subsection 4.05.2, "Materials," in these General Specifications.

4.06.2.6 RAP. RAP for hot-mix recycled bituminous concrete shall consist of bituminous concrete pavement which has been pulverized or crushed and reduced in size to the following grading:

Sieve Size	Percent Passing
37.5 mm (1 1/2 inch)	100
25 mm (1 inch)	90-100

4.06.3 PROPORTIONING HOT-MIX RECYCLED BITUMINOUS CONCRETE MIXTURES.

4.06.3.1 Job Mix Design Proposal. When Type I hot-mix recycled bituminous concrete is specified in the Special Specifications, or when the Contractor, at his option, elects to furnish Type I hot-mix recycled bituminous concrete, the Contractor shall prepare the Job Mix Design Proposal (JMF) in accordance with the requirements specified in Subsection 4.05.3, "Proportioning Bituminous Concrete Mixtures," in these General Specifications. When Type II hot-mix recycled bituminous concrete is specified in the Special Specifications, the Contractor shall prepare the Job Mix Design Proposal (JMF) in accordance with the requirements specified in this specification and the Special Specifications.

The JMF for both Types I and II hot mix recycled bituminous concrete shall conform to all of the requirements of Section 4.05, "Bituminous Concrete Pavement," in these General Specifications.

At least thirty (30) days before producing hot mix recycled bituminous concrete, the Contractor shall obtain representative samples of all materials specified to be furnished and submit said samples to the Engineer. Not less than fifty (50) kilograms of RAP and each size aggregate, eight (8) liters of each type and grade bituminous material and four (4) liters of recycling agent shall be furnished. The recycling agent shall be identified by trade-name, grade and source of supply.

The Contractor shall perform all testing required to establish the proportions of each material to be combined to produce the specified type of hot mix recycled bituminous concrete.

The Contractor shall submit the following information:

1. For the RAP. Extracted bituminous material content as a percent of dry aggregate and the gradation of the aggregate. Penetration of the bituminous material recovered from the RAP. One test shall be furnished for every one thousand (1,000) cubic meters of pavement to be pulverized and recycled.

2. Added aggregate. Fracture, gradation and quality requirements which, when blended with the RAP will produce all requirements specified for bituminous concrete in Section 4.05, "Bituminous Concrete Pavement," in these General Specifications.

3. Estimate total bituminous material demand based on mix design requirements in Subsection 4.05.3, "Proportioning Bituminous Concrete Mixes," in these General Specifications.

4. Determine type, grade and quantity of bituminous material to be added to the RAP and added aggregate. The criteria shall be:

(1) The total bituminous material demand as determined in Number 3, above, will be met and,

(2) The combined bituminous material in the final mixture shall have a penetration not less than forty (40).

5. Results obtained from trial mixes prepared in accordance with the requirements specified in Section 4.05, "Bituminous Concrete Pavement," in these General Specifications.

6. Recommended JMF with the following information:

(1) The percentage of RAP to be used, by total weight of mix.

(2) The gradation of each aggregate to be blended with the RAP and the percent of each aggregate, by total weight of mix.

(3) The type, grade and percent of bituminous material to be added, by total weight of mix. The type and amount of mineral filler, chemical admixture and asphalt modifier to be added by total weight of mix.

(4) The type and percent of hot-mix recycling agent to be added, by total weight of mix.

(5) The results of all tests performed by the Engineer.

(6) The theoretical maximum unit weight of the mixture based on ASTM D 2041.

7. The type and location of plants to be used for mixing each mix to be furnished.

8. The proposed beginning date for producing Hot-Mix Recycled bituminous concrete mixtures.

The Engineer shall be provided access to the materials sampling and testing operations at all times.

At the same time that the above information is provided, or at a later date, when requested by the Engineer, the Contractor shall supply to the Engineer twenty-five (25) kilogram samples of each individual aggregate size, four (4) liters of bituminous material and, when used, two (2) kilogram samples of mineral filler and chemical admixture, all representing the materials which the Contractor proposes to furnish.

4.06.3.2 Acceptance of Job Mixture Formula. The Engineer's review and acceptance of the hot-mix recycle bituminous concrete mixture job mix formula shall be in accordance with Paragraph 4.05.3.2, "Acceptance of Job Mix Formula," in these General Specifications including the field control strip provision.

4.06.3.3 Job Mix Formula Revisions. The Contractor shall not alter his methods of crushing, screening, blending, or stockpiling from that used to produce materials for the approved JMF. Changes to the JMF will not be permitted without retesting and resubmission of a processed (revised) JMF in accordance with all the steps in Paragraph 4.06.3.1, "Job Mix Design Proposal," in these General Specifications. Significant changes may include, but not be limited to, changes in the amount of type of materials rejected or wasted, changes in the amount of materials crushed, reductions in the amount of crushed fines, changes in the amount and type of mineral filler and mineral and chemical admixtures to be used.

Should the Contractor change his source of supply of aggregate and grade of bituminous material, he shall furnish a new information and samples of materials, as described in Paragraph 4.06.3.1, "Job Mix Design Proposal," in these General Specifications as determined by the Engineer to be necessary, at least twenty-one (21) days before their intended use.

At any time after the JMF is approved the Contractor may submit a new JMF for approval by the Engineer. If the revised JMF is approved it shall become the approved JMF.

The Engineer may, at any time, require a change in the JMF which will provide a hot mix recycled bituminous concrete mixture that conforms to the quality intended by the specifications.

4.06.4 EQUIPMENT. The Contractor shall supply the proper type and sufficient numbers of equipment to complete the work within the Contract time and in accordance with his Program of Work as approved by the Engineer.

4.06.5 WEATHER LIMITATIONS. The limitations specified in Subsection 4.05.5, "Weather Limitations," in these issued in these General Specifications shall apply.

4.06.6 CONSTRUCTION. The requirements specified in Subsection 4.05.6, "Construction," in these General Specifications, shall apply when Type I and Type II hot mix recycled bituminous concrete are produced in a central mixing plant. The following additional requirements shall also apply:

1. Before being fed into the mixing chamber, the RAP shall be stored separately. The stockpiles of RAP shall be prepared as specified in Subsection 3.01.5, "Stockpiling Aggregates," in these General Specifications. Stockpile height shall not exceed three (3) meters. The stockpiled RAP shall be protected from contamination during dust and sand storms by covering with heavy weight plastic sheeting held in place with vehicle tires or other objects.

2. The bituminous recycling agent, when used, shall be stored separately and added to the bituminous material in the storage tank, through an in-line blender or directly into the mixing chamber, as approved by the Engineer. When bituminous recycling agent is added to the bituminous material in storage the combined materials shall be uniformly blended together.

3. When the Contractor elects to use a batch-mixing plant, the RAP shall be fed from storage into the weigh hopper and the new aggregate sizes added in the proportion specified in the approved JMF. RAP shall not pass through the dryer. When the Contractor elects to use a batch-mixing plant, hot-mix recycled bituminous concrete shall be produced using automatic controls. The combined RAP and new aggregate shall be discharged into the mixer and mixed for an initial period not less than twenty (20) seconds before addition of bituminous material and/or bituminous modifying materials. Upon completion of the initial mixing period, the bituminous materials shall be introduced into the mixer, and all materials mixed for an additional time of not less than thirty (30) seconds before the hopper gates are opened.

4. When the Contractor elects to use a dryer-drum mixing plant, the RAP shall be introduced into the dryer-drum and combined with the hot, new aggregate in such a manner that the RAP is protected from direct contact with the burner's flame by a shield, separator, second drum, or other means as may be approved by the Engineer. The bituminous materials shall be introduced into the dryer-drum after the RAP and aggregate have been combined.

5. When the Contractor elects to use a continuous mix pugmill, the RAP and new aggregate shall be introduced into the mixing chamber simultaneously, followed by the bituminous materials. Mixing shall continue for not less than forty (40) seconds after introduction of the bituminous materials. RAP shall not pass through the dryer.

6. The grading of the combined RAP and aggregate, after extraction and gradation of the combined mixture, shall conform to the approved JMF within the tolerances listed

in Table 4.05-4 for the grading class of aggregate specified as modified in Paragraph 4.06.8.3, "Aggregate Gradation and Bituminous Material," in these General Specifications.

7. Spreading and compaction of Type I hot-mix recycled bituminous concrete shall conform to the requirements for bituminous concrete wearing course specified in Subsection 4.05.6.8, "Compaction of Bituminous Concrete Pavement," in these General Specifications. Spreading and compaction of Type II hot-mix recycled bituminous concrete shall conform to the requirements for bituminous concrete base course specified in Subsection 4.05.6.8, "Compaction of Bituminous Concrete Pavement," in these General Specifications.

4.06.7 TRAFFIC CONTROL. The Contractor shall take effective action to permit traffic to safely pass through recycling operations work zones as specified in Subsection 4.05.7, "Traffic Control," in these General Specifications.

4.06.8 QUALITY ASSURANCE PROCEDURES. The hot-mix recycled bituminous base and wearing courses shall be accepted by lot. Unless otherwise stated in the Special Specifications, the lot size shall be ten thousand (10,000) square meters for each layer constructed. The hot-mix recycled bituminous base and wearing courses shall be sampled, tested, and evaluated in accordance with Section 1.08, "Acceptance of Work," in these General Specifications. The Engineer may, during the beginning of placement of hot-mix recycled bituminous base and wearing courses, at times when test results indicate erratic characteristics, and at any other time, reduce the lot size to sections of hot-mix recycled bituminous base and wearing courses with similar quality characteristics. This should facilitate the isolation and modification or replacement of low quality materials with materials of acceptable quality to maintain the overall strength of the pavement structure.

The Engineer shall perform or supervise the performance of all quality assurance sampling and testing. The location of all samples and tests shall be recorded by roadway, lane and centerline station (kilometer). Quality assurance sampling and testing for each lot shall include:

1. Compaction
2. Thickness
3. Aggregate Gradation and Bituminous Material Content
4. Wearing Course Smoothness

4.06.8.1 Compaction. Hot-mix recycled bituminous concrete pavement compaction shall be tested and evaluated as detailed in Paragraph 4.05.8.1 "Compaction" in these General Specifications.

4.06.8.2 Thickness. Hot-mix recycled bituminous concrete pavement thickness shall be measured and evaluated as detailed in Paragraph 4.05.8.2 "Thickness" in these General Specifications.

4.06.8.3 Aggregate Gradation and Bituminous Material Content. Hot-mix recycled bituminous concrete pavement aggregate gradation and bituminous material content shall be sampled, tested and evaluated as detailed in Paragraph 4.05.8.3, "Aggregate Gradation and Bituminous Material Content," except that the allowable deviation from job mix target values shall be modified to reflect the RAP material as follows:

1. Bituminous Material Content. The upper and lower specification limits are the approved job-mix formula target value $\pm$0.4 x (1 + the ratio of the reclaimed asphalt pavement material to the total mixture rounded to the nearest 0.10%).

Example: If thirty percent (30%) of the mixture is reclaimed asphalt pavement material, then the allowable deviation from target value for percent asphalt content is 0.4(1.30) = 0.52%. Use plus 0.5% and minus 0.5% from approved job-mix formula target value for bituminous material content.

2. Aggregate gradation. The upper and lower specification limits are the approved job-mix formula target values plus or minus the allowable deviations shown in Table 4.05-4 multiplied by one plus the ratio of reclaimed asphalt pavement (RAP) material to the total mixture. Round to the nearest percent except for the 0.075 mm (No. 200) sieve that is rounded to the nearest 0.10%.

Example: If thirty percent (30%) of the mixture is reclaimed asphalt pavement material, then all allowable deviation from target value for percent of aggregate passing the 0.075 mm (No. 200) sieve is 2(1.30) = 2.6%. Use plus 2.6% and minus 2.6% from the approved job-mix formula target value for percent passing the 0.075 mm (No. 200) sieve.

4.06.8.4 Wearing Course Smoothness. The surface layer of hot-mix recycled bituminous concrete pavement surface smoothness shall be tested and evaluated as detailed in Paragraph 4.05.8.4, "Wearing Course Smoothness," in these General Specifications.

4.06.8.5 Acceptance. Bituminous materials will be accepted under Subsection 1.08.3, "Certification of Compliance," in accordance with Subsection 4.01.4, "Acceptance Procedures for Bituminous Materials," in these General Specifications.

Hot-mix recycled bituminous concrete construction will be accepted under Subsection 1.08.4, "Measured or Tested Conformance," in these General Specifications.

Hot-mix recycled bituminous concrete compaction, thickness, aggregate gradation, bituminous material content and wearing course smoothness will be accepted under Subsection 1.08.5, "Statistical Evaluation of Work for Acceptance and Determination of Pay Factor (Value of Work)," in these General Specifications in two (2) stages as follows:

The first stage shall be the selection of the lowest of the three (3) pay factors for the quality of the hot-mix recycled bituminous concrete relating to aggregate gradation, bituminous content and density. The smoothness quality pay factor shall be the fourth quality pay factor considered as part of the first state for hot-mix recycled bituminous concrete wearing courses. The second stage involves the selection and application of a quantity pay factor based on the thickness of the hot-mix recycled bituminous concrete. The reduced thickness pay factor for the lower courses of multiple course pavements will initially be applied provisionally based on the results of the depths of the cores taken from the lower courses. Additional cores will be taken of the total depth of all hot-mix recycled bituminous concrete courses within the lot represented by lower course reduced thickness pay factors. If the total thickness cores show that the increased upper level course thickness has resulted in total thickness acceptability, the lower level courses reduced thickness pay factor will be adjusted accordingly. The second stage thickness quantity pay factor will be applied to all the individual course lots in addition to the first stage lowest quality pay factor as determined in accordance with Subsection 1.08.5, "Statistical Evaluation of Work for Acceptance and Determination of Pay Factor (Value of Work)," in these General Specifications.

4.06.9 MEASUREMENT. Each course of hot-mix recycled bituminous concrete pavement shall be measured by the cubic meter, as placed and compacted to the required density, within the lines and grades and thickness shown on the plans, specified or directed by the Engineer. No measurement will be made for overdepth or areas of pavement placed outside authorized limits.

Asphalt cement and modified asphalt cement shall be considered subsidiary to the construction of the hot-mix recycled bituminous concrete pavement and shall not be measured separately unless specifically specified in the Special Specifications and listed in the Bill of Quantities. When they are listed separately in the Bill of Quantities and specified in the Special Specifications they shall be measured in liters in accordance with subsection 4.05.10 "Measurement" in these General Specifications.

Hot-mix bituminous recycling agent shall be measured separately in liters unless specifically stated in the Special Specifications and the item is not listed in the Bill of Quantities.

Mineral fillers, chemical admixtures and asphalt modifiers used by the contractor to meet the Job Mix Formula (JMF) requirements will be considered subsidiary to the construction of the hot-mix recycled bituminous concrete pavement and will not be measured separately unless specifically stated in the Special Specifications and listed in the Bill of Quantities. When they are listed separately in the Bill of Quantities and specified in the Special Specifications they shall be measured in liters, kilograms, or tons in accordance with Subsection 4.05.10 "Measurement" in these General Specifications.

Prime coat, when placed, shall be measured as specified in Section 4.02, "Bituminous Prime Coat and Tack Coat," in these General Specifications. Tack coat shall not be measured.

4.06.10 PAYMENT. Payment shall be made at the contract unit price, or adjusted contract unit price, per cubic meter measured as described above for each lot and type of hot-mix recycled bituminous concrete listed in the Bill of Quantities.

Asphalt cement and modified asphalt cement shall be considered subsidiary to the construction of hot-mix recycled bituminous concrete and shall not be paid for separately unless specifically stated in the Special Specifications and listed in the Bill of Quantities. When they are listed in the Bill of Quantities and specified in the Special

Specifications they shall be paid for as measured in subsection 4.05.11 "Payment" in these General Specifications.

Hot-mix bituminous recycling agent shall be measured as described above and paid for separately unless otherwise specifically stated in the Special Specifications and the item is not listed in the Bill of Quantities.

Prime coat shall be paid for at the contract unit price per liter of bituminous material as listed in the Bill of Quantities.

Tack coat shall be considered subsidiary to the construction of hot-mix recycled bituminous concrete and shall not be paid for unless stated in the Special Specifications and listed in the Bill of Quantities.

Mineral fillers, chemical admixtures, and asphalt modifiers used by the con tractor to meet the Job Mix Formula requirements shall be considered subsidiary to the construction of bituminous emulsion base course and shall not be paid for separately unless specifically stated in the Special Specifications and listed in the Bill of Quantities. When they are listed in the Bill of Quantities and specified in the Special Specifications they shall be paid for as provided in Subsection 4.05.11 Payment" in these General Specifications.

When a lot of Type I or Type II hot-mix recycled bituminous concrete pavement is accepted with non-specified compaction, thickness, aggregate gradation, bituminous material content or surface smoothness, the adjusted contract unit price for said lot shall be the product of the contract unit price for Type I or Type II Hot-Mix Recycled Bituminous Concrete listed in the Bill of Quantities and the appropriate quality and quantity pay factors determined as specified in Subsection 4.06.8, "Quality Assurance Procedures," in these General Specifications.

The above prices and payment shall cover and be full compensation for furnishing labor, materials, equipment, tools and incidentals necessary for completing and performing all work involved in construction of hot-mix recycled bituminous concrete pavement as specified in Subsection 1.07.2, "Scope of Payment," in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO.	PAY ITEM	PAY UNIT
40601	Hot-Mix Recycled Bituminous Concrete Base Course	Cubic Meter
4060101	Hot-Mix Recycled Bituminous Concrete Base Course, Type I, Grading I, Class A	Cubic Meter
4060102	Hot-Mix Recycled Bituminous Concrete Base Course, Type I, Grading I, Class B	Cubic Meter
4060103	Hot-Mix Recycled Bituminous Concrete Base Course, Type I, Grading I, Class C	Cubic Meter
4060104	Hot-Mix Recycled Bituminous Concrete Base Course, Type I, Grading II, Class A	Cubic Meter
4060105	Hot-Mix Recycled Bituminous Concrete Base Course, Type I, Grading II, Class B	Cubic Meter

4060106	Hot-Mix Recycled Bituminous Concrete Base Course, Type I, Grading II, Class C	Cubic Meter
4060107	Hot-Mix Recycled Bituminous Concrete Base Course, Type I, Grading III, Class A	Cubic Meter
4060108	Hot-Mix Recycled Bituminous Concrete Base Course, Type I, Grading III, Class B	Cubic Meter
4060109	Hot-Mix Recycled Bituminous Concrete Base Course, Type I, Grading III, Class C	Cubic Meter
4060110	Hot-Mix Recycled Bituminous Concrete Base Course, Type II, Grading I, Class A	Cubic Meter
4060111	Hot-Mix Recycled Bituminous Concrete Base Course, Type II, Grading I, Class B	Cubic Meter
4060112	Hot-Mix Recycled Bituminous Concrete Base Course, Type II, Grading I, Class C	Cubic Meter
4060113	Hot-Mix Recycled Bituminous Concrete Base Course, Type II, Grading II, Class A	Cubic Meter
4060114	Hot-Mix Recycled Bituminous Concrete Base Course, Type II, Grading II, Class B	Cubic Meter
4060115	Hot-Mix Recycled Bituminous Concrete Base Course, Type II, Grading II, Class C	Cubic Meter
4060116	Hot-Mix Recycled Bituminous Concrete Base Course, Type II, Grading III, Class A	Cubic Meter
4060117	Hot-Mix Recycled Bituminous Concrete Base Course, Type II, Grading III, Class B	Cubic Meter
4060118	Hot-Mix Recycled Bituminous Concrete Base Course, Type II, Grading III, Class C	Cubic Meter
40602	Hot-Mix Recycled Bituminous Concrete Wearing Course	Cubic Meter
4060201	Hot-Mix Recycled Bituminous Concrete Wearing Course, Type I, Grading I, Class A	Cubic Meter
4060202	Hot-Mix Recycled Bituminous Concrete Wearing Course, Type I, Grading I, Class B	Cubic Meter
4060203	Hot-Mix Recycled Bituminous Concrete Wearing Course, Type I, Grading I, Class C	Cubic Meter
4060204	Hot-Mix Recycled Bituminous Concrete Wearing Course, Type I, Grading II, Class A	Cubic Meter
4060205	Hot-Mix Recycled Bituminous Concrete Wearing Course, Type I, Grading II, Class B	Cubic Meter
4060206	Hot-Mix Recycled Bituminous Concrete Wearing Course, Type I, Grading II, Class C	Cubic Meter
4060207	Hot-Mix Recycled Bituminous Concrete Wearing Course, Type I, Grading III, Class A	Cubic Meter
4060208	Hot-Mix Recycled Bituminous Concrete Wearing Course, Type I, Grading III, Class B	Cubic Meter
4060209	Hot-Mix Recycled Bituminous Concrete Wearing Course, Type I, Grading III, Class C	Cubic Meter
4060210	Hot-Mix Recycled Bituminous Concrete Wearing Course, Type II, Grading I, Class A	Cubic Meter
4060211	Hot-Mix Recycled Bituminous Concrete Wearing Course, Type II, Grading I, Class B	Cubic Meter
4060212	Hot-Mix Recycled Bituminous Concrete Wearing Course,	

	Type II, Grading I, Class C	**Cubic Meter**
4060213	**Hot-Mix Recycled Bituminous Concrete Wearing Course, Type II, Grading II, Class A**	**Cubic Meter**
4060214	**Hot-Mix Recycled Bituminous Concrete Wearing Course, Type II, Grading II, Class B**	**Cubic Meter**
4060215	**Hot-Mix Recycled Bituminous Concrete Wearing Course, Type II, Grading II, Class C**	**Cubic Meter**
4060216	**Hot-Mix Recycled Bituminous Concrete Wearing Course, Type II, Grading III, Class A**	**Cubic Meter**
4060217	**Hot-Mix Recycled Bituminous Concrete Wearing Course, Type II, Grading III, Class B**	**Cubic Meter**
4060218	**Hot-Mix Recycled Bituminous Concrete Wearing Course, Type II, Grading III, Class C**	**Cubic Meter**
40603	**Hot Mix Recycling Agent**	**Liter**

SECTION 4.07 - BITUMINOUS CONCRETE FRICTION COURSE

4.07.1 DESCRIPTION. This work shall consist of furnishing and mixing aggregate and bituminous material in a central mixing plant, hauling, spreading and compacting the mixture on a prepared surface, all as shown on the plans, in accordance with these specifications and the Special Specifications and as directed by the Engineer.

Bituminous concrete friction course mixtures shall be produced in batch, continuous pugmill or dryer-drum mixing plant.

ITEMS IN BILL OF QUANTITIES
Bituminous Concrete Friction Course

4.07.2 MATERIALS.

4.07.2.1 Bituminous Material. Bituminous material for bituminous concrete friction course shall be the Viscosity or penetration grade specified in the Special Specifications conforming to the requirements in Table 4.01-1A or 1B, Section 4.01, "Bituminous Materials," in these General Specifications.

4.07.2.2 Aggregate. All aggregate shall be hard durable particles or fragments of crushed stone, crushed slag or crushed gravel free from decomposed materials, organic materials and other deleterious substances. The aggregate shall not contain more than one percent (1.0%) by weight particles having a specific gravity below 1.95.

Unless otherwise specified in the Special Specifications, the combined aggregate, prior to the addition of bituminous material, shall conform to the following gradation and quality requirements:

AGGREGATE GRADING REQUIREMENTS - MRDTM 419

BITUMINOUS CONCRETE FRICTION COURSE

Sieve Size	Percent Passing
12.5 mm (1/2 inch)	100
9.75 mm (3/8 inch)	95-100
4.75 mm (No. 4)	30-50
2.36 mm (No. 8)	5-15
0.075 mm (No. 200)	0-5

QUALITY REQUIREMENTS

Sodium Sulfate Soundness	
Loss, MRDTM 311 - Percent	10 Max.
Abrasion Loss, MRDTM 309 - Percent	30 Max.
Polish Value, MRDTM 317 - Percent	35 Min.
Flakiness Index, MRDTM 423 - Percent	25 Max.
Retained Strength, MRDTM 415 - Percent	50 Min.
Percent Fracture	
2 Face Fracture - Percent	75 Min.
1 Face Fracture - Percent	90 Min.

Percent fracture shall be determined for the material retained on the 2.36 mm (No. 8) sieve. Each fractured face shall have a minimum dimension from edge to edge across the fractured face which is not less than one-third (1/3) the maximum dimension of the aggregate particle.

4.07.2.3 Mineral Fillers. Mineral fillers shall be either Portland cement, blended hydraulic cement or lime conforming to the following requirements:

Materials	Requirement
Portland Cement, Type I or II	ASTM C-150
Blended Hydraulic Cement, Type IP	ASTM C-595
Lime, Type N or S	ASTM C-207

When required, the amount of mineral filler used shall be between one and two percent (1 - 2%) of the weight of the aggregate, with the exact amount to be stated in the Job Mix Formula.

4.07.2.4 Chemical Admixtures and Asphalt Modifiers. The types and amounts of chemical admixtures/asphalt modifiers used shall be limited to those listed in the Special Specifications or proposed by the Contractor and approved by the Ministry's Research and Materials Department to establish compliance with the job mix formula (JMF) requirements contained in Subsection 4.05.3, "Proportioning Bituminous Concrete Mixtures," in these General Specifications.

All chemical admixtures/asphalt modifiers including anti-stripping additives and polymers shall be thoroughly mixed and uniformly combined with the bituminous material.

4.07.3 PROPORTIONING BITUMINOUS CONCRETE FRICTION COURSE MIXTURES.

4.07.3.1 Job Mix Design Proposal. The Contractor shall submit to the Engineer his proposed Job Mix Formula (JMF) in accordance with the requirements of Subsection 4.05.3, "Proportioning Bituminous Concrete Mixtures," in these General Specifications, MRD Manual of Materials and Tests and all current circulars issued by the Ministry of Communications, modified as follows:

1. Marshall test data are not required.

2. The information furnished shall include a specific bituminous material content and the temperature at which the mixture will be discharged from the mixing plant.

3. The type, grade and quantity of any mineral, chemical or asphalt modifier admixture to be added to the mixture shall be stated.

The Engineer shall be provided access to the materials sampling and testing operations at all times.

At the same time that the above information is provided, the Contractor shall supply to the Engineer one hundred (100) kilogram samples of each individual aggregate size, eight (8) liters of bituminous material and, when used, sufficient quantities of mineral filler and chemical admixture to complete two (2) mix design checks, all representing the materials which the Contractor proposes to furnish.

4.07.3.2 Acceptance Job Mix Formula. The Engineer's review and acceptance of the bituminous concrete friction course mixture job mix formula shall be in accordance with Paragraph 4.05.3.2, "Acceptance of Job Mix Formula," in these General Specifications including the field control strip provision.

4.07.3.3 Job Mix Formula Revisions. The Contractor shall not alter his methods of crushing, screening, blending, or stockpiling from that used to produce materials for the approved JMF. Changes to the JMF will not be permitted without retesting and resubmission of a proposed (revised) JMF in accordance with all the steps in Paragraph 4.07.3.1, "Job Mix Design Proposal," in these General Specifications. Significant changes may include, but not be limited to, changes in the amount or type of materials rejected or wasted, changes in the amount of materials crushed, reductions in the amount of crushed fines, changes in the amount and type of mineral filler and mineral and chemical admixtures to be used.

Should the Contractor change his source of supply of aggregate and grade of bituminous material, he shall furnish a new information and samples of materials, as described in Paragraph 4.07.3.1, "Job Mix Design Proposal," in these General Specifications as determined by the Engineer to be necessary, at least twenty-one (21) days before their intended use. At any time after the JMF is approved the Contractor may submit a new JMF for approval by the Engineer. If the revised JMF is approved it shall become the approved JMF.

The Engineer may at any time require a change in the JMF which will provide a bituminous emulsion treated base that best conforms to the quality intended by the specifications.

4.07.4 EQUIPMENT. The Contractor shall supply the proper type and sufficient numbers of equipment to complete the work within the Contract time and in accordance with his Program of Work as approved by the Engineer.

4.07.5 WEATHER LIMITATIONS. Bituminous concrete friction course shall not be placed on any wet or frozen surface, during dust or sand storms, when wind or other weather conditions prevent the proper handling of the bituminous mixture or when the average temperature of the surface on which the mixture is to be placed is less than twenty-five degrees Celsius (25° C.).

4.07.6 CONSTRUCTION. Construction and quality control testing shall be performed in accordance with the requirements specified in Subsection 4.05.6, "Construction," in these General Specifications, modified as follows:

1. Marshall testing will not be required.

2. When the Contractor elects to use a plant equipped with hot-feed control, aggregate for bituminous concrete friction course, before being fed to the drier, need not be separated into sizes and stored separately. After being dried, aggregate for bituminous concrete friction course shall be separated into two (2) or more sizes and each size stored in a separate bin.

3. When the Contractor elects to use a plant equipped with cold-feed control, aggregate for bituminous concrete friction course, before being fed to the drier, shall be separated into two or more sizes and stored separately.

4. When discharged from the mixing plant, the temperature of the bituminous concrete friction course shall not exceed one hundred thirty-five degrees Celsius (135° C.).

5. Bituminous concrete friction course material shall be stored in silos only. All bituminous concrete friction course material placed in storage during any day shall be used before darkness. Any material remaining in storage at darkness shall be removed from storage and disposed of as may be approved by the Engineer.

6. Trucks used in hauling bituminous concrete friction course material shall be equipped with approved covers for the total area of load. When the air temperature is less than twelve degrees Celsius (12° C.) and the length of haul exceeds ten (10) kilometers, the bituminous concrete friction course material shall be covered, except when the Engineer approves otherwise.

7. Bituminous concrete friction course material shall be dumped directly into the hopper of a self-propelled paving machine. Dumping directly on the surface shall not be permitted.

8. Bituminous concrete friction course material shall be spread at a temperature not less than ninety-five degrees Celsius (95° C.) and not more than one hundred twenty (120° C.), measured in the hopper of the paving machine. Bituminous concrete friction course shall be spread at a rate between forty-five (45) and sixty (60) kilograms per square meter as necessary to provide a compacted thickness which is not less than eighteen (18) millimeters.

9. Bituminous concrete friction course shall be rolled only with a steel-tired, two (2) axle-tandem roller weighing not less than ten thousand (10,000) kilograms. Initial or breakdown rolling shall consist of three (3) coverages of the layer of bituminous concrete friction course and begin immediately after spreading of the bituminous concrete friction course material. Finish rolling shall follow breakdown rolling without delay and continue until the surface is smooth, without ridges or indentations.

10. When directed by the Engineer, the Contractor shall place a fog seal conforming to the requirements specified in Section 4.03, "Bituminous Surface Treatments," in these General Specifications.

4.07.7 TRAFFIC CONTROL. The Contractor shall take effective action to permit traffic to safely pass through bituminous concrete friction course construction work zones as specified in Subsection 4.05.7, "Traffic Control," in these General Specifications.

4.07.8 QUALITY ASSURANCE PROCEDURES. Bituminous Concrete Friction Course shall be accepted by lot. Unless otherwise stated in the Special Specifications, the lot size shall be five thousand (5,000) square meters. The bituminous concrete friction course shall be sampled, tested, and evaluated in accordance with Section 1.08, "Acceptance of Work," in these General Specifications. The Engineer may, during the beginning of placement of bituminous concrete friction course, at times when test results indicate erratic quality characteristics and at any other time, reduce the lot size to sections with similar quality characteristics. This should facilitate the isolation and modification or replacement of low-quality materials with materials of acceptable quality to maintain the overall strength of the pavement structure.

The Engineer shall perform or supervise the performance of all quality assurance sampling and testing. The location of all lots shall be recorded by roadway, lane and centerline station (kilometer). Quality assurance sampling and testing for each lot shall include:

1. Thickness
2. Aggregate Gradation and Bituminous Material Content
3. Surface Smoothness

4.07.8.1 Thickness. A lot shall be accepted when the average thickness is not less than the planned thickness. The bituminous concrete friction course thickness will be sampled, tested and evaluated as detailed in Paragraph 4.05.8.2, "Thickness," in these General Specifications.

The Contractor shall backfill density and thickness test holes with bituminous concrete friction course or other material approved by the Engineer.

4.07.8.2 Aggregate Gradation and Bituminous Material Content. The upper and lower specification units are the approved job-mix target values plus or minus the allowable deviations shown in Table 4.05-1 for Bituminous Wearing Course in these General Specifications.

Samples of bituminous concrete friction course shall be taken on a random time basis from the uncompacted pavement immediately behind the paving machine. The initial sample shall be randomly selected from within one and one-half (1 1/2) meters either side of the center line of the lane being paved and weigh at least twenty-five (25) kilograms. The samples shall be thoroughly mixed and quartered to obtain a test sample weighing at least six (6) kilograms. The test sample shall be forwarded to the laboratory and the aggregate gradation and bituminous material content determined by extraction.

The bituminous concrete friction course aggregate gradation and bituminous material content will be sampled, tested and evaluated as detailed in paragraph 4.05.8.3, "Aggregate Gradation and Bituminous Material," in these General Specifications.

4.07.8.3 Surface Smoothness. When a straightedge four (4) meters in length is laid on the finished surface of the base parallel with the centerline, the surface shall have no depressions greater than three (3) millimeters from the lower edge of the straightedge. When the straightedge is laid traverse to the centerline, the surface shall have no depressions greater than six (6) millimeters from the lower edge of the straightedge.

4.07.8.4 Acceptance. Bituminous materials will be accepted under Subsection 1.08.3, "Certification of Compliance," in accordance with Subsection 4.01.4, "Acceptance Procedures for Bituminous Materials," in these General Specifications.

Bituminous concrete friction course construction including surface smoothness will be accepted under Subsection 1.08.4, "Measured or Tested Conformance," in these General Specifications.

Bituminous concrete friction course thickness, aggregate gradation, and bituminous material content will be accepted under Subsection 1.08.5, "Statistical Evaluation of Work for Acceptance and Determination of Pay Factor (Value of Work)," in these General Specifications in two (2) stages as follows:

The first stage shall be the selection of the lowest of the two (2) pay factors for the quality of the bituminous concrete friction course relating to aggregate gradation and bituminous content. The second stage involves the selection and application of a quantity pay factor based on the thickness of the bituminous concrete friction course. The second stage thickness quantity pay factor will be applied to all the individual course lots in addition to the first stage lowest quality pay factor determined in accordance with Subsection 1.08.5, "Statistical Evaluation of Work for Acceptance and Determination of Pay Factor (Value of Work)," in these General Specifications.

4.07.9 MEASUREMENT. Bituminous concrete friction course shall be measured by the square meter, as placed and compacted within the lines and grades shown on the plans, specified in the specifications and Special Specifications and as directed by the Engineer. No measurement will be made of areas of bituminous concrete friction course placed outside authorized limits.

Asphalt cement and modified asphalt cement shall be considered subsidiary to the construction of the bituminous concrete and shall not be measured separately unless specifically stated in the Special Specifications and listed in the Bill of Quantities. When it is listed separately it shall be measured as provided in Subsection 4.05.10 "Measurement" in these General Specifications.

Tack coat and fog seal will not be measured.

Mineral fillers, chemical admixtures and asphalt modifiers used by the contractor to meet the Job Mix Formula (JMF) requirements will be considered subsidiary to the construction of the bituminous concrete friction course and will not be measured separately unless specifically stated in the Special Specifications and listed in the Bill of Quantities. When they are listed in the Bill of Quantities and specified in the Special Specifications they shall be measured in liters, kilograms, or tons in accordance with Subsection 4.05.10 "Measurement" in these General Specifications.

4.07.10 PAYMENT. Payment shall be made at the contract unit price, or adjusted contract unit price, per square meter measured as described above for each square meter of Bituminous Concrete Friction course when listed in the Bill of Quantities.

When a lot of bituminous concrete friction course is accepted with a deficiency, the adjusted contract unit price for said lot shall be the product of the contract unit price and the lowest quality and quantity pay factors specified in Subsection 4.07.8, "Quality Assurance Procedures," in these General Specifications.

Tack coat and fog seal shall be considered subsidiary to the construction of bituminous concrete friction course and shall not be paid for separately.

Asphalt cement, modified asphalt cement, mineral fillers, chemical admixtures, and asphalt modifiers shall be considered subsidiary to the construction of bituminous concrete friction course and shall not be paid for separately unless specifically stated in the Special Specifications and listed in the Bill of Quantities. When they are listed in the bill of Quantities and specified in the Special Specifications they shall be paid for as provided in Subsection 4.05.11 "Payment" in these General Specifications.

The above price and payment shall cover and be full compensation for furnishing labor, materials, equipment, tools and incidentals necessary to completing all work involved in construction of bituminous concrete friction course as in Subsection 1.07.2, "Scope of Payment," in these General Specifications.

PAYMENT WILL BE MADE UNDER THE FOLLOWING:

ITEM NO.	PAY ITEM	PAY UNIT
40701	Bituminous Concrete Friction Course	Square Meter

SECTION 4.08 - BITUMINOUS-RUBBER STRESS ABSORBING MEMBRANE

4.08.1 DESCRIPTIONS. This work consists of placing a bituminous-rubber stress absorbing membrane on the surface of an existing pavement as a wearing course or in preparation for placing an overlay of bituminous concrete pavement, as shown on the plans, specified in these specifications, the Special Specifications and as directed by the Engineer.

The membrane shall be undesignated or designated as Bituminous-Rubber Membrane, Bituminous-Rubber Membrane, Class 1, or Bituminous-Rubber Membrane, Class 2.

ITEMS IN BILL OF QUANTITIES
Bituminous-Rubber Membrane

4.08.2 MATERIALS.

4.08.2.1 Bituminous Binder. Bituminous binder shall be the Viscosity or Penetration Grade specified in the Special Specifications conforming to the requirements in Table 4.01-1A or 1B, in Section 4.01, "Bituminous Materials," in these General Specifications.

4.08.2.2 Rubber. Rubber for use in bituminous-rubber binder shall be of the type specified, free of loose fabric, wire and other contaminants except that calcium carbonate talc, in the maximum amount of four percent (4%) by weight of rubber, may be added to the rubber to prevent sticking together or caking of the rubber particles. Sieves required for testing rubber particle gradation shall comply with the requirements of AASHTO M-92.

4.08.2.3 Class 1 Bituminous-Rubber Binder. Class I bituminous-rubber binder shall consist of bituminous binder and diluent, if used, and ground tire rubber. The exact proportions shall be determined by the Engineer.

1. Bituminous binder for use in Class 1 bituminous-rubber binder shall be, at the option of the Contractor, Viscosity Grade AC-5 or AC-10.

2. Rubber for use in Class 1 bituminous-rubber binder shall consist of ground tire rubber and shall conform to the following:

GRADATION
(ASTM D-1151)

Sieve Size	Percent Passing
2.36 mm (No. 8)	100
2.00 mm (No. 10)	95-100
0.600 mm (No. 30)	0-10
0.300 mm (No. 50)	0-2

The specific gravity of the ground rubber shall be between 1.10 and 1.20.

3. Diluent, if used, shall be a solvent compatible with other materials of the mixture and conforming to the following requirements:

Test	ASTM Designation	Requirement Degrees Celsius
Flashpoint	D-92	27 Min.
Initial Boiling Point	D-850	177 Min.
Dry Point	D-850	232 Max.

Class 1 bituminous-rubber binder shall consist of between seventy-four and eighty percent (74 - 80%) bituminous binder of the grade selected by the Contractor, including diluent if used, and between twenty and twenty-six percent (20 - 26%) rubber, by weight of the total bituminous-rubber binder. The exact percentage will be determined by the Engineer.

The temperature of the bituminous binder, at the time rubber is added, shall be between one hundred seventy-five and two hundred twenty degrees Celsius (175-220° C.). The bituminous binder and rubber shall be combined and mixed together in the blending equipment until an homogeneous material is produced. The bituminous-rubber mixture shall be mixed for a minimum of thirty (30) minutes at not less than one hundred twenty nor more than two hundred twenty degrees Celsius (120-220° C.).

Diluent, if used, shall be added to the bituminous-rubber mixture to adjust the fluidity of the mixture for ease of spraying. Diluent shall be added to the bituminous-rubber mixture, at a rate not to exceed seven and one-half percent (7.5%) by volume of the bituminous-rubber mixture. The exact rate will be determined by the Engineer. The temperature of the bituminous-rubber mixture shall be less than the boiling point of the diluent at the time the diluent is added to the mixture.

Class 1 Bituminous-Rubber Binder shall be applied to the surface to receive the stress absorbing membrane after reaching the desired consistency and shall not be held at temperatures exceeding one hundred sixty degrees Celsius (160° C) for more than four (4) hours.

4.08.2.4 Class 2 Bituminous-Rubber Binder. Class 2 bituminous rubber binder shall consist of bituminous binder, extender oil and ground vulcanized rubber. The exact proportions will be determined by the Engineer.

1. Bituminous binder for use in Class 2 bituminous-rubber binder shall be, at the option of the Contractor, Viscosity Grade AC-5 or AC-10.

2. Rubber for use in Class 2 bituminous-rubber binder shall consist of vulcanized ground rubber and shall contain between twenty and thirty percent (20 and 30%), by weight, of natural rubber, when tested in accordance with ASTM D-297. The rubber shall conform to the following:

GRADATION
(ASTM D-1151)

Sieve Size	Percent Passing
2.36 mm (No. 8)	100
0.600 mm (No. 30)	25-50
0.300 mm (No. 50)	5-45
0.150 mm (No. 100)	0-10

3. Extender oil shall be a resinous high flash point aromatic hydrocarbon compound conforming to the following:

Test	ASTM Designation	Requirement
Viscosity, SSU at 38 degrees Celsius	D-88	2500 Min.
Flash Point, COC degrees Celsius	D-92	200 Min.
Molecular Analysis: Percent by Weight		
Maltenes -	D-200	70.1 Max.
Aromatics -	D-200	755 Min.

Extender oil shall be added to the bituminous material at a rate between one (1) and seven percent (7%) by weight, when the bituminous material is at a temperature between one hundred twenty and two hundred twenty degrees Celsius (120 - 220 ° C.).

Class 2 bituminous-rubber binder shall consist of between seventy-eight and eighty-two percent (78 - 82%) bituminous binder of the grade selected by the Contractor, including extender oil, and between eighteen and twenty-two percent (18 - 22%) rubber, by weight of the total bituminous-rubber binder. The exact percentage will be determined by the Engineer.

The temperature of the bituminous binder and extender oil, at the time rubber is added, shall be between one hundred seventy-five and two hundred twenty degrees Celsius (175-220° C.). The bituminous binder, extender oil and rubber shall be combined and mixed together in the blending equipment until an homogeneous material is produced. The bituminous-rubber mixture shall be mixed for a minimum of forty-five (45) minutes at a temperature not less than one hundred ninety (190) or more than two hundred twenty (220) degrees Celsius.

The viscosity of the Class 2 bituminous-rubber binder at the time of application shall be between six hundred (600) and two thousand (2000) cps, when tested in accordance with ASTM D-2994. The exact viscosity shall be as directed by the Engineer. Class 2 bituminous-rubber binder shall be applied to the surface to receive the stress absorbing membrane after reaching the desired viscosity and shall not be held at a temperature exceeding two hundred (200) degrees Celsius for more than four (4) hours.

The Contractor shall provide the Engineer, not less than fifteen (15) days prior to beginning work, with a certificate stating that the materials proposed for use in the particular class of bituminous-rubber binder meet all the requirements specified in this specification and the Special Specifications.

Bituminous-rubber binder shall not be applied after it has been retained more than 48 hours.

4.08.2.5 Aggregate Screenings. Aggregate screenings shall conform to the grading and quality requirements for grading VI in Paragraph 4.03.2.3, "Aggregate," in these General Specifications.

Aggregate screenings for construction of bituminous-rubber stress absorbing membrane shall be preheated to a temperature between one hundred forty-five and one hundred seventy-five degrees Celsius (145 - 175°C.) and then precoated with bituminous binder, Grade AC-5 or AC-10 conforming to the requirements in Table 4.01-1A, Section 4.01, "Bituminous Materials," in these General Specifications, in the amount of one-half to one percent (1/2 - 1%) by weight of dry aggregate. Immediately after precoating, the aggregate screenings shall be deposited in hauling equipment. Stockpiling of aggregate screenings after precoating will not be permitted.

Canvas or similar covers that completely cover each load of aggregate screenings shall be used during hauling to minimize temperature drop of the precoated aggregate. Aggregate screenings shall be spread before the temperature of the precoated screenings, at the time of depositing on the roadway, drops below one hundred five degrees Celsius (105° C.).

4.08.3 ACCEPTANCE OF MATERIALS. The materials will be accepted by the Engineer for placement on the roadway, after the required certificates have been furnished by the Contractor, in accordance with Paragraph 1.08.3, "Certification of Compliance," in these General Specifications. The bituminous-rubber binder has been blended in the proportions determined by the Engineer, the materials shall be mixed for the specified time period, the temperature of the bituminous-rubber binder shall be as specified and the aggregate screenings shall conform to the grading and quality requirements, have been preheated and precoated as specified and are above the minimum temperature specified at the time of spreading.

4.08.4 EQUIPMENT. The Contractor shall furnish and operate sufficient equipment in accordance with his Program of Work as approved by the Engineer and shall include:

1. Rotary type brooms, aggregate spreaders, bituminous materials distributors and equipment for heating bituminous materials and all equipment conforms to the requirements of Section 4.03, "Bituminous Surface Treatment," in these General Specifications. The bituminous material distributor shall be equipped with pumps and spray bar nozzles suitable for applying bituminous-rubber binder.

2. A minimum of three self-propelled pneumatic-tired rollers having a minimum weight of thirteen hundred (1300) kilograms on each wheel and an inflation pressure

between six and one-half and seven and one-half (6.5-7.5) kilograms per square centimeters in each tire.

3. A mechanical blender for proper proportioning and thorough mixing of the bituminous material and rubber together to produce the specified rubber content material. The unit shall have both an asphalt totalizing meter reading in liters and a flow meter reading in liters per minute.

4. The Contractor shall provide a skilled technician to accompany the distributor at all times and ride in a position so that all spray bar nozzles are in full view at all times and readily accessible in the event of plugging.

5. Trucks for hauling aggregate screenings shall be tail-gate discharge and shall be equipped with a device to lock onto the hitch at the rear of the aggregate spreader. Haul trucks shall be compatible with the aggregate spreader so that the dump bed will not push down on the aggregate spreader when fully raised or have too short a bed so that the aggregate screenings are spilled on the roadway surface while dumping into the aggregate spreader.

4.08.5 WEATHER LIMITATIONS. Subject to the determination of the Engineer, bituminous-rubber binder shall not be applied during sand or dust storms, rainfall, or before any imminent storms that might damage the construction. The Engineer shall have the discretion as to whether the surface on which bituminous-rubber binder is to be applied is dry enough to proceed.

Bituminous-rubber binder shall only be applied when the atmospheric temperature is twenty degrees Celsius (20° C.) or above and the temperature of the surface on which bituminous-rubber binder is to be applied is twenty-five degrees Celsius (25° C.) or above.

4.08.6 TRAFFIC CONTROL. While construction of a bituminous-rubber stress absorbing membrane is in progress, the treated surface of the roadway shall not be used by the Contractor, his agents or others until the Engineer is satisfied that the treated surface will not be damaged by traffic and has given approval for traffic to use the treated surface.

The Contractor shall erect and maintain signs, barricades and other traffic control devices and shall take effective action to exclude traffic of any description from the roadway surface for as long as may be required in the judgement of the Engineer. When traffic is restricted to a one-way basis, the Contractor shall provide such flagmen and pilot cars as deemed necessary for the protection of traffic and the treated surface. One-way traffic will not be permitted after dark. Traffic may be detoured around the construction, provided detours are properly constructed, signed and marked. When it is necessary to permit traffic to cross the treated surface, the crossing shall be blotted with sand, as directed by the Engineer, before the crossing is opened to traffic. Removal of excess aggregate screenings shall be completed before uncontrolled traffic is permitted on the bituminous-rubber stress absorbing membrane. All traffic control work will be done in accordance with Section 9.02, "Traffic Control through Work Zones," in these General Specifications.

4.08.7 CONSTRUCTION.

4.08.7.1 Preparation of Surface to Receive Bituminous-Rubber Stress Absorbing Membrane. Surfaces to receive bituminous-rubber stress absorbing membrane shall be prepared as specified for treated surfaces in Paragraph 4.03.7.1, "Preparation of Surfaces to Receive Bituminous Surface Treatment," in these General Specifications.

4.08.7.2 Adjustment of the Distributor. The distributor for applying bituminous-rubber binder shall be adjusted and maintained as described in Paragraph 4.03.7.3, "Adjustment of the Distributor," in these General Specifications.

4.08.7.3 Procedures for Applying Bituminous-Rubber Binder. The bituminous-rubber binder shall be applied at a rate between two and two-tenths and two and nine-tenths (2.2-2.9) liters per square meter to one-half (1/2) of the roadway surface at temperatures specified in this specification using distributors. The exact rate will be determined by the Engineer.

Areas missed during the application of bituminous-rubber binder shall be immediately covered using the hand held nozzle and the same class of bituminous-rubber binder.

The area covered with bituminous-rubber binder shall be no larger than can be covered with aggregate screenings within five (5) minutes from the time of application of bituminous-rubber binder.

Unless otherwise approved by the Engineer, construction of the bituminous-rubber stress absorbing membrane shall progress towards the source of aggregate screenings being applied.

Where application of the bituminous-rubber binder begins at the end of a previous application of bituminous-rubber binder, and when directed by the Engineer, the Contractor shall cover the full width of the end of the previous application with building paper at least eighty (80) centimeters wide and weighing at least one and one-half (1.5) kilograms per square meter. The application of bituminous-rubber binder shall begin on the paper when the distributor is advancing at a speed that provides for uniform distribution of the bituminous-rubber binder. The building paper shall be removed before application of the aggregate screenings.

Where the bituminous-rubber binder is placed alongside of a previous application of bituminous-rubber binder, all joint edges shall be swept clean of overlapping aggregate screenings, prior to the application of bituminous-rubber binder. The application of bituminous-rubber binder shall be placed against the edge of the previous application and all reasonable precautions shall be taken to avoid skips and overlaps at joints. Defects, as determined by the Engineer, shall be corrected by the Contractor.

4.08.7.4 Procedures for Applying Aggregate Screenings. After the bituminous-rubber binder has been evenly spread over the roadway surface, aggregate screenings shall be evenly applied to the roadway surface by a self-propelled spreader box at a rate between twelve (12) and sixteen (16) kilograms per square meter.

The aggregate spreader shall not be more than twenty (20) meters behind the bituminous-rubber binder distributor unless otherwise ordered by the Engineer. Trucks hauling aggregate screenings shall be kept clear of the freshly placed aggregate screenings until ready to dump aggregate in the spreader equipment.

The aggregate shall be spread in one (1) operation. Where necessary, thin or bare spots in the spread of aggregate shall be immediately corrected by hand spreading or other methods as may be approved by the Engineer.

As soon as the aggregate has been spread on the roadway, it shall be rolled with one or more pneumatic-tired rollers. The distance between the rollers and aggregate spreader shall not exceed seventy-five (75) meters at any time during the application of bituminous-rubber binder and aggregate spreading operations.

A total of four (4) complete coverages with pneumatic-tired rollers shall be made on the bituminous-rubber stress absorbing membrane.

4.08.8 MAINTENANCE OF SURFACE. The completed stress absorbing membrane shall be maintained and all damage resulting from any cause shall be repaired by the Contractor at his expense until such time as the project or portions of the contract have been accepted in writing by the Engineer.

4.08.9 PROGRESS OF WORK. The Contractor shall furnish and operate sufficient equipment, produce or purchase and make timely delivery of materials and organize his work so that his progress is equivalent to that contained in the approved work schedule. Work shall be commenced where the Engineer directs. The full width of the roadway to receive bituminous-rubber stress absorbing membrane shall be completed each day.

4.08.10 PROTECTION OF FACILITIES. All traffic and roadside facilities shall be protected from splashing of materials. The Contractor shall immediately clean and repair any vehicle and roadside facility coated or damaged by materials. Protection, cleaning and repair shall be at the Contractor's costs.

4.08.11 MEASUREMENT. Bituminous-rubber stress absorbing membrane completed within the lines shown on the plans or ordered by the Engineer shall be measured in square meters.

When bituminous wearing course material is furnished and placed for reshaping the roadway cross section or as a wearing surface as shown on the plans, specified or directed by the Engineer, it shall be measured in cubic meters in accordance with the methods described in Section 4.05, "Bituminous Concrete Pavement," in these General Specifications.

4.08.12 PAYMENT. Bituminous-rubber stress absorbing membrane completed as specified and measured shall be paid for at the contract unit price, or adjusted contract unit price, per square meter listed in the Bill of Quantities.

When bituminous concrete wearing course material is furnished and placed as specified and measured, it shall be paid for at the contract unit price per cubic meter listed in the Bill of Quantities for "Bituminous Concrete Wearing Course."

No separate payment shall be allowed for any materials placed outside the limits shown on the plans or directed by the Engineer.

Payment for traffic control shall be in accordance with Section 9.02, "Traffic Control through Work Zones," in these General Specifications.

No separate payment shall be allowed for rolling.

Prices and payments made under this section shall cover and be full compensation for furnishing labor, equipment, materials, tools and incidentals necessary to completing all work involved in the construction of bituminous-rubber stress absorbing membrane as specified in Subsection 1.07.2, "Scope of Payment," in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO.	PAY ITEM	PAY UNIT
40801	Bituminous-Rubber Membrane	Square Meter
4080101	Bituminous-Rubber Membrane, Class 1	Square Meter
4080102	Bituminous-Rubber Membrane, Class 2	Square Meter

SECTION 4.09 - COLD MIX RECYCLED BITUMINOUS BASE

4.09.1 DESCRIPTION. Cold mix recycled bituminous base shall consist of cold milled, crushed or pulverized bituminous concrete blended with one or more of the following materials:

1. Aggregate base material underlying the bituminous surface.
2. New crushed aggregate.
3. Liquid or emulsified bituminous materials.
4. Recycling oil, emulsified or non-emulsified.
5. Water

The Contractor shall cold mill, crush or pulverize bituminous concrete, blend and mix with additional materials, place and compact the mixed materials and finish the recycled bituminous base, all as shown on the plans and specified in these General Specifications and the Special Specifications.

ITEMS IN BILL OF QUANTITIES
Cold Mix Recycled Bituminous Base Course
Cold Mix Recycling Agent

4.09.2 MATERIALS. Materials for cold mix recycled bituminous base shall be as specified in the Special Specifications and include one or more of the following:

4.09.2.1 Pulverized Bituminous Concrete. Pulverized bituminous concrete, referred to in this specification as RAP (Recycled Asphalt Pavement), shall conform to the following gradation after mixing with all additional materials:

Sieve Size	Percent Passing
37.5 mm (1 1/2 inches)	100

4.09.2.2 Aggregate Base Underlying Bituminous Surface. Aggregate base underlying the bituminous surface shall be blended with RAP to the depth shown on the plans or specified in the Special Specifications.

4.09.2.3 New Aggregate. When specified in the Special Specifications or required by the Job Mix Formula, new aggregate shall be blended with RAP. The new aggregate shall conform to the fracture, gradation and quality requirements as necessary to produce the specified base course when combined with the RAP.

1. When the specified base course consists of RAP or RAP and additional aggregate blended with water. The combined materials shall conform to the requirements specified for Aggregate Base, Grading II in Section 3.03, "Aggregate Bases," in these General Specifications.

2. When the specified base course consists of RAP or RAP with additional aggregate blended with recycling oil and/or liquid and emulsified bituminous material, the combined materials shall conform to the requirements for Type II base specified in Section 4.04, "Bituminous Emulsion Dense Graded, Type II," in these General Specifications.

4.09.2.4 Liquid and Emulsified Bituminous Materials. The types and grades of bituminous materials shall conform to the Grade listed in the Special Specifications and requirements specified in the following tables in Section 4.01, "Bituminous Materials," in these General Specifications:

1. Liquid Bituminous Material. Tables 4.01-2 and 4.01-3
2. Emulsified Bituminous Material. Tables 4.01-4 and 4.01-5

4.09.2.5 Cold Mix Recycling Agent. Cold mix recycling agent shall conform to the requirements listed in Tables 4.09-1 or 4.09-2 or as specified in the Special Specifications.

TABLE 4.09-1
RECYCLING OIL

Property	ASTM/AASHTO Test Method	Requirement Light Grade	Requirement Medium Grade
Viscosity @ 60° C (140° F) cSt	T202	200-800	1000-4000
Flash Point, C.O.C., C(F) minimum	T48	205 (400)	219 (425)
Saturates, Wt, %	D 2007	28 Max.	30 Max.
Tests on Residue	T240 or		
From RTFO (Note 1)	T179		
or TFO Oven @ 163° C (325° F):			
Wt, Change, ± %		4.0 Max.	2.0 Max.
Viscosity Ratio (See Note 2)		2.5 Max.	2.5 Max.

Notes:

1. RTFO = Rolling Thin Film-Circulating Oven

2. Viscosity Ratio = $\frac{\text{RTFO Residue Viscosity @ 60° C (140° F), cSt}}{\text{Viscosity of the Original Material @ 60° C (140° F), cSt}}$

TABLE 4.09-2
EMULSIFIED RECYCLING AGENT (Note 1)

Property	Test Method	Requirement
Viscosity @ 25 degrees C., SFS	ASTM D 244	15-85
Pumping Stability	G.B Method (Note 2)	Pass
Emulsion Coarseness, %	Sieve Test ASTM D 244 (Note 3)	0.1 Max.
Sensitivity to Fines, %	Cement Mixing ASTM D 244	2.0 Max.
Particle Charge	ASTM D 244	Positive
Concentration of Oil Phase, %	ASTM D 244 (Note 4)	60 Min.

Notes:

1. Oils used for emulsions must meet specifications listed in Table 4.09-I or as specified in the Special Specifications.

2. Pumping stability is determined by charging four hundred fifty (450) milliliters of emulsion into a one (1) liter beaker and circulating the emulsion through a gear pump (Roper 29.B22621) having six and three-tenths (6.3) millimeters inlet and outlet. The emulsion passes if there is no significant oil separation after circulating ten (10) minutes.

3. Test procedure identical with ASTM D 244 except that distilled water will be used in place of two percent (2%) sodium oleate solution.

4. ASTM D 244 Evaporation Test for percent residue is modified by heating fifty (50) gram sample to one hundred fifty degrees Celsius (150° C.) until foaming ceases, then cooling immediately and calculating results.

Test reports and Certificates of Compliance shall be furnished with each shipment of emulsified recycling agent.

4.09.3 PROPORTIONING COLD MIX RECYCLED BITUMINOUS BASE MIXTURES.

4.09.3.1 Job Mix Design Proposal. A proposed Job Mix Formula (JMF) shall be formulated by the Contractor and submitted to the Engineer for approval. The JMF shall be prepared by the Contractor in precise compliance with procedures and requirements set forth in the MRD Manual of Materials and Tests and all current circular letters issued by the Ministry of Communications.

The Contractor shall select his sources of aggregate and bituminous material and, after sufficient quantities have been stockpiled or are available for use, obtain representative samples of the materials and test to determine if they conform to the requirements of these specifications.

Cold mix recycled bituminous base specified to conform to Section 3.03, "Aggregate Bases," in these General Specifications shall be produced as specified in Section 3.03. The Contractor shall submit to the Engineer his proposed method of operation and test data confirming that the base will conform to all specified fracture, gradation and quality requirements.

Cold mix recycled bituminous base specified to conform to Section 4.04, "Bituminous Emulsion Treated Base," in these General Specifications shall be prepared as follows:

The Contractor shall perform all testing required to establish the proportions of each material to be combined to produce the specified base.

The Contractor shall submit the following information:

1. For the RAP. Extracted bituminous material content as a percent of dry aggregate and the gradation of the aggregate. Penetration of the bituminous material recovered from the RAP. One test shall be furnished for every one thousand (1,000) cubic meters of pavement to be pulverized and recycled.

2. Added aggregate. Fracture, gradation and quality requirements which, when blended with the RAP will produce all requirements specified for Type II Bituminous Emulsion Treated Base in Section 4.04, "Bituminous Emulsion Treated Base," in these General Specifications.

3. Estimate total bituminous material demand based on mix design requirements for bituminous base in Section 4.05 "Bituminous Concrete Pavement," in these General Specifications.

4. Determine type, grade and quantity of liquid or emulsified bituminous material to be added to the RAP and added aggregate. The criteria shall be:

(1) The total bituminous material demand as determined in Number 3, above, will be met and,

(2) The combined bituminous material in the RAP will have a penetration not less than forty (40).

5. Results obtained from trial mixes prepared in accordance with the requirements specified in Section 4.05, "Bituminous Concrete Pavement," in these General Specifications.

6. Recommended JMF with the following information:

(1) The percentage of RAP to be used, by total weight of mix.

(2) The gradation of each aggregate to be blended and the percent of each aggregate, by total weight of mix.

(3) The type grade and percent of bituminous material to be added, by total weight of mix.

(4) The type and percent of cold-mix recycling agent to be added, by total weight of mix.

(5) The results of all tests performed by the Engineer.

(6) The theoretical maximum unit weight of the mixture based on ASTM D 2041.

At the same time the above information is provided, the Contractor shall obtain representative samples of all materials specified to be furnished and submit said samples to the Engineer. Not less than one hundred (100) kilograms of RAP and each size aggregate, eight (8) liters of each type and grade bituminous material and four (4) liters of emulsified recycling agent shall be furnished. The emulsified recycling agent shall be identified by trade-name, grade and source of supply.

4.09.3.2 Acceptance of Job Mix Formula. The Engineer's review and acceptance of the Cold Mix Recycled Bituminous base mixture job mix formula shall be in accordance with Paragraph 4.05.3.2, "Acceptance of Job Mix Formula," in these General Specifications including the field control strip provision.

4.09.3.3 Job Mix Formula Revisions. The Contractor shall not alter his methods of crushing, screening, blending, or stockpiling from that used to produce materials for the approved JMF. Changes to the JMF will not be permitted without retesting and resubmission of a proposed (revised) JMF in accordance with all the steps in Paragraph 4.09.3.1, "Job Mix Design Proposal," in these General Specifications. Significant changes may include, but not be limited to, changes in the amount or type of materials rejected or wasted, changes in the amount of materials crushed, reductions in the amount of crushed fines, changes in the amount and type of mineral filler and mineral and chemical admixtures to be used.

Should the Contractor change his source of aggregate and grade of bituminous material, he shall furnish a new information and samples of materials, as described in Paragraph 4.09.3.1, "Job Mix Design Proposal," in these General Specifications as determined by the Engineer to be necessary, at least twenty-one (21) days before their intended use.

At any time after the JMF is approved the Contractor may submit a new JMF for approval by the Engineer. If the revised JMF is approved it shall become the approved JMF.

The Engineer may, at any time, require a change in the JMF which will provide a cold mix recycled bituminous base mixture that conforms to the quality intended by the specifications.

4.09.4 EQUIPMENT. The Contractor shall furnish all equipment as may be necessary to produce cold mix recycled bituminous base in accordance with the plans, specifications and his Program of Work as approved by the Engineer. Such equipment shall be suitable for performing the following functions:

1. Pavement reduction (reducing to required gradation). Such equipment may include, at the Contractor's option, cold milling machines, rotary type pulverizers, rippers, jaw crushers, hammermills or such other devices that may be approved by the Engineer.

2. Blending and mixing. Such equipment may include, at the Contractor's option, attachments to the cold milling equipment which introduce and uniformly mix bituminous material with RAP, cold mixing pugmills, rotary type stabilizers, cross shaft travel plants or other equipment that may be approved by the Engineer.

3. Spreading and compaction. Standard equipment used for placing and compacting bituminous concrete pavement, Midland-Type mix paver or similar equipment utilizing a floating strike-off screed as approved by the Engineer.

Any equipment furnished by the Contractor, whether or not approved by the Engineer, which at any time fails to produce cold mix recycled bituminous base as planned and specified shall be removed from the work.

4.09.5 WEATHER LIMITATIONS. Cold mix recycled bituminous base shall not be mixed or placed during rainfall, dust or sand storms, when the ambient temperature is less than five degrees Celsius (5° C.) or when weather conditions prevent specified mixing and compaction requirements.

4.09.6 CONSTRUCTION. Construction shall conform to those requirements specified in the HMM, Part 5, Section 2.03 - Pavement Surface Problems, Paragraph I - Milling and Recycling, and as prescribed herein.

The exact locations of the areas to be recycled along with the respective thicknesses thereof shall be determined and delineated by the Engineer immediately prior to the start of the Work. The process shall involve pulverization of the existing pavement layer and the addition and mixing in place of any required new aggregate and new asphalt. The resultant mixture shall be spread, compacted and, when directed or shown on the plans, sealed with a surface treatment or an overlay. When such a treatment or an overlay is planned, it shall be carried out and paid for separately as specified in other sections of the specifications.

Milling, if any, shall be carried out as specified in Section 4.11 - Cold Milling Process for Removing Bituminous Pavement. Breaking up of the old bituminous surface by scarifying or ripping shall not be permitted. When directed by the Engineer, milling shall be so regulated as to eliminate the need for additional size reduction of the reclaimed materials. Unless otherwise shown on the plans or directed by the Engineer, undesirable contamination of the reclaimed materials with underlying untreated base course or subgrade materials, clay, silt, or other deleterious matter shall not be accepted. Should such undesirable contamination occur, as determined by the Engineer, the materials shall be discarded as directed and shall be replaced with new approved materials, all at the Contractor's expense.

Within five (5) days after execution of the contract, the Contractor shall submit to the Engineer the proposed method of pulverizing the existing bituminous surfacing, adding new aggregate, bituminous materials and/or recycling agent and mixing, placing, compacting and finishing the cold mix recycled bituminous base.

4.09.6.1 Mixing RAP or RAP and Aggregate with Water. This work shall be performed as specified in Section 3.03, "Aggregate Bases," in these General Specifications.

4.09.6.2 Mixing RAP, Aggregate and Bituminous Materials. The bituminous material and/or recycling agent shall be uniformly mixed with the RAP and aggregate by one of the following methods:

1. The bituminous material and/or recycling agent may be applied through the machine used to cold mill the bituminous surface as a part of the liquid used to cool the cutter teeth, provided it is applied uniformly across the width of cut and results in a complete and uniform blending of all materials.

2. The bituminous material and/or recycling agent may be applied through a mixing machine capable of mixing a windrow of RAP and other materials. The road mixing machine shall be of the pugmill or auger type. The machine shall be designed to pick up the materials to be mixed from the windrow and shall be equipped with a bottom shell or pan so that during at least fifty percent (50%) of the mixing cycle all materials are picked up and mixed while separated from the underlying road surface. Road mixing equipment shall not be operated at greater speeds than recommended by the manufacturer for the depth of treatment and quantity of materials passing through the machine while mixing.

3. The bituminous material and/or recycling agent may be added through a paving machine that is capable of mixing and placing the recycled bituminous base in its final position for compacting (Midland type mix-paver).

4. The cold mix recycled bituminous base may be produced using a continuous operation consisting of an interconnected cold milling device, portable crusher mounted on a trailer, cold mixing pugmill mounted on a trailer, paving machine, materials transfer belts for moving the materials from milling equipment through to the paving machine and compaction equipment. When new aggregates are required they shall be spread uniformly at the approved quantity on the road surface in advance of the cold milling machine.

Regardless of which method is used, mixing equipment shall have a positive displacement pump that can accurately meter the planned amount of bituminous material and/or recycling agent into the RAP and aggregate. A positive displacement pump shall be employed for each bituminous material and recycling agent introduced into the mixture.

The pump feed shall have electronic recording capabilities so that the amount of bituminous material and/or recycling agent incorporated into the mixture during any period of time may be read directly.

When directed by the Engineer, water shall be added to the RAP to facilitate uniform mixing with bituminous materials. Water may be added prior to or concurrently with adding the bituminous materials, as approved by the Engineer.

4.09.6.3 Placing and Compaction. The recycled mixture shall be compacted using a steel-drum tandem roller weighing not less than ten thousand (10,000) kilograms until the compacted density, at any point in the layer of recycled mixture, is between ninety-one percent and ninety-four percent (91-94%) of the theoretical maximum density determined from ASTM D -2041.

After the recycled mixture has been spread and compacted, it shall be allowed to cure for at least three (3) calendar days to reduce the moisture content prior to placing a wearing surface. Additional curing time may be required by the Engineer in the event that the recycled mixture becomes wet during rainfall. Any damage to the recycled mixture shall be repaired by and at the Contractor's expense and to the satisfaction of the Engineer.

Traffic may be allowed on the base when approved by the Engineer.

During the curing period, the Contractor may, when approved by the Engineer, place a fog seal as specified in Section 4.03, "Bituminous Surface Treatments," in these General Specifications to reduce surface abrasion caused by traffic. The fog seal shall be considered subsidiary to the work and shall not be measured separately. When a wearing course is shown on the plans or specified it shall be placed no sooner than three (3) days nor later than six (6) days after completion of compaction of the cold mix recycled bituminous base.

4.09.7 TRAFFIC CONTROL. The Contractor shall take effective action to permit traffic to safely pass through recycling operations as specified in Subsection 4.05.7, "Traffic Control," in these General Specifications.

4.09.8 QUALITY ASSURANCE PROCEDURES. The cold mix recycled bituminous base shall be accepted by lot. Unless otherwise stated in the Special Specifications, the lot size shall be ten thousand (10,000) square meters for each layer constructed. The cold mix recycled bituminous base shall be sampled, tested, and evaluated in accordance with Section 1.08, "Acceptance of Work," in these General Specifications. The Engineer may, during the beginning of placement of cold mix recycled bituminous base, at times when test results indicate erratic characteristics and at any other time, reduce the lot size to sections of cold mix recycled bituminous base with similar quality characteristics. This should facilitate the isolation and modification or replacement of low-quality materials with materials of acceptable quality to maintain the overall strength of the pavement structure.

The Engineer shall perform or supervise the performance of all quality assurance sampling and testing. The location of all samples and tests shall be recorded by roadway, lane and centerline station (kilometer). Quality assurance sampling testing for each lot shall include:

1. Compaction
2. Thickness
3. Bituminous Material Content and Aggregate Gradation
4. Surface Smoothness

4.09.8.1 Compaction. The specified range of acceptable compaction is between 91 and 94 percent. The average in-place densities from the ten (10) nuclear gauge readings or three (3) core or sand-cone holes shall be compared with the maximum theoretical density determined by ASTM D 2041. The result shall be the percent relative compaction of the lot. The cold mix recycled bituminous base course compaction will be sampled, tested and evaluated as detailed in Paragraph 4.06.8.1, "Compaction" in these General Specifications.

4.09.8.2 Thickness. A lot shall be accepted when the average thickness is not less than the planned thickness. The cold mix recycled bituminous base course thickness will be sampled, tested and evaluated as detailed in Paragraph, 4.06.8.2 "Thickness," in these General Specifications.

The thickness of the cold mix recycled bituminous base course after completion of compaction shall be determined from test holes, cored when possible or cut, at five (5) randomly selected locations in each lot. The average of the five (5) thicknesses shall be reported as the thickness of the lot.

The Contractor shall back fill density and thickness test holes with cold mix recycled bituminous base or other material approved by the Engineer.

4.09.8.3 Aggregate Gradation and Bituminous Material Content. The aggregate gradation of the cold recycled bituminous base will be sampled, tested and evaluated as detailed in Paragraph 4.06.8.3, "Aggregate Gradation and Bituminous Material Content," in these General Specifications.

Samples of cold recycled bituminous material shall be taken on a random time basis from the roadway immediately after all mixing is completed each one-half (1/2) day of work, or portion thereof. The initial sample shall be obtained one and one-half (1 1/2) meters from the center line of the lane being paved and weight at least twenty-five (25) kilograms. The initial sample shall be thoroughly mixed and quartered to obtain a test sample weighing at least six (6) kilograms. The test sample shall be forwarded to the project laboratory and the bituminous material content determined by extraction.

The bituminous content shall not vary from the approved job mix content by more than plus or minus the allowable deviation determined as outlined in paragraph 4.06.8.3, "Bituminous Content and Aggregate Gradation," in these General Specifications. When the bituminous material content varies by more than the allowable deviation the lot shall be removed, remixed with other materials added as necessary and/or replaced with other materials approved by the Engineer.

4.09.8.4 Surface Smoothness. The final surface after completion of compaction shall have no depressions under a four (4) meter straightedge greater than three (3) millimeters when laid parallel with the centerline and six (6) millimeters when laid transverse to the centerline.

4.09.8.5 Acceptance. Bituminous materials will be accepted under Subsection 1.08.3, "Certification of Compliance," in accordance with Subsection 4.01.4, "Acceptance Procedures for Bituminous Materials," in these General Specifications.

Cold-mix recycled base bituminous base construction including surface smoothness and bituminous content will be accepted under Subsection 1.08.4, "Measured or Tested Conformance," in these General Specifications.

Compaction cold-mix recycled base and thickness and aggregate gradation will be accepted under Subsection 1.08.5, "Statistical Evaluation of Work for Acceptance and Determination of Pay Factor (Value of Work)," in these General Specifications in two (2) stages as follows:

The first stage shall be the selection of the lowest of two (2) pay factors for the quality of the cold recycled bituminous base relating to aggregate gradation and density. The second stage involves the selection and application of a quantity pay factor based on the thickness of the cold recycled bituminous base. The reduced thickness pay factor for the lower courses of multiple course pavements will initially be applied provisionally based on the results of the depths of the cores taken from the lower courses. Additional cores will be taken of the total depth of all bituminous courses within the lot represented by lower course reduced thickness pay factors. If the total thickness cores show that the increased upper level course thickness has resulted in total thickness acceptability, the lower level courses reduced thickness pay factor will be adjusted accordingly. The second stage thickness quantity pay factor will be applied to all the individual lots in addition to the first stage lowest quality pay factor determined in accordance with Subsection 1.08.5, "Statistical Evaluation of Work for Acceptance and Determination of Pay Factor (Value of Work)," in these General Specifications.

4.09.9 MEASUREMENT. Cold mix recycled bituminous base course, cold mix recycled bituminous base course Class B or Type II as listed in the Bill of Quantities shall be measured by the cubic meter, as placed and compacted to the planned and specified thickness and within the lines and grades shown on the plans, as specified or directed by the Engineer. No measurement shall be made for material placed outside authorized limits.

The cold mix recycling agent will be measured in liters as applied to the bituminous surface within the widths specified or added to the mixing or paving machine.

4.09.10 PAYMENT. The amount of completed and accepted Work, measured as provided above, shall be paid for at the contract unit price per cubic meter, or adjusted contract unit price, as listed in the Bill of Quantities.

When a lot of cold mix recycled bituminous base course is accepted with a deficiency, the adjusted contract unit price for said lot shall be the product of the contract unit price and the lowest quality and quantity pay factors specified in Subsection 4.09.8, "Quality Assurance Procedures," in these General Specifications.

The quality and quantity pay factors shall be applied to the contract unit price for each course of cold mix recycled bituminous base listed on the Bill of Quantities. The reduced contract unit price shall apply to the quantity of work in the lot accepted at reduced payment.

Payment will be made at the contract unit price, or adjusted contract unit price, per liter of cold mix recycling agent as described above and listed in the Bill of Quantities.

Such price and payment shall cover and be full compensation for furnishing labor, materials, equipment, tools and incidentals necessary for completing all the work involved in construction of cold mix recycled bituminous base as specified in Subsection 1.07.2, "Scope of Payment," in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO.	PAY ITEM	PAY UNIT
40901	Cold Mix Recycled Bituminous Base Course	Cubic Meter
4090101	Cold Mix Recycled Bituminous Base Course, Class B	Cubic Meter
4090202	Cold Mix Recycled Bituminous Base Course, Type II	Cubic Meter
40903	Cold Mix Recycling Agent	Liter

SECTION 4.10 - SLURRY SEAL

4.10.1 DESCRIPTION. This work shall consist of mixing emulsified bituminous material, aggregate, water and specified additives and spreading the mixture on a surfacing or pavement within the lines shown on the plans, as specified in these specifications and the Special Specifications, and as directed by the Engineer.

ITEMS IN BILL OF QUANTITIES
Slurry Seal

4.10.2 MATERIALS. The materials for slurry seal immediately prior to mixing shall conform to the following requirements:

4.10.2.1 Emulsified Bituminous Material. Emulsified bituminous material shall conform to the requirements for SS-1h or CSS-1h grades in Section 4.01, Bituminous Materials, Tables 4.01-4 and 4.01-5 in these General Specifications.

4.10.2.2 Aggregate. Aggregate shall consist of natural or manufactured crushed stone, rock dust, crushed slag, crushed gravel sand and mineral filler. The total aggregate shall contain not less than eighty-five percent (85%) aggregate produced by crushing rock particles larger than 19.5 millimeters (3/4 inch) minimum dimension when the rock particles enter the crusher. Smooth textured sands of less than one and one-quarter percent (1.25%) water absorption shall not exceed fifteen percent (15%) of the total aggregate blend. Dune sand shall not exceed fifty percent (50%) of the percent of the smooth textured sand. The percentage by weight of the aggregate shall conform to one of the following gradings when tested in accordance with MRDTM 204:

Sieve Sizes	Type I Percent Passing	Type II Percent Passing	Type III Percent Passing
9.5 mm (3/8 Inch)	100	100	
4.75 mm (No. 4)	100	90-100	70-100
2.36 mm (No. 8)	90-100	65-90	45-70
1.18 mm (No. 16)	65-90	45-70	28-50
0.600 mm (No. 30)	40-65	30-50	19-34
0.300 mm (No. 50)	25-42	18-30	12-25
0.150 mm (No. 100)	5-30	10-21	7-18
0.075 mm (No. 200)	10-20	5-15	5-15

The aggregate shall also conform to the following requirements prior to the addition of any chemically active mineral fillers:

Abrasion Loss (MRDTM 309), Percent -	35 Max.
Sodium Sulfate Soundness Loss, (MRDTM 311), Percent -	15 Max.
Sand Equivalent (MRDTM 313 -	45 Max.

4.10.2.3 Water. Water shall be of such quality that the bituminous material will not separate from the emulsion before the slurry seal is in place in the work.

4.10.2.4 Mineral Fillers. Additives may be used to accelerate or retard the break-setting of the slurry seal, or improve the resulting finished surface texture and appearance. The type and quantity of additive shall be determined from the mix design approved by the Engineer.

Chemically active mineral fillers such as Portland cement, hydraulic cement, hydrated lime and ammonium sulfate conforming to the following requirements may be added to improve workability, regulate break-setting time and alter aggregate gradation.

Materials	Requirement
Portland Cement, Type I or II	ASTM C-150
Blended Hydraulic Cement, Type IP	ASTM C-595
Lime, Type N or S	ASTM C-207

When required by the Job Mix Design, the amount of mineral filler used shall be between one and two percent (1 - 2%) of the weight of the aggregate, with the exact amount to be stated in the Job Mix Design.

Chemically inactive mineral fillers such as limestone dust, fly ash and rock dust may be added to alter aggregate gradation.

4.10.2.5. Chemical Admixtures and Asphalt Modifiers. The types and amounts of chemical admixtures/asphalt modifiers used shall be limited to those listed in the Special Specifications or proposed by the Contractor and approved by the Ministry's Research and Materials Department to establish compliance with the job mix design requirements contained in Subsection 4.10.3, "Proportioning Slurry Seal Mixtures," in these General Specifications.

All chemical admixtures/asphalt modifiers including anti-stripping additives and polymers shall be thoroughly mixed and uniformly combined with the bituminous material.

4.10.3 PROPORTIONING SLURRY SEAL MIXTURES. MRDTM 427 shall be used for the design and testing of slurry seal mixtures. Not less than fourteen (14) days before the work is scheduled to commence, the Contractor shall submit to the Engineer a detailed mix design covering the specific materials and proportions of each to be used. The design shall be prepared by a laboratory under the supervision of a qualified technician. Samples of each of the materials to be used, sufficient to produce fifty (50) kilograms of slurry seal mixture, shall also be furnished to the Engineer. The Engineer will make additional tests at his option. When the Engineer is satisfied with the materials to be used, the mixture proportions and the test results, he shall notify the Contractor in writing of his approval of the mix design.

The laboratory report submitted by the Contractor to the Engineer shall show the results of tests on the individual materials and compare the results with those specified in these General Specifications and the Special Specifications. The report shall provide the following test information for the slurry mixture.

Test	Method	Requirement
Slurry Seal Consistency	ISSA T 106	20-30 mm
Excess Asphalt	ISSA T 109	500-700 grams per square meter
Wet Stripping Test	ISSA T 114	Pass
Compatibility	ISSA T 115	Pass (Note 1)
Quick Set Emulsion	ISSA T 102	Pass (Note 2)
Wet Track Abrasion Loss	ASTM D 3910	800 grams per square meter, Max.

Notes:
1. At the maximum air temperature occurring during placement.
2. For materials used when slurry seal is placed.
3. ISSA = International Slurry Seal Association.

Cure time and set time shall be determined and shall conform to the requirements described in MRDTM 427.

The laboratory shall report the quantitative effects of moisture content on the unit weight of the combined aggregates. The mix proportions shall include:

1. Percent by dry weight of aggregate.

2. Maximum and minimum quantity of mineral filler (if used) as a percent of the dry weight of aggregate.

3. Maximum and minimum quantity of water as a percent of the dry weight of aggregate.

4. Quantity of emulsified bituminous material as a percent of the dry weight of aggregate.

5. The type and quantity of mineral fillers and/or chemical admixtures/asphalt modifiers to be used.

The mixture shall be capable of uncontrolled traffic no more than three (3) hours after placement. The mixture shall not exhibit bleeding, raveling, separation or other distress.

4.10.4 EQUIPMENT. The Contractor shall furnish all necessary equipment, tools and machines to be used in the design, testing and production of slurry seals in accordance with his Program of Work as approved by the Engineer. All equipment shall be properly maintained and in good working condition.

4.10.4.1 Slurry Mixing Machine. The slurry mixing machine shall be a self-propelled continuous flow mixing unit. The mixing unit shall be capable of proportioning emulsified bituminous material, water, aggregate and additives by volume. The emulsified bituminous material shall be introduced into the mixing unit by a positive displacement pump. Water shall be introduced into the mixing unit through an indicating meter by a centrifugal-type pump. Aggregate shall be introduced into the

mixer through a feeder which is directly connected to the drive for the emulsified bituminous material pump. The drive shaft of the aggregate feeder shall be equipped with a revolution counter reading to one-tenth (1/10) revolution. Additives shall be introduced into the mixer through continuous feeding mechanisms which will accurately feed each individual additive.

Each feeder unit shall be calibrated at different gate settings for each slurry mixing unit used in the work. A means for weighing the aggregate, water and emulsified bituminous material shall be provided by the Contractor so that the accuracy of the pumps and feeder units may be checked at daily intervals during the production of slurry seal.

The slurry mixing machine shall be capable of proportioning and mixing individual materials within the following tolerances:

1. The Engineer approved emulsified bituminous material content plus or minus one percentage point (1).

2. The percent of aggregate passing each specified sieve shall not vary more than plus or minus four percent (4%) from the approved job mix formula.

3. The percent of aggregate passing each sieve shall not go from the high limit to the low limit for any two (2) successive sieves.

4. The slurry consistency (ISSA T 106) shall not vary more than five (5) millimeters from the approved mix design after field adjustments approved by the Engineer.

4.10.4.2 Slurry Spreading Device. The spreader device shall be a box equipped to prevent loss of slurry mixture along all sides and have a flexible rubber belt strike-off capable of being adjusted to various crown shapes. The spreader box shall be capable of placing a uniform surface over the width of one lane. It shall have a means for adjusting to deviations in the pavement surface being sealed. Replacement flexible strike-offs shall be available at all times during the placement of slurry seal.

The spreading device shall be capable of spreading the specified rate of slurry materials within a tolerance of plus or minus fifteen percent (+/- 15%) of the dry aggregate weight.

The spreading device shall be kept clean and build-up of slurry materials shall not be allowed.

4.10.5 WEATHER LIMITATIONS. Slurry seal shall not be mixed or placed when the temperature of the surface on which the slurry seal is to be placed is less than fifteen degrees Celsius (15° C.) and falling. Slurry seal shall not be placed during dust or sand storms, when there is a chance for rain within two (2) hours or when freezing may occur within twelve (12) hours.

4.10.6 TRAFFIC CONTROL. No traffic shall be allowed on the slurry seal for at least three (3) hours after placement. The Contractor shall take effective action to permit

traffic to safely pass through slurry seal operations in accordance with Section 9.02, "Traffic Control through Work Zones," in these General Specifications.

4.10.7 CONSTRUCTION. Construction requirements shall also be as specified in the HMM, Part 5, Section 2.04 - Surface Maintenance Techniques; Paragraphs A - Introduction; and D-Slurry Seal, and as prescribed herein.

The surface to be slurry sealed shall be thoroughly cleaned by brooming, blowing with high pressure air or with a suitable vacuum.

When specified in the Special Specifications, a tack coat consisting of SS-1h or CSS-1h emulsified bituminous material mixed in the proportion of one (1) part emulsified bituminous material to three (3) parts water shall be spread at a rate between two-tenths and four-tenths (0.2-0.4) liters per square meter. The exact rate shall be determined by the Engineer.

The surface to receive the slurry seal shall be pre-wetted by fogging with water at a rate determined by the Engineer. Said rate shall be adjusted during the day as temperature changes. Flowing water in front of the spreading device shall not be allowed.

Slurry seal material shall be placed within the following rates based on dry aggregate weight. The exact rate shall be as specified.

Type I - 3.3 to 5.4 kilograms per square meter
Type II - 5.4 to 8.2 kilograms per square meter
Type III - 8.2, or more, kilograms per square meter

The slurry seal mixture shall be smooth and homogeneous after spreading on the surface to be sealed and show no evidence of separation of aggregate and emulsified bituminous material after break-setting.

Hand tools shall be used to remove spillage. Ridges and bumps in the slurry seal surface shall not be permitted. Joints shall be worked with an appropriate hand operated fabric drag and no excessive build-up of slurry mixture, uncovered areas or unsightly appearance shall be permitted on longitudinal and transverse joints.

Areas inaccessible to the slurry mixing and spreading machine may be slurry sealed using hand operated fabric drags.

4.10.8 QUALITY ASSURANCE PROCEDURES. Slurry seal shall be accepted or rejected by lots. Unless otherwise stated in the Special Specifications, a lot shall consist of five thousand (5,000) square meters, or portion thereof placed each day. The Engineer shall perform or supervise on the performance of all quality assurance sampling and testing.

Quality assurance testing for each lot shall include:

1. Residual bituminous material content
2. Weight per square meter

The residual bituminous material content shall be determined by solvent extraction testing of a minimum of five (5) samples per lot randomly obtained from the mixing machine discharge. The thickness shall be determined by the weight of material used for each lot as determined from the recorders and measuring devices attached to the slurry seal mixing machine.

When the as-constructed bituminous material content varies from the approved mix design content, slurry seal may be accepted on the basis of reduced payment in accordance with the following pay factors:

PAY FACTORS

Variation From Approved Residual Bituminous Material Content	Slurry Seal
± 1.00 percentage points	100 %
± 1.01 - 1.50 percentage points	98 %
± 1.51 - 2.00 percentage points	92 %
± 2.01 - 2.50 percentage points	80 %
± 2.51 percentage points, or more	0 %

The pay factor shall be applied to the contract unit price listed in the Bill of Quantities. The reduced price shall apply to the quantity of work in the lot accepted at reduced price.

When the weight of slurry seal per square meter for any lot is less than the approved spread rate by more than fifteen (15%) the deficiency shall be corrected by spreading additional slurry seal mixture for the full width and length of the lot.

4.10.9 MEASUREMENT. Slurry seal shall be measured in square meters for the area upon which the slurry seal was actually placed within the lines shown on the plans, specified or ordered by the Engineer. Tack coat and water used to pre-wet the surface to be sealed shall not be measured separately.

Emulsified bituminous material, mineral fillers, chemical admixtures and asphalt modifiers used by the contractor to meet the Job Mix Design requirements will be considered subsidiary to the construction of the slurry seal and will not be measured separately unless specifically stated in the Special Specifications and listed in the Bill of Quantities. When they are listed in the Bill of Quantities and specified in the Special Specifications they shall be measured in liters, kilograms, or tons in accordance with Subsection 4.05.10 "Measurement" in these General Specifications.

4.10.10 PAYMENT. Slurry seal of each type completed as specified and measured shall be paid for at the contract unit price, or adjusted contract unit price, per square meter listed in the Bill of Quantities.

When a lot of slurry seal is accepted with a deficiency, the adjusted contract unit price for said lot shall be the product of the contract unit price and the lowest quality and quantity pay factors specified in Subsection 4.10.8, "Quality Assurance Procedures," in these General Specifications.

Emulsified bituminous material, mineral fillers, chemical admixtures, and asphalt modifiers used by the contractor to meet the Job Mix Design requirements shall be considered subsidiary to the construction of slurry seals and shall not be paid for separately unless specifically stated in the Special Specifications and listed in the Bill of Quantities. When they are listed in the Bill of Quantities and specified in the Special Specifications they shall be paid for as provided in Subsection 4.05.11 "Payment" in these General Specifications.

Prices and payment made under this section shall cover and be full compensation for furnishing labor, equipment, materials, tools and incidentals necessary to complete all the work involved as specified in Subsection 1.07.2, "Scope of Payment," in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO.	PAY ITEM	PAY UNIT
41001	Slurry Seal	Square Meter
4100101	Slurry Seal, Type I	Square Meter
4100102	Slurry Seal, Type II	Square Meter
4100103	Slurry Seal, Type III	Square Meter

SECTION 4.11 - COLD MILLING PROCESS FOR REMOVING BITUMINOUS PAVEMENT

4.11.1 DESCRIPTION. The cold milling process consists of planing and removing an existing bituminous surface to the lines and depths shown on the plans, as specified in these specifications, the Special Specifications and as directed by the Engineer.

The purposes for cold milling shall include, but not be limited to:

1. To revise by leveling and reshaping the longitudinal grade and transverse cross-section of an existing bituminous pavement.

2. To remove portions or all of a bituminous pavement in preparation for hot or cold mix recycling or placement of an overlay.

3. To prepare areas of an existing bituminous pavement for placement of an inlay patch of bituminous concrete.

4. To remove bituminous pavement alongside cracks in preparation for crack repairs using an inlay patch.

5. To texture the bituminous surface for improvement of skid resistance.

ITEMS IN BILL OF QUANTITIES

Cold Milling Bituminous Concrete

4.11.2 EQUIPMENT. The cold milling equipment shall be self-propelled, equipped with a rotating cutting cylinder and replaceable cutting teeth and be of such size and capacity as may be required to perform the milling work in accordance with his Program of Work as approved by the Engineer. The equipment shall have a water tank, pump and spray bar for applying cooling water to the teeth during cutting and for control of dust. The cold milling machine shall be equipped with a electronically controlled, hydraulically operated leveling device which will produce the grade and cross-slope specified.

The minimum acceptable size and capacity for the purposes listed in Subsection 4.11.1, "Description," in these General Specifications shall be:

1. For purposes Number 1. and Number 2., the minimum cutting width shall be one and nine-tenths (1.9) meters. The equipment shall be capable of milling to various selected depths up to fifteen (15) centimeters in one pass.

2. For purposes Number 3. and Number 4., the equipment shall be capable of cutting specified widths between fifteen and ninety (15-90) centimeters by removing cutting teeth. The equipment shall be capable of milling to various selected depths up to eight (8) centimeters in one pass.

3. For purpose Number 5., the rotary cutting cylinder shall contain sufficient teeth, properly spaced as necessary to produce a uniform surface texture. The equipment shall be capable of cutting to a minimum depth of one (1) centimeter.

When, in the opinion of the Engineer, crawler-mounted milling machines damage the surface of the pavement to remain in place, he may either direct that the work be carried out in more passes with reduced thickness per pass or that a pneumatic-tired machine be used instead. Whatever the Engineer's instructions in this respect, they shall not be grounds for additional payment to the Contractor.

4.11.3 TRAFFIC CONTROL. The Contractor shall take effective action to permit traffic to safely pass through cold milling operations in accordance with Section 9.02, "Traffic Control through Work Zones," in these General Specifications.

4.11.4 CONSTRUCTION. Construction requirements shall also conform to those specified in the HMM, Part 5, Section 2.03 - Pavement Surface problems, Paragraph I - Milling and Recycling, and as herein detailed.

The exact locations of the areas to be milled along with the respective depths thereof shall be determined and delineated by the Engineer immediately prior to start of the Work. The number of passes shall be proposed by the Contractor and approved by the Engineer. Trial sections shall be as directed by the Engineer.

Milling shall be carried out along the longitudinal direction of the road/shoulders, using an accurate direction reference. The operation shall produce a uniform surface free from holes, protrusions, humps, or unduly deep grooves, all as determined by the Engineer.

When directed, the process shall be so organized as to minimize downtime of the milling machine in position, by providing the required number of dump trucks. Worn out or broken teeth shall be replaced promptly to maintain the uniformity of the surface, so an adequate supply of good quality cutting teeth shall be on site prior to starting the work. In addition, a dedicated team of technicians shall be present at all times to undertake replacement as needed.

All cutting teeth shall be inspected and, if not in proper working order, teeth shall be replaced. When grade control is specified, a reference wire shall be established or, when approved by the Engineer, a reference ski shall be attached to the milling machine. Cold milling shall be carried out longitudinally to the width of the machine and the depth specified.

Prior to commencing cold milling operations, the surface to be milled shall be cleaned of dust, dirt and other deleterious materials.

During cold milling, water shall be added in a fog to the cutting teeth to reduce dust.

When specified that the milled material is to be picked up, an elevating belt or other pickup device approved by the Engineer shall be furnished. Milled materials shall be delivered to the location specified or as directed by the Engineer.

The milled surface shall be uniform with no depressions under a four (4) meter long straightedge laid parallel with and transverse to the centerline which are greater than:

1. When the purpose is to level and reshape the longitudinal grade and transverse cross slope six (6) mm Max.

2. When the purpose is to remove portions or all of the bituminous pavement in preparation for hot or cold recycling or placement of an overlay -

   (1) When the replacement layer is less than eight (8) centimeters thick - nine (9) mm Max.

   (2) When the replacement layer is greater than eight (8) centimeters thick - twelve (12) mm Max.

3. When the purpose is to prepare areas for inlay patching and crack repair nine (9) mm Max.

4. When the purpose is to texture the surface - six (6) mm Max.

4.11.5 ACCEPTANCE. Cold Milling will be accepted under Subsection 1.08.4, "Measured or Tested Conformance," in these General Specifications.

4.11.6 MEASUREMENT. Measurement shall be in square meters or cubic meters as listed in the Bill of Quantities:

1. For purposes 3, 4 and 5 listed in Subsection 4.11.1, "Description," in these General Specifications. Square meters measured within the lines shown on the plans, specified in the Special Specifications or as directed by the Engineer.

2. For purposes 1 and 2 listed in Subsection 4.11.1, "Description," in these General Specifications. Cubic Meters using principles of precise survey cross sections.

4.11.7 PAYMENT. Payment shall be made at the contract unit price for the square meters and/or cubic meters measured as prescribed above for the item number and pay unit listed in the Bill of Quantities.

Such payment shall cover and be full compensation for furnishing equipment, replacement teeth, labor, tools and incidentals necessary to complete all of the work involved in cold milling as specified in Subsection 1.07.2, "Scope of Payment," in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO.	PAY ITEM	PAY UNIT
41101	Cold Milling Bituminous Concrete	Square Meter
41102	Cold Milling Bituminous Concrete	Cubic Meter

SECTION 4.12 - SURFACE RECYCLING OF BITUMINOUS PAVEMENT

4.12.1 DESCRIPTION. Surface recycling of bituminous pavement consists of heating the existing bituminous surface in situ, scarifying and remixing the bituminous surface to the specified depth, treating the remixed material with an emulsified recycling agent and compacting all in accordance with the plans, these General Specifications, the Special Specifications and as directed by the Engineer. When the surface recycled bituminous pavement is to receive a wearing course, the Special Specifications will specify the grading, class and thickness of wearing course.

Surface recycling shall be a continuous operation, free from stops and starts, throughout the process of heating, scarifying and remixing the bituminous surface, spreading and compaction. The wearing surface, when specified may be placed concurrently with or after completion of the surface recycling operation.

ITEMS IN BILL OF QUANTITIES

Surface Recycling of Bituminous Pavement
Hot-Mix Recycling Agent

4.12.2 MATERIALS. The materials for surface recycling shall consist of the following:

4.12.2.1 Recycling Agent. The recycling agent shall conform to the requirements listed in Tables 4.06-1 or 4.06-2, Paragraph 4.06.2.2, "Hot-Mix Recycling Agent," as specified in these General Specifications.

4.12.2.2 Bituminous Concrete Wearing Course. The bituminous concrete wearing surface shall conform to the requirements in Section 4.05, "Bituminous Concrete Pavement," in these General Specifications. The grading and class of bituminous concrete wearing course shall be specified in the Special Specifications.

4.12.3 QUANTITY OF RECYCLING AGENT TO BE APPLIED. The quantity of hot-mix recycling agent to be applied will be determined from laboratory testing of samples of bituminous material obtained from the actual bituminous surface to be recycled (referred to as RAP). One (1) RAP sample, representing the top five (5) centimeters of the surface to be recycle and weighing at least twenty (20) kilograms shall be obtained from each ten thousand (10,000) square meters of surface to be recycled. The bituminous material shall be recovered from each RAP sample using MRDTM 418. The recycling agent selected for recycling shall be added to the recovered bituminous material to produce a modified bituminous material that will have characteristics and properties similar to paving grade bituminous material in Section 4.01, "Bituminous Materials," in these General Specifications. The penetration of the modified bituminous material shall be in the range forty to seventy (40-70) or as specified in the Special Specifications.

The Contractor shall be responsible for obtaining specified samples, performing all required tests and reporting the results to the Engineer with a recommendation for quantity of recycling agent to be applied as a percent of the weight of bituminous material to be remixed.

The Contractor shall furnish duplicate samples of RAP and not less than four (4) liters of recycling agent to the Engineer for comparative testing and evaluation. The Engineer shall direct the quantity of recycling agent to be added.

4.12.4 EQUIPMENT. The Contractor shall furnish all equipment as required to perform the work as outlined in his Program of Work and to maintain a minimum rate of production of one thousand (1000) square meters per hour.

1. The equipment used to heat and scarify the bituminous surface shall be equipped to burn liquid petroleum gas (LPG), natural gas or other fuel as may be approved by the Engineer. Diesel fuel shall not be allowed. The combustion chamber shall be insulated, rear wheel positioned and equipped with burners rated at fifteen million (15,000,000) BTU's per hour, minimum. The machine shall be equipped with two (2) rows of spring-equalized scarifier-leveling rakes which will automatically ride over obstructions in the surface such as man-hole covers.

Additional heater units, without scarifier rakes, shall be operated in advance of the scarifier so that the full train is capable of heating the bituminous surface to a temperature of one hundred fifty degrees Celsius (150° C.), plus or minus ten degrees Celsius (±10° C.) to a depth between twenty and thirty (20-30) millimeters.

Heater-scarifying equipment shall be capable of being adjusted to heat widths between two and four-tenths and three and eight-tenths (2.4-3.8) meters.

2. A mixer-repaver machine equipped with an oscillating or vibratory screed and capable of distributing and leveling the scarified material for the full width of scarified.

3. The mixer-repaver may be equipped with a means for uniformly applying the recycling agent across the full width scarified during the remixing operation. A distributor truck may also be used for applying the bituminous recycling agent after completion of remixing, spreading and leveling the scarified material. Whichever means for applying recycling agent is selected, it shall be capable of spraying the correct quantity of recycling agent within a tolerance of plus or minus three-tenths (± 0.3) percentage points.

4. A means for placing the bituminous concrete wearing surface when specified. This may be an integral part of the mixer-repaver equipment or a separate paving machine.

5. Compaction equipment - As necessary to achieve the compaction specified. In addition, a twenty (20) Ton pneumatic roller shall be furnished for compacting the recycled material.

4.12.5 WEATHER LIMITATIONS. Surface recycling shall not be performed when the air temperature is less than twenty degrees Celsius (20° C.), when raining or during dust or sand storms.

4.12.6 PROTECTION OF PROPERTY. The Contractor shall protect adjacent structures, passing vehicles, trees, shrubbery and other improvements from excessive

heat and damage. No flames outside the combustion chamber shall be permitted. Equipment that causes, or appears to cause damage shall be removed from the project.

The Contractor shall repair or replace any damaged facilities or landscaping at his sole cost.

4.12.7 CONSTRUCTION. The surface to be recycled shall be cleaned by sweeping or blowing with high pressure air.

The surface to be recycled shall be heated to the width shown on the plans or specified plus ten (10) centimeters on either side. Sufficient heater units shall be operated in tandem to heat the bituminous surface to the temperature and depth specified. The full depth of material heated to the width specified shall be scarified, remixed, distributed, leveled and compacted with a pneumatic roller.

The surface of the recycled bituminous pavement shall be smooth, free from ruts, humps or depressions. The surface shall have no depressions greater than six (6) millimeters under a straightedge three (3) meters in length when laid in any direction.

Concurrent with, but in any event, no later than four (4) hours after scarification, recycling agent shall be applied to the surface width specified at the rate specified in liters per square meter (L/M^2) within a tolerance of plus or minus five (± 5) percentage points.

The bituminous concrete wearing surface shall be placed to the thickness and width specified and compacted as specified in Section 4.05, "Bituminous Concrete Pavement," in these General Specifications.

The wearing course may be placed concurrently with the mixer-repaver operation or later.

4.12.8 COMPACTION OF SURFACE RECYCLED BITUMINOUS PAVEMENT. The recycled bituminous pavement, immediately after completion of heating, scarifying, distributing and leveling, shall be compacted by pneumatic rollers to between ninety percent (90%) and ninety-three percent (93%) of the maximum laboratory density determined by MRDTM 412.

The bituminous concrete wearing surface shall be compacted as specified in Section 4.05, "Bituminous Concrete Pavement," in these General Specifications.

4.12.9 QUALITY ASSURANCE PROCEDURES. The surface recycled bituminous pavement shall be accepted by lot. Unless otherwise stated in the Special Specifications, the lot size shall be ten thousand (10,000) square meters for each layer constructed. The surface recycled bituminous pavement shall be sampled, tested, and evaluated in accordance with Section 1.08, "Acceptance of Work," in these General Specifications. The Engineer may, during the beginning of surface recycling, at times when test results indicate erratic characteristics, and at any other time, reduce the lot size to sections of surface recycled bituminous pavement with similar quality characteristics. This should facilitate the isolation and modification or replacement of low-quality materials with materials of acceptable quality to maintain the overall strength of the pavement structure.

The Engineer shall perform or supervise the performance of all quality assurance sampling and testing. The location of all samples and tests shall be recorded by roadway, lane and centerline station (kilometer). Quality assurance sampling and testing for each lot shall include:

1. Compaction
2. Thickness
3. Surface Smoothness

4.12.9.1 Compaction. The upper and lower specifications limits are 90 and 93 percent. The bituminous emulsion treated base course compaction will be sampled, tested and evaluated as detailed in Paragraph 4.05.8.1, "Compaction," in these General Specifications.

4.12.9.2 Thickness. A lot shall be accepted when the average thickness is not less than the planned thickness. The Engineer will accept the lot on a thickness basis when the average thickness for five (5) cores at each location is equal to the planned and specified thickness for the sum of the two (2) layers. The surface bituminous recycled pavement thickness will be sampled, tested and evaluated as detailed in Paragraph 4.05.8.2, "Thickness," in these General Specifications.

The Contractor shall backfill density and thickness test holes with bituminous emulsion treated base or other material approved by the Engineer.

4.12.9.3 Smoothness. The Engineer will accept the lot on a smoothness basis when the surface of the wearing surface does not have any depressions greater than six (6) millimeters under a three (3) meter straight edge and in any direction on the surface.

4.12.9.4 Acceptance. Surface recycled pavement construction including surface smoothness will be accepted under Subsection 1.08.4, "Measured or Tested Conformance," in these General Specifications.

Surface compaction recycled bituminous pavement and thickness will be accepted under Subsection 1.08.5, "Statistical Evaluation of Work for Acceptance and Determination of Pay Factor (Value of Work)," in these General Specifications in two (2) stages as follows:

The first stage shall be the selection of the pay factor for the quality of the surface recycled bituminous pavement relating to density. The second stage involves the selection and application of a quantity pay factor based on the thickness of the surface recycled bituminous pavement. The second stage thickness quantity pay factor will be applied to all the individual lots in addition to the first stage pay factor.

The pay factors shall be applied to the contract unit price for each course of surface recycled bituminous pavement listed in the Bill of Quantities. The reduced contract unit prices shall apply to the quantity of work in the lot accepted at reduced payment.

4.12.10 MEASUREMENT. The recycled bituminous shall be measured in cubic meters based on the widths and depths shown on the plans or as specified or average widths and depths measured in-place, whichever is the least.

The hot-mix recycling agent shall be measured in liters as applied within the recycled widths specified.

4.12.11 PAYMENT. Payment shall be made at the contract unit price, or adjusted contract unit price, per cubic meter measured as described above for each lot of surface recycled bituminous pavement listed in the Bill of Quantities.

When a lot of surface recycled bituminous pavement is accepted with a deficiency, the adjusted contract unit price for said lot shall be the product of the contract unit price and the lowest calculated quality and quantity pay factors specified in Subsection 4.12.9, "Quality Assurance Procedures," in these General Specifications.

Payment will be made at the contract unit price or adjusted contract unit price per liter of recycling agent measured as described above and in accordance with Subsection 4.06 "Payment" in these General Specifications.

Such price and payment shall cover and be full compensation for furnishing labor, equipment, fuel and recycling agent, tools and incidentals necessary to complete the work as specified in Subsection 1.07.2, "Scope of Payment," in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO.	PAY ITEM	PAY UNIT
41201	Surface Recycling of Bituminous Pavement	Cubic Meter
40610	Hot-Mix Recycling Agent	Liter

SECTION 4.13 - ASPHALT PAVEMENT CRACK AND JOINT SEALING

4.13.1 DESCRIPTION. This work consists of saw cutting, when required, and cleaning and filling cracks and joints in asphalt pavement.

CRACK AND JOINT SEALING ITEMS IN THE BILL OF QUANTITIES:

Saw Cutting and Joint Sealing
Crack Cleaning and Sealing

4.13.2 MATERIALS. Materials shall conform to the following Subsections:

4.13.2.1 Asphalt Cement. Asphalt cement shall be a Viscosity Grade conforming to the requirements listed in Table 4.01-1, Section 4.01, "Bituminous Materials," in these General Specifications.

4.13.2.2 Blotter. Aggregate for blotter material shall consist of sound durable particles of gravel or crushed stone having a gradation so all particles will pass a sieve with nine and one-half (9.5) millimeter (3/8 inch) square openings. The Contractor shall furnish material that is free from organic matter and clay balls and meets the following:

(1) Liquid limit, MRDTM 209	25 maximum
(2) Plasticity index, MRDTM 208	6 maximum

4.13.2.3 Emulsified Asphalt. Emulsified asphalt shall be CRS-2 or CMS-2 or LMCRS-2H conforming to the requirements listed in Tables 4.01-5 and 4.01-6 in these General Specifications.

4.13.2.4 Fine Aggregate. Fine aggregate shall conform to the requirements listed in Subparagraph 5.01.2.2.1, "Fine Aggregates," in these General Specifications.

4.13.2.5 Joint Sealant. Joint sealant shall be hot poured conforming to the requirements of AASHTO M 301.

4.13.2.6 Slurry Seal. Slurry seal shall conform to the materials requirements contained in Subsection 4.10.2, "Materials," for Type I Slurry Seal in these General Specifications.

4.13.2.7 Rubberized Asphalt. Rubberized asphalt shall conform to the requirements of ASTM D1190 and AASHTO M 173.

4.13.3 EQUIPMENT. The Contractor shall supply the proper type and numbers of sufficient equipment to complete the work within the Contract time and in accordance with his Program of Work as approved by the Engineer. The equipment shall also conform to the following specific requirements:

1. Power saw and blades. Saw and blades of such size and configuration that saw cuts can be made with one pass shall be furnished. Spacers are not allowed.

2. Router. The Contractor shall furnish power rotary impact router or vertical spindle router capable of cleaning cracks or joints to the required depth and width.

3. Hot-compressed air lance. The Contractor shall furnish a lance capable of providing clean, oil-free compressed air at a volume of two and eighty-three hundreds (2.83) cubic meters per minute at a blast velocity of six hundred and ten (610) meters per second.

4. Application wand. A crack sealant applicator wand attached to a heated hose that is attached to a heated sealant chamber shall be furnished. The temperature controls shall maintain the temperature of the sealant within manufacturer's tolerances.

5. Heating kettle. The Contractor shall furnish an indirect-heating-type double boiler with the space between the inner and outer shells fixed with oil or other heat transfer medium capable of constant agitation. He shall provide an accurate and calibrated thermometer having a range from ninety-three degrees Celsius to three hundred sixteen degrees Celsius (93° C. to 316 ° C.) graduated in one (1 °) degree increments. The thermometer shall be located such that the temperature of the joint sealant may be safely checked.

6. Squeegee. The Contractor shall furnish a hand-held squeegee for ensuring that the crack is filled to the existing surface.

4.13.4 CONSTRUCTION REQUIREMENTS.

4.13.4.1 Saw Cutting and Joint Sealing. The Contractor shall saw cut, clean and seal joints in a continuous operation. Either dry or wet cutting is allowed. The Contractor shall clean dry-sawed joints with a stream of air sufficient to remove all dirt, dust, or deleterious matter adhering to the joint walls or remaining in the joint cavity. He shall blow or brush dry material off the pavement surface.

The wet-sawed joints shall be cleaned with a water blast, fifty pounds per square inch (50 psi) (345 kPa) minimum, immediately after sawing to remove any sawing slurry, dirt, or deleterious matter adhering to the joint walls or remaining in the joint cavity. All sawing slurry shall be immediately flushed from the pavement surface. Wet-sawed joints shall be air-blowed to dry joint surfaces.

The Contractor shall not allow traffic to knead together or damage the sawed joints. If cleaning operations cause interference with traffic the Contractor shall provide protective screening.

The sealant shall be placed when the pavement surface temperature is four degrees Celsius (4° C.) or higher. The Contractor shall discontinue operations when weather conditions detrimentally affect the quality of forming joints and applying sealants.

The Contractor shall submit a copy of and adhere to the manufacturer's recommendations for heating and applying the joint sealant. He shall not hold the material at the pouring temperature for more than six (6) hours and he shall not reheat the material.

The Contractor shall place a bond breaker tape designed for use with hot poured sealant in the bottom of the saw cut joint. He shall seal the joints with an applicator wand when the sealant material is at the pouring temperature. He shall heat or insulate the applicator wand to maintain the pouring temperature of the sealant during placing operation. He shall return the applicator wand to the machine and recirculate the joint sealant material immediately after sealing each joint.

The Contractor shall fill each joint such that, after cooling, the level of the sealant is no more than three (3) millimeters below the pavement surface. He will wait for the sealant to be tack free before opening the joint to traffic. Blotter will not be spread on the sealed joints to allow early opening to traffic.

4.13.4.2 Crack Cleaning and Sealing. The Contractor shall thoroughly clean the existing surface of all loose material, dirt, or other deleterious substances by brooming, flushing with water, or other approved methods. He shall route and clean all cracks with an average opening of six (6) millimeters or more to make a sealant reservoir to the depth of the routed crack or at least nineteen (19) millimeters depth. He shall dry cracks before sealing.

When using the hot-compressed air lance, it shall be kept moving so as not to burn the surrounding pavement and the joint. The Contractor shall place and finish sealant within five (5) minutes after heating with the hot-compressed air lance.

For cracks with a thirteen (13) millimeter width or less, the Contractor shall seal with hot-poured elastic sealant as described in 4.13.4.1, "Saw Cutting and Joint Sealing," in these General Specifications.

For cracks with a width greater than thirteen (13) millimeters, the Contractor shall seal with an approved slurry seal mixture, fine aggregate-asphalt cement mixture, or fine aggregate-emulsified asphalt mixture, or rubberized asphalt mixture. A squeegee or other suitable equipment shall be used to force the mixture into the cracks.

The Contractor shall immediately screed the joint sealant or asphalt mixture to the elevation of the existing surface. He shall use a squeegee to ensure that a seventy-five (75) millimeter wide band is centered on the finished sealed crack. The sealed crack shall be covered with a light application of blotter.

4.13.4.3 Resealing Defective Joints or Cracks. The Contractor shall reseal areas exhibiting adhesion failure, damage, missed areas, foreign objects in the sealant, or other problems which will accelerate failure.

4.13.4.4 Acceptance. Joint Sealant will be accepted under Subsection 1.08.3, "Certification of Compliance," in these General Specifications.

Crack and joint sealing will be accepted under Subsection 1.08.4, "Measured or Treated Conformance," in these General Specifications.

4.13.5 TRAFFIC CONTROL. While the saw cutting, cleaning and filling joints in asphalt pavement is in progress, the surface of the roadway shall not be used by the Contractor, his agents or others until the Engineer is satisfied that the sealed surface will not be damaged by traffic and has given approval for traffic to use the treated surface.

The Contractor shall erect and maintain signs, barricades and other traffic control devices and shall take effective action to exclude traffic of any description from the roadway surface for as long as may be required in the judgement of the Engineer. When traffic is restricted to a one-way basis, the Contractor shall provide such flagmen and pilot cars as deemed necessary for the protection of traffic and the treated surface. One-way traffic will not be permitted after dark. Traffic may be detoured around the construction, provided detours are properly constructed, signed and marked. When it is necessary to permit traffic to cross the freshly sealed surface, the crossing shall be blotted with sand, as directed by the Engineer, before the crossing is opened to traffic. Removal of excess sand shall be completed before uncontrolled traffic is permitted on the sealed surface. All traffic control work will be done in accordance with Section 9.02, "Traffic Control through Work Zones," in these General Specifications.

4.13.6 MEASUREMENT. Saw cutting and joint sealing will be measured by the linear meter of completed and accepted work. Crack cleaning and sealing will be measured by the linear meter of completed and accepted work. No separate measurement shall be made of joint sealant or other materials.

4.13.7 PAYMENT. Payment shall be made at the contract unit price, or adjusted contract unit price, listed in the Bill of Quantities for the linear meters measured as prescribed above.

Such payment shall cover and be full compensation for furnishing equipment, materials, labor, tools and incidentals necessary to complete all of the work involved in asphalt pavement crack and joint sealing as specified in Subsection 1.07.2, "Scope of Payment," in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO.	PAY ITEM	PAY UNIT
41301	Saw cutting and joint sealing	Linear Meter
41302	Crack cleaning and sealing	Linear Meter

SECTION 4.14 - PAVEMENT WIDENING

4.14.1 Description. This Work shall consist of the widening of the existing bituminous concrete pavement or aggregate base course and the shouldering and finishing of the completed Work in accordance with the specifications and in conformity with the lines, grades, thicknesses, and typical cross sections shown on the plans or established by the Engineer.

Pavement widening work shall be analyzed into the applicable removal pay items and the applicable new construction pay items, corresponding to the prescribed Work as shown on the plans or directed by the Engineer; and shall be executed as specified herein and in accordance with the provisions of the pertinent specification sections that refer to the pay items which are to constitute the complete Work.

4.14.2 Materials. Materials shall conform to the requirements prescribed in the corresponding specification sections for the several pay items which are to constitute the complete Work.

4.14.3 CONSTRUCTION REQUIREMENTS.

4.14.3.1 Trenching. The Contractor shall excavate along the edge of the existing pavement for the full depth and width as shown on the plans. The bottom of the trench shall be compacted with rollers and tampers to the type of compaction called for on the plans. If the plans do not call for a specific type of compaction, the embankment or subgrade shall be compacted to the provisions specified in Subsection 2.05.4 - Lift Thickness and Compaction Requirements; and the existing subgrade shall be treated as specified Paragraph 2.06.3.9 - Preparation of Existing Subgrade both, in these General Specifications.

Adequate provisions shall be made for drainage of the trench to prevent damage to the subgrade.

Before placing any widening material, the trench shall be cleaned of all loose materials. The edge of the existing pavement shall be thoroughly cleaned. The trench must be approved by the Engineer, prior to placement of any widening material.

4.14.3.2 Placing Aggregate Subbase or Base Course. This Work shall be carried out as specified in Section 3.02 - Aggregate Subbases and Section 3.03 - Aggregate Bases in these General Specifications as applicable and as shown on the plans.

4.14.3.3 Placing Bituminous Mixture. Prior to placing any material, the edge of the existing bituminous pavement and the entire base course shall be sprayed with a tack or prime coat, as applicable. These sections shall then be paved with the bituminous mixture designated on the plans.

The bituminous mixture shall be prepared as specified in Section 4.05 - Bituminous Concrete Pavement in these General Specifications. The material shall be placed in the prepared trench in two (2) or more layers as shown on the plans or as directed by the Engineer. This material shall be placed by approved machine methods.

After being spread, each layer shall be thoroughly compacted with trench rollers approved by the Engineer, in accordance with the requirements specified in Paragraph 4.05.6.8 - Compaction of Bituminous Concrete Pavement in these General Specifications.

4.14.3.4 Shoulders. After the surface courses have been completed, the shoulders shall be constructed to the cross section shown on the plans. Unless otherwise shown on the plans or directed by the Engineer, the embankment or subgrade material used for constructing the shoulders shall be obtained from the widening trench, the ditches and the backslopes. The removal of earth from ditches and backslopes shall be done in a manner that will provide adequate and satisfactory drainage without pockets that will impound water; with reasonably uniform ditch widths and depths; and with reasonably uniform backslopes. It may be necessary to haul material from locations within the Right of Way where a surplus exists to locations where a deficit exists, in order to construct the shoulders to the section indicated on the plans. Any surplus material from the widening trench shall be disposed of at approved locations.

During the operations of constructing shoulders, care shall be exercised to prevent injury to previously constructed surfaces.

The Contractor shall water during the shaping and rolling operations as directed by the Engineer. After the material has been shaped and bladed, the shoulders shall be compacted to the density shown on the plans or, if not shown, to that specified in Subsection 3.05.5 - Compaction Requirements or in Paragraph 4.05.6.8 - Compaction of Bituminous Concrete Pavements in these General Specifications as applicable.

4.14.3.5 Special Provisions for Handling Traffic. Widening operations shall be permitted on only one (1) side of the pavement at a time, and excavation of trenches shall be permitted only sufficiently in advance of other operations to insure a continuity of the operations of excavating, placing of widening materials and rolling.

Reflectorized barricades and lighting shall be placed along open trenches and traffic shall be protected and handled as specified in Section 9.02 - Traffic Control through Work Zones, in these General Specifications.

The Contractor shall make adequate provisions to enable traffic to cross open trenches at intersecting roads, streets and private entrances.

Partial shouldering shall be performed immediately after completion of widening of portions of the Work in order to eliminate the hazard of the open trench as soon as possible.

4.14.3.6 Quality Assurance. Tests for quality, conformity, density, and thickness shall be performed as outlined in the pertinent specification sections that refer to the pay items which are to constitute the complete Work; except that the numbers and locations of tests may be modified to those deemed necessary by the Engineer to determine conformity with the specifications.

4.14.3.7 Method of Measurement. The quantities of the various pay items which constitute the completed and accepted Work shall be measured for payment according to the plans and specifications for the several pay items appearing in the Bill of Quantities, and in terms of the prescribed units provided for the several pay items. Only accepted Work shall be included and the dimensions shall be those shown on the plans or ordered in writing by the Engineer.

4.14.3.8 Payment. The quantities, measured as provided above, will be paid for at the unit prices bid for the several pay items as specified in the Bill of quantities. Such prices shall be full compensation for furnishing, hauling, and placing all materials, for all labor, equipment, tools, and all other items necessary for the proper completion of the Work as specified in Subsection 1.07.2 - Scope of Payment, in these General Specifications. Such payment shall constitute full payment for the completed Work, and no allowance will be made for any item not specifically provided for or for any other incidental expense.

KINGDOM OF SAUDI ARABIA
MINISTRY OF COMMUNICATIONS

GENERAL SPECIFICATIONS
FOR
ROAD AND BRIDGE CONSTRUCTION

November 1998

PART FIVE
CONCRETE, STEEL AND STRUCTURES

PART FIVE: CONCRETE, STEEL AND STRUCTURES

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PART FIVE: CONCRETE, STEEL AND STRUCTURES

SECTION 5.01 - PORTLAND CEMENT CONCRETE

5.01.1 DESCRIPTION. Portland Cement concrete shall consist of a mixture of Portland cement, fine aggregate, coarse aggregate, and water, proportioned and mixed, transported, placed, consolidated and finished as specified in these General Specifications and the Special Specifications. Admixtures, when used, in Portland cement concrete shall be as specified in these General Specifications and the Special Specifications.

Concrete for each portion of the work shall be of the Class, minimum cement content in kilograms per cubic meter, twenty-eight (28) day compressive strength or minor concrete, all as shown on the plans, specified in these General Specifications or the Special Specifications. When directed, concrete work shall conform to the provisions of the "GUIDE FOR CONCRETE CONSTRUCTION IN THE GULF REGION", Special Publication No 31, published by the Construction Industry Research and Information Association (CIRIA).

TABLE 5.01-1 CONCRETE CLASS DESIGNATIONS

Specified Class	Minimum Cement Content (Kg. Per Cu. M)	Minimum Compressive Strength at 28 Days	Designated Coarse Aggregate Size	Alternate Coarse Aggregate Size
A	335	210 Kg./sq. cm.	A-50 mm(2 in.)	B
B	310	170 Kg./sq. cm	B-62.5(2½ in.)	A
C	375	250 Kg./sq. cm.	C-25 mm(1 in.)	D
D	375	250 Kg./sq. cm.	D-19 mm(¾ in.)	
E	375	280 Kg./sq. cm.	D-19 mm(¾ in.)	
K	390	315 Kg./sq. cm.	D-19 mm(¾ in.)	
S	410	350 Kg./sq. cm.	D-19 mm(¾ in.)	

Concrete for minor structures, when designated on the plans as minor concrete, shall conform to the requirements of Subsection 5.03.9, "Concrete for Minor Structures" in these General Specifications.

No-Fines and Cyclopean Concrete when designated on the Plans or permitted by the General or Special Specifications shall conform to the requirements of Subsection 5.01.7, "No-Fines and Cyclopean Concrete" in these General Specifications.

The cement content in kilograms per cubic meter for concrete in structures or portions of structures, unless otherwise specified in these General Specifications or the Special Specifications, shall conform to the following:

1. Bridges and roof section of exposed top of R.C. box culverts - 375 Minimum, 450 Maximum.

2. Other portions of R.C box culverts - 335 Minimum, 450 Maximum.

3. Prestressed Members 375 Minimum.

4. Sealing Concrete 310 Minimum.

5. Minor Structures 310 Minimum.

The exact cement content for concrete in structures shall be within the range stated and determined from mix design testing and the compressive strength shown on the plans or specified in the special specifications.

The Contractor shall perform all required mix design testing.

5.01.2 MATERIALS.

5.01.2.1 Portland Cement. Cement shall be either Types I, II M, III or V conforming to the requirements specified in ASTM C150 or Type IP(MS) conforming to AASHTO M240. Only one type and brand of cement shall be used in any individual structural member. Mixing of types or brands shall not be permitted.

Cement shall originate from manufacturers approved by the Engineer and shall be accompanied by a Certificate of Compliance and/or a laboratory test certificate furnished by the manufacturer. Portland cement shall be tested as stated in MRDTM 504 and shall have a compressive strength of standard cement mortar samples in accordance with ASTM C-150 or AASHTO M-240. The Engineer reserves the right to order a retest of the cement at any time.

Approval of cement quality shall not relieve the contractor of the responsibility to fabricate concrete of the specified strength. The Contractor shall bear all costs in connection with the Certificates of Compliance and laboratory tests. When factory tests or field tests, completed subsequent to the original approval tests, show that the cement does not comply with the specifications, the entire lot from which the sample was taken will be rejected and the Contractor shall immediately remove the rejected material from the site and replace it with cement which meets the required specifications.

Storage capacity shall be sufficient to meet the concrete production requirements for thirty (30) working days unless in the opinion of the Engineer, the supply from the manufacturer is so limited that more storage capacity is necessary. Cement shall be stored in moistureproof storage sheds. Sacked cement shall be piled to permit access for tally, inspection and identification. Neither stale, caked, nor reclaimed or resacked cement shall be used. The Contractor shall not store cement in areas subject to flooding.

Cement remaining in bulk storage at the mill, prior to shipment, for more than six (6) months or cement stored in bags in local storage by the Contractor or a vendor for more than three (3) months after shipment from the mill, may be retested before use and will be rejected if it fails to meet any of the requirements of these specifications.

5.01.2.2 Aggregate. Aggregate shall be free from clay coating, clay balls and other extraneous materials. Aggregate shall be of such character that it is possible to produce workable concrete meeting all specified requirements. It shall not contain materials which may adversely attack the reinforcement or materials in such a form or quantity to reduce the strength and durability of the concrete. If aggregate is found to be deleterious or potentially deleterious, as the terms are used in ASTM C 289, the Contractor may offer to furnish a mineral admixture in an attempt to utilize the aggregate source, and the performance of the selected mineral admixture shall be tested following the ASTM C441 prior to the final approval of the Engineer.

5.01.2.2.1 Fine Aggregate. Fine concrete aggregate shall conform to AASHTO M 6 and shall consist of natural, manufactured, or combinations of sand. Fine aggregate shall be thoroughly and uniformly washed unless otherwise approved by the Engineer.

Fine concrete aggregate shall meet the following requirements. Deleterious substances such as, but not limit to, pyrites, coal, or micas shall not exceed two percent (2%) by weight.

Fineness Modulus, AASHTO M 6	2.3 to 3.1
Sodium Sulfate Soundness, MRDTM 311, 5 cycles, Percent Loss	10 Maximum
Clay lumps and Friable Particles MRDTM 312, Percent	1 Maximum
Test for Organic Impurities, MRDTM 315	Lighter than standard
Sand Equivalent, MRDTM 313	75 Minimum
Potential Cement-Aggregate Reactivity, ASTM C 289, as supplemented by ASTM C 227	Innocuous

Fine aggregate shall meet the following requirements when tested by MRDTM 204:

TABLE 5.01-2 CONCRETE FINE AGGREGATE GRADATIONS

Sieve Size	Percent Passing by Weight
9.5 mm (3/8 inch)	100
4.75 mm (No. 4)	95-100
1.18 mm (No. 16)	45-80
0.300 mm (No. 50)	10-30
0.150 mm (No. 100)	2-10
0.075 mm (No. 200)	0-4

If the fineness modulus varies by more than two-tenths (0.2) from the value assumed in the concrete mix design, the use of such fine aggregate shall be discontinued until suitable adjustments can be made in the mix proportions to compensate for the difference in gradation.

In addition to the above and when directed by the Engineer, fine aggregate shall be tested in accordance with MRDTM 303 for determination of Total Moisture Content and MRDTM 306 for Surface Moisture.

5.01.2.2.2 Coarse Aggregate. Coarse concrete aggregate shall conform to AASHTO M 80 and shall consist of gravel, crushed gravel or crushed stone. Coarse aggregate shall not contain materials such as iron pyrites, coal, mica, laminated materials, or other materials which may adversely affect the strength and durability of the concrete.

Coarse concrete aggregate shall meet the following requirements:

Sodium Sulfate soundness, MRDTM 311, 5 cycles, Percent Loss	12 Maximum
Clay Lumps and Friable Particles AASHTO T 12, Percent	1 Maximum
Soft Fragments and Shale, AASHTO M 80, Percent	5 Maximum
Flakiness Index MRDTM 423, Percent	15
Potential Cement Aggregate Reactivity, ASTM C 289, as supplemented by ASTM 227	Innocuous

Coarse concrete aggregate shall meet the following gradation requirements when tested in accordance with MRDTM 204 and shall be uniformly graded within the following limits:

TABLE 5.01-3 CONCRETE COARSE AGGREGATE GRADATIONS

Percent Passing

Sieve Size	Size A Aggregate 50 mm	Size B Aggregate 62.5 mm	Size C Aggregate 25 mm	Size D Aggregate 19 mm
62.5 mm (21/2 inch)	- - -	100	- - -	- - -
50 mm (2 inch)	100	95-100	- - -	- - -
37.5 mm (11/2 inch)	95-100	- - -	- - -	- - -
25 mm (1 inch)	- - -	35-70	100	- - -
19 mm (3/4 inch)	35-70	- - -	95-100	100
12.5 mm (½ inch)	- - -	10-30	- - -	90-100
9.5 mm (3/8 inch)	10-30	- - -	20-55	40-70
4.75 mm (No. 4)	0- 5	0-5	0-10	0-15
2.36 mm (No. 8)	- - -	- - -	0-5	0-5
0.075 mm (No. 200)	0-1	0-1	0-1	0-1

In addition to the above an when directed by the Engineer, coarse aggregate shall be tested in accordance with MRDTM 303 for determination of Total Moisture Content, MRDTM 304 for Specific Gravity and Absorption and MRDTM 308 for Unit Mass and Voids in Aggregates.

5.01.2.2.3 Combined Aggregate. Approved coarse aggregate and fine concrete aggregate in each batch of concrete shall be combined in proportions as approved by the Engineer.

The combined concrete aggregate gradation used in the Work shall be as specified, except that when approved by the Engineer, a Size C coarse aggregate shall be used for curbs, handrails, parapets, posts and other similar sections or members with reinforcement spacing too close to permit proper placement and consolidation of the concrete. Changes from one gradation to another shall not be made during the progress of the work unless approved by the Engineer; and shall meet the following requirements for the combined aggregates:

Material passing the 200 sieve by weight	3% Maximum
Water-soluble Chlorides, MRDTM 319	0.04% Maximum
Water-soluble Sulfates, MRDTM 318:	
Pre-stressed concrete	0.5% Maximum
Reinforced concrete	1.0% Maximum
Non-reinforced concrete	2.0%

The water soluble chlorides and sulfates limits specified for the fine and coarse aggregate individually, are subject to the following overriding requirement:

The total water-soluble chloride content (AASHTO T260) in any mix from all sources, including any chloride present in other materials and the mixing water, shall not exceed the following limits as a percentage of the weight of cement in the mix.

Reinforced concrete in humid environment and exposed to chloride	0.10%
Reinforced concrete in humid environment but not exposed to chloride	0.15%
Prestressed concrete	0.06%

In case of any likeliness of alkali reactivity the following further tests shall be conducted, as soon as practicable after the Contract is awarded to the Contractor.

(1) Potential Reactivity Tests.

- Gel Pat Test (National Building Studies, Research Paper No. 14).
- ASTM Test C 289 - Standard Test Method for Potential Alkali-Silica Reactivity of Aggregates (Chemical Method).
- ASTM Test C 227 - Standard Test Method for Potential Alkali-Silica Reactivity of Aggregates (Mortar Bar Method).

(2) Shrinkage.

The properties of the aggregates shall be such that the Drying Shrinkage of concrete prepared and tested in accordance with the United Kingdom Building Research Station Digest No. 35 (Second Series) shall not exceed forty five thousandths percent (0.045%).

The initial Drying Shrinkage of all the proposed concrete mixes prepared and tested in accordance with BS 1881 shall not exceed six hundredths percent (0.06%).

(3) Reactivity.

Aggregates for use in concrete or mortar that will be subject to wetting, extended exposure to humid atmosphere, or contact with moist ground, shall not contain any materials that are deleteriously reactive with the alkalis in the cement, or any which may be additionally present in the aggregates and mixing water or water incontact with the concrete or mortar, in amounts sufficient to cause excessive localized or general expansion of concrete or mortar.

Under no circumstances shall the Contractor use Dacite Andesite, hyolites, Opal Cherts, or Tuffs.

Coarse and fine aggregates shall be tested for reactivity potential in accordance with the methods listed above and shall satisfy the various criteria given for innocuous aggregates in the foregoing standards.

It shall be noted that the above involve a testing period of eight (8) to twenty one (21) weeks.

(4) Petrographic examination and description, including approximate composition, ASTM C295.

The above additional tests may be waived only with the written approval of the Materials and Research Department of the Ministry, where evidence can be produced that satisfactory test results are already available for materials originating from the same sources with those to be used.

5.01.2.3 Water. All sources of water for use with cement shall be approved by the Engineer. If at any time during construction the water from an approved source becomes unsatisfactory, the Contractor will be required to provide satisfactory water from some other source.

Water shall be free from injurious quantities of oil, alkali, vegetable matter and salt. The water shall be reasonably clear and shall contain not more than twenty-five hundredths percent (0.25%) total solids and organic matter when tested in accordance with MRDTM 514.

If the specific conductance is less than fifteen hundred (1500) microhms per centimeter, the total solids content requirement may be waived. Water for washing aggregates, mixing, and curing shall contain no chlorides as Cl, nor sulfates as exceeding the values for the type of work as follows:

Type of Work	Chlorides (Parts per million)	Sulfates
Nonreinforced concrete	2000	1500
Conventionally reinforced	500	1000
Prestressed concrete	500	10000

Mortar prepared with water submitted by the Contractor for test shall show no marked change in time of set, no indication of unsoundness and a reduction of not more than ten (10) percent in mortar strength when compared with mortar made with water of known satisfactory quality.

5.01.2.4 Admixtures. Admixtures to be used in concrete shall conform to the requirements specified in these specifications, the special specifications and as approved by the Engineer. The Contractor may offer to furnish admixtures at his own expense when admixtures are not specified. The Engineer shall consider the offer and approve or disapprove the use.

Chemical and air entraining admixtures containing chlorides as determined by ASTM Designation C 1152 shall not be used in reinforced or prestressed concrete.

Calcium chloride shall not be used in concrete containing any embedded metals, including reinforcing steel, unless otherwise specified.

If more than one admixture is to be used, such admixtures shall be compatible in combination as used in the concrete.

Admixtures shall conform to the following test requirements:

Chemical Admixtures	AASHTO M194
Air Entraining Admixtures	AASHTO M154
Calcium Chloride	AASHTO M144
Mineral Admixtures	ASTM Designation C618

Loss on ignition shall not exceed four percent (4%).

All admixtures to be used in the work shall be accompanied by a Certificate of Compliance signed by a responsible representative of the manufacturer.

The contractor will be permitted to use admixtures conforming to the requirements in AASHTO M194 for Type A - Water reducing, Type B - Set-retarding, or Type D - Water reducing and retarding Type F - water-reducing, high range and Type G - Water-reducing, high range and retarding to facilitate the work, subject to the following:

When concrete is designated by compressive strength, no reduction in the minimum required cement will be allowed.

When the required use of air entraining admixture is specified or ordered by the Engineer, the air entraining agent shall be used in amounts required to produce a concrete having the specified air content as determined by MRDTM 519 or MRDTM 521.

Optional use of air entraining admixture will be permitted in the amounts which will result in concrete with an air content not exceeding four percent (4%). The contractor shall include the air entraining admixture and air content as specified in these General Specifications.

When the use of mineral admixtures is specified or their use is approved by the Engineer, the minimum amount of admixture and amount and type of Portland cement will be specified or ordered. If the minimum amounts are not specified, the concrete shall be proportioned to conform to the following criteria based on a series of trial mixes:

1. Concrete shall contain the specified cement content using Type IP(MS) conforming to Subsection 5.01.2, "Materials" in these General Specifications.

2. The concrete shall contain the specified cement content consisting of not less than eighty-five percent (85%) Type II M in addition to not less than fifteen percent (15%) by weight of approved mineral admixture conforming to the requirements of ASTM C618, except Type C mineral admixture will not be permitted in conjunction with alkali-silica reactive aggregate, as determined in Paragraph 5.01.2.2 "Aggregate" in these General Specifications.

3. High range admixtures shall comply with the special procedures contained in Subparagraph 5.01.3.1.2, "High Range Water-Reducing Admixtures" in these General Specifications.

5.01.2.5 Reinforcement. Reinforcing Bars and Welded Steel Wire Fabric. Reinforcing bars and welded steel wire fabric shall conform to the requirements of Section 5.02, "Reinforcing Steel" in these General Specifications.

5.01.2.6 Grout. Materials for cement grout in precast concrete Work, where indicated on the plans or approved by the Engineer, shall consist of Portland cement Type V, ASTM C150, and fine aggregate with special gradation requirement to ASTM C144.

Shrinkage-resistance grout, where indicated on the plans or approved by the Engineer, shall be of the premixed and packaged ferrous aggregate type.

Where non-metallic shrinkage-resistant grout is indicated on the plans or approved for use by the Engineer, it shall be a premixed, non-corrosive, non-staining product, containing selected silica sands; Portland cement; shrinkage compensating agents; plasticizing; and water-reducing agents, complying with the US Corps of Engineers CRD-C558, type A.

5.01.3 MIX DESIGN. The Contractor shall perform all necessary mix design testing and furnish the results in a written report not less than thirty-five (35) days prior to beginning concrete production. All mix design testing shall be performed in accordance with MRDTM 515 and M.O.C. Circular 855/409 dated 28/11/1409H except that sufficient cylinders will be cast to permit compressive strength determination at one (1), three (3), seven (7) and twenty eight (28) days when any admixtures is used. The report furnished by the Contractor shall contain all test results for materials proposed for use and trial mixes and specific recommendations for the following:

1. The weight ratio of coarse and fine aggregates per cubic meter.

2. The cement content in kilograms per cubic meter of concrete.

3. The maximum allowable water content in liters per kilogram of cement, or equivalent units including surface moisture, but excluding water absorbed by the aggregates.

4. Slump or slumps designated at the point of delivery.

5. Description of all changes from mix proportions previously approved.

6. Initial and final setting time for concrete AASHTO T197.

7. Drying shrinkage for the recommended concrete mix according to BS 1881.

8. The dosage of the proposed admixture in either liter or kilogram per cubic meter.

5.01.3.1 Design Limits. The specified cement content shall be determined from a yield test completed in accordance with MRDTM 518.

5.01.3.1.1 Consistency of Concrete. The consistency of concrete shall be determined as specified in MRDTM 516 and MRDTM 517 at the time of delivery.

TABLE 5.01-4 CONCRETE SLUMP REQUIREMENTS (CONSISTENCY)

Type of Work	Slump (mm)[1,2]
Concrete Pavement	25 - 50
Non-Reinforced Concrete Facilities	25 - 100
Reinforced Concrete Structures:	
Sections over 30 cm thick	25 - 75
Sections 30 cm thick or less	25 - 100
Concrete placed under water	50 - 150
Cast-in-place concrete piles:	
40 cm diameter or less	75 - 150
43 cm to 60 cm diameter	50 - 125
over 60 cm diameter	25 - 100

[1]Determined in accordance with MRDTM 516 and 517.

[2]Maximum slump is two hundred (200) mm if the approved mix design contains a high range water reducer.

5.01.3.1.2 Water. The quantity of water in concrete mixes shall be regulated so that the consistency of the concrete, as determined by MRDTM 517, is within the nominal slump range listed in the above Table 5.01-4 Concrete Slump Requirements (Consistency). When the slump of the concrete exceeds these limits, the water content for subsequent batches shall be adjusted to reduce the slump to the specified range. Batches of concrete with a slump exceeding the maximum slump shall not be used in the work and shall be disposed of at locations approved by the Engineer.

The amount of free water used in a structural concrete shall not exceed the free-water to cement ratio of forty-five hundredths (0.45) by weight. The term free water is defined as the total water in the mixture minus the water absorbed by the aggregates in reaching a surface dry condition.

Concrete members whose thickness exceeds seventy-five (75) centimeters will be considered as massive concrete members; recommendations and provisions of ACI 301 Chapter 14 - Massive Concrete, shall be applicable. Water-cement ratio in massive concrete shall be reduced to thirty-five hundredths up to forty hundredths (0.35-0.40), by weight.

Concrete in contact with aggregate road materials and/or soil containing water-soluble salts of chlorides or sulfates exceeding two-tenths percent (0.2%) or in waters containing an excess of one thousand (1000) parts per million (ppm) of either chlorides or sulfates,

as determined by MRDTM 318 or MRDTM 319, shall use Type V cement conforming to Paragraph 5.01.2.1, "Portland Cement," in these General Specifications and the free-water weight to cement weight ratio shall not exceed forty hundredths (0.40). Concrete in contact with soils containing water-soluble salts of chlorides or sulfates exceeding five-tenths percent (0.5%) or in waters containing an excess of three thousand (3000) parts per million (ppm) shall be constructed in accordance with special treatments detailed in the Special Specifications.

5.01.3.1.3 High-range Water-reducing Admixture (Super Water Reducer). When the mix design includes a high-range water reducing admixture meeting the requirements of AASHTO M 194 - Type F or Type G, the following procedures shall be followed:

1. The total (initial plus all subsequent) dosage of high-range water reducer shall not exceed the manufacturer's recommended percent of the weight of cement on a solids basis. Solids are determined by AASHTO M 194, Section 18.2, Residue by Oven Drying. Any change in source or type of material in the job-mix may require a new determination of total dosage.

2. The mix shall be designed to maintain the slump specified in Table 5.01-4 Concrete Slump Requirements (Consistency) during discharge and placement.

3. The Contractor shall verify mix proportions and admixture dosages with trial mixes prior to the start of production. Trial mixes shall be produced at the approximate mix temperature, air temperature and time lapse conditions expected during production. Trial mix twenty-eight (28) day cylinder strengths shall be available prior to the start of production.

4. The following properties shall be determined by field batch trial mix procedures each time a new material, batching, or mixing procedure is introduced:

(1) Water Cement (W/C) ratio and dosage of high-range water reducing admixture necessary to achieve desired slump at expected temperatures at the project site.

(2) Time-of-Set of Concrete (AASHTO T 197).

(3) Compressive Strength of Concrete (MRDTM 528) at 1, 3, 7 and 28 days.

(4) Expected slump loss during placement of concrete under project conditions.

5. If continuous on-site batching is used, equipment shall be totally calibrated in accordance with manufacturer's instructions using the design mix in the presence of the Engineer. The Contractor shall make adjustments in admixture dosages during production to maintain the slump specified in Table 5.01-4 Concrete Slump Requirements (Consistency) during discharge and placement.

6. If delivery truck mixing is used, the following batch test procedures shall be instituted:

Test Procedures

(1) Trial Batch Size - Minimum two (2) cubic meters.

(2) The number of cylinders shall be adjusted to permit testing of three (3) cylinders at one time.

(3) Measurements and cylinders to be taken on-site for each trial batch.

1) Initial, upon arrival on-site, and before dosing: slump, temperature, and cylinders twelve (12) for testing at one (1), three (3), seven (7) and twenty-eight (28) days; nine (9) under controlled conditions, and three (3) under field conditions. The three cylinders subjected to field conditions shall be tested after seven (7) days or as directed by the Engineer.

(4) Immediately after dosing and mixing: slump, temperature, and cylinders twelve (12) for testing at one (1), three (3), seven (7) and twenty-eight (28) days; nine (9) under controlled conditions, and three (3) under field conditions. The three (3) cylinders subjected to field conditions shall be tested after seven (7) days or as directed by the Engineer.

(5) Fifteen (15 min.), thirty (30 min.), forty-five (45 min.), sixty (60 min.), seventy-five (75 min.), and ninety (90 min). after dosing and mixing; slump, temperature with cylinders twelve (12) at thirty (30), sixty (60), and ninety (90 min.) sampling points for testing at one (1), three (3), seven (7) and twenty-eight (28) days; nine (9) under controlled conditions, and (3) under field conditions. The three (3) cylinders subjected to field conditions shall be tested after seven (7) days or as directed by the Engineer.

5.01.3.1.4 Mortar. Mortar for laying stone for patching for ties, rock pockets and small voids, for grouted stone riprap, grouted stone wash checks or grouted stone ditch lining shall be composed of one (1) part of Portland cement and three (3) parts of fine aggregate by volume with water added to make a workable mix of such consistency as to perform properly the functions required for the Work being done. Amount of water added shall be approved by the Engineer.

1. Aggregates for masonry mortar shall conform to AASHTO M 45.

2. Portland Cement shall conform to Paragraph 5.01.2.1, "Portland Cement" in these General Specifications.

5.01.3.2 Changes in Proportion. As the Work progresses, the Engineer reserves the right to require the Contractor to change the proportions from time to time if conditions warrant such changes to produce satisfactory results. Any such changes may be made within the limits of the specifications at no additional compensation to the contractor.

5.01.3.3 Testing of Trial Mixes. The Contractor shall provide the Engineer with access at all times to laboratory facilities and personnel during the preparation of trial mixes. The trial mixes prepared by the Contractor shall produce dense concrete mixtures containing the minimum cement content and having the specified consistency and minimum compressive strength for each Class of concrete listed in the Bill of Quantities. The compressive strength reported shall be the average cylinder strength of either three (3) or two (2) individual cylinder test results in accordance with the procedures contained in ACI 214-77.

Concrete mixes shall also be tested in accordance with MRDTM 519 for Air Content. When designing the concrete mixes, the Contractor shall take into account the following guidelines:

The maximum aggregate size in all classes of concrete included in the Specifications, except blinding concrete, shall be not larger than one-fifth of the narrowest dimension between sides of forms, one-third of the depth of slabs nor two-thirds of the minimum clear spacing between individual reinforcing bars or bundles of bars.

After the Contractor completes the necessary mix design testing and obtains approval of the job-mix proportions for each class of concrete by the Engineer, he shall sample all materials used in the design of the concrete mixtures along with a copy of the approved job-mix reports and submit them to the Materials Department of the Ministry for review. All material samples shall be certified by the Engineer as being representative of those used in the testing procedure and shall be in sufficient quantities for the conduct of all specified physical and chemical tests as well as for preparation of the required test specimens for strength evaluation purposes.

When the materials proposed for use by the Contractor are of such a nature or are so graded that proportions based on minimum cement content cannot be used without exceeding the maximum allowable water content, the proportions shall be adjusted to produce concrete with the required consistency and workability without exceeding such allowable water content. No increase in payment shall be allowed when such changes cause an increase in cement content.

Six (6) test cylinders shall be prepared for each trial mix and each class of concrete to be furnished. The Contractor shall provide facilities for the proper curing of the test cylinders. The Contractor, after giving notice to the Engineer and providing an opportunity for the Engineer to be present, shall break three (3) cylinders after seven (7) days curing and the remaining three (3) cylinders after twenty-eight (28) days curing.

After receipt of the Contractor's mix design report, the Engineer shall review the information. When the trial mix information, for any class of concrete, fails to meet the specifications, the Engineer will direct the Contractor to prepare additional trial mixes. When the Engineer has determined that the Contractor's recommended concrete materials and mix proportions conform to the specifications he shall allow production of concrete to begin. No class of concrete shall by produced or placed until the Engineer has reviewed trial mix information and allowed production to begin.

The approval of mix proportions by the Engineer, to the Contractor in establishing those proportions, shall not relieve the Contractor from responsibility for producing concrete which conforms to the specifications.

All costs connected with furnishing laboratory facilities and personnel, testing all materials, preparing every required trial mix, reporting the information to the Engineer and all other tasks associated with preparing design mixes for all specified classes of concrete shall be borne by the Contractor.

5.01.4 EQUIPMENT. Equipment shall conform to the requirements specified in the following Part Five Sections pertaining to the various items of work specified in the Bill of Quantities. Equipment for mixing, transporting and handling concrete shall be as specified in Section 5.03, "Conc rete Structures," in these General Specifications and as approved by the Engineer.

5.01.5 PROPORTIONING AND MIXING DURING CONSTRUCTION. The concrete may be produced using a batching plant or central mixing plant with truck agitators or using in-truck mixers conforming to AASHTO M157. It may also be produced using continuous volumetric mixing equipment conforming to AASHTO M241. Mixers shall be of a type and capacity approved by the Engineer. Materials which are combined to produce concrete shall be measured by weight, except water which may be measured by weight or volume. Weights or volumes shall be in accordance with the accepted design mix.

Cement weight shall be accurate to five-tenths (0.5) percent. Coarse and fine aggregate weight shall each be accurate to five-tenths (0.5) percent. Water, whether weighed or measured volumetrically, shall be accurate to one and five-tenths (1.5) percent.

During batching in windy conditions, it is to the discretion of the Engineer to discontinue the batching process or instruct the Contractor to add additional cement at no cost.

5.01.5.1 Handling of Materials. All materials required to produce the specified class of concrete shall be assembled at the batching site in sufficient quantities to complete any continuous pour necessary for structures. The batching site shall be of adequate size to allow for storage of all required materials.

Coarse and fine aggregate shall be stored separately in stockpiles prepared in accordance with Subsection 3.01.5, "Stockpiling Aggregates," in these General Specifications. The Contractor shall prevent segregation of aggregate. Aggregate which has become segregated shall not be used until they have been thoroughly remixed and the resultant pile is of uniform gradation at any point from which a representative sample is taken. The moisture content of the fine aggregate shall be uniform throughout the stockpile and not exceed eight percent (8%) at the time of mixing. The Contractor shall remix aggregate piles when ordered by the Engineer.

The use of equipment or methods of handling aggregates which results in the degradation of the aggregates is strictly prohibited. Bulldozers with metal tracks shall not be used on coarse aggregate stockpiles. All equipment used for handling aggregates

shall be approved by the Engineer.

Aggregates shall not be stock piled against the supports of proportioning hoppers and weighing devices.

When aggregates are transported from a central proportioning plant to the mixer in batch boxes or dump trucks, such equipment shall be of sufficient capacity to carry the full volume of materials for each batch of concrete. Transport vehicles having partitions between separate batches shall be approved by the Engineer and shall be constructed to prevent batched material spilling from one compartment to another while in transit or while being dumped.

Batches, where cement has been in contact with aggregate for more than one (1) hour and remain unmixed, may be rejected by the Engineer. Unmixed batches, which are rejected, shall be disposed of at locations approved by the Engineer.

Aggregates shall enter the mixer in a manner approved by the Engineer and in such a manner to insure that no matter foreign to the concrete or matter capable of changing the desired proportions is included.

Cement, water and admixtures when used shall be stored in a manner that allows effective introduction into the batch.

5.01.5.2 Mixing Concrete. Concrete shall be mixed in quantities required for immediate use. Concrete without retarder shall not be used when it is not in place within sixty (60) minutes after the water has been added or it has developed initial set. Retempering concrete by adding water or by other means will not be permitted. Concrete that is not within the specified slump limits at the time of placement shall not be used and shall be disposed of as directed by the Engineer.

When mixed at the work site or in a central mix plant, the mixing time shall not be less than fifty (50) seconds nor more than ninety (90) seconds. Four (4) seconds shall be added to the specified mixing time when timing starts the instant the skip reaches its maximum raised position. Mixing time ends when the discharge chute opens. Transfer time in multiple drum mixers is included in mixing time. The contents of an individual mixer drum shall be removed before a succeeding batch is introduced into the mixer drum.

The mixer shall be operated at a drum speed as shown on the manufacturer's nameplate on the approved mixer. Any concrete which, in the opinion of the Engineer, is mixed more or less than the specified time shall be discarded by the Contractor at his expense and disposed of at locations approved by the Engineer. The volume of concrete mixed per batch shall not exceed the mixer's nominal capacity in cubic meters, as shown on the manufacturer's standard rating plate on the mixer, except that an overload up to ten percent (10%) above the mixer's nominal capacity may be permitted when approved by the Engineer. Approval of the Engineer shall not be given unless test data for consistency and strength are satisfactory and provided no spillage of concrete from the mixer takes place.

The batch shall be so charged into the drum that a portion of the mixing water shall enter in advance of the cement and aggregate. The flow of water shall be uniform and all water shall be in the drum by the end of the first fifteen (15) seconds of the mixing period. The throat of the drum shall be kept free of such accumulations as may restrict the free flow of materials onto the drum.

5.01.5.3 Hauling. Concrete from central mixing plants shall be transported in truck mixers, truck agitators or nonagitating trucks having special bodies, or other approved containers.

The Contractor, when supplying concrete from a central plant, shall furnish a plant with a rate of production and operate sufficient hauling equipment to provide continuous and uniform delivery at the rate required to complete the pour during the work shift. The rate of delivery of concrete shall be such as to provide uniform and continuous handling, placing, consolidating and finishing of the concrete. The method of delivery and handling of the concrete shall be such as will facilitate placing with a minimum of rehandling and without damage to the structure or the concrete. Methods of delivery and handling for each site shall be approved by the Engineer. The Engineer may delay or suspend the mixing and placing of concrete at any site when the contractor does not provide sufficient mixing and delivery capacity.

Concrete delivered in truck agitators (transit mix trucks) shall conform to all of the requirements specified for ready-mixed concrete in AASHTO M157. Transit mix trucks with any section of the blades worn twenty-five (25) millimeters or more below the original manufactured height or with accumulated hard concrete or mortar in the mixing drum shall not be used.

5.01.6 WEATHER CONDITIONS & CURING REQUIREMENTS. Concrete shall not be mixed or placed during rain, dust or sand storms.

5.01.6.1 Cold Weather and General Curing Requirements. All newly-placed concrete shall be cured for at least seven (7) days. When there is a forecast of air temperatures below two degrees Celsius (2°C.), during the curing period, the Contractor shall submit for approval by the Engineer, a cold weather concreting and curing plan detailing the methods and equipment which will be used to assure that concrete temperature does not fall below ten degrees Celsius (10°C.) during the entire curing period which will be seven (7), eight (8), nine (9), or ten (10) days after placement. When fly ash cement is used, this period shall be extended as follows:

Percentage of Cement Replaced, by Weight	Required Period of Controlled Temperature
10%	8 Days
11-15%	9 Days
16-20%	10 Days

The above requirement for an extended period of controlled temperature may be waived if a compressive strength of sixty-five percent (65%) of the specified twenty-eight (28) day design strength is achieved in six (6) days based on site-cured cylinders.

The cold weather concreting and curing plan shall detail the Contractor's proposed method of maintaining or providing heat and moisture to the concrete during the placement and curing period. No part of the structure surface shall be heated in excess of thirty-three degrees Celsius (33°C.) or changes by more than ten degrees Celsius (10°C.) in eight (8) hours while heating or insulating equipment is in use or immediately thereafter.

The contractor shall provide continuous recording thermometers at the approximate frequency of one thermometer for each thirty (30) cubic meters curing during the initial seven (7) day period.

Thermometers shall be placed adjacent to the concrete at locations selected by the Engineer. Recorded temperatures shall be furnished the Engineer. The Contractor shall maintain heating units in continuous operation. When placement of concrete occurs at an air temperature of less than fifteen degrees Celsius (15° C.), the concrete shall be placed at a temperature of not less than fifteen degrees Celsius (15° C.), for sections less than sixty (60) centimeters thick and not less than ten degrees Celsius (10° C.), for sections greater than sixty (60) centimeters thick. The heating of the concrete components shall be done in a manner which is not detrimental to the mix. The cement shall not be heated or permitted to come into contact with aggregates which are in excess of thirty-five degrees Celsius (35° C.).

Concrete at the time of placement shall be of uniform temperature and free of frost lumps. Aggregates shall not be heated by means of direct flame, or sheet metal over fire. Fine aggregate shall not be heated by direct steam. The addition of salts to prevent freezing shall not be permitted.

All forms, reinforcing steel, girders, and construction joints shall be free of snow, ice and ponded water, before concrete placement begins. The temperature of all surfaces to be in contact with new concrete shall be at least fifteen degrees Celsius (15° C.) and shall be maintained at a temperature of fifteen degrees Celsius (15° C.) or above during placement of the concrete.

The temperature of the concrete shall be not less than fifteen degrees Celsius (15° C.) at the time of placing in the forms. In case of extremely low temperature, the Engineer may, at his discretion, raise the minimum limiting temperature for work, aggregates and mixed concrete. Salt, chemicals or other materials shall not be used to prevent freezing.

5.01.6.2 Hot Weather Limitations and General Curing Requirements.

5.01.6.2.1 All Concrete. The temperature of the concrete mixture as deposited shall never exceed thirty-three degrees Celsius (33°C.) and before pumping it shall never exceed twenty-seven degrees Celsius (27°C.). The Contractor is responsible for furnishing all equipment and other resources necessary for compliance with this specification. Actions may include but are not limited to:

1. Shading or enclosing and cooling aggregates and other components.

2. Shading or otherwise cooling the batching, hauling, pumping, and other equipment during production and placement.

3. Cooling aggregates by sprinkling.

4. The cooling of mix water by refrigeration or buried tanks or the use of chipped ice for part of the mix water. Ice shall be completely melted at the conclusion of the mixing.

Water used for sprinkling aggregates or for mix water ice shall conform to the requirements of MRDTM 514. When the temperature of the concrete mixture is expected to exceed twenty-five degrees Celsius (25°C.) a retarding chemical admixture meeting the requirements of AASHTO M 194 Type B or a water-reducing and retarding chemical admixture meeting the requirements of AASHTO M 194, Type D shall be included in the approved mix design. A water-reducing high range and retarding chemical admixture meeting the requirements of AASHTO M194, Type G, may be used subject to the special procedures detailed in Subparagraph 5.01.3.1.3, "High-Range Water-Reducing Admixtures" in these General Specifications.

The forms, reinforcing steel, steel beam flanges and other surfaces that will come in contact with the mix shall be cooled to below thirty-three degrees Celsius (33° C.) until the concrete is placed by means of covering with wet burlap or cotton mats, for spraying with water, covering with protective housing, or by other approved methods. Water used for spraying shall also conform to the requirements of MRDTM 514.

Curing shall be done so that moisture is always present, and shall be an integral part of the concreting operations. The Contractor shall provide the concrete with the curing protection specified in this Subsection 5.01.6, Weather Conditions and Curing Requirements," in these General Specifications as required for the weather conditions encountered. Improperly cured concrete will be considered defective, and the Engineer will stop all of the Contractor's placing operations until proper procedures are put into effect.

If a formed surface is to be rubbed, the concrete shall be kept moist before and during the rubbing, and the curing shall be initiated immediately following the first rub while the concrete surface is still moist.

5.01.6.2.2 Method One - Supplying Additional Moisture. This method shall provide additional moisture by ponding, sprinkling or fogging. Coverings such as burlap shall be used to retain water so supplied. The use of sawdust will be allowed and coverings that cause unsightly discoloration of concrete shall not be used. Any method that results in the concrete being alternately wet and dry will be considered an improper curing procedure. Coverings shall be placed as soon as possible after finishing operations have been completed and there is no danger of surface damage. Coverings shall be kept continuously moist.

5.01.6.2.3 Method Two - Preventing Moisture Loss. This method shall consist of preventing moisture loss from the concrete. It may be accomplished with the use of approved waterproof paper, plastic sheets, or liquid membrane curing compound except where other requirements prohibit the use of these compounds.

1. Waterproof Paper. The paper shall be the widest practicable width and adjacent sheets shall be tightly sealed with pressure sensitive tape, mastic, glue, or other approved methods to form a complete water-proof cover of the entire concrete surface. The paper shall be secured so that wind will not displace it. Should any portion of the sheets be broken or damaged before expiration of the curing period, the broken or damaged portions shall be immediately repaired. Sections that have lost their waterproof qualities shall not be used.

2. Plastic Sheets. The sheets shall be used in the same manner as required above for waterproof paper.

3. Curing Compounds. Type 2 liquid membrane curing compound as specified in AASHTO M 148 may be used as the initial and final curing agent on structural concrete subject to the following limitations.

If the membrane film is broken or damaged at any time during the curing period, the area or areas shall be re-coated to the original requirements. Curing compounds shall be applied to unformed areas as soon as the water sheen has practically disappeared from the concrete, or as soon as the forms have been removed from the surfaces not be rubbed. Areas receiving a rubbed finish shall be cured with Type 1 curing compound only, as specified in AASHTO M 148. If there is any delay in applying curing compound, the surface shall receive moist curing until the compound can be applied.

Curing compound shall be applied with equipment that will produce a fine spray, and all compounds shall be thoroughly agitated just prior to and during use. The surface shall be sprayed again immediately at right angles to the first application. The rate of each application shall be between one (1) and one and one-half (1.5) liters for each five (5) square meters of surface. The exact rate is to be determined by the Engineer based upon the Contractor's field trials which insure uniform coverage with no thin areas, runs, sags, skips or holidays. Care shall be taken to prevent application to joints where concrete bond to reinforcement steel is required, and to joints where joint sealer is to be placed.

The use of liquid membrane curing compound on surfaces of construction joints and areas to receive a spray finish is prohibited.

5.01.7 NO-FINES AND CYCLOPEAN CONCRETE.

5.01.7.1 Description. No-Fines and Cyclopean Concrete may be used as structural backfill around weep holes or drains and structures to prevent back pressure or uplift. They shall consist of Portland Cement, water, coarse aggregate and admixtures

5.01.7.2 Materials.

5.01.7.2.1 Portland Cement. Portland Cement shall be Type V cement as specified in Subsection 5.01.2.1, "Portland Cement" in these General Specifications.

5.01.7.2.2 Coarse Aggregate.

1. The coarse aggregate for No-Fines Concrete shall be as specified in Paragraph 5.01.2.2, "Coarse Aggregate" in these General Specifications. However, the grading shall be single-size grading, either 9.5 to 12.5 millimeters (3/8 - 1/2 inch), or 12.5 to 19 millimeter (½ -3/4 inch); five percent (5%) oversize and ten percent (10%) undersize are allowed, but no material shall be smaller than 4.76 millimeters (No. 4 Sieve). Sharp-edged, crushed aggregate shall be avoided if possible.

2. The coarse aggregate for Cyclopean Concrete shall consist of non-reactive broken stone spalls or boulders ranging in size from one hundred (100) millimeters to three hundred (300) millimeters. They shall be free from sharp or angular edges.

5.01.7.2.3 Water. Water used in mixing and curing of No-Fines and Cyclopean Concrete shall conform to the requirements of Section 5.01.2.3, "Water" in these General Specifications.

5.01.7.2.4 Admixtures. Admixtures for No-Fines and Cyclopean Concrete shall conform to the requirements of Paragraph 5.01.2.4 "Admixtures" in these General Specifications.

5.01.7.3 Proportioning.

The Contractor shall determine the mix proportions and shall furnish no-fines concrete with a free water cement ratio in the range of thirty-eight hundredths (0.38) to forty-five hundredths (0.45). The cement content shall be in the range of seventy to one hundred thirty (130) kilograms per cubic meter. The cement aggregate ratio by volume shall be in the range of 1:10 to 1:20. No-fines concrete shall attain a minimum compressive strength of seventy (70) kilograms per square centimeter after seven (7) days per MRDTM 528. The porosity shall be such that water will pass through a slab thirty (30) centimeters thick at a rate of not less than four hundred (400) liters per minute per square meter of slab with a constant one hundred (100) millimeters depth of water on the slab.

The Contractor shall determine the mix proportions and furnish Cyclopean Concrete with a maximum water-cement ratio, minimum cement content and minimum compressible strength as shown in Table 5.03-2 Composition of Minor Structure Concrete. The coarse aggregate shall not form more than thirty percent (30%) of the total volume of concrete and shall be evenly graded.

5.01.7.4 Mixing. Mixing shall be performed according with the requirements of Subsection 5.01.5, "Proportioning and Mixing during Construction," in these General Specifications. The Cyclopean Concrete coarse aggregate shall be soaked in water prior to incorporation into the mix and evenly distributed in the concrete matrix with a minimum cover of seventy (70) millimeters.

5.01.7.5 Curing. Curing shall be done according to method one (1) of Paragraph 5.01.6.2, "Hot Weather Limitations and General Curing Requirements," in these General Specifications. Sand or any other loose material shall be prohibited.

5.01.7.6 Acceptance. Acceptance shall be based on the same criteria as contained in Subsection 5.03.9, for "Concrete for Minor Structures," in these General Specifications.

5.01.8 CONTRACTOR QUALITY CONTROL PROCEDURES. The Contractor shall sample and test all materials and the Portland cement concrete mixture throughout the period of production and placement. The results of all tests shall be delivered to the Engineer within twenty-four (24) hours after completion of testing; unless otherwise specified in this specification.

Process control shall be by lot. Lot size for the individual materials and tests shall be as listed in the M.O.C. Highway Materials Manual, Volume 1 or as specified in these General Specifications, the Special Specifications, or by the Engineer, but never less than one lot per day. Process control testing requirements are listed in Subsection 5.01.8, Contractor Quality Control Procedures,' in these General Specifications.

5.01.8.1 Quality Control of the Mixing Process. The contractor shall have a competent and experienced concrete technician in charge of the mixing operations and overall quality control. Duties of the mixing technician shall include but not be limited to the following:

1. Assurance of the proper storage and handling procedures of all components of the mix.

2. Assurance of proper maintenance and cleanliness of plant, trucks and other equipment.

3. Gradation tests of fine and coarse aggregates at frequencies necessary to assure compliance with specifications.

4. Moisture tests on aggregates and adjustments to mix proportions accordingly before each production day or more often as necessary to maintain the specified water/cement ratio.

5. Batch weight computations for each production day or plant calibration checks as necessary, based on the approved mix design.

6. Accurate batching of all concrete in accordance with the specifications.

7. Accurate completion of each batch ticket including the following information to the extend it is available prior to delivery:

(1) Name of Concrete Supplier
(2) Serial Number of Ticket
(3) Date and Truck Number
(4) Name of Contractor
(5) Designation of Structure or Location of Placement
(6) Identification of the Mix-Design and Concrete Class
(7) Quantities of all Components and Total Volume of Concrete
(8) Moisture Corrections for Aggregate Moisture
(9) Total Water in Mix at Plant and Added Prior to Discharge
(10) Times of Batching and Discharge

Copies of worksheets for items (3), (4), and (5) above shall be furnished to the Engineer as they are completed. The Contractor shall provide all equipment necessary for the above tests and controls.

5.01.8.2 Delivery, Process Control Sampling. The Contractor shall have at least one competent and experienced concrete technician in charge of concrete delivery and discharge operations. The duties of the technician shall include but not be limited to the following:

1. Assurance that any final adjustments to the mix prior to discharge are in accordance with the specification.

2. Completion of the batch ticket including the computation of the apparent water/cement ratio. One copy of each batch ticket shall be delivered to the Engineer immediately after its completion.

3. Perform temperature, slump and other screening tests to verify compliance with the specification before each placement operation and periodically during placement operations. All equipment required for these tests shall be furnished by the Contractor. Every batch shall be sampled and tested [one hundred percent (100%) sampling and testing] for slump at the start of a concrete production lot. Random sampling and testing for slump at the rate of one for every five successive batches may be substituted for one hundred percent (100%) sampling and testing if the test results for three successive batches are within the specifications limitations for temperature and slump. However, one hundred percent (100%) sampling and testing will be reinstated for that particular property if a test result for any random sample is outside the specifications limitations. Slump will be determined by MRDTM 517. Slump acceptance but not rejection may be visually determined by the Engineer. Any batch that deviates from the specified requirements will be rejected and shall be removed from the job. Sampling for temperature and slump shall be in accordance with MRDTM 516 except samples may be taken after at least five-hundredths (0.05) cubic meters of concrete have been discharged but not more than

fifteen hundredths (0.15).

For purposes of controlling the maximum water/cement ratio, the water/cement ratio for fly ash modified concrete shall be the ratio of the weight of water to the combined weights of Portland Cement and sixty percent (60%) of the weight of the fly ash.

5.01.8.3 Water. Test per MRDTM 514

5.01.8.4 Portland Cement. Test per MRDTM 504

5.01.8.5 Admixtures. Test as required in these General Specifications.
The Engineer may reject concrete before placement or after placement, consolidation and curing, and require its removal when test results indicate that it fails to conform to specification requirements.

5.01.9 QUALITY ASSURANCE PROCEDURES. Portland cement concrete shall be accepted by lot unless otherwise stated in the Special Specifications. The lot shall consist of the quantity of the concrete items listed in the Bill of Quantities in each structure. At least one lot will be expected to occur for each class of concrete. More than one lot will usually be established due to the different items in the Bill of Quantities for each structure and the number of structures. The Portland cement concrete shall be sampled, tested and evaluated in accordance with Section 1.08, "Acceptance" in these General Specifications. The Engineer may, during the beginning of placement of Portland cement concrete, at times when test results indicate erratic characteristics and at any other time, reduce the lot size to sections of embankment with similar quality characteristics. This should facilitate the isolation and modification or replacement of low-quality materials with materials of acceptable quality to maintain the overall strength of the structure or pavement.

The Engineer shall perform or supervise the performance of all quality assurance sampling and testing. The location of all samples and tests shall be recorded by structure, structure segment and in the case of pavement by centerline station (kilometer) and offset. Quality assurance testing for each lot shall include:

1. Temperature
2. Slump
3. Water-Cement Ratio
4. Compressive Strength
5. Acceptance

5.01.9.1 Temperature and Slump. The temperature and slump of batched concrete shall be screened for compliance as detailed in Paragraph 5.01.8.2 "Delivery and Process Control Sampling" in these General Specifications. The Specification limits are shown in Table 5.01-4.

5.01.9.2 Water-Cement (W/C) Ratio. The water-cement(W/C) ratio of each load of concrete shall be checked for compliance with the W/C requirements for that class of concrete. This shall be accomplished by completion of the batch ticket detailed in Paragraph 5.01.8.2 "Delivery and Process Control Sampling" in these General Specifications. The W/C ratio specification limit is forty five hundredths (0.45) unless a lower limit is specified in subsequent sections of these General Specifications or in the Special Specifications.

5.01.9.3 Compressive Strength. The Contractor's site concrete technician shall obtain Quality Assurance (Acceptance) samples of fresh concrete from loads selected by the Engineer. Sampling shall be done on a random basis in accordance with MRDTM 516. The frequency for acceptance sampling shall be a minimum of one (1) sample for each days pour or for each fifty (50) cubic meters for each class of concrete placed in each structure, whichever is greater, unless otherwise specified in the Special Specifications

The Contractor's concrete technician shall cast all cylinders required to perform all compressive strength tests, shall perform the initial curing, and shall provide for shipment or transporting of the cylinders to the project laboratory. The Contractor shall also provide the required cylinders molds. Acceptance sampling and testing shall be in accordance with the applicable requirements as follows:

- 28 Day Compressive Strengths MRDTM 528 and 523

The lower specification limit is the minimum required compressive strength at twenty-eight (28) days (f'c) specified in the contract documents plus eighty (80) kilograms per square centimeter.

Compressive strength samples shall consist of six (6) cylinders each, three (3) for the acceptance sample and three (3) for verification, projected strengths or other purposes designated by the Engineer. The compressive strength test result will be the average of the three (3) designated cylinders. The strength of any cylinder from the group of these shall not deviate by more than two (2) standard deviations from the test group mean. If such a remarkable strength is determined the outlying strength value shall be discarded and the test group mean shall be recalculated using the remaining two (2) test cylinder strengths.

For purposes of acceptance tests for cylinder compressive strength, the standard twenty-eight (28) day curing period will be extended for fly ash modified concrete by one (1) day (rounded to the nearest whole day) for each one and five-tenths percent (1.5%) of cement replaced with fly ash at the selected rate. (Example: If the maximum twenty percent (20%) of cement is replaced, the curing period for cylinders will be forty-one (41) days). The pay factor resulting from this evaluation will be applied to the contract unit prices for each lot of each class of concrete.

The acceptance test results for cylinder compressive strength will be evaluated relative to compliance with the lower specification limit for each class of concrete in accordance with Subsection 1.08.5, "Statistical Evaluation of the Work for Acceptance and

Determination of Pay Factor (Value of Work)," in these General Specifications.

A lot will be accepted when the average compressive strength is not less than the lower specification limit.

A lot of Portland cement concrete may be accepted when the average cylinder compressive strength for the lot results in a reduced pay factor of 0.90 or higher determined in accordance with Subsection 1.08.5, "Statistical Evaluation of Work for Acceptance and Determination of Pay Factor (Value of Work)," in these General Specifications.

5.01.9.4 Defective Concrete. When the average cylinder compressive strength is less than the lower specification limit by an amount resulting in a reduced pay factor below 0.90 the concrete shall be considered defective. The contractor shall replace the defective concrete or submit a detailed proposal to core the concrete to more accurately determine the strength of the defective concrete. The Contractor's coring proposal shall contain a minimum of five (5) core locations in the portion of the structure represented by the lowest cylinder results. Non-destructive testing may be proposed for consideration in lieu of coring where the structure is so heavily reinforced that useful cores cannot be obtained. The core test results will also be statistically analyzed in accordance with Subsection 1.08.5, Statistical Evaluation of Work for Acceptance and Determination of Pay Factor (Value of Work),'in these General Specifications.

Any lot of concrete may be accepted with an average core compressive strength less than the lower specification limit by an amount resulting in a reduced pay factor 0.80 or higher determined in accordance with Subsection 1.08.5, "Statistical Evaluation of Work for Acceptance and Determination of Pay Factor (Value of Work)," in these General Specifications with no individual core compressive strength less than seventy-five percent (75%) of the lower specification limit.

When the average core compressive strength of a lot of concrete is below the lower specification limit by an amount resulting in a reduced pay factor below 0.80 or with one or more individual core compressive strengths less than seventy-five percent (75%) of the lower specification limit shall be removed and replaced at the Contractor's expense.

In addition to these procedures, the Engineer may reject any concrete that is obviously defective, or test and reject any concrete which does not meet the requirements for these specifications. Any concrete represented by cylinders or cores having a compressive strength of less than eighty-five percent (85%) of the lowest specification limit or is otherwise defective and is so located as to cause an intolerably detrimental effect on the structure will be ordered removed and replaced with acceptable concrete. The Engineer may order the defective area be cored or non-destructively tested to define the defective area more accurately. The Contractor shall perform the ordered coring or testing at no cost to the Ministry. Replacement concrete shall be produced and will be accepted in accordance with these Specifications.

5.01.9.5 Acceptance. Portland cement concrete materials will be accepted in accordance Subsection 1.08.3 "Certification of Compliance," and Subsection 1.08.4, "Measured or Tested Conformance" in these General Specifications.

Portland cement concrete construction including slump, temperature and water cement (W/C) ratio will be accepted in accordance with Subsection 1.08.4,"Measured or Tested Conformance" in these General Specifications.

Portland cement concrete compressive strength will be accepted in accordance with Subsection 1.08.5, "Statistical Evaluation of Work for Acceptance and Determination of Pay Factor (Value of Work)," and Paragraph 5.01.9.4 "Defective Concrete" in these General Specifications.

5.01.10 MEASUREMENT. Portland cement concrete will not be measured under this section. Measurement of Portland cement concrete, when made, shall be under the individual items of work in which the Portland cement concrete was placed.

5.01.11 PAYMENT. Payment for Portland cement concrete will not be made under this section. Payment for Portland cement concrete shall be included in all items listed in the Bill of Quantities in which Portland cement concrete was placed.

SECTION 5.02 - REINFORCING STEEL

5.02.1 DESCRIPTION. This Work shall consist of furnishing and placing reinforcing steel in accordance with the specifications and in conformity with the plans.

ITEMS IN BILL OF QUANTITIES
Reinforcing Steel, Grade 60
Epoxy Coated Reinforcing Steel, Grade 60

5.02.2 MATERIALS. Reinforcing steel shall be manufactured to conform to the requirements of Saudi Arabian Standards Organization Standard No. 2/1399 H, "Steel Bars for the Reinforcement of Concrete," for the type and grade specified on the plans as follows:

- High Tensile Steel reinforcing bars shall conform to AASHTO M31 (ASTM A 615) Grade 60 or BS 4449.

- Epoxy Coated Reinforcing bars shall conform to AASHTO M 284(1)

- Welded Steel Wire Fabric shall conform to AASHTO M55 or BS 4483.

- Cold Drawn Steel Wire shall conform to the requirements of AASHTO M32 or BS 4482 in the case of hard drawn steel wire.

Note (1): Inspect the reinforcing bars after the near white blast cleaning has been performed. Reject all bars that exhibit steel slivers or scabs. Selective sorting and rejection at the fabricator's shop may avoid unnecessary delays and subsequent rejection of bars determined unacceptable during the precoating inspection at the coating applicator's shop.

The Engineer reserves the right to observe the preparation, coating and testing of the reinforcing bars. The Engineer or his authorized representative shall have free access to the plant and any work done when access has been requested and denied shall be automatically rejected.

5.02.3 EQUIPMENT. Equipment shall be according to the type and number outlined in the Contractor's detailed Program of Work as approved by the Engineer.

5.02.4 CONSTRUCTION REQUIREMENTS.

5.02.4.1 Bending Diagrams. Before fabricating bars, all bending diagrams shall be furnished by the Contractor for the approval of the Engineer, and no materials shall be fabricated until such bending diagrams have been approved. Vertical reinforcement in columns, walls, piers, and shafts shall not be fabricated until footing elevations are established in the field. Approval of bending diagrams will in no way relieve the Contractor of his responsibility for ascertaining accuracy of such diagrams. Revision of materials furnished in accordance with such diagrams to meet compliance with design drawings shall be at the expense of the Contractor.

5.02.4.2 Protection and Storage. Reinforcing steel shall be protected at all times from damage. Reinforcing steel shall be stored above the ground on platforms, skids or other supports. It shall be stored in such a manner and adequately marked to facilitate inspection and checking. Before and after placement, reinforcing steel shall be free from detrimental dirt, mill scale, rust, paint, grease, oil or other foreign substances, fins, or tears. The Contractor will not be required to remove slight rusting which discolors the metal but he shall remove all loose mill scale and scalely rust. Brushing to clean blue metal will not be required.

5.02.4.3 Cutting and Bending. All cutting and bending of reinforcement bars shall be done by competent workmen and with equipment approved by the Engineer. Unless shown otherwise on the plans or unless written approval is obtained from the Engineer, all reinforcement bars shall be cut and bent in a fabrication shop accessible to the Engineer according to the following procedures:

1. Fabricate reinforcing bars to conform to required shapes and dimensions, with fabrication tolerance complying with CRSI Manual of Standard Practice.
Reinforcement with any of the following defects will not be permitted in the Work:

(1) Bar lengths, depths, and bends exceeding specified fabrication tolerances.
(2) Bends or kinks not indicated on the drawings or the final shop drawings.
(3) Bars with reduced cross-section due to excessive rusting or other cause.
(4) Epoxy coating not meeting the requirements of this section.

2. Cold worked bars and hot rolled high yield bars shall not be straightened or bent again once having been bent. Where it is necessary to bend mild steel reinforcement projecting from the concrete, the internal radius of bend shall not be less than twice the diameter of the bar.

3. Reinforcement bars shall be bent to the dimensions given in the Bar Bending Schedule. All reinforcement shall be cold bent at the temperature range of five degrees Celsius (5° C.) and one hundred degrees Celsius (100° C.). The minimum bending radii for high tensile steel and mild steel bars shall be not less than three (3) times and two (2) times, respectively, of the nominal bar diameter.

Bends shall conform to the following requirements:

D = 6d for six (6) millimeter through twenty-two (22) millimeter bar sizes.

D = 8d for twenty-four (24) millimeter through twenty-eight (28) millimeter bar sizes.

D = 10d for thirty (30) millimeter and over bar sizes.

Where (D) is the minimum pin diameter around which a bar may be bent and (d) is the bar diameter.

The overall height or Drop Bending Tolerance for deck truss bars shall be limited to plus 0 mm or minus six (6) millimeters.

5.02.4.4 Placing, Supporting and Fastening. Comply with the CRSI recommended practice for placing reinforcing bars, for details and methods of reinforcement placement and supports, and as herein specified.

All reinforcing steel shall be accurately placed and, during the placing of concrete, firmly held by approved supports in the position shown on the plans. Reinforcing bars shall be securely fastened together. Reinforcement placed in any member shall be inspected and approved before any concrete is placed. Laying or driving bars into the concrete after placement will not be permitted.

Bar supports shall be precast mortar blocks, plastic, or metal supports. Mortar blocks shall be constructed and cured in accordance with the requirements in Section 5.01, "Portland Cement Concrete" in these General Specifications as related to "Mortar" and "Curing." The minimum compressive strength of mortar used for blocks shall equal the minimum compressive strength of concrete for the structure in which they are used. Mortar block supports shall be attached to the supported bar by means of 16-gauge wire cast in the center of each block. Other supports shall be positively attached to the reinforcing steel. Over waterproofing membranes, the use of precast mortar blocks shall be encouraged, to prevent penetration of the membrane.

Cover supports in contact with exposed concrete surfaces shall be buff-colored plastic spacers or plastic protected. Bar supports shall not be used directly or indirectly to support runways for concrete buggies or other similar construction loads.

If supports indent the forms appreciably or deform due to the weight of the reinforcing steel, spacing shall be decreased or heavier duty supports shall be substituted. Reinforcement shall be placed and maintained in the position shown on the drawings. Unless otherwise permitted by the Engineer, all bar intersections shall be securely tied together with the ends of the tying wire turned into the main body of the concrete. Minimum one and two-tenths (1.2) millimeter diameter stainless steel wire shall be used for in-situ members having exposed soffits. Minimum one and six-tenths (1.6) millimeter diameter softer annealed iron wire may be used elsewhere.

In bridge decks, reinforcing bars shall be tied together at all intersections except where spacing is less than three hundred (300) millimeters in both directions, in which case alternate intersections may be tied securely to prevent displacement during concrete placement.

The supports for reinforcing steel shall not be spaced more than one and two-tenths (1.2) meters apart transversely or longitudinally. The placement of deck reinforcing steel shall not deviate more than ten (10) millimeters in the vertical direction or fifty (50) millimeters in the horizontal direction from the position shown on the plans.

Prior to the placement of bridge deck concrete, the Contractor, using the approved screed or finishing machine shall check and verify, in the presence of the Engineer, the minimum cover over reinforcing steel and total thickness of the deck. The verification process shall cover the entire surface of the deck with maximum intervals between

checkpoints of three (3) meters in both the lateral and longitudinal direction.

All reinforcement shall have a concrete coverage of fifty (50) millimeters or more except as shown otherwise on the plans or specified herein.

5.02.4.5 Splicing. Splicing, except where shown on the plans, will not be permitted without the approval of the Engineer. Lap lengths shall be as shown on the plans. Proprietary mechanical splicing devices shall be used only with the prior approval of the Engineer in writing.

No measurement or payment shall be made for additional reinforcement steel used for splices not shown on the plans. Splices shall be avoided at points of maximum stress. They shall, where possible, be staggered, and shall be designed to develop the strength of the bar without exceeding the allowable unit bond stress. Unless otherwise shown on the plans, all bars shall be lapped a minimum of fifty (50) diameters. Unless otherwise shown on the plans, splices in adjacent lines of reinforcing bars shall be staggered.

5.02.4.6 Welded Wire Mesh Reinforcement for Structures. Welded wire mesh reinforcement shall be of the sizes and spacing of bars and sheets as shown on the plans. Welded wire fabric furnished under this specification shall conform to the requirements of AASHTO M55. If mesh is shipped in rolls, the Contractor shall straighten them into flat sheets before placing. He shall splice sheets of mesh by overlapping not less than one mesh wide plus fifty (50) millimeters and shall securely fasten them at the ends and edges.

5.02.4.7 Drilled Shaft Reinforcing. The reinforcing steel unit for the shaft consisting of longitudinal bars and spiral hooping or lateral ties shall be completely assembled and placed into position as a unit for shafts of seven hundred fifty (750) millimeters in diameter and less. The longitudinal bars shall be tied to the spiral reinforcement at intervals, not to exceed four hundred fifty (450) millimeters on centers, and such tying shall be staggered on the various bars in order to provide a rigid unit. Bars shall be tied to lateral tie bars at all intersections. The lower end of each vertical bar shall be supported upon a suitable precast concrete spacer block. Side spacer blocks of concrete shall be used at suitable intervals along the unit to insure adequate spacing for the entire length of the shaft.

5.02.4.8 Welding of Reinforcement. Reinforcement in structures shall not be welded except where indicated on the drawings or by written approval of the Engineer. All welding of reinforcing steel where approved by the Engineer, shall conform to AWS D12.1, "Recommended Practices for Welding Reinforced Steel, Metal Inserts and Connections in Reinforced Concrete Construction." However, do not weld reinforcing steel if the chemical composition of the steel exceeds the percentages in Table 5.02.-1, Reinforcing Steel Components.

TABLE 5.02-1
REINFORCING STEEL COMPONENTS

Chemical Composition	***Percent***
Carbon (C)	0.30
Manganese (MA)	1.50
Carbon Equivalent (C.E.)	0.55

Use welders that are currently certified. When required in the contract, test each weld using magnetic particle, radiography or other nondestructive inspection techniques.

Mechanical couplers may be used in lieu of welding if approved. Use couplers with a yield strength that is at least one hundred twenty-five percent (125%) of the required yield strength of the reinforcing steel.

5.02.4.9 Epoxy Coated Reinforcing Steel. Support coated bars on padded contact areas. Pad all bundled bands. Lift with a strong back, multiple supports or a platform bridge. Prevent bar to bar abrasion. Do not drop or drag bundles.

Before placement, inspect coated bars for damage to the coating. Patch all defects in the coating that are discernible to the unaided eye with a prequalified patching/repair material according to AASHTO M 284. Clean areas to be patched by removing all surface contaminants and damaged coating. Roughen the area to be patched before applying the patching material. Where rust is present, remove the rust by blast cleaning or power tool cleaning immediately before applying the patching material.

Promptly treat the bar according to the resin manufacturer's recommendations and before detrimental oxidation occurs. Overlap the patching material onto the original coating for fifty (50) millimeters or as recommended by the manufacturer. Provide a minimum 8 mil (200 mm) dry film thickness on the patched areas.

Take necessary steps to minimize damage to the epoxy coating of installed bars. Clean and patch any damage to the coating noted after installation as described above.

Field repairs will not be allowed on bars that have severely damaged coatings. Replace bars with severely damaged coatings. A severely damaged coating is defined as a coating with a total damaged area in any three hundred (300) millimeter length of bar that exceeds five percent (5%) of the surface area of that portion of the bar. Coat mechanical splices after splice installation according to AASHTO M 284 for patching damaged epoxy coatings.

5.02.5 QUALITY ASSURANCE PROCEDURES. Reinforcing steel and epoxy coating material shall be evaluated and accepted under Subsection 1.08.5, "Certification of Compliance," in these General Specifications as outlined in the following procedures: Three (3) copies of a mill test report shall be furnished to the Engineer for each lot of billet-steel reinforcement bars proposed for use on the project. The mill test report shall be sworn to for the manufacturer of the steel by a person having legal authority to bind the manufacturer and shall show the following information:

1. The process or processes used in the manufacture of the steel from which the bars were rolled.

2. Identification of each heat of open hearth, basic oxygen, or electric furnace and/or each lot of acid bessemer steel from which the bars are rolled.

3. Chemical and physical properties of the heat from which the bars were rolled.

The bars in each lot shall be legibly tagged by the manufacturer and/or fabricator before the lot is offered for inspection. The tag shall show the manufacturer's test number and lot number or other designation that will identify the material with the certificate issued for that lot of steel.

The fabricator shall furnish three (3) copies of a certification which shows the heat number or numbers from which each size of bar in the shipment was fabricated.

The sampling and testing of reinforcement bars may be made at the source of supply when the quantity to be shipped or other conditions warrant such inspection. Bars not inspected before shipment will be inspected after arrival on the Work. Sample bars shall be a minimum of one (1) meter in length. Bars sampled at the Work site shall be replaced by the Contractor without additional compensation. The Engineer reserves the right to resample and inspect all reinforcement steel upon its arrival at the Work site.

5.02.6 METHOD OF MEASUREMENT. Measurement of "Reinforcing Steel" will be based on the theoretical number of tons complete in place as shown on the plans or placed as ordered in writing by the Engineer. No allowance will be made for the slips, wire or other fastening devices for holding the steel in place, and no measurement of splices not shown on the plans will be made. No deductions from the theoretical weights will be made for minor shortening at bends.

Calculated weights shall be based upon the following table:

TABLE 5.02-2 WEIGHTS OF REINFORCING BARS

DIAMETER (mm)	WEIGHT (kg/m)	DIAMETER (mm)	WEIGHT (kg/m)	DIAMETER (mm)	WEIGHT (kg/m)
6	0.222	20	2.470	34	7.130
8	0.395	22	2.980	36	7.990
10	0.617	24	3.550	38	8.900
12	0.888	26	4.170	40	9.870
14	1.210	28	4.830	50	15.40
16	1.580	30	5.550		
18	2.000	32	6.310		

No allowance will be made for the weight of weld metal used in the fabrication of bar trusses. No measurement will be made for welded (mesh) steel reinforcement or cold drawn steel wire as they are considered subsidiary to the construction of the item in which they are placed.

5.02.7 PAYMENT. The amount of completed and accepted material, measured as provided above, will be paid for at the contract unit price per ton of Reinforcing Steel and Epoxy Coated Reinforcing Steel, as specified in the Bill of Quantities, which price and payment shall be full compensation for furnishing, fabricating, transporting, delivering, erecting, and placing all materials, including all labor, equipment, tools, and all other items necessary for the proper completion of the Work as specified in Subsection 1.07.2, "Scope of Payment," in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO.	PAY ITEM	PAY UNIT
50201	Reinforcing Steel, Grade 60	Ton
50202	Epoxy Coated Reinforcing Steel, Grade 60	Ton

SECTION 5.03 - CONCRETE STRUCTURES

5.03.1 DESCRIPTION. This Work shall consist of designing, installing and removing formwork and falsework, furnishing, placing, consolidating and curing of Portland cement concrete for bridge, tunnel and minor structures and incidental construction in accordance with the specifications and in conformity with the lines, grades and dimensions as shown on the plans or established by the Engineer.

ITEMS IN BILL OF QUANTITIES
Structural Concrete for Bridge Superstructure
Structural Concrete for Bridge Substructure
Structural Concrete for Box Culverts
Structural Concrete for Retaining Walls
Structural Concrete for Tunnel Portals
Structural Concrete for Mainline Tunnel Lining
Structural Concrete for Cross Passage Tunnel Lining
Concrete for Minor Structures
Bearing Devices
Expansion Joints
Water Stops
Mineral Admixture

5.03.2 MATERIALS. The materials, handling of cement and aggregates, the classification, composition, consistency, proportioning, batching, mixing and transportation of bridge structure concrete shall conform to the requirements of Section 5.01, "Portland Cement Concrete," in these General Specifications.

Reinforcement shall conform to the requirements of Section 5.02, "Reinforcing Steel," in these General Specifications. Materials for expansion and contraction joints in concrete structures shall conform to the requirements specified in the plans, standard drawings, or Special Specifications as appropriate.

Materials for the bridge deck drainage system shall be as specified in Subsection 5.11.2, "Materials," in these General Specifications.

5.03.3 EQUIPMENT. Equipment shall conform to and be as detailed in the Contractor's Program of Work, as approved by the Engineer. All bridge decks shall be consolidated and finished using mechanical bridge deck finishing machines. Hand consolidation and finishing will not be permitted. Curing compound shall be applied off work bridges in accordance with Paragraph 5.03.4.5, "Handling and Placing Bridge Structure Concrete," in these General Specifications.

5.03.4 CONSTRUCTION REQUIREMENTS.

5.03.4.1 Bridge Structure Concrete. The handling of cement and aggregates, composition, consistency, proportioning, batching, mixing and delivery shall conform to the requirements of Section 5.01, "Portland Cement Concrete," in these General Specifications for the class of concrete specified in the plans or Special Specifications.

5.03.4.2 Bridge Structure Falsework.

5.03.4.2.1 General. Detailed plans for falsework and centering shall be prepared by the Contractor and submitted to the Engineer for approval. No Work shall be started until the plans are approved in writing. The Contractor shall submit to the Engineer for approval at least one month before commencing work, details of his proposed system of falsework, including detailed drawings and calculations. Falsework shall be capable of temperature changes without causing damage to the concrete.

Notwithstanding any approval of falsework design by the Engineer, the Contractor will not be relieved of his responsibility for the adequacy and correctness of the design, manufacture and assembly of the falsework. Falsework and centering shall be designed and constructed to support the total anticipated dead and live loads, including wind loads, during all stages of construction, with a deflection not to exceed two thousandths (0.002) of the falsework span. The Contractor shall submit calculations to support this requirement for all spans over three (3) meters and other spans if requested by the Engineer. On concrete bridge deck replacement works the Contractor shall submit calculations showing that shoring is not required including actual falsework calculations when the deck removal thickness is fifty (50) millimeters or greater.

Any embankment or backfill, whether permanent or temporary, required to support falsework shall meet the quality and compaction requirements of Subsection 2.09.4, "Backfilling of Structures" in these General Specifications. In situ material shall not be used to support falsework unless it is approved by the Engineer with respect to its load bearing capacity. In situ material approved for use to support falsework shall be compacted to Type 95 Compaction as determined by Subsection 2.05.4, "Lift Thickness and Compaction," requirements in these General Specifications.

Falsework and centering supports shall be designed and constructed to provide the necessary rigidity to support all loads placed upon it without appreciable settlement or deformation. Falsework columns shall be supported on concrete, wood, or metal bases to distribute the loads to the underlying material. The size of the bases shall be based on the supporting capacity of that material. If necessary, supporting material shall be removed, replaced, or recompacted to enable it to support the falsework. Falsework shall not be supported on any part of the structure, except the footings, without the written permission of the Engineer. The number and spacing of falsework columns, the adequacy of sills, caps and stringers, and the amount of bracing in the falsework framing shall be subject to approval of the Engineer.

All timber shall be of sound wood, in good condition, and free from defects that might impair its strength. If the vertical members are of insufficient length to cap at the desired elevation for the horizontal members, they shall preferably be capped and frames constructed to the proper elevation. Ends of the vertical members shall be cut square for full bearing to preclude the use of wedges. If vertical splices are necessary, the abutting members shall be of the same approximate size, the ends shall be cut square for full bearing, and the splices shall be scabbed in a manner approved by the Engineer.

The Contractor shall compute the estimated amount of settlement and deflection of the falsework due to placement of the concrete. Provisions shall be made in the falsework for this settlement and/or deflection so that the completed structure will conform to dimensions and grades shown on the plans. The Engineer will check and approve the Contractor's computations. Wedges or screw jacks shall be used in all falsework construction and shall be so placed that they can be adjusted to give proper form alignment. The Contractor shall provide means for adjusting forms at any time prior to concrete placement. If screw jacks are used, they shall be adequately braced and secured in such a manner that will prevent tipping of the jacks in any direction.

The Contractor shall provide means for accurately measuring settlement in falsework during placement of concrete, and shall provide a competent person to monitor the settlement and initiate corrective action when necessary.

The Engineer may refuse permission to proceed with other phases of the Work if he deems the falsework unsafe or inadequate to properly support the loads to which it will be subjected.

5.03.4.2.2 Falsework Design.

1. The falsework design drawings shall show the stresses and deflections in all load supporting members, and anticipated total settlement of falsework footings and joint take-up. Anticipated settlements shall not exceed twenty-five (25) millimeters. The maximum deflection used in the design of the falsework shall be 1/500 of the falsework span, irrespective of the fact that the deflection may be compensated for by camber strips.

2. The design of falsework shall be based on the use of loads and conditions which are no less severe than those described in this section. The stresses listed are based upon the use of undamaged, high quality materials and such stresses shall be reduced by the Contractor if lesser quality materials are to be used. The Contractor is responsible for the proper evaluation of his falsework materials and design of the falsework to safely carry the actual loads imposed.

3. The vertical design load for falsework shall consist of the sum of dead and live vertical loads and an assumed horizontal load.

(1) Dead loads shall include the weight of concrete, reinforcing steel, forms, and falsework. The weight of concrete, reinforcing steel and forms shall be assumed to be not less than two thousand six hundred (2,600) kilograms per cubic meter for normal concrete and not less than twenty one hundred (2,100) kilograms per cubic meter for lightweight

concrete.

(2) Horizontal pressure shall be based on an assumed unit weight between fourteen hundred (1,400) and twenty-four hundred (2,400) kilograms per cubic meter depending on the rate of placement and the effect of retarding admixture, as approved by the Engineer.

(3) Timber dead load is eight hundred (800) kilograms per cubic meter. The dead load of timber forms may be assumed at fifty (50) kilograms per square meter for members smaller than one hundred fifty (150) millimeters by one hundred fifty (150) millimeters. Dead load for steel and steel forms shall be seven thousand eight hundred fifty (7,850) kilograms per cubic meter. The weight of any other forming materials shall be specified on the drawings.

(4) Live loads shall consist of the actual weight of any equipment to be supported by falsework applied as concentrated loads at the points of contact and a uniform load of not less than two hundred forty-five (245) kilograms per square meter applied over the area supported plus eleven hundred (1100) new tons per meter at the outside edge of deck falsework overhangs..

(5) The total vertical design load for falsework is the sum of the vertical dead and live loads. A total vertical design load of not less than forty eight hundred (4800) shall be used.

4. The assumed horizontal load to be resisted by the falsework bracing system shall be the sum of the actual horizontal loads due to equipment, construction sequence or other causes and an allowance for wind; however, the assumed horizontal load to be resisted in any direction shall not be less than two percent (2%) of the total load for falsework up to ten (10) meters high. The falsework shall be designed so that it will have sufficient rigidity to resist the horizontal load prior to the placement of concrete.

5. The entire bridge superstructure cross-section, except railing, shall be considered to be placed at one time except as provided herein. Girder stems and connected bottom slabs, if placed more than five (5) days prior to the top slab, may be considered to be self-supporting between falsework posts at the time the top slab is placed, provided that the distance between falsework posts does not exceed four (4) times the depth of the portion of the girder placed in the first pour.

6. Falsework footings shall be designed to carry the load imposed upon them without exceeding the estimated soil bearing values and anticipated settlements.

7. Foundations for individual towers when the maximum leg load exceeds one hundred thirty-three (133) kilonewtons shall be designed and constructed to provide uniform settlement under all legs of each tower under all loading conditions.

8. If the concrete is to be post-tensioned in the field, the falsework shall be designed to support any increased or readjusted loads caused by the prestressing forces, as shown on the plans.

9. The falsework design drawings shall include the following minimum information:

(1) Type and grade of structural materials.
(2) Allowable material stresses in bending, compression, and shear.
(3) Modulus of elasticity, "E".
(4) Stress factors if used for short term duration loading (timber only).
(5) Summary of critical tower leg loads and locations on falsework drawings.
(6) Weight of deck finishing machine and wheel or support spacing.
(7) References for load data used for standardized falsework components.
(8) Specification references for design criteria.
(9) The bearing value of the soil as determined by the Contractor when footing type foundations are to be used.

10. Falsework design shall be based on the current edition of one of the following applicable specifications. However, it shall be based on AASHTO Specifications if highway traffic is to be supported.

AASHTO	American Association of State Highway and Transportation Officials, Standard Specifications for Highway Bridges.
AISC	American Institute of Steel Construction, Manual of Steel Construction.
ACI	American Concrete Institute, Formwork for Concrete SP4 Building Code Requirements for Reinforced Concrete.
NFPA	National Forest Products Association, National Design Specifications for Wood Construction.
AITC	American Institute of Timber Construction Manual.

11. The maximum loadings and deflections used on jacks, columns, brackets, joists, and other manufactured devices shall not exceed the manufacturer's recommendations.

12. Connection details shall be so designed that structural shoring members are secure for all loading conditions.

13. For identified grades of steel, do not exceed the design stresses (other than stresses due to flexural compression) specified in the Manual of Steel Construction as published by AISC.

14. When the grade of steel for structural shapes cannot be positively identified, do not exceed the design stresses, other than stresses due to flexural compression, specified in the AISC Manual for A36 steel or the following:

Tension, axial and flexural	**150 Megapascals (MPa)**
Compression, axial (L/r max. = 120)	**110,000 - 2.62$(L/r)^2$ kilopascals (kPa)**

Where:

L = the unsupported length of the column (mm)
r = the corresponding least radius of gyration of the section (mm)

Shear on the gross section of the web of rolled shapes 100 MPa

Web crippling for rolled shapes 180 MPa

For all grades of steel, do not exceed the following flexural compression design stress.

Compression, flexural [1] $= \dfrac{82750}{Ld/bt}$ **MPa**

NOTE [1]: Not to exceed one hundred fifty-two (152) MPa for unidentified steel or steel conforming to ASTM A36. Not to exceed (0.6)F_y for other identified steel.

Where:

L = The unsupported length.
d = The least dimension of a square or rectangular column or the width of a square of equivalent cross-sectional area for round columns or the depth for beams.
b = the width of the compression flange.
t = the thickness of the compression flange.
r = the radius of gyration of the member.
F_y = the specified minimum yield stress for the grade of steel used.

15. When timber is used as falsewark the allowable maximum design stresses and loads listed below are based on the use of undamaged, high-quality material. If lesser quality material is used the allowable stresses and loads shall be reduced accordingly.

The following maximum stresses and loads shall not be exceeded in falsework design using timber:

Compression perpendicular to the grain = 3100 kilopascals

Compression parallel to the grain (1) $\dfrac{3309}{(L/d)^2}$ **megapascals**

Note: (1) Not to exceed 11 megapascals.

Where:

L = Unsupported length

d = Least dimension of a square of equivalent cross-sectional area for round columns

Flexural stress = 12.4 megapascals

Note: Reduced to 10 megapascals for members with a nominal depth of two hundred (200) millimeters or less.

Horizontal shear = 1300 kilopascals

Axial tension = 8.3 megapascals

Modulus of elasticity (E) for timber - 11.7 gigapascals
Maximum axial loading on timber piles - 400 kilonewtons

Design timber connections according to the stresses and loads allowed in the National Design Specification for Wood Construction, as published by the National forest Products Association except:

(1) Reductions in allowable loads required therein for high moisture condition of the lumber and service conditions do not apply.

(2) Seventy five percent (75%) of the tabulated design value as the design value of bolts in two member connections (single shear) shall be used.

16. Falsework spans supporting T-beam girder bridges shall be limited to four and three-tenths (4.3) meters plus eight and one-half (8.5) times the overall depth of T-beam girder.

5.03.4.3 Bridge Structure Forms. Forms shall be mortartight and sufficiently rigid to prevent distortion from pressure of the concrete and other loads incidental to the construction operations, including vibration. Forms shall be constructed and maintained to prevent the opening of joints due to shrinkage of lumber. They shall be designed to permit easy removal without injury to the concrete. Form lining such as smooth, exterior grade plywood or other approved material shall be used for all exposed formed surfaces. The Contractor shall submit samples, specifications, and other pertinent information to the Engineer and secure his written approval prior to use of the form lining.

Form lining material shall not bulge, warp or blister, nor shall it stain the concrete. Form lining shall be used in the largest practicable panels to minimize joints. Small panels of the lining material shall not be permitted. The joints in the lining shall be tight and smoothly cut. Adjacent panels of form lining shall be so placed that the grain of wood will be in the same general direction. Thin metal form lining will not be permitted unless they are in new condition and firmly backed.

Undressed lumber of uniform thickness may be used for backing or form lining. Wooden

plywood, of adequate thickness, which is properly supported to meet the above requirements, may be used alone in lieu of the lined forms specified herein.

Forms shall be maintained after erection to eliminate warping and shrinkage. They shall be checked for dimensions and condition immediately prior to the placement of concrete. The Engineer may at any time require the revision or reconstruction of forms and may refuse permission to place concrete within the forms until they are satisfactorily constructed. If, at any period of the Work during or after placing the concrete, the forms shown signs of sagging or bulging, the concrete shall be removed to the extent directed by the Engineer, the forms brought to the proper position, and new concrete placed. No allowance will be made to the Contractor for such extra Work.

Metal forms may be used and are subject to the same requirements and approvals specified for wood forms. The specifications for wood forms with respect to design, mortartightness, filleted corners, beveled projections, bracing, alignment, removal, reuse and oiling, also apply to metal forms. The metal used for forms shall be of such thickness that the forms will remain true to shape. All bolt and rivet heads shall be countersunk. Clamps, pins, or other connecting devices shall be designed to hold the forms rigidly together and to allow removal without injury to the concrete. Metal forms which do not present a smooth surface or do not line up properly shall not be used. Care shall be exercised to keep metal forms free from rust, grease, or other foreign matter. Under such circumstances the continuance of use of the metal forms will depend upon satisfactory performance and their discontinuance may be required at any time by the Engineer. Steel panels or panels with metal frames and wood or combination facing which leave permanent impressions or ridges will not be approved.

The inside of all forms shall be oiled with a light, clear, paraffin base oil that will not discolor or otherwise injure the surface of the concrete. The oiling shall be done where possible after the completion of the forms and prior to placement of reinforcement.

Unless otherwise directed, the exterior side of all forms exposed to the sun shall be painted with an approved, good quality, high gloss white oil base enamel prior to placing concrete. When complete coverage is not obtained with one (1) coat, the Engineer will order additional coats as he deems necessary to obtain complete coverage. Forms shall be repainted when ordered by the Engineer.

Form joints shall be closed by moistening the forms with water prior to concrete placement. Forms that are to be reused shall be thoroughly cleaned and reoiled and, if necessary, shall be reconditioned by revision or reconstruction. Unsatisfactory lumber will be condemned by the Engineer, and shall be removed from the site.

The width and thickness of the lumber, the size and spacing of studs and wales shall be determined with due regard to the nature of the Work and shall be sufficient to insure rigidity of the forms and to prevent distortion due to the pressure of the concrete.

Forms bolts, rods, or ties shall be made of steel. Ties may be the type which permits the major part of the tie to remain permanently in the structure. They shall be held in place by devices attached to the wales capable of developing the strength of the ties. The

Engineer may permit the use of wire ties on irregular sections and incidental construction if the concrete pressures are nominal and the form alignment is maintained by other means. Form ties will not be permitted through forms for handrail. Pipe spreaders shall not be used unless they can be removed as the concrete is placed, as determined by the Engineer. Wood or metal spreaders shall be removed as the concrete is placed. Where the bottom of the forms is inaccessible, the lower form boards shall be left loose or other provisions made so that the extraneous material may be removed from the forms immediately before placing the concrete.

Unless provided otherwise on the plans or directed by the Engineer, all exposed edges shall be beveled by using dressed, mill-cut, triangular molding, having twenty (20) millimeter sides. All curved surfaces shall be formed with approved plywood or steel.

Placement of reinforcing steel shall not begin on any part of a structure until the location, alignment, and construction of forms and falsework are approved by the Engineer for that part of the structure. The Contractor shall conduct all surveyed and dimensional checks required by the Engineer to verify the adequacy of the forms and falsework. The forms shall be clean and free of all debris before concrete is placed.

Prior to the placement of bridge deck concrete, the Contractor, using the approved screed or finishing machine, shall check and verify, in the presence of the Engineer, the elevations, minimum cover over the reinforcing steel, and total thickness of the deck. The verification process shall cover the entire surface of the deck with maximum intervals between checkpoints of three (3) meters in both the lateral and longitudinal direction. Placement of bridge deck concrete shall not begin until the screed, location of screed rails, reinforcing steel, and deck forms are approved by the Engineer.

The Contractor shall submit to the Engineer all details of formwork, liners, joints, and other materials together with fabrication drawings, details of the working practices and the procedures he proposed to use for obtaining approvals before any fabrication work begins. No formwork shall be brought to the site without the prior approval of the Engineer. Adequate time shall be allowed by the Contractor in his program for these approvals.

Formwork for bridge structures shall comply with the following requirements in respect of classes of finish. In the following descriptions, F relates to formed surfaces and U relates to unformed surfaces.

Class F1

Formwork shall be lined with a material approved by the Engineer to provide a smooth finish of uniform appearance. This material shall leave no stain on the concrete and shall be so joined and fixed to its backing that it imparts no blemishes. It shall be of the same type and obtained from only one source for any one structure. The Contractor shall make good any imperfections in the finish as directed by the Engineer.

Class F2

Similar to F1, except with special additional features as shown on the drawings or as specified by the Engineer. These features shall be achieved by the use of approved form liners which shall have no horizontal or vertical joints except at locations shown on the drawings or as directed by the Engineer. Where F2 finishes are specified, through ties, whether sleeved or permanently embedded in the concrete, bolts, brackets or any other cast-in fixings will not be permitted except with the written consent of the Engineer.

Class F3

Irregularities in the finish shall be no greater than those resulting from the use of rough thick square edged boards arranged in a uniform pattern. The finish is intended to be left as struck. Imperfections such as fins and surface discoloration shall, however, be made good as and when required by the Engineer.

Class F4

No special requirements.

Permanently exposed concrete surfaces to Classes F1, F2 and F3 finish shall be protected from rust marks and stains of all kinds. Internal ties and embedded metal parts will not be permitted.

The Contractor shall submit to the Engineer all details of formwork, liners, joints, and materials including fabrication drawings and stating procedures involved in the use of formwork for approval before commencement of any work on fabrication. No formwork shall be brought to site without the prior approval of the Engineer. Adequate time shall be allowed by the Contractor in his program for these approvals after consultation with the Engineer.

Class U1

The Concrete shall be uniformly leveled and screeded to produce a plain or ridged surface as described in the Contract. No further work shall be applied to the surface unless it is used as the first stage for Class U2 or Class U3 finish.

Class U2

After the concrete has hardened sufficiently, the concrete Class U1 surface shall be floated by hand or machine sufficiently only to produce a uniform surface free from screed marks.

Class U3

When the moisture film has disappeared and the concrete has hardened sufficiently to prevent laitance from being worked to the surface, a Class U1 surface shall be steel-troweled under constant pressure to produce a dense, smooth uniform surface free from trowel marks.

Surfaces which are to receive deck waterproofing shall be finished to an accuracy such that when tested with a three meter long straightedge, the maximum depression shall not exceed five (5) mm.

The inside surfaces of all forms shall, except for pavement formwork, or unless otherwise agreed by the Engineer, be coated with a release agent approved by the Engineer. Release agents shall be applied strictly in accordance with the manufacturer's instructions and shall not come into contact with the reinforcement or prestressing tendons and anchorages. Different release agents shall not be used in formwork to concrete which will be visible in the finished work.

Immediately before placing concrete, all forms shall be thoroughly cleaned out.

It is of major importance that the finishes required on F1 and F2 surfaces be uniformly and consistently maintained with no variation in the color or consistency of the concrete within the same structure. In order to achieve this, the Contractor shall make trial panels of the formed finishes specified. These panels shall be not less than one and one-half (1.5) meters high by one (1.00) meter wide and two hundred fifty (250) millimeters thick and shall be cast in the manner and with materials proposed for the actual Work. These panels are for the approval of the liners and are preliminary to the test samples carried out on site.

The Contractor shall provide at his own expense as many panels as required by the Engineer until a satisfactory trial panel has been accepted by the Engineer. In addition, the Engineer will require samples of pier, part of a deck, section of retaining wall and/or underpass wall and typical precast edge unit to be cast on site in the same manner as proposed for the prototypes. The Contractor shall submit to the Engineer and obtain approval on all details before commencement of any trials thereof. These samples when approved, will form the standard against which the corresponding finishes on the actual Work will be judged. In all cases of approvals, the decision of the Engineer alone will be final.

If the required finish has not been attained in the Work, as determined by the Engineer, the Contractor shall promptly carry out as his expense all remedies required by the Engineer to obtain the specified finish. These may include grit blasting followed by the application of polyester or epoxy paint. Where such remedial action is ordered by the Engineer, the entire exposed surface shall be so treated, irrespective of whether the defective areas are localized or extensive.

5.03.4.4 Removal of Bridge Structure Forms and Falsework. All formwork shall be removed without damage to the concrete. Forms used to support the deck of box girders and forms in hollow abutments or pieces may remain in place when no permanent access is available into the cells. Where it is intended to re-use formwork, it shall be thoroughly cleaned and made good to the satisfaction of the Engineer prior to re-use.

To facilitate finishing, forms on handrails, ornamental Work, and other vertical surfaces that require a rubbed finish, shall be removed as soon as the concrete has hardened sufficiently that it will not be injured, as determined by the Engineer. Formwork shall be

constructed so that the side forms of members can be removed without disturbing the soffit forms. If props are to be left in place when the soffit forms are removed, these props shall not be disturbed during the striking.

In determining the time for the removal of forms, consideration shall be given to the location and character of the structure, weather, and other conditions influencing the setting of the concrete.

If field operations are not controlled by beam or cylinder tests, the following periods, exclusive of days when the temperature is below ten degrees Celsius (10 ° C.), for removal of forms and supports shall be used as a minimum:

Arch Center	**21 days**
Centering Under Beams	**14 days**
Supports Under Flat Slab	**14 days**
Floor Slabs	**14 days**
Vertical Walls Over Three (3) Meters	**3 days**
Columns Over Three (3) Meters	**3 days**
Top Slab Box Culverts	**14 days**

If high early strength cement is used, the time limits may be decreased as determined by the Engineer. Special notes on the plans relative to the removal of forms and falsework under arches, continuous spans, and other special structures shall have precedence over the above time limits for removal of forms and falsework.

When field operations are controlled by cylinder tests or any other approved control tests, the removal of forms, supports, and housing, and the discontinuance of heating and curing may begin when the concrete is found to have the minimum percentage of the specified twenty-eight (28) day compressive strength contained in Table 5.03-1, provided further that in no case shall supports be removed in less than seven (7) days after placing the concrete except for vertical walls and columns over three (3) meters as shown above (3 days).

TABLE 5.03-1

MINIMUM REQUIRED PERCENTAGE OF SPECIFIED 28-DAY STRENGTH (f'c)

Structural Element	Percentage of Specified 28-Day Strength
Columns and wall faces (not yet supporting loads)	50
Mass piers and mass abutments (not yet supporting loads) except pier caps	50
Sidewalk on bridges Sidewalk forms shall, in all cases, be released before the main girder and slab forms are released	70
Box girders	80
T-beam girders, slabs, cross-beams, caps, pier caps not continuously supported, struts, and top slabs on concrete box culverts	80
Trestle slabs, when supported on wood stringers	70
Slabs, when supported on steel stringers or prestressed concrete girders	70
Pier caps continuously supported	60
Arches	90
Rail bases, traffic railings and median barriers*	40

*To facilitate finishing of these items of work, the forms shall be removed in not less than twelve (12) hours nor more than forty eight (48) hours, depending upon weather conditions.

Methods of form removal likely to cause overstressing of the concrete shall not be used. Forms and their supports shall not be removed without approval. Supports shall be removed in such a manner as to permit the concrete to uniformly and gradually take the stresses due to its own weight. In order to determine the condition of column concrete, forms shall be removed from columns before releasing supports from beneath beams and girders.

Arch centering shall be struck and the arch made self-supporting before the railing or coping is placed. This precaution is essential in order to avoid jamming of the expansion joints and variations in alignment. For filled spandrel arches, such portions of the spandrel walls shall be left for construction subsequent to the striking of centers, as may be necessary to avoid jamming of the expansion joints.

Centers shall be gradually and uniformly lowered in such a manner as to avoid injurious stresses in any part of the structure. In arch structures of two or more spans, the sequence of striking centers shall be specified or approved.

Any remedial treatment to surfaces shall be agreed with the Engineer following inspection after removing the formwork and shall be carried out without delay. Any concrete surface which has been treated before being inspected by the Engineer, shall be liable to rejection.

Defects that will need repair, when removal of entire defective portions is not directed by the Engineer, shall also include crazing, cracks, spalls, popouts, air bubbles, honeycomb, and holes left by rods and bolts; other surface deficiencies that penetrate to the reinforcement; fins and other objectionable projections on the surface, as determined by the Engineer; and stains and discolorations that cannot be removed by cleaning.

Immediately after the removal of the forms and inspection by the Engineer, all fins caused by form joints and other projections shall be removed. All rock pockets and voids shall be cleaned by chipping to clean sound concrete. The voids shall then be premoistened and filled with a Portland cement mortar meeting the requirements of Subparagraph 5.01.3.1.4, "Mortar" in these General Specifications. Form ties shall be removed on all exposed surfaces. The ties shall be removed to a depth of at least fifteen (15) millimeters below the concrete surface. Wire ties shall be cut back at least ten (10) millimeters below the concrete surface. The cavities shall likewise be filled with cement mortar less than one (1) hour old meeting the requirements of the above referenced Subparagraph 5.01.3.1.4, "Mortar" in these General Specifications, and the surface left sound, smooth, even and uniform in color. All patches and repaired concrete shall be cured in accordance with Subsection 5.01.6, "Weather Conditions and Curing Requirements," in these General Specifications. Sufficient white Portland cement shall be mixed with the cement in the mortar, so that when dry, the color will match the surrounding concrete. When directed by the Engineer, the Contractor shall, at his own expense, substitute an approved epoxy grout for the Portland cement mortar or provide an epoxy bonding agent to be used in conjunction with the Portland Cement mortar. If, in the judgment of the Engineer, rock pockets are of such extent or character as to materially affect the strength of the structure or to endanger the life of the steel reinforcement, he may declare the concrete defective and require the removal and replacement of that portion of the structure affected. The resulting surfaces shall be finished in accordance with Paragraph 5.03.4.9, "Finishing" in these General Specifications. Portions of the structure which cannot be finished or properly repaired to the satisfaction of the Engineer shall be removed.

5.03.4.5 Handling and Placing Bridge Structure Concrete. The method and sequence of placing concrete shall be approved by the Engineer. No concreting operations will be approved unless the Contractor has scheduled sufficient personnel, material, and equipment, including standby equipment if required, to insure proper placement at the minimum rate specified as well as proper finishing, curing, and other necessary functions. All concreting operations shall conform to the requirements of Subsection 5.01.6, "Weather Conditions and Curing Requirements," in these General Specifications.

No concrete placement shall be scheduled when pile driving or other construction vibrations may subsequently damage the concrete during its initial strength gaining period. Unless otherwise noted on the plans or directed by the Engineer, end spans of bridges shall not be constructed until all riprap or other slope protection Work specified below the

span is complete and approved.

Concrete shall be placed so as to avoid segregation of the materials and the displacement of the reinforcement. Concrete shall be deposited as near its final location as practical and consolidated by vibration. Concrete shall not be moved laterally by repeated shoveling or vibration of large piles.

The concrete shall be deposited in the forms in horizontal layers and the Work shall be carried on rapidly and continuously between predetermined planes agreed upon by the Contractor and the Engineer.

Where steep slopes are required for placing concrete with chutes, the chutes shall be equipped with baffle boards or be in short lengths that reverse the direction of movement. Chutes and the use of chutes must be approved by the Engineer.

All pumps, chutes, troughs, and pipes shall be kept clean and free from coatings of hardened concrete by thoroughly flushing with water after each run. The water used for flushing shall be discharged clear of the concrete already in place. Standby pumps shall be available for bridge deck placement and other large placement operations as directed by the Engineer. The use of aluminum chutes, tremies, troughs and pipes will not be permitted.

Concrete shall not be dropped in the forms a distance of more than one and one-half (1.5) meters, unless confined by approved closed chutes or pipes, and care shall be taken to fill each part of the form by depositing the concrete as near final position as possible. The entire placement operation shall be conducted such that there is no displacement of forms and reinforcing steel. After initial set of the concrete, the forms shall not be jarred and no strain shall be placed on the ends of projecting reinforcement.

Unless otherwise directed, the concrete shall be consolidated using suitable mechanical vibrators operating within the concrete. When required, vibrating shall be supplemented by hand spading with suitable tools to assure adequate consolidation.

Vibrators shall be of an approved type and design. They shall be capable of transmitting vibration to the concrete at frequencies of not less than four thousand five hundred (4,500) impulses per minute and visibly effecting a properly designed mixture with twenty-five (25) millimeter slump for a distance of at least one-half (0.5) meter from the vibrator. Sufficient vibrators shall be on hand to insure continuous placement of the concrete without delay.

Vibrators shall be so manipulated as to work the concrete thoroughly around the reinforcement and embedded fixtures and into corners and angles of the forms. Vibrators shall not be used as a means to cause concrete to flow laterally into position in lieu of proper placing. The vibration at any point shall be of sufficient duration to accomplish consolidation but shall not be prolonged to the point where segregation occurs.

Pumping of surface water will not be permitted from the inside of the foundation forms while concrete is being placed. If necessary to prevent flooding, a seal shall be constructed in accordance with Paragraph 5.03.4.6, "Seal Courses and Underwater Concreting" in these General Specifications.

No concrete Work shall be stopped or temporarily discontinued within one-half (0.5) meter of the top of any finished surface, unless such Work is finished with a coping having a thickness less than one-half (0.5) meter, in which case the joint shall be made at the under edge of the coping.

In order to allow for shrinkage or settlement, at least two (2) hours shall elapse after placing concrete in walls or columns or stems of deep T-beams (over one hundred (100) cm total depth) before depositing concrete in girders, beams or slabs supported thereon, unless otherwise directed by the Engineer. If the columns are structural steel encased in concrete, the lapse of time to allow for shrinkage or settlement need not be observed.

Concrete in columns shall be placed in one continuous operation and allowed to set at least two (2) hours before the caps are placed.

No concrete shall be placed in the superstructure until the column forms have been stripped sufficiently to determine the character of the concrete in the columns, and the load of the superstructure shall not be allowed to come upon abutments, piers, and column bents until they have been in place at least seven (7) days, unless otherwise directed by the Engineer.

Concrete in simple slab spans shall be placed in one (1) continuous operation for each span, unless otherwise indicated on the plans or approved by the Engineer.

Concrete in simple T-beam slabs or voided slabs one hundred (100) centimeters or less in total depth at midspan shall be placed in one (1) continuous operation. If required by the Special Specifications, concrete in simple T-beam slabs or voided slabs greater than one hundred (100) centimeters in total depth at midspan shall be placed in two (2) continuous operations. The first operation shall include concrete placed in the bottom of the fillet or haunch immediately below the slabs in T-beams slabs and to the midpoint of the voids in voided slabs. The second operation, completing the slab, shall be performed not less than five (5) days after the first. Before beginning the second operation, the construction joint shall be cleaned of all mortar and debris by sandblasting or wire brushing. The joint shall be kept saturated until concrete is placed. It shall be washed thoroughly immediately prior to placement and the forms drawn tightly against the vertical concrete surfaces. Free water in key depressions shall be blown out or otherwise removed before concreting. Keys, if required, shall be as detailed in the plans. All falsework shall be checked for excessive settlement prior to the final concreting operation for the slab.

The concrete in arch rings shall be placed in such a manner as to load the centering uniformly.

Arch rings, preferably, shall be cast in transverse sections of such size that each section can be cast in a continuous operation. The arrangement of the sections and the sequence of placing shall be as approved by the Engineer, and shall be such as to avoid the creation of initial stress in the reinforcement. The sections shall be bonded together by suitable keys or dowels. When permitted by the Engineer, arch rings may be cast in a single

continuous operation.

Before concrete floors are placed on steel spans, the centering under the spans shall be released and the spans swung free on their supports unless otherwise indicated on the plans. The operation of placing the concrete in any floor slab shall be continuous until complete, except where joints are provided on the plans or authorized by the Engineer. When a special sequence or method of concrete placing operations is indicated on the plans, or designated by the Engineer, this sequence or method shall be followed.

The method used for transporting concrete batches, materials or equipment over previously placed floor slabs or floor units or over units of structures of continuous design types shall be subject to approval by the Engineer. Trucks, heavy equipment, and heavy concentrations of materials will be prohibited on floor slabs until the concrete has attained its design strength.

5.03.4.6 Seal Courses and Underwater Concreting. Except when a seal course is required by the plans, no concrete shall be placed underwater without written approval of the Engineer. Concrete for underwater placement shall be Class K modified by decreasing the minimum cement content to three hundred ten (310) kilograms per cubic meter and increasing the slump to approximately fifteen (15) centimeters. An anti-wash admixture may also be used. Underwater concrete shall be deposited by means of a tremie or a concrete pump. The concrete shall be carefully placed in a compact mass and shall not be disturbed after being deposited. Still water shall be maintained at the point of deposit. A tremie shall consist of a watertight tube having a diameter of not less than twenty-five (25) centimeters with a hopper at the top. When a batch is dumped into the hopper, the flow of concrete shall be induced by slightly raising the discharge end, always keeping it in the deposited concrete.

Concrete pump discharge tubes and tremie tubes used to deposit concrete under water shall be equipped with a device that will prevent water from entering the tube while charging the tube with concrete. Such tubes shall be supported so as to permit free movement of the discharge end over the entire top surface of the Work and to permit rapid lowering, when necessary, to retard or stop the flow of concrete. The tubes shall be filled by a method that will prevent washing of the concrete. The discharge end shall be completely submerged in concrete at all times and the tube shall contain sufficient concrete to prevent any water entry. The flow shall be continuous until the Work is completed and the resulting concrete seal shall be monolithic and homogenous.

Before dewatering, the concrete in a seal shall be allowed to cure for not less than five (5) days after placing.

After sufficient time has elapsed to insure adequate strength in a concrete seal, the cofferdam shall be dewatered and the top of the concrete cleaned of all scum, laitance, and sediment. Before fresh concrete is deposited, local high spots shall be removed as necessary to provide proper clearance for reinforcing steel.

5.03.4.7 Bridge Structure Construction Joints. Whenever the work of placing concrete is delayed until after the concrete has taken its initial set, the point of stopping

shall be deemed a construction joint. So far as possible the location of construction joints shall be as shown on the plans, but if not shown on the plans, they shall be planned in advance and the placing of concrete carried continuously from joint to joint. The joints shall be perpendicular to the principal lines of stress and in general be located at points of minimum shear.

Where dowel, reinforcing bars, or other adequate ties are not required by the plans, keys shall be made by embedding water-soaked beveled timbers in soft concrete. The key shall be sized as shown on the details, or as directed by the Engineer, which shall be removed when the concrete has set. In resuming concrete placement, the surface of the concrete previously placed shall be thoroughly cleaned of dirt, scum, laitance or other soft material with stiff wire brushes, and if deemed necessary by the Engineer, shall be sandblasted. The surface shall then be thoroughly washed with clean water and free water blown from shear keys and other depressions immediately prior to concreting. When directed by the Engineer, the shear key surface, after being cleaned as specified, shall be painted with a thick coat of neat cement mortar. Neat cement mortar shall consist of equal parts by weight of Portland cement and fine aggregate and not more than twenty-four (24) liters of water per sack of cement. The mortar shall be applied with a brush to a thickness of five (5) millimeters. Fresh concrete shall then be deposited, before the cement mortar has attained its initial set. In lieu of neat cement mortar, bonding grout may be a commercial bonding agent. The bonding agent shall be applied to cleaned concrete surfaces in accordance with the printed instructions of the bonding material manufacturer.

The exposed end of the end spans of all bridges which form a part of the road surface shall be finished with an edger having a six (6) millimeter radius and a header board installed to protect the edge of the wearing surface until the end span is backfilled and the pavement layers are placed.

5.03.4.8 Bridge Structure Cold Joints. When the continuous placement of concrete in any structural member is interrupted or delayed, for any reason, for a period long enough for the previously partially placed concrete to take its initial set, the Engineer may declare such joint a cold joint and the Contractor shall immediately remove the previously partially placed concrete from the forms. No extra payment will be made for the initial placement or the removal of concrete which is wasted because of a cold joint. The Engineer may suspend all or any part of subsequent concrete Work until he deems the Contractor has corrected the cause for the cold joint occurrence. In resuming concrete placement cold joints shall be treated in the same manner prescribed in Paragraph 5.03.4.7 "Bridge Structure Construction Joints,' in these General Specifications.

5.03.4.9 Bridge Structure Finishing.

5.03.4.9.1 Bridge Deck Placing, Consolidating and Finishing.

1. Placing. Concrete shall be placed in accordance with the requirements of Paragraph 5.03.4.5, 'Handling and Placing Bridge Structure Concrete,' in these General Specifications except for the following:

Concrete shall be placed in such manner as to require as little rehandling as possible and at sufficient depth to provide some excess for screeding and finishing operations. The concrete shall be directed through suitable drop chutes to as near its final location as practicable.

2. Consolidating. Consolidation shall conform to Paragraph 5.03.4.5, "Handling and Placing Bridge Structure Concrete," in these General Specifications and to the following:

The Contractor shall provide suitable mechanical vibrators to melt down the batch at the point of discharge and to densify the concrete within the forms. The bond of fresh concrete to concrete previously placed shall be achieved by vibrating the new concrete together with the old. Immersion vibrators shall operate at a speed of not less than ten thousand (10,000) vibrations per minute in air. Internal vibration shall be used along the edges of forms and in areas of congested reinforcing.

Plate vibrators, vibrating screeds, or rollers may be used for consolidating and finishing slabs with a nominal thickness of one hundred fifty (150) millimeters or less. A combination of internal vibration and surface consolidation shall be used when the nominal slab thickness is greater than one hundred fifty (150) millimeters.

3. Finishing. Following consolidation, the concrete shall be struck off and finished by an approved rail mounted, power driven, mechanical deck finisher utilizing longitudinal floating, mechanical rolling, surface vibration, or a combination of any of these methods. Rail supports shall be adjustable with the intervals between supports being such that the rail deflection shall be no more than four (4) millimeters. The entire rail system shall be in place, checked, and approved by the Engineer prior to the beginning of placement. Surface vibrators shall be of the low-frequency, high-amplitude type, operating at a speed of three thousand (3,000) to four thousand five hundred (4,500) vibrations per minute. If the vibrator speed is adjustable, maximum speed shall be used on the first pass and minimum speed shall be used on the second pass and subsequent passes. Bridge decks of less than three hundred (300) square meters may be struck off with a portable screed supported by rails or headers in an approved manner to provide the grade and crown as shown on the plans.

The Contractor shall state at the preplacement conference the make and type of deck finishing machine intended to be used. Deck finishing machines shall be supported beyond the edge of the bridge deck so that the greatest possible deck width will be finished by machine.

A paver's steel scraping straightedge or lute (one hundred (100) millimeter maximum width) will be the only hand tool permitted on deck surfaces, except for a minimum use of metal hand floats and edgers along the forms and in areas where machine finishing cannot be effectively used. Only minimum hand finishing will be permitted and when the Engineer deems the slab surface is being overworked, all hand finishing will be stopped. If the surface of the deck slab becomes dry immediately following finishing operations, due to an excessive evaporation rate, it shall be covered with wet burlap or fogged with water covering the entire deck surface using pneumatic atomizing nozzles. The fog spray shall be just enough to retard surface evaporation and shall not change the water-cement ratio. During periods of excessive drying, a cover of wet burlap or plastic sheeting will be maintained on the slab at all times until final cure cover is placed. Monomolecular film coatings applied to the surface of the slab to retain moisture may be used provided they effectively retard surface evaporation and are adequately maintained throughout the finishing operation.

Bridge decks that will not be covered with waterproofing membrane shall receive a final finish as specified in the Contract.

4. Straightedge Testing and Surface Correction. After the floating has been completed but while the concrete is still plastic, the Contractor will test the surface of the concrete for trueness. For this purpose the Contractor shall furnish and use an accurate three (3) meter straightedge or other approved device. Any depressions or variations of four (4) millimeters shall be immediately filled with freshly mixed concrete, struck off, consolidated and refinished. High areas shall be cut down and refinished. Special attention shall be given to assure that the surface across joints meets the requirements for smoothness.

(1) Bridge deck With Asphalt Surface. When the concrete is sufficiently hard, the pavement surface shall be retested with the three (3) meter straightedge or other approved device. Areas showing high spots of more than six (6) millimeters but not exceeding twelve (12) millimeters in three (3) meters shall be marked. The marked area shall be immediately ground with an approved grinding tool so that the surface deviation will not be in excess of six (6) millimeters in three (3) meters. Where the deviation from the established cross section exceeds twelve (12) millimeters in three (3) meters, the area or section shall be removed and replaced at the expense of the Contractor, unless permitted to remain with modifications approved by the Engineer.

Any area or section so removed shall not be less than three (3) meters in length nor less than the full width of the lane involved.

When it is necessary to remove and replace a section of deck slab, any remaining portion of the slab adjacent to the formed joints that is less than three (3) meters in length, shall also be removed and replaced.

(2) Bridge Deck With Concrete Riding Surface. Surface smoothness requirements for a bridge deck built with a concrete riding surface shall conform to Paragraph I above except that the surface deviation shall be four (4) millimeters in three (3) meters. The final surface shall be finished by means of a broom after the water sheen has practically disappeared. The broom shall be drawn transversely across the surface from the moveable bridge described in Paragraph (5) below with adjacent strokes slightly overlapping. The brooming operation shall be executed so that the corrugations produced in the deck surface shall be uniform in appearance and approximately two (2) millimeters in depth. Brooms shall be of the quality, size and construction and so operated as to produce a surface finish acceptable to the Engineer.

5. Movable Work Bridge for the Inspectors and Finishers. A movable bridge or platform shall be provided by the Contractor and moved as directed to allow the inspectors and finishers to work over the freshly plastic concrete. The movable bridge shall be kept

as close to the finishing screed as practical. The deck of the movable bridge shall be a minimum of six hundred (600) millimeters wide and no more than six hundred (600) millimeters above the surface of the concrete and shall be capable of supporting two (2) inspectors/finishers. The Contractor shall provide additional movable bridges as appropriate for use by the Contractor's workers. In applying membrane, curing compound and other curing treatments, the movable work bridges shall be in place and demonstrated by the Contractor before each bridge deck placement is allowed to begin.

Immediately after the curing period, the Contractor shall repair all minor bridge deck shrinkage cracks identified by the Engineer. Repairs shall be made as directed by the Engineer using an approved water resistant, high modulus, low viscosity epoxy. Epoxy shall meet the requirements of ASTM C 881, Type 1, Grade 1, Class C. Grade 2 epoxy may be used for vertical surfaces and the underside of horizontal surfaces except where injection is required. Alternate two-part epoxies may be approved by the Engineer after testing at an MOC approved laboratory at the expense of the Contractor. Such tests shall indicate that when tested in accordance with MRDTM 571, the epoxy shall have a slant shear strength of three hundred (300) kilograms per square centimeter when cured for one (1) day at twenty-five degrees Celsius (25° C.) dry, and shall also have a slant shear strength of three hundred (300) kilograms per square centimeter when cured an additional seven (7) days at twenty-five degrees Celsius (25° C.) wet.

Cracks in excess of two-tenths (0.2) millimeter in width identified by the Engineer on vertical surfaces and the undersides of horizontal surfaces shall be filled by the pressure injection of Grade 1 epoxy using equipment and procedures recommended by the manufacturer of the epoxy and approved by the Engineer. All injection equipment shall receive calibration and pressure checks in the presence of the Engineer prior to approval. Cracks shall be vacuumed or blown clean prior to sealing and the surfaces sealed except at the points of injection.

5.03.4.9.2 Other Bridge Structure Finishing. All top surfaces, such as the top of retaining walls, curbs, abutments, rails, etc. shall be treated by tamping and floating with a wooden float in such a manner as to flush the mortar to the surface and provide a uniform surface, free from pits or porous places. The surface thus obtained shall be troweled to produce a smooth surface and brushed lightly with a damp brush to remove the glazed surface.

After curing and any required epoxy patching, bridge decks shall be retested for irregularities by means of four (4) meter straightedge laid parallel to centerline and a crown template used transversely. Any variations of four (4) millimeters or more shall be corrected by grinding until variations are acceptable as determined by the Engineer.

All concrete surfaces shall be true and even, free from stone pockets, excessive depressions or projections beyond the surface. The concrete in bridge seats and walls shall be brought flush with the finished top surface and struck-off with a straightedge and floated. The concrete surfaces which are not in an acceptable condition or which are designated on the plans to be surface finished, shall be rubbed to a smooth and uniform texture with a carborundum brick and clean water as soon as the forms are removed and the concrete is ready to hone. The loose material formed on the surface, due to the rubbing with a carborundum brick, shall be removed as soon as it dries by means of rubbing the surface with burlap or by other approved methods. The finished surface shall be free from all loose material. A cement wash shall not be used.

Unless otherwise provided on the plans, all true and even surfaces, obtained by use of a form lining, which are of a uniform color, free from stone pockets, honeycomb, excessive depressions or projections beyond the surface shall be considered as acceptable surfaces and a rubbed finish will not be required, except as follows:

On bridges, the curbs and sidewalks, parapets, outer face of exterior beams and floor slabs, the underside of slab overhands and abutment curbs and wingwalls above roadway shoulder elevation and on box culverts all surfaces of the parapets, wingwall outer face, top face and top forty (40) centimeters of backface, and end faces of barrels shall be given a rubbed surface finish in all cases.

The above provisions for surface finish shall not preclude requiring the use of a dry carborundum brick for straightening molding lines, removing fins, etc., or requiring a rubbed surface finish on all portions of the structure which do not present an acceptable surface even though a form lining is used.

5.03.4.10 Bridge Structure Curing and Protection. All structural concrete shall be cured for a period of time required to obtain the full specified strength, but not less than seven (7) consecutive days beginning immediately after placement. Unless otherwise specified in the Special Specifications, curing shall be as follows:

5.03.4.10.1 Membrane Curing. Except for construction joints and surfaces sealed by metal forms, liquid membrane shall be used as follows:

- On bridge decks and other horizontal top surfaces, liquid curing membrane shall be applied immediately after final finishing from adequate work bridges.

- On wood formed vertical surfaces, forms shall be stripped as soon as practical and liquid curing membrane applied immediately except that those areas being rubbed or finished during the curing period shall be kept wet until finishing is complete when liquid curing membrane shall be uniformly applied.

- On metal formed surfaces, with or without wood lining, liquid curing membrane shall be applied if the Contractor elects to strip the forms within the curing period.

White pigmented liquid curing membrane shall be used for all non-exposed surfaces and bridge decks. Clear liquid curing membrane shall be used for other exposed surfaces. For bridge decks which are to receive a bituminous overlay, residual curing membrane shall be removed prior to the overlay. Removal methods and results shall be approved by the Engineer.

The curing membrane used shall be in accordance with the requirements specified for curing membrane material, AASHTO M 148. The curing membrane shall be applied in two (2) applications, one immediately following the other. The rate of each application of curing compound will be as prescribed by the Engineer with a minimum spreading rate per application of between one (1) and one and one-half (1.5) liters of liquid per five (5) square meters of concrete surface. The exact rate is to be determined by the Engineer based upon the Contractor's field trials which insure uniform coverage with no thin areas, runs, sags, skips or holidays. If the concrete is dry or becomes dry, it shall be thoroughly wet with water and the curing compound applied just as the surface film of water disappears. During curing operations, any unsprayed surfaces shall be kept wet with water. Any curing membrane material on construction joints and/or reinforcing steel shall be completely removed before the following concrete pour.

Hand operated spraying equipment shall be capable of supplying constant and uniform pressure to provide uniform and adequate distribution of the curing membrane at the rates required. The curing compound shall be thoroughly mixed at all times during usage.

No traffic of any kind will be permitted on the curing membrane until the curing period is completed, unless the Engineer permits the placement of concrete in adjacent sections, in which case the damaged areas shall be immediately repaired as directed.

5.03.4.10.2 Water Curing. All surfaces, unless sealed by metal forms or submerged, shall be water cured including those surfaces which have previously had liquid curing membrane applied. For construction joints or other surfaces where no liquid membrane is specified, water curing shall begin within one (1) hour of finishing. Where liquid membrane is placed, water curing shall begin within four (4) hours of placement. The water used for curing shall conform to the requirements in paragraph 5.01.2.3 "Water" in these General Specifications.

Surfaces to be water cured shall be covered with cotton mats, double thickness burlap, plastic, polyethylene, other equivalent absorbent and moisture sealing materials. The absorbent material shall be placed around and behind all reinforcing steel to completely cover the concrete surface. The material shall be completely saturated with water and kept continuously saturated throughout the curing period. After initial saturation, all surfaces shall be covered with polyethylene sheeting meeting requirements of ASTM C 171 or other approved impervious material. The sheeting shall be weighted or secured and overlapped one-half (0.5) meters to prevent moisture loss; however, the surfaces of the concrete shall be readily available for inspection of the Engineer. The sheeting shall be in good repair. Sheeting that contains holes or is otherwise damaged shall be repaired or replaced. The Contractor shall be responsible for thoroughly inspecting and monitoring the concrete surfaces throughout the curing period. Additional water shall be added to any areas which are not still saturated. Inspections by the Contractor shall be conducted at least twice per day for the duration of the curing period and more often if ordered by the Engineer. The Engineer shall be advised of the inspection schedule and may accompany the workman to verify the acceptability of curing.

5.03.4.10.3 Steam Curing. In lieu of the minimum seven (7) day water cure, the Contractor may elect to steam cure precast elements subject to the following provisions:

1. After placement of the concrete, members shall be held for a minimum four (4)

hour presteaming period. If the ambient air temperature is below ten degrees Celsius (10 ° C.), steam shall be applied during the presteaming period to hold the air surrounding the member at a temperature between ten degrees and thirty-two degrees Celsius (10-32 ° C.).

2. To prevent moisture loss on exposed surfaces during the presteaming period, members shall be covered as soon as possible after casting or the exposed surfaces shall be kept wet by fog spray or wet blankets.

3. Enclosures for steam curing shall allow free circulation of steam about the member and shall be constructed to contain the live steam with a minimum moisture loss. The use of tarpaulins or similar flexible covers will be permitted, provided they are kept in good repair and secured in such a manner to prevent the loss of steam and moisture.

4. Steam at the jets shall be low pressure and in a saturated condition. Steam jets shall not impinge directly on the concrete, test cylinders, or forms. During initial application of the steam, the temperature rise within the enclosure shall not exceed twenty degrees Celsius (20° C.) per hour. The curing temperature throughout the enclosure shall not exceed sixty-five degrees Celsius (65° C.) and shall be maintained at a constant level for a sufficient time necessary to develop the required transfer strength. A minimum fifteen (15) centimeter space shall be maintained around the entire element to enable the circulation of steam. The maximum differential temperature of any two (2) points within the enclosure shall be ten degrees Celsius (10° C.). At the conclusion of the steam curing, the enclosure shall be vented such that the drop in ambient temperature within does not exceed twenty degrees Celsius (20° C.) per hour. Control cylinders shall be covered to prevent moisture loss and shall be placed in a location where temperatures are representative of the average temperature of the enclosure.

5. Accessible temperature recording devices that will provide an accurate continuous permanent record of the curing temperature shall be provided. A minimum of one (1) temperature recording device per sixty (60) meters of continuous bed length will be required for checking temperature.

6. Members in pretension beds shall be detensioned immediately after the termination of steam curing while the concrete and forms are still warm or the temperature under the enclosure shall be maintained over fifteen degrees Celsius (15° C.) until the stress is transferred to the concrete.

7. Steam curing will be considered complete when all of the following criteria have been met:

(1) A minimum of twenty-four (24) hours of curing has elapsed exclusive of heat-up and cool-down periods.

(2) The concrete has reached the minimum stress transfer or handling strength based on cylinders cured with the element.

(3) The concrete has reached a minimum of seventy (70) percent of the specific ultimate strength based on cylinders cured with the element.

All newly placed concrete for precast concrete piles, both conventionally reinforced and prestressed, shall be cured by steam as provided above except that piles with a designation of "Corrosion Resistant" shall be kept continuously wet for their entire length for a period of not less than seven (7) days, including the holding and steam curing periods.

5.03.4.10.4 Additional Hot Weather Limitations and Curing Requirements for Bridge Decks and Slabs.

Unless otherwise directed, bridge deck concrete shall not be placed during periods when the ambient temperature is expected to exceed thirty-five degrees Celsius (35° C.) during placement and finishing operations. Bridge deck concrete shall not exceed twenty-six degrees Celsius (26° C.) at the time of placement.

Concrete shall not be placed in bridge decks or other exposed slab type construction when any combination of air temperature, relative humidity, concrete temperature, and wind velocity throughout the area of placement is expected to result in an evaporation rate in excess of one (1.0) kilograms per square meter per hour as determined from Figure 5.03-1.

When natural conditions are expected to approach an evaporation rate of one (1.0) kilograms per square meter per hour, the Contractor shall take actions approved by the Engineer to effectively maintain the expected evaporation throughout the area of placement to less than one (1.0) kilograms per square meter per hour. Such actions shall include one or more of the following:

1. The construction of windbreaks and/or enclosures to effectively reduce the wind velocity throughout the area of placement. The construction of windbreaks and/or enclosures shall not proceed without approval of the Engineer with respect to their structural design relative to safety and lack of adverse loads with vibration in the existing falsework.

2. The installation of stationary fog sprayers upwind of the operation to effectively increase the relative humidity throughout the area of placement. Water used fog sprays shall conform to MRDTM 504.

Figure 5.03-1

Fig. 5.03-1 - Effect of concrete and air temperatures, relative humidity, and wind velocity on the rate of evaporation of surface moisture from concrete. This chart provides a graphic method of estimating the loss of surface moisture for various weather conditions. To use the chart, follow the four steps outlined above. When the evaporation rate exceeds 1.0 kg/m^2/hr, measures shall be taken to prevent excessive moisture loss from the surface of unhardened concrete to the extent that the evaporation rate is reduced to below 1.0 kg/m^2/hr. When excessive moisture loss is not prevented, plastic shrinkage cracking is likely to occur.

Effectively reducing the temperature of the concrete in accordance with Paragraph 5.01.6.2, "Hot Weather Limitations and General Curing Requirements," in these General Specifications. The top surface of bridge decks, approach slabs, rigid pavement and sidewalks shall be cured by a combination of membrane curing compound, followed by water curing. The membrane curing compound shall be applied to the completed bridge deck concrete surface within thirty (30) minutes after completion of the surface finishing operations and before any drying shrinkage cracks begin to appear. Curing compound shall not be applied on free-standing water. The curing compound shall be applied progressively to individual portions of the concrete surface from movable work bridges. Application shall be such that an even continuous membrane is produced on the concrete deck on slab surface.

The liquid membrane shall be of such formulation that it will harden thirty (30) minutes after application. Personnel and equipment shall be kept off the freshly-applied material to prevent damage to the seal. Should the film become damaged from any cause, the damaged portions shall be repaired immediately with additional membrane. The water curing shall be applied immediately after the initial set of placed concrete. The surface shall be covered with burlap, cotton mats or other suitable moisture-retaining materials. This moisture-retaining material shall then be saturated with water and the entire area covered with waterproof paper or plastic sheeting.

5.03.4.11 Tunnel Concrete. The producing and combining of cement, water, aggregates and admixtures into acceptable composition, consistency, batching, mixing and delivery of tunnel concrete shall conform to the requirements of Section 5.01, "Portland Cement Concrete," in these General Specifications for the Class of concrete specified in the Plans or Special Specifications.

5.03.4.12 Tunnel Concrete Formwork. The Contractor shall design the tunnel concrete formwork in accordance with Paragraph 5.03.4.3, "Bridge Structure Forms," in these General Specifications. The formwork shall be adequately braced and have adequate strength and stability to ensure finished concrete within specified tolerances. The formwork shall be sufficiently designed to compensate for anticipated deflection and creep due to weight and pressure of the fresh concrete and construction loads. The Contractor shall be responsible for the adequacy of forms and form supports.

5.03.4.13 Tunnel Arch Forms. Steel or reinforced fiberglass plastic forms shall be used except where special conditions make use of such materials impractical. These arch forms shall be designed in accordance with Paragraph 5.03.4.3, "Bridge Structure Forms," in these General Specifications. The Contractor shall construct the tunnel forms so that they can be secured tight against the tunnel arch footing concrete at the joints for the full length of the form. The forms shall produce a relatively rough scored concrete surface for future tunnel wall finish coverage unless otherwise shown on the drawings. The scoring will be done with continuous longitudinally placed wire not exceeding seventy-five (75) millimeter spacings (transversely) or alternatively, sand blasting. Other means of scoring may be at the Contractor's option but subject to the Engineer's approval.

The Contractor shall provide forms for the tunnel arch sections with rows of openings along each side vertically spaced a maximum of every two (2) meters. He shall locate the first or bottom row with the centerline of the openings approximately two (2) meters above the longitudinal construction joint at the invert footing. The openings in the rows shall be staggered. The Contractor shall make openings which permit access for concrete placement, inspection and vibration of concrete being placed behind the forms. The rows of openings shall be provided with a safe and convenient platform for access to the openings. The openings shall be located on two and one-half (2½) meter centers and be fifty (50) centimeters by sixty (60) centimeters minimum, with the long dimension parallel to the centerline of the tunnel.

5.03.4.14 Tunnel Concrete Placement. Tunnel concrete shall be placed by pumping in accordance with Section 5.03, "Concrete Structures" and discharged into the work through a pipe inserted into the formed space. The end of the discharge line shall be marked to indicate the depth of burial at any time. Special care shall be taken to force concrete into all irregularities in work surfaces and to completely fill tunnel walls and crown. Placing equipment shall be operated only by experienced operators. The Contractor shall vibrate pumped concrete in accordance with Section 5.03, "Concrete Structures," in these General Specifications. Concrete shall not be pumped through aluminum alloy pipe.

5.03.4.15 Tunnel Construction Joints. Construction joints between the tunnel arch roadway barrier curb and tunnel arch footing shall be made only where located on the plans, unless directed otherwise by the Engineer.

A construction/contraction joint shall be placed perpendicular to the roadway at ten (10) meter intervals in the main tunnel.

All construction joints shall be cleaned of surface laitance, curing compound and other foreign materials before fresh concrete is placed against the surface of the joint. All reinforcing steel shall run through construction joints unless otherwise approved by the Engineer.

Surfaces on which concrete is to be placed, except for waterproofing membrane, shall be thoroughly moistened with water immediately before placing concrete.

When the plans show new concrete to be joined to existing concrete by means of bar reinforcing dowels used in holes drilled in the existing concrete, the diameter of the holes shall be the minimum needed to place non-shrink epoxy grout or epoxy grout and the dowel. Immediately prior to placing the dowels, the holes shall be cleaned of dust and other foreign material and sufficient epoxy grout placed in the holes so that there are no voids in the drilled holes after the dowels are inserted.

5.04.4.16 Tunnel Concrete on Rock Surfaces. Rock surfaces against or upon which concrete is to be placed shall be clean, free of oil, and other objectionable coatings, water, mud, debris, dummy rock and loose semi-detached or unsound fragments, and shall be sufficiently rough to assure satisfactory bond with the concrete. Discontinuities shall be cleaned to hard rock on the sides, and to a depth that is approved by the Engineer. All overbreak beyond the excavation limit shown on the plans shall be backfilled with shotcrete or concrete at the Contractor's expense.

5.03.4.17 Tunnel Concrete Curing and form Removal. Concrete curing and form removal shall be in accordance with Paragraph 5.03.4.4, "Removal of Bridge Structure Forms and Falsework," and Paragraph 5.03.4.10, "Bridge Structure Curing and Protection," in these General Specifications. Concrete arch forms may be removed by the Contractor at his risk when the concrete is sufficiently set so as not to slump but in no case before the concrete has attained a compressive strength of at least sixty (60) kilograms per square centimeter as determined from job cast and cured cylinders.

5.03.4.18 Repair of Tunnel Surface Defects. All obvious surface defects or surface defects designated by the Engineer, shall be repaired, in accordance with Section 5.03, "Concrete Structures," in these General Specifications at no cost to the Ministry.

5.03.4.19 Finishing of Formed Surfaces. Portions of the arch sidewalls shall have a scored finish as described in Paragraph 5.03.4.12, "Tunnel Arch Form," in these General Specifications. All remaining formed surfaces shall have a finish as specified under Class 1, Surface Finish, as described in Paragraph 5.03.4.3 "Bridge Structure Forms," in these General Specifications.

5.03.4.20 Tunnel Concreting Tolerances. Tolerances for tunnel arch footings with respect to plan location shall be ± fifteen (15) millimeters. Tunnel arch concrete and roadway barrier shall be placed to the nominal dimensions and thickness shown on the Plans with ± fifteen (15) millimeter tolerance.

When approved by the Engineer, concrete may be ground to meet the above requirements. Concrete may not be added to meet the above requirements.

The overall appearance of the concrete work shall be one of straight lines and smooth curves with no visible angles or breaks in lines or curvature.

Complete tests on piping and other items which are required to be tested before starting concrete placement.

Before depositing concrete, check the location and support of piping, electrical conduits, and other items which are to be wholly or partially embedded.

5.03.4.21 Tunnel Excavation. All tunnel excavation shall be complete within one hundred (100) meters from any locations to be concreted. Concrete less than seven (7) days old shall not be subject to any peak particle velocities in excess of one and one-half (1.5) millimeters per second at all frequencies. All other tunnel concrete shall not be subject to peak particle velocities in excess of fifty (50) millimeters per second. No blasting will be permitted within ten (10) meters of any concrete less than five days old.

5.03.4.22 Tolerances for Bridge Structure Concrete Work. The dimensions of finished Work, unless otherwise shown on plans or directed by the Engineer, shall be within the tolerances given below and the Contractor will be held responsible for the cost of all corrective measures required, where Work is not within these tolerances. The location(s) of cast-in holding-down bolts and other work to locate steel work shall also comply with these tolerances and shall also meet any specified tolerances for steelworks, consistent with proper connection of steelworks site joints without distress.

1. Acceptable tolerances :
   (1) Dimensions three (3) meters and over : Plus or minus six (6) millimeters
   (2) Dimensions below three (3) meters : Plus or minus three (3) millimeters
   (3) Dimensions of cross-section members and slab thicknesses : Plus or minus three (3) millimeters
   (4) Tops of beams and slabs or bases : Plus or minus six (6) millimeter in level; Plus or minus three (3) millimeters in line
   (5) Vertical lines out of plumb or inclined elements out of true line : five (5) millimeters if less than fifteen (15) meters in height/length; plus five (5) millimeters for every additional fifteen (15) meters in height/length; total plus or minus ten (10) millimeters at any location.

2. In addition to the foregoing tolerances under Subparagraphs 1(1), (2) and (3), precast concrete Work shall be subject to the following installation tolerances:
   (1) Variation from theoretical position in plan : Plus or minus six (6) millimeters maximum at any location
   (2) Variations from level or elevation : six (6) millimeters in any six (6) meter run; plus six (6) millimeters for every additional six (6) meter run; total plus or minus twelve (12) millimeters at any location
   (3) Variations from plumb for vertical lines or from true line for inclined elements: six (6) millimeters in any six (6) meter run or storey height, whichever is less; plus six (6) millimeters for every additional six (6) meter run; total plus or minus twelve (12) millimeters at any location.

5.03.4.23 Precast Concrete. In addition, precast concrete Work shall conform to the following requirements, except when otherwise specifically indicated on the plans or approved by the Engineer:

1. The Contractor shall submit shop drawings showing complete information for the fabrication and installation of precast concrete units. The drawings shall indicate member dimensions and cross-section, location, size and type of reinforcement and special reinforcement and lifting devices necessary for handling and erection. The drawings shall detail the erection procedure for precast units, sequence of erection and required handling equipment. Each precast unit shall be identified to correspond to the sequence and procedure of installation. Welded connections shall be indicated with AWS standard symbols. All inserts, anchorage devices that are to be embedded, openings, connections, joints, and accessories shall be indicated on the drawings.

2. Precast concrete units shall be delivered to the site in such quantities and at such times as will assure the continuity of the installation. Units shall be stored so as to ensure against cracking, distortion, staining, or other physical damage, and so that markings are visible. Units shall be lifted and supported at the designated lift points only.

3. All parts of the supporting structure and the conditions under which the precast concrete work is to be erected shall be examined and verified. Installation shall

not proceed until unsatisfactory conditions have been corrected.

4. Design modifications may be made only as necessary to meet field conditions and to ensure proper fitting of the Work, and only as approved by the Engineer. If design modifications are anticipated, the Contractor shall provide complete design calculations and drawings prepared by a qualified professional, for approval by the Engineer.

5. Concrete shall be placed in a continuous operation to prevent the formation of seams or planes of weakness in precast units. Placed concrete shall be thoroughly consolidated in each precast unit by internal and external vibration without dislocation of or damage to reinforcement and built-in items.

6. Precast units shall be provided with permanent markings to identify pick-up points and orientation in the structure, complying with the markings indicated on the approved shop drawings. The date of casting shall be imprinted on each precast unit where it will not show in the finished structure.

7. Curing by low-pressure steam, by steam vapor, by radiant heat and moisture, or other similar process may be employed to accelerate concrete hardening and to reduce the curing time, only as approved by and to the satisfaction of the Engineer.

8. Field welding shall be performed in compliance with AWS D1.1 and D12.1, including qualification of welders. Units shall be protected from damage by field welding or cutting operations, by means of non-combustible shields as required. Damaged metal surfaces shall be repaired by cleaning and applying a coat of liquid galvanizing repair compound to galvanized surfaces; and compatible primer to painted surfaces, according to the manufacturer's instructions, as approved by the Engineer.

9. Powder-actuated fasteners for surface attachment of accessory items in any precast, prestressed unit shall not be used, unless approved in writing by the precast manufacturer, if any, and only as approved by and to the satisfaction of the Engineer.

10. Grouting connections and joints after precast concrete units have been placed and secured, shall be performed as follows:

- **(1) Cement grout consisting by volume of one (1) part Portland cement, two and one-half (2 1/2) parts sand, and only enough water to properly mix and for hydration.**
- **(2) Shrinkage-resistant grout consisting of premixed compound and only enough water to provide a flowable mixture without segregation or bleeding.**

Forms or other acceptable method shall be provided to retain the grout in place, until sufficiently hard to support itself. Pack spaces with stiff grout material, tamping until voids are completely filled. Place grout to finish smooth, plumb, and level with adjacent concrete surfaces. Keep grout damp for not less than twenty-four (24) hours after it has taken its initial set. Promptly remove any grout material from exposed surfaces before it hardens.

11. Testing Precast Concrete Units for Strength:

When there is evidence that the strength of a constructed precast concrete unit does not meet the specification requirements, the Contractor shall take cores drilled from hardened concrete for compressive strength determination, complying with ASTM C42 and as follows:

(1) Take at least three (3) representative cores from precast units of suspect strength, from locations directed by the Engineer.

(2) Test cores in a saturated-surface-dry condition per ACI 318 if the concrete will be wet during the use of the completed structure.

(3) Test cores in an air-dry condition per ACI 318 if the concrete will be dry at all times during use of the completed structure.

(4) Strength of concrete for each series of cores may be considered satisfactory if their average compressive strength is at least ninety percent (90%) of and if no single core test is less than eighty percent (80%) of the twenty-eight-day design compressive strength.

(5) Test results will be made in writing on the same day that tests are made, with copies to the Engineer, and precast manufacturer, if any. Include in test reports the project identification name and number; date; name of precast concrete manufacturer; name of individual responsible for concrete testing; identification letter, number, and type of member or members represented by core tests; nominal maximum size aggregate, design compressive strength, compression breaking strength and type of break (corrected for length-diameter ratio); direction of applied load to core with respect to horizontal plane of the concrete as placed; and the moisture condition of the core at the time of testing.

Where core test results are satisfactory and precast units are acceptable for use in the Work, core holes shall be filled solid with low-slump concrete or patching mortar, and finished to match adjacent concrete surfaces.

All testing, making good and replacement of precast units as described hereinabove, shall be carried out by the Contractor at his expense, under the direction and supervision of the Engineer. Precast concrete units which do not conform to the specified requirements, including strength, tolerances, and finishes, shall be replaced with precast concrete units that meet the requirements of this section. The Contractor shall be responsible for the cost of corrections to any other work affected by or resulting from corrections to the precast concrete work.

12. When directed by the Engineer or indicated on the plans, precast concrete Work to be placed in contact with soil shall be waterproofed or dampproofed. Precast concrete surfaces below water table shall be waterproofed and the water-proofing shall be extended to five hundred (500) mm above the water table. Waterproofing and shall be

in accordance with Section 5.12, "Waterproofing for Structures," in these General Specifications and will be paid for separately as specified therein.

5.03.5 BRIDGE EXPANSION JOINTS.

5.03.5.1 Description. This work shall consist of furnishing and installing special bridge expansion joints as shown on the plans. Unless otherwise shown on the drawings, expansion joints shall be fully waterproof type and to the Engineer's approval.

The Contractor shall submit the type of expansion joint he intends to use and obtain the Engineer's approval of the joint type. The Contractor is then required to furnish detailed drawings of all the joints and method assembly and installation procedure for the approval of the assembly and installation procedure. All joints shall be installed in accordance with the manufacturer's recommendations using only materials and tools recommended by the manufacturer. The bedding and nosings of expansion joints shall be considered integral parts of the joint and the joint manufacturer shall be responsible for the supply of all constituent materials required for bedding and nosing of joints.

5.03.5.2 Materials. Joint sealing compounds shall conform to the requirements of AASHTO M282 and shall be as specified in Paragraph 6.22.2.2, "Joint Sealing Compounds," while joint fillers shall conform to the requirements of Paragraph 6.22.2.4, "Preformed Expansion Joint Filler" in these General Specifications.

Alternatively, if approved by the Engineer, hot-applied sealants shall comply with the requirements of BS 2499 and cold-poured sealants shall comply with the requirements of BS 5212.

Materials for manufactured joints shall satisfy the requirements of the applicable standards specified in Technical Memorandum 3/72 - Expansion Joints for use in Highway Bridge Decks, issued by the Bridge Engineering Design Standards Division, Department of Environment, UK

Finished expansion joints shall provide movement to the required degree as shown on the plans, and shall have good riding qualities. They shall not cause a skidding hazard nor generate excessive noise or vibration during the passage of traffic. Parts of all bridge joints shall be easily replaceable and shall facilitate inspection and maintenance. Finished expansion joints shall either be sealed, as shown on plans, or have provision for carrying away water, silt, grit and sand.

Epoxy mortar and epoxy concrete composition for joint bedding and nosing shall be submitted to the Engineer for approval.

When directed, all materials shall be tested prior to commencement of the bridge work as deemed necessary by the Engineer and as specified herein. Test samples shall be supplied by the Contractor at his own expense. Samples shall be tested in accordance with the requirements stipulated in the AASHTO Standard Specifications for Highway Bridges, Division 2, Section 423. Testing shall be conducted by a qualified laboratory, which will issue a certificate indicating the test results. All costs in connection with manufacturer's certificates of guarantee, laboratory analyses and certificates, and all subsequent testing shall be borne by the Contractor.

5.03.5.2.1 Submittals. The Contractor shall submit to the Engineer for approval copies of manufacturer's specifications, certifications and laboratory test reports and instructions for maintenance for all manufactured materials. Installation procedure of finished expansion joints and items of equipment recommended to be used by the manufacturer, shall be also included.

5.03.5.2.2 Storage and Handling. Manufactured joints shall be delivered in weatherproof and protective packaging and shall be so handled and stored so that they remain free from physical damage.

Epoxy resin mortar and two-part sealants shall be delivered in ready-to-use packs with the components in the manufacturer's original sealed containers, labeled clearly with the manufacturer's name, product identification and batch number. The size of the packs shall be such that batches of material for mixing shall be in whole-number multiples of packs. The re-use of a portion of a used pack will not be permitted. The materials shall be stored in dry, weatherproof conditions away from the effects of hot sun and in strict accordance with the manufacturer's instructions.

5.03.5.3 Construction Requirements.

5.03.5.3.1 Joints. The size of the opening shall be compatible with the mean bridge temperature at the time of installation. This temperature shall be determined in accordance with arrangements agreed with the Engineer. A poured sealant shall be placed only when the mean bridge temperature is thirty plus or minus five degrees Celsius (30 ± 5° C), unless otherwise approved by the Engineer. The pouring temperature of a hot-applied sealant shall not exceed the manufacturer's recommended safe heating temperature.

Materials mixed and applied by hand shall be supplied in separate containers in the correct proportions and shall be mixed using a power stirrer or mixer.

The position of all bolts cast into concrete and holes drilled in plates shall be accurately determined from templates. Also, the threads should be kept clean and clear of dust.

During the placing and hardening of concrete or mortar under expansion joints components, relative movement shall be prevented between them and the supports to which they are being fixed.

When one-half of the joint is being set, the other half shall be completely free from longitudinal restraint. In particular, where strong backs or templates are used to locate the two sides of the joint, they shall not be fixed simultaneously to both sides.

Ramps shall be provided and maintained to protect all expansion joints from vehicular loading. Vehicles shall pass over the joint only through ramps until the Engineer approves removal of the same.

5.03.5.3.2 Bedding and Nosing. For bedding and nosing of joints, epoxy mortar and epoxy concrete shall be used under the direction of a competent supervisor. The work shall be carried out preferably in warm dry weather. The air temperature around the joint shall not be less than ten degrees Celsius (10° C.) which shall be achieved artificially if necessary. Concrete surfaces to which the nosings are applied shall be dry, sound and free from laitance. Before application of the prime coat, loose materials and dust should be removed by a tested air compressor to ensure that no oil is leaking from the compressor.

Unless otherwise specified, surfacing shall be carried across the joint and then cut back to accommodate the nosing. Masking material shall be provided to prevent surfacing materials adhering to the deck where nosings are to be formed and shall be adequately located to prevent displacement by the paving machine. The cutting shall be done with a diamond saw.

A priming coat of unfilled epoxy resin composition shall be well worked in by brush to all surfaces with which the nosings will be permanently in contact, at a uniform rate of not less than three hundred (300) grams per square meter. The mortar shall then be applied while the priming coat is still tacky. Epoxy mortar shall be compacted in courses of thickness not exceeding fifty (50) millimeters.

The mixed constituents shall be placed in position within the item recommended by the manufacturer, well worked against the primed surfaces and trowelled flush with the adjacent road surface to form a dense mortar to the required profiles.

Traffic shall not be permitted until the joint bedding and nosing have gained full strength or approved by the Engineer.

The elevation of the top of expansion joint shall be five (5) millimeters below the elevation of the pavement (or as specified by the manufacturer).

5.03.5.4 Water Stops. This work consists of furnishing and installing water stops in expansion and construction joints.

Water stops are designated as copper, plastic, or rubber.

5.03.5.4.1 Materials. Materials shall conform to the following requirements:

1. Copper Water Stops or Flashings. Sheet copper for water stops or flashings shall conform to AASHTO M 138, copper USN No. C11000. The resistivity test is not required.

2. Rubber Water Stops. Water stops may be molded or extruded rubber with a uniform cross-section and free from porosity or other defects. If approved, an equivalent standard shape may be furnished.

Rubber water stops may be fabricated from a compound of natural rubber, synthetic rubber, or a blend of the two, together with other compatible material. Do not use any reclaimed material. Furnish a certification from the producer showing the composition of the material. The material shall conform to the following:

(1) Hardness (shore), 3021[1]	60 -70
(2) Compression set, 3311[1]	30% max.
(3) Tensile Strength, 4411[1]	17.2 MPa
(4) Elongation at breaking, ASTM D 412	450% min.
(5) Tensile stress, 300% elongation, 4131[1]	6.2 MPa min.
(6) Water absorption by weight, 6631[1]	5% max.
(7) Tensile strength after aging, 7111[1]	80% of original

Note[1]: Federal Test Method Standard No. 601.

3. Plastic Water Stops. Plastic water stops shall be fabricated to a uniform cross-section that is free from porosity or other defects. If approved, an equivalent standard shape may be furnished.

Water stops shall be fabricated from a homogeneous, elastomeric, plastic compound of basic polyvinyl chloride and other material. Reclaimed material may not be used.

A product certification shall be supplied by the producer showing test values for the following properties. If directed, the Contractor shall furnish samples in lengths adequate for performing the specified tests.

(1) Tensile strength, ASTM D 638	9.65 MPa
(2) Elongation at breaking, ASTM D 638	250% min.
(3) Hardness (shore), ASTM D 2240	60 to 75
(4) Specific gravity, 5011[1]	Note (2)
(5) Resistance to alkali[3], ASTM D 543	Max% Wt. change - 0.10 to +0.25 Max. change in hardness 5 shore.
Min. decrease in tensile strength 15%	
(6) Water Absorption (48 hours), ASTM D 570	0.50% max.
(7) Cold bending, Note (4)	No cracking
(8) Volatile loss, ASTM D 1203	Note (5)

Note:

[1] Federal Test Method Standard No. 406.

[2] Manufacturer's value ± 0.02.

[3] Use a 10% solution of NaOH for a seven (7) day test period.

[4] Subject a twenty five (25) by one hundred fifty (150) mm strip that is three (3) mm thick to a temperature of minus twenty nine degrees Celsius (-29° C.) for a period of two (2) hours. After the two (2) hours, immediately bend the sample 180° (3.1 rad) around a 3 mm diameter rod. Apply sufficient force to maintain contact with the rod during bending. Examine the sample for evidence of cracking. Test and report results for at least three (3) individual samples from each lot.

[5] Not more than manufacturer's value.

5.03.5.4.2 Construction.

1. Copper Water Stops. Copper sheet shall be used of the thickness, weight, width, and shape required. Joints shall be soldered for a continuous watertight unit.

2. Rubber Water Stops. Before installation the following shall be submitted to the Engineer for approval:

   (1) Performance test data
   (2) One (1) meter sample of each type of water stop required
   (3) If splices are used, at least one (1) preliminary field splice.

Water stops shall be formed with a cross-section that is uniform in width and web thickness. Straight strips shall not be spliced.

All junctions shall be full-molded in the special connection pieces. Well cured, dense, homogeneous special connection pieces, that are nonporous and are free from other defects shall be supplied.

Splices shall be fabricated that are dense and homogenous throughout the cross-section. Splices shall be fabricated watertight by vulcanizing or by mechanical means. Splices shall have a tensile strength of at least fifty percent (50%) of the reported tensile strength of the unspliced rubber water stop.

3. Plastic Water Stops. Before installation the Contractor shall submit for approval at least one (1) preliminary field splice sample. Splices shall be heated according to the manufacturer's instructions to make them watertight. Splices shall be fabricated to have a tensile strength of at least eighty percent (80%) of the reported tensile strength of the unspliced plastic water stop.

4. Placing Water Stops. Water stops shall be carefully placed and supported. Water stops shall not be displaced or damaged by construction operations or other activities. All surfaces of water shall be kept free from oil, grease, dried mortar, or any other deleterious material until embedded in concrete. The embedded portions of the water stop shall be completely enclosed in dense concrete.

5. Acceptance. Water stop materials will be accepted under Subsection 1.08.3, "Measured or Tested Conformance," in these General Specifications.

5.03.6 BEARING DEVICES.

5.03.6.1 Description. This work shall consist of furnishing and installing replaceable bridge bearings as shown on the plans or as directed by the Engineer.

All special bearing devices shall be of the pot type, either fixed, sliding or guided. Movement and restraint characteristics will be shown on the drawings and specified in the Special Specifications and Bill of Quantities.

The base of pot bearings shall be formed from a single monolithic material such as solid steel plate or cast steel.

Elastomeric bearing devices can be either plain or laminated elastomeric bearing pads.

Pads nineteen (19) millimeters or less in thickness may be either laminated or plain. Pads over nineteen (19) millimeters in thickness shall be laminated.

Laminated pads shall be individually molded and consist of alternate laminations of elastomer and metal laminates. Laminations of elastomer shall be twelve (12) millimeters, plus or minus three (3) millimeters in thickness. The top and bottom layers of metal shall be uniformly covered with a minimum of three (3) millimeters of elastomer, except as laminate restraining devices and around holes that will be entirely closed on the finished structure. Variations in the location of the metal reinforcement from its theoretical location shall not exceed three (3) millimeters.

The Contractor shall submit to the Engineer well in advance details of bearings he intends to use for approval. Then the Contractor is required to submit one sample and detail drawings on all types of bearings and installation procedures for approval by the Engineer. Bearings shall be installed according to the manufacturer's recommendations and as agreed with the Engineer, by competent personnel who are well trained in the installation procedures of the bridge bearings.

5.03.6.2 Materials.

5.03.6.2.1 Bearing Devices.

1. The Contractor shall submit to the Engineer details of all the bearings he proposes to use in the Works along with their specifications. Also, one sample of such bearings shall be submitted, which will form the basis for a tentative approval of the bearings prior to the carrying out of the detailed examination and field tests.

2. Weldable structural steel for bearings shall comply with BS 4360 and steel castings with BS 3100. Stainless steel sheets used in bearings shall comply with BS 1449: Part 2: 1975. Iron castings with spheroidal or nodular graphite shall comply with BS 2789: 1973. Grade 500/7.

(Where BS is referred to, equivalent specifications shall be accepted).

3. All bearings shall be provided with all fittings, fixtures, bolts and/or shear keys required either for installation of to ensure satisfactory in-service operation.

Vulcanized natural rubber and chloroprene rubber for bearings shall conform to the AASHTO Standard Specifications for Highway Bridges or to BS 1154 and BS 2752. Shore hardness of the rubber, tensile strength, minimum elongation at break and shear modulus shall be in the range specified on the plans.

Bearings shall be delivered in protective packaging and shall be so handled and stored that they remain free from any physical damage or dust accumulation.

Epoxy mortar shall be delivered in ready-to-use packs in the manufacturer's original sealed containers, labeled clearly with the manufacturer's name, product identification and batch number. The size of the packs shall be such that batches of materials for mixing shall be in whole number multiples of packs. The re-use of the portion of a used pack will not be permitted. The packs shall be stored in dry, weather-proof conditions away from the effects of hot sun.

The Contractor shall submit manufacturer's recommendations for periodic inspection and maintenance of the bridge bearings for the phase of actual operation.

4. Testing. Before approval is given, at least one of each type of bearing shall be tested for material quality, load capacity and friction characteristics. Then, the Engineer shall demand bearings selected by him at random which will similarly be tested.

Elastomeric bearings consisting of one or more elastomer slabs, bonded to metal plates, shall be subjected to tests for compliance with requirements stipulated herein or to the following specifications, codes and standards, as shown on the plans or as directed by the Engineer:

1. BS 5400 Part 9 - Code of Practice for Bearings
2. Technical memorandum No. 802 - Provisional Rules for the use of Rubber Bearings in Highway Bridges.
3. BS 1154 - Specification for Natural Rubber Compounds (High quality).
4. BS 903 - Methods of Testing Vulcanized Rubber.
5. BS 2752 - Specification for Chloroprene Rubber Compounds.
6. BS 4395 - High strength friction grip bolts and associated nuts and washers for structural engineering.

5. Load Bearing Tests shall be as follows:

(1) Vertical Load - Load-deformation test to a maximum of one and one-half (1.5) times rated load, with the load applied in equal increments and decrements in equal increments and equal decrements to obtain a load cycle. Two such load cycles shall be performed. At maximum load in the first cycle, the load shall be held for six (6) hours. At maximum load in the second cycle, the load shall be held for fifteen (15) minutes.

(2) Guide Test - This test shall be carried out at constant vertical loads of ten (10) and one hundred percent of rated load. The horizontal load shall be applied in ten equal increments to a maximum of designed horizontal load. Two load cycles for each test shall be performed. Where required by the Engineer, electrical strain gauges shall be installed on the base plate at thirty (30) degrees spacing on one-quarter of the base plate to measure the stress occurring at the rim/base junctions.

All steel elements of the bearing load tested shall be tested for mechanical strength and chemical compositions and where rolled steel sheets are used, the mechanical strength test shall be carried out in the directions both of rolling and perpendicular to rolling.

Elastomeric components of pot bearings shall comply with the requirements given in sub-clause 2 of this clause for the requirements of elastomeric bearings.

PTFE sheets used in metal bearings shall comply with BS 3784: 1973, Grade B and shall be tested for hardness, tensile strength and elongations and specific gravity in accordance with the ASTM D 2240, ASTM D638 and ASTM D792, respectively. Additionally, the arrangements and shapes of grease pockets, if used, shall be surveyed and tested.

All tests shall be carried out at independent laboratories approved by the Engineer. Adequate notice shall be given to the Engineer or his representative before carrying out load tests.

5.03.6.2.2 Elastomeric Bearings.

1. Vulcanized natural elastomer shall comply with the requirements of ASTM standards D2240, D412, D573, D395, D1149, D429B and D746 or equivalent BS or DIN Specifications.

Flash tolerances, finish and appearance shall meet the requirements of the latest editions of the "Rubber Handbook" published by the Rubber Manufacturers Association, Inc., RMA F3 and TO63 for molded bearings and RMA F2 for extruded bearings. For both plain and laminated bearings, the permissible variation from the dimensions and configuration required shall be as follows:

(1) Average total thickness	-0, +3mm
(2) Overall horizontal dimensions	-0, +6mm
(3) Thickness of individual layers of elastomer	+/- 2mm
(4) Variation from a plane parallel to the theoretical surface (top, sides, laminates)	2 mm
(5) Edge corner of embedded laminates	0-, +2mm
(6) Size and positions of holes	+/- 2mm

2. Steel for plate reinforcement shall comply with the requirements of AASHTO M185 (ASTM A36) or A245 Grade C or D or equivalent BS and DIN specifications and shall be free from sharp edges. The thickness of outer plates not less than three (3) millimeters and of inner plates not less than one and five-tenths (1.5) millimeters.

3. Resistance to Weathering. This is predominantly determined by the resistance to ozone which is present in the atmosphere in variable amounts. The elastomer shall have good resistance to ozone attack and shall be tested in accordance with ASTM D1149.

4. Number and Nature of Tests.

(1) Bond Test. Test pieces for this purpose shall be prepared from one of the selected bearings, which may previously have been used for tests specified in sub-paragraph (3) above.

(2) Test for Physical Properties and Weathering Test. Test pieces shall be taken from the inside and outside regions of the bearing and they shall be prepared as for the bond test. Alternately, they may be prepared from a test sheet formed from the elastomer used in the manufacture of the bearing and being in a similar state of cure. A test piece cut from a bearing should produce not less than seventy-five percent (75%) of specified performance results required from a prepared test sheet.

(3) Stiffness Test. At least one full scale stiffness test for each bearing type and additional tests as required of the same type shall be carried out in respect of stiffness in compression and where applicable in shear. The rate of loading shall be agreed with the Engineer.

(1) Stiffness in Compression. The bearing shall be loaded to one and one-half (1.5) times the design load and this load shall be maintained for a period of two (2) minutes. The loading shall then be reduced to ten percent (10%) of the design load and maintained at this value for ten (10) minutes, when gauge readings shall be taken. The bearing shall then be reloaded to one and one-half (1.5) times the design load and maintained at this value for ten (10) minutes. Gauge readings shall be taken again and used in conjunction with the earlier readings to evaluate the stiffness. The compressive stiffness shall be within twenty percent (20%) of the value quoted by the manufacturer. In addition, for any one structure, the compressive stiffness for bearings of the same type shall not deviate from the value quoted by more than fifteen percent (15%).

(2) Stiffness in Shear. The bearing shall be loaded to produce one and one-half (1.5) times the design movement and this load shall be maintained for a period of two minutes. The loading shall then be reduced to produce ten (10) percent of the design movement and maintained at this value for ten (10) minutes, when gauge readings shall be taken. The bearing shall then be reloaded to produce one and one half (1.5) times the design movement and maintained at this value for ten (10) minutes. Gauge readings shall be taken again and used in conjunction with the earlier readings to evaluate the stiffness. The shear stiffness shall be within twenty percent (20%) of the value quoted by the manufacturer.

No surface flaws shall become apparent during both stiffness tests and laminated bearings shall show no irregularities in deflected shape.

(4) Bond of Elastomer to Metal. Tests shall be performed in accordance with Method B of BS 903, Part A 21. The average of the peak values of load during separation shall be not less than seven (7) N per millimeter - width of the test piece.

(5) Physical properties. The physical properties of the elastomer with respect to hardness, tensile strength, elongation at break, and compression set shall comply with the requirements of BS 1154 or BS 2752, both as received and after aging. The respective tests shall be as described in the following:

(1) Determination of Hardness; BS 903, Part A 26.
(2) Determination of Tensile Strength and Elongation at Break, BS 903, Part A 2.
(3) Determination of Compression Set, BS 903, Part A 6.
(4) Accelerated Aging Tests, BS 903, Part A 19.

Where a prototype bearing has been tested satisfactorily and the Engineer is satisfied that the materials and workmanship in the bearings to be supplied for incorporation in the Work comply with this Section, no further acceptance testing of whole bearings will be required.

Subject to the approval of the Engineer, any or all of the tests may be waived where evidence can be produced that satisfactory test results are already available for materials and bearings identical with those to be used.

5.03.6.3 Construction Requirements. The fixing of all bearings shall comply with the manufacturer's recommendations and be approved by the Engineer.

The maximum allowable value of the coefficient of friction between sliding surfaces of metal bearings shall be three-hundredths (0.03).

The manufacturer shall inscribe on the top of each bearing the longitudinal axis and transverse axis of the bearing.

All bearings shall be indelibly marked with the appropriate type number clearly marked top and bottom. Bearings shall be clearly identified by "pier number/bearing number," "abutment number/bearing number."

For each type of bearing, the Contractor shall furnish detailed calculations and drawings to demonstrate the adequacy of the bearings and that they can be properly installed, maintained and replaced if necessary. Manufacturer of bearings should not commence until the Engineer has approved the design calculations and shop drawings.

Bearings shall not be dismantled. Any transit bolts, straps or other temporary fixing shall not be removed until the bearing is fixed in its final position and the structure immediately above the bearing is in place. Care shall be taken to ensure that all transit bolts, straps or other temporary fixings are finally removed.

Bearings which incorporate low friction material, such as PTFE, shall not be opened up to expose the surface of the low friction material. Should this happen accidentally, bearing surfaces are to be cleaned and regreased and assembled as required by the manufacturer and to the satisfaction of the Engineer.

All bearings shall be set horizontal in both directions and all bearings shall be positioned so that the inscribed longitudinal axis is parallel to the structure axis at the point of support, unless otherwise noted on the drawings.

All metal bearings must have positive fixing such that the bearing is subsequently removable without excessive jacking. Horizontal forces shall be transferred from the superstructure to bearings and from the bearings to supports by means of shear keys or fixing bolts.

However, where precast segmental deck construction is used, it may not be possible to use positive fittings for the top bearing plates. In such circumstances, the top bearing plates shall be fixed to the deck by epoxy injection. The epoxy used, the method of injection and strength of the fixing shall be to the approval of the Engineer and will be subjected to laboratory and field tests.

The longitudinal movements listed for metal bearings may require presetting the top plates with respect to the bottom plates and also variable orientation of the bearings with respect to the pier axes. Such preset and orientation angles shall be marked on each bearing by the manufacturer before shipment. Full installation drawings of all bearings shall be submitted by the Contractor for approval.

Any devices such as steel packs used to hold bearings level whilst being fixed, must be removed finally, so that the bearing seats only on its dry pack mortar bedding.

Metal bearings shall be set in position on steel wedges to within plus or minus five mm of the specified level. The location of these wedges beneath the bearings shall be agreed with the bearing manufacturer prior to installation.

The gap between the underside of bearing and substructure shall be fixed with steel-rammed dry pack mortar or epoxy mortar as specified by the Engineer which have a minimum of twenty-eight (28) day cylinder strength of three hundred ten (310) kilograms per square centimeter (kg/sq. cm) and the resulting voids filled with dry pack mortar or with an approved epoxy mortar. Construction of the bridge super-structure may then proceed. The supporting falsework and formwork of the bridge superstructure shall not be removed nor permit the transfer of load to the bearings prior to removal of the temporary supporting wedges.

Bearings shall be maintained in their correct position during placing of the bridge deck. Mating surfaces of bearings shall be kept clean from contamination and after the deck has been completed, each bearing and the area around it shall be left clean and tidy, to the satisfaction of the Engineer. No bearing shall be accepted on Site or be allowed to be installed until approval of the Engineer is obtained in respect of shop drawings material and load tests, installation drawings and installation trials.

In elastomeric bearings, welding for connecting metal to metal surfaces will not be permitted as there is a risk of burning the elastomer or of affecting adversely the bonding in the bearing.

5.03.7 CONTRACTOR QUALITY CONTROL PROCEDURES. Contractor quality control procedures shall be in accordance with Subsection 5.01.8, "Contractor Quality Control Procedures," in these General Specifications.

5.03.8 QUALITY ASSURANCE PROCEDURES. Quality assurance screening, sampling and testing of Portland cement concrete used in concrete structures and tunnels shall be in accordance with Subsection 5.01.9, "Quality Assurance Procedures," in these General Specifications. Unless otherwise stated in the Special Specifications the lot size will be the number of cubic meters of superstructure and substructure concrete in each bridge structure and in each section of tunnel for each class of concrete specified in the Bill of Quantities.

5.03.9 CONCRETE FOR MINOR STRUCTURES.

5.03.9.1 Description. This work consists of constructing minor concrete structures such as pipe culvert headwalls, wingwalls and aprons, spillways, slope paving, sidewalks, curbs and other minor concrete structures in accordance with these specifications and in reasonable close conformity with the lines, grades, details and locations shown on the plans or established by the Engineer.

5.03.9.2 Materials. All minor concrete structure materials shall conform to the requirements contained in Subsection 5.01.2, "Materials" in these General Specifications.

5.03.9.3 Concrete Composition. Concrete shall conform to the requirements of Table 5.03-2. Before batching concrete, the Contractor shall submit the proposed concrete proportions for approval. As a minimum, the following shall be submitted:

1. Type and source(s) of all material proposed for use.
2. Material certification for all material proposed for use including cement.
3. Saturated surface dry weight of the fine and coarse aggregate per cubic yard of concrete.
4. Gradation of fine and coarse aggregate.
5. Weight of mixing water per cubic meter of concrete.
6. Weight of cement per cubic meter of concrete.
7. Maximum slump of plastic concrete in millimeters.

<u>TABLE 5.03-2</u>

COMPOSITION OF MINOR STRUCTURE CONCRETE

Property	Specification
Minimum cement content, (kg/m^3)	310
Maximum W/C ratio	0.49
Maximum slump (mm)	(100)
Size of coarse aggregate	Paragraph 5.01.2.2
Minimum 28-day compressive strength (kilograms per square centimeter)	170

Class B structural concrete complying with Subsection 5.01, "Portland Cement Concrete," in these General Specifications will be acceptable as an approved mixture with appropriate certification.

5.03.9.4 Construction Requirements.

5.03.9.4.1 General. The Contractor shall perform the preparatory work in accordance with Section 2.09, "Structure Excavation and Backfill," in these General Specifications. He shall design and construct forms that are free of bulge and warp and allow for removal without injuring the concrete. Reinforcing steel shall be placed according to the *"Manual of Standard Practice"* of the Concrete Reinforcing Steel Institute. When concrete contains a retarding admixture, fly ash, or other pozzolan replacement for cement, forms shall be designed for a lateral pressure equal to that exerted by a fluid weighing twenty-four hundred kilograms per cubic meter (2400 kg/m^3).

Wood, metal, or other suitable material shall be used. Forms shall be kept clean and coated with a form release agent or form oil before placing concrete.

Class B structural concrete complying with Subsection 5.01, "Portland Cement Concrete," in these General Specifications will be acceptable as an approved mixture with appropriate certification.

5.03.9.4.2 Placing Concrete. The forms and foundation shall be moistened immediately before placing concrete. The concrete shall be discharged within the time limit shown in Paragraph 5.01.5.2, "Mixing Concrete," in these General Specifications.

Concrete shall be handled and placed to avoid segregation in accordance with Paragraph 5.03.4.5, ‘Handling and Placing Bridge Structural Concreted,” in these General Specifications. Aluminum pipe for transporting or placing concrete shall not be used. The intervals between delivery of batches for a single pour on a structure shall not exceed thirty (30) minutes.

Placement shall conform to the requirements of Subsection 5.01.6, "Weather Conditions and Curing Requirements," in these General Specifications when there is a forecast of air temperatures below an atmospheric temperature of two degrees Celsius (2° C.) or above twenty-five degrees Celsius (25° C.).

Water shall not be supplied to plastic concrete finishes during finishing operations.

5.03.9.5 Curing Concrete. Minor concrete shall be cured a minimum of seven (7) days. If high early strength cement is used, cure concrete a minimum of three (3) days. Cure shall be according to Subsection 5.01.6, "Weather Conditions and Curing Requirements" in these General Specifications.

5.03.9.6 Acceptance. Concrete for minor structures will be subject to acceptance or rejection by visual inspection and review of the load certification at the placement site. Retempering of concrete will not be permitted. The Engineer will take or supervise the taking of slump tests, test cylinders or cores for strength determination checks.

5.03.10 METHOD OF MEASUREMENT. Structural Concrete for Bridge Superstructure, Structural Concrete for Bridge Superstructure, Class ___ , Structural Concrete for Bridge Substructure, Structural Concrete for Bridge Substructure, Class ___, Structural Concrete for Box Culverts, Structural Concrete for Box Culverts, Class ___, Structural Concrete for Retaining Walls, Structural Concrete for Retaining Walls, Class___, Structural Concrete for Tunnel Portals, Structural Concrete for Tunnel Portals, Class___, Structural Concrete for Mainline Tunnel Lining, Strucural Concrete for Mainline Tunnel Lining, Class___, Structural Concrete for Cross Passage Tunnel Lining, Structural Concrete for Cross Passage Tunnel Lining, Class ___, and Concrete for Minor Structures shall be measured by the cubic meter for the Classes provided in the Bill of Quantities based on the dimensions shown on the plans or otherwise authorized in writing by the Engineer, completed and verified by the Engineer.

No measurement will be made for additional tunnel concrete in overbreak areas. No measurement will be made for chemical, air entraining or calcium chloride admixtures. Mineral admixtures will only be measured for payment on a ton basis when specified in the Plans or Special Specifications and listed in the Bill of Quantities.

Unsolicited test panels made by the Contractor for his own purposes to determine the suitability of the form, form-liner, mold oil or any other parameter that affects the concrete finish, texture and color shall not be measured for payment.

Satisfactory and accepted test panels ordered by the Engineer shall be measured for payment as indicated in the Bill of Quantities for the appropriate element and class of concrete.

Accepted test samples carried out on site and exhibited throughout the duration of the Works shall be measured for payment as indicated in the Bill of Quantities for the appropriate element and class of concrete.

Bearing devices shall be measured as provided in the Bill of Quantities for each type, capacity and member of bearings authorized, completed and accepted by the Engineer. Bearing tests, installation trials, epoxy mortar bedding nuts and bolts and where applicable epoxy injection shall not be measured separately but shall be deemed to be subsidiary to the bearing devices. Where temporary restraint of bearing is necessary due to the sequence of deck construction, it will not be measured separately for payment.

Bridge expansion joints shall be measured per linear meter for the width(s) specified in the Bill of Quantities for each type and number of expansion joints authorized, completed and accepted by the Engineer. The measurement shall be made from parapet to parapet whether or not the joint types over carriageway, verges and walkways for a particular joint size are similar. No separate measurement shall be made for special curb-units, cover plates over walkways, epoxy mortar bedding and epoxy concrete nosing, but shall be deemed subsidiary to bridge expansion joints.

Water stops shall be measured by the linear meter for the type(s) specified in the Bill of Quantities.

5.03.11 PAYMENT. The amount of completed and accepted structural concrete and minor concrete, measured as provided above, will be paid for at the contract unit price(s) per cubic meter for the several classes of concrete as specified in the Bill of Quantities, which price(s) shall be full compensation for furnishing, quarrying, preparing, transporting, delivering, mixing and placing all materials, (except reinforcing steel, structural steel, cast iron, expansion plates, and waterproofing), including forms and falsework, for all labor, equipment, tools and all other items necessary for the proper completion of the Work as specified in Subsection 1.07.2 - "Scope of Payment" in these General Specifications.

The amount of completed and accepted bearings, as measured, will be paid for at the corresponding contract unit price(s) per unit for each type of bearing device appearing in the Bill of Quantities, which price(s) will be considered full compensation for furnishing and placing all materials, labor, equipment, tools, supplies and all other items necessary for the proper completion of the Work as specified in Subsection 1.07.2 - "Scope of Payment" in these General Specifications.

The amount of completed and accepted expansion joints and waterstops, as measured above, will be paid for at the corresponding contract unit prices per linear meter for each type of expansion joint or waterstop specified in the Bill of Quantities, which prices shall be considered full compensation for furnishing and placing all materials, labor, equipment, tools, supplies and all other items necessary for the proper completion of the Work as specified in Subsection 1.07.2 - "Scope of Payment" in these General Specifications.

Mineral admixtures will only be paid for at the contract unit price per ton only when specified in the Plans or Special Specifications and listed in the Bill of Quantities and as specified in Subsection 1.07.2 - "Scope of Payment" in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO.	PAY ITEM	PAY UNIT
50301	Structural Concrete for Bridge Superstructure	Cubic Meter
5030101	Structural Concrete for Bridge Superstructure, Class A	Cubic Meter
5030102	Structural Concrete for Bridge Superstructure, Class B	Cubic Meter
5030103	Structural Concrete for Bridge Superstructure, Class C	Cubic Meter
5030104	Structural Concrete for Bridge Superstructure, Class D	Cubic Meter
5030105	Structural Concrete for Bridge Superstructure, Class E	Cubic Meter
5030106	Structural Concrete for Bridge Superstructure, Class K	Cubic Meter
5030107	Structural Concrete for Bridge Superstructure, Class S	Cubic Meter
5030108	Structural Concrete for Bridge Superstructure, Class ____	Cubic Meter
50302	Structural Concrete for Bridge Substructure	Cubic Meter
5030201	Structural Concrete for Bridge Substructure, Class A	Cubic Meter
5030202	Structural Concrete for Bridge Substructure, Class B	Cubic Meter
5030203	Structural Concrete for Bridge Substructure, Class C	Cubic Meter
5030204	Structural Concrete for Bridge Substructure, Class D	Cubic Meter
5030205	Structural Concrete for Bridge Substructure, Class E	Cubic Meter
5030206	Structural Concrete for Bridge Substructure, Class K	Cubic Meter
5030207	Structural Concrete for Bridge Substructure, Class S	Cubic Meter
5030208	Structural Concrete for Bridge Substructure, Class ____	Cubic Meter
50303	Structural Concrete for Box Culverts	Cubic Meter
5030301	Structural Concrete for Box Culverts, Class A	Cubic Meter

5030302	Structural Concrete for Box Culverts, Class B	Cubic Meter
5030303	Structural Concrete for Box Culverts, Class C	Cubic Meter
5030304	Structural Concrete for Box Culverts, Class D	Cubic Meter
5030305	Structural Concrete for Box Culverts, Class E	Cubic Meter
5030306	Structural Concrete for Box Culverts, Class K	Cubic Meter
5030307	Structural Concrete for Box Culverts, Class S	Cubic Meter
5030308	Structural Concrete for Box Culverts, Class ____	Cubic Meter
50304	Structural Concrete for Retaining Walls	Cubic Meter
5030401	Structural Concrete for Retaining Walls, Class A	Cubic Meter
5030402	Structural Concrete for Retaining Walls, Class B	Cubic Meter
5030403	Structural Concrete for Retaining Walls, Class C	Cubic Meter
5030404	Structural Concrete for Retaining Walls, Class D	Cubic Meter
5030405	Structural Concrete for Retaining Walls, Class E	Cubic Meter
5030406	Structural Concrete for Retaining Walls, Class K	Cubic Meter
5030407	Structural Concrete for Retaining Walls, Class S	Cubic Meter
5030408	Structural Concrete for Retaining Walls, Class ____	Cubic Meter
50305	Structural Concrete for Tunnel Portals	Cubic Meter
5030501	Structural Concrete for Tunnel Portals, Class A	Cubic Meter
5030502	Structural Concrete for Tunnel Portals, Class B	Cubic Meter
5030503	Structural Concrete for Tunnel Portals, Class C	Cubic Meter
5030504	Structural Concrete for Tunnel Portals, Class D	Cubic Meter
5030505	Structural Concrete for Tunnel Portals, Class E	Cubic Meter
5030506	Structural Concrete for Tunnel Portals, Class K	Cubic Meter
5030507	Structural Concrete for Tunnel Portals, Class S	Cubic Meter
5030508	Structural Concrete for Tunnel Portals, Class ____	Cubic Meter
50306	Structural Concrete for Tunnel Lining	Cubic Meter
5030601	Structural Concrete for Mainline Tunnel Lining, Class A	Cubic Meter
5030602	Structural Concrete for Mainline Tunnel Lining, Class B	Cubic Meter
5030603	Structural Concrete for Mainline Tunnel Lining, Class C	Cubic Meter
5030604	Structural Concrete for Mainline Tunnel Lining, Class D	Cubic Meter
5030605	Structural Concrete for Mainline Tunnel Lining, Class E	Cubic Meter
5030606	Structural Concrete for Mainline Tunnel Lining, Class K	Cubic Meter
5030607	Structural Concrete for Mainline Tunnel Lining, Class S	Cubic Meter
5030608	Structural Concrete for Mainline Tunnel Lining, Class ____	Cubic Meter
5030611	Structural Concrete for Cross Passage Tunnel Lining, Class A	Cubic Meter
5030612	Structural Concrete for Cross Passage Tunnel Lining, Class B	Cubic Meter
5030613	Structural Concrete for Cross Passage Tunnel Lining, Class C	Cubic Meter
5030614	Structural Concrete for Cross Passage Tunnel Lining, Class D	Cubic Meter
5030615	Structural Concrete for Cross Passage Tunnel Lining, Class E	Cubic Meter
5030616	Structural Concrete for Cross Passage Tunnel Lining, Class K	Cubic Meter
5030617	Structural Concrete for Cross Passage Tunnel Lining, Class S	Cubic Meter
5030618	Structural Concrete for Cross Passage Tunnel Lining, Class ____	Cubic Meter
50307	Concrete for Minor Structures	Cubic Meter
50308	Bearing Devices, Pot, Fixed	Unit
5030801	Bearing Devices, Pot, Fixed, 250 Ton Maximum Load	Unit
5030802	Bearing Devices, Pot, Fixed, 300 Ton Maximum Load	Unit
5030803	Bearing Devices, Pot, Fixed, 400 Ton Maximum Load	Unit
5030804	Bearing Devices, Pot, Fixed, 500 Ton Maximum Load	Unit
5030805	Bearing Devices, Pot, Fixed, 600 Ton Maximum Load	Unit
5030806	Bearing Devices, Pot, Fixed, 700 Ton Maximum Load	Unit
5030807	Bearing Devices, Pot, Fixed, 800 Ton Maximum Load	Unit
5030808	Bearing Devices, Pot, Fixed, 900 Ton Maximum Load	Unit
5030809	Bearing Devices, Pot, Fixed, 1000 Ton Maximum Load	Unit
50309	Bearing Devices, Pot, Sliding	Unit
5030901	Bearing Devices, Pot, Sliding, 250 Ton Maximum Load	Unit
5030902	Bearing Devices, Pot, Sliding, 300 Ton Maximum Load	Unit
5030903	Bearing Devices, Pot, Sliding, 400 Ton Maximum Load	Unit
5030904	Bearing Devices, Pot, Sliding, 500 Ton Maximum Load	Unit
5030905	Bearing Devices, Pot, Sliding, 600 Ton Maximum Load	Unit
5030906	Bearing Devices, Pot, Sliding, 700 Ton Maximum Load	Unit
5030907	Bearing Devices, Pot, Sliding, 800 Ton Maximum Load	Unit
5030908	Bearing Devices, Pot, Sliding, 900 Ton Maximum Load	Unit
5030909	Bearing Devices, Pot, Sliding, 1000 Ton Maximum Load	Unit

50310	Bearing Devices, Pot, Guided	Unit
5031001	Bearing Devices, Pot, Guided, 250 Ton Maximum Load	Unit
5031002	Bearing Devices, Pot, Guided, 300 Ton Maximum Load	Unit
5031003	Bearing Devices, Pot, Guided, 400 Ton Maximum Load	Unit
5031004	Bearing Devices, Pot, Guided, 500 Ton Maximum Load	Unit
5031005	Bearing Devices, Pot, Guided, 600 Ton Maximum Load	Unit
5031006	Bearing Devices, Pot, Guided, 700 Ton Maximum Load	Unit
5031007	Bearing Devices, Pot, Guided, 800 Ton Maximum Load	Unit
5031008	Bearing Devices, Pot, Guided, 900 Ton Maximum Load	Unit
5031009	Bearing Devices, Pot, Guided, 1000 Ton Maximum Load	Unit
50311	Bearing Devices, Elastomeric	Unit
5031101	Bearing Devices, Elastomeric, 60 Ton Maximum Load	Unit
5031102	Bearing Devices, Elastomeric, 90 Ton Maximum Load	Unit
5031103	Bearing Devices, Elastomeric, 100 Ton Maximum Load	Unit
5031104	Bearing Devices, Elastomeric, 120 Ton Maximum Load	Unit
5031105	Bearing Devices, Elastomeric, 140 Ton Maximum Load	Unit
5031106	Bearing Devices, Elastomeric, 150 Ton Maximum Load	Unit
50312	Bearing Devices, Elastomeric	Cubic Decimeter
50313	Bearing Devices, Metal	Unit
50314	Expansion Joints	Linear Meter
5031401	Expansion Joints, Less than 50 mm	Linear Meter
5031402	Expansion Joints, 50 mm to 100 mm	Linear Meter
5031403	Expansion Joints, 100 mm to 200 mm	Linear Meter
5031404	Expansion Joints, greater than 200 mm	Linear Meter
50315	Water Stop	Linear Meter
5031501	Water Stop, Rubber	Linear Meter
5031502	Water Stop, Copper	Linear Meter
5031503	Water Stop, Plastic	Linear Meter
50316	Mineral Admixture	Ton

SECTION 5.04 - PRESTRESSED CONCRETE STRUCTURES

5.04.1 DESCRIPTION. This Work shall consist of furnishing and placing precast, pretensioned, Portland cement concrete members or post-tensioning cast-in-place concrete structures in accordance with details shown on the plans and as specified in these General Specifications and the Special Specifications.

This Work shall include the furnishing and installation of all items necessary for the particular prestressing system to be used, including but not limited to prestressing and reinforcing steel, ducts, anchorage assemblies and grout used for pressure grouting ducts. The Work also includes curing, storing, transporting and erection of precast pretensioned members complete and in-place. For cast-in-place post-tensioned concrete the term "member" as used in this Section shall be considered to mean the concrete which is to be post-tensioned.

ITEMS IN BILL OF QUANTITIES:
Prestressing Steel
Precast, Prestressed Concrete Structural Members
Cast-in-Place Prestressed Concrete Structural Members

5.04.2 PRESTRESSING SYSTEM APPROVAL. The Contractor shall submit to the Engineer for review and approval working drawings of the prestressing system proposed for use. For initial review, six (6) sets of such drawings shall be submitted. The Engineer shall return one (1) approved set or one (1) set with corrections and modifications. After modification, six (6) sets showing any required corrections shall be submitted for final approval. Working drawings shall be submitted sufficiently in advance of the start of the affected work to allow time for review by the Engineer and correction by the Contractor of the drawings without delaying the approved programmed commencement of the Work. Such time shall be proportional to the complexity of the work but, in no case, shall such time be less than two months.

The working drawings of the prestressing system shall show complete details and substantiating calculations of the method and materials the Contractor proposes to use in the prestressing operations, including any additions or rearrangement of reinforcing steel and any revision in concrete dimensions from that shown on the plans. Such details shall outline the method and sequence of stressing and shall include complete specifications and details of the prestressing steel and anchoring devices, working stresses, anchoring stresses, stress-strain curves of the prestressing steel, anticipated gauge pressures, cable profiles, elongation of prestressing cables, type of ducts and all other data pertaining to the prestressing operation, including the proposed arrangement of the prestressing steel in the members.

The designs shall be prepared and signed by a qualified contractor's Structural Engineer who has been approved in advance by the Engineer.

Approval of working drawings and other submittals does not absolve the Contractor of the responsibility for any of his Contractual obligations. No additional payment will be made to the Contractor for any changes required as a result of reviews or approvals.

The Contractor shall submit for approval experience records and qualification details of all the Contractor's key structural design, fabrication, installation, and quality control personnel who will be working on the prestressing and concrete operation. Once approved, the Contractor shall not change or substitute any of the personnel without the prior approval of the Engineer.

All criteria covered by this Section on submittals and approval shall also apply to any subcontractor intended to be employed respective to prestressed concrete work.

5.04.3 MATERIALS.

5.04.3.1 Concrete. Concrete shall be controlled, mixed and handled as specified in Section 5.01, "Portland Concrete Cement" in these General Specifications, unless otherwise specified herein or on the drawings. Class shall be as indicated. Concrete for prestressed work shall be designated Class S, having a 28-day cylinder test compressive strength of not less than three hundred fifty (350) kilograms per square centimeter.

5.04.3.2 Concrete Reinforcement. Concrete reinforcement shall be in accordance with Section 5.02, "Reinforcing Steel" in these General Specifications unless otherwise specified herein or on the drawings.

5.04.3.3 Prestressing Reinforcement. Prestressing reinforcement shall be high-tensile strength steel wire, high-tensile strength seven wire strand or high-tensile strength alloy bars as called for on the plans or in these specifications.

1. High-tensile strength wire shall conform to AASHTO M 204.

2. High-tensile strength seven-wire strand shall conform to the requirements of AASHTO M 203.

3. High-tensile strength alloy bars shall be stress relieved and then cold stretched to a minimum of nine hundred (900) MPa. After cold stretching, the physical properties shall be as follows:

Minimum ultimate tensile strength	1000 MPa
Minimum yield strength, measured by the 0.7 percent extension under load method shall not be less than	900 MPa
Minimum modulus of elasticity	172369 MPa
Minimum elongation in 20 mm bar diameter after rupture	4 percent, min.
Diameter tolerance	+0.76 mm, - 0.25 mm

Subject to the Engineer's approval, prestressing steel manufactured to standards equivalent to those indicated herein may be used, provided that all requirements be satisfied.

In addition to the requirements of ASTM A 722 for deformed bars, the reduction of area shall be determined from a bar which the deformations have been removed. Such a bar shall be machined no more than necessary to remove the deformations over a length of three hundred (300) millimeters and reduction will be based on the area of the machined portions.

All bars in any individual member shall be of the same grade, unless otherwise permitted by the Engineer.

When bars are to be extended by the use of couplers, the assembled units shall have a tensile strength of not less than the manufacturer's minimum guaranteed ultimate tensile strength of the bars. Failure of any one sample to meet this requirement will be cause for the rejection of the heat of the bars and lot of couplers. The location of the couplers in the member shall be subject to the approval of the Engineer.

Wire shall be straightened if necessary to produce equal stress in all wires or wire groups or parallel lay cables that are to be stressed simultaneously or when necessary to ensure proper positioning in the ducts.

Where wires are to be button-headed, the buttons shall be cold formed symmetrically about the axis of the wires. The buttons shall develop the minimum guaranteed ultimate tensile strength of the wire. No cold forming process shall be used that causes indentations in the wire. Button heads shall not contain wide open splits, more than two (2) splits per head, or splits not parallel with the axis of the wire.

Tendons shall not be welded within the length to be tensioned and, unless other methods of cutting are approved by the Engineer, tendons shall be sawn or cropped using an abrasive disc cutter.

5.04.3.4 Duct Enclosures. Duct enclosures shall be rigid ferrous metal galvanized and mortar tight. Ducts shall be fabricated with either welded or interlocked seams. Galvanizing of the welded seam will not be required. Ducts shall have sufficient strength to maintain their correct alignment during placing of concrete. Joints between sections of duct shall be positive metallic connections which do not result in angle changes at the joints. Waterproof tape shall be used at the connections. Ducts shall be bent without crimping or flattening. Transition couplings, connecting said ducts to anchoring devices need not be galvanized.

When approved by the Engineer, ducts shall be of the flexible, corrugated type, delivered to the site on large diameter wooden drums. Ducts shall be protected from rusting, damage, oil, or any other deleterious matter.

All ducts or anchorage assemblies shall be provided with pipes or other suitable connections for the injection of grout after prestressing. Joints in adjacent ducts shall be staggered by at least thirty (30) centimeters.

Provide ducts with an inside diameter at least ten (10) millimeters larger than the nominal diameter of a single wire, bar, or strand tendon. For multiple wire, bar or strand tendons, provide a duct cross-sectional area at least two (2) times the net area of the prestressing steel.

Ducts for prestressing steel when bars are used shall have a minimum inside diameter ten (10) millimeters larger than the diameter of the bars to be used.

5.04.3.5 Anchorages. All anchorages shall be approved cast anchorages complying with the requirements of BS 5557 or approved equivalent specifications and capable of securing the permanent type anchoring device. All anchorages and couplers for post-tensioning shall be capable of holding the prestressing steel at a load producing a stress of not less than ninety-five (95) percent of the specified ultimate tensile strength of the prestressing steel. The coupling of tendons shall not reduce the elongation at rupture below the requirements of the tendon itself. Couplers and coupler components shall be enclosed in housings long enough to permit necessary movements. Couplers for tendons shall be used only at locations specifically indicated or approved by the Engineer.

Couplers shall not be used as points of sharp tendon curvature.

Anchorage devices shall have a minimum clear concrete or grout coverage of fifty (50) millimeters in every direction. Alternate corrosion protection methods for anchorages shall be shown on the shop drawings submitted by the Contractor.

The prestressing force shall be effectively distributed to the concrete by means of an approved anchoring device. Any allowance for draw-in of the tendon during anchoring shall be in accordance with the Engineer's instructions, and the actual slip occurring shall be recorded for each individual anchorage.

When headed wires are used, the outside edge of any hold for any prestressing wire, through a stressing washer or through an unthreaded bearing ring or plate, shall not be less than six (6) millimeters from the root of the thread of the washer or from the edge of the ring or plate.

If loop tendon anchorages are used, they shall be enclosed in ducts for their entire length.

5.04.3.6 Grout. The Grout shall conform to the following requirements:

- Portland Cement Conforming to ASTM C 150, Type 1 and Water conforming to MRDTM 514.
- Maximum water cement ratio: 0.45
- Initial Set of 3.5 MPa with a 161 mm^2 probe according to AASHTO T 197.
- Minimum compressive strength per AASHTO T 106.
  - o Three days: 23 MPa
  - o Seven days: 30 MPa
  - o Twenty-eight days: 35 MPa

The grout shall be mixed for a minimum of two minutes and until a uniform consistency is obtained. The pumpability of the grout shall be determined in accordance with the US Corp of Engineers Method ASTM C 939. The efflux time of the grout sample immediately after mixing shall not be less than eleven (11) seconds. The flow cone test does not apply to grout which incorporates a thixotropic additive.

Admixtures, if used, should impart the properties of low water content, good flowability, minimum bleed and expansion if desired. Its formulation should contain no chemicals in quantities that may have harmful effect on the prestressing steel or cement. Admixtures containing chlorides (as C1 in excess of 0.5% by weight of admixture), fluorides, sulfites and nitrates shall not be used.

Aluminum powder of the proper fineness and quantity or other approved gas evolving material which is well dispersed through the other admixture may be used to obtain five (5) to ten (10) percent unrestrained expansion of the grout.

All admixtures should be used in accordance with the instructions of the manufacturer.

5.04.4 EQUIPMENT. Equipment shall conform to the requirements specified in the Contractor's Program of Work as approved by the Engineer.

Equipment for effectively distributing the load from anchoring devices to the concrete shall be such that the final unit compressive stress on the concrete directly underneath the plate or assembly does not exceed twenty (20) MPa.

Jacks used to stress tendons shall be equipped with either a pressure gauge or a load cell for determining the jacking stress.

1. The pressure gauge shall have an accurately reading dial at least one hundred fifty (150) millimeters in diameter and each jack and its gauge shall be calibrated as a unit with the cylinder extension in the approximate position that it will be at final jacking force, and shall be accompanied by a certified calibration chart.

2. The load cell shall be calibrated and shall be provided with an indicator by means of which the prestressing force in the tendon may be determined. The range of the load cell shall be such that the lower ten percent (10%) of the manufacturer's rated capacity will not be used in determining the jacking stress.

Grouting equipment shall be capable at a pressure of at least seven (7) kilograms per square centimeter (0.669 MPa). Grouting equipment shall be furnished with a pressure gauge having a full-scale reading of not more than twenty (20) kilograms per square centimeter (2.07 MPa). Reciprocating pumps or equipment that produces a pulsating flow shall not be used. Grouting equipment shall be thoroughly washed with clean water at least once every three (3) hours during the grouting operations and at the end of use each day. Unless waived by the Engineer, a complete grouting plant for immediate use in case of emergency or breakdown of the equipment in operation shall be available on stand-by.

When vents are required, standby flushing equipment capable of developing a pumping pressure of eighteen (18) kilograms per square centimeter and/or sufficient capacity to flush out any partially grouted ducts shall be provided.

Grout injection pipes shall be fitted with positive mechanical shutoff valves. Vents and ejection pipes shall be fitted with valves capable of withstanding the pumping pressure.

5.04.5 CONTRACTOR QUALITY CONTROL PROCEDURES. Contractor Quality Control Procedures shall conform to the requirements of Subsection 5.01.8, "Contractor Quality Control Procedures" in these General Specifications. Contractor Process Control Sampling and Testing of prestressing bars and wires shall conform to the requirements of ASTM A 416 and A 421 and as follows:

1. Samples from each size and each heat of prestressing bars, from each manufactured reel of prestressing steel strand, from each coil of prestressing wire and from each lot of anchorage assemblies and bar couplers to be used shall be furnished and tested by a testing laboratory approved by the Engineer. With each sample of prestressing steel wires, bars or strands furnished for testing, there shall be submitted a certification stating the manufacturer's minimum guaranteed ultimate tensile strength of the sample furnished.

2. All materials for testing shall be furnished by the Contractor at his expense. The Contractor shall have no claim for additional compensation in the event his work is delayed awaiting approval of the materials furnished for testing.

3. All bars of each size from each mill heat, all wire from each coil, and all strand from each manufactured reel to be shipped to the site shall be assigned an individual lot number and shall be tagged in such a manner that each such lot can be accurately identified at the job site. Each lot of anchorage assemblies and bar couplers to be installed at the site shall be likewise identified. All unidentified prestressing steel, anchorage assemblies or bar couplers received by the site will be rejected.

4. The following sample materials and tendons, selected by the Engineer from the prestressing steel at the plant site, shall be furnished by the Contractor to the Engineer for check testing well in advance of anticipated use:

(1) For wire or bars, one two (2) meters long sample and for strand, one one and five tenths (1.5) meters long sample of each size shall be furnished for each heat or reel.

(2) If the prestressing tendon is a bar, one two (2) meters long length shall be furnished and in addition, if couplers are to be used with the bar, two one (1) meter lengths of bar equipped with one coupler and fabricated to fit the coupler shall be furnished.

5. For prefabricated tendons, the Contractor shall give the Engineer at least ten (10) days notice before commencing the installation of end fittings or the heading of the wires. The Engineer will inspect end fitting installations and wire headings while such fabrication is in progress at the plant and will approve the required testing of the materials before they are shipped to the site.

6. No prefabricated tendon shall be shipped to the site without first having been released by the Engineer, and each tendon shall be tagged before shipment for identification purposes at the site. All unidentified tendons received at the site will be rejected.

7. The release of any material by the Engineer shall not preclude subsequent rejection if the material is damaged in transit or later damaged or found to be defective.

5.04.6 STORAGE AND HANDLING. All prestressing steel shall be protected against physical damage and rust or other results of corrosion at all times from manufacture to grouting or encasing in concrete. Prestressing steel that has sustained physical damage at any time shall be rejected. The development of visible rust or other results of corrosion shall be cause for rejection, when ordered by the Engineer.

Prestressing steel shall be packaged in containers or shipping forms for the protection of the steel against physical damage and corrosion during shipping and storage. A corrosion inhibitor which prevents rust or other results of corrosion shall be placed in a corrosion inhibitor carrier type packing material, or when permitted by the Engineer, may be applied directly to the steel. The corrosion inhibitor shall have no deleterious effect on the steel or concrete or bond strength of steel to concrete. Packaging or forms damaged from any cause shall be immediately replaced or restored to original condition.

The shipping package or form shall be clearly marked with a statement that package contains high-strength prestressing steel, and the type of corrosion inhibitor used, including the date packed.

Prestressing steel for post-tensioning which is installed in members prior to placing and curing of the concrete, shall be continuously protected against rust or other corrosion, until grouted, by means of a corrosion inhibitor placed in the ducts or applied to the steel in the duct. The corrosion inhibitor shall conform to the requirements specified herein.

Precast prestressed members shall be transported in an upright position, and points of support and directions of the reactions with respect to the girders should be approximately the same during transportation and storage as when the member is in its final position. In the event that the Contractor deems it expedient to transport or store members in other than this position, it shall be done at his own risk.

Care shall be taken during storage, hoisting, and handling of the precast units to prevent cracking or damage. Units damaged by improper storing or handling shall be replaced by the Contractor at his expense.

5.04.7 CONSTRUCTION REQUIREMENTS.

5.04.7.1 Formwork. Formwork and casting beds shall be designed to withstand all pressure due to compaction of concrete and also all stressing induced during prestressing operations. The forms shall be constructed such that shortening of member during prestressing shall be permitted and resistance to relative movement of member shall be minimized. Side and bottom surface forms shall be constructed without joints or with joints

smooth and flush with the surface. The requirements in these General Specifications shall also apply.

All exposed edges shall be chamfered and chamfer strips secured in place to prevent movement during subsequent operations.

All forms shall be thoroughly coated with form release agent prior to each casting. The reinforcing steel shall not be contaminated by form release agent.

5.04.7.2 Shoring. Adequate shores, shoreheads, rakers, trusses and other suitable form supports shall be provided as necessary to prevent deflection of forms and non-prestressed members.

Shoring or form supports shall not be removed until sufficient prestressing has been applied enabling the member to carry all dead loads including forms, and all anticipated construction loads.

5.04.7.3 Concrete and Reinforcement. All work involving concrete and reinforcement shall be carried out in accordance with Section 5.03, "Concrete Structures" and Section 5.02, "Reinforcing Steel" in these General Specifications or as shown on the drawings.

Concrete shall not be placed in the forms until the placing of reinforcement, conduits, anchorages, and prestressing steel has been inspected and approved by the Engineer.

5.04.7.4 Prestressing Steel. Prestressing steel for pretensioning which is installed in members prior to placing and curing of the concrete, may be continuously protected against rust or other corrosion, until grouted, by means of a corrosion inhibitor placed in the ducts or applied to the steel in the duct. The corrosion inhibitor shall conform to the requirements specified herein.

Any time acceptable prestressing steel for pretensioning is placed in the stressing bed and is exposed to the elements for more than thirty-six (36) hours prior to encasement in concrete, adequate measures shall be taken by the Contractor, as approved by the Engineer, to protect said steel from contamination or corrosion.

When steam curing is used, prestressing steel for post-tensioning shall not be installed until the steam curing is completed.

When acceptable prestressing steel for post-tensioning is installed in the ducts after completion of concrete curing, and if stressing and grouting are completed within ten (10) days after the installation of the prestressing steel, rust which may form during said ten (10) days will not be cause for rejection of the steel. Prestressing steel installed, tensioned and grouted in this manner, all within ten (10) days, will not require the use of a corrosion inhibitor in the duct following installation of the prestressing steel. Prestressing steel installed as above but not grouted within ten (10) days shall be subject to all the requirements in this Specification pertaining to corrosion protection and rejection because of rust.

Whenever electric welding is performed on or near members containing prestressing steel, the welding ground shall be attached directly to the steel being welded.

5.04.7.5 Anchoring Devices and Load Distribution. The load from the anchoring device shall be distributed to the concrete by means of apparatus that will effectively distribute the load to the concrete. Such approved devices shall conform to the following requirements:

1. The final unit compressive stress on the concrete directly underneath the anchoring plate or assembly shall not exceed two hundred (200) kilograms per square centimeter but shall also not exceed ninety (90) percent of the ultimate strength of the concrete at time of post-tensioning.

2. Bending stresses in the anchoring plates or assemblies induced by the pull of the prestressing steel shall not exceed the yield point of the material or cause visible distortion in the anchorage plate when one hundred percent (100%) of the ultimate load is applied as determined by the Engineer. Should the Contractor elect to furnish an anchoring device of a type which is sufficiently large and which is used in conjunction with a steel grillage embedded in concrete that effectively distributes the compressive stresses to the concrete, the steel distribution plates or assemblies may be omitted.

Where the end of a post-tensioned assembly will not be covered by concrete, the anchoring device shall be recessed so that the ends of the prestressing steel and all parts of the anchoring devices will be at least fifty (50) millimeters inside of the end surface of the members, unless a greater embedment is shown on the plans. Following post-tensioning, the recesses shall be filled with concrete conforming to the requirements for the structure and finished flush.

5.04.7.6 Ducts. Ducts enclosures for prestressing steel shall be accurately placed at the locations shown on the plans or approved by the Engineer and securely fastened in place to prevent movement.

After installation in the forms, the ends of ducts shall at all times be covered as necessary to prevent the entry of water or debris. If prestressing steel is to be installed after the concrete has been placed, the Contractor shall demonstrate to the satisfaction of the Engineer that the ducts are free of water and debris immediately prior to installation of the steel.

All ducts over one hundred twenty-two (122) meters long shall have vents placed within one and eight-tenths (1.8) meters of the high points in the duct profile so that spacing of vents does not exceed one hundred twenty-two (122) meters. Vents shall be thirteen (13) millimeters minimum diameter standard pipe or suitable plastic pipe. Connections to ducts shall be made with metallic or plastic structural fasteners. Plastic components, if selected, shall not react with the concrete or enhance corrosion of the prestressing steel, and shall be free of water soluble chlorides. The vents shall be mortar tight, taped as necessary, and shall provide means for injection of grout through the vents and for sealing the vents. Ends of vents shall be removed twenty (20) millimeters below the roadway surface after grouting has been completed.

5.04.7.7 Pretensioning Procedures. All prestressing steel shall be pretensioned by means of hydraulic jacks so that the force in the prestressing steel shall be not less than the value shown on the plans.

Unless otherwise specified or shown on the plans, the average working stress in the prestressing steel shall not exceed eighty percent (80%) of the specified minimum yield point stress of the prestressing steel. The maximum temporary tensile stress (jacking stress) in prestressing steel shall not exceed ninety percent (90%) of the specified minimum yield point stress of the prestressing steel. The prestressing steel shall be anchored at stresses (initial stress) that will result in the ultimate retention of working forces of not less than those shown on the plans, but in no case shall the initial stress exceed seventy percent (70%) strength of the prestressing steel.

Working force and working stress will be considered as the force and stress remaining in the prestressing steel after all losses, including creep and shrinkage of concrete, elastic compression of concrete, creep of steel, losses in post-tensioned prestressing steel due to sequence of stressing, friction and take up of anchorages, and all other losses peculiar to the method or system of prestressing have taken place or have been provided for.

Prior to construction, the Contractor shall submit calculations to check concrete stresses based upon the approved system of prestressing and anchorage for approval.

The formula and friction coefficient used in calculating friction losses in tendons shall be in accordance with AASHTO specification, subject to approval.

5.04.7.8 Post-Tensioning Equipment and Procedures. The post-tensioning process as applied to post-tensioned members shall be so conducted that tension being applied and the elongation of the prestressing steel may be measured at all times.

Prior to placing of forms for closing slabs of box girder cells, the Contractor shall demonstrate to the satisfaction of the Engineer that either the prestressing steel is free and unbonded in the duct, or, if prestressing steel has not yet been placed, that all ducts are unobstructed.

Prior to post-tensioning any member, the Contractor shall demonstrate to the satisfaction of the Engineer that the prestressing steel is free and unbonded in the duct.

Post-tensioning forces shall not be applied to cast-in-place concrete until at least ten (10) days after the last concrete has been placed in the member to be post-tensioned and until the concrete complies with one of the following requirements:

1. When the concrete is designated by compressive strength, the concrete compressive strength shall have reached the strength shown on the plans at the time of post-tensioning.

2. At least twenty-eight (28) days shall have elapsed since the last concrete to be post-tensioned has been placed.

Unless otherwise indicated on the plans, the tendons in continuous post-tensioned members shall be tensioned by jacking at each end of the tendon.

For patented prestressing systems, the manufacturer's procedure and instruction shall be strictly complied with.

Tensioning shall be done with approved jacking equipment. Hydraulic jacks shall be equipped with accurate pressure gauges at least one hundred fifty (150) millimeters in diameter. The combination of jack and gauge shall have been calibrated within the last twelve (12) months. A certified calibration chart, graph, or table showing this calibration of the jack and gauge combination shall be furnished to the Engineer. The range of calibrations must encompass the range of required forces indicated on the shop plans. The jacking equipment shall be capable of simultaneously stressing all wire, strands, or bars for each individual tendon, unless otherwise approved.

Tendons shall be stressed in accordance with the approved sequence as indicated on the approved shop drawings. If the Contractor chooses to deviate from the approved sequence, the Contractor shall resubmit the shop drawings for approval. The sequence shall not cause stresses in excess of the maximum allowable stresses shown on the plans.

Tendons shall be preloaded to twenty percent (20%) of their total jacking force. Accessible dead end anchors shall be inspected by the Engineer for adequacy before completing the post-tensioning of the tendon.

The following procedure shall apply to groups of similar tendons. (The same duct type, the same prestressing steel size, similar path, and similar length.)

After the first three (3) tendons are pulled to the jack force stipulated on the approved shop drawings, stressing shall stop until an evaluation of jacking forces and elongations can be completed by the Engineer as described herein. The actual measurable elongations from these first three (3) tendons are to be compared to the calculated measurable elongations. If the three (3) actual measurable elongations are not within eight percent (8%) of the calculated measurable elongations, the tensioning shall be stopped and the tendons and elongations shall be evaluated by the Engineer. If each of the actual measured elongations is within eight percent (8%) of its calculated measurable elongation, the following procedures shall apply:

(1) Determine the following factor:

$$5/8 + 1/8\ \frac{\text{Tendon 1 AE}}{\text{Tendon 1 CE}} + 1/8\ \frac{\text{Tendon 2 AE}}{\text{Tendon 2 CE}} + 1/8\ \frac{\text{Tendon 3 AE}}{\text{Tendon 3 CE}}$$

Where "AE" is the actual measured elongation observed in the field and "CE" is the calculated measurable elongation for each tendon. This factor multiplied by the calculated measurable elongations for the tendons remaining to be tensioned will be the new base elongations for the remainder of the member tensioning.

(2) Acceptance of any remaining tendon will be made if that tendon elongation is within five percent (5%) of the new base elongation at the required jacking force.

(3) If a tendon's measurable elongation is five percent (5%) more than that of the new base elongation, then the tendon will be evaluated and will be subject to rejection.

(4) If a tendon's measurable elongation is less than the new base elongation by more than five percent (5%), the tendon may be overjacked to eighty percent (80%) of its ultimate strength, and it may be jacked from either end. If this yields an elongation within five percent (5%) of the new base elongation, the tendon will be accepted; otherwise it will be evaluated and will be subject to rejection.

A broken or damaged strand is cause for rejection of the tendon. If rejected, the strands in the tendon will be evaluated by the Engineer for reuse.

Where dead end anchorages and tendons are accessible, the anchorage system and length of projecting prestressing steel shall permit jacking with the same jacking equipment that was used on the live end.

Tendon projections at the live end and accessible dead ends shall not be cut off until all post-tensioning is completed and accepted.

The use of water soluble oil is an accepted method for loosening bound tendons.

The Contractor shall keep full and detailed record of all tensioning operations, including the measured elongations, pressure gauge or load cell readings and the amount of pull-in at each anchorage. Copies of these records shall be submitted to the Engineer within twenty-four (24) hours of each tensioning operation.

5.04.7.9 Bonding and Grouting. Post-tensioned prestressing steel shall be bonded to the concrete by completely filling the entire void space between the duct and the tendon with grout carried out not sooner than two (2) hours and not later than forty-eight (48) hours after completion of the stressing operations and in accordance with Section 10.4.2.2.1 in the AASHTO Bridge Standard Specifications Division II - Construction (Protection of Steel After Installation).

Grout shall consist of Portland cement and water, and may contain an admixture if approved by the Engineer.

Water shall be first added to the mixer followed by cement and admixture. The grout shall be mixed in mechanical mixing equipment of a type that will produce uniform and thoroughly mixed grout. Retempering of grout will not be permitted. Grout shall be continuously agitated until it is pumped.

The quality of the grout shall be approved by the Engineer. The efflux time of a grout sample immediately after mixing shall not be less than eleven (11) seconds.

Grouting equipment shall be furnished with a pressure gage having a full-scale reading of not more than twenty (20) kilograms per square centimeter.

Standby flushing equipment capable of developing a water pumping pressure of fifteen (15) kilograms per square centimeter and of sufficient capacity to flush out any partially grouted ducts shall be provided.

All ducts shall be clean and free of water and deleterious materials that would impair bonding of the grout or interfere with grouting procedures.

All grout shall pass through a two (2) millimeter (No. 10) sieve prior to being introduced into the grout pump.

Grout injection pipes shall be fitted with positive mechanical shutoff valves. Vents and ejection pipes shall be fitted with valves capable of withstanding the pumping pressures.

Leakage of grout through the anchorage assembly shall be prevented by positive mechanical means.

Grout shall be pumped through the duct and continuously wasted at the outlet until no visible slugs or other evidence of water or air are ejected and the efflux time of ejected grout is not less than eleven (11) seconds. The outlet valve shall then be closed and the pumping pressure held for a minimum of ten (10) seconds. The valve at the inlet shall then be closed while maintaining this pressure. Valves shall not be removed or opened until the grout has set.

When hot weather conditions would contribute to quick stiffening of the grout, the grout shall be cooled by approved methods as necessary to prevent blockages during pumping operations.

When temperatures below two degrees Celsius (2° C.) will prevail during and following the placement of grout, the Contractor shall provide adequate means to protect the grout in the ducts from damage by freezing or other causes.

The surfaces of concrete against which concrete encasement over anchorage assemblies is to be placed shall be abrasive blast cleaned and clean aggregate exposed after grouting of the ducts has been completed.

Vents shall be sealed consecutively in the direction of flow and the injection tube shall be sealed under pressure until the grout has set. The filled ducts shall be protected to the satisfaction of the Engineer, to ensure that they are not subjected to shock or vibration for one day and that the temperature of the grout in them does not fall below three (3) degrees Celsius (3° C) for at least three (3) days after its injection. Two days after grouting, the level of grout in the injection and vent tubes shall be inspected and made good, if necessary.

The Contractor shall keep full and detailed records of grouting, including the date each duct was grouted, the proportion of the grout and any admixtures used, the pressure, details of any interruptions and topping up required. Copies of these records shall be submitted to the Engineer within three (3) days of grouting.

Where required by the Engineer, the Contractor shall provide facilities and attendance for the radiographic testing of ducts.

5.04.7.10 Workmanship. Pretensioned & Post-tensioned Members. The following Table 5.04.1 contains dimension tolerances that will be used by the Engineer as a guide for acceptance of pretensioned and post-tensioned members. The Contractor shall make every effort to furnish acceptable members of uniform high quality that are within these dimensional tolerances. Any member not within these tolerances is subject to rejection depending on the effect of the deficiency on the structural adequacy and visual quality of the member in the completed structure as determined by the Engineer.

TABLE 5.04-1
PRESTRESSED CONCRETE MEMBER TOLERANCES

Description	Tolerance
I Box Beams & Slab Units Length	 +/- 19 mm
Width (overall)	+/- 6 mm
Depth (overall)	+/- 6 mm
Depth (top flange)	+/- 13 mm
Depth (bottom flange)	+/- 13 mm
Width (web)	+/- 10 mm
Sweep (1) Up to 40 ft. (12 m) member length 40 to 60 ft. (12 to 18 m) member length Greater than 60 ft. (18 m) member length	 +/- 6 mm +/- 10 mm +/- 13 mm
Variation from end squareness or skew Horizontal Vertical	+/- 10 mm +/- 13 mm, max. +/- 13 mm
Camber variation from design camber	+/- 3.1 mm/3 m +/- 13 mm, max.
Differential camber between adjacent members of the same design	0.75 inch max. (6.2 mm/3 m, 19 mm max.)
Position of Strands: Individual Bundled Position from design location of deflection points for deflected strands	 +/- 6 mm +/- 6 mm +/- 510 mm

Description	Tolerance
Position of plates other than bearing plates	+/- 25 mm
Tipping and flushness of plates	+/- 6 mm
Position of inserts for structural connections	+/- 13 mm
Position of handling devices: Parallel to length Transverse to length	 +/- 150 mm +/- 25 mm

(1) Variation from straight line parallel to centerline of member.

TABLE 5.04-1
PRESTRESSED CONCRETE MEMBER TOLERANCES

Description	Tolerance
I Beams- Length	 +/- 8 mm/m, +/- 25 mm max.
Width (overall)	+/- 10 mm, 6 mm
Depth (overall)	+13 mm, 6 mm
Depth (flanges)	- 6 mm
Width (web)	+10 mm, - 6 mm
Sweep(1)	3.1 mm/3 m
Variation from end squareness of skew	+/- 16 mm/m, +/ 25 mm max.
Camber variation from design camber	+/- 3.1 mm/3m +/- 13 mm, max. 24 m length +/- 25 mm, max. over 24 m length
Position of strands: Individual Bundled Position from design location of deflection points for deflected strands	 +/- 6 mm - bundled +/- 13 mm +/- 510 mm
Position of plates other than bearing plates	+/- 25 mm
Position of bearing plates	+/- 16 mm
Tipping and flushness of plates	+/- 6 mm
Tipping and flushness of bearing plates	+/- 3 mm
Position of inserts for structural	+/- 13 mm

Description	Tolerance
connections	
Position of handling devices: Parallel to length Transverse to length	 +/- 150 mm +/- 25 mm
Position of stirrups: Longitudinal spacing Projection above top	 +/- 50 mm +/- 19 mm
Local smoothness [(2)]	+/- 6 mm in 3 m any surface

(1) Variation from straight line parallel to centerline of member.

(2) Does not apply to top surface left rough to receive a topping or to visually concealed surfaces.

TABLE 5.04-1
PRESTRESSED CONCRETE MEMBER TOLERANCES

Description	Tolerance
I Box Beams and Slab Units - Position of stirrups: Longitudinal spacing Projection above top	 +/- 25 mm +/- 6 mm, -19 mm
Tipping of beam seat bearing area	+/- 3 mm
Position of dowel tubes	+/- 16 mm
Position of tie rod tubes: Parallel to length Vertical	 +/- 13 mm +/- 10 mm
Position of slab void: End of void to center of tie hole Adjacent to end block	 +/- 13 mm +/- 25 mm
Local smoothness [(1)]	+/- 6 mm in 3 m any surface
Post-Tension Members- Position of post tensioning ducts	 +/- 6 mm
Position of tendon anchorage bearing plates	+/- 6 mm

[(1)] Does not apply to top surface left rough to receive a topping or to visually concealed surfaces.

5.04.8 SEGMENTAL BRIDGE DECK CONSTRUCTION. Where bridge decks are pre-cast in segments and assembled in position for gluing and stressing, the Contractor shall satisfy the Engineer that his proposed construction method will achieve the required standard of workmanship and finish in the time available. Wherever match-casting of segments is required this shall be obtained by the use of long-line method. The length of the forms to achieve a satisfactory long-line system of match casting shall be approved by the Engineer. The Contractor is required to submit details of all his forms, falsework, and pre-casting factory, and his method of lifting, transporting, assembling, supporting, threading cables, gluing, and stressing the pre-cast units before commencement of any work for the approval of the Engineer.

5.04.8.1 Epoxy Adhesives in Segmental Bridge Deck Construction.

5.04.8.1.1 Epoxy Adhesive Suppliers. The epoxy resin adhesive shall be supplied by an approved manufacturer. It shall be made up and packaged by approved formulators and comply with the requirements of AASHTO M235 for Type VI epoxy resin adhesive or meet the compression shear and flexure tests as outlined in this Paragraph.

The material shall be supplied in accurately measured packs with the pack containing the hardener clearly distinguished by both size and labeling. The pack containing the resin shall be large enough to permit the addition of the hardener. Resin and hardener shall be pigmented with dissimilar colors to indicate when even mixing has been completely attained and to produce an even gray color to match the concrete.

Each batch of resin mixed shall be tested for setting by compression and shear tests as described below or in AASHTO M235. No permanent prestress shall be applied to a joint until the epoxy has achieved the required strength. Should these tests show that the resin is not setting the joint should be broken and the resin removed. Set resin shall be removed by grit blasting.

Further tests may be requested by the Engineer at various times to ensure that the material as mixed is complying with the Specification.

All the instructions of the manufacturer and/or the formulator shall be submitted to the Engineer for agreement. Such agreed instructions shall be adhered to in all respects.

The supplier shall carry out a program of testing to verify the acceptability and compatibility of epoxy Bonding Agents for segmental construction after consultation with the Engineer on the range of temperatures and work cycles that are to be considered in the tests. The Engineer may require the tests to be witnessed either in person or by an approved independent authority.

5.04.8.1.2 Flexure and Compression Test Specimens. Six (6) test specimens shall be cast for each joint which shall measure forty by forty by one hundred sixty (40 X 40 X 160) millimeters. The Contractor shall carry out flexure and compression tests at six (6) hours as described below. The cost of these samples and tests will be deemed to be included in the rates.

5.04.8.1.3 Flexure Strength Test. The specimens described above are to be supported at a distance of one hundred (100) millimeters and a single load applied to the center until failure occurs (Test in accordance with DIN 1164). The load is increased at the rate of one (1) km/5 sec.

5.04.8.1.4 Compression Strength Test. Prisms of forty by forty by eighty (40 X 40 X 80) millimeters which have passed the flexure strength test are used to determine the compressive strength. The surface area of the punches shall be forty by forty (40 X 40) millimeters. The loading speed shall be ten (10) km/5 sec.

5.04.8.1.5 Shear Test. Test with lapped metal strips of agreed dimensions. The Contractor shall inform the Engineer in writing in advance the name of the Engineer who will be supervising the mixing and application of the epoxy resin. Containers which are opened or mixes made without the presence of the Engineer will be rejected.

Mixing shall be carried out in a mechanical mixer and shall continue until a uniform color is achieved. A continuous check shall be kept on the temperature of the mix.

Any constituent which has exceeded its shelf life will be rejected.

5.04.8.1.6 Surface Preparation. The interfaces of the units shall be lightly grit blasted before erection to remove laitance. Before applying epoxy the interfaces must be clean and free from laitance or any bond breaking material. Any oil or grease which may be harmful shall be removed. The surface shall have no free moisture.

5.04.8.1.7 Application of Epoxy. Application shall begin immediately as or after a batch has been mixed. Application shall be to both interfaces to a nominal thickness of two (2) millimeters with a spatula or by hand. No epoxy may be applied after the specified pot life. Epoxy is not to be applied within twenty-five (25) millimeters of any duct.

5.04.8.1.8 Preliminary Prestress. Immediately after the interfaces are covered (or coated) with epoxy, the unit shall be brought into position and the preliminary prestress applied. This preliminary prestress is to be just sufficient to start squeezing epoxy resin out of the joint. The amount of prestress required will depend on the formulation of resin chosen by the Contractor. If this operation is not completed within the contract time of the first batch of epoxy to be applied, the units shall be moved apart. All the epoxy on both interfaces shall be removed with spatulas and an approved solvent. No epoxy may be applied to the joint until twenty-four (24) hours after a solvent has been used. The contact time shall be reckoned from the end of the pot life unless the manufacturer's instructions direct otherwise. All excess epoxy shall be cleaned off from the outer faces of the webs and the soffit in such a way as not to smear the concrete face.

5.04.8.1.9 Records of Jointing. The Contractor shall keep a record of each joint with the following details:

- Joint Number
- Date and Time of jointing

- Batch number of resin and hardener
- Weather conditions (temperature and humidity) continuously recorded
- Results of tests

5.04.9 COMPOSITE SLAB CONSTRUCTION. Where in-situ concrete deck is cast to act compositely with pre-cast beams, the beams shall be installed to correct line and level, starting from the outer most beam and working inward progressively. When the beams are laid side-by-side just before erection, the difference in soffit level between beams shall nowhere exceed six (6) millimeters. Where permanent soffit shutter are used, they shall be to the approval of the Engineer and they shall be fixed securely so that there is no movement or grout loss during deck concreting.

The in-situ concrete deck over any one span shall be poured in one continuous operation and shall be placed in such a sequence that the advancing edge of the freshly deposited concrete over the full width of deck or between longitudinal construction joints is approximately parallel to the deck supports. Lateral displacement of beams shall be prevented during the placing of in-situ concrete.

5.04.10 QUALITY ASSURANCE PROCEDURES. Quality assurance procedures used on prestressed concrete structures shall be in accordance with Subsection 5.01.9, "Quality Assurance Procedures" in these General Specifications. Unless otherwise stated in the Special Specifications the lot size will be each unit of precast, pretensioned concrete members. The concrete in cast-in-place prestressed concrete structures shall be sampled and tested in accordance with Subsection 5.01.3, "Concrete Structures," in these General Specifications.

Quality assurance sampling and testing of the prestressing wires, bars and tendons shall be in accordance with Subsection 1.08.2, "Visual Inspection" and Subsection 1.08.3, "Certification of Compliance" of these General Specifications. Quality assurance sampling and testing of prestressed concrete structure construction shall be in accordance with Subsection 1.08.4, "Measured or Tested Conformance" in these General Specifications.

5.04.11 METHOD OF MEASUREMENT. Unsolicited test panels made by the Contractor for his own purposes to determine the suitability of the form, form-liner, mold oil or any other parameter that affects the concrete finish, texture and color shall not be measured for payment.

Satisfactory and accepted test panels ordered by the Engineer shall be measured for payment as indicated in the Bill of Quantities for the appropriate structural element and class of concrete.

Accepted test samples carried out on site and exhibited throughout the duration of the Works shall be measured for payment as indicated in the Bill of Quantities for the appropriate structural element and class of concrete.

Blinding concrete shall not be measured separately, but shall be considered subsidiary to the items listed in the Bill of Quantities.

Prestressing steel shall be measured by the theoretical number of metric tons complete in place as shown on the plans or placed as ordered in writing by the Engineer. No measurement shall be made of unauthorized work as specified in Subsection 1.07.6 - "Unauthorized Work" in these General Specifications. No measurement shall be made of excess tendon lengths required for threading or stressing, of grout or grouting, and of concreting of anchorage pockets. Cable ducts, sheaths, supports, anchorages, couplers, joints, and all testing required in connection with this Work including tensioning or retensioning, shall not be measured separately. All of the items listed as above shall be considered subsidiary to prestressing steel.

Precast or cast-in-place prestressed concrete for bridge superstructure shall be measured by the cubic meter of the several pay items, complete in place and accepted. Measurements shall be based on the dimensions as shown on the plans or as otherwise directed and authorized by the Engineer. No deductions will be made for the volume occupied by ducts, sheaths, drainage system components, or any other embedded item. No measurement will be made of unauthorized areas or for extra thickness as specified in Subsection 1.07.6 - "Unauthorized Work" in these General Specifications. This item shall include the furnishing of all materials, formwork, and the placing, finishing, and curing of the concrete as specified or directed. Reinforcing steel and/or structural steel used in this item of Work shall be measured and will be paid for as specified in other Sections of the Specifications and as specified in the Bill of Quantities.

5.04.12 PAYMENT. All completed and accepted Work will be paid for at the contract unit price(s) for the items in the Bill of Quantities, measured in accordance with Subsection 5.04.11, "Method of Measurement," in these General Specifications.

The amount of completed and accepted Work for prestressing steel, measured as above, will be paid for at the unit price bid per metric ton for prestressing steel appearing in the Bill of Quantities, which price will be considered full compensation for furnishing and placing all materials, for all labor, equipment, tools, supplies and all other items necessary for the proper completion of the Work as specified in Subsection 1.07.2 - "Scope of Payment" in these General Specifications.

The amount of completed and accepted Work for precast or cast-in-place prestressed concrete for bridge superstructures, measured as provided above, will be paid for at the corresponding contract unit price(s) per cubic meter for the several pay items as specified in the Bill of Quantities, which price(s) shall be full compensation for furnishing, quarrying, preparing, transporting, delivering, mixing and placing all materials, including forms and falsework, for all labor, equipment, tools and all other items necessary for the proper completion of the Work as specified in Subsection 1.07.2 - "Scope of Payment" in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO.	PAY ITEM	PAY UNIT
50401	Prestressing Steel	Ton
50402	Precast Prestressed Concrete Structural Members	Cubic Meter
5040201	Precast Prestressed Concrete Structural Members, I-Beam, Standard Type	Cubic Meter
5040202	Precast Prestressed Concrete Structural Member, Slab, Standard Type	Cubic Meter
5040203	Precast Prestressed Concrete Structural Member, Box Beam, Standard Type	Cubic Meter
5040204	Precast Prestressed Concrete Structural Member, ____, Standard Type	Cubic Meter
50403	Cast-in-Place Prestressed Concrete Structural Members	Cubic Meter

SECTION 5.05 - STEEL STRUCTURES AND MISCELLANEOUS METAL WORK

5.05.1 DESCRIPTION. This Work shall include all structural steel and castings used in structures, and all metals, ferrous and nonferrous, except reinforcing bars which are specified in Section 5.02, "Reinforcing Steel" in these General Specifications. Fabrication and construction shall be in accordance with the specifications and in conformity with the lines, grades, dimensions and design shown on the plans or established by the Engineer.

ITEMS IN BILL OF QUANTITIES
Structural Steel, Furnished, Fabricated and Erected
Aluminum Bridge Railing
Steel Bridge Railing

5.05.2 MATERIALS. Except as otherwise called for herein or shown on the plans, the grades and qualities shall conform to the applicable standards of AASHTO and ASTM outlined as follows:

1. Structural Carbon Steel shall conform to AASHTO M 270, Grade 36 F for primary bridge members, structural carbon steel shall conform to AASHTO M 270, Grade 36T. For fracture critical bridge members, structural carbon steel shall conform to AASHTO M270, Grade 36F.

2. Bolts and nuts shall conform to ASTM A307.

3. Structural Steel for Welding and Structural Rivet Steel shall conform to AASHTO M183.

4. High-Strength Low-Alloy Structural Steel (HSLA) shall conform to AASHTO M 270, Grade 50 or Grade 50W. For primary bridge members, HSLA steel shall conform to AASHTO M270, Grade 50T or Grade 50 WT. Fracture critical welded members shall conform to AASHTO M270, Grade 50F or 50WF.

5. High-Strength Quenched and Tempered (QT) Steel. All QT steel shall conform to AASHTO M270, Grade 70W, Grade 100 or Grade 100W. For primary bridge members, QT steel shall conform to AASHTO M270, Grade 70T, Grade 100T, or Grade 100WT. Fracture critical bridge members shall conform to AASHTO M 270, Grade 70WF, Grade 100F or Grade 100WF.

6. Wrought-Iron Plates shall conform to ASTM A 42. Rolled Wrought Iron Shapes and Bars shall conform to ASTM A207.

7. Carbon-Steel Castings shall conform to AASHTO M 102. Unless otherwise specified, Class C1 forgings shall be furnished.

8. Carbon-Steel Castings shall conform to AASHTO M 192. Unless otherwise specified, Class 70 shall be furnished, all as designated on the plans.

9. Gray-Iron Castings shall conform to AASHTO M 105. Unless otherwise specified, Class No. 30B shall be furnished.

10. Malleable Iron Castings shall conform to ASTM A47 or AASHTO M 105. Unless otherwise specified, Grade No. 35018 shall be furnished.

11. Rolled Copper-Alloy Bearing and Expansion Plates shall conform to AASHTO M 108. Unless otherwise specified, Alloy No. 1 shall be furnished.

12. High-Tensile-Strength Bolts, including nuts and washers for structural connections, shall conform to AASHTO Standard Specifications for Highway Bridges and to AASHTO M 164 or AASHTO M 253 as specified.

Bolts shall conform to the requirements for heavy hex structural bolts or heavy hex nuts of the ANSI Standard B18.2.1. The length of the bolts shall be such that the point of the bolt will be flush or outside the face of the nut when completely installed.

Threads of bolts and nuts up through twenty five and four tenths (25.4) mm diameter shall be UNC Series and for over twenty five and four tenths (25.4) mm diameter shall be 8 UN Series as specified in ANSI B1.1, and shall have Class 2A tolerance for bolts and Class 2B tolerance for nuts. Galvanized nuts shall be tapped or chased after galvanizing.

Circular, beveled and clipped hardened washers shall conform to the requirements of ASTM F436. Where shown on the plans or directed by the Engineer, washers may be clipped on one side. The clipped edge shall be not closer than 7/8 of the corresponding bolt diameter from the center of the washer.

ASTM A325 (AASHTO M164) provides for three types of high-strength bolts. Any of these types may be used when the structural steel is to be painted. Unless otherwise shown on the plans or specified hereinafter, Type 1 bolts shall be used. Type 2 bolts shall not be used when hot-dip galvanized bolts are required. Type 3 bolts, nuts and washers shall be used when weathering steel (ASTM A242 or ASTM A588) is used. Bolts or nuts of only one type shall be used for any one structure.

Heavy hex structural bolts manufactured to ASTM A325 are identified on the top of the head by the legend "A325" and the manufacturer's symbol. In addition, Type 1 bolts, at the manufacturer's option, may be marked with three radial lines one hundred twenty (120) degrees apart. Type 2 bolts shall be marked with three radial lines sixty (60) degrees apart. Type 3 bolts shall have the legend "A325" underlined and the manufacturer may add other distinguishing marks indicating that the bolt is of a weathering type.

Bolts manufactured to ASTM A490 (AASHTO M253) are marked with the legend "A 490" and the manufacturer's symbol.

Heavy hex nuts for A325 bolts are identified on at least one face by the manufacturer's mark and the number "2" or "2H", or by three equally spaced circumferential lines, or by the legend "D" or "DH". Heavy hex nuts for A325 Type 3 bolts shall be marked on one face with three circumferential marks and the numeral "3", and with other distinguishing marks the manufacturer may elect to use.

Heavy hex nuts for use on A490 bolts shall be marked with the legend "2H" and the manufacturer's mark or by the legend "DH".

Nuts may be washer-faced or double-chamfered as shown on the plans or as directed.

Washers for A325 Type 3 bolts shall be marked on one face near the outer edge with the numeral "3", or other distinguishing marks indicating that the washer is of a weathering type.

The markings on bearing surfaces of nuts and washers shall be depressed.

13. Steel Pipe for Metal Handrail shall conform to ASTM A 53, Grade A seamless.

14. Pins and Rollers. Fabricate pins and rollers more than two hundred twenty-nine (229) millimeters in diameter from annealed carbon-steel forgings conforming to AASHTO M 102, Class C or cold-finished carbon-steel shafting conforming to AASHTO M 169, Grade 1016 to 1030 inclusive, with a minimum Rockwell Scale B hardness of eighty-five (85). The hardness requirement may be waived if the steel develops a tensile strength of 490 kilograms per square centimeter (483 MPa) and a yield point of 252 kilograms per square centimeter (248 MPa).

Pin threads shall conform to ANSO B1.1 Coarse Thread Series, Class 2A. Thread pin ends with a diameter of thirty-five (35) millimeters or more with six (6) threads to each twenty-five (25) millimeters.

15. Welded Stud Connectors. Shear connector studs shall conform to AASHTO M 169 for standard quality, cold finished, carbon steel bars. Provide the connectors according to all subsections of the AASHTO Standard Specifications for Highway Bridges, Division II, Section 11.3.3, Welded Stud Shear Connectors.

16. Galvanized steel pipe shall conform to ASTM A 53, Type F, standard weight class and plain ends for the designation specified in the contract.

17. Steel Grid Floors. Steel grid floors shall conform to AASHTO M 270, Grade 36 or Grade 50W. AASHTO M 270, Grade 36 steel shall have a minimum copper content of two-tenths percent (0.2%) unless galvanized. Galvanize steel grid floors unless painting is specified.

18. Anchor Bolts. Unless otherwise shown on the plans, plain and threaded bars used for anchorage purposes shall conform to the requirements of ASTM A36. When high-strength anchor bolts are designated on the plans, they shall conform to ASTM A 193-B-7. Nuts for high-strength anchor bolts shall conform to ASTM A194-2H. Threads for anchor bolts and nuts with diameters through to twenty five and four tenths (25.4) mm inclusive, shall be UNC Series, Class 2 fit. Threads for anchor bolts and nuts over twenty five and four tenths (25.4) mm diameter shall be 8 UN Series, Class 2 fit.

19. Structural Steel Tubes shall conform to the physical and chemical requirements of ASTM A500, and shall be of the Grades specified on the plans.

20. Filler Metal for welds, including electrode, flux or combination electrode and shielding medium, shall conform to the requirements of AWS A5.1, A5.5, A5.18, A5.20, and A5.28, as applicable to the types and grades of the connected parts and the welding process, and shall be tested and certified as specified in the AWS Standard Specifications for Welded Highway and Railway Bridges.

The loading, transporting and unloading of structural material shall be so conducted that the metal will be kept clean. Material to be stored shall be placed above ground upon platforms, skids, or other supports, and shall be kept free from dirt, grease, and other foreign material and properly drained and protected from corrosion. Girders and beams shall be placed upright and shored. Long members, such as columns and chords, shall be supported on skids placed near enough together to prevent damage from deflection.

5.05.3 PRELIMINARY REQUIREMENTS.

5.05.3.1 Drawings (Shop Drawings, Erection Drawings and Transportation Drawings).

5.05.3.1.1 General. The Contractor shall submit to the Engineer for approval working drawings in the form of shop drawings, erection drawings and transportation drawings for structural steel. For initial review, six (6) sets of such drawings shall be submitted. After review, between six (6) and twelve (12) sets, as requested by the Engineer, shall be submitted for final approval and for use during construction.

The working drawings shall show any changes proposed in the Work, details for connections not dimensioned on the plans, the direction of rolling of plates where specific orientation is required, the sequence of shop and field assembly and erection, welding sequences and procedures, the location of all butt welded splices on a layout drawing of the entire structure, the location of any temporary supports that are to be used, and the vertical alignment of the girder at each stage of the erection. Substantiating camber calculations and diagrams shall be submitted with the working drawings.

Working drawings shall be submitted sufficiently in advance of the start of the affected Work to allow time for review by the Engineer and correction by the Contractor of the drawings without delaying the Work. Such time shall be proportional to the complexity of the Work, but in no case shall such time be less than six (6) weeks.

Any material ordered by the Contractor and the fabrication of any material, prior to final approval of the drawings by the Engineer, shall be at the Contractor's risk.

5.05.3.1.2 Shop Drawings. The Contractor shall prepare and submit shop drawings which show full detailed dimensions and sizes of component parts of the structure and details of all miscellaneous parts (such as pins, nuts, bolts, drains, weld symbols, etc.) on shop drawings for steel structures.

Where specific orientation of plates is required, show the direction of rolling of plates. Cut flanges and webs of plate girders from plates so the long dimension of the girder parallels the rolling direction.

The Contractor shall identify on the shop drawings the type and grade of each piece that is to be made of steel and other than AASHTO M 270 Grade 36 steel.

The Contractor shall also show on the shop drawings assembly marks that are cross-referenced to the original pieces of mill steel and their certified mill test reports.

The location of all shop welded splices shown on the shop drawings are subject to approval. Locate all shop welded splices to avoid points of maximum tensile or fatigue stress. Locate splices in webs at least three hundred (300) millimeters from shop splices, butt joints in flanges, or stiffeners. Additional nondestructive tests may be required on shop welded splices.

5.05.3.1.3 Erection Drawings. The Contractor shall submit drawings fully illustrating the proposed method of erection. Show details of all falsework bents, bracings, guys, dead-men, lifting devices, and attachments to the bridge members. Show the sequence of erection, location of cranes and barges, crane capacities, location of lifting points, and weights of bridge members. Show complete details for all anticipated phases and conditions of erection. Calculations may be required to demonstrate that allowable stresses are not exceeded and that member capacities and final geometry will be correct.

5.05.3.1.4 Camber Diagram. The Contractor shall furnish a camber diagram that shows the camber at each panel point of trusses or arch ribs and at the location of field splices and fractions of span length (1/4 points minimum) of continuous beams and girders or rigid frames. On the camber diagram, show calculated cambers to be used in preassembly of the structure.

5.05.3.1.5 Transportation Drawings. If required, the Contractor shall furnish transportation drawings for approval.

The transportation drawings shall show all support points, tie-downs, temporary stiffening trusses or beams, and any other details needed to support and brace the member. Provide calculation sheets showing the dead load plus impact stresses induced by the loading and transportation procedure. Use impact stresses of at least two hundred percent (200%) of the dead load stress. Use a total load, including impact, of not less than three hundred percent (300%) of the dead load.

The Contractor shall ship and store all members, both straight and curved, with their webs vertical.

The approval of the drawings will cover the requirements for strength and detail only in general, and such approval will not relieve the Contractor of any responsibility for the correctness of the drawings or for errors in fabrication or field connections.

No changes shall be made on approved drawings without the written consent of the

Engineer.

5.05.3.2 **Inspection.** Structural steel shall be inspected at the fabrication site by an experienced, independent inspection firm engaged by the Contractor and approved by the Engineer. The Contractor shall furnish the qualifications of the inspection firm to the Engineer for approval along with a copy of the Contractor's agreement (contract) with that firm. At the conclusion of fabrication, the Contractor shall submit to the Engineer a report summarizing in detail all inspection activities of the approved firm during fabrication and a certified summary of payments made to the firm for the services performed.

The Contractor shall furnish to the Engineer a copy of all mill orders, certified mill test reports, and a Certificate of Compliance for all structural steel to be used in the Work. Copies of mill orders shall be furnished at the time orders are placed with the manufacturer. The Certificate of Compliance shall be submitted in accordance with the provisions in Subsection 1.08.3, "Certification of Compliance" in these General Specifications.

The inspection firm shall have free access at all times to any portion of the fabrication site where said material is stored or where Work on said material is being performed.

Inspection at the shop is intended as a means of facilitating the Work and avoiding errors, and it is expressly understood that it will not relieve the Contractor from any responsibility in regard to defective material or workmanship and the necessity of replacing defective material or doing the Work again.

The Engineer shall have the authority to reject materials or workmanship which do not comply with the requirements of the plans or the specifications.

The acceptance of any material or finished member by the Engineer shall not bar subsequent rejection if found defective. Rejected materials shall be replaced promptly and rejected workmanship shall be made good, all at no expense to the Ministry.

5.05.4 FABRICATION.

5.05.4.1 **Quality of Workmanship.** Workmanship and finish shall be equal to the best general practice in modern structural steel fabrication shops.

5.05.4.2 **Identification of Steels.** Use a system of assembly-marking individual pieces and cutting instructions to the shop (generally by cross referencing of the assembly-marks shown on the shop drawings with the corresponding item covered on the mill purchase order) that maintains the identity of the original piece.

Material may be furnished from stock which can be identified by heat number and mill test report.

During fabrication, up to the point of assembling members, show clearly and legibly the specification of each piece of steel (other than Grade 36 steel) by writing the material specification on the piece or using the identification color code shown in Table 5.05-1.

TABLE 5.05-1
IDENTIFICATION COLOR CODES

Grade	Color
50	Green and Yellow
50W	Blue and Yellow
70W	Blue and Orange
100	Red
100W	Red and Orange

For other steels (except Grade 36 steel) not shown in Table 5.05-2 or included in AASHTO M160, provide information on the color code used.

Mark for grade by steel die stamping, or by a substantial firmly attached tag, pieces of steel (other than Grade 36 steel) that before assembling into members will be subject to fabricating operations (such as blast cleaning, galvanizing, heating for forming or painting) which obliterate paint color code marking. Where the steel stamping method is used, place the impressions on the thicker tension-joint member in transition joints.

The maximum allowed depth of the impression is three-tenths (0.3) millimeters. Use a tool that will make character sizes with corresponding face radii as shown in Table 5.05-2. Avoid impressions near edges of tensile-stressed plate members.

TABLE 5.05-2
SIZE OF STEEL DIE STAMP MARKINGS

Character Size (mm)	Minimum Face Radii (mm)
3 mm	0.1 mm
5 mm	0.2 mm
6 mm	0.3 mm

Use low-stress type steel die stamps. Do not use die stamps on fracture-critical members. If requested, furnish an affidavit certifying that throughout the fabrication operation the identification of steel has been maintained.

Heat curving of steel girders is not allowed.

5.05.4.3 Plates and Plate Cut Edges.

5.05.4.3.1 Direction of Rolling. Unless otherwise shown on the drawings, cut and fabricate steel plates for main members and splice plates for flanges and main tension members, not secondary members, so that the primary direction of rolling is parallel to the direction of the principal tensile and/or compressive stresses.

5.05.4.3.2 Edge Planing. Remove sheared edges on plates thicker than sixteen (16) millimeters to a depth of six (6) millimeters beyond the original sheared edge, or beyond any re-entrant cut produced by shearing. Fillet re-entrant cuts before cutting.

1. Oxygen Cutting. Oxygen cut structural steel according to ANSI/AASHTO/AWS Bridge Welding Code D1.5.

2. Visual Inspection and Repair of Plate Cut Edges. Visually inspect and repair plate cut edges. The cut edges shall conform to ANSO/AASHTO/AWS Bridge Welding Code D1.5.

5.05.4.3.3 Flange Plates. Furnish flange plates with either oxygen cut edges that have the corners chamfered at least two (2) millimeters by grinding or furnish Universal Mill plates unless oxygen cut edges are required.

5.05.4.3.4 Web Plates. Oxygen cut to the prescribed camber web plates of built-up beams and girders, box girders and box arches. Cut sufficient extra camber into the webs to provide for all camber losses due to welding, cutting, etc.

5.05.4.3.5 Truss Members. Prepare, by oxygen cutting, all longitudinal edges for all plates in welded sections of truss web and chord members. Chamfer, by grinding the edges of the corners of plates not joined by welding, at least two (2) millimeters.

5.05.4.3.6 Stiffeners and Connection Plates. Stiffeners and connection plates welded transverse to girder webs and flanges may be furnished with sheared edges provided the plate thickness does not exceed nineteen (19) millimeters. Universal mill plate may be used provided its thickness does not exceed twenty-five (25) millimeters. Furnish other stiffeners and connection plates with oxygen cut edges.

5.05.4.3.7 Lateral Gusset Plates. Oxygen cut, parallel to lines of stress, gusset plates and other connections welded parallel to lines of stress in tension members where the plate thickness exceeds ten (10) millimeters. Bolted lateral gusset plates may be furnished with sheared edges provided the thickness is equal or less than nineteen (19) millimeters.

5.05.4.3.8 Splice Plates and Gusset Plates. Furnish girder and stringer splice plates and truss gusset plates with oxygen cut edges.

5.05.4.4 Bent Plates. The Contractor shall furnish unwelded, load-carrying, rolled-steel plates to be bent as follows:

Take material from the stock plates such that the bent line will be at right angles to the direction of rolling, except that cold-bent ribs for orthotropic-deck bridges may be bent with bend lines in the direction of rolling.

Before bending, round the corners of the plates to a radius of two (2) millimeters throughout the portion of the plate where the bending occurs.

5.05.4.4.1 Cold Bending. Cold bend so that no cracking of the plate occurs. Use the minimum bend radii shown in Table 5.05-3 measured to the concave face of the metal.

TABLE 5.05-3
MINIMUM BENDING RADII

Plate Thickness - (t) (mm)	Bending Radius
$\leq$ 13	2 (t)
13 to 25	2.5 (t)
25 to 38	3 (t)
38 to 64	3.5 (t)
64 to 102	4 (t)

Allow for springback of Grades 100 and 100W steels equal to about three times that for Grade 36 steel.

5.05.4.4.2 Hot Bending. If a radius shorter than the minimum specified for cold bending is essential, hot bend the plates at a temperature not greater than six hundred forty nine degrees Celsius (649° C), except for Grades 100 and 100W. When Grades 100 and 100W steel plates are heated to temperatures greater than six hundred seven degrees celsius (607° C), requench and temper according to the producing mill's standard practice.

5.05.4.4.3 Fit of Stiffeners. Fabricate (mill, grind, or weld as shown on the plans or as specified) end bearing stiffeners for girders and stiffeners intended as supports for concentrated loads to provide full bearing on the flanges to which they transmit load or from which they receive load. Fabricate intermediate stiffeners not intended to support concentrated loads to provide a tight fit against the compression flange.

5.05.4.4.4 Abutting Joints. Mill or saw-cut abutting joints in compressive members of trusses and columns to give a square joint and uniform bearing. The maximum allowed opening at other joints, not required to be faced, is ten (10) millimeters.

5.05.4.4.5 Facing of Bearing Surfaces. Finish bearing and base plates and other bearing surfaces that will come into contact with each other or with concrete to the ANSI surface roughness defined in ANSI B46.1, "Surface Roughness, Waviness and Lay, Part 1," as shown in Table 5.05-4.

TABLE 5.05-4
ANSI SURFACE ROUGHNESS VALUES

Bearing Surface	Surface Roughness Value (mm)
Steel slabs	50
Heavy plates in contact in shoes to be welded	25
Milled ends of compression members, milled or ground ends of stiffeners and fillers	13
Bridge rollers and rockers	6
Pins and pin holes	3
Sliding bearings	3

Machine sliding bearings that have a surface roughness greater than ANSI of two (2) (mm) so the lay of the cut is parallel to the direction of movement.

Fabricate parts in bearing to provide a uniform even contact with the adjacent bearing surface when assembled. Limit the maximum gap between bearing surfaces (1 mm). Base and sole plates that are plane and true and have a surface roughness not exceeding the above tabulated values need not to be machined, except machine sliding surfaces of base plates.

Do not machine surfaces of fabricated members until all fabrication on that particular assembly or subassembly is complete. Machine metal components that are to be heat treated after heat treatment.

5.05.4.4.6 Straightening Material. If approved, straighten plates, angles, other shapes and built-up members by methods that will not produce fracture or other damage to the metal. Straighten distorted members by mechanical means, or, if approved, by carefully planned procedures and supervised application of a limited amount of localized heat. Use rigidly controlled procedures and do not exceed the temperatures specified in Table 5.05-5 when heat straightening Grades 70W, 100 and 100W steel members.

TABLE 5.05-5
HEAT STRAIGHTENING TEMPERATURES

Material to be Straightened	Maximum Temperature
Grade 70W > 150 mm from weld	580 degrees C
Grade 70W < 150 mm from weld	480 degrees C
Grade 100 or 100W > 150 mm from weld	610 degrees C
Grade 100 or 100W < 150 mm from weld	510 degrees C

Keep parts to be heat straightened substantially free of external forces and stress, except stresses resulting from mechanical means used in conjunction with the application of heat.

Evidence of fracture following straightening of a bend or buckle will be cause for rejection of the damaged piece.

5.05.4.5 Annealing and Stress Relieving. Machine, finish bore, and straighten annealed or normalized structural members subsequent to heat treatment. Normalize and anneal (full annealing) according to ASTM E 44. Maintain uniform temperatures throughout the furnace during the heating and cooling so that the temperature at no two points on the member will differ by more than fifty-six degrees Celsius (56°C.) at any one time.

Do not anneal or normalize members of Grades 100/100W or Grade 70W steels. Stress relieve these grades only with approval.

Record each furnace charge, identify the pieces in the charge and show the temperatures and schedule actually used. Provide proper instruments, including recording pyrometers, for determining at any time the temperature of members in the furnace. Make records of the treatment operation available for approval. The maximum allowed holding temperature for stress relieving Grades 100/100W and Grade 70W steels is six hundred ten degrees Celsius (610°C.) five hundred eighty degrees Celsius (580°C.), respectively. Stress relieve members (such as bridge shoes, pedestals, or other parts that are built up by welding sections of plate together) according to Subsection 4.4 of ANSI/AASHTO/AWS Bridge Welding Code D1.5.

5.05.4.6 Bolt Holes. Punch or drill all bolt holes. Material forming the parts of a member that is composed of not more than five (5) thicknesses of metal may be punched two (2) millimeters larger than the nominal diameter of the bolts where the thickness of the material is not greater than nineteen (19) millimeters for structural steel, for high-strength steel sixteen (16) millimeters, or thirteen (13) millimeters for quenched and tempered alloy steel, unless subpunching and reaming is required under eight (8), the preparation of field connections.

Where there are more than five (5) thicknesses or where any of the main material is thicker than nineteen (19) millimeters for structural steel, sixteen (16) millimeters for high-strength steel, or thirteen (13) millimeters for quenched and tempered alloy steel, either subdrill and ream or drill all holes full size.

If required, either subpunch or subdrill (subdrill if thickness limitation governs) five (5) millimeters smaller and, after assembling, ream two (2) millimeters larger or drill full size to two (2) millimeters larger than nominal diameter of the bolts. Bolt holes shall be fabricated in accordance with the following procedures:

1. Punched Holes. Use a die diameter that is not more than two (2) millimeters larger than the punch diameter. Ream holes that require enlarging to admit bolts. Clean cut the holes without torn or ragged edges.

2. Reamed or Drilled Holes. Ream or drill holes so they are cylindrical and perpendicular to the member. Where practical, direct reamers by mechanical means. Remove burrs on the outside surfaces. Ream and drill with twist drills, twist reamers, or roto-broach cutters. Assemble and securely hold together connecting parts that are being reamed or drilled and match-mark before disassembling.

3. Accuracy of Holes. Holes not more than one (1) millimeter larger in diameter than the true decimal equivalent of the nominal diameter of the drill or reamer are acceptable. The slightly conical hole resulting from punching operations is acceptable. The width of slotted holes produced by flame cutting or a combination of drilling or punching and flame cutting shall be no more than one (1) millimeter greater than the nominal width. Grind flame cut surfaces smooth.

4. Accuracy of Hole Group Before Reaming. Accurately punch full size, subpunched, or subdrilled holes so that after assembling (before any reaming is done) a cylindrical pin three (3) millimeters smaller in diameter than the nominal size of the punched hole may be entered perpendicular to the face of the member, without drilling, in at least seventy-five percent (75%) of the contiguous holes in the same plane. Punched pieces not meeting this requirement will be rejected. Holes, through which a pin five (5) millimeters smaller in diameter than the nominal size of the punched hole cannot be inserted, will be rejected.

5. Accuracy of Hole Group After Reaming. After reaming, the maximum allowed offset of eighty-five percent (85%) of any contiguous group of holes through adjacent thickness of metal is one (1) millimeter.

Use steel templates having hardened steel bushings in holes accurately dimensioned from the centerlines of the connection as inscribed on the template. Use connection centerlines when locating templates from the milled or scribed ends of members.

6. Numerically-Controlled Drilled Field Connections. In lieu of drilling undersized holes and reaming while assembled, or drilling holes full-size while assembled, drilling or punching bolt holes full-size in unassembled pieces and/or connections, including templates for use with matching undersized and reamed holes by means of suitable

numerically-controlled (N/C) drilling or punching equipment is allowed.

7. Holes for Ribbed Bolts, Turned Bolts or Other Approved Bearing-Type Bolts. Provide finished holes with a driving fit.

8. Preparation of Field Connections. Subpunch or subdrill and ream while assembled, or drill full size to a steel template, holes in all field connections, and field splices of main members of trusses, arches, continuous beam spans, bents, towers (each face), plate girders, and rigid frames.

Holes for field splices of rolled beam stringers continuous over floor beams or cross frames may be drilled full-size unassembled to a steel template. Holes for floor beams or cross frames may be drilled full size unassembled to a steel template. Subpunch and ream while assembled, or drill full size to a steel template, all holes for floor beam and stringer field end connections.

When reaming or drilling full size field connection holes through a steel template, carefully locate and position the template and firmly bolt in place before drilling. Use exact duplicates of templates used for reaming matching members, or the opposite faces of a single member. Accurately locate templates used for connections on like parts or members so that the parts of members are duplicates and require no match-marking.

For any connection, in lieu of subpunching and reaming or subdrilling and reaming, holes drilled full-size through all thicknesses or material assembled in proper position may be used.

5.05.4.7 Pins and Rollers. Accurately fabricate pins and rollers that are straight, smooth and free from flaws. Forge and anneal pins and rollers more than two hundred thirty (230) millimeters in diameter. Pins and rollers two hundred thirty (230) millimeters or less in diameter may be either forged and annealed or cold-finished carbon-steel shafting.

In pins larger than two hundred thirty (230) millimeters in diameter, bore a hole not less than fifty (50) millimeters in diameter full length along the pin axis after the forging has been allowed to cool to a temperature below the critical range (under suitable conditions to prevent damage by too rapid cooling and before being annealed).

5.05.4.7.1 Boring Pin Holes. Bore pin holes true to the specified diameter smooth and straight, at right angles with the axis of the member and parallel to each other. Produce the final surface using a finishing cut.

Produce a pin hole diameter that does not exceed that of the pin by more than one-half (0.50) millimeter for pins one hundred twenty-seven (127) millimeters or less in diameter, or by more than one (1) millimeter for larger pins.

The maximum allowed variation of the outside-to-outside distance of end holes in tension members and the inside-to-inside distance of end holes in compression members is one (1) millimeter from that specified. Bore pin holes in built-up members after the member has been assembled.

5.05.4.7.2 Threads for Bolts and Pins. Provide threads on all bolts and pins for structural steel construction that conform to the Unified Standard Series UNC ANSI B1.1, Class 2A external threads and Class 2B for internal threads, except when pin ends have a diameter of thirty-five (35) millimeters or more, provide six threads to the twenty-five (25) millimeters.

5.05.4.8 Eyebars. Pin holes may be flame cut at least fifty (50) millimeters smaller in diameter than the finished pin diameter. Securely fasten together (in the order to be placed on the pin hole) eyebars that are to be placed side by side in the structure and bore at both ends while clamped. Pack and match-mark eyebars for shipment and erection. Stamp with steel stencils, so as to be visible when the bars are nested in place on the structure, all identifying marks on the edge of one head of each member after fabrication is completed. Use low-stress type steel die stamps.

Provide eyebars, straight and free from twists, with pin holes accurately located on the centerline of the bar. Do not allow the inclination of any bar to the plane of the truss to exceed two and six-tenths (2.6) millimeters per meter.

Simultaneously cut the edges of eyebars that lie between the transverse centerline of their pin holes with two mechanically operated torches abreast of each other, guided by a substantial template to prevent distortion of the plates.

5.05.4.9 Assembly-Bolting. Clean surfaces of metal in contact before assembling. Assemble parts of a member. Securely pin and firmly draw together before drilling, reaming, or bolting is commenced. Take assembled parts apart, if necessary, for the removal of burrs and shavings produced by the operation. Assemble members to be free from twists, bends and other deformation.

Drift during assembling only enough to bring the parts into position without enlarging holes or distorting the metal.

5.05.5 CONNECTIONS.

5.05.5.1 Welded Connections. Fabricate surfaces and edges to be welded smooth, uniform, clean and free of defects that would adversely affect the quality of the weld. Prepare edge according to ANSI/AASHTO/AWS Bridge Welding Code D1.5.

5.05.5.2 Preassembly of Field Connections. Preassemble field connections of main members of trusses, arches, continuous beams, plate girders, bents, towers, and rigid frames before erection to verify the geometry of the completed structure or unit and to verify or prepare field splices. Present the method and details of preassembly for approval.

Use methods and details of preassembly that are consistent with the procedure shown on the approved erection camber diagram. Assemble all girders and beams in their cambered (no load) condition.

When members are assembled with their webs vertical, support them at intervals of six (6) meters or two-tenths (0.2) of the span length, whichever is less. When the webs are horizontal, the above intervals of support may be increased provided there is no noticeable deflection between points of support.

Assemble trusses in full dead load position unless the design of the structure provides for the secondary stresses created by assembling the truss in the fully cambered (no load) position. Support trusses during assembly at each panel point. Preassemble at least three (3) contiguous panels that are accurately adjusted for line and camber. For successive assemblies include at least one section or panel of the previous assembly (repositioned if necessary and adequately pinned to assure accurate alignment) plus two (2) or more sections or panels added at the advancing end. For structures longer than forty-six (46) meters, make each assembly not less than forty-six (46) meters long regardless of the length of individual continuous panels or sections. Assembly may start from any location in the structure and proceed in one or both directions as long as preceding requirements are satisfied and the following assembly procedures are followed:

1. Bolted Connections. Where applicable, assemble major components with milled ends of compression members in full bearing and then ream subsized holes to the specified size while the connections are assembled.

2. Check Assembly/Numerically-Controlled Drilling. When using numerically-controlled drilling or punching, make a check assembly for each major structural type of each project. Fabricate the check assembly of at least three (3) contiguous shop sections or, for a truss, all members in at least three (3) contiguous chord lengths (such as the length between field splices). Base check assemblies on the proposed order of erection, joints in bearings, special complex points, and similar considerations. Shop assemblies other than the check assemblies are not required.

If the check assembly fails in some specific manner to demonstrate that the required accuracy is being obtained, further check assemblies may be required.

Receive approval of each assembly (including camber, alignment, accuracy of holes, and fit of milled joints) before reaming is commenced or before any N/C drilled check assembly is dismantled.

3. Field Welded Connections. Field welded connections are prohibited unless specifically shown on the drawings. Verify the fit of members (including the proper space between abutting flanges) with the segment preassembled.

4. Match Marking. Match mark connecting parts preassembled in the shop to assure proper fit in the field. Provide a diagram showing such match marks.

5.05.5.3 Connections Using Unfinished, Turned or Ribbed Bolts. Use unfinished, turned or ribbed bolts, where specified, conforming to ASTM A 307 for Grade A Bolts. Use bolts with single self-locking nuts or double nuts. Use beveled washers where bearing faces have a slope of more than 1:20 with respect to a plane normal to the bolt axis.

Furnish turned bolts with a body surface ANSI roughness not exceeding three (3) mm. Furnish hex headed bolts and nuts of the nominal size specified. Carefully ream holes for turned bolts and furnish bolts to provide a light driving fit. Keep bolt threads entirely outside of the holes. Provide a washer under the nut.

Use approved form of ribbed body with continuous longitudinal ribs. Provide a body diameter measured on a circle through the points of the ribs two (2) mm greater than the nominal diameter specified for the bolts.

Furnish ribbed bolts with round heads conforming to ANSI B18.5. Furnish hexagonal nuts that are either recessed or have a washer of suitable thickness. Ribbed bolts shall have a driving fit when installed in holes. Provide sufficiently hard ribs such that the ribs do not compress or deform and allow the bolts to turn in the holes during tightening. If the bolt twists before drawing tight, ream the hole and provide an oversized replacement bolt.

5.05.5.4 Connections Using High-Strength Bolts. This subsection covers the assembly of structural joints using AASHTO M 164 or AASHTO M 253 high-strength bolts or equivalent fasteners, tightened to a high tension.

5.05.5.4.1 Bolted Parts. Use steel material within the grip of the bolt with no compressible material such as gaskets or insulation. Fabricate bolted steel parts to fit solidly together after the bolts are tightened. Limit the maximum slope of the surfaces of parts in contact with the bolt head or nut to 1:20 with respect to a plane normal to the bolt axis.

5.05.5.4.2 Surface Conditions. At the time of assembly clean all joint surfaces (including surfaces adjacent to the bolt head and nut) of dirt or foreign material and scale, except tight mill scale. Remove burrs that would prevent solid seating of the connected parts in the snug-tight condition.

Paint or other coatings are not permitted on the faying surfaces of slip-critical connections. All connections are considered to be slip-critical. Exclude paint (including any inadvertent overspray) from areas closer than one bolt diameter, but not less than twenty-five (25) millimeters from the edge of any hole and all areas within the bolt pattern.

5.05.5.4.3 Installation. Install fasteners of the same lot number together. Protect fasteners from dirt and moisture. Take from protected storage only as many fasteners as are anticipated to be installed and tightened during a work shift. Return to protected storage fasteners not used at the end of the shift. Do not clean lubricant from fasteners that is required to be present in the as-delivered condition. Clean and re-lubricate, before installation fasteners for slip-critical connections which accumulate rust or dirt.

Provide a tension measuring device (a Skidmore-Wilhelm calibrator or other acceptable bolt tension indicating device) at all job sites where high-strength fasteners are being installed and tightened. Use the tension measuring device to perform the rotational-capacity test and to confirm:

- the requirements of Table 5.05-7 of the complete fastener assembly
- the calibration of the wrenches, if applicable, and
- the understanding and proper use of the tightening method.

For short grip bolts, direct tension indicators (DTI) with solid plates may be used to perform this test. First check the DTI with a longer grip bolt in the Skidmore-Wilhelm calibrator. The frequency of confirmation testing, number of tests to be performed, and test procedures shall conform to (3) through (6) as applicable. Confirm the accuracy of the tension measuring device by an approved testing agency at least annually.

Install fasteners together with washers of size and quality specified, located as required below, in properly aligned holes and tightened by any of the methods described in (3) to (6) inclusive to at least the minimum tension specified in Table 5.05-7 after all the fasteners are tight.

If approved, tightening may be performed by turning the bolt while the nut is prevented from rotating when it is impractical to turn the nut. If impact wrenches are used, provide adequate capacity and sufficient air to tighten each bolt in approximately ten (10) seconds.

Do not re-use AASHTO M 253 fasteners and galvanized AASHTO M 164 fasteners. If approved, other AASHTO M 164 bolts may be re-used once. Touching up or re-tightening previously tightened bolts that may have been loosened by the tightening of adjacent bolts will not be considered as re-use, provided the snugging up continues from the initial position and does not require greater rotation, including the tolerance than that required by Table 5.05-6.

1. Rotational-Capacity Tests. Subject high-strength fasteners, black and galvanized, to job-site rotational capacity tests performed according to AASHTO M 164, Subsection 8.5, and the following:

(1) After tightening to a snug-tight condition, as defined in (3), tighten the fastener two (2) times the required number of turns indicated in Table 5.05-6, in a Skidmore-Wilhelm Calibrator or equivalent tension measuring device, without stripping or failure.

(2) During this test, the maximum recorded tension must be equal to or greater than the turn test tension which is one and fifteen hundreths (1.15) times the required fastener tension indicated in Table 5.05-7.

(3) The measured torque at a tension "P", after exceeding the turn test tension required above in (2), shall not exceed the value obtained by the following equation:

Torque = 0.25 PD
where:
Torque = Measured torque in ft.lbs. (N.m)
P = Measured bolt tension in pounds (N)
D = Nominal bolt diameter in feet (m)

For rotational capacity tests, use washers even though their use may not be required in

the actual installation.

2. Washers. Where the outer face of the bolted parts has a slope greater than 1:20 with respect to a plane normal to the bolt axis, use a hardened beveled washer to compensate for the lack of parallelism.

Use hardened square or rectangular beveled washers for American Standard Beams and Channels conforming to AASHTO M 293.

Where necessary, washers may be clipped on one side not closer than seven-eighths (7/8) of the bolt diameter from the center of the washer.

Hardened washers will not be required for connections using AASHTO M 164 and AASHTO M 253 bolts except under the following conditions:

(1) Use hardened washers under the element turned in tightening when the tightening is done by the calibrated wrench method.

(2) Use hardened washers under both the head and the nut when AASHTO M 253 bolts are installed in material having a specified yield point less than 276 MPa regardless of the tightening method.

(3) Use a hardened washer conforming to ASTM F 436 where AASHTO M 164 bolts of any diameter or AASHTO M 253 bolts equal to or less than twenty-five (25) millimeters in diameter are to be installed in oversize or short-slotted holes in an outer ply.

(4) Use hardened washers conforming to ASTM F 436, except with eight (8) millimeters minimum thickness, under both the head and the nut in lieu of standard thickness hardened washers where AASHTO M 253 bolts over twenty-five (25) millimeters in diameter are to be installed in an oversize or short-slotted hole in an outer ply. Multiple hardened washers with combined thickness equal to or greater than eight (8) millimeters do not satisfy this requirement.

(5) Where AASHTO M 164 bolts of any diameter or AASHTO M 253 bolts equal to or less than twenty-five (25) millimeters in diameter are installed in a long-slotted hole in an outer ply, provide a plate washer or continuous bar of at least 8 mm thickness with standard holes with sufficient size to cover the slot after installation and is structural grade material that need not be hardened.

When AASHTO M 253 bolts over twenty-five (25) millimeters in diameter are used in long-slotted holes in external plies, use a single hardened washer conforming to ASTM F 436 with eight (8) millimeters minimum thickness in lieu of washers or bars of structural grade material. Multiple hardened washers with combined thickness equal to or greater than eight (8) millimeters do not satisfy this requirement.

3. Turn of Nut Tightening. At the start of work, test nut tightening using a device capable of indicating bolt tension a sample of not less than three (3) bolt-and-nut assemblies of each diameter, length and grade to be used in the work. Demonstrate with

the test that the method for estimating the snug-tight condition and controlling the turns from snug tight to be used develops a tension not less than five percent (5%) greater than the tension required by Table 5.05-7. Perform periodic re-testing when required.

Install bolts in all holes of the connection and initially tighten to a snug-tight condition. Snug tight is defined as the tightness that exists when the plies of the joint are in firm contact. This may be attained by a few impacts of an impact wrench or the full effort of a worker using an ordinary-spud wrench.

Systematically snug-tighten bolt groups from the most rigid part of the connection to the free edges. Then re-tighten the bolts of the connection in a similar systematic manner as necessary until all bolts are snug tight and the connection is fully compacted. Following the snug-tightening operation, tighten all bolts in the connection by the applicable amount of rotation specified in Table 5.05-6.

During all tightening operations, do not allow rotation of the fastener part not turned by the wrench. Tighten systematically from the most rigid part of the joint to its free edges.

4. Calibrated Wrench Tightening. Calibrated wrench tightening may be used only when installation procedures are calibrated on a daily basis and when a hardened washer is used under the element turned in tightening. Standard torques taken from tables or from formulas that assume to relate torque to tension are not acceptable.

If calibrated wrenches are used for installation, set them to provide a tension not less than five percent (5%) in excess of the minimum tension specified in Table 5.05-7. Calibrate the installation procedure at least once each working day for each bolt diameter, length, and grade using fastener assemblies that are being installed in the work.

Perform the calibration with a device capable of indicating actual bolt tension by tightening three (3) typical bolts of each diameter, length, and grade from the bolts and washers being installed using a job-supplied washer under the element turned in tightening. Re-calibrate wrenches when significant difference is noted in the surface condition of the bolts, threads, nuts or washers. Verify during use that the wrench adjustment selected by the calibration does not produce a nut or bolt head rotation from snug tight greater than permitted in Table 5.05-6. Turn nuts in the tightening direction when measuring the torque of manual torque wrenches.

If calibrated wrenches are used to install bolts in a connection, install bolts with hardened washers under the turned element. When tightening bolts in all holes of the connection, tighten to a snug-tight condition. Following this initial tightening operation, tighten all bolts in the connection using a calibrated wrench. Tighten systematically from the most rigid part of the joint to its free edges. "Touch up" previously tightened bolts that may have been relaxed during the subsequent tightening of adjacent bolts until all bolts are properly tightened.

5. Installation of Alternate Design Bolts. When fasteners that incorporate a design feature intended to indirectly indicate the bolt tension or to automatically provide the tension required by Table 5.05-7 are to be installed, test a representative sample of not

less than three (3) bolts of each diameter, length and grade at the job site with a device capable of indicating bolt tension.

Include in the test assembly flat-hardened washers, if required in the actual connection, arranged as in the actual connections to be tensioned. The calibration test must demonstrate that each bolt develops a tension not less than five percent (5%) greater than the tension required by Table 5.05-7. Follow manufacturer's installation procedure. Perform periodic re-testing when required.

When alternate design fasteners that are intended to control or indicate bolt tension of the fasteners are used, install bolts in all holes of the connection and initially tighten sufficiently to bring all plies of the joint into firm contact, but without yielding or fracturing the control or indicator element of the fasteners. Continue to tighten systematically from the most rigid part of the connection to the free edges in a manner that will minimize relaxation of previously tightened fasteners.

Proper tensioning of the bolts may require more than a single cycle of systematic partial tightening before final twist-off of the control or indicator element of individual fasteners.

6. Direct Tension Indicator Tightening. When tightening of bolts using direct tension indicator devices is used, assemble a representative sample of not less than three (3) devices for each diameter and grade of fastener to be used in the work in a calibration device capable of indicating bolt tension. Include in the test assembly flat-hardened washers, if required in the actual connection, arranged as those in the actual connections to be tensioned. The calibration test must demonstrate that the device indicates a tension not less than five percent (5%) greater than that required by Table 5.05-7.

Follow the manufacturer's installation procedures for installation of bolts in the calibration device and in all connections. Give special attention to proper installation of flat-hardened washers when direct tension indicator devices are used with bolts installed in oversize or slotted holes and where the load indicating devices are used under the turned element.

When bolts are installed using direct tension indicators conforming to ASTM F 959, install bolts in all holes of the connection and bring to a snug-tight condition. Snug tight is indicated by partial compression of the direct tension indicator protrusions. Then tighten all fasteners systematically from the most rigid part of the connection to the free edges in a manner that will minimize relaxation of previously tightened fasteners. Proper tensioning of the bolts may require more than a single cycle of systematic partial tighten before final tightening to deform the protrusion to the specified gap.

7. Lock-Pin and Collar Fasteners. Install lock-pin and collar fasteners using approved methods and procedures.

8. Inspection. Inspect, in the presence of the Engineer, the tightened bolts using an inspection torque wrench.

Individually place three (3) bolts of the same grade, size, and condition as those under inspection in a device calibrated to measure bolt tension. Perform this calibration operation at least once each inspection day.

Use a washer under the part turned in tighten each bolt if washers are used on the structure. If washers are not used on the structure, use the same specification material which abuts the part turned in the tension measuring device as used on the structure. In the calibrated device, tighten each bolt by any convenient means to the specified tension. Apply the inspecting wrench to the tightened bolt to determine the torque required to turn the nut or head five (5) degrees (0.09 rad) approximately twenty-five (25) millimeters at a three hundred (300) millimeter radius, in the tightening direction. Use the average of the torque required for all three (3) bolts as the job-inspection torque.

Select at random in each connection ten percent (10%) (at least two) of the tightened bolts on the structure represented by the test bolts and apply the job-inspection torque to each selected bolt with the inspecting wrench turned in the tightening direction. If this torque turns no bolt head or nut, the bolts in the connection will be considered to be properly tightened. If the torque turns one or more bolts heads or nuts, apply the job-inspection torque to all bolts in the connection. Tighten and reinspect any bolt whose head or nut turns at this stage. As an option retighten all bolts in the connection and re-submit for inspection.

TABLE 5.05-6 [1]
(NUT ROTATION FROM THE SNUG-TIGHT CONDITION) [2]

	Geometry of Outer Faces of Bolted Parts		
Bolt length measured from underside of head to end of bolt	**Both faces normal to bolt axis**	**One face normal to bolt axis and other face sloped not more than 1:20. (Bevel washer not used)**	**Both faces sloped not more than 1:20 from normal to bolt axis (Bevel washers not used)**
Up to and including 4 diameters	**1/3 turn**	**1/2 turn**	**2/3 turn**
Over 4 diameters but not exceeding 8 diameters	**1/2 turn**	**2/3 turn**	**5/6 turn**
Over 8 diameters but not exceeding 12 diameters [3]	**2/3 turn**	**5/6 turn**	**1 turn**

[1] Applicable only to connections where all material within the grip of the bolt is steel.
[2] Nut rotation is relative to bolt, regardless of the element (nut or bolt) being turned. The tolerance is +/- 30 degrees (0.5 rad) for bolts installed by ½ turn or less. The

tolerance is +/- 45 degrees (0.8 rad) for bolts installed by 2/3 turn or more.

(3) Determine the required rotation by actual tests in a suitable tension device simulating the actual condition.

TABLE 5.05-7
MINIMUM FASTENER TENSION (1)

Bolt Size (mm)	AASHTO M 164, ASTM A 325 (kN)	AASHTO M 253, ASTM A 490 (kN)
13	53.4	66.7
16	84.5	106.8
19	124.6	155.7
22	173.5	218.0
25	226.9	284.7
29	249.1	355.9
32	315.8	453.7
38	458.2	658.3

(1) Equal to 70% of the specified minimum tensile strength of bolts (as specified in ASTM Specifications for tests of full size ASTM A 325 and ASTM A 490 bolts with UNC threads loaded in axial tension) rounded to the nearest 0.1 kN.

5.05.6 CONSTRUCTION REQUIREMENTS.

5.05.6.1 Falsework. Falsework used for the erection of structural steel shall conform to the general requirements for falsework contained in Section 5.03, "Concrete Structures" in these General Specifications.

Falsework and forms supporting the concrete work on steel structures shall be constructed so that any loads applied to girder webs shall be applied within one hundred fifty (150) millimeters of a flange or stiffener and shall be distributed in a manner that will not produce local distortion of the web. Temporary struts and ties shall be provided as necessary to resist lateral loads applied to the girder flanges and to prevent appreciable vertical movement between the edge of deck form and the adjacent steel girder. Loads imposed on existing, new or partially completed structures shall not exceed the load carrying capability of the structure, or portion of the structure, as determined by the Load Factor Design methods of AASHTO using Load Group III.

5.05.6.2 Continuous Members. Unless otherwise noted on the plans, structural steel girders have been designed for continuity in supporting girder dead load. The Contractor may at his option, erect the girders in such a manner that the girder continuity for dead load is or is not as assumed in design. Furnishing and erecting the girders shall be subject to the requirements in this Section.

If erection procedures are to be used which will provide the designed girder continuity for dead load, the Contractor shall furnish to the Engineer for review a statement of intended steel erection procedures with calculations in sufficient detail to substantiate that the girder geometry will be correct.

If erection procedures are to be used which will provide the designed girder continuity for dead load, members with field joints shall be preassembled in a no-load condition in a horizontal or an upright position.

If erection procedures are to be used which will result in steel girders not attaining the continuity for dead load assumed in design, the Contractor shall furnish to the Engineer for review a statement of steel erection procedures with calculations, in sufficient detail to substantiate that girder capacity and geometry will be correct.

If erection procedures are to be used which will result in steel girders not attaining the continuity for dead load assumed in design, the structure shall, after erection, have a load carrying capacity at least equal to the designed structure shown on the plans. The Contractor may increase the cross-sectional area or change the grades of steel to provide the specified load carrying capacity, subject to approval by the Engineer. Any additional steel or higher strength steels required to accommodate the method of erection selected shall be considered to be for the convenience of the Contractor and no additional payment will be made therefor.

5.05.6.3 Erection.

5.05.6.3.1 Handling and Storing Material. Place material stored at the job site on skids above ground. Keep material clean and properly drained. Place and shore girders and beams upright. Support long members, such as columns and chords, on skids placed near enough together to prevent damage due to deflection.

5.05.6.3.2 Bearings and Anchorages. Furnish and install bridge bearings according to Subsections 5.03.6, "Bearing Devices," 5.03.7, "Contractor Quality Control Procedures," 5.03.8, "Quality Assurance Procedures," in these General Specifications. If the steel superstructure is to be placed on a substructure that was built under a separate contract, verify that the masonry has been correctly constructed before ordering material.

5.05.6.3.3 Erection Procedures.

1. Conformance to Drawings. Erect according to approved erection drawings. Modifications to or deviations from the approved erection procedure will require revised drawings and verification of stresses and geometry.

2. Erection Stresses. Allow for erection stresses induced in the structure as a result of the use of a method of erection or equipment that differs from that previously approved, and that will remain in the finished structure as locked-in stresses. Provide additional material, as needed, to keep both temporary and final stresses within the allowable limits used in the design.

Provide temporary bracing or stiffening devices to accommodate handling stresses in individual members or segments of the structure during erection.

3. Maintaining Alignment and Camber. During erection, support segments of the structure in a manner that will produce the proper alignment and camber in the completed structure. Install cross frames and diagonal bracing as necessary during erection to provide stability and assure correct geometry. As necessary, provide temporary bracing at any stage of erection.

5.05.6.3.4 Field Assembly. Accurately assemble as shown on the erection drawings and required by match-marks. Carefully handle the material. Do not hammer, damage or distort the members. Clean bearing surfaces and permanent contact surfaces before assembly.

Assemble splices and field connections with at least two (2) cylindrical erection pins per part (4 minimum per splice or connection). A plate girder splice requires for example, at least four (4) cylindrical erection pins for the top flange splice, four (4) pins for the web splice, and four (4) pins for the bottom flange splice. These provide two (2) pins for each part. Place the pins in the corner holes of the splice plates.

Install more cylindrical erection pins, if necessary, to accurately align the parts. Fill the remaining holes in the connection with bolts and tighten systematically from the most rigid part of the connection to the free edges. Remove cylindrical erection pins and replace with tightened bolts.

Release temporary erection supports at a splice or connection only after all bolts are installed and tightened. Show special assembly and support situations on the erection drawings.

Fitting-up bolts may be the same high-strength bolts used in the same installation. If other fitting-up bolts are required, use the same nominal diameter as the high-strength bolts. Use cylindrical erection pins eight-tenths (0.8) millimeters larger than the bolts.

5.05.6.3.5 Pin Connections. Use pilot and driving nuts in driving pins. Drive the pins so that the members will fully bear on the pins. Screw pin nuts tight and burr the threads at the face of the nut with a pointed tool.

5.05.6.3.6 Misfits. Correction of minor misfits involving minor amounts of reaming, cutting, and chipping may be done, if approved. Any error in the shop fabrication or deformation resulting from handling and transporting will be cause for rejection.

5.05.6.4 Bolted Connections. Bolted connections unless otherwise shown on the plans or specified in the special specifications shall be made with high-strength steel bolts.

All connections made with high-strength bolts shall be friction-type joints, unless otherwise designated on the plans.

Except when the structural steel is not required to be painted, contact surfaces of all high-strength bolted connections shall be cleaned in accordance with Section 5.13, "Painting of Structures," in these General Specifications and coated with zinc-rich primer, organic vehicle type, before assembly. The total thickness on each surface shall be between two one hundredths (.02) and eight one hundredths (.08) millimeter.

All bolts shall conform to ASTM Designation A 325 and shall be installed with a hardened washer under the nut or bolt head, whichever is the element turned in tightening.

Bolts may be tightened by any method to the required tension. The torque value or the direct tension indicator gap needed to develop the required bolt tension will be determined by the Engineer. Bolt tension shall be checked at locations selected by the Engineer. Checking of bolt tension shall be done by the Contractor in the presence of the Engineer and in such a manner that the Engineer can read the torque wrench gage or direct tension indicator during checking.

Nuts shall be located, wherever practicable, on the side of the member which will not be visible from the traveled way. Nuts for bolts that will be partially embedded in the concrete shall be located on the side of the member that will be encased in concrete.

Bolts with diameters exceeding by up to six (6) millimeters the diameter of the bolt shown on the plans may be used, provided that required clearances and edge distances are not reduced below that required for the larger bolt.

Other fasteners approved by the Engineer as equivalent to these specifications may be used. Such fasteners, if used, shall have a positive tensioning procedure capable of calibration for accurately determining the bolt tension. For such fasteners using other than threaded connectors, the torque measurement requirements will not apply.

5.05.6.5 Field Fabrication and Welding. All painting, welding and other aspects of fabrication which are performed totally or partially at the project site shall conform to the requirements of Subsection 5.05.4, "Fabrication" in these General Specifications.

Before assigning any welder on site to Work covered by this Section of the specifications, the Contractor shall provide the Engineer with the names of the welders to be employed on the Work together with certification that each of these welders has passed qualification tests using procedures covered in the American Welding Society Standard B3.0, Part II, or such qualification test acceptable to the Engineer. If required by the Engineer, the Contractor shall submit identifying stenciled test coupons made by any operator whose workmanship is subject to question. The Contractor shall require any welder to retake the test when, in the opinion of the Engineer, the Work of the welder creates a reasonable doubt as to the proficiency of the welder. Tests, when required, shall be conducted at no additional expense to the Ministry. Recertification of the welder shall be made to the Engineer only after the welder has taken and passed the required retest. Welders shall have passed the qualification tests within the preceding twelve (12) month period. The Engineer may require coupons to be cut from any location in any joint for testing. All sections of weld found defective shall be chipped or cut out to base metal and properly rewelded before proceeding with the Work. Should any two (2) coupons cut from the Work of any welder show strengths, under test, less than that of the base metal, it will be considered evidence of negligence or incompetence and such welder shall be permanently removed from the Work. When coupons are removed from any part of the structure, the members cut shall be repaired in a neat and workmanlike manner, with joints of proper type to develop the full strength of the members and joints cut, with peening as necessary or directed to relieve residual stress, all at no additional cost to the Ministry.

5.05.7 QUALITY ASSURANCE PROCEDURES.

5.05.7.1 General. Quality assurance sampling, testing and the acceptance of materials shall be based on Certificates of Guarantee shall be in accordance with the requirements of Section 1.04, "Control of Materials" and 1.08, "Acceptance" in these General Specifications.

5.05.7.2 Inspection of Welds. Radiographic inspection of welds will be required, as specified in the current edition of the Standard Specifications for Welded Highway and Railway Bridges of the American Welding Society. Additional welds to be inspected radiographically will be specified on the plans.

When specified on the plans, other methods of nondestructive inspection of welds will be required.

The Contractor shall secure the services of an approved organization qualified in the inspection of welds and will bear the cost of this inspection service. Inspection of all welds shall be done only by persons skilled in such inspection and who are acceptable to the Engineer. The Engineer shall review and interpret radiographs and other non-destructive or destructive testing and has the sole authority to accept or reject the inspection of Works.

All film and/or other records of weld inspection shall become the property of the Ministry.

In the inspection of welds, the presence of any of the following defects in the excess of the specified limits will result in rejection of the weld as being defective.

1. Cracks. Cracks, regardless of length or location, will not be allowed.

2. Overlaps. Overlaps, lack of penetration or incomplete fusion will not be allowed.

3. Inclusions, Including Slag, Porosity and Other Deleterious Materials. Inclusions less than one and one-half (1.5) millimeters in the greatest dimension will be allowed if well-dispersed, such that the sum of the greatest dimensions of the inclusion in any twenty-five (25) millimeters of welded joint does not exceed ten (10) millimeters and there is no inclusion within twenty-five (25) millimeters of the edge of the joint or a point of restraint.

Inclusions one and one-half (1.5) millimeters or larger in greatest dimension will be allowed provided that such defects do not exceed the following limits:

1. Six (6) millimeters, for T up to twenty (20) millimeters, one-third (1/3) T, for T from twenty (20) millimeters to sixty (60) millimeters, twenty (20) millimeters, for T over sixty (60) millimeters, where T is the thickness of the thinner plate being welded.

2. Any group of inclusions in line that have an aggregate length greater than T in a length of twelve (12) T will not be allowed.

Defects shall be removed by mechanical means or by oxygen gouging, after which the joints shall be welded again. Repeated, unsuccessful repairs shall be cause for removal and replacement of the damaged portions of the adjacent steel.

5.05.8 METHOD OF MEASUREMENT. The computed weight of Work measured by weight shall be obtained by the use of the following rules and assumptions:

- The weight of steel shall be assumed at seven thousand eight hundred fifty (7,850) kilograms per cubic meter.

- The weight of bronze shall be assumed at eight thousand seven hundred twenty (8,720) kilograms per cubic meter.

- The weight of cast iron shall be assumed at seven thousand two hundred (7,200) kilograms per cubic meter.

The weights of steel, bronze and cast iron shall be computed on the basis of final dimensions at the unit weights as shown on the drawings and as verified and listed in standard steel handbooks. The net finished dimensions of the parts, as shown on the approved shop drawings, shall be used, deducting for copes, cuts, clips, and all holes including bolt and rivet holes.

The weight of bolts, including washers, heads and nuts shall be attained by scaled weight measurement methods. The weight of rivets shall be attained either by scaled weight measurement methods or by accurate volumetric computations and unit weight.

The weight of weld metal shall be computed on the basis of the theoretical volume from dimensions of the shop drawing welds at the unit weight of seven thousand eight hundred fifty (7,850) kilograms per cubic meter. For ease in computations, weld metal deposited in fillets, joint chamfers, and bevels will be measured but no measurement will be made for weld metal deposited outside the heat lines of the approved shop drawings. No deductions will be made for material removed by beveling or other cutting and subsequently replaced with weld metal.

No allowance will be made for erection bolts, temporary laterals, excess field rivets or other similar items.

At the option of the Engineer, cast steel, cast iron, wrought iron, small structural steel items composed of any single metal or combination of metals, excluding bearing devices, may be measured by the kilogram, complete in place, as determined by weighing on an accurate set of scales.

5.05.8.1 Structural Steel. This Work shall be measured by the ton as specified in the Bill of Quantities, complete in place as determined from the Engineer's computed weights.

For the purpose of payment, all metal parts, other than metal handrail and metal reinforcement for concrete, such as anchor bolts and nuts, pins and nuts, expansion dams, weld metal, bolts embedded in concrete, shear connectors, plates and shapes for pier protection, and similar metal items shall, unless otherwise specified, be measured for payment as Structural Steel.

The quantity of Structural Steel to be paid for shall include the weight of any full-size members which are tested to destruction as ordered by the Engineer and which meet the requirements of the specifications. Full-size members which fail to meet the requirements, and all members rejected as a result of tests, will not be paid for. All costs incurred in conducting tests shall be borne by the Contractor, except as otherwise specified.

If the Contractor elects (with the Engineer's permission) to use equivalent sections of greater weight than those shown on the approved plans, he shall bear all additional costs thereof.

5.05.8.2 Bridge Railing. Bridge railing, of the specified material and type, shall be measured by the linear meter, including open joints, complete in place and accepted.

5.05.9 PAYMENT.

5.05.9.1 Structural Steel. The amount of completed and accepted materials, measured as provided above, will be paid for at the contract unit price(s) per ton (as specified in the Bill of Quantities for Structural Steel, which price shall be full compensation for furnishing, fabricating, welding, delivering, erecting, radiographic inspection, painting and placing all materials, for all labor, equipment, tools and all other items necessary for the proper completion of the Work as specified in Subsection 1.07.2, "Scope of Payment," in these General Specifications.

5.05.9.2 Bridge Railing. The amount of completed and accepted Work, measured as provided above, will be paid for at the contract unit price per linear meter as specified in the Bill of Quantities, which price shall be full compensation for furnishing all anchor bolts, washers, etc., fabricating, delivering, erecting and painting, for all labor, equipment, tools, supplies and all other items necessary for the proper completion of the Work as specified in Subsection 1.07.2, "Scope of Payment" in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
50501	Structural Steel Finished, Fabricated and Erected	Ton
50502	Aluminum Bridge Railing	Linear Meter
5050201	Aluminum Bridge Railing, One Rail	Linear Meter
5050202	Aluminum Bridge Railing, Two Rail	Linear Meter
5050203	Aluminum Bridge Railing, Three Rail	Linear Meter
5050204	Aluminum Bridge Railing, W-Beam	Linear Meter
5050205	Aluminum Bridge Railing, Thrie Beam	Linear Meter
5050206	Aluminum Bridge Railing, (Type)	Linear Meter
50503	Steel Bridge Railing	Linear Meter
5050301	Steel Bridge Railing, One Rail	Linear Meter
5050302	Steel Bridge Railing, Two Rail	Linear Meter
5050303	Steel Bridge Railing, Three Rail	Linear Meter
5050304	Steel Bridge Railing, W-Beam	Linear Meter
5050305	Steel Bridge Railing, Thrie Beam	Linear Meter
5050306	Steel Bridge Railing, (Type)	Linear Meter

SECTION 5.06 - PILING

5.06.1 DESCRIPTION. This Work shall consist of furnishing, driving or placing and, if required, load testing piling of the type and dimensions shown on the Plans and listed in the Bill of Quantities, all in accordance with these General Specifications, the Special Specifications, and approved by the Engineer.

ITEMS IN BILL OF QUANTITIES
Cast-in-Place Concrete Piles, In-Place
Cast-in-Place Concrete Piles, In Steel Shells, In-Place
Precast Concrete Piles, Furnished
Precast Concrete Piles, In-Place
Precast Concrete Hexagonal Piles, Furnished
Precast Concrete Hexagonal Piles, In-Place
Precast Prestressed Concrete Piles, Furnished
Precast Prestressed Concrete Piles, In-Place
Steel H-Piles, Furnished
Steel H-Piles, In Place
Pile Load Test
Pile Splices

5.06.2 MATERIALS.

5.06.2.1 Precast Concrete Piling. Precast concrete piling shall conform to the details and dimensions shown on the plans. Concrete shall be Class C for normal precast piling and Class K for prestressed precast piling. Concrete shall conform to the requirements of Section 5.01, "Portland Cement Concrete" in these General Specifications.

Reinforcement shall be placed as shown on the plans and shall conform to the requirements specified in Section 5.02, "Reinforcing Steel," or Section 5.04, "Prestressed Concrete Structures" in these General Specifications.

Precast concrete piles shall be cast in a horizontal position. The forms shall be of an approved type conforming to the requirements for forms specified under Section 5.03, "Concrete Structures" in these General Specifications. The casting platform shall be constructed on a firm foundation, free from settlement. The piles shall be cast in a continuous operation, filling the forms with a slight excess of concrete.

Consolidation shall be accomplished by external or interval vibrators approved by the Engineer and the excess concrete shall be struck off to the level of the forms. The piles may be cast the full length of the reinforcing bars, provided that the excess concrete is cut off after form removal.

The side forms may be removed in twenty-four (24) to forty-eight (48) hours, but the piles shall not be moved until the compressive strength, shown by test cylinders cured with the piles, is equal to the specified minimum twenty-eight (28) day strength and in no case shall they be moved in less than four (4) days.

When removed from the forms, the pile shall present a true, smooth, even surface free from honeycombs, stone pockets, or other such defects and shall be so straight that a line stretched from butt to tip on any face will not be more than twenty-five (25) millimeters from the face of the pile at any point.

Precast concrete piles shall be cured either in wet sand, with wet burlap, or in steam for the period of time required to attain the specified twenty-eight (28) day strength but not less than four (4) days. When raising or transporting precast concrete piles, the Contractor shall submit his proposal for the location of the lifting points (or supporting points during transport) together with his arrangements to maintain the allowable stresses, for approval. Piles shall be so handled at all times as to avoid breaking or chipping the edges. Piles determined by the Engineer to be materially damaged in handling or driving shall be replaced by the Contractor at no expense to the Ministry.

5.06.2.2 Cast-In-Place Concrete Piling. Concrete to be used shall be Class C and shall conform to the requirements specified in Section 5.01, "Portland Cement Concrete" in these General Specifications.

Reinforcement shall be placed as shown on the standard plans and shall conform to the requirements specified in Section 5.02, "Reinforcing Steel" in these General Specifications. When welding of the reinforcement steel is permitted on the drawings, it shall conform to AWS D121 "Recommended Practices for Welding Reinforcement Steel, Metal Inserts and Connections in Reinforced Concrete Construction."

When using shells or castings for cast-in-place piles, the shells or casings shall be of an approved material having sufficient strength and rigidity to permit their driving and to prevent distortion caused by soil pressure or the driving of adjacent piles. The shells shall be sufficiently water-tight to exclude water before and during the placing of concrete.

The Contractor should be aware of "CII - Review of problems associated with the Construction of Cast-in-Place Concrete Piles" and submit his proposal accordingly.

The shells may be straight, tapered, step-tapered, or a combination of each with cylindrical sections.

Stepped or tapered sections shall have a minimum outside tip diameter of twenty (20) centimeters and a minimum outside butt diameter as shown on the plans. Straight shells shall have a minimum outside diameter as shown on the plans. For pile shells with a fluted section, the diameter shall be measured from crest to crest of the flutes. All joints in the shell shall be electrically welded. The lower end of each section shall be provided with a steel driving point having a wall thickness of not less than ten (10) millimeters.

The above specifications shall also apply to mandrel driven shells, except that the driving point shall have sufficient thickness and strength to permit driving without distortion and remain watertight and shall be approved by the Engineer.

5.06.2.3 Steel Piling. Steel piling shall consist of structural steel shapes of the section, size, and weight specified on the plans. The steel shall conform to requirements of AASHTO M 183.

5.06.2.4 Splice Materials. Splice materials shall conform to the requirements shown on the plans or in the Special Specifications. Alternate, equivalent material may be approved by the Engineer based on manufacturer's Certificates of Compliance or results of additional tests ordered by the Engineer.

5.06.2.5 Bentonite. Where bentonite is to be used in the boring process the material shall comply with specification DFCP4 of the Oil Companies Association and the supplier shall submit a test certificate, representative of the material delivered, to show its apparent viscosity and gel strength ranges.

5.06.2.6 Bentonite Slurry. Where the Contractor intends to use bentonite slurry or water during boring of the piles, a detailed method statement shall be submitted to the Engineer for approval. Bentonite shall be thoroughly mixed and allowed to pre-hydrate for twenty-four (24) hours before use. The properties of the slurry shall be such as to ensure adequate support of the sides of the bore and immediately prior to concreting, slurry shall be sampled from the level of the pile toe. The density of the slurry from such a test shall not exceed one and twenty-five hundredths grams per cubic centimeter (1.25 gr/cm^3)and the viscosity shall not exceed seventy-five (75) Marsh seconds.

5.06.3 EQUIPMENT. Equipment shall conform to the requirements specified herein and shall be as detailed in the Contractor's Program of Work, as approved by the Engineer. Equipment shall also conform to the requirements outlined in the HCM, Section 5-6-Piling, Paragraph A.3.

5.06.3.1 General. Piles shall be driven with a steam, compressed air, or diesel hammer. Diesel hammers which have fully enclosed ram shall be equipped with a gauge and accompanying charts which evaluate the equivalent manufacturer's rated energy being produced under any driving condition.

All hammers shall be maintained in an approved mechanical condition so that maximum efficiency will be obtained at all times. Hammers deemed inefficient by the Engineer shall be removed from the Work.

5.06.3.2 Hammers for Precast Concrete Piles. Precast concrete piles shall be driven with an approved steam or air, or diesel hammer. The hammer shall develop an energy per blow of not less than three-tenths (0.3) kilogram-meters for each kilogram of weight driven. In no case shall the total energy developed by the hammer be less than fourteen hundred (1,400) kilogram-meters per blow.

5.06.3.3 Hammers for Metal Shell for Cast-In-Place Concrete Piles. Shells for cast-in-place concrete piles shall be driven with an approved steam or air, or diesel hammer. For shells driven with the aid of a mandrel, the combined weight of the shell and the mandrel shall be considered as the weight of the pile and the hammer shall meet the requirements specified under Paragraph 5.06.3.2 "Hammers for Precast Concrete Piles" above. Hammers used to drive shells without a mandrel shall develop an energy per blow of not less than one thousand (1,000) kilogram-meters.

5.06.3.4 Hammers for Steel Piles. Steel piles shall be driven with an approved steam or air, or diesel hammer which shall develop an energy per blows of not less than one thousand (1,000) kilogram-meters.

5.06.3.5 Leads. Pile driver leads shall be constructed in such an approved manner as to afford freedom of movement to the hammer and they shall be held in position by guys or stiff braces to insure support to the pile during driving. The leads shall be blocked in position on the pile and shall be of sufficient length and rigidity so that the pile will be held in accurate alignment while being driven.

5.06.3.6 Followers. The driving of piles with followers shall be avoided if practicable and shall be done only with written permission of the Engineer. When followers are used, one pile of each group of ten (10) shall be a long pile driven without a follower, and shall be used, in effect, as a test pile to determine the average bearing power of the group.

5.06.4 CONSTRUCTION REQUIREMENTS.

5.06.4.1 Jetting and Drilling. When required to obtain the specified penetration, the Contractor shall furnish and operate approved jetting equipment, or shall furnish approved drilling equipment and drill holes not larger than the diameter of the pile, and drive the pile therein. Piles jetted or set in drilled holes shall be driven to the specified bearing capacity after completion of jetting or drilling.

5.06.4.2 Driving and Casting.

5.06.4.2.1 General Requirements. The Contractor shall submit to the Engineer for approval, full details of his proposed method, equipment and program for installing the concrete piles indicated on the plans or for installing an alternative type of piling proposed by the Contractor. Improved construction methods (e.g. grouted piles) may be considered. No claim for extra payment will be accepted if another piling system is approved.

The Contractor shall confirm existing soil information by carrying out at least one deep sounding (penetration) test at each pier or abutment location at a depth at least two (2) meters below the specified pile depth. Test results and evaluation shall be promptly submitted to the Engineer. In case of unexpected soil conditions, the Contractor shall so inform the Engineer and submit his proposals for resolution. Pile design must be based on actual soil conditions at each location.

Any circumstance indicating that the ground conditions differ from those expected by the Contractor so as to affect materially the bearing capacity of a pile shall be reported by the Contractor to the Engineer immediately, together with remedial proposals.

Unless otherwise specified, or approved by the Engineer, piles for any substructure element shall not be driven until after the excavation for that element is complete. Any material forced up between the piles shall be removed to correct elevation without cost to the Ministry before concrete for the foundation is placed.

The piles shall be driven to the depth shown on the plans or as may be required to develop the specified bearing capacity and stability against scour and shall be of sufficient length therefor.

Piles shall be driven or cast in position with a maximum tolerance of 1:75 to the vertical or battered lines indicated on the plans. The maximum variation on the butt of the pile after driving from the position shown on the plans shall be one hundred (100) millimeters. Piles shall be driven or cast to the levels shown on the plans or as directed, within a maximum tolerance of plus or minus twelve (12) millimeters from the theoretical cut-off levels.

If any pile is driven or cast in a position beyond the limits of the specified tolerances, the design of the pile cap shall be revised and additional piles shall be installed, if necessary, all at the Contractor's expense.

All piles pushed up by the driving of adjacent piles or by any other cause shall be driven down again. Any pile damaged by reason of internal defects, or improper driving, or by having been driven out of its proper location shall be removed or, at the option of the Engineer, a second pile may be driven adjacent thereto, if this can be done without detriment to the structure. Care shall be taken when a hard stratum or rock boulders are encountered so that the pile will not be damaged. Piles which are to be capped shall be accurately cut off so that true bearing is obtained on all piles without the use of shims. Piles cut off otherwise shall be replaced at the Contractor's expense.

The driving of individual piles, once driving has commenced, shall be a continuous operation. No Force shall be applied to rectify the verticality or position of the already driven Piles.

5.06.4.2.2 Driving Precast Concrete Piles. The tops of all precast concrete piles shall be protected from injury by the impact of the hammer in a manner approved by the Engineer. This protection shall be so designed, maintained and used as to cause the minimum absorption of energy consistent with adequate protection of the top of the pile.

The pile shall be driven with equipment as herein specified. The protection shall be designed and care shall be exercised to prevent injury to or displacement of any reinforcement which might be projecting above the top of the pile.

5.06.4.2.3 Driving Metal Shell for Cast-In-Place Concrete Piles. An approved driving head, as furnished by the manufacturer, or equal, which shall be of proper size and design for the particular size and type of hammer to be used, shall be provided to distribute properly the hammer blows and to prevent damage to the shell while driving.

The Contractor shall have available at all times a suitable light of a type approved by the Engineer, for thoroughly illuminating the interior of the pile shells for their entire length after being driven. Any shell that shows bends, kinks, or other deformations, incurred during the process of driving, that would impair the strength or efficiency of the completed pile, shall be replaced at the direction of the Engineer and at the expense of the Contractor. After all the shells have been driven to proper alignment, spacing and elevation, and cut off at the required elevation, they shall be given a final inspection before they are filled with concrete. Any water or other foreign substance found in them shall be removed. Upon approval of the shells by the Engineer, the shells shall be filled with concrete as specified and in the presence of the Engineer.

No concrete shall be placed until all driving within a six (6) meter radius has been completed, except that driving within the above limit may be permitted by the Engineer if the concrete in the last pile cast has set not less than seven (7) days.

Following final cleaning up, the reinforcement shall be placed as indicated on the plans and shall be maintained in its correct position during the concreting of the pile. Where the reinforcement is made up into cages, these shall be sufficiently rigid to enable them to be handled without damage or distortion. Sufficient length of reinforcement shall be left projecting from the head of the pile after filling, to provide full bond length above the soffit of the pile cap.

The time interval between the final cleaning up and the placing of concrete shall not exceed two hours. In the event that there is any appreciable delay, the depth to the pile bottom shall be checked against the measured drilled depth before placing concrete, to ensure that no soil has fallen into the bore.

Tremie pipes shall be used in concreting. Once concreting has commenced, the concrete shall be placed without such interruption as would allow the previously placed batch to have hardened. The concrete shall be compacted to form a dense homogeneous mass such that a continuous monolithic concrete shaft of the full cross-section is formed.

Temporary casings shall be extracted while the concrete within them remains sufficiently workable to ensure that the concrete is not lifted. When a casing is being extracted, a sufficient quantity of concrete shall be maintained within it to ensure that pressure from external water or soil is exceeded and that the pile is neither reduced in cross-section nor contaminated.

Concreting shall continue beyond the required cut-off level so that the pile will consist of fully-compacted concrete to at least the cut-off level.

When preparing the head of a pile for incorporation into a pile cap, the head shall be cut off square at the required cut-off level and all loose particles shall be removed by wire brushing followed by washing with water. Projecting reinforcement shall be cleaned and straightened.

5.06.4.2.4 Driving Steel Piles. The heads of steel piles shall be cut squarely and a cast or structural steel driving head or cap shall be used to hold the axis of the pile in line with the axis of the hammer and to prevent excessive upsetting of the pile head under extremely hard driving conditions.

When shown on the plans or ordered by the Engineer, the Contractor shall furnish and attach brackets, lugs, core stoppers, or other devices to increase the bearing value of the pile. Plate caps shall be provided when shown on the plans.

Steel piles shall be cut off at the designated elevation.

5.06.4.3 Determination of Bearing Values.

5.06.4.3.1 Load Tests. When shown on the plans or specified in the Special Specifications or when ordered by the Engineer, the Contractor shall perform load tests on any pile or piles designated by the Engineer. The load test and load settlement relationship for individual piles shall be performed in accordance with the requirements of ASTM D 1143. The test load shall be placed so that a uniform pressure over the pile is assured and so that settlement readings may be taken directly on the piles. Before any portion of the test load is applied, the piles shall be allowed to rest for not less than twenty-four (24) hours. The safe allowable load per pile shall be taken as fifty (50) percent of that load which after remaining in place for forty-eight (48) hours, produces a permanent settlement not greater than six (6) millimeters measured at the top of the pile.

The above safe bearing value shall be closely correlated with the appropriate pile driving formulas to determine the adequacy of the driving methods. The safe allowable load as determined by the above load test shall be used in conjunction with other tests to correlate bearing values.

The load shall be measured by a load measuring device and by a calibrated pressure gauge in a hydraulic loading system. Readings of both, the measuring device and the pressure gauge, shall be recorded.

The load measuring device may consist of a proving ring, load cell or other approved system. The device shall be calibrated before and after each series of tests. The pressure gauge and any hydraulic jack shall be calibrated together. Certificates of calibration shall be supplied to the Engineer.

The measurement of pile or beam movement shall be made by dial gauges that are rigidly mounted on an independent reference frame that bear on surfaces normal to the pile axis and fixed to the pile beam or head. Alternatively the gauges may be fixed to the pile or beam and bear on the surface of the frame. The frame shall be supported in such a manner that it does not move during the test.

A check shall be made of the movement of the pile head and frame relative to an external datum during the progress of the test.

Throughout the test, all equipment for measuring load and movement shall be protected from the weather. Construction equipment and persons who are not involved in the test shall be kept at sufficient distance from the test to avoid disturbance to the measurement apparatus.

Loading tests on working piles shall be carried out at one location minimum per bridge.

In the event of a working pile failing the loading test, its load-carrying capacity shall be determined as specified below. The working load of the pile group as designated shall be de-rated accordingly, and additional piles shall be introduced such that the larger pile group meets the design load requirements. It shall be the Contractor's responsibility to submit a revised design to the Engineer for his approval, and the additional work carried out shall be at the Contractor's expense.

The procedure for loading shall be as follows:

1. The test load shall be measured within an accuracy of two (2) percent. Settlements shall be measured within an accuracy of one-tenth (0.1) millimeters.

2. Unless otherwise directed the test load shall be applied in the following manner:

(1) to the working load (as described on the appropriate plans) by four equal increments;

(2) removal of all the

(3) to one-and-one-half (1.5) times the working load by two equal increments up to the working load and thereafter by four equal increments;

(4) removal of all the load.

3. The load after each increment shall be kept constant until the rate of settlement does not exceed twenty-five hundredths (0.25) millimeters per hour.

4. The amount of settlement shall be recorded before the next increase of load.

5. The maximum test load shall be maintained for forty-eight (48) hours and the total settlement recorded.

6. The load shall be reduced in stages equal to those in which it is applied.

7. The load after each reduction shall be kept constant until the rate of recovery does not exceed twenty-five hundredths (0.25) millimeters per hour.

8. The amount of recovery shall be recorded before the next decrease of load.

9. The Contractor shall, within twenty-four (24) hours of the completion of the test, submit to the Engineer for each pile tested graphs showing:

(1) Load and settlement plotted above and below a common base line of time;
(2) Settlement and recovery plotted vertically against a base line of load.

10. The settlement of the pile under the test load shall be not greater than fifteen (15) millimeters, and the recovery of the pile after the subsequent removal of the test load shall be not less than five (5) millimeters.

5.06.4.3.2 Formulas. If loading tests are not required, the formulas shown in the following table shall be used to determine the bearing values for piles.

Steam All Types (Single Acting) $P = \dfrac{WH}{0.06S + 0.015}$

Steam All Types (Double Acting) $P = \dfrac{E}{0.06S + 0.015}$

Diesel All Types $P = \dfrac{E}{0.06S + 0.015\ X/W}$

P = safe bearing capacity in kilograms
W = weight, in kilograms, of striking parts of hammer
H = height of fall in meters
E = energy of ram in kilogram-meters per blow
S = the average penetration in centimeters per blow for the last twenty (20) blows
X = weight, in kilograms of the pile plus the weight of any cap used on the pile during driving

The above formulas are applicable only when:
The piles are driven in a vertical position.
The hammer is operating at full efficiency.
The head of the pile is not broomed or crushed.
The penetration is reasonably quick and uniform.
There is no appreciable bounce after the blow.
A follower is not used.

In case water jets are used in connection with the driving, the bearing power shall be determined by the above formulas from the results of driving after the jets have been withdrawn, or a load test may be applied.

5.06.4.3.3 Diesel Hammers. The energy rating of a diesel hammer to be used in formulas for computing bearing values or to be used to determine if hammer is of adequate size, will be eighty (80) percent of the manufacturer's rating for the model being used.

5.06.4.4 Test Piles and Order Lists.

5.06.4.4.1 Test Piles. Test piles, of the number and lengths and at the locations shown on the plans, or as otherwise ordered in writing by the Engineer, shall be driven by the Contractor to furnish information to the Engineer in determining the length of piles to be used.

Test piles shall be installed outside the limits in plan of the permanent pile cap, in close proximity to it, but not less than ten meters center-to-center from the designed location of any permanent pile.

The loading tests shall be as specified in Paragraph 5.06.4.3, "Determination of Bearing Values" in these General Specifications. If a test pile fails the loading test, a further test pile, of increased length, shall be installed and load-tested.

The tops of test piles shall be demolished to a depth of one (1) meter below ground level on termination of their use, and the resulting holes shall be backfilled with approved materials.

5.06.4.4.2 Order Lists for Piling. The Contractor shall furnish piles in accordance with the list shown on the plans and verified in writing by the Engineer or modified in writing by the Engineer. The Engineer may require that test piles be ordered and driven before verifying the list of remaining piles.

The lengths given in the verified list shall be based on the lengths which are assumed to remain in the completed structure. The Contractor shall, at his own expense, increase the lengths given to provide for fresh heading and additional length as may be necessary to suit the Contractor's method of operation. The Contractor shall be responsible for satisfying himself that he has sufficient data to be able to determine the lengths of piles required and the method of installation to be used. The Contractor shall be responsible for carrying out any further site investigation which he deems necessary. Each pile shall be of sufficient length to develop at least twice the working load capacities indicated on the plans, the necessary lengths being determined from the site investigation data.

If the plans provide for the driving of test piles and the Contractor elects to order the piling for the structure prior to driving of the test piles, it shall be his responsibility to furnish piling of adequate lengths as determined from data obtained at the time of driving the test piles. The splicing of piles or cut-offs in excess of the ordered and accepted length, as determined by the Engineer from the test pile data, shall be at the expense of the Contractor. In case the Contractor orders all piling for the structure before the test piles are driven and is charged with the responsibility of furnishing the proper length as shown above, the test piles shall not be underrun.

5.06.4.5 Falsework and Defective Piles. No measurement or payment will be made for the furnishing or driving of falsework piles, nor will payment be made for piles driven out of place, for defective piles, or for piles which are damaged in handling or driving. Defective, damaged, or falsework piles or piles driven out of place shall be pulled and removed, or cut off below exposed surfaces, in a manner satisfactory to the Engineer.

5.06.4.6 Splicing Piles.

5.06.4.6.1 General Requirements. Full length piles shall be used where practicable but may be spliced with the written permission of the Engineer. Splices shall be made in accordance with the details shown on the plans and as otherwise described by the Engineer. Splices for steel and metal shells shall be welded by the manual shielded metal arc welding process.

5.06.4.6.2 Welded Splices. Welded splices shall be made by an experienced welder acceptable to the Engineer; however, any failure in the splice shall be corrected or replaced at the Contractor's expense.

5.06.4.6.3 Steel Piles. Steel piles to be spliced for further driving or steel piles to be extended without further driving shall be spliced in accordance with the plan details and as otherwise approved by the Engineer. The indiscriminate splicing of steel piles will not be allowed.

Ten percent (10%) of the welded splices shall be tested by X-Ray using three hundred (300) millimeter length for each Welded Joint and the results shall show no visual evidence of cracks, lack of fusion, undercutting, excessive piping or porosity in compliance with AASHTO/ASW D 1.5 Bridge Welding Code.

5.06.4.6.4 Precast Concrete Piles. If an increase in length becomes necessary after driving a precast concrete pile, the concrete at the top of the driven pile shall be removed, leaving the reinforcing steel exposed for a length of forty (40) bar diameters. The final cut of the concrete shall be perpendicular to the axis of the pile. Main reinforcement similar to that used in the pile shall be fastened securely to the projecting steel with spirals and ties placed adjacent to the splice as shown on the plans. Just prior to the placing of concrete, the top of the pile shall be wetted thoroughly and covered with a thin coating of neat cement or other suitable bonding material. Care shall be taken to prevent concrete leakage at the splice to give a finished joint.

5.06.4.7 Painting. Unless otherwise specified, when steel piles, or metal shells or casings for cast-in-place piles extend above the ground or water surface, all surfaces thereof that will be exposed in the completed Work shall be protected by three (3) coats of paint as specified for new structural steel in Section 5.13, "Painting of Structures," in these General Specifications except that all three (3) coats shall be applied in the field. This protection shall extend from an elevation one (1) meter below the low water surface or ground surface to the top of the exposed steel.

5.06.4.8 Records and Reports. A record of all piles installed shall be kept by the Contractor and a copy of the record of work carried out each day shall be submitted to the Engineer within the following day for his approval and retention. The record shall contain the information listed in the HCM, Section 5-6-Piling, Paragraph E - Records and Reports, as well as any other information required by the Engineer; such as details of strata penetrated, time interval between completion of final cleaning and commencement of concreting, etc.

5.06.5 QUALITY CONTROL AND ASSURANCE PROCEDURES. Contractor sampling, testing and the Engineer's acceptance of material based on Certificates of Guarantee shall be in accordance with the requirements of Section 1.04, "Control of Materials" and Section 1.08, "Acceptance" in these General Specifications.

In addition to the codes and standards specified herein, the contractor shall comply with the following:

1. CP 2004, 1972 - Code of Practice for Foundations.
2. I.C.E. 1978 - Piling Model Procedures and Specification.
3. HCM, Section 5-6-Piling, paragraphs B and C.

5.06.6 METHOD OF MEASUREMENT.

5.06.6.1 Cast-in-Place Concrete Piles, In-Place. Cast-In-Place Concrete Piles (Size), In-Place, will be measured by the linear meter for each size of piling, or by the cubic meter, as shown in the Bill of Quantities, based upon the total lengths shown on the plans or as approved by the Engineer. The total length measured will include test piles.

5.06.6.2 Cast-In-Place Concrete Piles in Steel Shells, In-Place. Cast-in-Place Concrete Piles (Size) in Steel Shells In-Place will be measured by the linear meter for each size of piling or by the cubic meter, as shown in the Bill of Quantities, based upon the total lengths shown on the plans or approved by the Engineer. The total length measured will include test piles.

5.06.6.3 Precast Piles, Furnished. Precast Piles, Furnished will be measured by the linear meter for each type and size of piling or by the cubic meter, as shown in the Bill of Quantities, based on the total lengths shown on the Order List verified in writing by the Engineer. The total length measured will include test piles.

Piling damaged by the Contractor through handling, driving, or for other reason shall be replaced by him at no additional expense to the Ministry.

Should the quantity of piling furnished exceed the quantity placed, the excess piling will become the property of the Ministry and shall be delivered without additional cost to the Ministry to the nearest Road District Compound as ordered by the Engineer. Alternatively, the Engineer may convey excess piling to the Contractor at a mutually agreed price or convey short lengths to the Contractor for disposal at no cost to either the Ministry or the Contractor.

5.06.6.4 Precast Piles, In-Place. Precast Piles, In-Place, will be measured by linear meter for each type and size of piling, or by the cubic meter, driven and cut off as ordered, as accepted in the structure by the Engineer and as listed in the Bill of Quantities. No separate measurement will be made for concrete and reinforcing steel in concrete piles.

Preboring, jetting, or other methods used for facilitating pile driving procedures will not be measured directly, but will be considered as subsidiary to this Work.

5.06.6.5 (Type) Pile Load Tests. These Pile Load Tests will be measured by the unit of each for the number of load tests completed and accepted, except that load tests made at the option of the Contractor and load tests made to calibrate diesel or other designated types of hammers, when test piles are not included in the Bill of Quantities, will not be included in the quantity measured for payment.

5.06.6.6 Pile Splices, (Type). Splices, (Type) will be measured by the unit for those splices ordered by the Engineer on piles which exceed the lengths shown on the Order List verified by the Engineer. Splices made for the convenience of the Contractor will not be paid for. Splices made to fabricate piles from cut-offs will not be paid for unless ordered by the Engineer.

No measurement shall be made for payment of pile cut-offs.

5.06.7 PAYMENT. The amount and type of piling authorized, completed, accepted, and measured as provided above, will be paid for at the contract unit price(s) shown in the Bill of Quantities. Pile Load Tests and Splices will be paid by the unit of each at the contract unit price shown in the Bill of Quantities for each load test or splice ordered and completed in accordance with the specifications and accepted by the Engineer.

The amount of completed and accepted material, measured as provided above, will be paid for at the contract unit price(s), which price and payment shall be full compensation for furnishing, fabricating, transporting, delivering, erecting, and placing all materials, including all labor, equipment, tools, and all other items necessary for the proper completion of the Work as specified in Subsection 1.07.2, "Scope of Payment" in these General Specifications.

No separate payment will be made for cutting off of pile heads at the specified cut-off levels as this work is considered subsidiary to the other pile item(s) appearing in the Bill of Quantities.

Finally, payment shall be considered to cover for all soil testing, dewatering when required, and cutting off of pile heads.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
50601	Cast-in-Place Concrete Piles, In-Place	Linear Meter
5060101	Cast-in-Place Concrete Piles, 0.6 m dia, In-Place	Linear Meter
5060102	Cast-in-Place Concrete Piles, 0.8 m dia, In-Place	Linear Meter
5060103	Cast-in-Place Concrete Piles, 1.0 m dia, In-Place	Linear Meter
5060104	Cast-in-Place Concrete Piles, 1.2 m dia, In-Place	Linear Meter
5060105	Cast-in-Place Concrete Piles, 1.4 m dia, In-Place	Linear Meter
5060106	Cast-in-Place Concrete Piles, 1.6 m dia, In-Place	Linear Meter
5060107	Cast-in-Place Concrete Piles, 1.8 m dia, In-Place	Linear Meter
5060108	Cast-in-Place Concrete Piles, 2.0 m dia, In-Place	Linear Meter
5060109	Cast-in-Place Concrete Piles, ___ m dia, In-Place	Linear Meter
5060112	Cast-in-Place Concrete Piles, 0.3 m x 1.1 m, In-Place	Linear Meter
5060113	Cast-in-Place Concrete Piles, 0.6 m x 2.2 m, In-Place	Linear Meter
5060114	Cast-in-Place Concrete Piles, ___ m x ___ m, In-Place	Linear Meter
50602	Cast-in-Place Concrete Piles, In-Place	Cubic Meter
50603	Cast-in-Place Concrete Piles, In Steel Shells, In-Place	Linear Meter
5060301	Cast-in-Place Concrete Piles, 0.6 m dia, In Steel Shells, In-Place	Linear Meter
5060302	Cast-in-Place Concrete Piles, 0.8 m dia, In Steel Shells, In-Place	Linear Meter
5060303	Cast-in-Place Concrete Piles, 1.0 m dia, In Steel Shells, In-Place	Linear Meter
5060304	Cast-in-Place Concrete Piles, 1.2 m dia, In Steel Shells, In-Place	Linear Meter
5060305	Cast-in-Place Concrete Piles, 1.4 m dia, In Steel Shells, In-Place	Linear Meter
5060306	Cast-in-Place Concrete Piles, 1.6 m dia, In Steel Shells, In-Place	Linear Meter
5060307	Cast-in-Place Concrete Piles, 1.8 m dia, In Steel Shells, In-Place	Linear Meter
5060308	Cast-in-Place Concrete Piles, 2.0 m dia, In Steel Shells, In-Place	Linear Meter
5060309	Cast-in-Place Concrete Piles, ___ m dia, In Steel Shells, In-place	Linear Meter
50604	Cast-in-Place Concrete Piles, In Steel Shells, In-Place	Cubic Meter
50605	Precast Concrete Piles, Furnished	Linear Meter
5060501	Precast Concrete Piles, 0.2 m dia, Furnished	Linear Meter
5060502	Precast Concrete Piles, 0.3 m dia, Furnished	Linear Meter
5060503	Precast Concrete Piles, 0.4 m dia, Furnished	Linear Meter
5060504	Precast Concrete Piles, 0.5 m dia, Furnished	Linear Meter
5060505	Precast Concrete Piles, 0.6 m dia, Furnished	Linear Meter
5060506	Precast Concrete Piles, ___ m dia, Furnished	Linear Meter
50606	Precast Concrete Piles, Furnished	Cubic Meter
50607	Precast Concrete Piles, In-Place	Linear Meter
5060701	Precast Concrete Piles, 0.2 m internal dia, In-Place	Linear Meter
5060702	Precast Concrete Piles, 0.3 m internal dia, In-Place	Linear Meter
5060703	Precast Concrete Piles, 0.4 m internal dia, In-Place	Linear Meter
5060704	Precast Concrete Piles, 0.5 m internal dia, In-Place	Linear Meter
5060705	Precast Concrete Piles, 0.6 m internal dia, In-Place	Linear Meter
5060706	Precast Concrete Piles, ___ m internal dia, In-Place	Linear Meter
50608	Precast Concrete Piles, In-Place	Cubic Meter
50609	Precast Concrete Hexagonal Piles, Furnished	Linear Meter

5060901	Precast Concrete Hexagonal Piles, 0.2 m internal dia, Furnished	Linear Meter
5060902	Precast Concrete Hexagonal Piles, 0.3 m internal dia, Furnished	Linear Meter
5060903	Precast Concrete Hexagonal Piles, 0.4 m internal dia, Furnished	Linear Meter
5060904	Precast Concrete Hexagonal Piles, 0.5 m internal dia, Furnished	Linear Meter
5060905	Precast Concrete Hexagonal Piles, 0.6 m internal dia, Furnished	Linear Meter
5060906	Precast Concrete Hexagonal Piles, ___ m internal dia, Furnished	Linear Meter
50610	Precast Concrete Hexagonal Piles, Furnished	Cubic Meter
50611	Precast Concrete Hexagonal Piles, In-Place	Linear Meter
5061101	Precast Concrete Hexagonal Piles, 0.2 m internal dia, In-Place	Linear Meter
5061102	Precast Concrete Hexagonal Piles, 0.3 m internal dia, In-Place	Linear Meter
5061103	Precast Concrete Hexagonal Piles, 0.4 m internal dia, In-Place	Linear Meter
5061104	Precast Concrete Hexagonal Piles, 0.5 m internal dia, In-Place	Linear Meter
5061105	Precast Concrete Hexagonal Piles, 0.6 m internal dia, In-Place	Linear Meter
5061106	Precast Concrete Hexagonal Piles, ___ m internal dia, In-Place	Linear Meter
50612	Precast Concrete Hexagonal Piles, In-Place	Cubic Meter
50613	Precast Prestressed Concrete Piles, Furnished	Linear Meter
5061301	Precast Prestressed Concrete Piles, 0.2 m internal dia, Furnished	Linear Meter
5061302	Precast Prestressed Concrete Piles, 0.3 m internal dia, Furnished	Linear Meter
5061303	Precast Prestressed Concrete Piles, 0.4 m internal dia, Furnished	Linear Meter
5061304	Precast Prestressed Concrete Piles, 0.5 m internal dia, Furnished	Linear Meter
5061305	Precast Prestressed Concrete Piles, 0.6 m internal dia, Furnished	Linear Meter
5061306	Precast Prestressed Concrete Piles, ___ m internal dia, Furnished	Linear Meter
50614	Precast Prestressed Concrete Piles, Furnished	Cubic Meter
50615	Precast Prestressed Concrete Piles, In-Place	Linear Meter
5061501	Precast Prestressed Concrete Piles, 0.2 m internal dia, In-Place	Linear Meter
5061502	Precast Prestressed Concrete Piles, 0.3 m internal dia, In-Place	Linear Meter
5061503	Precast Prestressed Concrete Piles, 0.4 m internal dia, In-Place	Linear Meter
5061504	Precast Prestressed Concrete Piles, 0.5 m internal dia, In-Place	Linear Meter
5061505	Precast Prestressed Concrete Piles, 0.6 m internal dia, In-Place	Linear Meter
5061506	Precast Prestressed Concrete Piles, ___ m internal dia, In-Place	Linear Meter
50616	Precast Prestressed Concrete Piles, In-Place	Cubic Meter
50617	Steel H-Piles, Furnished	Ton
50618	Steel H-Piles, In Place	Linear Meter
50619	Pile Load Test	Unit
5061901	Working Pile Load Test	Unit
5061902	Ultimate Pile Load Test	Unit
5061903	Tension Pile Load Test	Unit
5061904	Pile Integrity Testing	Unit
50620	Pile Splices	Unit
5062001	Pile Splices, Precast Concrete	Unit
5062002	Pile Splices, Steel H-Piles	Unit

SECTION 5.07 - LEAN CONCRETE BASE COURSE

5.07.1 DESCRIPTION. The work under this section consists of furnishing all materials and constructing a lean concrete base course in accordance with the details shown on the project plans and the requirements of these specifications.

ITEM IN BILL OF QUANTITIES

Lean Concrete Base Course

5.07.2 MATERIALS.

5.07.2.1 Portland Cement. Portland cement shall conform to the requirements of Paragraph 5.01.2.1, "Portland Cement," in these General Specifications.

5.07.2.2 Aggregate. At the option of the contractor, the aggregate for lean concrete base course shall be either Grading II aggregate base material conforming to the requirements of Section 3.03, "Aggregate Bases," in these General Specifications, or a combination of fine and coarse aggregate for Portland cement concrete conforming to Paragraph 5.01.2.2, "Aggregate," in these General Specifications.

5.07.2.3 Water. Water used in the construction of lean concrete base course shall conform to the requirements of Paragraph 5.01.2.3, Water," in these General Specifications.

5.07.2.4 Admixtures. Admixtures shall conform to the requirements of Paragraph 5.01.2.4, "Admixtures," in these General Specifications.

5.07.2.5 Curing Compounds. Liquid membrane curing compounds shall conform to the requirements of AASHTO M-148, Type 2.

5.07.3 EQUIPMENT. Equipment shall be according to the type and number outlined in the Contractor's detailed Program of Work as approved by the Engineer.

5.07.4 CONSTRUCTION REQUIREMENTS.

5.07.4.1 Preparation of Subgrade, Subbase, or Base. Lean concrete base course shall be placed on a prepared subgrade, subbase, or base which shall have been constructed conforming to the surface finish and grade tolerance requirements specified for the material involved.

The subgrade, subbase, or base shall be free of loose or extraneous material, kept uniformly moist, but free of ponded water, immediately before placing lean concrete base course and maintained in an acceptable condition throughout the placement operation. Any soft or yielding area of the subgrade shall be corrected before placing lean concrete base course.

5.07.4.2 Forming. Lean concrete base course shall be constructed with slip-form

paving equipment. Forming shall conform to the requirements of Paragraph 5.08.4.3 "Forming" in these General Specifications.

5.07.4.3 Proportioning and Mixing Lean Concrete Base Course - Mix Design. **The contractor shall determine the mix proportions and shall furnish lean concrete base course which shall exceed one hundred eighty (180) kilograms of Portland Cement per cubic meter, except the amount of cement in the mix may be reduced when fly ash is added as determined by Paragraph 5.01.2.4, "Mineral Admixtures," in these General Specifications. The lean concrete base course shall attain a minimum compressive strength of fifty (50) kilograms per square centimeter after seven (7) days per MRDTM 528.**

The contractor shall submit a complete solid-volume mix design to the Engineer for review before incorporating the proposed mix into the work.

Mix designs submitted for review shall include:

1. **The weights, volumes, and specific gravities of all ingredients**
2. **The brand, type, and source of cement**
3. **The type of admixtures**
4. **The source of aggregate**
5. **The code number to identify the mix design**

The contractor may submit mix designs from previous or concurrent projects. The contractor shall make no changes in the concrete mix designs or code numbers without review by the Engineer. A new mix design shall be submitted for the Engineer's review any time the contractor proposes a change in materials or material proportions.

The contractor shall prepare trial batches of lean concrete base course for each mix design. The number of trial batches required will be established by the Engineer and the Engineer may waive the requirements for trial batches at any time. The contractor shall prepare trial batches using materials, mixing equipment, procedures, and batch sizes which are the same as those to be used in the work.

The Engineer will take test samples from the trial batches. When test results indicate the proposed mix will not meet the specified compressive strength requirements, the contractor shall submit a new mix design for review.

In no case will the Engineer's review or test of a mix design relieve the contractor of the responsibility to provide lean concrete base course with the specified properties or material contents.

5.07.4.3.1 Cement, Water, and Aggregate - Cement, water, and aggregate shall be proportioned in accordance with the requirements of Subsection 5.01.2, "Materials" in these General Specifications.

5.07.4.3.2 Admixtures - Admixtures shall be proportioned in accordance with the requirements of Paragraph 5.01.2.4 "Admixtures" in these General Specifications.

Air-entraining admixtures will be required for lean concrete base course placed at elevations above two thousand (2000) meters. The amount of entrained air in the lean concrete mixture shall not be less than six (6) $\pm$ 1.5% by volume. At elevations below two thousand (2000) meters, air-entraining admixtures may be used at the option of the contractor; however, the amount of entrained air in the lean concrete mixture shall not exceed four (4) percent by volume.

5.07.4.3.3 Mixing - Mixing shall be performed according with the requirements of Subsection 5.01.5, "Proportioning and Mixing During Construction" in these General Specifications.

5.07.4.3.4 Consistency - The contractor shall furnish lean concrete base course having a slump of seven (7) centimeters or less, or as provided for in Subsection 5.01.3, "Mix Design" in these General Specifications. Lean concrete base course that fails to conform to this consistency requirement will be rejected. Tests for consistency will be performed according to the requirements of MRDTM 517.

5.07.4.4 Joints. There shall be no longitudinal or weakened plane joints in lean concrete base course. Transverse construction joints shall be constructed normal to the centerline of the pavement at the end of each day's production and during other work interruptions as directed by the Engineer. When Portland cement concrete pavement is to be placed over lean concrete base course, longitudinal construction joints in the lean concrete base course shall be at least six hundred (600) millimeters from any subsequent longitudinal joint in the Portland cement concrete pavement.

5.07.4.5 Placing and Finishing. Lean concrete base course shall be placed and finished according to the applicable requirements of Paragraph 5.08.4.4 "Placing and Finishing" in these General Specifications, except the Surface Texturing portion is not applicable.

Lean concrete base course may be placed either for the full width in a single pass, or in two or more passes, provided each pass is a minimum of four (4) meters wide whenever possible. Longitudinal construction joints between passes shall conform to the requirements of Paragraph 5.08.4.5 "Joints" in these General Specifications.

5.07.5 CURING. Curing of lean concrete base course shall begin immediately after surface finishing operations. Liquid membrane-forming compound shall be applied uniformly to the surface and sides of the lean concrete base course at the rate of not less than one (1) liter per five (5) square meters. Alternately continuous water sprinkling or flogging can be applied.

The curing compound container shall be equipped with a calibrated sight-glass for verification of quantities used.

5.07.6 WEATHER LIMITATIONS. Lean concrete base course shall be constructed in accordance with the weather limitations of Subsection 5.01.6, "Weather Conditions and Curing Requirements" in these General Specifications.

5.07.7 LEAN CONCRETE BASE COURSE STRENGTH TESTS.

5.07.7.1 Production Lot. The compressive strength and thickness of lean concrete base course will be evaluated for each lot of production. A lot shall consist of three hundred fifty (350) lineal meters, or fraction thereof, of lean concrete base course placed with one pass of the production equipment, measured parallel to the roadway centerline.

5.07.7.2 Compressive Strength. The minimum average compressive strength of lean concrete base course shall be fifty (50) kilograms per square centimeter for each lot at seven days. Each lot shall be represented by four random samples. Each strength test will consist of the average of three cylinders prepared with material taken from a single load of lean concrete base course. If any cylinder shows obvious evidence as stated in ACI 214 of improper sampling, molding, or testing, it will be discarded and the strength test will consist of the strength of the remaining cylinders. All test cylinders will be prepared according to the requirements of MRDTM 528. The mean value of the four compressive strength tests will be reported to the nearest twenty-five hundredths (0.25) kilograms per square centimeter. The unit price paid for the lean concrete base course in that lot will be adjusted as provided in the provisions of Paragraph 5.07.11.1 "Adjustment in Concrete Unit Price" in these General Specifications.

5.07.8 OPENING TO TRAFFIC. No traffic or equipment will be permitted on lean concrete base course until the material has attained the specified seven day compressive strength as determined by the cores cut for the thickness determination. However, when the lean concrete base course is to be placed adjacent to previously constructed lean concrete base course, the paver and work bridges required for the completing new width will be permitted on the lean concrete base course seventy-two (72) hours after placement.

The contractor shall schedule his operations and route his equipment such that the base is subjected to minimal traffic. When it is necessary for construction traffic to travel on lean concrete base course which has attained the specified compressive strength, the traffic shall comply with all legal load restrictions applicable to traffic on kingdom highways. No overloaded vehicles will be permitted to travel on the lean concrete base course under any circumstances.

Damage to the curing compound or to the lean concrete base course which occurs as a result of the contractor's construction activities shall be promptly repaired by the contractor at his expense, when so directed by the Engineer.

5.07.9 LEAN CONCRETE BASE COURSE THICKNESS. Lean concrete base course shall be constructed to the specified thickness. Tolerances allowed for base and subgrade construction and other provisions of the specifications that may affect thickness shall not be construed to modify the lean concrete base course thickness requirements.

To determine thickness acceptability, the contractor shall drill one hundred (100) millimeters minimum diameter cores at the locations specified by the Engineer.

The Engineer will determine average core lengths in accordance with the provisions of MRDTM 525, except that the measurements will be made to the nearest tenth (0.10) of a millimeter and the average of the measurements will be reported to the nearest tenth (0.10) of millimeter.

When calculating average core lengths, cores which exceed the specified thickness by more than three (3) millimeters will be considered to have the specified thickness plus three (3) millimeters.

The Engineer may make field thickness measurements instead of measurements in accordance with MRDTM 525 when an initial core taken from any unit exceeds the specified thickness; however, when the initial core is less than the specified thickness, or when there is any question as to the unit thickness, thickness will be determined according with MRDTM 525.

To determine the acceptability of each lot of lean concrete base course, the following procedures will be followed:

An initial core shall be drilled in each lot and, if the thickness by the core is not deficient by more than three (3) millimeters, the thickness of the lean concrete base course in that lot will be considered acceptable.

If the thickness by the initial core is deficient by more than three (3) millimeters, but less than nineteen (19) millimeters, two (2)additional cores shall be drilled within that lot and the thickness by the three (3) cores will be averaged. The average of the three (3) cores will be used to determine acceptability, and the unit price will be adjusted as specified in Paragraph 5.07.11.1, "Adjustment in Concrete Unit Price," in these General Specifications.

If any core is deficient by more than nineteen (19) millimeters, additional cores shall be drilled at intervals not to exceed three meters in each direction from the deficient core, parallel to the roadway centerline, until one core is obtained in each direction that is not deficient by more than nineteen (19) millimeters. The lean concrete base course between these two cores will be evaluated separately from the balance of the lean concrete base course in that lot, and unless otherwise directed by the Engineer, shall be removed and replaced with lean concrete base course of the specified thickness.

At locations where cores have been drilled, the resulting holes shall be filled with lean concrete base course or other similar material as approved by the Engineer.

5.07.10 MEASUREMENT. Lean concrete base course will be measured by the square meter. The area to be paid for will be calculated on the basis of the dimensions shown on the plans, and adjusted by the amount of any change ordered by the Engineer.

5.07.11 PAYMENT. The contract unit price paid for lean concrete base course shall include full compensation for furnishing all labor, materials including at least one hundred eighty (180) kilograms cement per cubic meter of lean concrete base course, tools, equipment and incidentals, and doing all of the work involved in constructing lean concrete base course as shown on the plans, as specified in these specifications, subject to the following adjustment:

5.07.11.1 Adjustment in Concrete Unit Price. The accepted quantities of lean concrete base course, measured as provided above, will be paid for at the contract unit price, complete in place, except that an adjustment in the contract unit price will be made in accordance with Table 5.07-1, when the average lengths of the cores indicates deficiencies in thickness by more than three (3) millimeters but less than nineteen (19) millimeters, or Table 5.07-2 when the quality of the concrete represented by the mean value of the four (4) compressive strength tests is less than the specified seven day compressive strength.

When the lean concrete base course is deficient both thickness by more than three (3) millimeters, and in compressive strength, the percentage of the contract unit price shall be the product of the applicable percentages from Tables 5.07-1 and 5.07-2.

TABLE 5.07-1
ADJUSTMENT IN CONTRACT UNIT PRICE FOR
DEFICIENCY IN THICKNESS OF LEAN CONCRETE BASE COURSE

Core Length Less Specified Thickness in Millimeters Allowed	Contract Unit Price
0.0 to 3.0	100
3.0 to 6.0	93
6.0 to 9.0	85
9.0 to 12.0	75
12.0 to 15.0	63
15.0 to 19.0	50
less than 19.0	25*

TABLE 5.07-2
ADJUSTMENT IN CONTRACT UNIT PRICE FOR DEFICIENCY IN COMPRESSIVE STRENGTH OF LEAN CONCRETE BASE COURSE

Percent of Specified Strength (to the nearest whole percent)	Percent of Contract Unit Price Allowed
>100	100
97 to 99	92
94 to 96	85
90 to 93	77
85 to 89	68
80 to 84	60
75 to 79	50
<75	Remove and Replace, or leave in place at no payment.

* Material represented by cores deficient by more than nineteen (19) millimeters thickness and/or represented by lots attaining seven day compressive strengths with the mean value of the four (4) compressive strengths of less than seventy-five (75) percent of requirement, will be evaluated as to acceptance. The Engineer will determine if the lean concrete base course may remain in place. If allowed to remain in place, no payment will be made for such base. Lean concrete base course not permitted to remain in place shall be removed and replaced at the contractor's expense.

PAYMENT WILL BE MADE UNDER THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
50701	Lean Concrete Base Course	Square Meter

SECTION 5.08 - PORTLAND CEMENT CONCRETE PAVEMENT

5.08.1 DESCRIPTION. The work under this section consists of furnishing all materials and constructing a pavement surface using Portland cement concrete, furnishing and placing dowels and tie bars, furnishing and placing miscellaneous reinforcing steel and joint materials, constructing joints, and coring operations, in accordance with the details shown on the plans and the requirements of these specifications.

ITEM IN BILL OF QUANTITIES

Portland Cement Concrete Pavement

5.08.2 MATERIALS.

5.08.2.1 Portland Cement Concrete. Portland cement concrete for pavement shall consist of Portland cement, water, fine and coarse aggregates, and admixtures. The concrete shall be Class B as specified in Section 5.01.1, "Description" in these General Specifications.

5.08.2.2 Portland Cement. Portland cement shall be as specified in Paragraph 5.01.2.1, "Portland Cement" in these General Specifications.

5.08.2.3 Aggregates. Aggregates shall be of the Size B as listed in Paragraph 5.01.2.2, "Aggregate" in these General Specifications.

5.08.2.4 Water. Water shall be as specified in Paragraph 5.01.2.3, "Water" in these General Specifications.

5.08.2.5 Admixtures. Admixtures shall be the type approved for use as specified in Paragraph 5.01.2.4, "Admixtures" in these General Specifications, and as follows:

Air-Entraining admixtures shall be used for all concrete pavements above two thousand (2000) meters or cast in a high salt-laden environment, as specified in the special specifications. In either case, concrete shall be entrained to six percent (6%) +/ - 1.5% as determined by Test MRDTM 519 or 521.

Water-Reducers, may be used at the option of the contractor, as approved by the Engineer and the cost shall be borne by the contractor.

Mineral Admixtures, Type F, may be added to the concrete at the contractor's option to increase workability, or shall be required if alkali-silica reactive aggregates are used without Type 1P-MS cements.

5.08.2.6 Expansion Joint Filler. Materials for expansion joints shall conform to Paragraphs 6.22.2.2, "Joint Sealing Compounds" and 6.22.2.4, "Preformed Expansion Joint Filler," in these General Specifications.

5.08.2.7 Steel Reinforcement. Materials for tie bars and dowel bars shall conform to the requirements of Subsection 5.02.2, " Materials" in these General Specifications, for the dowel bars shall conform to the requirements of AASHTO M-254 with Type B coating except that the base metal shall conform to the requirements of ASTM A615. When epoxy coated reinforcing steel is designated it shall conform to the requirements of Paragraph 5.02.4.9 "Epoxy Coated Reinforcing Steel" in these General Specifications.

5.08.2.8 Plastic Sheet Bond Breaker. Bond Breaker shall be either polyvinyl chloride (PVC) plastic film conforming to the requirements of ASTM D 1593, Type II, or polyethylene plastic film conforming to the requirements of ASTM D 2103, Type II. The thickness shall be a nominal fifteen hundredths to two tenths (0.15 to 0.20) millimeters.

5.08.2.9 Curing Compound. Liquid membrane curing compound shall conform to the requirements of AASHTO2 M-148, Type 2.

5.08.3 EQUIPMENT. Equipment shall be as detailed in the Contractor's Program of Work, as approved by the Engineer.

5.08.4 CONSTRUCTION.

5.08.4.1 General. At least forty-five (45) days prior to paving, the contractor shall furnish for the Engineer's review for the following specification compliance:

A detailed sequence and schedule of concrete placement operations including, but not limited to; the proposed width of pavement to be placed, equipment, production rates, working hours, transporting, placement methods, curing, sawing, and sealing methods.

A detailed staking plan for grade control, including offset requirement.

A traffic control plan for pavement construction operations which includes provision for placement and maintenance of barriers required to protect the pavement from traffic for a minimum of seven days after concrete placement.

Mainline concrete pavement shall be constructed with slip-form paving equipment; however, areas inaccessible to slip-form pavers may be constructed with fixed side forms. Ramps and irregular pavement areas shall be constructed with either slip-form or fixed side forms.

Unless otherwise shown on the plans, mainline roadway pavement, including concrete shoulders or laybys, shall be placed in a single monolithic pass. Paving widths which are less than the full mainline width shall be constructed with longitudinal joints that are located on the lane line or at the edge of the main roadway, as provided for in Paragraph 5.08.4.5, "Joints" in these General Specifications.

The contractor may submit an alternate paving plan in writing at least forty-five (45) days prior to paving for review by the Engineer. The Engineer's approval shall be obtained before proceeding with the alternate plan.

5.08.4.2 Pavement Base. The surface of lean concrete base, cement treated base, or cement treated subgrade upon which the concrete pavement is to be placed shall first conform to the finish and elevation requirements specified for the material involved. The surface shall be free of all loose and extraneous material.

The plastic sheet bond breaker, specified in Paragraph 5.08.2.8, "Plastic Sheet Bond Breaker" in these General Specifications shall be placed on the base or subgrade before placing required load-transfer dowel assembles, expansion joint headers, or pavement concrete. The seams of the sheeting shall be overlapped a minimum of one hundred fifty (150) millimeters and the material shall be anchored to prevent displacement from all causes by methods approved by the Engineer. Areas that are damaged due to dowel assembly installation or other operations shall be repaired as approved by the Engineer.

Portland Cement concrete pavement shall not be constructed on lean concrete base, cement treated base, or cement treated subgrade prior to at least seven days after the placement of the lean concrete base, cement treated base or, cement treated subbase, unless otherwise approved by the Engineer.

5.08.4.3 Forming. Concrete pavement forms shall be placed in accordance with the following procedures:

1. The Contractor shall provide survey control for elevation control and alignment as approved by the Engineer.

2. Slip-Form Method. The contractor shall set taut guide lines to control both line and grade to conform to the requirements of Section 5.05, 'Steel Structures and Miscellaneous Metal Work,' in these General Specifications.

Slip-form paving equipment shall be equipped with automatic sensing and control devices and shall operate such that the machine automatically follows the guide line.

Slip-form pavers shall be equipped with traveling side forms designed to laterally support the concrete for a length of time sufficient to produce pavement of the required cross-section.

No abrupt changes in longitudinal alignment will be permitted. Horizontal deviation from the alignment shown on the plans shall not exceed three (3) centimeters.

3. Fixed-Form Method. Forms shall be set to the required line and grade and shall be as approved by the Engineer well in advance of placing concrete.

Forms shall be made of steel and have an approved section with a base width of at least one hundred (100) millimeters and a depth equal to or greater than the thickness of the pavement. The forms shall be staked with steel stakes of appropriate lengths. Each form section shall have a stake pocket at each end and intervals of not more than six hundred fifty (650) millimeters. The stake pockets shall have a device for locking the form to the

steel stakes. Each form section shall be straight and true, free from bend or warps at all times. The top of each form section shall not vary from a true plane by more than four (4) millimeters in one and three-tenths (1.3) meters.

Wood or other rigid forms may be used in irregular areas as approved by the Engineer.

Before forms are placed, the underlying material shall be finished to the required grade and shall be firm and smooth. The forms shall be uniformly supported upon the subgrade or base and shall be adjusted to the required grade and alignment. Forms shall be supported so that they will not deviate more than four (4) millimeters from the proper elevation during paving operations.

Forms shall remain in place until the day after placing concrete and shall be removed without damaging the pavement. Pry bars will not be used between the forms and the pavement concrete under any circumstance.

5.08.4.4 Placing and Finishing.

5.08.4.4.1 General. When the daytime temperatures are expected to exceed thirty-five degrees Celsius (35° C.) , the concrete shall be placed, compacted, and finished only when the temperature is below that limit and expected to decline.

Immediately prior to placing concrete, the contractor shall verify that the elevation of the grade wires controlling slip-form pavers and the elevation of the fixed-forms are such that the thickness and the finished grade of the pavement will meet the requirements of the project plans and these specifications.

Concrete shall be placed using methods that result in a minimum of handling and segregation.

Concrete placement shall be continuous between expansion or construction joints. The concrete shall be struck off, consolidated and floated by mechanical methods. When widths are less than one and three-tenths (1.3) meters, and where it is impractical to use mechanical methods, manual methods may be used to finish the surface of the concrete.

If surface drying or cracking should occur before the application of curing material, the entire surface of the concrete shall be kept moist by applying water with an atomizing nozzle so that a mist, and not a damaging spray, is formed. The water from the nozzle shall not be applied directly upon the concrete in a quantity sufficient to cause a flow or wash of the surface.

The contractor shall protect the base or subgrade from equipment cleaning operations at the end of each day's production. All concrete deposited on the base or subgrade during cleaning operations shall be removed from the base or subgrade immediately after cleaning is completed. Any damage to the base or subgrade shall be immediately repaired as approved by the Engineer, before resuming paving operations. Wash water will not be permitted to pond on the roadway.

Concrete which is spilled, splattered or scattered on existing pavement shall be removed before the end of each day's paving operations.

Pavement results and production rates are closely related to well managed operations; therefore, no work shall lag and all operations shall be completed within the optimum or specified time. If, in the opinion of the Engineer, satisfactory results cannot be obtained, the work shall be suspended until the contractor can assure the Engineer of satisfactory results.

5.08.4.4.2 Slip-Form Method. The equipment shall spread, consolidate, screen, and float-finish the concrete so that a minimum of hand finishing will be necessary and a well consolidated and homogeneous pavement is produced. Additional labor and equipment shall be supplied when paving beyond the limits of the side forms is required.

The machine shall vibrate the concrete for the full width and depth of the concrete. Such vibration shall be accomplished with vibrating tubes or arms working in the concrete and spaced not more than one (1) millimeter on centers. Vibrators shall operate at a minimum of five thousand (5,000) impulses per minute. Concrete placement shall cease immediately if a vibrator fails to function and cannot be immediately repaired, replaced, or supplemented with additional vibrators.

The machine shall be operated with as nearly a continuous forward movement as possible and all mixing, delivering, and concrete spreading operations shall be coordinated to provide uniform progress. If for any reason it is necessary to stop the forward movement of the paver, the vibratory and tamping elements shall also be stopped simultaneously.

Pavement edge slump, exclusive of edge rounding, in excess of six (6) millimeters shall be corrected at the time of operation, if possible. If correction is not possible while concrete is plastic, excessive edge slump shall be removed by saw cutting a minimum of one hundred thirty (130) millimeters from the pavement edge and replacing the removed section. At the contractor's option, the entire slab may be removed and replaced rather than saw cutting. Repairs required by excessive edge slump shall be done at the Contractor's expense.

When concrete is placed adjacent to previously constructed pavement, work bridges for placing and finishing the pavement and tracks on one side of the paver may be allowed on the new pavement provided that:

1. The previously placed pavement has been placed for a minimum of seventy-two (72) hours;

2. Pressure exerted on the pavement by the paver shall not exceed two (2) kilograms per square centimeter;

3. Tracks on the paver shall be equipped with protective pads, or the surface of the existing pavement shall be protected so that the surface is not damaged;

4. No part of the track shall be operated within three hundred thirty (330) millimeters of the edge of the pavement.

Any pavement which is damaged by the contractor's equipment or operations shall be repaired as approved by the Engineer and at the Contractor's expense.

With the exception of saws used for the construction of weakened plane joints, no other contractor's equipment will be allowed on the pavement until all the requirements specified herein have been met.

5.08.4.4.3 Fixed Form Method - Three types of self-propelled mechanical equipment will be required; the spreader, the finisher, and the float. A single machine incorporating two or more of these operations may be used if it has been demonstrated that such machine will accomplish satisfactory results. All wheels of all machines that ride on the finished concrete surfaces shall be equipped with rubber tires.

The concrete shall be spread uniformly between the forms immediately after it is placed by means of the spreading machine. The spreader shall be followed by the finishing machine equipped with not less than two oscillating or reciprocating screeds. The spreading machine, or the finishing machine, shall be equipped with vibrating equipment that will consolidate the concrete to the full paving width. Vibrators shall be attached to the rear of the spreading or finishing machine. Vibrators shall not rest on new pavements or the side forms or contact any tie bars, and power to the vibrators shall be such that when the motion of the machine is stopped, vibration will cease. Vibrators shall operate at a minimum of five thousand (5000) impulses per minute.

The concrete shall be spread full width before being struck off by the finishing machine. The concrete shall be struck off and consolidated so that the surface will conform to the finished grade and cross-section shown on the project plans and at the same time leave sufficient material for the floating operation. The spreading or finishing machine shall move over the pavement as many times and at such intervals as may be required to insured thorough consolidation.

After the pavement has been struck off and consolidated, it shall be floated with an approved longitudinal float.

The contractor may use a longitudinal float composed of one or more cutting and smoothing floats, suspended from and guided by a rigid frame the frame shall be carried on at least four wheels riding on and constantly in contact with the forms.

The contractor may use a longitudinal float which is worked with a sawing motion while being held in a floating position parallel to the roadway centerline and while passing gradually from one side of the pavement to the other. Forward movements along the centerline of the roadway shall be in successive advances of not more than one half the length of the float.

Instead of using either type of longitudinal float, a single machine which will satisfactory consolidate, finish, and float may be used. This machine may be towed by a spreading machine. This combination finishing-floating machine shall be equipped with screeds and vibrators as previously described. Floating shall be accomplished with a non-oscillating float held in a suspended position from the frame.

If any spreading, finishing, and floating equipment used proves inadequate to obtain the results prescribed, such equipment shall be remedied or satisfactory equipment substituted or added.

5.08.4.4.4 Fixed Form Manual Methods. Manual methods may be permitted by the Engineer in areas inaccessible to mechanical equipment.

When manual methods are permitted, concrete shall be deposited, spread, and struck off to such an elevation that, when properly consolidated, the surface shall conform to the required lines and grades. The strike-off board shall be moved forward with a combined longitudinal and transverse motion so that neither end is raised from the side forms. While striking off, a slight excess of concrete shall be maintained in front of the cutting edge at all times.

The concrete shall be consolidated by internal vibrator. Vibrators shall operate at a minimum of five thousand (5000) pulses per minute. The use of vibrators for shifting the concrete mass will not be permitted.

After consolidation, the concrete shall be tamped to the proper surface elevation and cross-section with an approved tamping or screening device or with a mechanical vibrating unit spanning the full width between forms. A small surplus of concrete shall be maintained in front of the tamper or vibrating unit. Tamping or vibrating shall continue until the required cross-section is obtained and the mortar is flushed slightly to the surface.

Other approved methods may be used to finish the concrete.

On grades in excess of five percent, a second strike-off board may be required to follow behind the tamper or vibrating unit and used in the same manner as the tamper to remove waves caused by concrete flow.

5.08.4.4.5 Joint Finishing and Edging. The pavement edges and joints shall be edged according to the details shown on the plans.

5.08.4.4.6 Surface Texturing. Surface texturing of the plastic concrete shall begin immediately after placement and finishing of the concrete. All excessive surface water shall be removed before texturing operations begin. Texturing shall be performed by applying a longitudinal burlap drag followed by a transverse texturing using steel tines.

Burlap and steel tines shall be supported by rolling mechanical bridges. They shall not be supported manually except in areas inaccessible to the bridges.

Rolling mechanical bridges supporting steel tines shall be equipped and operate with automatic sensing and control devices which follow the same control line as the slip-form paver. This machine shall be used for texturing the pavement only. Burlap shall not be

supported on the same rolling mechanical bridge used to support the steel tines.

Burlap shall be four ply, three hundred forty (340) grams per square meter (10oz) material and shall traverse the full width of the pavement to within one hundred thirty (130) millimeters of the pavement edge.

The timing of the texturing operations is critical. Grooves that close following texturing will not be permitted, and texturing shall be completed before excessive tearing of the tinning grooves occur.

Hand tinning brooms shall be provided and available at the job site at all times. Tine texturing shall be preformed so that the grooves produced will be uniform, normal to the roadway centerline, and shall extend over the entire roadway width to within eighty (80) millimeters of the pavement edge. Swerving groove patterns will not be permitted.

Texture grooves shall be one and five-tenths (1.5) to three (3) millimeters) wide and two and five-tenths (2.5) to five (5) millimeters deep. The center-to-center spacing of the grooves shall be from twelve (12) to twenty-five (25) millimeters.

If necessary, hardened concrete shall be textured by any method that will produce the required grooves, providing the pavement surface is not damaged.

5.08.4.4.7 Curing. Curing compound shall be applied to the completed concrete surface within fifteen (15) minutes after surface texturing operations and before any drying shrinkage or craze cracks begin to appear. In the event of surface drying or cracking, water applied with an atomizing nozzle shall begin immediately and continue until curing compound is applied. Curing compound shall not be applied on free standing water.

Liquid curing compound shall be applied in one or more uniform applications totaling between (1) and one and one-half (1.5) liters per square meters. The exact rate is to be determined by the Engineer based upon the Contractor's field trials which insure uniform coverage with no thin areas, runs, sags, skips or holidays. The curing compound container shall be equipped with a calibrated sight glass for verification of quantities used.

When the ambient temperature is above thirty degrees Celsius (30° C.), the contractor shall fog the surface of the concrete with an atomized mist of water. The surface of the pavement shall be kept moist until initial joint sawing is completed; fogging done after the application of the curing compound has been applied shall not begin until the curing compound has hardened sufficiently to prevent damaging it.

When misting is required, the entire surface of the concrete shall be kept damp by applying water with an atomizing spray nozzle in such a manner to avoid scouring or washing of the concrete.

Concrete curing shall be continued for not less than seven days and any damaged curing material shall be immediately repaired.

5.08.4.5 Joints.

5.08.4.5.1 General. Joints in concrete pavement will be designated as transverse expansion joints, longitudinal or transverse construction joints, or longitudinal or transverse weakened plane joints.

The faces of all joints shall be constructed perpendicular to the surface of the concrete pavement.

Joints shall be constructed of the type, to the dimensions, and at the location shown on the plans and as specified herein. Concrete placed in lanes adjacent to previously placed concrete shall have transverse weakened plane joints located to align with the weakened plane joints in the adjacent pavement.

5.08.4.5.2 Longitudinal Joints. Longitudinal joints in the main roadway shall be weakened plane joints or construction joints. Weakened plane joints shall be constructed by sawing.

Longitudinal weakened plane joints shall be constructed between traffic lanes and also between traffic lanes and shoulders if concrete shoulders wider than one and sixty-five hundredths (1.65) meters are specified.

Longitudinal joints in ramps and tapers shall be either weakened plane joints or construction joints. The location of longitudinal joints in ramps and tapers shall be as approved by the Engineer.

Unless otherwise shown on the plans, tie bars shall be placed in all longitudinal construction joints and all longitudinal weakened plane joints either by acceptable mechanical methods while the concrete is still plastic or after the concrete has hardened. When pavement is being placed adjacent to existing concrete pavement, tie bars shall be inserted into the existing concrete by drilling twenty (22) millimeter diameter holes into the hardened concrete. Tie bars shall be placed according with the details shown on the plans and shall be anchored into the existing concrete with nonshrink grout or epoxy. The Engineer's approval of the anchoring material shall be obtained before the start of work.

Tie bars shall be deformed No. 5 reinforcing steel bars conforming to AASHTO M 31, spaced seven hundred fifty (750) millimeters apart. Tie bars placed in pavement which is constructed without load transfer dowel assemblies shall be six hundred (600) millimeters long. Tie bars placed in pavement which is constructed with load transfer assemblies shall be five hundred (500) millimeters long. Tie bars shall be placed within twenty-five (25) millimeters of mid-depth of the slab. Tie bars placed in adjacent slabs of different thickness shall be placed at mid-depth of the thinner slab.

5.08.4.5.3 Transverse Expansions Joints. Transverse expansion joints shall be located at the junction of roadway pavement slabs and bridge approach slabs. The joints shall be formed in accordance with the details shown on the plans. Transverse expansion joints at locations other than bridge approaches shall be constructed as shown on the plans.

Transverse construction joints with tie bars shall be formed as shown on the plans and as specified herein. They shall be placed at the end of each day's production, or when placement of concrete is discontinued for more than one hour. Excess concrete shall not be placed beyond a construction joint at the end of a day's production. Tie bars shall be twenty five millimeter (25) diameter deformed (No. 8) reinforcing steel bars, six hundred (600) millimeters in length, spaced five hundred (500) millimeters apart. All tie bars shall be placed at mid-depth in the slab.

Transverse construction joints shall be formed perpendicular to the centerline of the roadway.

Transverse weakened plane joints shall be sawed as shown on the plans. Sawed joints shall extend over for the full main roadway width with a right forward skew extending the entire width at a rate of six hundred fifty (650) millimeters longitudinally per four (4) meters of width transversely. The sequence of spacing between adjacent transverse weakened plane joints shall be five (5) millimeters, four (4) millimeters, and repeat unless otherwise shown on the plans.

Transverse weakened plane joints in ramps and cross-roads shall be constructed perpendicular to the centerline of the ramp or cross-road.

Transverse weakened plane joints shall be constructed at least two (2) meters from transverse construction joints as measured along any longitudinal joint between lanes. The last sawed joint before a construction joint shall be omitted if it cannot meet the spacing requirements. A new joint sequence shall be started after a construction joint. The first weakened plane joint shall be constructed with the closest portion of the joint located two (2) meters from the transverse construction joint.

5.08.4.5.4 Joint Construction.

1. Sawed joints. Longitudinal or transverse weakened plane joints shall be sawed to the dimensions shown on the plans. Excess water from the sawing operations will not be permitted to stand on any subgrade to be paved. The contractor shall provide and maintain acceptable methods to control the water used in the sawing so the subgrade is not damaged.

Sawed joints shall be constructed before uncontrolled cracking of the pavement occurs; however, joints shall not be sawed until the concrete has hardened enough to prevent excessive tearing or raveling during sawing operations. The exact time when sawing will be done shall be determined by the contractor.

The contractor shall keep a properly maintained spare concrete saw on the project site at all times during which sawed joints are being constructed and shall be readily available as a substitute for the primary concrete saw.

Any procedure used to saw joints which results in premature uncontrolled cracking shall be revised immediately. The contractor shall repair damaged areas or random cracks as specified and directed by the Engineer. Any spalled or chipped concrete along the joints shall be repaired as approved by the Engineer.

If the joints are sawed in stages, the initial saw cut shall be of the minimum specified width and shall be sawed to the full depth shown on the plans.

Suitable guide lines or other devices shall be used to assure that the joints are constructed at the locations shown on the plans. When dowel assemblies are used, care shall be taken to assure joints are centered over the dowels.

Just prior to sealing, each joint shall be thoroughly cleaned of all foreign material, including curing compound and the joint faces shall be clean and surface dry when the seal is applied.

Immediately prior to applying joint sealant, an inert compressible material, approved by the Engineer, shall be inserted along the joint as shown on the plans. The compressible material shall be compatible with the joint sealant to be applied.

Sealant shall be applied according to the manufacture's recommendations. Any sealant spilled on the concrete pavement shall be removed.

Joints shall be sealed within ten (10) working days after the concrete has been placed and before opening the pavement to any traffic.

2. Construction Joints. Longitudinal and transverse construction joints shall be formed according to the details shown on the plans or as directed by the Engineer.

When the concrete is not finished, textured, and protected with curing material within one hour after placement, the Engineer may order the contractor to construct a transverse construction joint by sawing at the location established by the Engineer. All concrete placed beyond the construction joint shall be removed and disposed of by the contractor, at his expense, prior to continuing paving operations.

3. Transverse Expansion Joints. Transverse expansion joints shall be formed according to the details shown on the plans or as directed by the Engineer.

5.08.4.6 Opening Pavement to Traffic. Pavement shall not be opened to traffic less than twenty-eight (28) days after placement, and until all joints are sealed and the concrete has attained a compressive strength of at least one hundred seventy (170) kilograms per square centimeter unless otherwise approved by the Engineer.

5.08.5 PAVEMENT EVALUATION AND REMEDIAL MEASURES.

5.08.5.1 Pavement Surface Texture. The depth of surface texture grooves shall be measured according to the following requirements:

1. The depth of surface texture grooves shall be measured from the original concrete surface using a tire depth gauge with 1 mm gradations or a similar device approved by the

Engineer. Any projections above the original surface shall be remove by wire brushing or with a steel straightedge prior to taking measurement on hardened concrete. If measurements are being made on fresh concrete, the depth gauge shall be pressed down until substantially at the level of the original concrete surface.

2. With the depth gauge guides in contact with the original concrete surface, the plunger is depressed until contact is made with the bottom of the groove in the concrete. The gauge is then removed and the measurement recorded.

5.08.5.2 Pavement Smoothness. Pavement smoothness shall be evaluated by testing with a profilograph according to ASTM E-1274 (88).

Profilograph equipment will be furnished by the Ministry or the Contractor, as stated in the Special Specifications. All profilograph measurements shall be made by a team composed of one Engineer operator and one contractor. The work shall be shared equally. At the completion of each profilograph run, both operators shall sign the profilograph, certifying that they are in agreement that the equipment was found to be operating correctly and that the profilograph is a correct representation of the surface profile.

A pavement Profile Index shall be obtained as soon as possible after concrete placement.

Two profilograph readings shall be taken in each traffic lane, including ramps tapers, and climbing lanes, but excluding laybys, shoulders, and side street returns. The profilograph readings shall be taken in the vehicle wheel paths, one meter from each edge of the traffic lane.

The tested profile shall begin seventeen (17) meters ahead of concrete placed during the day's production and shall end seventeen (17) meters behind the end of the placed concrete. The tested profile will include bridge approaches and seventeen (17) meters of any pavement which abuts the new pavement.

If during the day's production, less than one thousand (1000) lane meters of pavement is placed, that pavement shall be tested with the subsequent day's production.

The contractor shall broom or clean the pavement by other approved methods immediately before to profilograph testing.

Surface profiles will be evaluated by the Engineer according to ASTM E-1274 (88). The Profile Index for a traffic lane will be the average of the two Profile Indexes obtained for that lane.

Pavement shall conform to the following Profile Index requirements:

1. Mainline pavement on tangent alignment and horizontal curves with a centerline radius of six hundred sixty (660) meters or more shall have a Profile Index of one hundred ten (110) millimeters per kilometer or less for any one hundred seventy-six (176) meter section.

2. Ramps and mainline paving on horizontal curves with a centerline radius three hundred thirty (330) meters or more but less than six hundred sixty (660) meters and within the superelevation on such curves shall have a profile index of one hundred forty (140) millimeters or less per kilometer of section.

3. Other pavement surfaces shall have a Profile Index of one hundred sixty (160) millimeters per kilometer or less in any one hundred seventy-six meters.

The contractor shall remove localized high pavement areas with a vertical deviation greater than eight (8) millimeters in eight (8) meters or less. High pavement areas shall be removed with grinding devices or multiple-saw machines as approved by the Engineer. Grinding machines shall be of the rotary type with a wheel base of at least three (3) meters and with vertically adjustable grinding wheels. Bush hammers or other impact devices shall not be used.

After removal of localized high areas, the affected one hundred seventy-six (176) meter pavement section shall be re-profiled; however, if the original Profile Index for the pavement was within the specified range, only that portion of the pavement which was originally contained in localized high areas shall be re-profiled.

Evaluations of localized pavement depressions will be made based on the presumed correction of adjacent high areas. When the pavement contains depressions greater than eight (8) millimeters in eight (8) meters or less, the contractor shall grind adjacent pavement as directed by the Engineer and the pavement shall be re-profiled as specified above.

If, after repair of highs and lows, the pavement does not conform to the specified requirements, additional pavement grinding and profile measurements shall be performed as directed by the Engineer.

In addition to the Surface Profile Index requirements, the pavement surface will be tested with a three (3) meter straightedge. The surface shall not vary in any one direction by more than three (3) millimeters, except at longitudinal and transverse construction joints. The surface shall not vary by more than six (6) millimeters across any longitudinal or transverse construction joint. Grinding will be required to insure that these requirements are satisfied.

The pavement shall be ground in such a manner that it does not form a smooth or polished pavement texture.

All pavement profile repairs shall be made before pavement thickness evaluations. Remedial work required to correct pavement smoothness deficiencies shall be performed at the Contractor's expense.

The contractor shall provide for the maintenance and protection of traffic during pavement profile repairs and subsequent pavement profile measurements as directed by the Engineer, at the Contractor's expense.

5.08.5.3 Pavement Cracks.

5.08.5.3.1 General. Cracks wider than twenty-five hundredths (0.25) millimeters penetrating the full depth of the pavement shall be repaired or the cracked pavement shall be removed and replaced, as specified herein, before opening the pavement to public traffic.

Within twenty-eight (28) days after concrete placement and before acceptance of the work, the Engineer will perform a pavement crack survey. The pavement shall be cleaned prior to the crack survey.

Cracks visible without magnification and which require repair (wider than twenty-five hundredths (0.25) millimeters) and pavement slabs which require replacement will be marked by the Engineer and shall be repaired or replaced by the contractor as specified, at the Contractor's expense.

Cracks observed later than twenty-eight (28) days after concrete placement and prior to final acceptance of the work shall be repaired by the contractor as specified and fifty (50) percent of the cost of such repairs will be allowed.

The contractor shall provide the Engineer with detailed information concerning the methods and materials to be used for crack repair for the Engineer's approval of the proposed methods and materials before beginning the required repairs.

The contractor, at his option and expense, may core cracked pavement as approved by the Engineer to determine the extent of cracking.

5.08.5.3.2 Crack Repair. Repair of random cracks shall be performed when any of the following types of full depth pavement cracks occur:

1. Transverse cracks which at any point are more than three (3) meters from transverse joints;

2. Longitudinal cracks which at any point are within three hundred (300) millimeters of longitudinal joints;

3. Longitudinal cracks which occur more than five hundred forty (540) millimeters from the longitudinal joint.

Cracks in pavement constructed without load transfer devices and longitudinal cracks in pavement constructed with load transfer devices shall be repaired by sawing or routing the cracks to a width of at least thirteen (13) millimeters and a depth of twenty-five (25) millimeters and sealing with a gray colored joint sealant material as approved by the Engineer. Just prior to sealing, each crack shall be thoroughly cleaned and all foreign material and the crack faces shall be clean and surface dry when the sealant is applied.

When any portion of a repaired crack is within one hundred fifty (150) millimeters of a

non-working sawed joint, that sawed joint shall be filled with epoxy as approved by the Engineer.

Transverse cracks in pavement constructed with load transfer devices shall be repaired by deepening any immediately adjoining uncracked saw cuts to thirteen (13) millimeters above the dowels and pressure injecting an approved gray colored epoxies into the random crack. Pressure injection of epoxy shall be done only between five (5) and thirty-five degrees Celsius (35° C.).

Crack repair shall begin seven days after completion of the crack survey and shall be completed within thirty (30) days after the start of repairs.

Payment for pavement slab which require crack repairs as specified herein, will be adjusted as specified under Paragraph 5.08.7.2, "Adjustment in Contract Unit Price For Deficiency in Concrete Pavement Specified Strength" in these General Specifications.

5.08.5.3.3 Pavement Removal and Replacement - Cracks not detailed in Subparagraph 5.08.5.3.1, "General," in these General Specifications shall be repaired by removal and replacement of the Portland cement concrete pavement. Cracked pavement shall be removed to the limits established by the Engineer. Cracked pavement will generally require removal of the full lane width of the slab over the length of at least two (2) meters. Excessively cracked pavement areas will require full width pavement removal as directed by the Engineer. Pavement to be removed shall be cut full depth prior to removal.

Base material which is damaged as a result of pavement removal shall be repaired or replaced by the contractor as approved by the Engineer.

Removed pavement and base material shall be disposed of by the contractor as approved of by the Engineer.

After removal of cracked pavement, tie bars and dowel bars shall be replaced by drilling and grouting at approximately mid depth in the existing concrete pavement. Tie bars shall be placed in transverse construction joints and shall be six hundred (600) millimeters long, No. 5 deformed bars, placed on six hundred (600) millimeters centers. Dowel bars shall be placed in construction joints which coincide with existing transverse weakened plane joints. The dowel bars shall be five hundred (500) millimeters long, smooth three hundred twenty (320) millimeter diameter bars placed at distances of 15, 65, 105, 225, 295, 340 millimeters from the adjacent longitudinal joint which is nearest to the outside shoulder lane.

Replacement concrete shall be placed, finished, and cured in accordance with the requirements of the original pavement.

5.08.5.4 Pavement Thickness. Concrete pavement shall be constructed to the specified thickness. Tolerances allowed for base and subgrade construction and other provisions of these specifications which may affect thickness shall not be construed to modify such thickness requirements. To determine thickness acceptability, the contractor

shall drill one hundred (100) millimeters minimum diameter cores at the locations specified by the Engineer.

The Engineer will determine average core thickness according to MRDTM 525, except that measurements will read to the nearest tenth of a millimeter and the average will be reported to the nearest tenth of a millimeter.

When calculating average core thickness, cores which exceed the specified thickness by more than three (3) millimeters will be considered to have the specified thickness of plus three (3) millimeters. The Engineer may make field length measurements instead of measurements according to MRDTM 525 when the original core in any secondary unit, as defined below, meets or exceeds the specified thickness. However, measurements will be made according to provisions of MRDTM 525 when any question arises concerning the thickness, and on all cores used to determine the average pavement thickness for payment.

Payment will be evaluated on the basis of primary and secondary units. A primary unit of pavement will be the area of mainline pavement placed during one day's paving operations. Additionally, each ramp, including tapers, each intersection, each cross-over, etc. will be considered as a primary unit.

A secondary unit of pavement will consist of three hundred fifty (350) meters or fraction thereof, of each mainline traffic lane and each shoulder in the primary unit. Additionally, each thirteen hundred (1300) square meters of pavement in ramps, tapers, intersections, crossroads, etc., will be considered as a secondary unit, regardless of when the concrete was placed.

One core shall be drilled in each secondary unit. If the length of the core is not deficient by more than three (3) millimeters, that secondary unit will be paid for at one hundred percent (100%) of the contract unit price. If the length of that core is deficient by more than three (3) millimeters, but less than fifteen (15) millimeters, two (2) additional cores shall be drilled within the secondary unit and the length of the three cores will be averaged. If the average length of the three cores is not deficient by more than three (3) millimeters, the secondary unit will be paid for at one hundred percent (100%) of the contract unit price. If the average length of the three cores is deficient by more than three (3) millimeters, payment for the secondary unit will be made in accordance with the provisions of Table 5.08-I, Subsection 5.08.7, "Adjustment in Contract Unit Price for Deficiency in Concrete Pavement Thickness" in these General Specifications.

If the core in a secondary unit is deficient by more than fifteen (15) millimeters, that core will not be used to determine the average thickness of the secondary unit, and additional cores shall be drilled at intervals not exceeding three and three-tenths meters in each direction from the deficient core, measured parallel to the centerline, until one core is obtained in each direction which is not deficient by more than fifteen (15) millimeters. The pavement between these two cores will be evaluated separately from the balance of the pavement in that secondary unit. The limits for the evaluation will be between the longitudinal weakened plane or construction joint on each side of the core and between the next transverse weakened plane, construction, or expansion joint beyond the last two

cores. Unless the Engineer allows the pavement to remain, it shall be removed and replaced with pavement of the specified thickness and no payment will be made for removal of the deficient pavement. If deficient pavement is allowed to remain, no payment will be made for the deficient pavement and one additional core will be drilled in the remaining portion of the secondary unit and that portion will be separately evaluated for payment as previously specified.

If deficient pavement is removed either by the order of the Engineer or at the option of the contractor, it shall be removed and replaced within the evaluation limits. After the pavement has been replaced, one core shall be drilled at random in the secondary unit outside of the limits of the replaced pavement and one core shall be drilled in the new pavement. Pavement represented by the drilled core outside of the limits of the replaced pavement will be evaluated for payment as previously specified. If the core drilled in the replaced pavement is less than the specified thickness, no payment will be made for the replaced pavement.

At all locations where cores have been taken, the resulting holes shall be filled with concrete as approved by the Engineer and at the contractor's expense.

5.08.5.5 Compressive Strength. The minimum average compressive strength of Portland cement concrete pavement shall be one hundred seventy (170) kilograms per square centimeter for each lot at twenty-eight (28) days. Each lot shall be represented by four (4) random samples. The lots shall be the same as listed in Paragraph 5.08.5.4, "Pavement Thickness" in these General Specifications. Each strength test will consist of the average of three cylinders prepared with material taken from a single load of the paving Portland cement concrete. If any cylinder shows evidence of improper sampling, molding, or testing as stated in ACI 214, it will be discarded and the strength test will consist of the strength of the remaining cylinders. All test cylinders will be prepared according to the requirements of MRDTM 528. The mean value of the four compressive strength tests will be reported to the nearest one (1) kilogram per square centimeter. The unit price paid for the Portland cement concrete pavement in that lot will be adjusted as provided in the provisions of Paragraph 5.08.7.2, "Adjustment in Contract Unit Price For Deficiency in Concrete Pavement Specified Strength" in these General Specifications.

5.08.6 MEASUREMENT. Portland cement concrete pavement will be measured by the square meter, calculated from the dimensions shown on the plans and adjusted by the amount of any change ordered by the Engineer. No deduction will be made for areas less than one (1) square meter. No allowance will be made for concrete pavement placed outside the planned dimensions unless otherwise ordered by the Engineer.

5.08.7 PAYMENT. The accepted quantities of Portland cement pavement, measured as provided above, will be paid for at the contract unit price which shall include full payment for furnishing all labor materials, tools, equipment, including surface profile equipment if required by the Special Specifications, and incidentals, including drilling and filling core holes, and for doing all the work involved in constructing the pavement, complete in place as shown on the plans, and as specified. When load transfer dowel assemblies are specified, separate payment for this work will be as specified in the Special Specifications.

5.08.7.1 Adjustment in Contract Unit Price for Deficiency in Concrete Pavement Thickness. Cracked pavement slabs which require repair according to Paragraph 5.08.5.3 "Pavement Cracks" will be paid for at eighty (80) percent of the contract unit price for the pavement repaired, as measured between the original longitudinal and transverse pavement joints abutting the repaired pavement. However, no adjustment to the contract unit price will be made for pavement slabs which contain only cracks which are observed later than twenty-eight (28) days after concrete placement.

When the average length of cores indicates pavement thickness is deficient by more than three (3) millimeters but not more than fifteen (15) millimeters, payment will be made as specified in Table 5.08-1.

TABLE 5.08-1

Core Thickness, Less Than Specified Thickness Mm.	Percent of Contract Unit Price Allowed
0.0 to 3.0	100
3.0 to 6.0	93
6.0 to 9.0	85
9.0 to 12.0	75
12.0 to 15.0	63

5.08.7.2 Adjustment in Contract Unit Price for Deficiency in Concrete Pavement specified strength. Pavement represented by compressive strength tests which do not meet the minimum strength specified, will be paid for in accordance with Table 5.08-2. All pavement represented by compressive strength test which do not provide at least seventy-five (75) percent of the specified strength shall be removed and replaced unless allowed to remain in place by the Engineer. If allowed to remain in place, no payment will be made for such pavement.

TABLE 5.08-2

Percent of Specified Strength (to nearest whole percent)	Percent of Contract Unit Price Allowed
>100	100
97 to 99	92
94 to 96	85
90 to 94	77
85 to 89	68
80 to 84	60
75 to 79	50
< 75	Remove and Replace, or (leave in place at no payment).

When pavement is determined to be deficient in thickness by more than three (3) millimeters and deficient in strength, the percentage of unit price allowed shall be the product of the applicable percentages from Tables 5.08-1 and 5.08-2. However, when

such product results in a payment of less than fifty (50) percent, of the contract unit price, the Engineer may require the deficient pavement to be removed and replaced. If allowed to remain in place, no payment will be made for such pavement.

When pavement contains cracks which are observed within twenty-eight (28) days after the concrete placement, and when the pavement is deficient in thickness by more than three (3) millimeter but less than fifteen and zero-tenths (15.0) millimeters and/or deficient in strength, the percent of the contract unit price allowed will be eighty (80) percent of the unit price allowed in Table 5.08-1 or 5.08-2 or eighty (80) percent of the product of the appropriate percents from Table 5.08-1 and 5.08-2.

The amount of authorized, completed, and accepted Work measured as provided above, will be paid for at the unit price (s) bid in the Bill of Quantities. Such price(s) shall include furnishing, transporting and placing all materials except those materials specified to be paid for under other items of Work, and shall include all labor, equipment, tools and other items of Work necessary for the proper completion of the Work as specified in accordance with Subsection 1.07.2, "Scope of Payment" of these General Specifications.

PAYMENT WILL BE MADE UNDER THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
50801	Portland Cement Concrete Pavement	Square Meter

SECTION 5.09 - PORTLAND CEMENT CONCRETE PAVEMENT REPAIRS

5.09.1 DESCRIPTION. The work done under this section shall consist of furnishing all labor, materials, and equipment necessary to repair Portland cement concrete pavement according with the requirements of these specifications, and as shown on the plans, or established by the Engineer.

ITEMS IN BILL OF QUANTITIES

Spall Repair
Slab Repair
Pavement Grinding
Pavement Grooving
Joint and Crack Repair
Edge Sealing

5.09.2 SPALL REPAIRS.

5.09.2.1 Description. The work shall consist of furnishing all materials and removing loose patches and materials incompatible with the new repairs, such as temporary bituminous patching materials from potholes, damaged joints and spalled areas, thoroughly cleaning the repair area, and placing new patching material according with the details shown on the plans, and as specified herein, and in reasonably close conformity with the existing pavement cross-section.

5.09.2.2 Material Requirements.

5.09.2.2.1 General. Patching materials shall be suitable for the anticipated work conditions before allowing traffic loads, or as shown on the plans, the special specifications and these specifications.

Accelerated Strength Portland Cement Concrete Patching Material. The patching material for Accelerated Strength Portland Cement Concrete shall consist of either Type III or Type II Portland cement and calcium chloride or other accelerators meeting the AASHTO M-144 requirements and shall attain a minimum compressive strength of fourteen (14) kilograms per square centimeter in six (6) hours. Materials for the concrete mix shall conform to the requirements of Section 5.01, "Portland Cement Concrete," in these General Specifications for Class A concrete. The coarse aggregate shall be as designated for size No. 67 in accordance to AASHTO M-43.

5.09.2.2.2 Rapid Setting Patching Material. Rapid setting material shall be a product approved by the Engineer. A list of approved patching materials is maintained by the Ministry .

5.09.2.2.3 Epoxy Resin Patching Material. Epoxy resin patching material shall be a low-modulus, moisture insensitive epoxy blended with suitable fillers, as prepared in accordance with the manufacturer's recommendations and as approved by the Engineer.

5.09.2.3 Construction Requirements.

5.09.2.3.1 General. Spalled areas to be repaired will be designated by the Engineer and shall be repaired prior to any required pavement grinding. The extent of the repair area will be marked out by the Engineer and will be no less than seventy (70) millimeters outside of the area of delamination. The Engineer will be the final authority if questions arise in regard to the need for patching or the extent of a required patch.

Spalled areas less than one hundred and fifty (150) by thirty (30) millimeters, adjacent to joints, need not be repaired under this specification.

Patching material shall not be placed under conditions which will adversely affect the quality of work. The Engineer shall be the sole judge in determining suitability of working conditions.

Concrete within the patch area shall be removed to the minimum depth specified for the patching material being used, with tools that will remove concrete without excessively damaging sound concrete. If the depth of the spall exceeds half the thickness of the concrete pavement slab, the affected pavement shall be removed and replaced, as directed by the Engineer and in accordance with Subsection 5.09.3, "Full Depth Slab Repairs" in these General Specifications.

Asphalt concrete shoulders adjacent shall be cut longitudinally to the depth of the patch and to a width of not more than three hundred (300) millimeters. The cut shall extend three hundred (300) millimeters beyond both transverse limits of the patch to facilitate placement of formwork. Shoulders shall be patched with material similar to the existing shoulder material.

Patch perimeters shall be cut substantially vertical, with sharp tools to minimize fracturing beyond the cut, for at least thirty (30) millimeters in depth.

Prior to patching, the area to receive patching material shall be abrasively blasted to remove foreign materials. Prior to placing patching materials, residue and dusts shall be blown free with a oil-less air source, or other satisfactory means.

The area to receive the patching material shall be clean and dry to promote proper bond. Patching material shall be done in a workmanship like manner and lapping over to surrounding pavement will not be permitted.

Patching material shall be placed, consolidated, and finished to produce a dense patch. If the area to be patched abuts a joint or working crack, a bond-breaker of styrofoam, polyethylene foam or other suitable material not less than four (4) millimeters or the joint or crack width, whichever is greater, shall be placed prior to patching.

The finishing and texture of the patched surface shall conform to the elevation and texture of the existing pavement.

Any repair material that develops any appreciable thickening while being placed shall be discarded and no additional payment will be allowed.

5.09.2.3.2 Accelerated Strength Portland Concrete Pavement Patch. Following the excavation and abrasive blast cleaning of the repair void as previously specified, the entire area to be filled with patching material shall be coated with an approved "new-to-old" epoxy according to the recommendations of the manufacture. The patching material shall be placed promptly to before hardening of the bond coat occurs. Should the bond coat harden prior to patching, a new application of bond coat shall be applied before patch filling operations resume.

5.09.2.3.3 Rapid Set Patch. Rapid set patching materials shall be blended and mixed installed as recommended by the manufacture.

Upon completing removal and surface preparation, as previously stated, the surface shall be either lightly damped or dry prior to filling with rapid setting material, as recommended by the manufacture.

The material shall be consolidated to the proper grade and float finished. Texturing to match the existing pavement will not be required.

5.09.2.3.4 Epoxy Resin Patches. Epoxy resin shall be proportioned and blended according to the manufacture's directions and the suitable filler shall then be combined to produce a mortar or grout, uniform in consistency according to the recommendations of the resin manufacture.

Upon completing removal and surface preparation, as previously stated, the surface shall be dry prior to filling with the epoxy mixture.

The material shall be consolidated to the proper grade and float finished. Texturing to match the existing pavement will not be required.

5.09.3 FULL DEPTH SLAB REPAIRS.

5.09.3.1 Description. The work shall consist of furnishing all materials and removing existing concrete pavement, constructing full depth repairs of Portland cement concrete at locations shown on the plans, as specified herein, and in reasonably close conformity with the existing pavement.

5.09.3.2 Material Requirements. Repair material shall conform to Subsection 5.01.1, Description" in these General Specifications, except concrete shall be the same Class used in the original construction or Class B, using size 57 coarse aggregate as designated in AASHTO M-43.

Tie bars, Dowel bars, expansion joint fillers, joint seal, and liquid membrane-forming curing compound, shall conform to the requirements as stated in Section 5.08, "Portland Cement Concrete Pavement" in these General Specifications.

5.09.3.3 Construction Requirements. Areas to be repaired will be designated by the Engineer and shall be repaired before any specified pavement grinding. The Engineer shall be the final authority in determining the extent of repairs.

Repairs shall be carried out under conditions that will not adversely affect the quality of work. If these conditions arise, the Engineer shall have the final determination as to whether or not to proceed with the planned work.

Removal of those portions of pavement to be removed shall be performed in such a manner to avoid damaging the adjacent pavement or areas adjacent to the repair work. In no case shall the work be done in such a manner as to damage the existing base material. Any damaged base, or spalling of the existing pavement to remain, shall be remedied by replacing the damaged base with concrete repair material, and spalls greater than thirty (30) millimeters deep and thirty (30) millimeters wide shall be repaired by full depth saw cut removal of the damaged portion, or as directed by the Engineer at the Contractor's expense.

Pavement slabs containing multiple full depth cracks separating the slab in three or more pieces, and other slabs as designated by the Engineer, shall be entirely removed and replaced. Pavement slabs containing a single diagonal crack intersecting the longitudinal and transverse joints by less than one-third (1/3) of the length and width of the slab shall be repaired by removal and replacement of that corner piece.

Other areas to be repaired shall have the configuration and minimum dimensions shown on the plans. These areas shall be saw cut to the full depth of the slab.

When the repair boundary is at an existing contraction joint, the new joint shall be constructed using the plain round thirty-two (32) millimeter diameter, five hundred (500) millimeter long dowel bars. The dowel bars shall be placed as shown on the plans, and shall be placed at mid-depth of the existing slab. Holes drilled for the dowel bars shall be not less than thirty-five (35) millimeters in diameter, and extend two hundred fifty (250) millimeters into the existing slab. The dowel shall be grouted in place by an approved non-shrink grout or approved epoxy. Prior to placing repair concrete, the protruding two hundred fifty (250) millimeters dowel shall be uniformly coated with a thin film of heavy waterproof grease.

When the repair boundary is adjacent to an existing longitudinal joint, six hundred (600) millimeters long sixteen (16) millimeter diameter (No. 5) deformed steel tie bars shall be placed in three hundred (300) millimeter deep holes drilled into the existing slab at seven hundred fifty (750) millimeter intervals, as shown on the plans, and grouted into place with approved non-shrink grout or approved epoxy.

When the repair boundary does not abut a joint, six hundred (600) millimeter long twenty five (25) millimeter diameter (No. 8) deformed steel bars shall be placed at five hundred (500) millimeter spacings in the transverse perimeter, and six hundred (600) millimeter long sixteen (16) millimeter diameter (No. 5) deformed steel bars shall be placed in the longitudinal perimeter of the repair. Holes drilled into the existing slab shall be three hundred (300) millimeters deep at mid-depth and shall be grouted in place by approved non-shrink grout or approved epoxy, thoroughly consolidated, finished to the plane of the existing slab, and textured to match the existing slab texture. However, no texturing will be required if pavement grinding or grooving will be the final finished surface.

New sealant reservoir may be either cast or saw cut into the repaired-to-existing concrete interface as shown on the plans and as specified under Subsection 5.06.4," Pavement Grinding," in these General Specifications.

5.09.4 PAVEMENT GRINDING.

5.09.4.1 Description. The work shall consist of furnishing all materials and grooving the surface of existing Portland cement concrete pavement at the locations shown on the project plans and according to the requirements of these General Specifications.

5.09.4.2 Equipment and Procedures. Grinding shall be done with diamond blades, mounted on a self-propelled machine that has been designed for grinding and texturing pavements. The equipment shall be designed such that it will not cause strain or damage to the underlying surface of the pavement. Grinding equipment that causes excessive ravels, aggregate fractures, spalls, or disturbances of the transverse or longitudinal joints shall not be used.

All grinding machines used in the cross-section of a lane shall have the same wheel or grinding head configuration. Overlapping of grinding passes will not be allowed.

The noise level created by any one machine shall not exceed eighty-six (86) dbA at a distance of fifteen (15) meters normal to the direction of traffic.

No equipment will be allowed within three meters of the lane open to public traffic. Maintenance and protection of traffic shall conform to the requirements of Section 9.02 'Traffic Control Through Work Zones' in these General Specifications.

5.09.4.3 Construction Requirements. Before grinding, repaired areas shall be completed as specified. Grinding shall be done prior to any specified sawing and sealing of existing transverse and longitudinal joints.

Pavement grinding shall be performed longitudinally. The contractor shall grind a test section of pavement, where designated by the Engineer, to determine that the equipment proposed for use will provide the desired texture.

Grinding shall produce a uniform surface appearance over the entire designated area. Grinding shall continue for the full lane width until the pavement surface on both sides of all transverse joints and of all cracks is in the same plane. Longitudinal ridges in adjacent passes of the grinding equipment shall not exceed three (3) millimeters in depth.

In any one lane, a maximum distance of three hundred (300) meters of unfinished area between the lead grinder and the last grinder in that lane will be allowed at the end of the work shift.

Ground surfaces shall not be smooth or polished and shall have a coefficient of friction of not less than forty-hundredths (0.40) as measured by ASTM E-1274 (88).

The surface shall have a finish texture of grooves between two (2) to three (3) millimeters wide, and spaced from one and one-half (1.5) millimeters to three (3) millimeters and not less than one (1) millimeter to three (3) millimeters.

Residue and excess water resulting from grinding shall be removed from the roadway by vacuuming or other methods approved by the Engineer. The residue shall be removed before restoring traffic to the lane. Residue and water from the grinding operations shall not be allowed to flow across lanes occupied by traffic, onto roadway shoulders, or to flow into gutters and drainage facilities. Dried residue shall be removed before allowing traffic to occupy the work area.

After grinding has been completed, the pavement surface will be tested according to ASTM E-1274 (88). Two Profilograph readings will be taken in the wheel paths one meter from each edge of the traffic lane.

The Profile Index shall not exceed nineteen (19) centimeters per sixteen hundred (1600) meter section. In addition all areas representing localized high points having deviations in excess of eight (8) millimeters in eight (8) meters, shall be reground until such deviations as indicated by re-runs of the Profilograph do not exceed eight (8) millimeters in eight (8) meters.

Additional grinding shall be performed, if necessary, to reduce the overall Profile Index, as measured by the Profilograph, to nineteen (19) centimeters per kilometer section, or remaining portion thereof, along any line parallel to the edge of the pavement. In any area requiring regrinding, the regrinding shall be done over the full lane width.

The contractor shall broom the surface of the concrete where Profilograph readings are to be taken. Profilograph measurements are the responsibility of the contractor on all but the final acceptance measurement. The contractor shall bear the full cost of profilograph measurements and associated traffic control.

5.09.5 PAVEMENT GROOVING.

5.09.5.1 Description. The work consists of furnishing all materials and grooving the surface of the existing pavement at the locations shown on the plans and according to the requirements of these specifications.

5.09.5.2 Equipment and Procedures. Grooving shall be done with diamond blades mounted on a multi-blade arbor on a self-propelled machine which has been built for grooving pavements. The groover shall have a depth control device which will detect variations in the pavement surface and adjusts the cutting head height to maintain the specified groove depth. The grooving machine shall have alignment control devices. Flailing type grooving will not be permitted.

5.09.5.3 Construction Requirements. The pavement surface shall be grooved longitudinally. The methods used and tolerances employed shall provide a surface which will provide good wet or dry driving characteristics.

Longitudinally grooved areas shall begin and end at lines normal to the width of the pavement centerline and shall be centered within the lane line.

No equipment shall be allowed within one (1) meter of a traffic lane open to the public. Maintenance and traffic control shall be according to Section 9.02 "Traffic Control Through Work Zones" in these General Specifications.

Removal of all slurry or residue resulting from the grooving operations shall be continuous. Residue from grooving operations shall not be permitted to flow across shoulders or lanes occupied by public traffic or to flow into gutters or other drainage facilities. Dried residue resulting from grooving operations shall be removed from pavement surfaces with a pick-up or power broom before such residue is blown by the action of the traffic or wind.

The noise level created by any one machine shall not exceed eighty-six (86) dbA at a distance of fifteen (15) meters normal to the direction of traffic.

At the beginning of each work shift, all grooving machines shall be equipped with a full compliment of grooving blades that are capable of cutting grooves of the specified width, depth, and spacing.

If during the course of the work a single blade becomes incapable of cutting a groove, work will be permitted to continue for the remainder of the work shift and the contractor will not be required to otherwise cut the groove omitted because of the failed blade. Should two or more grooving blades on any individual grooving machine become incapable of cutting grooves, the contractor shall cease operations.

The grooved area of any selected six hundred (600) millimeters by thirty (30) millimeters longitudinal area of pavement specified to be grooved shall not be less than ninety (90) percent of that area. Ungrooved pavement within the selected area shall be that which occurs as a result of pavement irregularities.

5.09.5.4 Tolerances. Longitudinal grooving shall begin one hundred fifty (150) millimeters from the outside edge of pavement or reflective marker and run in a continuous pattern across the lane surface to within one hundred fifty (150) millimeters of the longitudinal joint. The groove pattern shall be three (3) millimeters width by five (5) millimeters in depth with a center-center spacing of nineteen (19) millimeters. The groove spacing tolerance shall be plus or minus three (3) millimeters. The width of the groove shall have a tolerance of plus or minus one and one-half (1.5) millimeters.

On curves or superelevations, the width of the groove may exceed the above dimensions as approved by the engineer.

If the pavement profile is very uneven, the Engineer may permit a variation in maximum groove depth in areas adjacent to rutted pavement or faulted joints.

Grooving shall be terminated a minimum of three hundred (300) millimeters from any device in place in the pavement, such as manholes, inlet castings, valve boxes, etc.

5.09.6 JOINT AND CRACK REPAIR.

5.09.6.1 Description. The work shall consist of furnishing all materials and renovating longitudinal and transverse contraction control joints and routing and sealing random cracks in existing pavement, as specified herein, detailed on the plans and as directed by the Engineer.

5.09.6.2 Material Requirements. Joint sealant shall conform to the requirements of Paragraph 6.22.2.2 "Joint Sealing Compounds" in these General Specifications. Grout for filling wide joints shall be a low modulus, moisture insensitive epoxy resin grout of a viscosity suitable for flowing into the irregular cracked portion of the joint. The ratio of epoxy resin to sand shall be 1:7 and 1:10 or as specified by the epoxy manufacture. Epoxy binder material shall conform to the requirements of ASTM C-881-78(83).

Sand used in epoxy grout shall conform to the requirements of Subsection 5.01.2, "Materials" in these General Specifications except the gradation shall be as follows:

Sieve Size	Percent Passing
2.38 mm (No 8)	100%
1.19 mm (No. 16)	95-100
0.297 mm (No. 50)	10-40
0.074 mm (No. 200)	0-4

A rapid set Portland cement concrete pavement patching material may be substituted for epoxy grout as approved by the Engineer.

5.09.6.3 Construction Requirements.

5.09.6.3.1 General. Joint and crack repairs shall be accomplished by first removing old joint sealant and joint insets, then refacing and cleaning the joints and cracks followed by installation of a backer rod (if required) and installation of new joint sealant.

5.09.6.3.2 Joint and Crack Preparation. Cracks shall be sawed or routed to the dimensions shown on the plans.

Inserts shall be removed from insert-formed joints by sawing to provide a clean vertical face. The width and depth of the saw cuts shall be sufficient to insure complete removal of the insert and to provide a finished joint of the proper dimensions specified for the sealant material to be used. If the insert is not vertical additional parallel saw cuts shall be provided as required to insure full removal of the inserts.

Joints that are not insert formed shall be sawed to the widths and depths specified herein. Joints previously sawed and sealed will be inspected to assure the proper dimensions and shall be re-sawed to the proper widths and depths, when required.

Joints shall be sawed as follows:

Initial Joint Width..."W"		Sawed Joint Width	Sawed Joint Depth "D" Pavement Surface to bottom of backer rod
"W"	<13 mm	13 mm	43 mm
13 mm<W	<19 mm	19 mm	54 mm
19 mm<W	<38 mm	No Sawing Required	2W+19 mm

Immediately after saw cutting a joint or routing a crack, old sealant shall be removed and internal surfaces of the joint or crack shall be thoroughly cleaned by sandblasting. Sand for sandblasting shall be sharp and clean. The amount of compressed air and the nozzle pressure shall be such that the joints and cracks will be thoroughly cleaned and the edges will have etched surfaces.

5.09.6.3.3 Dowel Placement. Dowel bars shall be placed in transverse joints when the initial joint width is greater than thirty-eight (38) millimeters. Slots for dowel bar placement shall be made with two saw cuts perpendicular to the joint and thirty-eight (38) millimeters apart. Saw cuts shall be one half the depth of the slab plus thirteen (13) millimeters. Concrete shall be removed between the saw cuts and smooth epoxy coated dowels which are thirty-two (32) millimeters in diameter and five hundred (500) millimeters long shall be inserted into the formed slot. Dowels shall be supported above the bottom of the slot so that epoxy grout can flow around the circumference of the dowel. Dowels shall be placed so that the dowel is embedded equal distances into the two slabs. Dowel bars shall conform to the requirements of AASHTO M254 with type B coatings except that the core material shall conform to the requirements of ASTM A615. Dowel bars shall be placed as shown on the plans, and shall be thoroughly and uniformly coated with a waterproof grease prior to placement into the slot then covered with an approved epoxy grout. A thirteen (13) millimeter thickness of preformed joint filler shall be placed next to one edge of the joint such that a twenty-five (25) millimeter deep reservoir, +/- three (3) millimeters, can be formed at the top, as shown on the plans. The wide joint shall be filled with epoxy grout.

On longitudinal joints where the joint opening exceeds thirty-eight (38) millimeters, the saw cuts for placement of tie bars perpendicular to the joint, shall be twenty-two (22) millimeters apart so that a sixteen (16) millimeters diameter (No.5) deformed tie bar two hundred forty (240) millimeter long can be inserted into the slot. This two hundred forty (240) millimeter inch tie bar shall be placed at mid slab depth and equal distance into each slab, then covered with an approved epoxy grout. The bars shall be at three hundred sixty (360) millimeter spacing. The wide joint shall also be filled with epoxy grout.

5.09.6.3.4 Cleaning Prior to Sealing. Prior to sealing, all foreign or loosened particles shall be removed from the joints to the full depth of the original sawed joints. The removal of all foreign or loosened particles shall be accomplished with compressed air or other means approved by the Engineer. Air compressors shall be capable of furnishing a sufficient supply of compressed air to clean the joints properly.

5.09.6.3.5 Separating or Blocking Medium (Backer Rod). Immediately following the cleaning of joints and prior to the application of sealant, a backer rod composed of an inert, compressible material shall be inserted along the lower portion of the joint groove at a depth as shown on the plans.

The backer rod shall be compatible with the sealant in accordance with the manufacture's recommendation. The product shall be clean, free of scale, foreign matter, oil or moisture and shall be non-absorbing. The Engineer shall be assured that the material proposed for use has been used successfully in similar installations.

Backer rod sizes shall be as follows:

Joint Width Millimeters (mm)	Backer Rod Diameter Millimeters (mm)
13 mm	16 mm
19 mm	25 mm
25 mm	32 mm
32 mm	38 mm
38 mm	50 mm

5.09.6.3.6 Installation of Sealer. Sealant compound shall not be placed unless the joint is dry, clean, and free of dust. The face of the joint shall be surface dry and the ambient temperature shall both be at least ten degrees Celsius (10° C.) at the time of application of the sealant. Installation of the sealant shall be such that the in-place sealant shall be well bonded to the concrete and free of voids or trapped air. The joints shall be sealed in a neat and workmanlike manner, so that upon completion of the work, the surface of the joint sealant material will be six (6) millimeters, +/- 3 millimeters below the adjacent pavement surface. The contractor shall refill all low joints before final acceptance. Any excess material on the surface of the pavement shall be removed and the pavement surface shall be left in a clean condition. Vehicular or heavy equipment traffic shall not be permitted on the pavement in the area of the joints during the curing period.

5.09.7 EDGE SEALING.

5.09.7.1 Description. The work shall consist of furnishing all materials and sawing or routing, and sealing the joints between the Portland cement concrete pavement and the asphaltic concrete distress lane. This work shall be done after the completion of any specified rehabilitation of the distress lane or outside shoulder. The work shall be accomplished in accordance with the details shown on the plans and as specified herein.

5.09.7.2 Materials.

5.09.7.2.1 General. The sealant to be used shall be any one of the following:

A mixture of asphalt and one hundred percent (100%) vulcanized, granulated rubber;

A mixture of asphalt, extender oil, and reclaimed high natural and ground vulcanized rubber;

Premix block material consisting of asphalt and one hundred percent (100%) percent vulcanized rubber;

Premixed block material consisting of asphalt and extender oil, reclaimed high natural and ground vulcanized rubber.

5.09.7.2.2 Ground Rubber. All material shall meet the requirements of these specifications and the contractor shall furnish certification showing that the material meets the requirements. The certificate shall be signed by the party legally able to bind the supplier and his signature shall be notarized.

Rubber shall be free of fabric, wire or other contaminating materials. No more than four (4) percent by weight calcium carbonate may be included to prevent the particles from sticking together.

The gradation of the material will be determined by apparatus consisting of the following:

1. Sieves conforming to AASHTO Designation M92 with a diameter of thirty-two (32) millimeters. The sieves shall be nested in such a manner that overloading on any given sieve will not happen.

2. Balance. The capacity of the balance shall be five hundred (500) grams or more, with a sensitivity to the nearest one (1) gram.

3. The size of the sample is a critical factor. Sample size shall be in the range of one hundred (100) to one hundred fifty (150) grams. Samples shall be obtained either by use of a sample thief or by splitting an entire bag using rifle splitter.

4. The sample shall be separated into a series of sizes using such sieves as are necessary. The sieving operation shall be conducted by means of a lateral and vertical motion of the sieve, accompanied by jarring action so as to keep the sample moving continuously over the surface of the sieve. The motion of the sieves shall be accompanied by a mechanical shaker. In no case shall fragments in the sample be turned or manipulated through the sieve by hand. Sieving shall continue for a five (5) minute period.

5. The mass of each size shall be determine on a scale or balance conform ing to the requirements as specified above in paragraph (2). The material shall be weighed to the nearest one (1) gram.

6. The results of the sieve analysis shall be reported as total percentages passing each sieve. Percentages shall be calculated on the basis of the total mass of the sample including material finer than the 0.075 mm (No. 200) sieve.

The gradation and the specific gravity shall meet the requirements in Table 5.09-1.

TABLE 5.09-1

Sieve Size	Asphalt Rubber Vulcanized	Asphalt Rubber Reclaimed Hi Natural	Premixed Asphalt Rubber 100% Vulcanized	Premixed Asphalt RubberReclaimed Hi Natural
No. 8	100%	100%	100%	100%
No. 10	95-100	---	95-100	---
No. 30	0-10	25-50	---	25-50
No. 50	---	10-45	---	10-45
No. 100	---	0-10	---	0-10
Sp. Gr.	1.15+/-0.2	1.25+/-0.2	1.15+/-0.2	1.25+/-0.2

Ground rubber (reclaimed high natural) shall be dry, free flowing blend of reclaimed high natural rubber and rubber scrap which has a natural rubber content of at least twenty-five percent (25%). The natural rubber content will be determined in accordance with the requirements of ASTM D297.

5.09.7.2.3 Asphalt Cement. Asphalt-Rubber (vulcanized):

Type A - The asphalt cement shall conform to the require ments for Asphalt Cement AC-10 in Table 4.0I-1 in Subsection 4.01, "Bituminous Materials" in these General Specifications.

Type B - The asphalt cement shall conform to the requirements for Asphalt cement AC-20 in Table 4.01-1 in Subsection 4.01, "Bituminous Materials" in these General Specifications.

Extender Oil - Extender oil shall be resinous, aromatic hydrocarbon meeting the requirements in Table 5.09-2 when tested as indicated:

TABLE 5.09-2

Test	ASTM Test	Requirement
Viscosity, SSU at38 degrees	D 88	2,500 Min.
Flash Point, COC Open Cup	D 92	392 Min.
Molecular Analysis, Asphaltene, % by wt. Aromatic, % by wt.	D 2007	0.1 Max., 55 Min.

5.09.8 MEASUREMENT.

5.09.8.1 Spall Repair. Spall repair shall be measured by the square meter for all patches successfully constructed. Each patch will be measured to the nearest three (3) centimeters. The total cumulative calculated area based on the measurements will be rounded off to the nearest tenth of a square meter.

5.09.8.2 Full Depth Slab Repairs. Full depth slab repairs shall be measured by the square meter for all repairs successfully constructed. Each repair area will be measured to the nearest three (3) centimeters. The total cumulative calculated area based on the measurements will be rounded off to the nearest tenth of a square meter.

Full depth slab repairs shall be measured by the square meter for all repairs successfully constructed. Each repair area will be measured to the nearest three (3) centimeters. The total cumulative calculated area based on the measurements will be rounded off to the nearest.

5.09.8.3 Pavement Grinding. Pavement grinding will be measured by the square meter of pavement ground and accepted. The quantity will be determined by multiplying the width by the length of the ground area.

5.09.8.4 Pavement Grooving. Pavement grooving will be measured by the square meter of grooved pavement and accepted. The quantity of grooved pavement will be the product of length and width of grooved area. No deduction will be made for grooving omitted items at joints, manholes, inlets or other similar installations in the pavement surface.

5.09.8.5 Joint and Crack Repairs. Joint and crack repairs will be measured by the linear meter.

5.09.8.6 Edge Sealing. Edge sealing will be measured by the linear meter.

5.09.9 PAYMENT.

<u>PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:</u>

5.09.9.1 Spall Repairs. The accepted quantities of spall repairs, measured as provided for above, will be paid for at the contract unit price per square meter, which shall include full compensation for furnishing all materials, tools, equipment, incidentals, and for doing all the work of preparing, filling, finishing, and texturing of spalls, if required, complete and in place, including the removal and disposal of waste concrete, and the reconstruction of shoulder work which was removed or damaged during the spall repair work.

5.09.9.2 Depth Slap Repair. The accepted quantities of full depth slab repair, measured as provided for above, will be paid for at the contract unit price per square meter, which shall include full compensation for furnishing all materials, tools, equipment, and incidentals, and for doing all the work of preparing, filling, finishing, and texturing, if required, complete and in place, including the removal and disposal of waste concrete, and the reconstruction of shoulder work which was removed or damaged during the repair work.

5.09.9.3 Pavement Grinding. The accepted quantities of pavement grinding, measured as provided above, will be paid for at the contract unit price, which shall be full compensation for the work complete as specified, including providing profilograph equipment, if required by the Special Specifications.

5.09.9.4 Pavement Grooving. The accepted quantities of pavement grooving, measured as provided above, will be paid for at the contract unit price per square meter, which price shall be full compensation for the work, complete as specified herein.

5.09.9.5 Crack Repairs. The accepted quantities of joint and crack repairs measured as provided above, will be paid for at the contract unit price per linear meter, which price shall be full compensation for the work, complete in place.

5.09.9.6 Edge Sealing. The accepted quantities of edge sealing measured as provided above, will be paid for at the contract unit price per linear meter, which price shall be full compensation for the work, complete in place.

The amount of authorized, completed, and accepted Work, measured as provided above, will be paid for at the contract unit prices(s) in the Bill of Quantities. Such price(s) shall include furnishing, transporting and placing all materials except those materials specified to be paid for under other items of Work, and shall include all labor, equipment, tools and other items of Work necessary for the proper completion of the Work as specified in accordance with Subsection 1.07.2, "Scope of Payment" in these General Specifications.

PAYMENT WILL BE MADE UNDER THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
50901	Spall Repair	Square Meter
50902	Slab Repair	Square Meter
50903	Pavement Grinding	Square Meter
50904	Pavement Grooving	Square Meter
50905	Joint and Crack Repair	Linear Meter
50906	Edge Sealing	Linear Meter

SECTION 5.10 - BRIDGE PARAPETS

5.10.1 DESCRIPTION. This Work shall consist of furnishing and installing bridge parapets as and where shown on the drawings or as established by the Engineer.

The finishes of exposed areas of concrete parapets shall be uniform without blow holes and blemishes.

5.10.2 MATERIALS.

5.10.2.1 Concrete. Concrete for bridge parapets shall be Class A and meet the requirements of Subsection 5.01.1, "Description" in these General Specifications.

5.10.2.2 Steel. Reinforcing steel for bridge parapets shall meet the requirements of Section 5.02, "Reinforcing Steel" in these General Specifications.

5.10.3 CONSTRUCTION REQUIREMENTS. Concrete parapets shall be constructed in accordance with Section 5.03, "Concrete Structures" in these General Specifications.

5.10.4 METHOD OF MEASUREMENT. Bridge parapets shall be measured by the linear meter installed, completed and accepted. No separate measurement shall be made for expansion joints, specially fabricated units for nosing areas, special requirements at junction with transition walls, reinforcement, stitching concrete, and grit blasting if needed, but shall be considered subsidiary to bridge parapets.

5.10.5 PAYMENT. The amount of completed and accepted Works will be paid for at the contract unit price(s) for Bridge Parapets as specified in the Bill of Quantities, which prices shall be full compensation for furnishing all materials, labor, equipment, tools, supplies and other items necessary for the completion of the Work as specified in Subsection 1.07.2, "Scope of Payment" in these General Specifications

PAYMENT WILL BE MADE UNDER:

ITEM NO.	PAY ITEM	PAY UNIT
51001	Bridge Parapets	Linear Meter

SECTION 5.11 - DRAINAGE ON STRUCTURES

5.11.1 DESCRIPTION. This Work shall consist of furnishing and installing gully and channel grates and frames on bridge deck, subways and underpasses for collecting surface water from structures and draining pipes and downpipes which are connected to the gully and channel grates by hoppers. The gully and channel grates and frames may be of cast iron or cast steel with or without integral cast hoppers. In the absence of integral cast hoppers, fabricated uPVC or GRP hoppers will be necessary.

The Contractor shall submit, as early as possible, details of all drainage material and components he proposes to use for the approval of the Engineer. No material or component shall be incorporated in the Works without written approval of the Engineer.

The Work shall also consist of installing permeable backing and weep pipes to earth retaining structures, weep and backfilling with selected free draining granular material to the line and extent indicated on the plans.

ITEMS IN THE BILL OF QUANTITIES
Heavy Duty Gully Grates and Frames
Permeable Backing
Granular Backfill
Bridge Deck Drainage System

5.11.2 MATERIALS.

5.11.2.1 Gully and Channel Grates and Frames. Gully and channel grates and frames shall conform to the requirements of Saudi Arabian Standards or BS 497 Amendments PD 6398 (1968) and AMD 554 (1979) and they shall be Grade A (BS 497). Alternatively, drainage gullies shall be of heavy duty design of the type(s) indicated on the plans, made of structural steel or gray cast iron to conform with AASHTO M105, Class No. 25 S, or equivalent.

Integral cast hoppers shall be of the same grade and quality as the gully or channel grate and frame. Fabricated uPVC or GRP shall be to the approval of the Engineer who may require material and load testing before giving approval.

5.11.2.2 Iron and Steel Pipes. Cast iron pipes shall conform to the requirements of Saudi Arabian Standards Organization or BS 78 Parts 1 and 2 and spun iron pipes to BS 1211. Steel pipes shall conform to the requirements of BS 3534 or SASO (Saudi Arabian Standards Organization).

5.11.2.3 PVC and uPVC Pipes. Pipes of synthetic material for general drainage use shall be approved pipes of polythene, polypropylene, or polyvinylchloride. Unplasticized polyvinylchloride pipes shall conform to the requirements of Class 2 and 3 ASTM D3333 or BS 3506; alternatively, PVC pipes and sleeves shall comply with SAS14, DIN 8062 and 150.R/161 and fittings shall comply with ISO/DIN 4422, 10 bars class.

5.11.2.4 Permeable Backing. Permeable backing to structures shall be precast porous concrete blocks laid in stretcher bond with dry joints in a minimum of two hundred twenty-five (225) millimeters thick walling or approved geotextile composite with a high density polyethylene core, eight (8) millimeters thick completely wrapped in a spun bound polypropylene geotextile on the approved list, such as HITER or MIRADRAIN.

5.11.2.5 Granular Backfill. Granular backfill to structures shall be natural sands, gravel, crushed rock or crushed concrete. The materials shall be well-graded and lie within the following gradation limits:

Sieve Size	Percentage Passing
75 mm (3")	100
37.5 mm (1 1/2")	85 - 100
9.5 mm (3/8")	45 - 100
4.75 mm (No. 4)	25 - 85
0.425 mm (No. 40)	8 - 45
0.075 mm (No. 200)	0 - 10

5.11.2.6 Aluminum Pipes. Aluminum pipes, sleeves and fittings shall conform to ASTM B211, alloy 6061-T6.

5.11.2.7 Fiberglass Pipes. Fiberglass pipes, sleeves and fittings shall conform to ASTM D2996, class C liner.

5.11.2.8 Miscellaneous Materials. Miscellaneous metal items, including supports, accessories, fittings, fixtures, embedded items, hangers, and strips, shall conform to AASHTO M183, ASTM A207, A42 and AASHTO M164, as applicable. All ferrous items shall be hot dip galvanized after fabrication, in conformance with AASHTO M111 and ASTM A153.

Concrete surface primer shall be cut-back asphalt conforming to ASTM D41 and waterproofing asphalt shall conform to ASTM D 449, type A.

Non-shrink grout shall be as approved by the Engineer.

Joint sealants shall be as specified in Paragraph 6.22.2.2, "Joint Sealing Compounds" in these General Specifications.

Paint shall be as specified in Section 5.13, " Painting of Structures" in these General Specifications.

5.11.3 CONSTRUCTION REQUIREMENTS. Drainage pipes and gullies shall be laid to the lines and levels and bedded, laid, jointed and protected, all as shown on the drawings or as established by the Engineer. (Top elevation of the gullies shall be five (5) to ten (10) millimeters below the surface of the asphalt).

When drainage pipes are cast into concrete structures, the Contractor shall take adequate precautions to prevent any displacement of the pipes during the concreting operation.

Drainage pipes shall be tested for water tightness and the test procedure shall be agreed with the Engineer. Where drainage pipes are located within the cellular parts of a bridge deck where access after completion of the deck is limited, then the installation and testing of the pipes shall be completed and accepted by the Engineer before the deck construction is allowed to proceed to the stage where free access will be available.

5.11.4 METHOD OF MEASUREMENT.

5.11.4.1 Gully Grates and Frames. Gully grates and frames shall be measured by the number of units installed, completed and accepted. Hoppers connecting the gully frames to drainage pipes shall not be measured separately but shall be considered subsidiary to gully grates and frames.

5.11.4.2 Bridge Deck Drainage Pipes. Bridge deck drainage pipes which are part of the bridge deck drainage system shall be measured by the linear meter of the total length of pipes installed, completed and accepted. No separate measurement will be made for pipes cast into concrete or for pipes connecting fully the channel frames to drainage pipes or for pipe supports and joints or for discharge hoppers from drainage pipes to downstand pipes, but shall be considered subsidiary to drainage pipes.

5.11.4.3 Permeable Backing. Permeable backing shall be measured by the square meter successfully placed and accepted.

5.11.4.4 Granular Backfill. Granular Backfill shall be measured by the volume in cubic meters placed and compacted to the approval of the Engineer.

5.11.4.5 Subsidiary Work. No measurement will be made for weep pipes or for testing of gully grates and frames or for pipe supports or for testing of drainage pipes as these are subsidiary work to the items listed in Subsection 5.11.5 Payment" in these General Specifications.

5.11.5 PAYMENT. The amount of completed and accepted Work measured as provided above, will be paid for at the contract unit price for each item as specified in the Bill of Quantities, which price shall be full compensation for furnishing, fabricating and placing all materials, for all labor, equipment, tools and all other items necessary for the proper completion of the Work as specified in Subsection 1.07.2 "Scope of Payment" in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
51101	Heavy Duty Gully Grates and Frames	Unit
51102	Permeable Backing	Square Meter
51103	Granular Backfill	Cubic Meter
51104	Bridge Deck Drainage System	Linear Meter

SECTION 5.12 - WATERPROOFING FOR STRUCTURES

5.12.1 DESCRIPTION. The Work shall consist of furnishing and placing and an approved waterproofing membrane over bridge deck and box-culverts, undersides of foundation to bridges, box culverts and walls and faces of foundation to bridges as directed by the Engineer.

The Work shall include the proper cleaning and preparation of the substrate; the application, protection, drying, and curing of the waterproofing membrane; the protection of pedestrian, vehicular or other traffic upon or underneath or near the Work; the protection of all portions of structures (superstructure and substructure) and other portions of the Work against disfigurement by spatters, splashes and smirches, or waterproofing materials; and the supplying of all tools, scaffolding, labor, workmanship, and materials necessary for the entire Work.

ITEM IN BILL OF QUANTITIES
Waterproof Membrane

5.12.2 MATERIALS.

5.12.2.1 Primer. Primer for sealing concrete surfaces prior to waterproofing shall be fully compatible with the bonding agent and waterproofing.

5.12.2.2 Bonding Agent. Unless otherwise specified, the bonding agent shall be hot applied oxidized bitumen having a softening point (Ring and Ball) within the range of eighty to one hundred degrees Celsius (80 to 100° C.) and penetration within the range of twenty to thirty degrees Celsius (20 to 30° C.).

5.12.2.3 Proprietary Waterproofing Systems. Proprietary waterproofing systems shall be bituminous membranes reinforced with two layers of suitable reinforcement to provide impervious membranes easy to lay and able to withstand the laying and compaction of bridge wearing courses. They shall be of a type accepted by the Engineer who will give approval only after satisfactory site trials.

5.12.2.4 Submittals. The Contractor shall submit for the Engineer's approval specifications, installation instructions and general recommendations by the manufacturer(s) of the waterproofing membrane materials. Submittals shall include published data or certified test data for each material, showing compliance with the requirements specified herein.

The Contractor shall furnish a five year guarantee for repair or replacement of any waterproofing barrier installed under this Contract, which leaks water or otherwise fails to perform as required within the guarantee period, due to failure of materials or workmanship. The guarantee shall include an agreement to remove and replace other Work which has been superimposed on or otherwise placed against the waterproofing barrier, to the extent required to repair or replace the waterproofing barrier Work.

All materials furnished under this specification shall be accompanied by the manufacturer's Certificate of Guarantee. The certificate shall give the quantity of waterproofing material in the shipment and shall identify same by order number, project location and destination. Materials not accompanied by a Certificate of Guarantee shall be sampled in the field and samples submitted to an approved independent laboratory for testing, all at the Contractor's expense.

The Engineer will approve materials on the basis of the Certificates of Guarantee and/or laboratory tests, but reserves the right to resample and have retested any materials used during the progress of the work. Should any material not conform to the specifications, it shall be rejected, previous approval notwithstanding.

Materials shall be tested by the methods specified herein or in the ASTM or AASHTO as applicable.

5.12.2.5 Membrane Waterproofing Materials.

1. Asphalt primer : ASTM D41, cut-back asphalt.
2. Waterproofing asphalt : ASTM D449, Type A for vertical wall surfaces below grade, Type B for horizontal surfaces which are concealed, Type C for exposed surfaces.
3. Asphalt-saturated felt : ASTM D226, No. 15 (630 gr/sq.m., organic fiber).
4. Asphalt-saturated fabric : ASTM D173 (215 gr/sq.m., cotton fabric, asphalt saturated).
5. Glass fiber fabric : ASTM D1668 (68 gr/sq.m., impregnated with bitumen).
6. Plastic cement : Proper type for application indicated and compatibility with other materials.
7. Coated base sheet : ASTM D2626, Type I (1.5 kg/sq.m., asphalt coated).
8. Coal-tar pitch : ASTM D450.
9. Creosote primer for coal tar pitch : ASTM D43
10. Coal-tar saturated felt : ASTM D227.

5.12 .2.6 Miscellaneous Materials.

1. Primers, fillers, sealers, joint tapes, adhesives, flashings, cant strips, and accessories shall be as recommended by the manufacturer of the primary protective barrier materials, for the intended application.

2. Paper slip sheet : two and seven tenths (2.7) kg. rosin-sized paper.

3. Protection Course : On waterproofed surfaces exposed to backfill, a twelve (12) millimeter thick, asphalt impregnated and coated, rigid fiber-type insulation board shall be provided.

5.12.3 CONSTRUCTION REQUIREMENTS.

5.12.3.1 Preparation of Surfaces. The concrete deck on which the waterproofing membrane is to be laid shall have a surface finish as shown on the drawings. The surface shall be finished to such an accuracy that when tested with a three meter straight edge,

the maximum depression shall not exceed ten (10) millimeters, and abrupt irregularities shall not exceed three (3) millimeters.

Immediately before waterproofing is laid, the surface to be waterproofed shall be clean, dry and free from membrane curing compounds and projecting tying wire.

Waterproofing work shall proceed only after substrate construction and preparation, and all penetrating work have been satisfactorily completed; and only when weather conditions comply with the manufacturer's recommendations and will permit the materials to be applied in accordance with such recommendations.

Preparation of concrete surfaces shall conform to the requirements of Subparagraphs 5.13.3.1.6 through 5.13.3.1.17, in these General Specifications, and as specified herein.

The repair of defects in concrete shall be carried out in accordance with the waterproofing membrane manufacturer's specific recommendations, specially insofar as patching is concerned. Conventional Portland cement patching materials may not be compatible with certain waterproofing systems, and proprietary materials may need to be used for this purpose.

Acid to be used for etching, when approved, shall be a 10/90 to 15/85 dilution ratio of commercial grade phosphoric acid in water solution, applied at a rate of one (1.0) liter per square meter of surface to be prepared. In all other respects, the requirements of Subparagraph 5.13.3.1.9 in these General Specifications shall apply.

Upon completion of surface preparation, the surface to be waterproofed shall be primed, cant strips shall be installed, joints shall be sealed and bond breakers shall be applied thereto as shown or as directed. Separate flashings, as recommended by the manufacturer, shall be installed, wherever indicated to precede the waterproofing system.

5.12.3.2 Laying Waterproofing Materials. Waterproofing materials shall be laid and installed according to the recommendations of the manufacturer and to the approval of the Engineer. Waterproofing shall not be laid when the ambient temperature is below four degrees Celsius (4° C.).

Only plant and equipment fitted with rubber tires may travel with the permission of the Engineer, on water-proofed surfaces which have been adequately protected with an approved protective layer.

The following requirements shall be complied with:

1. Hot bitumen shall not be applied under conditions which result in foaming of the material. The manufacturer's limitations on heating shall be complied with. High temperatures shall not be maintained for periods longer than needed for installation, and in no case for more than three (3) hours. Bitumen shall not be heated to a temperature higher than fourteen degrees Celsius (14° C) below flash point.

2. Multiple-ply courses of hot bitumen and felts or fabrics shall be installed in

individual courses, unless manufacturer recommends shingle-fashion courses. Courses shall be laid in the direction or directions recommended.

3. Membranes to vertical substrates shall be nailed as shown and as recommended. Nails shall be covered with courses of fabric set in hot bitumen or plastic cement.

4. Membranes shall be reinforced at corners and around projections in substrate, with double course of glass fiber, set in hot bitumen or plastic cement.

5. Membranes shall be extended as flashing at edges, openings and projections, so as to complete the waterproof enclosures as required for leak-proof performance.

6. Membrane composition : Alternate plies of felt and glass fiber fabric, set in continuous moppings of bitumen, with top ply of felt, as shown on the plans :

(1) Two-ply Membrane : one (1) fabric, one (1) felt, forty (40) kg bitumen [three (3) moppings].

(2) Three-ply Membrane : one (1) fabric, two (2) felt, fifty-four (54) kg bitumen [four (4) moppings].

7. Membranes shall be protected from melting due to temporary exposure to high ambient air temperatures, solar heat or other heat sources.

5.12.3.3 Concrete Surfaces. Concrete Surfaces sealed with one coat of primer where specified. Primed surfaces shall not be covered until all solvent constituent has evaporated. When spirit-based primer is used, a minimum of twenty (20) hours at temperatures between ten and sixteen degrees Celsius (10 to 16° C.) shall elapse before waterproofing is laid. When bituminous emulsion is used, all water shall be allowed to evaporate.

The sheeting shall be installed in accordance with the manufacturer's instructions and shall be laid so that no air is trapped between it and the concrete surface or between successive layers of sheeting. Unless otherwise specified, joints between sheets shall be lapped with end laps of at least one hundred fifty (150) millimeters and side laps of at least one hundred (100) millimeters. The joints shall be arranged so that at no point are there more than three thicknesses of sheeting, and, as far as possible, so that water will drain away from the exposed edge.

5.12.3.4 Protective Layers to Waterproofing. The protective layer shall be laid and compacted without damage to the waterproofing.

5.12.3.5 Painting with Tar or Bitumen. Prior to the application of tar or bitumen paint, surfaces to which it is to be applied shall be clean and dry. The first coat shall be allowed to dry before the second coat is applied.

Tar or bitumen painting shall consist of two coats of hot-applied tar complying with BS 76 of viscosity grade within the range thirty to thirty-eight degrees Celsius (30 to 38° C.) equi-viscous temperature (evt) with a coverage of one (1.0) square meters per liter or two (2) coats of cutback bitumen complying with BS 3690 of viscosity grade within the range of twenty-five (25) to fifty (50) seconds (standard tar viscometer) at forty degrees Celsius (40° C.) with a coverage of one and eight-tenths (1.8) square meters per liter or any material approved by the Engineer.

5.12.3.6 Acceptance of Waterproofing Membranes.

1. The waterproofing membranes shall be water-tight and not deteriorate in excess of limitations published by the manufacturer.

2. In-place Testing : Before completed membranes on horizontal surfaces are covered by protection course or other Work, the surface waterproofed shall be tested for leaks with fifty (50) millimeters depth of water maintained for twenty-four (24) hours. Substrates shall be examined for leaks. Leakage, if any, shall be corrected, and the test shall be repeated until no leakage is observed.

5.12.4 METHOD OF MEASUREMENT. Waterproofing membrane shall be measured by the square meter laid, completed and accepted for different types of waterproofing membranes. No separate measurement shall be made for site trials to determine the suitability of waterproofing membranes, but shall be considered subsidiary to the type of waterproofing membrane for which site tests have been carried out. The tuck-in of waterproofing membranes will not be measured for payment.

Tar or bituminous painting to surfaces permanently in contact with backfilled material shall be measured by the square meter of surface area so painted, irrespective of whether or not more than one coat of paint is used.

No measurement will be made for protective layers to waterproofing membranes or to surfaces painted with bituminous coatings, but shall be considered subsidiary to the waterproofing membrane or to the bituminous paint.

No separate measurement shall be made of tapes, bond breakers, flashings, cant strips, and other accessories as they are considered subsidiary to the pay items of this section. No measurement shall be made of unauthorized areas as specified in Subsection 1.07.6 - "Unauthorized Work" in these General Specifications. In addition, waterproofing barriers that are applied to unauthorized areas shall be completely removed, when so directed, to the satisfaction of the Engineer and at the Contractor's expense.

5.12.5 PAYMENT. The amount of completed and accepted Work measured as provided above will be paid for at the contract unit price(s) for "Waterproof Membrane, Two (2) layer or Three (3) Layer," as specified in the Bill of Quantities, which prices shall be full compensation for furnishing all materials, labor, equipment, tools, supplies and all other items necessary for the completion of the Work as specified in Subsection 1.07.2, "Scope of Payment" in these General Specifications.

PAYMENT WILL BE MADE UNDER:

ITEM NO	PAY ITEM	PAY UNIT
51201	Waterproof Membrane	Square Meter
5120101	Waterproof Membrane, 2 Layer	Square Meter
5120202	Waterproof Membrane, 3 Layer	Square Meter

SECTION 5.13 - PAINTING OF STRUCTURES

5.13.1 DESCRIPTION. This Work consists of painting structures in accordance with the following general specifications covering the painting of concrete, steel and other materials.

This work shall also consist of providing a protective coating to existing concrete structures or to structures built in the course of the work. Protective coatings shall be used when the primary function is to improve the durability of concrete by protecting it from degradation by chemicals and subsequent loss of structural integrity. Typical uses of protective coatings include protection of concrete in contact with chemical solutions having a pH value as low as four (4), reduction of chloride and sulphate intrusion, reduction of water absorption and as barriers against salt water.

ITEM IN BILL OF QUANTITIES

Painting of Existing Concrete Structure No _____
Painting of Existing Steel Structure No _____
Protective Coating for Concrete Structure

5.13.2 MATERIALS.

5.13.2.1 General. Unless otherwise specified, paints furnished shall be composed of paint materials meeting the applicable requirements of this Section. The term "paint" as used herein, includes enamels, paints and primers. Specifications hereinafter referred to by organizations' letters and numbers are hereby made a part of the specifications to the same extent as if fully set out herein. Finish paint for factory-primed items shall be of a type compatible with the primer. Primers for unprimed items shall be as recommended by the manufacturer for use with the finish paint.

The paint manufacturer(s) shall supply evidence that the proposed products have performed satisfactorily for a minimum of five (5) years in conditions similar to those of Saudi Arabia as to ultraviolet light exposure and intensive climatic conditions.

5.13.2.1.1 Condition. Paints furnished under these specifications shall be factory-mixed or in paste form. The mixing of dry pigment and a vehicle by the Contractor will not be permitted, except as specifically required by the specifications. Mixed paints shall be easily mixed with a paddle to a smooth and homogenous condition. Mixed paints or pastes which have hardened, thickened or otherwise deteriorated during storage or shipment will not be accepted.

5.13.2.1.2 Pigments. Pigment shall be considered that portion of the paint that is not soluble in the vehicle. All pigments shall be finely ground to a smooth uniform consistency.

5.13.2.1.3 Thinners. Thinners which are specified as thinners for a particular type of paint must mix readily with that type of paint.

5.13.2.1.4 Tinting. When paint is tinted, the tinting material shall be thoroughly mixed into the paint to form an even, uniform shade.

5.13.2.1.5 Covering Qualities. All mixed paint furnished under these specifications shall have satisfactory protective and covering qualities. Mixed paint shall not run, streak, break or sag when brushed on a clean one hundred fifty (150) millimeters by two hundred fifty (250) millimeter glass panel placed in a vertical position. The paint shall dry to a smooth, uniform finish, free from roughness, grit, unevenness and other surface imperfections.

5.13.2.1.6 Containers. Paint containers shall be sufficiently strong and durable to withstand shipment and normal handling procedures without damage. Paint containers shall be equipped with lids which positively prevent the entrance of air into the container.

5.13.2.1.7 Delivery. All paint shall be delivered to the site in original manufacturer's metal containers with labels which give type, color, quantity, gross and tare, and paint ingredient proportions of every item of the contents.

5.13.2.1.8 Storage and Handling. Water-based polymer latex paint shall be stored at temperatures above zero (0) degrees C, to avoid freezing of the water in the paint which will destroy the film-forming qualities of the latex. Storage temperature of solvent-based and oil-based paints is not critical. However, the temperature of such paints just prior to use shall be between sixteen and thirty two degrees Celsius (16-32 ° C), to insure a dense paint film of the required thickness.

5.13.2.2 Pigments and Pastes. When specified in mixed paints, the following pigments and pastes shall comply with the requirements of the ASTM designations indicated below:

	ASTM
Zinc Oxide	D 79
White Lead, Basic Carbonate	D 81
White Lead, Basic Sulfate	D 82
Red Lead, ninety-seven (97) percent Grade	D 83
Iron Oxide, Class II Type A	D 84
Lampblack	D 209
Chrome Oxide Green	D 263
Titanium Dioxide, Type I	D 476
Carbon Black	D 561
Magnesium Silicate Pigment	D 605
Aluminum Pigments, Type II Class B (except coarse particles may be two (2) percent maximum)	D 962
Copper Phtalocyanine Blue	D 963
Basic Lead Silico-Chromate	D 1648
Copper Phthalocyanine Green	D 3021

Siliceous Red Iron Oxide shall meet the following requirements:

Total Iron Oxide, Calculated as Fe_2O_3	Eighty-five percent (85%) min.
Coarse Particles, on Number 325 mesh sieve	One percent (1%) maximum
Calcium Oxide	Five-tenths percent (0.5%) max.
Moisture and other volatile material	Two percent (2%) max.
Water Soluble Matter	One and five-tenths percent (1.5%) max.
Oil Absorption	Sixteen (16%) percent min.
Siliceous Matter	Balance
Organic Colors	None Permitted

5.13.2.3 Paint Oils, Thinners and Dryers. When specified in mixed paints or vehicles the following paint liquids shall comply with the designations indicated below:

	ASTM
Turpentine, Steam Distilled	D 13
Pine Oil, Type 1	FSS LLL-P-400
Raw Linseed Oil	D 234
Mineral Spirits	D 235
Mineral Spirits, Grade 1 and Grade 2	FSS TT-T-291
Boiled Linseed Oil, Type 1	D 260
Dryers, Liquid Paint, Class B	D 600
Alkyd Resin Solutions, Type 1, II and III	FSS TT-R-266

5.13.2.4 Paint No. 1 - Red Lead Paint.

5.13.2.4.1 Description. Rapid-dry red lead paint shall consist only of lead pigment, iron oxide pigment, magnesium silicate pigment, raw linseed oil, linseed oil modified alkyd resin, thinners and dryers. The paint shall contain not more than four-tenths (0.4) percent aluminum stearate to produce loose suspension of the pigment during storage.

5.13.2.4.2 Composition. Rapid-dry red lead paint shall conform to the following composition by weight:

1. Paint.

Pigment	Sixty-six (66) percent min.
Vehicle	Thirty-four (34) percent max.
Non-volatile Material in vehicle	Fifty-six (56) percent min.

Phthalic Anhydride Based on Vehicle Solids	Fifteen (15) percent min.
Water	Five-tenths (0.5) percent max.

2. Pigment. The extracted pigment shall conform to the following by weight:

True Red Lead	Sixty-two and Five-tenths (62.5) percent min.
Ferric Oxide	Twelve and Five-tenths (12.5) percent min.
Siliceous Matter and Other Oxides of Lead	Remainder

5.13.2.4.3 Weight Per Liter. Red lead paint furnished under this specification shall weigh not less than two (2) kilograms per liter.

5.13.2.4.4 Coarse Particles. Coarse particles and skins retained on a forty-five thousandths (0.045) millimeter (No. 325) sieve shall not exceed one percent (1%) by weight based on pigment.

5.13.2.4.5 Consistency. Consistency shall be not less than seventy-three (73) nor more than eighty-six (86) Krebs Units (K.U.).

5.13.2.4.6 Condition in Container. The paint shall be thoroughly ground and mixed; it shall not be settled, caked or thickened to such a degree that it cannot be redispersed easily with a paddle to a uniform and homogenous state.

5.13.2.4.7 Skinning. Skinning shall be entirely absent from a sample that has been stored forty-eight (48) hours in a dark place in a three-quarters-filled tightly-closed container.

5.13.2.4.8 Dilution Stability. The paint shall remain stable and uniform after reduction with mineral spirits in the proportions of eight (8) parts by volume of paint to one (1) part by volume of mineral spirits.

5.13.2.4.9 Brushing Properties. The paint, after thorough mixing, shall have satisfactory brushing and leveling properties and show no running or sagging tendencies when brushed on a vertical steel surface.

5.13.2.4.10 Spraying Properties. The paint, when thinned as specified in subparagraph (8), shall spray satisfactorily, show no tendency to orange-peel, sag, creep, or run, and shall show satisfactory spraying properties in all other respects. The mineral spirits used as a reducer shall conform to FSS TT-T-281 Grade 1, and shall be tested and approved prior to use.

5.13.2.4.11 Drying Time. The paint shall set to touch in not more than four (4) hours and dry-through in not more than sixteen (16) hours when applied as in FSS Test Method, Standard Number 141, Method 4061.

5.13.2.4.12 Tinting. When used for the shop (prime) and second coat, sufficient black synthetic or magnetite iron oxides shall be added to the second coat paint as a tinting agent for identification of the coated surfaces.

5.13.2.5 Paint No. 2 - Basic Lead Silico-Chromate Primer.

5.13.2.5.1 Description. This specification covers one (1) type and grade of paint suitable for use as a structural metal, shop or spot primer. This primer shall consist only of basic lead silico-chromate, and red iron oxide eighty-five (85) percent, linseed-soya oil modified alkyd resin, raw linseed oil, thinners and dryers. The primer shall contain not more than seven-tenths (0.7) percent pigment suspended agent. The alkyd resin shall conform to FSS TT-R-266, Type III.

5.13.2.5.2 Composition. Basic lead silico-chromate primer shall conform to the following by weight:

1. Paint:

Pigment	Fifty-seven (57) percent min.
Non-volatile material in vehicle	Fifty-two (52) percent min.
Phthalic Anhydride based on Vehicle Solids	Fifteen (15) percent min.
Water	Five-tenths (0.5) percent max.

2. Pigment. The extracted pigment shall conform to the following by weight:

Basic Lead Silico-Chromate	Ninety-three and two-tenths (93.2) percent minimum
Ferric Oxide	Four and eight-tenths (4.8) to five and eight-tenths (5.8) percent

5.13.2.5.3 Weight Per Liter. Basic lead silico-chromate primer shall weigh not less than one and six-tenths (1.6) kilograms per liter.

5.13.2.5.4 Coarse Particles. Coarse particles and skins retained on a forty-five thousandths (0.045) millimeter (No. 325) sieve shall not exceed one (1) percent by weight based on pigment.

5.13.2.5.5 Consistency. Consistency shall be not less than seventy (70) nor more than eighty-three (83) Krebs Units (K.U.).

5.13.2.5.6 Flash Point. The flash point shall be not less than thirty degrees Celsius (30°C) when tested in accordance with Federal Test Method, Standard Number 141, Method 4293 using Pensky-Martens Closed Cup Tester.

5.13.2.5.7 Condition in Container. The paint shall be thoroughly ground and mixed; it shall not be settled, caked or thickened to such a degree that it cannot be dispersed easily with a paddle to a uniform and homogenous state.

5.13.2.5.8 Skinning. Skinning shall be entirely absent from a sample that has been stored forty-eight (48) hours in a dark place in a three-quarters-filled tightly-closed container.

5.13.2.5.9 Dilution Stability. The paint shall remain stable and uniform after reduction with mineral spirits in the proportions of eight (8) parts by volume of paint to one (1) part by volume of mineral spirits.

5.13.2.5.10 Appearance. After a flow-out panel of the paint on a one hundred (100) millimeters by three hundred (300) millimeter clean glass plate has dried in a nearly vertical position at room temperature, it shall show no streaking or separation.

5.13.2.5.11 Brushing Properties. The paint, after thorough mixing, shall have satisfactory brushing and leveling properties and show no running or sagging tendencies when brushed on a vertical steel surface at a spreading rate of twelve and three-tenths (12.3) square meters per liter.

5.13.2.5.12 Spraying Properties. The paint, when thinned as specified in subparagraph 5.12.2.5.9 above shall spray satisfactorily, show no tendency to orange-peel, sag, creep, or run, and shall show satisfactory spraying properties in all other respects. The mineral spirits used as a reducer shall conform to FSS TT-T-291, Grade 1 and shall be tested and approved prior to use.

5.13.2.5.13 Drying Time. The paint shall dry to a smooth uniform surface, free from roughness, grit, unevenness, and other surface imperfections. The paint shall set to touch in not more than four (4) hours and shall dry-through in not more than sixteen (16) hours when applied as in FSS Test Method, Standard Number 141, Method 4061.

5.13.2.6 Paint No. 3 - Zinc Dust-Zinc Oxide Primer.

5.13.2.6.1 Description. Type II zinc dust-zinc oxide-phthalic alkyd resin primer, conforming to FSS TT-P-641d Type II, shall be a ready-to-mix paint for use on galvanized metal surfaces, with the zinc oxide mill-ground into the entire vehicle in one (1) container and the dry zinc dust in a separate container. The zinc dust shall show an analysis of not less than ninety-four percent (94%) metallic zinc by weight. The zinc oxide vehicle shall consist of zinc oxide and a vehicle containing a long oil, linseed-modified alkyd resin of the air drying type, petroleum or terpene thinners, dryers and anti-skimming agents.

5.13.2.6.2 Zinc Oxide Vehicle.

1. Composition. Zinc oxide vehicle shall conform to the following by weight:

Zinc Oxide in the Extracted and Ignited Pigment	Ninety-eight (98) percent min.
Non-volatile Material in the Vehicle	Forty-three (43) percent min.
Phthalic Anhydride based on Vehicle Solids	Twenty-three (23) percent min.
Rosin or Rosin Derivatives	None

2. Condition in Container. The zinc oxide vehicle shall be thoroughly ground and mixed. It shall not be settled, caked, or thickened to such a degree that it cannot be redispersed easily with a paddle to a uniform and homogenous state. It shall be readily incorporated with the zinc dust to form a smooth uniform paint of good brushing consistency.

5.13.2.6.3 Zinc Dust-Zinc Oxide Mixed Primer.

1. Composition. Zinc dust-zinc oxide mixed primer shall conform to the following by weight when mixed in the proportions as submitted in the original containers:

(1) Primer.

Pigment	**Sixty-two (62) to sixty-five (65) percent**
Vehicle	**Thirty-five (35) to thirty-eight (38) percent**
Water	**Three-tenths (0.3) percent max.**

(2) Pigment. The extracted pigment shall conform to the following by weight:

Metallic Zinc	**Seventy-four (74) percent min.**
Zinc Oxide	**Eighteen (18) percent min.**
Metallic Zinc plus Zinc Oxide	**Ninety-seven (97) percent min.**
Sulfide Sulfur	**None**

2. Weight Per Liter. Zinc dust-zinc oxide mixed primer shall weigh not less than one and eight-tenths (1.8) kilograms per liter.

3. Coarse Particles. Coarse particles and skins retained on a forty-five thousandths (0.045) millimeter (No. 325) sieve shall not exceed four (4) percent by weight based on pigment.

4. Consistency. Consistency shall be not less than sixty-seven (67) nor more than eight-six (86) Krebs Unit (K.U.).

5. Dilution Stability. The mixed primer shall remain stable and uniform after reduction with mineral spirits in the proportions of eight (8) parts by volume of paint to one (1) part by volume of mineral spirits. After standing twenty-four (24) hours there shall be no curdling or precipitation on the vehicle.

6. Flexibility. After air-drying eighteen (18) hours, baking for twenty-four (24) hours at one hundred five degrees Celsius (105°C) and cooling to twenty-three degrees Celsius (23°C), a film of the mixed primer applied to flat tin panel with a five-hundredths (0.05) millimeter Bird Film Applicator shall show no cracking after bending double over a three (3) millimeter mandrel. This test shall be conducted according to FSS Test Method Number 141, Method 2012.

7. Adhesion. After air-drying for eighteen (18) hours, baking for three (3) hours at one hundred twenty-one degrees Celsius (121°C), a film of the mixed primer brushed on a clean new galvanized iron panel, seventy-five (75) millimeters by one hundred fifty (150) millimeters, shall cut loose in the form of a ribbon without flaking or otherwise loosening from the panel when tested with a knife blade.

8. Brushing Properties. The mixed primer, after thorough mixing, shall have satisfactory brushing and leveling properties and show no running or sagging tendencies when brushed on a vertical surface three hundred (300) millimeters by six hundred (600) millimeters of smooth, clean, untreated galvanized iron.

9. Spraying Properties. The mixed primer when thinned with not more than one (1) part by volume of mineral spirits to eight (8) parts by volume of paint shall spray satisfactorily, show no tendency to orange-peel, sag, creep, or run, and shall show satisfactory spraying properties in all other respects.

10. Drying Time. The mixed primer shall set to touch in not less than thirty (30) minutes nor more than four (4) hours and dry-hard in not more than eighteen (18) hours when applied as in FSS Test Method, Standard Number 141, Method 4061.

5.13.2.7 Paint No. 4 - Aluminum Paint.

5.13.2.7.1 Description. Aluminum paint shall be composed of aluminum paste and aluminum vehicle and shall conform to the requirements specified in AASHTO M 69, Type 1. The paste and vehicle shall be delivered to the project unmixed and in separate containers.

5.13.2.7.2 Proportions. The mixed paint shall be prepared for use on the project by combining the aluminum paste and aluminum vehicle in the proportions of twenty-four hundredths (0.24) kilogram paste per liter of vehicle.

5.13.2.7.3 Mixing. The paste and vehicle shall be thoroughly mixed before use. The quantity of paint mixed shall not be greater than will be used within twenty-four (24) hours after mixing.

5.13.2.8 Paint No. 5 - Tinted Aluminum Paint.

5.13.2.8.1 Description. Tinted aluminum paint shall consist of a mixture containing aluminum paint that conforms to the requirements of Paint No. 4 and Prussian Blue Paste or Chrome Green paste, conforming to the requirements specified in ASTM D 212 or D 261.

5.13.2.8.2 Proportions. Tinted aluminum paint shall be prepared by mixing one (1) liter of aluminum paint meeting this specification with between thirty (30) and forty-five (45) grams of either Prussian Blue paste or Chrome Green paste in oil or varnish.

5.13.2.9 Paint No. 6 - Basic Lead Silico-Chromate Maroon Field Coat.

5.13.2.9.1 Description. This specification covers paint intended for use as a field coat over a properly primed surface. Hiding power shall be sufficient to obtain a complete hiding when applied at normal spreading rates and shall have a good contrast with the primer coat. This paint shall consist only of basic lead silico-chromate, siliceous red iron oxide, raw linseed oil, linseed-soya oil modified alkyd resin, thinners, dryers, and from five-tenths (0.5) to seven-tenths (0.7) percent suspending agent, based on the pigment, to insure soft settlement of the pigment during storage. The alkyd resin shall conform to FSS TT-R-266, Type III and the thinner to FSS TT-T-291, Grade 2.

5.13.2.9.2 Composition. Maroon field coat paint shall conform to the following composition by weight:

1. Paint.

Pigment	Fifty-nine and five-tenths (59.5) percent minimum
Vehicle	Forty and five-tenths (40.5) percent maximum
Non-volatile Material in Vehicle	Fifty-two (52) percent minimum
Phthalic Anhydride	Fourteen and nine-tenths (14.9) percent minimum
Water	Five-tenths (0.5) percent max.

2. Pigment. The extracted pigment shall conform to the following by weight:

Basic Lead Silico-Chromate	Sixty-six and five-tenths (66.5) percent minimum
Siliceous Red Iron Oxide	Thirty-three (33) percent max.

5.13.2.9.3 Weight Per Liter. Maroon field coat paint shall weigh not less than one and sixty-seven hundredths (1.67) kilograms per liter.

5.13.2.9.4 Coarse Particles. Coarse particles and skins retained on a forty-five thousandths (0.0450) millimeter (No. 325) sieve shall not exceed one (1) percent by weight based on pigment.

5.13.2.9.5 Consistency. Consistency shall be not less than seventy (70) nor more than eighty-two (82) Krebs Units (K.U.).

5.13.2.9.6 Condition in Container. The paint shall be thoroughly ground and mixed; it shall not be settled, caked, or thickened to such a degree that it cannot be redispersed easily with a paddle to a uniform and homogenous state.

5.13.2.9.7 Skinning. Skinning shall be entirely absent from a sample that has been stored forty-eight (48) hours in a dark place in a three-quarters-filled tightly-closed container.

5.13.2.9.8 Dilution Stability. The paint shall remain stable and uniform after reduction with mineral spirits in the proportions of eight (8) parts by volume of paint to one (1) part by volume of mineral spirits.

5.13.2.9.9 Brushing Properties. The paint, after through mixing, shall have satisfactory brushing and leveling properties, and show no running or sagging tendencies when brushed on a vertical steel surface.

5.13.2.9.10 Spraying Properties. The paint, when thinned as specified in Subparagraph (9), shall spray satisfactorily, show no tendency to orange-peel, sag, creep or run, and shall show satisfactory spraying properties in all other respects. The mineral spirits used as a reducer shall conform to FSS TT-T-291 Grade 1, and shall be tested and approved prior to use.

5.13.2.9.11 Drying Time. The paint shall set to touch in no more than four (4) hours and dry-through in not more than twenty-four (24) hours.

5.13.2.10 Paint No. 7 - Basic Lead Silico-Chromate Dark Green Finish Coat.

5.13.2.10.1 Description. This paint is intended for use as a finish coat over a properly primed and field-coated surface. Dark green finish coat paint shall consist only of basic lead silico-chromate, chromium oxide green, phthalocyanine green and/or phtalocyanine blue, lampblack, soya oil modified alkyd resin, raw linseed oil, thinners, dryers and from six-tenths (0.6) to seven-tenths (0.7) percent suspended agent, based on the pigment, to insure soft settlement of the pigment during storage. The alkyd resin solution shall conform to FSS TT-R-266, Type I, and the thinner shall conform to FSS TT-T-291, Grade 2.

5.13.2.10.2 Composition. Dark green finish coat paint shall conform to the following by weight:

1. Paint:

Pigment	Forty-one (41) percent min.
Vehicle	Fifty-nine (59) percent max.
Non-volatile Material in Vehicle	Fifty-three (53) percent min.
Phthalic Anhydride Based on Vehicle Solids	Twenty & five-tenths (20.5) percent max.
Water	Five-tenths (0.5) percent max.

2. Pigment. The extracted pigment shall conform to the following by weight:

Basic Lead Silico-Chromate	Eighty-six (86) percent min.
Chromium Oxide Green	Nine (9) percent min.

5.13.2.10.3 Weight Per Liter. Dark green finish coat paint shall weigh not less than one and thirty-three hundredths (1.33) kilograms per liter.

5.13.2.10.4 Coarse Particles. Coarse particles and skins retained on a forty-five thousandths (0.045) millimeter (No. 325) sieve shall not exceed one (1) percent by weight based on pigment.

5.13.2.10.5 Consistency. Consistency shall be not less than seventy-two (72) nor more than eighty (80) Krebs Units (K.U.).

5.13.2.10.6 Color. Dark green finish coat paint color shall be as approved by the Engineer. The Contractor shall submit to the Engineer, for approval, color chips of the paint proposed for the Work.

5.13.2.10.7 Condition in Container. The paint shall be thoroughly ground and mixed; it shall not be settled, caked, or thickened to such a degree that it cannot be redispersed easily with a paddle to a uniform and homogenous state.

5.13.2.10.8 Skinning. Skinning shall be entirely absent from a sample that has been stored forty-eight (48) hours in a dark place in a three-quarters-filled tightly-closed container.

5.13.2.10.9 Dilution Stability. The paint shall remain stable and uniform after reduction with mineral spirits in the proportions of eight (8) parts by volume of paint to one (1) part by volume of mineral spirits.

5.13.2.10.10 Brushing Properties. The paint, after through mixing, shall have satisfactory brushing and leveling properties, and show no running or sagging tendencies when brushed on a vertical steel surface.

5.13.2.10.11 Spraying Properties. The paint, when thinned as specified in Subparagraph 5.13.2.10.9, shall spray satisfactorily, show no tendency to orange-peel, sag, creep or run, and shall show satisfactory spraying properties in all other respects. The mineral spirits used as a reducer shall conform to FSS TT-T-291 Grade 1, and shall be tested and approved prior to use.

5.13.2.10.12 Drying Time. The paint shall set to touch in not less than twenty (20) minutes or more than four (4) hours and dry-through in not more than twenty-four (24) hours.

5.13.2.11 Paint No. 8 - Zinc Dust Paint.

5.13.2.11.1 Description. This specification covers a ready-mixed, high zinc dust content paint suitable for repairing damaged spelter coating on galvanized steel.

5.13.2.11.2 Requirements. This paint shall comply with all the requirements of U.S. Military Specification MIL-P-21035 (Ships), Paint, High Zinc Dust Content, Galvanizing Repair, dated August 23, 1957, with the following additions and exceptions:

1. The paint shall be supplied ready-mixed. Material supplied in two (2)

compartment cans to be mixed on the job will not be accepted.

2. Pigment content expressed as a weight percent of total nonvolatile content may be a minimum of ninety-two (92) instead of the ninety-four (94) minimum required by the Military Specification.

3. Percent metallic zinc by analysis in the pigment may be minimum of ninety-four (94) instead of the ninety-seven and five-tenths (97.5) minimum required by the Military Specification.

5.13.2.12 Paint No. 9 - Gloss Enamel.

5.13.2.12.1 Description. This specification covers a high-grade synthetic-type high gloss enamel for use on exterior and interior metal. It is highly weather-resistant and is characterized by easy brushing, good color and gloss retention, good drying and flexibility, with freedom from after-tack.

5.13.2.12.2 Requirements. This paint shall conform in all respects to Federal Specification TT-E-489, Class A, Air Drying. This enamel may be thinned with Thinner; Federal Specification TT-T-291E, Type II, Grade A (Mineral Spirits).

5.13.2.13 Sampling and Testing. All materials furnished under this specification shall be accompanied by the manufacturer's Certificate of Guarantee. The certificate shall give the quantity of paint in the shipment and shall identify the paint by order number, project location and destination. Materials not accompanied by a Certificate of Guarantee shall be sampled in the field and samples submitted to an approved independent laboratory for testing.

The Engineer will approve materials on the basis of the Certificates of Guarantee and/or laboratory tests, but reserves the right to resample and have retested any materials used during the progress of the Work. Should the paint not conform to the specifications, it shall be rejected, previous approval notwithstanding.

Materials and paints shall be analyzed or tested by the methods specified in the ASTM, AASHTO, or FSS Test Method Standard No. 141, for the material to be analyzed or tested.

No paint or paint materials shall be used which have not been approved by the Engineer. Paint or paint materials for which samples and/or Certificates of Guarantee of the same paint or paint materials have previously been submitted to the Engineer and approved thereby, may be used if the additional shipments are accompanied by the manufacturer's guarantee that the product is equal in all respects to the previously approved materials.

The required color, and, if applicable, texture of the coating shall be as specified on the plans or as directed by the Engineer and the coating shall be selected by the Engineer on the basis of trial panels prepared by the Contractor.

The Contractor shall supply manufacturer's samples, specifications and chemical compositions of paint(s) meeting the requirements of these specifications and which correspond to the color and texture specified. A minimum of five (5) samples per pay item shall be provided, of which not more than three (3) shall be from any one manufacturer. The Engineer shall select a maximum of three (3) coatings per pay item for which trial panels shall be constructed by the Contractor as specified herein.

5.13.2.14 Paint No 10 - Portland Cement Paint.

5.13.2.14.1 Description. This paint shall conform to the US Federal Specification TT-P-0035(1) - Paint, Cementitious, Powder, White and Colors and is intended for use on properly prepared concrete surfaces; this paint shall not be applied over old paint or other types of surfaces. Portland cement paint is suitable for use on interior and exterior concrete surfaces, below and above grade, under normal service and climatic conditions. Where more stringent requirements are anticipated, preference shall be given to solvent-based polymer paints, described below under paint No. 12.

5.13.2.14.2 Composition. Portland cement paint shall be a water-based pigmented cement wash coating, having properties similar to the concrete surface itself. Portland cement paint shall be supplied as dry powder to be mixed with water prior to using. After addition of water, thorough mixing shall follow to obtain a creamy consistency to facilitate a uniform application, and paint shall thereafter be used within the time limits specified by the manufacturer.

5.13.2.14.3 Colors. Portland cement paint colors are normally restricted to flat white, field green and earth colors and shall be as shown on the plans or as directed by the Engineer.

5.13.2.15 Paint No. 11 - Polymer Latex Paint.

5.13.2.15.1 Description. This paint shall conform to the US Federal Specifications TT-P-0033 - Paint, Latex Base, Exterior, or TT-P-96D - Paint Latex Base, for Exterior Surfaces and is intended for use on properly prepared concrete surfaces, not less than 3 weeks old, with normal, high or varying moisture content, on masonry surfaces, and on other types of old paints. Application over other types of paint is subject to the manufacturer's written instructions/limitations and to the approval of the Engineer. Polymer latex paint is suitable for use on interior and exterior concrete and masonry surfaces, below and above grade, under normal service and climatic conditions. Where more stringent requirements are anticipated, preference shall be given to solvent-based polymer paints, described below under Paint No.12.

5.13.2.15.2 Composition. Polymer latex paint shall be a water-based dispersion of pigments and polymeric film-forming materials. Film formers may be butadiene-styrene, chlorinated rubber, vinyl acetate or butyrate, or acrylic resins. Exterior grade shall be used in all cases, with a flat or semigloss mildew-resistant finish, as shown on the plans or as directed.

5.13.2.15.3 Colors. Polymer latex paint colors are available in a wide range and shall be as shown on the plans or as directed by the Engineer.

5.13.2.16 Paint No. 12 - Polymer Paint.

5.13.2.16.1 Description. This paint shall conform to the requirements of the US Federal Specifications TT-P-1411A-Paint, Copolymer Resin, Cementitious; TT-P-95C-Paint, Rubber for Swimming Pools and Other Concrete and Masonry Surfaces; TT-P-97D-Paint, Styrene-Butadiene Solvent Type, White; TT-P-1181A(1)-Paint, Styrene-Acrylate Solvent Types, Tints and Deep Tones; TT-C-545 D(1) - Coating : Polyester-Epoxy (Two Component), High-Build, Gloss and Semigloss, White and Tints; TT-C-1659A - Coatings : Epoxy Emulsion, Two-Component Gloss and Semigloss; TT-C-535B(1) - Coating, Epoxy, Two Component; TT-C-542D - Coating, Polyurethane, Oil Free, Moisture Curing; or MIL-C-22750C - Coating, Epoxy-Polyamide. Polymer paint is intended for use on properly prepared interior or exterior concrete and masonry surfaces, with low or relatively stable moisture content, below and above grade, under normal or adverse service conditions and normal, humid or wet climatic conditions; and on certain types of old paints, subject to the manufacturer's written instructions/limitations, to the approval of the Engineer, and as herein specified.

5.13.2.16.2 Composition. Single-component polymer paints shall be pigmented solvent-based solutions of resins, such as chlorinated rubber, styrene butadiene and vinyl chloride-vinyl acetate copolymers. Such "rubber-based" paints shall be of a formulation so as to possess a considerable degree of flexibility and extensibility when applied to the specified thickness, in order to maintain a continuous coating over minor cracks which may exist or develop in the concrete substrate.

The paint formulation shall have a potential to resist soiling and be cleanable with commercial detergents. Thermoplastic formulations and formulations soluble in organic solvents shall not be approved for use on surfaces that need to be cleaned with steam cleaning or strong detergents and aggressive solvents.

Two-component polymer paints : One of the components shall be a pigmented solution of a compounded polymer, with or without solvent, such as epoxy, urethane or polyester; the other component shall contain a reactive chemical, the hardener. After mixing the two components to the manufacturer's instructions, application to the substrate and curing, the painted surface shall be a hard, strong, chemical- and moisture-resistant film with excellent adhesion to the protected, properly prepared surface. The finished surface shall be easy to clean, resistant to fungus and strong detergents, and inert to heat and steam in order to be used as antigraffiti paint, when required. Two-component epoxy formulations shall not be used on surfaces that are exposed to sunlight. In such cases, two-component exterior grade urethane formulations (aliphatic grades) shall be approved for use.

5.13.2.16.3 Colors. Polymer paint colors are available in a wide range and shall be as shown on the plans or as directed by the Engineer.

Sealers and primers for paints Nos. 10 through 12 shall be provided by the manufacturer of the finish paint, compatible with the substrate to be sealed or primed, and with the finish paint, and suitable for the intended use.

5.13.2.17 Protective Coating Materials. Materials shall conform to ASTM C722 and be as listed below, depending on the actual application and the severity of the chemical environment, as shown on the plans, verified by the Contractor and approved by the Engineer. Primers and solvents shall be as recommended by the product manufacturer for the intended purpose. Colors shall be as shown on the plans or as directed by the Engineer.

1. Polyvinyl butyral shall be applicable when sealing concrete surfaces for increased weathering resistance. Alternately, acrylic resins, including styrene-acrylic copolymer, resulting from the vinyl polymerization of acrylic monomers which are modified by the addition of plasticizers and prepolymers may be used for this purpose.

2. Polyurethane resins shall be applicable when high resistance to chemical attack, impact and abrasion are required. Urethanes may be single- or two-component systems, based on the reaction of a polyol component and an isocyanate curing agent. Care shall be exercised to match job service conditions with the proper type of urethane barrier; these barriers shall be applied to dry surfaces only.

3. Epoxy resins shall be applicable when very tough, durable coatings are required with high caustic, acid and solvent resistance. Epoxy resins shall be two-component systems, based on a reaction product of bisphenol A and epichlorohydrin with a curing agent. Special formulations shall be used when the coating must adhere to damp surfaces.

5.13.3 CONSTRUCTION REQUIREMENTS.

5.13.3.1 General. The painting of metal, concrete, masonry, and metal and concrete structures shall include, unless otherwise provided, the proper cleaning and preparation of the substrate surfaces; the application, protection, drying, and curing of the paint coatings; the protection of pedestrian, vehicular or other traffic upon or underneath or near the Work; the protection of all portions of structures (superstructure and substructure) and other portions of the Work against disfigurement by spatters, splashes and smirches, or paint or of paint materials; and the supplying of all tools, scaffolding, labor, workmanship, and materials necessary for the entire Work.

1. When directed by the Engineer and prior to starting painting operations on concrete surfaces, the Contractor shall construct trial panels for the coatings selected by the Engineer. The trial panels shall be constructed of the class of concrete used in the Work. Where the same coating is to be applied to different classes of concrete, the class of concrete to be used for the trial panels shall be selected by the Engineer.

For all trial panels, the concrete shall be mixed, cured, finished, and the surfaces shall be prepared and painted in the same manner as that intended for the permanent Work.

2. The trial panels shall be one and one-half (1.5) meters high by one (1.0) meter wide and two hundred (200) millimeters thick. The panel finally accepted by the Engineer as the standard for the permanent works shall be stored by the Contractor in direct

sunlight with one half of the panel masked, in a manner satisfactory to the Engineer, to prevent light reaching the coating. The masking shall be easy to remove and replace so that at any time the aging of the coating may be assessed.

3. The concrete surface preparation and coating application procedure details for the approved trial panel shall be recorded and will provide the basis for the relevant permanent works.

4. Trial panels shall be broken up and disposed of by the Contractor when so instructed by the Engineer.

5. When so directed by the Engineer, trial panels, as specified herein shall be prepared for each and every color and texture of coating specified in the plans.

6. Preparation of concrete and masonry surfaces shall comply with the requirements of this specification. Due to the continuous development of new products, absolute adherence to the paint manufacturer's recommendations and written instructions is critical for the proper performance of the Work. The Engineer may, at any time, require the presence of the manufacturer's technical representative on site, for as long as the Engineer deems necessary, to insure proper execution of the Work.

7. The concrete and masonry surfaces shall not be contaminated by chemicals, such as form release agents or curing compounds, that can prevent good adhesion between the paint material and the substrate. The surfaces shall be newly exposed, free of loose, weak and unsound materials. Laitance, efflorescence, inadequately cured concrete, and condensed surface moisture are conditions objectionable to paint application. The dryness or dampness of the surface shall be compatible with the paint type to be used as per the manufacturer's instructions.

8. Repair of surface defects on concrete surfaces shall be performed as specified in Paragraph 5.03.4.4, "Removal of Bridge Structure Forms and Falsework," in these General Specifications.

9. Preparation of repaired concrete surfaces may include chemical cleaning and mechanical cleaning. Acid etching shall be employed only at the recommendation of the paint manufacturer and upon approval by the Engineer, and shall be performed by crews experienced in its use.

10. Chemical cleaning shall be employed prior to mechanical cleaning or acid etching when removal of surface contaminants such as oil, grease and dirt is required. Solutions of caustic soda or trisodium phosphate may be used, as well as proprietary detergents specially formulated for use on concrete. Solvents shall not be used for this purpose. The approved detergent shall be applied with vigorous scrubbing, followed by flushing with water to remove all traces of both the detergent and the contaminant.

11. Mechanical cleaning may include scarification and grinding when small areas are involved. For larger areas, wet sandblasting and, preferably, high-pressure water jetting shall be employed, according to methods and procedures specified in Paragraph

5.03.4.7, "Bridge Structure Construction Joints" in these General Specifications. Conventional dry sandblasting shall not be permitted.

12. Acid to be used for etching, when approved, shall be a 10/90 maximum dilution ratio of commercial grade phosphoric acid in water solution, applied at a rate of one (1.0) liter per square meter of surface to be prepared. Hydrochloric acid solutions shall not be permitted for this purpose. For small areas, plastic sprinkling cans may be used for dispensing the acid solution. Larger areas shall be sprayed with low pressure automatic spray equipment. Upon subsidy of the foaming action of the acid (3 to 5 minutes) the entire treated surface shall be thoroughly flushed with water, while scrubbed with stiff bristle or wire brushes to remove the salts formed on the surface and to dislodge loose particles. The adequacy of the flushing operation shall be checked at several points within the cleaned area by placing litmus or pH paper on the wet surface to determine whether the acid has been completely neutralized. Further flushing may be necessary to ensure an absolutely neutralized surface.

13. When forced drying of wet surfaces is necessary, as approved by the Engineer, heat may be applied or dry, oil-free air may be blown over the surface.

14. Concrete and masonry surfaces to be painted shall be tested for surface quality prior to application of paint. Tests shall include cleanliness, dryness and strength qualities of the substrate as specified below.

15. Cleanliness of Surface.

(1) Dusty condition : wipe the surface with a dark cloth; if a white powder is on the cloth, the surface is unsatisfactory.

(2) Oily condition : Sprinkle water on the dried suspect surface; if the water spreads out immediately instead of standing as droplets, the surface is not contaminated by oils.

(3) Acid condition : Use pH paper to determine the acidity at the concrete surface; a pH value below four (4) is unacceptable.

16. Dryness of Surface. Unless otherwise specified by the paint manufacturer, this test is applicable only to solvent-based paints. Water-based paints may be required to be applied on damp surfaces to promote adhesion; however, free-standing water on the surface to be painted shall not be acceptable.

Moisture content is considered excessive on a tested surface, if moisture collects at the bond plane between the concrete and the paint material before the paint has cured. Tape a one and two tenths by one and two tenths (1.20 x 1.20) meters clear, polyethylene sheet to the tested surface and determine the time required for moisture to collect on the underside of the sheet. Compare the time required for moisture to collect, (1), with the time required for the paint to cure, (2), as supplied by the paint manufacturer. If (1) is greater than (2), the surface is adequately dry.

17. Strength of Surface, when laitance is present. Unless otherwise specified by the paint manufacturer, this test is applicable to water-based paints and to two-component, solvent-based paints.

Scrape the concrete surface with a putty knife; if a loose powdery material is

readily observed, excessive laitance is present that could adversely affect the adhesion of the paint. Consult the paint manufacturer as to the intensity of mechanical cleaning required.

5.13.3.2 Application. The paint shall be applied in accordance with the following procedures:

1. Painting shall be done in a neat and workmanlike manner. Paint may be applied with hand brushes or by spraying, except that aluminum paint preferably shall be applied by spraying. All spraying equipment is subject to the Engineer's approval. By either method, the coating of paint applied shall be smooth and spread uniformly so that no excess paint will collect at any point. If Work done by spraying is not satisfactory to the Engineer, hand brushing will be required.

2. Paint shall be applied only when the air temperature is at or above five degrees Celsius (5°C.). It shall not be applied upon damp surfaces or upon metal containing frost, nor shall it be applied when the air is misty or otherwise unsatisfactory for the Work, in the judgment of the Engineer.

3. Material painted under cover in damp or cold weather shall remain under cover until dry or until weather conditions permit its exposure in the open. Painting in open yards or upon erected structures shall not be done when the metal has absorbed sufficient heat to cause the paint to blister and produce a porous paint film.

4. When brushes are used, the paint shall be so manipulated under the brush as to produce a uniform even coating in close contact with the metal, or with previously applied paint. In general, the primary movement shall describe a series of small circles to thoroughly fill all irregularities in the surface, after which the coating shall be smoothed and thinned by a series of parallel strokes. To secure a maximum thickness of paint film upon rivet heads, the edges of plates, angles, or other rolled shapes, these areas shall be "striped" in advance of the general painting, and shortly afterwards shall be given a second or "wash" coat when the general coat is applied. The paint shall be well-worked into all joints and open spaces.

5. Power spraying equipment shall apply the paint in a fine, even spray, without the addition of thinner. Paint, when applied with spray equipment shall be immediately followed by brushing, when necessary, to secure uniform coverage and to eliminate wrinkling, blistering and air holes.

6. On all surfaces which are inaccessible for paint brushes, the paint shall be applied with sheepskin daubers specially constructed for the purpose.

7. All metal coated with paint which is not acceptable shall be thoroughly cleaned and repainted, by the Contractor, to the satisfaction of the Engineer, without additional compensation.

8. If it is necessary in cool weather to thin the paint in order that it shall spread more freely, this shall be done only by heating in hot water or on steam radiators, and liquid shall

not be added nor removed.

9. Portland cement paint shall be applied to damp surfaces without any free surface water. After application, the paint shall be cured by keeping it moist for forty-eight (48) to seventy-two (72) hours. For two-coat applications, the second coat shall be applied within twenty-four (24) hours from completion of the first coat. Dry film thickness shall be not less than three hundred eighty (380) microns per coat. One coat shall be applied, unless otherwise shown on the plans.

10. Polymer latex paint shall be applied to damp concrete surfaces, so water will not be absorbed from the paint before it has a chance to properly cure, unless otherwise specified by the manufacturer. When latex paint does not properly adhere to chalky surfaces, the prior application of a low viscosity penetrant primer will be required, per the manufacturer's instructions. Any embedded or adjacent steel work shall be coated with a rust inhibitive primer as specified in this Section, before application of any water-based paint. Dry film thickness shall be not less sixty-five (65) microns per coat. Two coats, shall be applied, excluding sealer or primer, unless otherwise shown on the plans.

11. Polymer paint shall be applied to dry surfaces, unless otherwise specifically permitted by the paint manufacturer in writing. Two-component paints require the mixture of the two components supplied as a kit, in the correct proportions as per the manufacturer's instructions. To insure a complete chemical reaction between the hardener and the polymer, power stirrers shall be used for thorough mixing. The paint shall be used after expiration of the required induction period and within the expected pot-life period of the mixed system, as specified by the manufacturer. Should thinning or viscosity reduction be necessary, only thinners recommended by the manufacturer shall be used. Thinners shall be added only after the two components are blended.
Dry film thickness shall be not less than forty (40) microns per coat. A minimum of two coats shall be applied, excluding primer, unless otherwise shown on the plans or recommended by the paint manufacturer for the intended purpose.

12. Unless otherwise permitted or required by the manufacturer's printed instructions, the following shall apply :

(1) Water-based paints shall be applied when the temperatures of the surfaces to be painted and of the surrounding air are between ten and thirty-two degrees Celsius (10-32° C).

(2) Solvent-based paints shall be applied when the temperatures of the surfaces to be painted and of the surrounding air are between seven and thirty-five degrees Celsius (7-35° C).

(3) Paint shall not be applied in fog, mist, rain or when the relative humidity exceeds eighty-five percent (85%). Painting operations shall not start when rain is anticipated to strike the painted surface within twenty-four (24) hours of application.

13. The finished coating shall be uniform in color and texture, free from runs, drops, ridges, waves, laps, etc., and shall match the color and texture of the approved sample panel to the Engineer's satisfaction.

14. Should the coating, in the Engineer's opinion, be non-uniform in color and/or texture

or should there be runs, drops, ridges, waves, laps, etc., in the coating, the Contractor shall propose remedial works for the Engineer's approval. Should the Contractor's proposals be unacceptable, or should the remedial works result in an unsatisfactory finish, the Engineer shall require the Contractor to :

(1) Recoat the complete area affected; or

(2) Remove, to the extent possible, the coating from the affected area and re-apply the coating.

The Engineer shall notify the Contractor which option he requires and, in the case of a re-coating being unsatisfactory, the Engineer shall require the Contractor to remove, to the extent possible, the re-coating and the original coating and re-apply a new coating.
All re-coating works and removal and re-application of coatings shall be at the Contractor's expense.

15. If the color of the coating as applied to the permanent works departs from that of the approved trial panel color (as marked) to a degree which, in the opinion of the Engineer, is unacceptable, the Contractor shall stop application and shall demonstrate to the Engineer's satisfaction that the coating formulation and/or application method can be suitably adjusted to produce a color matching that of the trial panel. If considered necessary by the Engineer, the Contractor shall produce additional trial panel(s) at his own expense to demonstrate that a color match can be obtained.

16. If, in the opinion of the Engineer, a satisfactory color match cannot be obtained, the Engineer, at his option, may require the Contractor to remove, to the extent possible, the unacceptable coating applied to the permanent works and/or to apply an alternative coating. Such an alternative coating will be selected by the Engineer on the basis of the previously prepared trial panels, except that where in the opinion of the Engineer such trial panels are unacceptable, the Contractor shall supply additional manufacturer's samples and trial panels as the Engineer may require until a coating satisfactory to the Engineer is obtained.

5.13.3.3 Structural Steel Requirements. Unless otherwise specified on the plans, or in the Special Specifications, all new structural steel shall be given three (3) coats of paint. The numbers of the paints to be used for the shop and field coats shall be as specified on the plans. The first coat shall be applied immediately after shop fabrication is complete. The second and third coats shall be applied after all erection is complete, except that immediately following the field riveting or bolting of members, the heads of field rivets, bolts, and all abrasions of the shop coat due to handling at the shop, shipment, erection, etc., and all field erection marks shall be thoroughly covered with one (1) coat of primer as specified for shop coat and permitted to become thoroughly dry before the first field coat is applied.

After the steel is completely erected in place, and the touching up is thoroughly dry, it shall be given a second and third coat of paint of the number or numbers specified.

All metal coated with impure or unauthorized paint shall be thoroughly cleaned and repainted to the satisfaction of the Engineer, at the expense of the Contractor.

Prime coats of paint shall be at least four hundredths (0.04) millimeter thick when dry and each intermediate and finish coat of paint shall be at least three hundredths (0.03) millimeter thick when dry. No portion of the paint films shall be less than these specified thicknesses. The film thickness shall be not so great that either the appearance or service life of the paint will be detrimentally affected.

5.13.3.4 Shop Coat (Prime).

5.13.3.4.1 Shop Cleaning. All surfaces of metal to be painted shall be thoroughly cleaned of rust, loose mill scale, dirt, oil or grease, and all other foreign substances. The removal of rust, scale and dirt shall generally be done by the use of metal brushes, scrapers, chisels, hammers, sandblasting, or other effective means. Oil and grease may be removed by the use of gasoline or benzene. Bristle or wood fiber brushes shall be used for removing loose dirt. Unless cleaning is to be done by sandblasting, all weld areas, before cleaning is done, shall be neutralized with a proper chemical, after which they shall be thoroughly rinsed with water. All cleaning shall conform to the requirements of AASHTO Standard Specifications for Highway Bridges.

5.13.3.4.2 Shop Painting. Shop painting shall be done in accordance with the following procedures:

1. When all fabrication Work is complete and has been accepted, all surfaces not painted before assembling shall be given an approved shop coat of paint. Steel members shall not be loaded for shipment until thoroughly dry. No painting shall be done after loading.

2. Structural steel which is to be welded shall not be painted before welding is complete. If it is to be welded only in the fabricating shop and subsequently erected by bolting, it shall receive one (1) coat of paint after shop welding is finished. Steel which is to be field welded shall be given one (1) coat of boiled linseed oil or other approved protected coating after shop welding and shop fabrication are completed.

3. Surfaces of metal to be in contact when assembled shall not be painted. Surfaces of field connections gusset plates of trusses and areas of girders or plates where floor beam or stringer connections are to come in contact shall not be painted.

4. With the exception of pins and pinholes in bearings, unless otherwise shown in the plans, all surfaces except those described in Subparagraph (3), whether machine finished or otherwise, shall be given the regular coat of shop paint, and those parts inaccessible after erection shall be given two (2) coats of field paint. Pins and pinholes shall be coated, as soon as practicable after being accepted, with a hot mixture of white lead and tallow before removal from the shop.

5. The composition used for coating machine finished surfaces shall be mixed in the following proportions:

One and eight-tenths (1.8) kilograms of pure tallow
Nine-tenths (0.9) kilograms of pure white lead

Ninety-five hundredths (0.95) liters of pure linseed oil

6. Erection marks for field identification of members shall be painted upon previously painted surfaces.

5.13.3.5 Field Coat.

5.13.3.5.1 Field Cleaning. When the erection Work is complete, including all riveting, bolting, welding, straightening of bent metal, etc., all adhering rust, scale, dirt, grease, or other foreign matter shall be removed as specified under Subparagraph 5.13.3.4.(1), "Shop Cleaning" in these General Specifications.

5.13.3.5.2 Field Painting.

1. As soon as the field cleaning is done to the satisfaction of the Engineer, the heads of field rivets and bolts, welded surfaces, and any surface from which the shop coat of paint has worn off, or has otherwise become defective, and all shipping and erection marks shall be thoroughly covered with one (1) coat of the same type of paint used in the shop, and permitted to become thoroughly dry before the first field coat is applied.

2. When the paint for "touching up" has become thoroughly dry, the first and second field coats may be applied. In no case shall a succeeding coat be applied until the previous coat has dried through the full thickness of the paint film.

3. All small cracks and cavities which have not become sealed in a watertight manner by the first coat shall be filled with a pasty mixture of red lead and linseed oil before the second coat is applied.

4. If, in the judgment of the Engineer, produces an objectionable quantity of dust, the Contractor shall, at his own expense, allay the dust for the necessary distance on each side of the bridge and take any other precautions necessary to prevent dust and dirt from coming in contact with freshly painted surfaces or with surfaced before the paint is applied.

5. The Contractor shall protect pedestrians, vehicular, and any other upon or underneath the bridge, and also all portions of the bridge superstructure and substructure against damage or disfigurement by spatters, splashes and smirches of paint or paint materials.

5.13.3.6 Bridge Railing and Guardrail.

5.13.3.6.1 Bridge Railing. Metal bridge railing shall be painted as specified herein and the number of the paint and the number of coats of shop paint and field paint shall be as specified in the Special Specifications.

Aluminum hand rails shall not be painted except that the portion of posts to be inserted in concrete shall first be painted with one (1) coat of Paint Number 3 to a point two (2) centimeters above the concrete line. Aluminum hand rail after erection shall be wiped with a rag saturated with lacquer thinner to remove stains.

5.13.3.6.2 Guardrail. Guardrail posts shall be painted as specified herein and the number of the paint and the number of coats of shop paint and field paint shall be as specified on the plans. Under no circumstances shall a paint other than Paint Number 3 be used for the shop or prime coat on galvanized posts.

5.13.3.7 Painting Existing Structures. The painting of existing structures shall be done in accordance with the following procedures:

1. Unless otherwise provided, this painting shall include the removal of the rust, scale, dead paint, dirt, grease or other foreign matter from the metal parts or portions of existing bridge structures and the application of paint thereto. All work shall be in full compliance with the provisions of Subsection 1.05.21, "Air Pollution" in these General Specifications.

2. All metal surfaces not in close contact with other metal surfaces or truss members, concrete, stone masonry, or other structure materials shall be considered as exposed to deterioration by rusting and shall be thoroughly cleaned and given the number of coats of designated paint or paints indicated in the plans.

3. Unless otherwise provided, the metal after being cleaned to the satisfaction of the Engineer shall be given at least two (2) coats of paint.

4. The requirements and methods of procedure for maintenance cleaning and painting shall be the same as specified for shop and field painting herein.

5. When repainting with the same type of paint as that on an existing surface, the surface shall be thoroughly washed with commercial detergents, or, where approved, with solvents, to remove any dirt, chalk and grime accumulation, along with dead paint.

6. When repainting with a different type of paint from that on an existing surface, the paint manufacturer shall be consulted as to their compatibility, to avoid poor intercoat adhesion problems. Any paint may be applied over Portland cement paint, but Portland cement paint cannot be applied over any other type of paint. In general, latex paints will normally adhere satisfactorily to other types of paints, provided that any gloss on the old paint be first removed by sanding. The adhesion between a fully-cured polyurethane paint and newly-applied polyurethane is generally questionable, and a coat of an epoxy-polyamide paint may be required in between. Certain solvent-based paints are incompatible with fully-cured oil-based coatings, and wrinkling or lifting may be encountered; when this occurs, the old coat must be removed first.

Loose paint, curled edges and blistered paint shall be removed before repainting. Light wet sandblasting, water-jet blasting, machine sanding, or paint strippers may be utilized. Filling of any cracks and holes in the concrete shall be done in the same manner as for new concrete. If the old paint has become partially removed, but that remaining is in good condition, the bare areas shall be painted first, followed by two coats over all. If the old paint is failing by blistering, peeling or disrupting from efflorescence, it shall be investigated whether the source of supply of moisture is still present and the Engineer will evaluate the viability of its elimination, and direct corrective measures thereof; or else, the type of paint may be changed.

5.13.3.8 Painting Steel Piling and Steel Pile Shells.

Unless otherwise provided in the plans or Special Specifications, steel bearing piles, steel sheet piles, and steel pile shells need not be painted if they are to be encased in concrete or other solid waterproof materials from six hundred (600) millimeters below the water line or ground line to the tops of the piles.

When steel bearing piles, and steel pile shells are not to be encased, or when provided in the plans, they shall be painted in accordance with the requirements stated hereinbefore, except that three (3) coats of shop paint shall be applied from the tops of the piles to an elevation three (3) meters below the water line or finished ground line before driving, and then two (2) field coats of paint as specified for structural steel shall be applied to each steel bearing pile, or steel pile shell which extends above the low water line or finished ground line after driving.

5.13.3.9 Painting Steel Pile Enclosures and Tubular Steel Piers. The exterior surfaces of steel pile enclosures and tubular steel piers shall be painted in accordance with the requirements of Paragraph 5.13.3.7, Painting Existing Structures, in these General Specifications.

5.13.3.10 Protective Coating System Application. Protective coatings shall be applied in accordance with the product manufacturer's printed instructions, especially, as to number of coats and total dry film thickness which shall not exceed one (1) millimeter.

In particular, polyvinyl butyral and acrylic resins shall be dissolved in an approved solvent and applied in thin films not exceeding eighty (80) microns per coat. Polyurethane and epoxy resins shall be applied in two or more coats, to attain the total dry film thickness recommended by the manufacturer.

5.13.4 METHOD OF MEASUREMENT. The painting of new structures, miscellaneous metals, and piling will not be measured directly, but will be considered subsidiary to other items in the Bill of Quantities.

The painting of existing structures shall be measured on a square meter basis for the items listed in the Bill of Quantities.

The protective coating of new or existing structures shall be measured on a square meter basis for the items listed in the Bill of Quantities.

Unsolicited trial panels made by the Contractor for his own purposes to determine suitability of surface preparation methods and of the finished coating color and/or texture shall not be measured for payment.

Satisfactory and accepted trial panels ordered by the Engineer and exhibited throughout the duration of the Work, shall be measured for payment as indicated in the Bill of Quantities for the appropriate element and class of concrete, only if not already measured

for payment under the stipulations of Subsection 5.03.10 -"Method of Measurement" in these General Specifications. Paint on such panels shall be measured for payment, as authorized by the Engineer, by the square meter of completed and accepted painted area.

5.13.5 PAYMENT. Contracts which include painting or repainting in whole or in part of existing structure(s) provide for payment of the amount of completed and accepted Work as measured, at the unit price(s) bid per square meter as specified in the Bill of Quantities.

The amount of completed and accepted protective coating, measured as provided above, will be paid for at the unit price(s) bid per square meter for the several types of coatings applicable, as shown in the Bill of Quantities.

Unit price(s) shall be full compensation for furnishing all materials, tools, tackle, scaffolding and any other equipment, and for performing all surface preparation and cleaning and all other items necessary for the proper completion of the Work as specified in Subsection 1.07.2 - "Scope of Payment" in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
51301	Painting of Existing Concrete Structure No ___	Square Meter
51302	Painting of Existing Steel Structure No ___	Square Meter
51303	Protective Coating for Concrete Structure	Square Meter
5130301	Protective Coating for Concrete Structure, Resistance to Weathering	Square Meter
5130302	Protective Coating for Concrete Structure, Resistance to Chemicals, Impact and Abrasion	Square Meter
5130303	Protective coating for concrete Structure, Resistance to Strong Caustics, Acids and Solvents	Square Meter

SECTION 5.14 - CONCRETE BRIDGE DECK OVERLAYS

5.14.1 DESCRIPTION. This work shall consist of the construction of a latex concrete overlay or a Portland cement concrete overlay on a concrete bridge deck and shall include the furnishing of all labor, materials, and equipment necessary to blast clean the deck; apply an epoxy bonding agent; to place, consolidate, finish and cure the overlay; to apply the epoxy--sand slurry; and to perform all other associated work required by the contract.

ITEMS IN BILL OF QUANTITIES
Epoxy Bonding Agent
Concrete Overlay, Latex
Concrete Overlay, Polymer
Concrete Overlay, Portland Cement
Epoxy-Sand Slurry

5.14.2 MATERIALS.

5.14.2.1 General. All materials shall be approved before use. The Contractor is advised that certain combinations of materials in concrete overlay mixtures may cause chemical reactions resulting in significant cracking of the overlay, even though the materials are individually acceptable. The Contractor shall be responsible for furnishing materials that are compatible with each other, and shall repair or remove and replace any overlay damaged because incompatible materials were used, at no cost to the Ministry.

The moisture contents of the aggregates used in overlay mixtures, especially the fine aggregate, shall be controlled by the Contractor so that, at the time of mixing, the moisture content of each aggregate is relatively uniform; the material will feed uniformly when continuous type mixers are used; and the moisture contents of the aggregates are not so great that the water-cement ratio or slump requirement for the concrete mixture is violated. Any concrete overlay mixture produced which is not properly proportioned or is not in conformity with the specified slump and/or water-cement ratio will be rejected by the Engineer, and shall be removed and replaced with concrete mixture meeting the requirements of this Section at no cost to the Ministry. When the water-cement ratio or slump requirements are violated due to excessive moisture content of the aggregates, this condition shall be corrected by the Contractor at his expense before mixing operations are continued.

5.14.2.2 Fine Aggregate. Fine aggregate for the concrete overlay mixture shall be natural sand conforming to the requirements of Subparagraph 5.01.2.2.1, "Fine Aggregate" in these General Specifications. The Engineer will verify the moisture content of the natural sand in order to calculate its free water content and resulting water-cement ratio of the concrete mixture.

5.14.2.3 Coarse Aggregate. Coarse aggregate for the concrete overlay mixture shall be maximum size nineteen (19) millimeters (¾ inch) conforming to the requirements of Subparagraph 5.01.2.2.2, "Coarse Aggregate," in these General Specifications. The Engineer will verify the moisture content of the coarse aggregate in order to calculate its free water content and resulting water-cement ratio of the concrete mixture.

5.14.2.4 Epoxy Bonding Agent. Epoxy bonding agent for bonding new, or wet concrete, to old concrete shall be two-component epoxy resin binder and shall be a product approved by the Ministry Materials and Research Department. It shall be of the type specifically intended for bonding wet concrete to existing concrete. Each container of epoxy shall conform to ASTM C881. The manufacturer's instructions regarding the use of the epoxy bonding agent are to be strictly followed.

5.14.2.5 Latex and Polymer Admixture. The Contractor shall select the latex or polymer admixture from the listing of acceptable products and their manufacturers on file at the Ministry's Material and Research Department.

Manufacturers desiring prequalification of new products shall have their product tested and evaluated by a qualified independent laboratory, or the Ministry's Materials and Research Department in accordance with the Prequalification Test Program in the U.S. Department of Transportation Research Report No. FHWA-RD-78-35. When analysis is performed by an independent laboratory, certified test results from the independent laboratory and a five (5) gallon sample of latex or polymer admixture shall be submitted to the Ministry's Materials and Research Department. Approval of the latex or polymer admixture will be based upon the submitted information and evaluation of the sample.

The latex or polymer admixture shall not contain any chlorides.

Each shipment of latex or polymer admixture shall be accompanied by a report of tests performed in accordance with the Certification Program in Report No. FHWA-RD-78-35. In addition to actual test results, the report shall include date of manufacture, batch or lot number(s), quantity represented, manufacturer's name, place of manufacture, a statement that all test results are satisfactory, the date on which the one (1) year certification period will expire, and signature of manufacturer's representative.

Each lot of latex or polymer will be check sampled and tested, and will be removed from the approved product listing at any time there is an indication of nonconformity or questionable quality.

The latex or polymer admixture shall be packaged and stored in containers and storage facilities which will protect the material from freezing and from temperatures above thirty degrees Celsius (30^{o} C) or as the manufacturer recommends. Additionally, the material shall not be stored in direct sunlight and shall be shaded when stored outside of buildings during moderate temperatures. No latex or polymer admixture which has been exposed to freezing temperatures shall be used. The products presently on the approved list are:

Modifier A - Dow Chemical Company
Thermoflex 8002 - Reichold Chemicals, Inc.
Deco-Rez 4776 - General Polymers Corp.
Arco Dylex 1186 - Arco Polymers

5.14.2.6 Epoxy Cement for Sand Slurry. Epoxy cement for sand slurry shall meet the requirements of ASTM C881-Type III or AASHTO M 200, Class II.

5.14.2.7 Sand for Epoxy Sand Slurry. Sand for epoxy mixtures shall be silica sand containing no less than ninety percent (90%) acid insolubles and shall be rounded to subangular in shape, clean, dry and non-friable. The gradation shall be as follows:

Sieve Size	Percent Passing
2.36 mm (No. 8)	100
0.300 mm (No. 50)	0-40
0.150 mm (No. 100)	0-5

5.14.2.8 Other Materials. Other materials shall meet requirements specified in the following Paragraphs in these General Specifications:

Cement	5.01.2.1
Water	5.01.2.3
Admixtures	5.01.2.4

5.14.3 CONSTRUCTION REQUIREMENTS.

5.14.3.1 General. These general requirements shall apply to both latex concrete overlays and Portland cement concrete overlays. General and special requirements for polymer concrete overlays shall be as recommended by the manufacturer of the approved polymer admixture.

The sequence of operations shall be: blast cleaning of the existing deck; application of the epoxy bonding agent coat; mixing, placing and consolidating the concrete overlay mixture; finishing; texturing; curing; sealing joints and cracks; and application of the epoxy-sand slurry. The deck which is to be overlaid shall be at least fourteen (14) calendar days old before overlay operations are started. When longitudinal construction joints are necessary, each section of overlay shall be completely cured before the adjacent overlay is placed.

The Contractor shall notify the Engineer at least one working day in advance of the date and time he intends to begin placing concrete for the overlay. When placing of concrete is not begun within two (2) hours after the scheduled time, then all engineering costs from the scheduled time until the time placing actually begins or is canceled will be deducted from monies due or to become due the Contractor. No engineering costs will be deducted when placing is delayed for reasons beyond the control of the Contractor, such as inclement weather or equipment failure after placing begins. No time extension will be granted for delay to placing concrete resulting from the Engineer receiving less than the twelve (12) hour notice specified above.

5.14.3.2 Weather Limitations. During warm weather concrete shall only be placed in accordance with the requirements in Subparagraph 5.03.4.10.4, "Additional Hot Weather Limitations and Curing Requirements for Bridge Decks and Slabs" in these General Specifications. During cool weather, concrete shall not be placed when the air temperatures away from artificial heat is less than eight degrees Celsius (8^o C.) and falling. In all instances, all concrete shall be placed and kept at a temperature above eight degrees Celsius (8^{o} C.) for at least ninety-six (96) hours after it is placed. Provisions shall be made for the uniform distribution of heat, and no area of the concrete surface shall be heated to a temperature above thirty degrees Celsius (30^{o} C.) This will require approved housing, heating, or insulation methods during cold weather. In no case shall the concrete be placed when raining or drizzling. If during the process of placing concrete it should begin to rain or drizzle, placement shall be stopped and the material already in place shall be finished and protected.

5.14.3.3 Epoxy Bonding Agent. Before the epoxy bonding agent is applied, the entire area of the deck surface shall be blast cleaned to a bright, clean appearance which is free from curing compound, laitance, dust, dirt, oil, grease, bituminous material, paint, and all other foreign matter. The blast cleaning of an area of the deck shall be performed within the twenty-four (24) hour period preceding placement of the epoxy bonding agent and overlay on the area. However, if the project is done under traffic, all blast cleaning must be done within twelve (12) hours prior to the placement of the epoxy bonding agent. Blast cleaning shall be performed as specified in Paragraph 5.15.4.4 "Blast Cleaning" and Subsection 1.5.14, "Protection and Preservation of Property and Landscape" in these General Specifications.

Blast cleaned areas shall be protected, as necessary, against contamination prior to placement of the epoxy bonding agent and overlay. Contaminated areas and areas exposed more than twenty-four (24) hours [twelve (12) hours when under traffic] shall be blast cleaned again as directed by the Engineer at the Contractor's expense.

The epoxy bonding agent shall be applied to the blast cleaned sound existing concrete surfaces, which are free of laitance, oil, grease, dust, sand, form releasing agent and other substances that are detrimental to a good bond. The epoxy bonding agent shall be applied just prior to casting/pouring of new concrete. If pouring of new concrete is delayed after the application of epoxy bonding agent to the old concrete surfaces, remedial measures as deemed necessary by the Engineer and the manufacturer's recommendation shall be carried out by the contractor at his own expense before any new concrete is cast.

5.14.3.4 Mixing and Placing. Concrete for concrete overlays shall be mixed at the work site by either batch or continuous mixers approved by the Engineer. Drum type transit truck mixers or rotating drum batch-type mixers shall not be used in any circumstance for Portland cement concrete overlays. All batch mixers shall be equipped with rotating blades or paddles. The maximum time between completion of mixing and placement shall be twenty (20) minutes.

Batch-type mixers shall be equipped with or accompanied by suitable devices for accurately measuring the weight of the cement, fine aggregate, and coarse aggregate for each batch and for accurately determining either the volume or the weight of the water, the water-reducing and air-entraining admixtures, and latex admixture, as applicable, for each batch. Approved methods for adding the air-entraining admixture and the water-reducing admixture shall be provided. The admixtures shall be kept separated, and shall be separately added to the mixture. Batch-type mixers which entrap unacceptable volumes of air in the mixture shall not be used.

Continuous type mixers shall be equipped so that the proportions of latex admixtures (when required), cement, fine aggregate, and coarse aggregate can be fixed by calibration of the mixer, and thereafter shall not be changed without approval by the Engineer. The latex admixture supply portion of the mixer shall be equipped with a cumulative-type meter which can be read to the nearest one-half (½)liter or one-half (½)kilogram. The water supply portion of the mixer shall be equipped with a flow meter or other suitable device for calibrating the water supply, and a cumulative-type water meter which can be read to the nearest one-half (½)liter or one-half (½)kilogram. The latex and water meters shall be readily accessible, accurate to within ± one percent (±1%), and easy to read. Approved methods for adding the air-entraining admixture and water-reducing admixture, when required, shall be provided. Admixtures shall be added so as to be kept separated as far as is practicable.

The continuous-type mixer shall be calibrated at least once during each fifty (50) cubic meters production if yield checks indicate recalibration is necessary, and at any other times the Engineer deems necessary to ensure proper proportioning of ingredients. Continuous-type mixers which entrap unacceptable volumes of air in the mixture shall not be used.

The mixer, whether batch or continuous-type, shall be kept clean and free of partially dried or hardened materials at all times. It shall consistently produce a uniform, thoroughly blended mixture within the specified air content and slump limits. Malfunctioning mixers shall be immediately repaired or replaced with acceptable units. Operation and maintenance of continuous-type mixers shall be in accordance with the mixer manufacturer's recommendations.

Formation of longitudinal joints and transverse construction joints shall be held to the minimum number necessary, and both types of joints shall be thoroughly blast cleaned and coated with grout-bond coat material before fresh concrete is placed against the hardened sides of the joints. When longitudinal joints are necessary, they shall be formed by use of a longitudinal header secured to the deck, six (6) millimeters less in thickness than the overlay. Longitudinal joints shall be located along lane lines unless otherwise permitted. After removal of the header, the overlay shall be sawed longitudinally seventy-five (75) millimeters or more inside the formed edge and the overlay outside the saw cut removed before the adjacent overlay is placed. The volume of the overlay removed will be deducted from the volume measured for payment. Alternate methods of constructing longitudinal joints may be used on latex concrete overlays if approved by the Engineer.

The mixture shall be produced at a uniform rate so that finishing is performed immediately after mixing.

5.14.3.5 Epoxy-Sand Slurry. After the overlay has been completed and cured, a thin coat (approximately two (2) millimeters) of an epoxy-sand slurry shall be applied to the thirty (30) centimeters of the overlay adjacent to the curbs, concrete barrier walls, or other vertical walls. The epoxy-sand slurry mixture shall extend up the faces of curbs and walls for seventy-five (75) millimeters above the overlay. The areas to receive the epoxy-sand slurry shall be thoroughly blast cleaned to a clean, bright appearance and shall be

thoroughly clean and dry before the slurry is applied. The deck must be dry when slurring is started and not have been subject to rain within thirty-six (36) hours preceding application of the slurry. Before applying the slurry, all joints in the area receiving the application shall be protected by placing strips of masking tape along the joints in a manner to exclude the slurry from the joints. Masking will also be required to ensure a straight line for applying the epoxy-sand slurry.

The epoxy-sand slurry mixture shall be proportioned by volume as follows:

1 part of Component A
1 part of Component B, and
2 parts of dry, silica sand.

The Engineer may make minor adjustments in the quantity of sand, in order to produce a more workable mixture. The ingredient materials shall be thoroughly mixed from three (3) to five (5) minutes. The slurry shall then be spread and squeegeed as smoothly and uniformly as possible so as to completely fill the blast cleaned pitted areas, cracks, and rough surfaces. The finished elevation of the slurry shall be no more than two (2) millimeters above the elevation of the deck. Silica sand shall be sprinkled very lightly over the slurry so as to prevent slipperiness.

At the Contractor's option, thoroughly mixed neat epoxy may be spread on the specified areas and sprinkled with dry silica sand if the process used and results produced are acceptable to the Engineer.

5.14.3.6 Unacceptable Work. Overlay thickness will be determined by coring done under the supervision of the Engineer. Any core made in the overlay shall be filled by the Contractor using concrete overlay material at no additional cost to the Ministry. Areas found to be deficient in thickness no more than twelve (12) millimeters will be paid for as specified hereinafter. Areas found deficient by more than twelve (12) millimeters shall be removed and replaced with concrete overlay of the specified thickness at no cost to the Ministry.

Any areas of the overlay which display extensive cracking or other characteristics indicating the waterproofing effectiveness or expected life of the overlay may be reduced, or the overlay may not be intimately bonded to the underlying deck, will be cored by the Contractor when deemed necessary by the Engineer.

Any area shown by the cores to either have cracks exceeding a depth of six (6) millimeters or to not be intimately bonded to the underlying deck shall be removed and replaced with acceptable concrete at the Contractor's expense. Removal and placement may be required without coring when significant cracking or lack of bond so apparent as to make coring unnecessary in the judgment of the Engineer. All cracks which are not significant enough to require removal of the overlays shall be sealed with grout to the satisfaction of the Engineer.

5.14.4 SPECIAL REQUIREMENTS FOR LATEX CONCRETE OVERLAYS. In addition to the General Requirements, the following shall apply to Latex Concrete Overlays.

5.14.4.1 Prewetting and Epoxy Bonding Agent. The blast cleaned areas to receive the overlay shall be thoroughly and continuously wetted with water at least one (1) hour before placement of the overlay is started. The areas shall be kept wet and cooled with water until the overlay is placed. Any accumulations of water shall be dispersed and/or removed prior to applying the epoxy bonding agent. Immediately ahead of placing the overlay mixture, a thin coating of the epoxy bonding agent shall be thoroughly brushed and scrubbed onto the wetted surface. Accumulations of coarser particles of the mixture which cannot be scrubbed into intimate contact with the surface will not be permitted.

The epoxy bonding agent shall be applied only for a short distance in advance of the placement of the overlay and shall not be allowed to show any signs of drying prior to being covered with the overlay.

5.14.4.2 Proportioning. The latex concrete shall be accurately proportioned through trial mixes to satisfy the below required properties. It shall contain no less than one hundred twenty-one (121) liters of latex admixture per cubic meter.

Material	Quantities per Cubic Meter
Type I or Type II Portland Cement	300 kilograms minimum
Latex Admixture	121 liters minimum
Fine Aggregate	474 to 540 kilograms*
Coarse Aggregate	364 to 430 kilograms*
Water (including free moisture on the fine and coarse aggregates)	48.5 kilograms maximum

*The actual quantities to be used within this limit shall be determined by the Contractor and shall be subject to approval by the Engineer.

The properties of the latex concrete shall be as follows when determined by the Materials and Research Department's Highway Materials Manual test methods.

Properties	Values
Slump (slump test shall be performed four (4) to five (5) minutes after discharge from the mixer when continuous type mixers are used.)	75 to 200 mm
Air Content	No more than 7%
Water-cement ratio (considering all the non-solids in the Latex Admixture as part of the total water)	No more than 0.40
Compressive strength at seven (7) calendar days	210 kilograms per square centimeter
Chloride Ion permeability	ASTM C-1202 maximum 1000 coulombs

In the event compressive strength is tested at twenty-eight (28) days or later during unusual circumstances, the compressive strength shall be at least two hundred eighty (280) kilograms per square centimeter.

5.14.4.3 Placing, Consolidating, and Finishing the Overlay. Latex concrete for the overlay shall be placed on the blast cleaned and prewetted deck immediately after the grout-bond coat has been applied. The minimum thickness of the latex concrete overlay is twenty-five (25) millimeters. The surface of the overlay shall conform to the existing deck section while maintaining the minimum thickness. The deck section will be determined in the field, and cross slope and/or crown will be determined by the Engineer. The finishing machine shall be passed over the existing deck prior to placing the overlay so that measurements can be made to ensure that the proper cross slope and thickness will be achieved.

The top surface of the overlay shall be uniform, smooth, and even-textured after finishing by an approved finishing machine. The finishing machine shall be equipped with a vibrator positioned in advance of or attached to the screeding device, and the latex concrete shall be thoroughly consolidated by vibration during the finishing operations.

A transverse construction joint shall be constructed whenever placing is interrupted for any reason for twenty (20) minutes or longer.

The top surface of the consolidated and finished concrete overlay shall be smooth, uniform, and tight, and variations in the surface, when checked with a three (3) meter straightedge, shall not exceed three (3) millimeters.

5.14.4.4 Curing. Immediately following the texturing operation, the overlay shall be covered with a thoroughly wetted layer of burlap immediately followed by a layer of polyethylene film one-tenth (0.10) millimeters [four (4) mils] or more in thickness. Sections or strips of burlap shall be placed transversely, so the overlay can be covered immediately after finishing or texturing. The burlap and polyethylene film shall be left in place for at least twenty-four (24) hours, and the burlap shall be rewetted if any signs of drying appear. New burlap shall be soaked in water for at least twelve (12) hours before the first use.

After the twenty-four (24) hour period has ended, the burlap and polyethylene shall be removed and the overlay shall be allowed to air-cure. The air-cure shall continue an additional forty-eight (48) hours (additional twenty-four (24) hours for Type III cement) in which the ambient air temperature is ten degrees Celsius (10^{o} C.) or more.

After curing of the overlay has been completed, the tops of all longitudinal and transverse construction joints shall be given a thorough coating of grout of the same proportions as the grout-bond coat material with the coarse aggregate omitted. The coating shall be at least fifty (50) millimeters wide, and shall be neatly and uniformly applied. This coating is intended to seal any minute cracks which may have developed at these locations. Use of epoxy-sand slurry to seal construction joints in lieu of grout will not be permitted. The overlay may be opened to traffic as soon as all curing is completed.

5.14.5 SPECIAL REQUIREMENTS FOR PORTLAND CEMENT CONCRETE OVERLAYS. In addition to the General Requirements, the following shall apply to Portland Cement Concrete Overlays.

5.14.5.1 Epoxy Bonding Agent. After the concrete surface has been blast cleaned and accepted, and immediately prior to placing the concrete overlay mixture on the deck, a thin coat of epoxy bonding agent shall be vigorously scrubbed into the dry, clean surface areas. The surface areas shall not be wetted prior to applying the epoxy bonding agent. When the bridge deck is exposed to rain prior to application of the epoxy bonding agent application shall be delayed until the bridge deck has dried sufficiently to proceed as determined by the Engineer; a minimum drying time of four (4) hours will be required. The epoxy bonding agent shall be as specified. The consistency of the epoxy bonding agent shall be such that it can be applied with a stiff brush or broom in a thin, even coating which will not run or puddle in low spots. Care shall be exercised to ensure that all areas of the blast cleaned deck receive a thorough even coat of epoxy bonding agent and that no excess grout is permitted to collect in any areas. Epoxy bonding agent shall be applied only for a short distance in advance of the placement of the overlay and shall not be allowed to show any signs of drying prior to being covered with the overlay. Any areas which show any signs of drying shall be thoroughly recoated with fresh grout.

5.14.5.2 Proportioning. Concrete for the overlay shall be accurately proportioned according to currently established M.O.C. methods and its properties shall be verified by laboratory and field trials. It shall contain a minimum of four hundred (400) kilograms of cement and have a maximum water-cement ratio of forty hundredths (0.40) including free moisture in the aggregates. The contractor shall determine the amount of water to be added to the mixture to maintain proper slump, except that the above specified water-

cement ratio shall not be exceeded. The required minimum compressive strength, at seven (7) calendar days, is two hundred fifty (250) kilograms per square centimeter.

Water-reducing admixture shall be added to the concrete in accordance with the manufacturer's recommendations, or as otherwise approved in writing by the Engineer.

The slump of the concrete shall be consistently maintained at eighteen (18) millimeters. The slump test shall be performed four (4) to five (5) minutes after discharge from the mixer. A tolerance of plus or minus six (±6) millimeters will be permitted for occasional samples. Concrete with a slump of more than twenty-five (25) millimeters shall not be used in any circumstance and shall be wasted at the Contractor's expense. Concrete with a slump less than twelve (12) millimeters shall not be used unless the finishing machine can finish and consolidate the concrete in accordance with requirements specified herein. Slump requirements shall be met at both the site of mixing and at the time of placing.

5.14.5.3 Placing and Finishing Equipment. Equipment shall include sufficient hand tools for placement of still, plastic concrete and for working it down to approximately the correct elevation for striking off with a screed.

Supporting rails upon which the finishing machine travels shall be placed outside the area to be surfaced, when possible, and shall extend beyond each end of the bridge a sufficient distance to accommodate the finishing machine. Anchorage for the supporting rails shall be substantial enough to provide for rigid horizontal and vertical stability of the rails. Methods proposed for anchoring the supporting rails to the deck shall be submitted to the Engineer for approval prior to beginning the work.

The finishing machine shall be equipped with a strikeoff to provide a uniform thickness of concrete in front of the screeds and with two (2) oscillating screeds set accurately to the crown specified. The screeds of the finishing machine shall be of metal.

The front oscillating screed shall be designed to thoroughly consolidate the concrete by vibration to the specified density. A sufficient number of identical vibrators shall be effectively installed on the screed so that at least one (1) vibrator is provided for each one and one-half (1½) meter of screed length. The bottom face of this screed shall be at least one hundred twenty-five (125) millimeters wide with a turned up or rounded leading edge to minimize tearing of the surface of the plastic concrete. Each screed shall be provided with positive control of the vertical position, the angle of tilt, and the slope of the crown. The final screed shall oscillate and finish without vibration.

Design of the finishing machine together with appurtenant equipment shall be such that positive machine screeding of the plastic concrete will be obtained within twenty-five (25) millimeters of the face of the existing curbs; the vibrating screed shall be of sufficient length to extend at least one hundred fifty (150) millimeters beyond an intended longitudinal joint, and to extend at least one hundred fifty (150) millimeters beyond the longitudinal edge of a previously placed section of overlay.

The finishing machine shall be capable of forward and reverse motion under positive control. Provision shall be made for raising the screeds to clear the screeded surface

when traveling in reverse.

5.14.5.4 Placing, Consolidating, and Finishing the Overlay. The minimum thickness of the overlay is fifty (50) millimeters. The surface of the overlay shall conform to the existing deck section while maintaining the minimum thickness. The existing deck section will be determined in the field and cross slope and/or crown will be verified by the Engineer. The finishing machine shall be passed over the existing deck prior to placing the concrete overlay in order that measurements can be made to ensure that proper cross slope and thickness will be achieved.

Promptly after the grout-bond coat has been applied, the concrete shall be deposited on the deck, and struck off and consolidated with the finishing machine. Consolidation using hand-held vibrators may be required when placing the mixture around steel reinforcement or structural steel members.

A transverse construction joint shall be constructed whenever placing is interrupted for twenty (20) minutes or longer, for any reason.

Concrete shall first be struck off at six (6) millimeters or more above the specified final thickness, and then consolidated by vigorous mechanical vibration. The in-place density of the consolidate mixtures will be determined by nuclear gages immediately following the screeding operation; the in-place density thus determined will be adjusted using the following formula:

$$\text{Adjusted Density} = \frac{\text{in-place density x 0.98}}{\text{1.00 - actual air content*}}$$

*Express actual air content as a decimal.

The adjusted density shall equal or exceed the target density; target density will be one hundred percent (100%) of the maximum theoretical density. Areas of concrete of deficient density shall be immediately corrected by additional passes of the finishing machine. When any concrete cannot be consolidated to the specified density, it shall be removed and replaced with acceptable concrete, at the Contractor's expense. Hand finishing of the consolidated concrete with a float may be required in order to produce a tight uniform surface.

The top surface of the consolidated and finished concrete overlay shall be smooth, uniform, and tight, and variations in the surface when checked with a three (3) meter straightedge shall not exceed three (3) millimeters.

5.14.5.5 Curing. Curing of the overlay shall be initiated immediately after texturing. Curing shall be by a double layer of wetted burlap. Sections or strips of burlap shall be placed transversely so that the overlay can be covered immediately after texturing. The burlap shall be continuously and thoroughly wetted by automatic fogging or sprinkling equipment for at least ninety-six (96) hours after the curing is started. New burlap shall be soaked in water for at least twelve (12) hours before the first use. Improper curing will be a basis for rejection of the concrete and nonpayment for the total cost of the rejected concrete. Curing compound will not be permitted on the overlay.

After curing of the overlay has been completed, the tops of all longitudinal and transverse construction joints shall be given a thorough coating of grout of the same consistency as the grout-bond coat material. The coating shall be neatly and uniformly applied. This coating is intended to seal any minute cracks which may have developed at these locations. Use of epoxy-sand slurry to seal construction joints in lieu of grout will not be permitted. The overlay may be opened to traffic as soon as all curing is completed.

5.14.6 METHOD OF MEASUREMENT.

5.14.6.1 Epoxy Bonding Agent. The area of the deck acceptably blast cleaned and coated with epoxy bonding agent prior to placing the concrete overlay, including the three hundred (300) millimeter width adjacent to the curbs will be measured in square meters. The blast cleaning and epoxy coating of any longitudinal and transverse construction joints will not be measured for payment.

5.14.6.2 Concrete Overlay, Latex or Polymer. The volume of the latex or polymer concrete in the completed and accepted overlay will be measured in cubic meters. In computing the volume for payment, the dimensions used shall be those shown on the plans or as ordered by the Engineer; the volume of material wasted or not incorporated into the finished work will not be included in the measured quantity. Grout used for the bond coat and crack sealing is considered incidental to the latex or polymer concrete overlay and will not be measured for separate payment.

5.14.6.3 Concrete Overlay, Portland Cement. The volume of Portland cement concrete in the completed and accepted overlay will be measured in cubic meters. In computing the volume for payment, the dimensions used shall be those shown on the plans as ordered by the Engineer; the volume of material wasted or not incorporated into the finished work will not be included in the measured quantity. Grout used for crack sealing is considered incidental to the concrete overlay and will not be measured for separate payment.

5.14.6.4 Epoxy-Sand Slurry. The accepted epoxy-sand slurry will be measured in square meters. The entire area covered, including the three hundred (300) millimeter width of the overlay and the seventy-five (75) millimeters extending up the faces of curbs and walls will be measured for payment.

5.14.7 PAYMENT.

5.14.7.1 Epoxy Bonding Agent. Payment for the measured areas at the contract unit price per square meter for epoxy bonding agent will be considered full payment for all expenses associated with the epoxy bonding agent application including the blast cleaning.

5.14.7.2 Concrete Overlay. The accepted quantity will be paid for at the contract unit price per cubic meter for Concrete Overlay, Latex; Concrete Overlay, Polymer; or Concrete Overlay, Portland Cement; as applicable, provided however, that for any area of overlay

found deficient by no more than twelve (12) millimeters, payment will be made at an adjusted contract price as specified in the following table:

Average Deficiency in Thickness (mm)	Proportional Part of Contract Price Allowed (percent)
0	100.0
1.5	95.0
3	90.0
4.5	80.0
6	70.0
7.5	57.5
9	45.0
10.5	25.0
12	0.0

At the Contractor's option, areas with an average deficiency in thickness of no more than twelve (12) millimeters may be removed and replaced with concrete overlay of the specified thickness at no cost to the Ministry. Payment at the contract unit price will be made for areas on which deficient overlay was removed and replaced with overlay meeting all requirements specified herein.

No additional payment will be made for concrete overlay in excess of the specified thickness.

5.14.7.3 Epoxy-Sand Slurry. Payment at the contract unit price per square meter shall be full compensation for all expenses associated with the epoxy-sand slurry construction necessary to complete the work.

Payment for the above listed items at the contract unit prices shall be full compensation for purchasing all materials, labor equipment, tools, supplies and all other expenses incurred which are necessary for completion of the bridge overlay work as specified in Subsection 1.07.2, Scope of Payment, in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
51401	Epoxy Bonding Agent	Square Meter
51402	Concrete Overlay, Latex	Cubic Meter
51403	Concrete Overlay, Polymer	Cubic Meter
51404	Concrete Overlay, Portland Cement	Cubic Meter
51405	Epoxy-Sand Slurry	Square Meter

SECTION 5.15 - STRUCTURE RESTORATION AND REHABILITATION

5.15.1 DESCRIPTION. This work shall consist of restoration or rehabilitation or a combination of restoration and rehabilitation, including any or all of the following:

- Maintaining and controlling traffic;
- Supporting the bridge;
- Furnishing all labor, materials, and equipment;
- Removal of all bituminous surfacing including patching materials;
- Removal of all bridge deck structural concrete to an average depth of up to 10 millimeters below the existing concrete surface;
- Removal of all bridge deck structural concrete to an average depth of at least 25 millimeters below the bottom of the existing top mat of reinforcing steel;
- Removal of existing concrete as necessary to construct bridge end transitions;
- Removal of all spalled and deteriorated concrete in curbs, sidewalks, and plinths;
- Removal of all spalled and deteriorated concrete in abutment caps, pier caps and superstructures;
- Removal of all other deteriorated concrete;
- Sand blasting and blast cleaning;
- Removal of corroded steel;
- Application of an anti-corrosion primer to the steel designated to remain in place;
- Drilling and grouting of dowels;
- Installation of epoxy coated reinforcing steel;
- Raising expansion devices;
- Removal of existing expansion joint and the installation of new expansion joints;
- Furnishing and installation of miscellaneous structural steel;
- Application of epoxy bonding agent to substrate;
- Partial or Full-depth patching;
- Placing, finishing, and curing of deck replacement concrete or other replacement structural concrete;
- Placing, finishing, and curing of a Portland cement, latex, polymer, or bituminous concrete overlay;
- Application of an epoxy-sand slurry;
- Any other work specified as part of the contract;

All of the Work described herein shall be carried out in accordance with these General Specifications, the Special Specifications, as shown on the plans, and as directed by the Engineer.

ITEMS IN BILL OF QUANTITIES
Removal of Epoxy, Bituminous, and Foreign Surface Overlay
Removal of Structural Concrete Deck Surface
Breaking and Removal of Structural Concrete
Drilling and Grouting Anchors
Joint Sealing
Miscellaneous Structural Steel
Special Expansion Joint
Anti-Corrosion Primer

Replacement Concrete for Partial Depth Patching
Replacement Concrete for Full Depth Patching
Replacement Deck Concrete or Other Replacement Structural Concrete

5.15.2 MATERIALS.

5.15.2.1 General. All materials shall be approved before use. The Contractor is advised that certain combinations of materials in concrete mixtures may cause chemical reactions resulting in significant cracking of the overlay, even though the materials are individually acceptable. The Contractor shall be responsible for furnishing materials that are compatible with each other, and shall repair or remove and replace any overlay damaged because incompatible materials were used, at no cost to the Ministry.

The moisture contents of the aggregates used in replacement structural concrete or concrete overlay mixtures, especially the fine aggregate, shall be controlled by the Contractor so that, at the time of mixing, the moisture content of each aggregate is relatively uniform; the material will feed uniformly when continuous type mixers are used; and the moisture contents of the aggregates are not so great that the water-cement ratio or slump requirement for the concrete mixture is violated. Any replacement structural concrete or concrete overlay mixture produced which is not properly proportioned or is not in conformity with the specified slump and/or water-cement ratio will be rejected by the Engineer, and shall be removed and replaced with concrete mixture meeting the requirements of this Section at no cost to the Ministry. When the water-cement ratio or slump requirements are violated due to excessive moisture content of the aggregates, this condition shall be corrected by the Contractor at his expense before mixing operations are continued.

5.15.2.2 Fine Aggregate. Fine aggregate for the replacement structural concrete or concrete overlay mixtures shall be natural sand conforming to the requirements of Subparagraph 5.01.2.2.1, "Fine Aggregate," in these General Specifications. The Engineer will verify the moisture content of the natural sand in order to calculate its free water content and resulting water-cement ratio of the concrete mixture.

5.15.2.3 Coarse Aggregate. Coarse aggregate for the replacement structural concrete or concrete overlay mixtures shall be maximum size nineteen (19) millimeters (¾ inch) conforming to the requirements of Subparagraph 5.01.2.2.2, "Coarse Aggregate," in these General Specifications. The Engineer will verify the moisture content of the coarse aggregate in order to calculate its free water content and resulting water-cement ratio of the mixture.

5.15.2.4 Replacement Structural Concrete. Deck replacement concrete or other structural concrete shall meet the requirements of Section 5.01, "Portland Cement Concrete," in these General Specifications for structural concrete Class E of 280 kg/cm^2 or the Class of the existing concrete; whichever requires the higher strength.

5.15.2.5 Replacement Concrete for Partial or Full Depth Patching. Concrete for partial or full depth patching shall meet the requirements for structural concrete in Paragraph 5.15.2.4, "Replacement Structural Concrete" in these General Specifications.

5.15.2.6 Miscellaneous Structural Steel. Miscellaneous structural steel for expansion dams and joint build-up shall be new, commercial grade steel suitable for welding. Acceptance will be based on visual inspection by the Engineer on the project.

5.15.2.7 Other Materials. Other materials shall meet requirements specified in the following Sections and Paragraphs in these General Specifications:

Cement	5.01.2.1
Water	5.01.2.3
Admixtures	5.01.2.4
Drilling and Grouting of Anchors	5.15.4.1.2
Epoxy Coated Steel	5.02
Anti-Corrosive Primer	5.15.4.2.2
Special Expansion Joint	5.15.4.5.2
Aggregates for Concrete Overlay	5.14.2.2 and 5.14.2.3
Epoxy Bonding Agent	5.14.2.4
Latex	5.14.2.5
Epoxy Cement for Epoxy Sand Slurry	5.14.2.6
Sand for Epoxy Sand Slurry	5.14.2.7
Preformed Expansion Joint Filler	6.23.2.4
Joint Sealing Compound	6.22.2.2
Waterproof Membrane	5.12
Bituminous Concrete Wearing Course Overlay	4.05

5.15.3 CONSTRUCTION REQUIREMENTS.

5.15.3.1 General Requirements. These general requirements shall apply to all restoration or rehabilitation work to be carried out on the structures in scope.

5.15.3.1.1 Scheduling. The Contractor shall notify the Engineer at least one (1) working day in advance of the date and time he intends to begin placing concrete overlay or replacement structural concrete. When placing of concrete is not begun within two (2) hours after the scheduled time, then all engineering costs from the scheduled time until the time placing actually begins or is canceled will be deducted from monies due or to become due the Contractor. No engineering costs will be deducted when placing is delayed for reasons beyond control of the Contractor, such as inclement weather or equipment failure after placing begins. No time extension will be granted for delay in placing concrete resulting from the Engineer receiving less than the one (1) working day notice specified above.

5.15.3.1.2 Weather Limitations. During warm weather, replacement structural concrete or replacement concrete for partial or full depth repairs shall only be placed in accordance with the requirements in subparagraph 5.03.4.10.4, "Additional Hot Weather Limitations and Curing Requirements for Bridge Decks and Slabs," in these General Specifications. During cool weather, concrete shall not be placed when the air temperatures away from artificial heat is less than eight degrees Celsius (8 ° C.) and falling. In all instances, all concrete shall be placed and kept at a temperature above eight degrees Celsius (8° C.) for at least ninety-six (96) hours after it is placed. Provisions shall be made for the uniform distribution of heat, and no area of the concrete surface shall be heated to a temperature above thirty degrees Celsius (30 ° C.) This will require approved housing, heating, or insulation methods during cold weather. In no case shall the concrete be placed when raining or drizzling. If during the process of placing concrete it should begin to rain or drizzle, placement shall be stopped and the material already in place shall be finished and protected.

Weather limitations for concrete overlays shall be as specified in Paragraph 5.14.3.2, "Weather Limitations," in these General Specifications.

5.15.3.1.3 Removal of Epoxy, Bituminous, and Foreign Surface Overlay. Epoxy, bituminous, and foreign surfaces and patches shall be removed in a manner approved by the Engineer. Hammers exceeding fifty (50) kilograms in weight or any other equipment that may cause damage to the underlying concrete shall not be used. Generally, epoxy, bituminous, and foreign surfaces (overlays) placed over the existing slab or surface profile will be listed as a separate bid item entitled "Removal of Epoxy, Bituminous, and Foreign Overlays" and will be paid for as a separate item. If, however, no bid item is set up for removal of these overlays in the contract, removal shall become incidental to the overlay.

Bituminous surfaces and patches may be removed in a manner approved by the Engineer and in accordance with Section 4.11, "Cold Milling Process for Removing Bituminous Pavement," in these General Specifications.

5.15.3.1.4 Removal of Structural Concrete Deck Surface, Restoration of Reinforcement and Surface Preparation. The area of the deck shown on the plans and delineated by the Engineer shall have the concrete removed to an average depth of up to ten (10) millimeters below the existing concrete surface. This operation shall be accomplished by use of Milling Machines or Hydrodemolition Methods described in Paragraph 5.15.3.2, "Concrete Removal Methods," in these General Specifications. The method used shall produce a surface matching the existing slab cross section and each pass of the machine shall match the previous pass in elevation. If satisfactory results are not achieved, the Engineer may direct that the work be performed with other equipment.

All other concrete deemed unsound by the Engineer shall be removed. Removal of concrete within areas where the depth of removal exceeds ten (10) millimeters shall be carried out as specified in Paragraph 5.15.3.1.5, "Breaking and Removal of Structural Concrete," and may be accomplished by use of Mechanical Impact Methods (Pneumatic Breakers). Should removal of unsound concrete extend through two-thirds (2/3) of the concrete slab or more, the remaining sound concrete shall be removed and replaced as outlined herein for full depth patching.

All exposed steel reinforcement and structural steel shall be sand blasted to remove scale, rust, grease, oil, etc. Prior to placing concrete, deteriorated or damaged reinforcement shall be replaced or supplemented as directed by the Engineer. All dust and chips of bituminous materials, concrete, or other debris shall be removed and the entire area shall be cleaned with compressed air supplied by an air compressor having suitable separators and traps. The compressed air shall be free of detrimental qualities

of water, oil, grease, or any other injurious substances. Leakage of oil, grease, gasoline, or other substances from the compressor(s) or other equipment on the deck shall be prohibited. Protective sheeting (plastic, tarpaulins, etc.) shall be suspended under any equipment which leaks.

All spalled or deteriorated concrete in curbs, sidewalks, and plinths shall be removed (minimum of twenty-five (25) millimeters in depth). These areas shall be blast cleaned, coated with a bonding agent, restored to the original section with overlay material, then sealed with epoxy-sand slurry.

5.15.3.1.5 Breaking and Removal of Structural Concrete. The area of the deck including curbs, as shown on the plans and delineated by the Engineer, shall have the concrete removed to an average depth of at least twenty-five (25) millimeters below the existing top mat of reinforcing steel, as shown on the plans. This operation shall be accomplished by use of Mechanical Impact Methods (Pneumatic Breakers), Milling Machines, or Hydrodemolition Methods described in Paragraph 5.15.3.2, "Concrete Removal Methods," in these General Specifications. The method used shall produce a surface matching the existing slab cross section and each pass of the machine shall match the previous pass in elevation. If satisfactory results are not achieved, the Engineer may direct that the work be performed with other equipment. Endwalls will not require machine preparation unless otherwise noted. No deductions in area will be made for existing deck drains, castings, expansion dams, patches of foreign material, etc.

All other concrete deemed unsound by the Engineer shall be removed. Removal of concrete may be accomplished by the use of hammers not exceeding fourteen (14) kilograms in weight or other such small equipment. Precaution shall be exercised by the Contractor not to damage any steel reinforcement. Concrete shall be removed to a depth of twenty-five (25) millimeters below any reinforcing bar which is more than half (1/2) exposed or any other which appears not to be bonded to the existing concrete. Precautions shall be exercised to protect any underlying sound concrete and steel reinforcement. The periphery of routed area shall be as nearly vertical as possible. Any exposed steel reinforcement that is not tied shall be tied.

Inferior concrete in the deteriorated and spalled areas near joints shall be removed, and all joint filler removed. The joints shall be reformed to exact width and true alignment by installation of a template made of styrofoam, timber covered with polyethylene sheeting, or other suitable materials.

All exposed steel reinforcement and structural steel shall be sand blasted as per requirements of Paragraph 5.15.4.3, "Sand Blasting," in these General Specifications to remove scale, rust, grease, oil, etc. Prior to placing concrete, deteriorated or damaged reinforcement shall be replaced. Corroded steel reinforcements shall be replaced by using epoxy coated reinforcements as shown on the plans or supplemented as directed by the Engineer. All dust and chips of bituminous materials, concrete, or other debris shall be removed and the entire area shall be blast cleaned as described in Paragraph 5.15.4.4, "Blast Cleaning," in these General Specifications.

All spalled or deteriorated concrete in abutment caps, pier caps and superstructure shall

be removed a minimum of twenty-five (25) millimeters behind the reinforcements or as directed by the engineer. These areas shall be blast cleaned as described in Paragraph 5.15.4.4, "Blast Cleaning," in these General Specifications, all existing exposed steel shall be sand blasted as described in Paragraph 5.15.4.3, "Sand Blasting," in these General Specifications and coated with anti-corrosion primer as described in Paragraph 5.15.4.2, "Anti-corrosion Primer," in these General Specifications. The substrate shall be coated with an epoxy bonding agent as described in Paragraph 5.15.4.6, "Epoxy Bonding Agent," in these General Specifications and restored to the original section with structural concrete.

5.15.3.1.6 Field Welding Prohibited. No welding of any nature shall be performed on load carrying members of bridge, except as approved on the plans, without written consent of the Engineer, and then only in the manner and at locations designated.

5.15.3.1.7 Drilling and Grouting of Anchors. The Contractor shall drill and grout anchors as specified in the plans in accordance with Paragraph 5.15.4.1, "Drilling and Grouting of Anchors," in these General Specifications.

5.15.3.1.8 Anti-Corrosion Primer for Steel. The Contractor shall apply anti-corrosion primer to the exposed existing steel reinforcement prior to placing of the concrete in accordance with Paragraph 5.15.4.2, "Anti-Corrosion Primer," in these General Specifications.

5.15.3.1.9 Epoxy Coated Reinforcing Steel. The Contractor shall remove the steel reinforcements that are deteriorated at any point to greater than twenty (20) per cent of their original cross section, as judged by the Engineer, and replace them with epoxy coated reinforcing steel as shown on the plans and in accordance with Section 5.02, "Reinforcing Steel," in these General Specifications.

5.15.3.1.10 Special Expansion Joints. The Contractor shall remove the existing expansion joints and replace them with polymer modified bituminous joints as shown in the plans in accordance with Paragraph 5.15.4.5, "Special Expansion Joints," in these General Specifications.

5.15.3.1.11 Expansion Dam Treatment. Unless otherwise specified, existing expansion dams shall be treated as shown on the plans. Painting of structural steel will not be required unless specified in the plans.

5.15.3.1.12 Epoxy Bonding Agent. The Contractor shall apply epoxy bonding agent to the substrate before placing of new concrete in accordance with Paragraph 5.15.4.6, "Epoxy Bonding Agent," in these General Specifications.

5.15.3.1.13 Deck Drainage Pipes. The Contractor shall install deck drainage pipes as shown in the drawings in accordance with Section 5.11, "Drainage on Structures," in these General Specifications.

5.15.3.1.14 Replacement Structural Concrete Placement. The proportioning, production, placing, consolidating, finishing and curing of deck replacement concrete or other replacement structural concrete shall be in accordance with Section 5.03, "Concrete Structures" in these General Specifications.

The top surface of the consolidated and finished concrete shall be smooth, uniform and tight, and variations in the surface when checked with a three (3) meter straightedge shall not exceed four (4) millimeters.

5.15.3.1.15 Partial Depth Patching. Partial depth patching shall be constructed in accordance with Paragraph 5.15.3.1.16, "Full Depth Patching," in these General Specifications except that the concrete shall only be brought up to the elevation of the surrounding concrete thereby permitting the replacement structural concrete layer or the concrete overlay to be placed as one uniformly thick surface layer.

5.15.3.1.16 Full Depth Patching. The area of removal of concrete to full depth shall be as shown on the plans and delineated on site by the Engineer. Full depth holes shall be filled with the class of concrete specified in Paragraph 5.15.2.5, "Replacement Concrete for Partial or Full Depth Patching," in these General Specifications. Immediately prior to placement of concrete, the contact surfaces shall be treated with epoxy bonding agent as specified in Paragraph 5.15.4.6, "Epoxy Bonding Agent," in these General Specifications. The new concrete shall be carefully placed and tamped or vibrated into place. Full depth patched areas shall be rough-finished to an elevation corresponding to the scarified grade and shall be cured for a period of no less than seven (7) calendar days, or until the overlay is placed, by means of a double layer of wetted burlap or similar material. If the concrete surrounding a full depth concrete patch requires partial depth removal, then the full depth concrete patch shall be finished to an elevation corresponding to the bottom of the partial depth routed areas instead of the elevation of the original deck.

After the concrete has hardened sufficiently to maintain the proper shape, all joint templates shall be removed in a manner to avoid chipping or breaking down the edges of the repaired joint. All forming material shall be removed prior to completion of the project unless otherwise specified.

Existing concrete parapet and other deck sections may require temporary support while removing and replacing full depth concrete; the cost of this work will be incidental to the concrete overlay. The proposed method of supporting these sections shall be submitted to the Engineer for approval prior to beginning work.

The surfaces of all patched areas shall be blast cleaned to remove all laitance prior to the overlayment and all sand shall be removed. All full depth patching in each lane shall be completed prior to beginning overlaying operations on that lane, unless otherwise permitted.

Latex concrete overlays, Portland cement concrete overlays and polymer concrete overlays may not be placed until full depth patches are at least seven (7) days old; however, Portland cement concrete overlay may be placed when the full depth patches are three (3) days old, provided the Contractor elects to use Type III (high early strength) cement in the concrete patches, and the concrete has developed a compressive strength of two hundred eighty (280) kilograms per square centimeter. The Contractor's equipment

will not be permitted on the full depth patches until the patches are at least seven (7) days old, or have developed a compressive strength of two hundred eighty (280) kilograms per square centimeter.

5.15.3.1.17 Mixing and Placing of Concrete Overlay. Mixing and placing of concrete overlays shall be in accordance with Section 5.14, "Concrete Bridge Deck Overlays," in these General Specifications. Concrete overlays shall only be placed on decks which have been prepared for an overlay in accordance with Paragraph 5.15.3.1.4, "Removal of Structural Concrete Deck Surface, Restoration of Reinforcement and Surface Preparation," in these General Specifications.

In the vicinity of drainage scuppers or gullies, the overlay shall be finished as shown on the plans unless otherwise directed by the Engineer.

Consolidation using hand-held vibrators may be required when placing the mixture around steel reinforcement or structural steel members.

The overlay may be opened to traffic as soon as curing is completed, all full depth patches are at least seven (7) days old or have attained a compressive strength of two hundred eighty (280) kilograms per square centimeter, and all construction joints have been sealed.

5.15.3.1.18 Bridge End Transitions. End sections of the bridge shall be overlaid and finished in a manner dependent on the type of adjacent approach pavement. For a rigid type approach, the finishing machine rails shall be set so as to provide a fifteen (15) meter transition on the ends of the bridge to match the finished grade of the overlay with the existing grade of the adjacent pavement. Existing concrete shall be removed as necessary to maintain the minimum specified thickness of the overlay. For a non-rigid approach or a rigid approach with bituminous overlay, no transition will be required. These requirements shall apply unless otherwise noted.

5.15.3.1.19 Cleaning and Sealing Joints. Each joint shall be reworked as shown in the plans and prescribed as follows:

1. All joint and sealer and filler materials, incompressibles and other foreign materials shall be removed down to the waterstop or one hundred fifty (150) millimeters below the top of the deck when no waterstop exists. Care shall be taken to avoid damaging the water stop and any damage shall be repaired at the Contractor's expense.

2. All vertical faces of the joint shall be blast cleaned to a depth of thirty (30) millimeters so as to be free of all bituminous materials, tar, grease, and other materials which would prevent the best possible bond between the concrete and the joint sealing compounds.

3. A preformed joint filler, of the proper dimensions, shall be inserted into the joint. The filler shall be of such depth that when resting on the waterstop, it will be thirty (30) millimeters below the top surface of the deck.

4. Before the joint sealing compound is applied, the joint shall be inspected for cleanness. When the cleanness of the joint is approved by the Engineer, the joint shall be sealed with joint sealing compound. The joint shall be filled to within six (6) millimeters of the top surface of the deck. All joints shall be sealed from the outside face of one plinth to the outside face of the other plinth, including the deck, curbs, sidewalks, and plinths.

5.15.3.1.20 Waterproof Membrane. When shown on the plans, the Contractor shall apply waterproof membrane to the bridge deck prior of placement of bituminous concrete wearing course overlay in accordance with Section 5.12, "Waterproofing for Structures," in these General Specifications.

5.15.3.1.21 Bituminous Concrete Wearing Course Overlay. When shown on the plans, the Contractor shall place and finish a bituminous concrete wearing course overlay in accordance with Section 4.05, "Bituminous Concrete Pavement," in these General Specifications.

5.15.3.1.22 Material Hauling. The hauling of all material for latex concrete or Portland cement concrete overlays by trucks with continuous mixers or any other types of trucks shall be performed with vehicles which do not exceed the regulation for either the legal axle weights or axle spacing contained in the Ministry's Truck Weight Regulations.

Prior to doing any overlay work on a structure, the Contractor shall furnish to the Engineer a certified statement listing the empty weight of each hauling vehicle, axle weights when empty, axle weights when fully loaded, gross weight of each vehicle when loaded with a specific number of cubic meters, and the spacing of axles. This information will be used by the Engineer for the purpose of limiting the quantity of materials permitted to be hauled by the Contractor and this limitation shall be based on the capacity and condition of the bridge after unsound concrete has been removed and prior to placement of the overlay. Under no circumstances will loads which exceed legal gross or axle load limits be permitted .

5.15.3.1.23 Maintain and Control Traffic. All necessary traffic controls, signs, devices, and flagmen shall be properly placed before any work is started. All work shall be performed in accordance with the applicable standard drawings, Section 9.02, "Traffic Control Through Work Zones," in these General Specifications and any special requirements in the plans or Special Specifications.

5.15.3.1.24 Damage to Structures. The Contractor is responsible for any and all damage to the structure during construction until all work is completed, even to the replacement of entire spans at his expense, should they be allowed to fail as a result of this construction.

5.15.3.1.25 Unacceptable Work. Any areas of the overlay which display extensive cracking or other characteristics indicating the waterproofing effectiveness or expected life of the overlay may be reduced, or the overlay may not be intimately bonded to the underlying deck, will be cored by the Contractor when deemed necessary by the Engineer. Any area shown by the cores to either have cracks exceeding a depth of six (6) millimeters or to not be intimately bonded to the underlying deck shall be removed and replaced with acceptable concrete at the Contractor's expense. Removal and replacement may be required without coring when significant cracking or lack of bond are so apparent as to make coring unnecessary in the judgment of the Engineer. All cracks which are not significant enough to require removal of the overlay shall be sealed with grout to the satisfaction of the Engineer.

5.15.3.2 Concrete Removal Methods.

5.15.3.2.1 General. The concrete removal shall be accomplished by one of the following methods:

1. Mechanical Impact Methods (Pneumatic Breakers).
2. Milling Machines.
3. Hydrodemolition Methods.

The Contractor shall arrange an advance approval of the Engineer for the method(s) which he intends to use for the accomplishment of the work.

The following definitions of the quality of existing concrete are used:

Sound concrete is defined as concrete that is free from spalls, cracks and/or delaminations.

Deteriorated concrete is defined as concrete that has spalls, cracks and/or delaminations.

Contaminated concrete is defined as concrete that has a chloride ion content greater than 1.18 kg/cubic meter, when tested in accordance with AASHTO T260. Contaminated concrete may be either sound or deteriorated.

5.15.3.2.2 Work Plan. Prior to commencement of the work, the Contractor shall submit for approval to the Engineer his work plan. This work plan shall include complete details of the following items:

1. The method or methods proposed for concrete removal including the protection and safety of nearby traffic.

2. When there is a risk to the structural integrity of the structure, which is under treatment, the Contractor shall suggest, provide and install the adequate supporting system to ensure the safety of the structure during the retrofitting operation.

3. The Contractor shall be responsible for compliance with all environmental regulation regarding the discharge of removed materials, dust and the runoff water resulted from the hydrodemolition process into the environment. The Contractor shall provide specific details of the method of treatment of these materials and obtain any necessary permits required for its discharge into the environment.

4. The Contractor shall suggest and provide a means for controlling runoff water to

control its flowing into adjacent lanes which are open to traffic. The control measures must be approved by the Engineer.

5. The Contractor shall clean up all debris immediately after demolition. If for any reason or another the debris rebond to the deck, the Contractor shall clean the deck to the Engineer's satisfaction at no additional cost to the Ministry and with no additional allowance for contract time extension.

5.15.3.2.3 Construction Procedures. The Contractor shall arrange an advanced approval of the Engineer on the methods and work plans which he intends to follow for the accomplishment of the work.

The Contractor shall take all steps necessary to prevent cutting or otherwise damaging the reinforcing steel bars. Any bars damaged by the Contractor shall be repaired or replaced at no additional cost to the Ministry and with no additional allowance for contract time extension.

Following the concrete removal, the Engineer will inspect any exposed steel reinforcement. If, in the opinion of the Engineer, the bars are deteriorated at any point to greater than twenty (20) per cent of their original cross section, the Contractor will be directed by the Engineer to remove and replace these bars or section of bars. New epoxy-coated bars of the same size shall be spliced by providing the laps shown on the plans.

5.15.3.2.4 Equipment.

1. General. The Contractor shall provide the necessary scaffolding and safety net as well as a lighting system when needed.

The Contractor shall be responsible for supplying the water and all other materials as well as the labor necessary to do the specified work.

The Contractor shall maintain on site an adequate supply of wear items, repair parts and service personnel to guarantee that the removal operation will not be interrupted for more than twenty-four (24) hours when an equipment breakdown occurs.

The Contractor shall be responsible for disposing of all removed materials at an off-site location, and he shall get the necessary prior approvals from the concerned bodies.

2. Concrete Removed by Mechanical Impact. Only breakers powered by pneumatic pressure shall be used. The weight of the breaker shall be limited to a maximum of fourteen (14) kg above reinforcements and seven (7) kg below reinforcements. For vertical or overhead surface or light duty applications the weight shall not be more than ten (10) kg. However, the upper weight limits shall be governed by the quality requirements of the job and the weight which can be handled by the operator with ease and safety.

The pneumatic breaker shall be capable of removing concrete from around and below the steel reinforcement.

The breaker shall be operated by qualified labor capable of controlling the impact angle between forty-five (45) and sixty (60) degrees.

3. Concrete Removed by Milling. The milling machine shall consist of a cutting mandrel with carbide-tungsten tipped cutting teeth arranged in a spiral which runs inward from the sides. The mandrel drive system shall rotate the mandrel in a direction opposite to direction of travel of the machine so as to fracture the concrete in tension.

The milling machines of weight not more than ten (10) tons may run on tires. Large size machines of a maximum weight of twenty (20) tons shall be equipped with tracks.

The machine shall be equipped with a hydraulically controlled conveyor system for the removal of debris.

The milling machine shall be capable of removing the contaminated or damaged concrete cover in one pass or several passes. The depth of cutting shall be controlled by an automatic or manual depth control system.

The milling machine shall be operated by qualified experienced personnel approved by the Engineer prior to the beginning of the milling process.

4. Concrete Removed by Hydrodemolition. The hydrodemolition equipment shall consist of a water supply system, a high pressure water pumping system and a demolishing unit. The demolishing unit shall be fully automated to provide precise control of the water-jet and guarantee consistent operation.

The hydrodemolition equipment shall be capable of removing concrete from around and below the steel reinforcement. The hydrodemolition equipment shall clean all exposed reinforcing steel from rust, concrete fragments, laitance, loose scale and other coatings which may destroy or inhibit the bond with the new concrete.

The hydrodemolition shall be operated by qualified personnel certified by the equipment manufacturer. Operator certification shall be submitted to the Engineer for approval prior to beginning the hydrodemolition operation.

The hydrodemolition equipment shall be calibrated and tested in trial sections prior to commencement of the actual operation to demonstrate that the equipment, personnel and method of operation are capable of producing results satisfactory to the Engineer. The trial area shall consist of two (2) patches, each approximately three (3) meters long. The first trial patch shall consist of sound concrete as determined by the Engineer. The second trial patch shall consist of deteriorated concrete as determined by the Engineer.

The hydrodemolition equipment shall first be calibrated on the sound trial patch to remove concrete to a depth specified by the Engineer ± half (1/2) of the maximum aggregate size in the existing concrete.

The hydrodemolition equipment shall then be used to remove concrete from the deteriorated trial patch using the operating parameters established from the sound trial patch. If all the deteriorated concrete is removed as determined by the Engineer then the hydrodemolition system shall be considered calibrated. These operating parameters shall be used as the basis for the production removal.

The Contractor shall record the calibrated hydrodemolition equipment's operating parameters and provide the Engineer with a copy. The Contractor shall not change the hydrodemolition system's operating parameters unless directed or approved by the Engineer.

5.15.4 EXECUTION REQUIREMENTS.

5.15.4.1 Drilling and Grouting of Anchors.

5.15.4.1.1 Description. Drilling and grouting of anchors into the sound existing concrete shall be carried out where the stirrups are damaged and/or corroded and where additional bond or shear resistance is required between the old existing concrete and new concrete.

5.15.4.1.2 Material. The following two types of anchors may be used:

1. Adhesive anchors. The binder is in a glass capsule, which will be broken when the anchor is driven into the hole.

2. Grouted anchor. The binder is a polymer modified cement mortar placed in the holes. These types of anchors are only to be used on top sides of horizontal surfaces.

5.15.4.1.3 Execution. The diameters of the drilled holes shall be four (4) millimeters greater than the diameter of the anchors or shall be in accordance with the manufacturer's recommendations.

The holes shall be drilled perpendicular to the sound concrete surface and the holes shall be cleaned carefully from dust before inserting the anchors.

The adhesive anchors shall be installed in accordance with the supplier's specifications and as approved by the Engineer.

The length of the anchors shall be as shown on the drawing or as directed by the Engineer.

When using grouted anchors, the holes shall be saturated before inserting and grouting the anchors.

The holes for the grouted anchor shall be completely filled from the bottom using a tube before the anchors are inserted. The anchors shall be totally surrounded by mortar for the full depth of the hole.

After hardening, the Contractor shall carry out tests of tensile strength on approximately five percent of the anchors, for a minimum of five pieces in every stage. The anchors should achieve the required tensile strength and should not fail in bond by slipping through the cement mortar or by failure of the cement mortar itself. If the results of the tests are not satisfactory, further tests and/or replacements may be carried out in accordance with the Engineer's instructions.

Anchors shall have the proper concrete cover as specified in the contract drawings.

5.15.4.2 Anti-Corrosion Primer.

5.15.4.2.1 Description. This work shall consist of application of approved anti-corrosion primer over all the exposed steel as shown on the drawings and/or as directed by the Engineer.

5.15.4.2.2 Material. Anti-corrosion primer shall possess the following properties:

1. Actively resist/prevent corrosion in steel over which it is applied.

2. It should not be harmful in any way to the concrete or the steel.

3. It should not be detrimental to the bond between the steel and the concrete.

5.15.4.2.3 Application. Before applying the anti-corrosion primer, all the exposed steel shall be sand blasted as per Paragraph 5.15.4.3, "Sand Blasting," in these General Specifications. The approved anti-corrosion primer shall be applied over all the exposed steel as shown on the drawings or as directed by the Engineer. The manufacturer's instructions for surface preparation and application shall be strictly followed.

5.15.4.3 Sand Blasting.

5.15.4.3.1 Description. This work shall consist of cleaning by sand blasting the steel, including the underside and/or back of the steel, of all loose scale, rust/corrosion, mortar or other materials.

5.15.4.3.2 Material. Sharp natural sand shall be used. The sand shall consist of non-disintegrating grains, free of clay particles and other detrimental materials for steel and concrete.

The compressed air used for sand blasting must be free of oil, and substances that contaminate the surfaces and other detrimental materials.

5.15.4.3.3 Application. Sand blasting shall be performed within twenty-four (24) hour period preceding placement of the concrete on the area. However, if the project is done under traffic, all sand blasting must be done within twelve (12) hours prior to placement of concrete.

The sand blasted steel shall be protected, as necessary against contamination prior to placement of concrete. Contaminated areas and areas exposed more than twenty-four (24) hours (twelve (12) hours when under traffic) shall be sand blasted again as directed by the Engineer at the Contractor's expense.

5.15.4.4 Blast Cleaning.

5.15.4.4.1 Description. This work shall consists of cleaning the designated areas with clean water from a high pressure water jet or compressed air supplied by an air compressor having suitable separations and traps.

5.15.4.4.2 Material. The water used for blast cleaning shall conform to the requirements in Paragraph 5.01.2.3, "Water," in these General Specifications. The compressed air used for blast cleaning must be free of water, oil, grease and other injurious substances.

5.15.4.4.3 Application. All dust chips and particles from previous concrete breaking removal, sand blasting and other rehabilitation work shall be removed prior to the start of blast cleaning. Leakage of oil, grease, gasoline, diesel fuel, or other substances from the compress or other equipment or to the deck shall be prohibited.
Protective sheeting (plastic, polyethylene, tarpaulin, etc.) shall be suspended under any equipment which leaks.

The blast cleaning shall produce areas cleaned to a bright clean appearance free from all foreign material.

5.15.4.5 Special Expansion Joints.

5.15.4.5.1 Description. This work shall consist of removal and installing/replacement of expansion joints. The Contractor shall remove the existing expansion joints and or pavement mortar in such a manner so as not crack/damage the concrete below and around the joint. If the concrete is damaged, the Contractor shall carry out immediately at his own cost, the appropriate remedial measures deemed necessary by the Engineer.

5.15.4.5.2 Material. The type of expansion joint to be used shall be a polymer modified bituminous joint. The Contractor shall provide all the information with regard to the material, properties, installation procedures, guarantees etc. and detailed drawings of the joint, for the approval by the Engineer.

The joints must possess the following properties under normal and extreme weather conditions:

- Waterproof under all conditions, also at boundaries ends and connections etc.
- Sufficient mechanical stability and strength to withstand loads from the traffic in the form of compressive and shear forces, also in curves and during braking and acceleration.
- Resistance against cracking or separation in layers under the influence of the traffic and movement of supports.
- Wearing strength.
- Expansion and contraction capacity as required 0-50 millimeters.
- Provide good riding surface.

- Should be flexible even in very cold conditions and not become too soft in very warm conditions.

5.15.4.5.3 Application. The joint shall be installed under the Rehabilitation Engineer's supervision. The manufacturer's detailed description of all steps of the work procedure and requirements for the finished work shall be strictly followed. The size of the opening shall be compatible with the mean bridge temperature at the time of installation.

5.15.4.6 Epoxy Bonding Agent.

5.15.4.6.1 Description. This work shall consist of applying a coat of epoxy bonding agent of uniform thickness and consistency on properly prepared areas of old concrete, designated to receive replacement structural or overlay concrete.

5.15.4.6.2 Material. Epoxy bonding agent shall be as specified in Paragraph 5.14.2.4, "Epoxy Bonding Agent," in these General Specifications.

5.15.4.6.3 Application. Application of the epoxy bonding agent shall be as specified in Paragraph 5.14.3.3, "Epoxy Bonding Agent," in these General Specifications. Except that, for the scope of this section, the entire area of the surface to receive concrete overlay, concrete for partial or full depth repairs or replacement concrete, shall be blast cleaned to a bright, clean appearance which is free from curing compound, laitance, dust, dirt, oil, grease, bituminous material, paint, and all foreign matter.

5.15.5 PERSONNEL REQUIREMENTS.

5.15.5.1 Bridge Rehabilitation Engineer. The Contractor shall provide a full time on-site Bridge Rehabilitation Engineer with the following experience and qualifications, while bridge rehabilitation work is under way.

1. Education. Graduate civil or structural engineer or equivalent.

2. Experience. Several years of acceptable construction experience in rehabilitating bridges and similar structures.

3. Proficient in the English and Arabic languages and able to clearly communicate observations, determinations and proposed ground support category recommendations.

4. The Contractor shall not commence field work until written approval of the bridge rehabilitation engineer has been received.

Duties shall be as follows:

1. Propose appropriate concrete removal areas based upon observed deck condition, crack mapping and appropriate test data.

2. Hold daily discussion with the Engineer on-site regarding bridge conditions and the performance of rehabilitation work and keep written records thereof.

3. Submit weekly summary reports on rehabilitation work progress and conditions encountered.

4. Participate in all pertinent coordination meetings with the Engineer, and submit minutes of the meetings within one week after each meeting.

5.15.6 METHOD OF MEASUREMENT.

Quantities to be paid for will be measured in units of completed and accepted work, as hereinafter specified. In computing quantities, all dimensions used shall be those measured by the Engineer.

5.15.6.1 Removal of Epoxy, Bituminous and Foreign Overlay. The area of removal of epoxy, bituminous, and foreign overlays, including patches, complete and accepted, will be measured in square meters. This item will not be measured separately when a bid item for removal of the epoxy, bituminous, and foreign overlays is not included in the contract, but will be considered incidental to the overlay.

5.15.6.2 Removal of Structural Concrete Deck Surface . The total area prepared by removal of concrete to an average depth of up to ten (10) millimeters below the existing surface, as specified, complete and accepted, will be measured in square meters.

5.15.6.3 Breaking and Removal of Structural Concrete. The total quantity of concrete removed to an average depth of at least twenty-five (25) millimeters below the existing top mat of reinforcing steel, as specified, complete and accepted, will be measured in cubic meters in accordance with Subparagraph 5.15.3.1.5, "Breaking and Removal of Structural Concrete," in these General Specifications.

5.15.6.4 Drilling and Grouting of Anchors. Measurement of drilling and grouting of anchors will be the number acceptably placed and grouted in accordance with Paragraph 5.15.4.1, "Drilling and Grouting of Anchors," in these General Specifications.

5.15.6.5 Joint Sealing. Joint sealing will be measured in linear meters.

5.15.6.6 Miscellaneous Structural Steel. Structural steel will be measured in accordance with Paragraph 5.5.8.1, "Structural Steel," in these General Specifications.

5.15.6.7 Special Expansion Joint. Measurement will the number of linear meters of a special expansion joint properly installed and accepted in accordance with Paragraph 5.15.4.5, "Special Expansion Joints," in these General Specifications.

5.15.6.8 Anti-Corrosion Primer. Measurement will be the liters of material used to satisfactorily coat the surface area of the exposed steel reinforcement over which the primer is satisfactorily applied and accepted in accordance with Paragraph 5.15.4.2, "Anti-Corrosion Primer," in these General Specifications. The preparatory sand blasting shall not be measured as it is considered to be subsidiary to the anti-corrosion primer application.

5.15.6.9 Replacement Concrete for Partial or Full Depth Patching and Replacement Structural Concrete . The quantity measured for payment will be the number of cubic meters actually placed, accepted and measured in accordance with Section 5.03.10, "Method of Measurement," in these General Specifications. This will include material used to patch spalled or deteriorated sections of curbs, sidewalks or plinths. The volume of material wasted or not incorporated in the work will not be included in the measured quantity. Crack sealing is considered incidental and will not be measured for payment.

5.15.6.10 Sand Blasting and Blast Cleaning. The surface area of the reinforcing steel acceptably sand blasted in accordance with Paragraph 5.15.4.3, "Sand Blasting," in these General Specifications shall not be measured separately as it is considered subsidiary to the anti-corrosion primer.

The surface area of concrete substrate acceptably blast cleaned in accordance with Paragraph 5.15.4.4, "Blast Cleaning," in these General Specifications shall not be measured as it is considered subsidiary to the epoxy bonding agent.

5.15.6.11 Epoxy Coated Reinforcing Steel. Measurement will be in accordance with Subsection 5.02.6, "Method of Measurement," in these General Specifications.

5.15.6.12 Epoxy Bonding Agent. The area of acceptable application of epoxy bonding agent including blast cleaning will be measured in square meters in accordance with Paragraph 5.15.4.6, "Epoxy Bonding Agent," in these General Specifications. The preparatory sand blasting shall not be measured as it is considered to be subsidiary to the bonding agent application.

5.15.6.13 Concrete Overlay, Latex, Portland Cement or Polymer. Measurement will be in accordance with Paragraphs 5.14.6.2, "Concrete Overlay, Latex or Polymer," 5.14.6.3, "Concrete Overlay, Portland Cement," in these General Specifications, as applicable.

5.15.6.14 Epoxy-Sand Slurry. Measurement will be in accordance with Paragraph 5.14.6.4, "Epoxy-Sand Slurry," in these General Specifications.

5.15.6.15 Waterproof Membrane. Measurement will be in accordance with Subsection 5.12.4, "Method of Measurement," in these General Specifications.

5.15.6.16 Bituminous Concrete Wearing Course Overlay. Measurement will be in accordance with Subsection 4.05.10, "Method of Measurement," in these General Specifications.

5.15.7 PAYMENT.

5.15.7.1 Removal of Epoxy, Bituminous and Surface Overlay. Payment at the contract unit price per square meter shall be full compensation for the satisfactory removal and disposal of existing epoxy, bituminous, and foreign overlay measured as specified in

Paragraph 5.15.6.1, "Removal of Epoxy, Bituminious and Foreign Overlay," in these General Specifications.

5.15.7.2 Removal of Structural Concrete Deck Surface. Payment at the contract unit price per square meter will be made for the area prepared by removal of existing concrete to an average depth of up to ten (10) millimeters below the existing surface, complete and accepted, measured in accordance with Paragraph 5.15.6.2, "Removal of Structural Concrete Deck Surface," in these General Specifications.

5.15.7.3 Breaking and Removal of Structural Concrete. Payment at the contract unit price per cubic meter shall be full compensation for the breaking and removal of existing concrete to an average depth of at least twenty-five (25) millimeters below the existing top mat of reinforcing steel, measured as specified in Paragraph 5.15.6.3, "Breaking and Remval of Concrete," in these General Specifications.

5.15.7.4 Drilling and Grouting of Anchors. Payment will be made at the contract unit price for the number of units of completed and accepted work measured in accordance with Paragraph 5.15.6.4, "Drilling and Grouting of Anchors," in these General Specifications.

5.15.7.5 Joint Sealing. Payment will be made at the contract unit price per linear meter for all completed and accepted work measured in accordance with Paragraph 5.15.6.5, "Joint Sealing," in these General Specifications.

5.15.7.6 Miscellaneous Structural Steel. Payment will be made in accordance with the requirements of Paragraph 5.5.9.1, "Structural Steel," in these General Specifications.

5.15.7.7 Special Expansion Joint. Payment will be made at the contract unit price per linear meter for all work authorized, completed and accepted by the Engineer measured in accordance with Paragraph 5.15.6.7, "Special Expansion Joint," in these General Specifications.

5.15.7.8 Anti-Corrosion Primer. Anti-corrosion primer will be paid for at the contract unit price per liter for all authorized, completed and accepted work by the Engineer and measured in accordance with Paragraph 5.15.6.8, "Anti-Corrosion Primer," in these General Specifications.

5.15.7.9 Replacement Concrete for Partial or Full Depth Patching and Replacement Structural Concrete. Payment will be made at the contract unit prices per cubic meter for all completed and accepted work measured in accordance with Paragraph 5.15.6.9, "Replacement Concrete for Partial or Full Depth Patching and Replacement Structural Concrete," in these General Specifications.

5.15.7.10 Epoxy Coated Reinforcing Steel. Payment will be made at the contract unit price per ton in accordance with Subsection 5.02.7, "Payment," in these General Specifications.

5.15.7.11 Epoxy Bonding Agent. Epoxy bonding agent will be paid for at the contract unit price for all work completed and accepted by the Engineer and measured in accordance with Paragraph 5.15.6.12, "Epoxy Bonding Agent," in these General Specifications.

5.15.7.12 Concrete Overlay, Latex, Portland Cement or Polymer . Payment will be made in accordance with Paragraph 5.14.7.2, "Concrete Overlay," in these General Specifications.

5.15.7.13 Epoxy-Sand Slurry. Payment will be made in accordance with Paragraph 5.14.7.3, "Epoxy-Sand Slurry," in these General Specifications.

5.15.7.14 Waterproof Membrane. Payment will be made in accordance with Subsection 5.12.5, "Payment," in these General Specifications.

5.15.7.15 Bituminous Concrete Wearing Course Overlay. Payment will be made at the contract unit price in accordance with Subsection 4.05.11, "Payment," in these General Specifications.

Payment for the above listed items at the contract unit prices shall be full compensation for furnishing all materials, labor, equipment, tools, supplies and all other expenses incurred which are necessary for completion of the work as specified in Subsection 1.07.2, "Scope of Payment," in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
51501	Removal of Epoxy, Bituminous and Foreign Surface Overlay	Square Meter
51502	Removal of Structural Concrete Deck Surface	Square Meter
51503	Breaking and Removal of Structural Concrete	Cubic Meter
51505	Drilling and Grouting Anchors	Unit
5150501	Drilling and Grouting Anchors, 50 cm	Unit
5150502	Drilling and Grouting Anchors, 75 cm	Unit
5150503	Drilling and Grouting Anchors, 100 cm	Unit
5150504	Drilling and Grouting Anchors, ___ cm	Unit
51506	Joint Sealing	Linear Meter
51507	Miscellaneous Structural Steel	Kilogram
51508	Special Expansion Joint	Linear Meter
5150801	Special Expansion Joint, width less than 50 mm	Linear Meter
5150802	Special Expansion Joint, width 51 - 100 mm	Linear Meter
5150803	Special Expansion Joint, width 101 - 200 mm	Linear Meter
5150804	Special Expansion Joint, width 201 - 300 mm	Linear Meter
5150805	Special Expansion Joint, width ___ - ___ mm	Linear Meter
51509	Anti-Corrosion Primer	Liter
51510	Replacement Concrete for Partial Depth Patching	Cubic Meter
51511	Replacement Concrete for Full Depth Patching	Cubic Meter
51512	Replacement Deck Concrete or Other Replacement Structural Concrete	Cubic Meter

SECTION 5.16 - PORTLAND CEMENT CONCRETE BRIDGE DECK REPAIRS

5.16.1 DESCRIPTION. The work done under this section shall consist of furnishing all labor, materials, and equipment necessary to repair Portland cement concrete bridge decks according with the requirements of these General Specifications, as shown on the plans, and in the Special Specifications or established by the Engineer.

ITEMS IN BILL OF QUANTITIES

Spall Repair Concrete
Slab Repair Concrete
Bridge Deck Grinding
Concrete Bridge Deck Joint and Crack Repair

5.16.2 SPALL REPAIRS.

5.16.2.1 Description. The work shall consist of furnishing all materials and removing loose patches and materials incompatible with the new repairs, such as temporary bituminous patching materials from potholes, damaged joints and spalled areas, thoroughly cleaning the repair area replacing corroded reinforcing steel, and placing new patching material according with the details shown on the plans, and as specified herein, and in reasonably close conformity with the existing bridge deck cross-section.

5.16.2.2 Material Requirements.

1. General. Patching materials shall be suitable for the anticipated work conditions before allowing traffic loads, or as shown on the plans, the Special Specifications and these General Specifications.

Accelerated Strength Portland Cement Concrete Patching Material. The patching material for Accelerated Strength Portland Cement Concrete shall consist of either Type III or Type II Portland cement or other accelerators meeting the AASHTO M-144 requirements and shall attain a minimum compressive strength of fourteen (14) kilograms per square centimeter in six (6) hours. Materials for the concrete mix shall conform to the requirements of Section 5.01, "Portland Cement Concrete," in these General Specifications for Class K concrete. The coarse aggregate shall be as designated for size D coarse aggregate (19 mm).

Rapid Setting Patching Material - Rapid setting material shall be a product approved by the Engineer. A list of approved patching materials is maintained by the Ministry.

Epoxy Resin Patching Material - Epoxy resin patching material shall be a low-modulus, moisture insensitive epoxy blended with suitable fillers, as prepared in accordance with the manufacturer's recommendations and as approved by the Engineer.

5.16.2.3 Construction Requirements.

1. General. Spalled areas to be repaired will be designated by the Engineer. The extent of the repair area will be marked out by the Engineer and will be no less than

seventy (70) millimeters outside of the area of delamination. The Engineer will be the final authority if questions arise in regard to the need for patching or the extent of a required patch.

Spalled areas less than one hundred and fifty (150) by thirty (30) millimeters, adjacent to joints, need not be repaired under this specification.

Patching material shall not be placed under conditions which will adversely affect the quality of work. The Engineer shall be the sole judge in determining suitability of working conditions.

Saw cut approximately nineteen (19) millimeters deep along all boundaries of the repair areas. Point saw cuts, extending beyond the limits of repair areas, flush with the surface with Portland cement or epoxy mortar.

Where the bond between existing concrete and reinforcing steel has been destroyed, remove the concrete adjacent to the steel to a depth that will permit new concrete to bond to the entire periphery of the exposed steel. Provide a minimum of nineteen (19) millimeters clearance behind the steel.

Remove and replace all reinforcing steel that is corroded more than twenty (20) percent. Apply a anti-corrosive primer to the existing steel after sand blasting and prior to concreting.

After removal of deteriorated or unsound concrete, sandblast exposed structural steel, reinforcing steel, and any concrete surfaces which will be in contact with repair material until free of rust and foreign material. Clean the sound concrete surface by flushing with clean water from a high pressure water jet or compressed air.

For all vertical and overhead concrete repairs, and those horizontal repairs to areas less than one hundred twenty-five (125) millimeters in depth, use a high strength concrete patching compound placed according to the manufacturer's recommendations.

For all other repairs, apply a bonding coat of a two-component epoxy resin binder to the surfaces of the sound existing concrete immediately before placing new concrete against it. Follow the manufacturer's recommendations for the epoxy resin binder. Repair areas using Class K concrete.

Patch perimeters shall be cut substantially vertical, with sharp tools to minimize fracturing beyond the cut, for at least thirty (30) millimeters in depth.

Remove and dispose of concrete according to Section 2.02, "Removal of Structures and Obstructions" in these General Specifications.

The area to receive the patching material shall be clean and dry to promote proper bond. Patching material shall be done in a workmanlike manner and lapping over to surrounding bridge deck will not be permitted. If there is an interval of more than twenty-four (24) hours between cleaning of the sound concrete surface and placement of new concrete, or there are previously prepared concrete surfaces that have been contaminated by any substance detrimental to good bonding, clean or remove the concrete.

Patching material shall be placed, consolidated, and finished to produce a dense patch. If the area to be patched abuts a joint or working crack, a bond-breaker of styrofoam, polyethylene foam or other suitable material not less than four (4) millimeters or the joint or crack width, whichever is greater, shall be placed prior to patching.

The finishing and texture of the patched surface shall conform to the elevation and texture of the existing bridge deck.

Any repair material that develops any appreciable thickening while being placed shall be discarded and no additional payment will be allowed.

Accelerated Strength Portland Concrete Bridge Deck Patch - Following the excavation and abrasive blast cleaning of the repair void as previously specified, the entire area to be filled with patching material shall be coated with an approved "new-to-old" epoxy according to the recommendations of the manufacture. The patching material shall be placed promptly to before hardening of the bond coat occurs. Should the bond coat harden prior to patching, a new application of bond coat shall be applied before patch filling operations resume.

Rapid Set Patch - Rapid set patching materials shall be blended and mixed installed as recommended by the manufacture.

Upon completing removal and surface preparation, as previously stated, the surface shall be either lightly damped or dry prior to filling with rapid setting material, as recommended by the manufacture.

The material shall be consolidated to the proper grade and float finished. Texturing to match the existing bridge deck will not be required.

Epoxy Resin Patches - Epoxy resin shall be proportioned and blended according to the manufacture's directions and the suitable filler shall then be combined to produce a mortar or grout, uniform in consistency according to the recommenda tions of the resin manufacture.

Upon completing removal and surface preparation, as previously stated, the surface shall be dry prior to filling with the epoxy mixture.

The material shall be consolidated to the proper grade and float finished. Texturing to match the existing bridge deck will not be required.

5.16.3 SLAB REPAIRS.

5.16.3.1 Description. The work shall consist of furnishing all materials and removing existing concrete bridge deck, constructing partial and full depth repairs of Portland cement concrete bridge decks and reinforcing steel at locations shown on the plans, as specified herein, and in reasonably close conformity with the existing bridge deck.

5.16.3.2 Material Requirements. Repair material shall conform to Subsection 5.01.1, "Description" in these General Specifications, except concrete shall be Class K, using size D coarse aggregate (19 mm).

Reinforcing steel, expansion joint fillers, joint seal, and liquid membrane-forming curing compound, shall conform to the requirements as stated in Section 5.02, "Reinforcing Steel" and 5.03, "Concrete Structures" in these General Specifications.

5.16.3.3 Construction Requirements. Areas to be repaired will be designated by the Engineer. Areas to be repaired shall have the configuration and minimum dimensions shown on the plans. However the Engineer shall be the final authority in determining the extent of repairs.

Repairs shall be carried out under conditions that will not adversely affect the quality of work. If these conditions arise, the Engineer shall have the final determination as to whether or not to proceed with the planned work.

Breaking and removal of partial and full depth bridge deck concrete shall be performed in accordance with Subparagraph 5.15.3.1.5, "Breaking and Removal of Structural Concrete," in these General Specifications. This work shall be done in such a manner as to avoid damaging the adjacent deck and other bridge elements adjacent to the repair area in compliance with the requirements in Paragraphs 1.05.2.1 "Air Pollution" and 5.15.3.2 "Concrete Removal Methods" in these General Specifications.

When the repair boundary is adjacent to an existing longitudinal joint, six hundred (600) millimeters long, sixteen (16) millimeters diameter (No. 5) deformed steel tie bars shall be placed in three hundred (300) millimeters deep holes drilled into the existing deck at seven hundred fifty (750) millimeters intervals, as shown on the plans, and grouted into place with approved non-shrink grout or approved epoxy.

The Contractor shall saw cut approximately nineteen (19) millimeters deep along all boundaries of the repair areas and point saw cuts, extending beyond the limits of repair areas, flush with the surface with Portland cement or epoxy mortar.

All exposed steel reinforcement and structural steel shall be sand blasted as per requirements of Paragraph 5.15.4.3, "Sand Blasting," in these General Specifications to remove scale, rust, grease, oil, etc. Prior to placing concrete, deteriorated or damaged reinforcement shall be replaced. Corroded steel reinforcements shall be replaced by using reinforcements as shown on the plans or supplemented as directed by the Engineer. All dust and chips of concrete, or other debris shall be removed and the entire area shall be blast cleaned as described in Paragraph 5.15.4.4, "Blast Cleaning," in these General Specifications. An anti-corrosive primer shall be applied to the existing steel prior to concreting.

Full depth slab repairs shall be constructed in accordance with Subparagraph 5.15.3.1.16, "Full Depth Patching" in these General Specifications.

Partial depth slab repairs shall be constructed in accordance with Subparagraph 5.15.3.1.16, "Full Depth Patching" except that the concrete shall only extend from the bottom of the removal area to the elevation of the surrounding concrete.

5.16.4 BRIDGE DECK GRINDING.

5.16.4.1 Description. The work consists of furnishing all materials and grooving the surface of existing Portland cement concrete bridge deck at the locations shown on the project plans and according to the requirements in these General Specifications.

5.16.4.2 Equipment and Procedures. Grinding shall be done with diamond blades, mounted on a self-propelled machine that has been designed for grinding and texturing bridge decks. The equipment shall be designed such that it will not cause strain or damage to the underlying surface of the bridge deck. Grinding equipment that causes excessive ravels, aggregate fractures, spalls, or disturbances of the transverse or longitudinal joints shall not be used.

All grinding machines used in the cross-section of a lane shall have the same wheel or grinding head configuration. Overlapping of grinding passes will not be allowed.

The noise level created by any one machine shall not exceed eighty-six (86) dbA at a distance of fifteen (15) meters normal to the direction of traffic.

No equipment will be allowed within three (3) meters of the lane open to public traffic. Maintenance and protection of traffic shall conform to the requirements of Section 9.02, "Traffic Control Through Work Zones," in these General Specifications.

5.16.4.3 Construction Requirements. Before grinding, repaired areas shall be completed as specified. Grinding shall be done prior to any specified sawing and sealing of existing transverse and longitudinal joints.

Bridge deck grinding shall be performed longitudinally - The Contractor shall grind a test section of bridge deck, where designated by the Engineer, to determine that the equipment proposed for use will provide the desired texture.

Grinding shall produce a uniform surface appearance over the entire designated area. Grinding shall continue for the full lane width until the bridge deck surface on both sides of all transverse joints and of all cracks is in the same plane. Longitudinal ridges in adjacent passes of the grinding equipment shall not exceed three (3) millimeters in depth.

In any one lane, a maximum distance of three hundred (300) meters of unfinished area between the lead grinder and the last grinder in that lane will be allowed at the end of the work shift.

Ground surfaces shall not be smooth or polished and shall have a coefficient of friction of not less than forty-hundredths (0.40) as measured by ASTM E-1274 (88).

The surface shall have a finish texture of grooves between two (2) to three (3) millimeters wide, and spaced from one and one-half (1.5) millimeters to three (3) millimeters and not less than one (1) millimeter to three (3) millimeters.

Residue and excess water resulting from grinding shall be removed from the roadway by vacuuming or other methods approved by the Engineer. The residue shall be removed before restoring traffic to the lane. Residue and water from the grinding operations shall not be allowed to flow across lanes occupied by traffic, onto roadway shoulders, or to flow into gutters and drainage facilities. Dried residue shall be removed before allowing traffic to occupy the work area.

After grinding has been completed, the bridge deck surface will be tested for smoothness using a three (3) meter straightedge to insure that the surface elevation does not exceed plus or minus (±6) six millimeters.

Additional grinding shall be performed, if necessary, to reduce the surface deviation as measured with the three (3) meter straightedge to within plus or minus (±6) six millimeters, or remain portion thereof, along any line parallel to the edge of the bridge deck. In any area requiring regrinding, the regrinding shall be done over the full lane width.

The Contractor shall broom the surface of the concrete where straightedge measurements are to be taken. The Contractor shall bear the full cost of straightedge measurements and associated traffic control.

5.16.5 BRIDGE DECK JOINT AND CRACK REPAIR.

5.16.5.1 Description. The work shall consist of furnishing all materials and renovating longitudinal and transverse contraction control joints and routing and sealing random cracks in existing bridge deck, as specified herein, detailed on the plans and as directed by the Engineer.

5.16.5.2 Material Requirements. Joint sealant shall conform to the requirements of Paragraph 6.23.2.2, "Joint Sealing Compounds," in these General Specifications. Grout for filling wide joints shall be a low modulus, moisture insensitive epoxy resin grout of a viscosity suitable for flowing into the irregular cracked portion of the joint. The ratio of epoxy resin to sand shall be 1:7 and 1:10 or as specified by the epoxy manufacture. Epoxy binder material shall conform to the requirements of ASTM C-881-78(83).

Sand used in epoxy grout shall conform to the requirements of Subsection 5.01.2, "Materials" in these General Specifications except the gradation shall be as follows:

Sieve Size	Percent Passing
2.36 mm (No 8)	100%
1.18 mm (No. 16)	95-100
0.300 mm (No. 50)	10-40
0.075 mm (No. 200)	0-4

A rapid set Portland cement concrete pavement patching material may be substituted for epoxy grout as approved by the Engineer.

5.16.5.3 Construction Requirements.

5.16.5.3.1 General. Joint and crack repairs shall be accomplished by first removing old joint sealant and joint insets, then refacing and cleaning the joints and cracks followed by installation of a backer rod (if required) and installation of new joint sealant.

5.16.5.3.2 Joint and Crack Preparation. Cracks shall be sawed or routed to the dimensions shown on the plans.

Inserts shall be removed from insert-formed joints by sawing to provide a clean vertical face. The width and depth of the saw cuts shall be sufficient to insure complete removal of the insert and to provide a finished joint of the proper dimensions specified for the sealant material to be used. If the insert is not vertical additional parallel saw cuts shall be provided as required to insure full removal of the inserts.

Joints that are not insert formed shall be sawed to the widths and depths specified herein. Joints previously sawed and sealed will be inspected to assure the proper dimensions and shall be re-sawed to the proper widths and depths, when required.

Joints shall be sawed as follows:

Initial Joint Width..."W"	Sawed Joint Width	Sawed Joint Depth "D" Pavement Surface to bottom of backer rod
"W" <13 mm	13 mm	43 mm
13 mm<W <19 mm	19 mm	54 mm
19 mm<W <38 mm	No Sawing Required	2W+19 mm

Immediately after saw cutting a joint or routing a crack, old sealant shall be removed and internal surfaces of the joint or crack shall be thoroughly cleaned by sandblasting. Sand for sandblasting shall be sharp and clean. The amount of compressed air and the nozzle pressure shall be such that the joints and cracks will be thoroughly cleaned and the edges will have etched surfaces.

5.16.5.3.3 Cleaning Prior to Sealing. Prior to sealing, all foreign or loosened particles shall be removed from the joints to the full depth of the original sawed joints. The removal of all foreign or loosened particles shall be accomplished with compressed air or other means approved by the Engineer. Air compressors shall be capable of furnishing a sufficient supply of compressed air to clean the joints properly.

5.16.5.3.4 Separating or Blocking Medium (Backer Rod). Immediately following the cleaning of joints and prior to the application of sealant, a backer rod composed of an inert, compressible material shall be inserted along the lower portion of the joint groove at a depth as shown on the plans.

The backer rod shall be compatible with the sealant in accordance with the manufacture's recommendation. The product shall be clean, free of scale, foreign matter, oil or moisture and shall be non-absorbing. The Engineer shall be assured that the material proposed for use has been used successfully in similar installations.

Backer rod sizes shall be as follows:

Joint Width Millimeters (mm)	Backer Rod Diameter Millimeters (mm)
13 mm	16 mm
19 mm	25 mm
25 mm	32 mm
32 mm	38 mm
38 mm	50 mm

5.16.5.3.5 Installation of Sealer. Sealant compound shall not be placed unless the joint is dry, clean, and free of dust. The face of the joint shall be surface dry and the ambient temperature shall both be at least ten degrees Celsius (10 ° C.) at the time of application of the sealant. Installation of the sealant shall be such that the in-place sealant shall be well bonded to the concrete and free of voids or trapped air. The joints shall be sealed in a neat and workmanlike manner, so that upon completion of the work , the surface of the joint sealant material will be six (6) millimeters, ± 3 millimeters below the adjacent bridge deck surface. The Contractor shall refill all low joints before final acceptance. Any excess material on the surface of the bridge deck shall be removed and the bridge deck surface shall be left in a clean condition. Vehicular or heavy equipment traffic shall not be permitted on the bridge deck in the area of the joints during the curing period.

5.16.6 MEASUREMENT.

5.16.6.1 Spall Repair Concrete. Spall repair concrete shall be measured by the square meter for all patches successfully constructed. Each patch will be measured to the nearest three centimeters. The total cumulative calculated area based on the measurements will be rounded off to the nearest tenth of a square meter.

5.16.6.2 Slab Repair Concrete. Full depth and partial depth slab repair concrete shall be measured by the square meter for all repairs successfully constructed. The dimensions of each repair area will be measured to the nearest centimeter. The total cumulative calculated area based on the measurements will be rounded off to the nearest tenth of a square meter.

5.16.6.3 Bridge Deck Grinding. Bridge deck grinding will be measured by the square meter of pavement ground and accepted. The quantity will be determined by multiplying the width by the length of the ground area.

5.16.6.4 Concrete Bridge Deck Joint and Crack Repair. Concrete bridge deck joint and crack repair will be measured by the linear meter.

5.16.7 PAYMENT.

5.16.7.1 Spall Repair Concrete. The accepted quantities of spall repair concrete, measured as provided for above, will be paid for at the contract unit price per square meter, which shall include full compensation for furnishing all materials, tools, equipment, incidentals, and for doing all the work of preparing, filling, finishing, and texturing of spalls, complete and in place, including the removal and disposal of waste concrete, and the reconstruction of the spalled areas.

5.16.7.2 Depth Slab Repair. The accepted quantities of full and partial depth slab repair concrete, measured as provided for above, will be paid for at the contract unit price per square meter, which shall include full compensation for doing all preparing, filling, finishing, and texturing, complete and in place, including the breaking, removal and disposal of waste concrete, and the reconstruction of the full or partial depth slab.

5.16.7.3 Bridge Deck Grinding. The accepted quantities of bridge deck grinding, measured as provided above, will be paid for at the contract unit price, which shall be full compensation for the work complete as specified.

5.16.7.4 Concrete Bridge Deck Joint and Crack Repair. The accepted quantities of concrete bridge deck joint and crack repair measured as provided above, will be paid for at the contract unit price per linear meter, which price shall be full compensation for the work, complete in place.

The amount of authorized, completed, and accepted Work, measured as provided above, will be paid for at the unit price(s) bid in the Bill of Quantities. Such price(s) shall include furnishing, transporting and placing all materials except those materials specified to be paid for under other items of Work, and shall include all labor, equipment, tools and other items of Work necessary for the proper completion of the Work as specified in accordance with Subsection 1.07.2, "Scope of Payment" in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
51601	Spall Repair Concrete	Square Meter
51602	Slab Repair Concrete	Square Meter
51603	Bridge Deck Grinding	Square Meter
51604	Concrete Bridge Deck Joint and Crack Repair	Linear Meter

SECTION 5.17 - EXTENSION AND WIDENING OF STRUCTURES

5.17.1 DESCRIPTION. This Work shall consist of extending and/or widening of existing structures as indicated on the plans, in conformity to the lines, grades, dimensions and designs shown, in accordance with the specifications, and as directed by the Engineer.

This Work shall be carried out in accordance with the provisions of Sections 2.02, "Removal of Structures and Obstructions"; 2.09, "Structural Excavation and Backfill"; 5.01, "Portland Cement Concrete"; 5.02, "Reinforcing Steel"; 5.03, "Concrete Structures"; 5.05, "Steel Structures and Miscellaneous Metal Work," in these General Specifications; and all other pertinent specification sections that refer to the pay items which are to constitute the complete extended and/or widened structure.

For purposes of this section, the term "extended" shall mean "extended and/or widened", and the term "extension" shall mean "extension and/or widening".

5.17.2 MATERIALS. Materials shall be those prescribed for the several items which are to constitute the complete extended structure.

5.17.3 CONSTRUCTION REQUIREMENTS. The construction methods shall be those prescribed for the several items which are to constitute the complete extended structure and as specified herein.

The Contractor shall verify all pertinent dimensions of the existing structure prior to ordering materials required for the extensions.

Portions of the old structure shall be removed to the lines and dimensions shown on the plans and all waste materials shall be disposed of as directed. Unless otherwise shown on the plans, salvageable materials shall be removed in such a manner that they will not be damaged and shall be stored neatly at approved locations. Salvageable materials so removed shall remain the property of the Ministry. Any portion of the existing structure, outside the limits designated for removal, damaged during the operations of the Contractor, shall be restored to its original condition and at the Contractor's expense. Explosives shall not be used in the removal of portions of the existing structures unless approved by the Engineer in writing.

When directed by the Engineer, culverts shall be extended as detailed in Standard Drawings Nos. E/C/01 and BC/I/01, issued by the Ministry. When the headwalls, wingwalls and apron are specified on the plans to be reused in the extended culvert, the portion to be reused shall be severed from the old structure to the lines and details shown on the plans. The headwall unit shall be moved to the new location by methods approved by the Engineer, and the extension concrete and reinforcement placed according to the plan details. Any portion of the headwall unit damaged by the moving operation shall be restored to its original condition at the expense of the Contractor.

Unless otherwise noted on the plans, a demolition ball, other swinging weight or impact tool, will be permitted on those portions of the structure not immediately adjacent to the break line of the concrete. The concrete shall be severed at the break line by pneumatic

tools. Slabs shall first be sawed along the break line to a depth of twenty (20) millimeters prior to beginning the removal of concrete.

Except when otherwise provided on the plans, new reinforcing bars shall be spliced to exposed bars in the old structure by lap splices as specified in Paragraph 5.02.4.5, "Splicing," in these General Specifications. When welded splices are permitted on the plans, they shall conform to the requirements of Paragraph 5.02.4.8, "Welding of Reinforcement," in these General Specifications. For lap splices (not welded), new reinforcing steel need not be tied to existing steel, where spacing and/or elevation does not match that of the existing steel, provided the proper lap length is attained. All splices, lap or welded, shall be staggered as indicated or directed.

Dowels or starter bars, if indicated in the plans, shall be installed by grouting reinforcing bars to the lengths shown into the old structure, in accordance with the requirements of Paragraph 5.15.4.1, "Drilling and Grouting of Anchors," in these General Specifications.

Concrete surfaces which will be in contact with new construction shall be roughened, cleaned and prepared as specified in Paragraph 5.03.4.7, "Bridge Structure Construction Joints," in these General Specifications.

The widened portion of bridges and direct-traffic culverts shall not be opened to construction traffic or to the traveling public until authorized by the Engineer. In this respect, the Contractor shall comply with the requirements of Section 9.02, "Traffic Control through Work Zones," in these General Specifications.

5.17.4 QUALITY ASSURANCE. Quality assurance shall be performed as outlined in the pertinent specification sections that refer to the pay items which are to constitute the complete Work; except that the numbers and locations of tests may be modified to those deemed necessary by the Engineer to determine conformity with the specifications.

5.17.5 METHOD OF MEASUREMENT. The quantities of the various items which constitute the completed and accepted extended structure shall be measured for payment according to the plans and specifications for the several pay items appearing in the Bill of Quantities, and in terms of the prescribed units provided for the several pay items. Only accepted Work shall be included and the dimensions and pay items shall be those shown on the plans or ordered in writing by the Engineer.

In addition, all incidental work shown on the plans or directed by the Engineer, shall be measured and will be paid for separately as specified elsewhere in these General Specifications and as specified in the Bill of Quantities.

Headwall units of culverts severed from the old structure and reused at a new location shall be measured for payment under pay item Removal of Box Culvert and Pipe Culvert End Section. No separate measurement will be made of relocation work.

5.17.6 PAYMENT. The quantities, measured as provided above, will be paid for at the unit prices bid for the several pay items as specified in the Bill of Quantities. Such prices shall be full compensation for furnishing, handling, and placing all materials, for all labor,

equipment, tools, and all other items necessary for the proper completion of the work as specified in Subsection 1.07.2, "Scope of Payment," in these General Specifications. Such payment shall constitute full payment for the completed extended structure, and no allowance will be made for cofferdam construction, form lumber, falsework, or other incidental expense.

KINGDOM OF SAUDI ARABIA
MINISTRY OF COMMUNICATIONS

GENERAL SPECIFICATIONS
FOR
ROAD AND BRIDGE CONSTRUCTION

November 1998

PART SIX
INCIDENTAL CONSTRUCTION

PART SIX: INCIDENTAL CONSTRUCTION

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PART SIX: INCIDENTAL CONSTRUCTION

SECTION 6.01 - CRASHWORTHY SAFETY BARRIERS

6.01.1 DESCRIPTION. This Work shall consist of the construction of crashworthy metal beam and rope cable guardrail, New Jersey concrete and other similarly shaped safety barriers, barrier terminals, portable and permanent impact attenuators, glare screens, and steel safety railing. This work also includes the reinstallation/retrofitting of metal beam and rope cable guardrail, New Jersey Concrete Barriers and guardrail terminals, impact attenuators and steel safety railings in accordance with these General Specifications and in conformity with the lines and grades shown on the plans or established by the Engineer.

ITEMS IN BILL OF QUANTITIES

W-Beam Guardrail
Thrie Beam Guardrail
Tensioned Four Wire Rope Cable Guardrail
W-Beam Guardrail Terminal, Approach End
W-Beam Guardrail Terminal, Trailing End
Thrie Beam Guardrail Terminal, Approach End
Thrie Beam Guardrail Terminal, Trailing End
Tensioned Four Wire Rope Cable Guardrail Terminal
Tensioned Four Wire Rope Cable Guardrail Terminal, Approach End
Tensioned Four Wire Rope Cable Guardrail Terminal, Trailing End
Reinstallation of Guardrail
Reinstallation/Retrofit of Guardrail Terminal
New Jersey Concrete Barrier
Reinstallaltion of New Jersey Concrete Barrier
Impact Attenuator
Reinstallation/Retrofit of Impact Attenuator
Glare Screen
Steel Safety Railing
Reinstallation of Steel Safety Railing

6.01.2 MATERIALS.

6.01.2.1 Metal Beam Guardrail. Rail elements and backup plates for W-Beam or Thrie-Beam rail shall conform to the requirements of AASHTO M 180, Class A, Type 2 galvanized. Rail elements to be erected on a radius of forty-five (45) meters or less shall be shaped in the shop. The radius of curvature shall be stenciled on the back of each section of rail. Rail elements shall be designed to be spliced at intervals not to exceed either four (4) or eight (8) meters and such splices shall be made at posts, unless otherwise shown on the plans.

6.01.2.2 Tensioned Four Rope Wire Rope Guardrail. The ropes shall be of nineteen (19) millimeter diameter 3x7 (6/1) coreless construction having a minimum

breaking load of seventeen and seven-tenths (17.7) tons. The rope shall exhibit a minimum modulus of elasticity of eight thousand three hundred (8300) kilograms per square millimeter based on an area of two hundred eighty-three (283) square millimeters, after prestressing by an approved method to ensure the ropes behave elastically and retain their tension in service.

All wire used for the manufacture of the ropes shall be general purpose wire to BS 2763 grade 1370, A, or to AASHTO M30, Type II, finally zinc coated by the hot dip method.

All threaded terminals and rigging screws shall be hot dip galvanized to BS 729 or AASHTO M232.

The posts, which are designed to collapse on impact, shall be one thousand and eighty (1080) millimeters long, six (6) millimeters thick steel to BS 4360 grade 50A, one hundred (100) millimeters by thirty-two (32) millimeters "Z" (median applications) or "S" section (shoulder applications) as determined by the contract but always with the rounded edge of the post facing the traffic, and shall be slotted at one end through the center of the web one hundred thirteen (113) millimeters deep by twenty-two (22) millimeters wide prior to galvanizing, in which the ropes are located. A black polyethylene cap to which is affixed a retroreflective Class 1 prismatic reflector (color to be specified in the contract) complying with Table 1 of BS 873:Part 6, shall be placed on the top of the post. A polyethylene excluder shall be placed at the bottom of the post to prevent the ingress of sand, etc., into the foundation.

The anchor frames shall be fabricated from mild steel and galvanized to BS 729 before being embedded in a block of concrete one and twenty-two hundredths (1.22) meters long by one (1) meter wide by one (1) meter deep.

A check rope, one and eight-tenths (1.8) meters in length, eight (8) millimeters diameter, with a minimum breaking load of three and nine-tenths (3.9) tons when tested as an assembly, fitted with a galvanized thimble at one end and a fork terminal at the other, shall be provided at each anchor. The thimble shall be passed over the end of the tail rope and the fork terminal connected to the anchor.

6.01.2.3 Other Wire Rope. Wire rope for metal beam guardrail anchor terminals shall conform to AASHTO M 30, Type II, Class A. Equivalent galvanized wire rope with a minimum breaking strength of nineteen thousand four hundred (19,400) kilograms will be acceptable.

6.01.2.4 Posts and Miscellaneous Barrier Rail Hardware. Unless otherwise indicated on the plans, all steel posts, plates, angles, channels, brackets, and anchor assembly units shall conform to the requirements of ASTM A 36. Cold rolled post sections shall conform to the requirements of ASTM A 446, Grade B.

The swage fittings for anchor terminals shall be machined from hot-rolled carbon steel conforming to the requirements of ASTM A 576, Grade 1035, and shall be annealed suitable for cold swaging. A lock pin hole shall be drilled through the swage fitting head to accommodate a seven (7) millimeter, plated, spring steel pin to retain the stud in the proper position. The stud shall be steel conforming to the requirements of ASTM A 449. Prior to galvanizing, a ten (10) millimeter slot for the locking pin shall be milled into the stud end. The swage fitting, stud, and nut shall develop the full breaking strength of the wire cable.

Anchor rod eyes shall be hot forged or formed with full penetration welds. After fabrication, anchor rods with eyes that have been formed with any part of the eye below eight hundred seventy degrees Celsius (870_ C) during the forming operation or with eyes that have been closed by welding shall be thermally stress relieved prior to galvanizing. The completed anchor rod, after galvanizing, shall develop a strength of twenty-three thousand (23,000) kilograms.

All bolts shall conform to the requirements of ASTM A 307, except those designated on the plans as high strength shall conform to the requirements of ASTM A 325 or A 449. All nuts shall conform to the requirements of ASTM A 563, Grade A or better, except those designated on the plans as high strength shall conform to the requirements of ASTM A 563, Grade C or better.

Clevises shall be drop forged galvanized steel and shall develop the full specified breaking strength of the wire cable.

The concrete insert assembly for Type 4 anchor terminals shall be fabricated as shown on the plans. Ferrules shall be steel conforming to the requirements of ASTM A 108, Grade 12 L 14. Inserts shall be tapped to the dimensional requirements specified in ASTM A 563 for nuts receiving galvanized bolts. Insert assembly wires shall conform to the requirements of ASTM A 510, Grade 1030, and have a minimum tensile strength of seven thousand (7,000) kilograms per square centimeter. Welded attachment of wire to ferrule shall develop the full tensile strength of the wire.

Turnbuckles shall be steel of commercial quality and shall have a minimum breaking strength of one thousand five hundred (1,500) kilograms. Turnbuckles shall be galvanized in accordance with ASTM A 153. Compensating and non-compensating cable ends shall be cast steel conforming to the requirements of ASTM A 27 or malleable iron conforming to the requirements of ASTM A 47. Compensating devices shall have spring constants of eight thousand (8,000) kilograms per meter, plus or minus five hundred (500) kilograms per meter, and permit a travel of one hundred fifty (150) millimeters, plus or minus twenty-five (25) millimeters. All elements shall be galvanized. The cable connecting hardware shall develop the full strength of the wire rope. At all locations where the cable is connected to a cable end with a wedge type connection, one (1) wire of the wire rope shall be crimped over the base of the wedge to hold the cable firmly in place.

6.01.2.5 Galvanizing. All of the exposed materials for guardrail, guardrail anchor terminals, impact attenuators, glare screen, and delineators, which are made of steel or iron, shall be galvanized after fabrication unless otherwise specified. Galvanization shall be in accordance with the specific referenced specification. When no galvanization requirements is included in the specification, galvanization shall be in accordance with ASTM A 123 or ASTM A 153 as appropriate.

All components shall be fabricated and galvanized for installation without further drilling, bending, cutting or welding. When field modifications are approved by the Engineer, or when minor damage to the galvanized coating occurs, the exposed surface shall be repaired by thoroughly cleaning and applying two (2) applications of Paint No. 3 as specified in Paragraph 5.13.2.6, "Zinc Dust-Zinc Oxide Primer" in these General Specifications.

6.01.2.6 Glare Screens. Glare screens shall be chain-link mesh conforming to ASTM A 491 or ASTM A 392 or plastic slats as detailed on the plans and in the Bill of Quantities. Chain-link mesh size and wire diameter shall be as specified in the plans.

Posts shall be galvanized steel pipe conforming to ASTM A 53 of the diameter shown on the plans. Posts shall be furnished with galvanized watertight caps.

Tension wire shall conform to ASTM A 641, Class 1, Hard Temper, with a minimum diameter of four and five tenths (4.5) millimeter.

Tension cable shall conform to ASTM A 474 or A 475, six (6) millimeter minimum diameter, high strength grade. All hardware shall be typical of that shown on the plans and shall be galvanized in accordance with ASTM A 153.

When required by the plans or Special Specifications, the fence fabric, posts, and all exposed galvanized hardware shall be coated with a minimum twenty-five hundredths (0.25) millimeter coating of bonded polyvinyl chloride (PVC). The polyvinyl chloride shall be applied by the thermal extrusion process and shall withstand a minimum exposure of one thousand five hundred (1,500) hours at sixty-two degrees Celsius (62 _ C) without any deterioration when tested in accordance with ASTM D 1499.

Slats, when required, shall be either wood or plastic and of the dimensions shown on the plans. Wood slats shall be treated with a preservative.

Plastic slats shall be made of polyethylene or polymeric materials. They shall be color pigmented, and designed to retard ultraviolet penetration. The material shall remain flexible without distortion and without becoming brittle through a temperature range of zero degrees Celsius (0 _ C) to sixty degrees Celsius (60_ C). The system will use a nonmetallic base designed so the flexible slat can be retained in place by two (2) friction locking pins or a U-shaped retainer at the bottom and top of the glare screen.

Samples for the color for plastic slats shall be submitted to the Engineer for approval.

6.01.2.7 Concrete. Concrete for post supports, burried footings, and anchors shall conform to the requirements of Minor Concrete as described in Subsection 5.03.9 "Concrete For Minor Structures," in these General Specifications. Concrete for the New Jersey concrete barriers and terminal sections shall conform to Class C in Subsection 5.01.1, "Description" in these General Specifications. All other concrete, unless otherwise specified, shall conform to Class B in Subsection 5.01.1 "Description" or "Minor Concrete" as described in Subsection 5.03.9 "Concrete for Minor Structures," in these General Specifications.

6.01.2.8 Reinforcing Steel. Reinforcing steel shall be of the size and grade shown on the plans and shall conform to the provisions of Section 5.02, "Reinforcing Steel" in these General Specifications.

6.01.2.9 Guardrail Delineators. Metal W-Beam and Thrie-Beam guardrail delineators, when required, shall conform to the requirements of the plans, Special Specifications, M.U.T.C.D., and Paragraph 6.5.2.10 "Delineators" in these General Specifications. Hardware shall conform to the requirements shown on the plans. An acceptable alternative delineator will be a replaceable barrier marker post with a locking mechanism compatible with the base. The replaceable barrier marker post will be a minimum of three hundred fifty (350) millimeters long and seventy (70) millimeters wide. The replaceable barrier marker post should be available in a variety of colors and compatible with reflective sheeting. When shown on the Plans or stated in the Special Specifications reflective sheeting shall be placed on the approach ends of metal beam guardrail terminals and be Type IV high intensity retroreflective sheeting with Class III backing meeting the requirements of Paragraph 9.05.2.9 "Retroreflective Sheeting" in these General Specifications.

New Jersey concrete barrier delineators shall conform to the requirements of the plans, Special Specifications, M.U.T.C.D. Subsection 5.03 F and Paragraph 9.05.2.10 "Delineators" in these General Specifications. Epoxy Resin Adhesives for bonding delineators to hardened Portland cement concrete shall conform to AASHTO M 237.

6.01.2.10 Other Materials. Other materials shall be as shown in the plans, stated in the Special Specifications or in the U.S. American Road Builders Transportation Association (ARBTA) Bulletin No. 268 "A Guide to Standardized Highway Barrier Rail Hardware." Special materials for impact attenuators shall be as specified by the manufacturer.

6.01.2.11 Reinstallation of Guardrail, Guardrail Terminals, New Jersey Concrete Barrier and Steel Safety Railing.

1. Metal beams, cables, posts, anchor terminal sections, concrete barriers or safety railings shall be salvaged materials, as provided by the Ministry or as salvaged by the Contractor and approved by the Engineer.

2. Bolts, nuts, washers, fittings, adhesives, and accessories shall be new materials conforming to the requirements for the construction of new guardrail, concrete barrier and steel safety railing as detailed in Section 5.05 - Steel Structures and Miscellaneous Metal Work and Section 6.01 Crashworthy Safety Barriers in these General Specifications.

6.01.2.12 Impact Attenuators. - Rail elements for thrie beam rail (used in G.R.E.A.T. Impact Attenuators) shall conform to AASHTO M 180, Class B, Type galvanized. Rail element joints shall be fabricated to lap not less than thirty (30) centimeters and be bolted. The rail metal, in addition to conforming to the requirements of AASHTO M 180, shall withstand a cold bend, without cracking, of two hundred (200) grads around a mandrel of a diameter equal to two and one half (2½) times the thickness of thesheet metal plate.

Wire rope restraining cable for G.R.E.A.T. impact attenuators shall be a minimum of twenty-two (22) millimeter nominal diameter galvanized wire rope conforming to ASTM A 603, Class A.

Pull out and secondary cable for G.R.E.A.T. impact attenuators shall be minimum nine and five tenths (9.5) millimeter nominal diameter galvanized wire rope conforming to ASTM A 603, Class A.

Restraining chains for G.R.E.A.T. impact attenuators shall be twelve (12) millimeter nominal size and shall conform to the requirements of ASTM A 413, Grade 28.

Materials for the impact attenuation systems shall conform to the requirements of the HDM, Volume 4, Standard Drawings TB1 Series, A, B and C, and TB3 Series, A through I.

QuadGuard metal work shall be fabricated from either M1020 Merchant Quality or ASTM A-36 steel. After fabrication, metal work shall be galvanized in accordance with ASTM A-123. All welding shall be done by or under the direction of a certified welder.

The QuadGuard System shall be assembled with galvanized fasteners. All bolts, nuts and washers shall be Commercial Quality "American National Standard" unless otherwise specified.

The QuadGuard diaphragms shall be made from 10 gauge steel Quad-beam sections. The diaphragms shall be available in widths of 610, 760 and 910 mm [2', 2'-6" and 3']. Two support legs shall be welded to the Quad-beam. Ski-shaped plates shall be welded to the bottom of the support legs. The diaphragms shall be designed to lock onto and be guided by a ground-mounted, center monorail support structure.

The QuadGuard fender panels shall be fabricated from 10 gauge steel Quad-beam sections. Each fender panel shall be drilled and slotted in accordance with the manufacturer's specifications so that when assembled in the field, the front end shall be bolted to a diaphragm by means of the three (3) 15.9 mm (5/8") bolts.

Impact attenuation devices with cartridges filled with liquids, such as antifreeze agents, that may become a skid hazard when impacted, shall not be used; replaceable cartridges with foam-filled cardboard, lightweight concrete and similar materials will be acceptable. All units shall be identified by identification labels fastened at a protected but conspicuous location.

6.01.3 CONSTRUCTION AND INSTALLATION REQUIREMENTS

6.01.3.1 Metal W-Beam and Thrie-Beam Guardrail. Guardrail shall be installed at the locations shown on the plans or as ordered by the Engineer. Posts shall be installed by driving plumb to the required grades or set in concrete as required by the plans. When the pavement is within one (1) meter of the guardrail, the posts shall be set before placing the pavement.

If ground conditions are such that pilot holes are necessary to prevent damage to posts during driving, all space around steel posts after driving shall be filled with dry sand or fine gravel.

When posts are set in concrete, the concrete shall be placed against the excavated earth unless otherwise permitted. All curved guardrail with a radius of forty-five (45) meters or less shall be bent in the shop.

Continuous lengths of rail or cable shall be installed and alignment checked and adjusted before final tightening of bolts, etc. Unless otherwise specified, bolted connections shall be torqued to six (6) to seven (7) kilogram-meters. Bolts that extend at least six (6) millimeters but not more than twenty-five (25) millimeters beyond the nuts shall be used.

Rail elements shall be erected in a smooth continuous line with the laps in the direction of traffic flow.

Posts may be erected by driving with approved mechanical devices. The method of driving shall not substantially alter the cross-sectional dimensions of the posts or materially damage the coating. Battered tops shall not be accepted. Posts which, in the opinion of the Engineer, are bent or otherwise damaged during or after erection, shall be removed and replaced at the Contractor's expense.

Damaged galvanized surfaces may be repaired, only if so approved by the Engineer. Such surfaces shall be repaired by thoroughly wire brushing and then by applying two (2) coats of an approved zinc-dust zinc-oxide primer.

The guardrail ropes shall be joined together by rigging screws, which are also used for tensioning. The maximum length of any one (1) individual rope shall be one hundred fifty-four (154) meters. Immediately prior to each anchorage there shall be a tail rope six (6) meters in length and connected to the anchorage in the ground. All ropes shall be fitted on each end with a threaded terminal of right hand or left hand thread as appropriate to ensure a right hand and left hand thread is in the rigging screw to effect the tension. A minimum insertion of twenty-five (25) millimeters into the rigging screw is required. The tail rope shall have a right hand thread on the end which is connected to the anchor.

The installation of the cable guardrail shall be in accordance with the manufacturer's instructions and working drawings.

The foundation for the post shall be as detailed on the manufacturer's working drawings unless advised otherwise in the Contract due to local ground conditions. It shall be of sufficient size to ensure that it is not displaced when the post is knocked down, and withstand an overturning moment of six thousand (6000) Nm.

When all the components are in place, the ropes shall be uniformly tensioned to 25 kN by turning the rigging screws. Backfill above the tops of concrete anchor footings shall not be placed before the cables are tensioned.

6.01.3.3 Guardrail Anchor Terminals. Guardrail anchor terminals shall be installed at the locations shown on the plans or ordered by the Engineer in accordance with the Standard Drawings in the M.O.C. Highway Design Manual Volume 4 or as modified by the Contract Drawings or Special Specifications.

Posts, anchors, and footings shall be driven or installed in concrete as required. Concrete shall be placed against the excavated earth unless otherwise permitted.

Bolted connections shall be torqued to six (6) to seven (7) kilogram-meters unless otherwise specified.

6.01.3.4 New Jersey Concrete Barriers and Terminal Sections. Construction of concrete barriers shall also conform to the Ministry's Sta ndard Drawings, TB-2 Series. Concrete barriers shall present a smooth, uniform appearance in their final position, conforming to the horizontal and vertical lines shown on the plans or ordered by the Engineer, and shall be free of lumps, sags, or other irregularities. The top and exposed faces of the barrier shall not vary more than more than six (6) millimeters between any two (2) contact points when tested with a four (4) meter straightedge laid on the surfaces. Transverse expansion joints of one (1) centimeter thick premoulded filler shall be provided in all New Jersey Barriers at spacings not exceeding fifteen (15) meters center to center.

Concrete barriers may be precast, cast-in-place with fixed forms, or extruded with slip forms at the Contractor's option. Concrete barriers constructed by casting-in-place with fixed forms shall conform to the provisions in Section 5.03, "Concrete Structures" in these General Specifications.

Concrete barriers constructed by means of an extrusion machine or other similar type equipment shall be of thoroughly consolidated concrete, and the exposed surfaces shall conform to the requirements of Section 5.03, "Concrete Structures" and this Subsection 6.01.3 "Construction and Installation Requirements" in these General Specifications. The Contractor shall furnish evidence of successful operation of the extrusion machine or other equipment by constructing a trial section of barrier or by other evidence suitable to the Engineer. Concrete shall be fed to the extrusion machine at a uniform rate. The machine shall be operated under sufficient uniform restraint to forward motion to produce a thoroughly consolidated mass of concrete free from surface pits larger than two (2) centimeters in diameter and requiring no further finishing. The concrete shall be of such consistency that, after extrusion, it will maintain the shape of the barrier without support. The grade for the top of the concrete barrier shall be indicated by an offset guide line set by the Contractor and approved by the Engineer. The forming portion of the

extrusion machine shall be readily adjustable vertically during the forward motion of the machine to conform to the predetermined grade line. A grade line gauge or pointer shall be attached to the machine in such a manner that a continual comparison can be made between the barrier being placed and the established grade line as indicated by the offset guide line. Other means of controlling barrier grade may be permitted by the Engineer. Expansion joints of the width shown on the plans shall be constructed by sawing through the barrier section to its full width. If sawing is performed before the concrete has hardened, the adjacent portions of the barrier shall be firmly supported with close fitting shields. When sawing is performed after the application of curing compound, the exposed faces of the barrier in the vicinity of the joint shall be treated with curing compound after sawing the joint.

If stationary forms for concrete barriers are used, they shall be removed as soon as possible after the concrete has set enough to maintain the shape of the barrier without support in order to facilitate finishing. The surface shall be free from pits larger than two (2) centimeters in diameter. The surface shall be given a final soft brush finish with strokes parallel to the line of the barriers. Finishing with a brush application of grout will not be permitted. Surfaces shall be finished as necessary to produce smooth, even surfaces of uniform texture and appearance, free from bulges, depressions, and other imperfections. The use of power sanders, carborundum stones, or disks may be required to remove bulges or other imperfections.

Exposed surfaces of concrete barriers shall be cured by the "water method" in accordance with the provisions of Paragraph 5.03.4.10 "Curing and Protection" in these General Specifications. The Engineer may permit the concrete barriers to be cured by means of the "curing compound method" in accordance with the provisions of Paragraph 5.03.4.10 "Curing and Protection" in these General Specifications.

6.01.3.5 Impact Attenuators. G.R.E.A.T. system and other impact attenuators shall be installed in accordance with the requirements shown in the M.O.C. Highway Design Manual - Volume 4 Standard Drawings TB 1 series A, B, and C and TB 3 series A through I, or as modified by the Contract Drawings or Special Specifications and with the manufacturer's recommendations and instructions. A copy of these recommendations and instructions shall be furnished to the Engineer upon delivery of the materials.

The QuadGuard System shall consist of crushable cartridges surrounded by a framework of steel Quad-beam guardrail which can telescope rearward during head-on impacts. The QuadGuard System shall have a center monorail which will resist lateral movement during side angle impacts. The nose shall consist of a formed plastic nose wrap.

A bay describes a section of the QuadGuard System consisting of a cartridge, a diaphragm and two fender panels. Each bay shall be fitted with an energy absorbing cartridge. The outside of the cartridge shall be fabricated from a weather resistant plastic. The front portion of the system shall be fitted with Type I cartridges. The rear portion of the system shall be fitted with Type II cartridges. All cartridges shall include a cartridge replacement indicator.

The back end of each Quad-beam fender panel shall overlap and be connected to the diaphragm of the next bay by means of a bolt and enlarged "mushroom" washer. The bolt fits through the long horizontal slot in the forward fender panel. This permits the movement, front to back, of one set of fender panels relative to the panels in the underlying-rearward bay. The back portion of each fender panel shall be tapered to help maximize performance during wrong-way, redirective impacts.

The monorail support structure shall be made of steel and be anchored to a specified concrete pad. The monorail shall prevent lateral movement, vertical movement and overturning movement of the diaphragms during design impacts.

The nose section shall contain a nose cover and a crushable cartridge and is not counted as a bay. The nose cover shall be made from a plastic material formulated to resist weathering. The nose shall attach to the front diaphragm. Standard colors shall be gray or yellow.

6.01.3.6 Glare Screens. Glare screen fabric shall be placed on the face of the posts designated by the Engineer. On curves, the fabric shall be placed on the face of the post which is on the outside of the curve.

The fabric shall be stretched taut and securely fastened to the posts as shown on the standard plans. The fabric shall be cut and each span attached independently at all pull and brace posts. Rolls of wire fabric shall be joined by weaving a single strand into the end of the rolls to form a continuous mesh between pull posts.

6.01.3.7 Reinstallation of Guardrail. Remove and store the existing guardrail, posts and appurtenances. Remove and dispose of posts that are set in concrete. Replace and reinstall guardrail, posts and hardware damaged during removal, storage or resetting.

6.01.3.8 Reinstallation/Retrofit of Guardrail Terminals and Impact Attenuators. Remove and store the existing attenuator guardrail, hardware posts and appurtenances. Remove and dispose of posts that are set in concrete. Replace and reinstall the attenuator and including the hardware damaged or lost during removal, storage or resetting.

6.01.3.9 Steel Safety Railing. Construction requirements shall conform to the Ministry's standard drawings and to Section 5.05 - "Steel Structures and Miscellaneous Metal Work" in these General Specifications.

6.01.4 QUALITY ASSURANCE PROCEDURES. The guardrails and crashworthy safety barriers will be inspected, sampled, tested and evaluated in accordance with Section 1.08, "Acceptance of Work" in these General Specifications as follows:

The materials incorporated into the crashworthy safety barriers shall be sampled, tested and evaluated in accordance with the specifications and test methods referenced in Subsection 6.01.2, "Materials" in these General Specifications. The installation of the crashworthy safety barriers will be accepted in accordance with Subsection 1.08.4, "Measured or Tested Conformance" in these General Specifications.

The manufacturer of the guardrail systems shall be approved to a Quality Assurance scheme complying with ISO 9002 (eg., EN29002, BS 5750 Part 2) as a supplier of components for use in vehicle safety barriers.

Only components complying with the manufacturer's specification may be used.

Copies of Certificates of Guarantee and test reports shall be provided for the components of each guardrail system manufactured off site.

6.01.5 METHOD OF MEASUREMENT. Guardrail, Reinstallation of Guardrail, New Jersey Concrete Barrier, Glare Screen, Steel Safety Railing and Reinstallation of Steel Safety Railing shall be measured by the linear meter along the front face excluding terminal sections for all Work of each type authorized, completed and accepted by the Engineer based on the dimensions as shown on the plans or ordered by the Engineer.

The pay limits for guardrail and anchor terminal sections shall be as specified in the Ministry's Standard Drawings, Series TB-4 and TB-5.

No measurement will be made for barrier base, dowel bars or of concrete filling or backing behind curbs. Excavation for the New Jersey Barriers and removing and resetting guardrail shall not be measured separately but will be considered as subsidiary work except when such excavation is part of and is measured in conjunction with the roadway excavation. In such instances, the barrier excavation shall be measured and included in the quantity of unclassified excavation as provided in Section 2.03, "Excavation" in these General Specifications.

There shall be separate measurement for guardrail transition sections including hardware necessary to meet the requirements of the installation when the transition section is shown on the Plans or Standard Drawings and listed in the Bill of Quantities. Otherwise such work shall be considered subsidiary to the standard guardrail section.

Guardrail and New Jersey Barrier delineators shall not be measured for separate payment. Their installation will be considered subsidiary to the construction of the guardrail or New Jersey barriers.

Terminals, Terminal Sections, and Impact Attenuators shall be measured by the unit of each for all Work of each type authorized, completed and accepted by the Engineer based on the number of units shown on the plans or ordered by the Engineer.

Reinstallation and retrofitting of guardrail terminals and impact attenuators shall be measured by the unit for all work of each type authorized completed and accepted by the Engineer based on the number of units shown on the Plans or ordered by the Engineer base on the number of units shown on the Plans or ordered by the Engineer.

There shall be no separate measurement of the backfill, concrete, reinforcing steel or any other component materials required for this Work as they are considered subsidiary to the items listed in this Subsection for measurement.

6.01.6 PAYMENT. The completed and accepted Work, as measured above, will be paid for at the contract unit prices in the Bill of Quantities, which prices shall include all required materials, equipment, tools, labor, and all other items necessary for the proper completion of the Work as specified in Subsection 1.07.2., "Scope of Payment" in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
60101	W-Beam Guardrail	Linear Meter
6010101	W-Beam Guardrail, Standard Section	Linear Meter
6010102	W-Beam Guardrail, Transition Section	Linear Meter
6010201	Thrie Beam Guardrail, Standard Section	Linear Meter
6010202	Thrie Beam Guardrail, Transition Section	Linear Meter
60103	Tensioned Four Wire Rope Cable Guardrail	Linear Meter
6010301	Tensioned Four Wire Rope Cable Guardrail, Standard Section	Linear Meter
6010302	Tensioned Four wire Rope Cable Guardrail, Transition Section	Linear Meter
60104	(Type), Guardrail	Linear Meter
6010401	(Type), Guardrail, Standard Section	Linear Meter
6010402	(Type), Guardrail, Transition Section	Linear Meter
60105	W-Beam Guardrail Terminal, Approach End	Unit
6010501	W-Beam Guardrail Terminal, Approach End, BCT (Type 1)	Unit
6010502	W-Beam Guardrail Terminal, Approach End, SRT (Type 1A)	Unit
6010503	W-Beam Guardrail Terminal, Approach End, Cut Slope Buried End (Type 2)	Unit
6010504	W-Beam Guardrail Terminal, Approach End, ET-2000/BEST	Unit
6010505	W-Beam Guardrail Terminal, Median Anchor, (Type 4)	Unit
6010506	W-Beam Guardrail Terminal, Approach End, Anchor to Structural Element or concrete Barrier, (Type 5)	Unit
6010507	W-Beam Guardrail Terminal, Approach End (Type)	Unit
60106	W-Beam Guardrail Terminal, Trailing End	Unit
6010601	W-Beam Guardrail Terminal, Trailing End Anchor (Type 3)	Unit
6010603	W-Beam Guardrail Terminal, Trailing End, Cut Slope Buried End	Unit

	(Type 2)	
6010604	W-Beam Guardrail Terminal Trailing End (Type)	Unit
60107	Thrie Beam Guardrail Terminal, Approach End	Unit
6010701	Thrie Beam Guardrail Terminal, Approach End, Connector (Thrie to W-Beam)	Unit
6010702	Thrie Beam Guardrail Terminal, Approach End SENTRE	Unit
6010703	Thrie Beam Guardrail Terminal, Approach End, Cut Slope Buried End (Type 2A)	Unit
6010704	Thrie Beam Guardrail Terminal, Approach End, Anchor to Structural Element or Concrete Barrier	Unit
6010705	Thrie Beam Guardrail Terminal, Approach End, (Type)	Unit
60108	Thrie Beam Guardrail Terminal, Trailing End	Unit
6010801	Thrie Beam Guardrail Terminal, Trailing End, Anchor Turndown 90° to Concrete Footing	Unit
6010802	Thrie Beam Guardrail Terminal, Trailing End, Cut Slope Buried End (Type 2A)	Unit
6010803	Thrie Beam Guardrail Terminal, Trailing End, (Type)	Unit
60109	Tensioned Four Wire Rope Cable Guardrail Terminal	Unit
6010901	Tensioned Four Wire Rope Cable Guardrail Terminal, Approach End, Anchor Block	Unit
6010902	Tensioned Four Wire Rope Cable Guardrail Terminal, Approach End, Cut Slope Buried End	Unit
6010903	Tensioned Four Wire Rope Cable Guardrail Terminal, Approach End, (Type)	Unit
6010904	Tensioned Four Wire Rope cable Guardrail Terminal, Trailing End, Anchor Block	Unit
6010905	Tensioned Four Wire Rope Cable guardrail Terminal, Trailing End, Cut Slope Buried End	Unit
6010906	Tensioned Four Wire Rope Cable Guardrail Terminal, Trailing End, (Type)	Unit
60110	Reinstallation of Guardrail	Linear Meter
6011001	Reinstallation of Guardrail, W-Beam, Standard Section	Linear Meter
6011002	Reinstallation of Guardrail, W-Beam, Transition Section	Linear Meter
6011003	Reinstallation of Guardrail, Thrie Beam, Standard Section	Linear Meter
6011004	Reinstallation of Guardrail, Thrie Beam, Transition Section	Linear Meter
6011005	Reinstallation of Guardrail, Tensioned Four Wire Rope Cable, Standard Section	Linear Meter

6011006	Reinstallation of Guardrail Tensioned Four Wire Rope Cable, Transition Section	Linear Meter
6011007	Reinstallation of Guardrail, (Type), Standard Section	Linear Meter
6011008	Reinstallation of Guardrail, (Type), Transition Section	Linear Meter
60111	Reinstallation/Retrofit of Guardrail Terminal	Unit
60112	Reinstallation/Retrofit of Guardrail Terminal, Approach End	Unit
6011201	Reinstallation/Retrofit of W-Beam Guardrail Terminal, Approach End, BCT (Type 1)	Unit
6011202	Reinstallation/Retrofit of W-Beam Guardrail Terminal, Approach End, SRT (Type 1A)	Unit
6011203	Reinstallation/Retrofit of W-Beam Guardrail Terminal, Approach End, Cut Slope Buried End (Type 2)	Unit
6011204	Reinstallation/Retrofit of W-Beam Guardrail Terminal, Approach End, ET-2000/BEST	Unit
6011205	Reinstallation/Retrofit of W-Beam Guardrail Terminal, Approach End, Anchor to Structural Element or Concrete Barrier, (Type 5)	Unit
6011206	Reinstallation/Retrofit of W-Beam Guardrail Terminal, Approach End, (Type)	Unit
6011210	Reinstallation/Retrofit of Thrie Beam Guardrail Terminal, Approach End, Connector (Thrie to W-Beam)	Unit
6011211	Reinstallation/Retrofit of Thrie Beam Guardrail Terminal, Approach End, SENTRE	Unit
6011212	Reinstallation/Retrofit of Thrie Beam Guardrail Terminal, Approach End, Cut Slope Buried End (Type 2A)	Unit
6011213	Reinstallation/Retrofit of Thrie Beam Guardrail Terminal, Approach End, Anchor to Structural Element or Concrete Barrier	Unit
6011214	Reinstallation/Retrofit of Thrie Beam Guardrail Terminal, Approach End, (Type)	Unit
6011220	Reinstallation/Retrofit of Tensioned Four Wire Rope Cable Guardrail Terminal, Approach End, Anchor Block	Unit
6011221	Reinstallation/Retrofit of Tensioned Four Wire Rope Cable guardrail Terminal, Approach End, Cut Slope Buried End	Unit
6011222	Reinstallation/Retrofit of Tensioned Four Wire Rope Cable Guardrail Terminal, Approach End, (Type)	Unit
60113	Reinstallation/Retrofit of Guardrail Terminal, Trailing End	Unit
6011301	Reinstallation/IRetrofit of W-Beam Guardrail Terminal, Trailing End, Anchor Turndown 90° to Concrete Footing	Unit
6011302	Reinstallation/Retrofit of W-Beam Guardrail Terminal, Trailing End, Anchor (Type 3)	Unit
	Reinstallation/Retrofit of W-Beam Guardrail Terminal, Trailing	

6011303	End, Cut Slope Buried End, (Type 2)	Unit
6011304	Reinstallation/Retrofit of W-Beam Guardrail Terminal, Trailing End, (Type)	Unit
6011310	Reinstallation/Retrofit of Thrie Beam Guardrail Terminal, Trailing End, Anchor Turndown 90° to Concrete Footing	Unit
6011311	Reinstallation/Retrofit of Thrie Beam Guardrail Terminal, Trailing End, Cut Slope Buried End (Type 2A)	Unit
6011312	Reinstallation/Retrofit of Thrie Beam Guardrail Terminal, Trailing end, (Type)	Unit
6011320	Reinstallation/Retrofit of Tensioned Four Wire Rope Cable Guardrail Terminal, Trailing End, Anchor Block	Unit
6011321	Reinstallation/Retrofit of Tensioned Four Wire Rope Cable Guardrail Terminal, Trailing End, Cut Slope Buried End	Unit
6011322	Reinstallation/Retrofit of Tensioned Four Wire Rope Cable Guardrail Terminal Trailing End, (Type)	Unit
60114	New Jersey Concrete Barrier	Linear Meter
6011401	New Jersey Concrete Barrier, Single Face	Linear Meter
6011402	New Jersey Concrete Barrier, Double Face	Linear Meter
60115	New Jersey Concrete Barrier, Terminal Section	Unit
6011501	New Jersey Concrete Barrier, Terminal Section, Approach End	Unit
6011502	New Jersey Concrete Barrier, Terminal Section, Trailing End	Unit
60116	Reinstallation of New Jersey Concrete Barrier	Linear Meter
6011601	Reinstallation of New Jersey Concrete Barrier, Single Face	Linear Meter
6011602	Reinstallation of New Jersey Concrete Barrier, Double Face	Linear Meter
60117	Reinstallation of New Jersey Concrete Barrier, Terminal Section	Unit
6011701	Reinstallation of New Jersey Concrete Barrier, Terminal Section, Approach End	Unit
6011702	Reinstallation of New Jersey Concrete Barrier, Terminal Section, Trailing End	Unit
60118	Impact Attenuator	Unit
6011801	Impact Attenuator, GREAT	Unit
6011802	Impact Attenuator, Sand-filled Plastic Containers	Unit
6011803	Impact Attenuator, HY-DRI	Unit
6011804	Impact Attenuator, HI-DRO	Unit
6011805	Impact Attenuator, QuadGuard	Unit
6011806	Impact Attenuator, (Type)	Unit

60119	Reinstallation/Retrofit of Impact Attenuator	Unit
6011901	Reinstallation/Retrofit of Impact Attenuator, GREAT	Unit
6011902	Reinstallation/Retrofit of Impact Attenuator, Sand Filled Plastic Containers	Unit
6011903	Reinstallation/Retrofit of Impact Attenuator, HY-DRI	Unit
6011904	Reinstallation/Retrofit of Impact Attenuator, HY-DRO	Unit
6011905	Reinstallation/Retrofit of Impact Attenuator, QuadGuard	Unit
6011906	Reinstallation/Retrofit of Impact Attenuator, (Type)	Unit
60120	Glare Screen	Linear Meter
6012001	Glare Screen, Fabric, Type 1A	Linear Meter
602002	Glare Screen, Fabric, Type 1B	Linear Meter
6012003	Glare Screen, Fabric, Type 1C	Linear Meter
6012004	Glare Screen, Slats, Type 2	Linear Meter
6012005	Glare Screen, (Type)	Linear Meter
60121	Steel Safety Railing	Linear Meter
60122	Reinstallation of Steel Safety Railing	Linear Meter

SECTION 6.02 - CURBS AND GUTTERS

6.02.1 DESCRIPTION. This Work shall consist of the construction of Portland cement concrete curbs, curbs and gutters, gutters, and bituminous concrete curbs and gutters in accordance with the specifications and in conformity to the locations, lines, grades, and typical sections shown on the plans or established by the Engineer.

ITEMS IN BILL OF QUANTITIES
Precast Channelization Curb
Precast Bridge Curb
Concrete Curb
Bituminous Curb
Combined Curb and Gutter
Gutters

6.02.2 MATERIALS.

6.02.2.1 Concrete. Portland cement concrete shall conform to the requirements of Subsection 5.01.1, "Description" for Class A concrete, except that footing concrete may conform to Minor Concrete as described in Subsection 5.03.9, "Concrete for Minor Structures" in these General Specifications.

6.02.2.2 Reinforcing Steel. Reinforcing steel shall conform to the requirements of Section 5.02, "Reinforcing Steel" in these General Specifications.

6.02.2.3 Preformed Expansion Joint Filler. Preformed expansion joint filler shall meet the requirements of AASHTO M-33.

6.02.2.4 Bituminous Mix. Bituminous mix for bituminous curbs and gutters shall meet the materials, mix design and mix preparation requirements of Section 4.05, "Bituminous Concrete Pavement" in these General Specifications for Bituminous Concrete Wearing Course, Grading III, except that the asphalt content shall be increased approximately one-half (½) percent or as directed by the Engineer.

6.02.2.5 Mortar. Mortar shall conform to the requirements of Subparagraph 5.01.3.1.2, "Mortar" in these General Specifications.

6.02.2.6 Bedding. Bedding material shall conform to the requirements of Subsection 3.02.2, "Materials for Aggregate Subbase," Grading I or II in these General Specifications.

6.02.2.7 Epoxy Adhesive. Epoxy adhesive shall conform to the requirements of AASTO M 235 for the type of application required.

6.02.3 CONSTRUCTION REQUIREMENTS

6.02.3.1 Precast Channelization and Bridge Curb.

1. Casting Curb Sections. Curb sections shall be hydraulically pressed into approved molds under conditions of controlled temperature and humidity. Section shall be water or steam cured until the concrete attains one hundred (100) percent of specified strength. Curbs shall have a clean finish with smooth surfaces. Segregation, honeycombing or broken corners will not be allowed and remedial measures will not be accepted.

2. Installation. The adhesive shall be placed uniformly on the cleaned pavement surface or on the bottom of the curb sections in a quantity sufficient to result in complete coverage of the area of contact of the curb and the pavement, with no voids present and with a slight excess after the curb has been pressed in place. The curb shall be placed in position and pressure applied until firm contact is made with the pavement. Excess adhesive around the edge of the marker, excess adhesive on the pavement, and adhesive on the exposed surfaces of the marker shall be immediately removed. The curb shall be protected against impact until the adhesive has hardened.

Mixing of adhesive shall be performed in limited quantities such that the curb sections shall be aligned and pressed into place within five (5) minutes after mixing the adhesive components. Any mixed batch of adhesion which becomes so viscous that the adhesive is not readily extruded from under the curb on application of slight pressure shall not be used.

Curbs shall be placed to the lines shown on the plans or established by the Engineer. The Contractor shall mark the location where each section is to be placed and the marks shall be approved by the Engineer prior to beginning mixing operations. No curb sections shall be placed over longitudinal or transverse joints of the pavement surface.

Final acceptance of the curbs will be given by the Engineer only after proper incorporation in the Work.

6.02.3.2 Cast-in-Place Portland Cement Concrete Curbs, Combined Curbs and Gutters.

1. Subgrade. The subgrade for concrete curb, gutter, combined curb and gutter, and cast-in-place concrete base shall be excavated to the grades and sections shown on the plans. If the section is not indicated, the width to be excavated shall be thirty (30) centimeters each side of the outside edges of the curb or gutter. The subgrade shall be of uniform density as approved by the Engineer. When required by the plans or ordered by the Engineer, the foundation shall be subexcavated a minimum of one hundred fifty (150) millimeters and the material replaced with bedding material. The bedding material shall be compacted to meet the requirements of Type 90 compaction as specified in Paragraph 2.05.4.3, "Earth Embankment Lift Thickness and Compaction Requirements" in these General Specifications. All foundation shall be rolled or compacted to provide

a smooth surface and shall be approved by the Engineer and moistened before placing concrete.

2. Forms.

(1) Stationary Side Form Construction. Forms for edge curb or header curb constructed monolithically with concrete pavement or base course shall be of steel. Forms for all other types of curb and gutter shall preferably be of steel but, with the permission of the Engineer, may be of wood for curb or gutter of nonstandard section or when small quantities are involved. All forms shall be sufficiently strong and rigid and securely staked and braced to obtain a finished product correct to the dimensions, line and grade required. Forms shall be cleaned and oiled before each use.

(2) Slip-Form Construction. The curb and/or gutter may be constructed by the use of approved slip-form or extrusion equipment provided the completed curb and/or gutter is true to shape, grade and line, and the concrete is dense and of the required surface texture.

The extrusion machine shall be equipped with grade line gages or pointers in a manner which will provide a continuous comparison between the curb, curb and gutter, or gutter being placed and the planned grade, indicated by an offset guide line. The finished curb shall comply with the following tolerances:

Top of curbs ± 3 mm in 3 meters; vertical face on longitudinal axis, ± 6 mm in 3 meters.

3. Placing Concrete. Edge curb and header curb shall be constructed monolithically with concrete pavement. Immediately after finishing, the pavement area where the curb is to be constructed shall be cleaned of all laitance and roughened. The concrete shall be placed, consolidated, and shaped with a steel template conforming to the section shown on the plans. Concrete for other types of curbs and gutters shall be placed upon the previously prepared and moistened subgrade. The concrete shall be consolidated with an approved internal type vibrator. The surface shall be shaped by use of a steel template to produce the section shown on the plans. The edges shall be rounded with edgers to form the radii indicated on the plans.

4. Contraction and Construction Joints for Curbs and/or Gutters. Joints shall be constructed at the intervals and places shown on the plans. All joints shall be of the type and materials and conform to the dimensions shown on the plans.

When constructed monolithically with or abutting concrete pavement, the joints in curbs and/or gutters shall coincide with joints in the pavement.

When constructed separately from concrete pavement, or adjacent to flexible base or surface courses, weaker plane construction joints in curbs and/or gutters may be constructed by sawing through the curb and to a depth of not less than thirty (30) millimeters below the surface of the gutter, or they may be formed by inserting an approved removable metal template in the fresh concrete, or by other methods approved

by the Engineer. Sealing of the joints will not be required unless the curb and/or gutter is constructed monolithically with or abutting concrete pavement.

Unless otherwise shown on the plans or directed by the Engineer, contraction joints shall be provided at 3 meters on center, and shall be either tooled (in fresh concrete) or sawed (in hardened concrete). Further, expansion joints shall be located at 9 meters on center. Preformed joint fillers shall be provided for expansion joints and locations abutting catch basins, manholes, inlets, structures, sidewalks and other fixed objects.

Construction joints shall be preplanned to coincide with expansion joints.

5. Finish. The exposed surfaces shall be finished full width with a trowel and edger. The top face of curbs shall receive a light brush finish. Within twenty-four (24) hours after the concrete is placed, the forms of the roadway face of curbs shall be removed and the concrete given a light rubbed finish.

6. Curing. Curbs and/or gutters shall be moist cured until stripped and finished, and then cured in accordance with the provisions of Paragraph 5.03.4.10, "Curing and Protection" in these General Specifications.

7. Removal of Forms. Forms may be removed as soon as practical, as long as no damage results to the curb or gutter. Required finishing shall be performed immediately followed by application of curing compound.

8. Backfilling. The area adjacent to curbs and/or gutters shall be backfilled with approved material to the top edges of the curbs or gutters or to the elevation shown on the plans. The backfill shall be placed and compacted in accordance with Type 95 compaction as defined in Paragraph 2.05.4.3 "Earth Embankment Lift Thickness and Compaction Requirements" in these General Specifications.

6.02.3.3 Precast Portland Cement Concrete Curbs and Combined Curbs and Gutters.

1. Subgrade. The subgrade for the concrete base shall be as specified above in Subparagraph 6.02.3.2.1, "Subgrade" in these General Specifications.

2. Forms. Forms shall be approved and constructed of steel fiberglass or other durable material. All forms shall be sufficiently strong and rigid and securely supported to obtain a finished product correct to the shape and dimensions required. Forms shall be cleaned before each use.

For radii of twelve (12) meters or less, forms shall be curved and curbs, curbs and gutter or gutter of appropriate radii shall be used. The use of straight units shall not be permitted.

Precast concrete curb may be constructed by the use of approved extrusion or other specially designed equipment, provided the finished curb is true to the dimensions

shown on the plans and the concrete is properly consolidated and finished to the required surface texture.

3. Placing Concrete. All concrete shall be placed, consolidated, and shaped to the section shown on the plans. The concrete shall be consolidated with an approved vibrator. Edges of precast curb shall be rounded as shown on the plans.

The method used in placing concrete shall be such as to produce a uniformly dense concrete element.

Unless otherwise shown on the plans or directed by the Engineer, the concrete base shall be not less than one hundred fifty (150) mm thick and of a width that will allow for a one hundred fifty (150) mm wide backing, to be poured upon completion of placing the units.

The sand-cement mortar bedding shall be not less than twenty (20) mm thick. After curbs, curbs and gutter or gutter have been laid, a continuous concrete backing not less than one hundred fifty (150) mm wide shall be poured against the units. For curbs abutting earth or aggregate surfaces the backing shall be to a height of fifty (50) mm below the top of the curb. For curbs abutting surfaces to be filled or paved, the backing shall be to a height which permits laying of tiles or similar surface. The top of the backing shall be battered downward from the back of the curb to a height of fifty (50) mm.

No pavement layer shall be laid against curbs until such time as the backing has cured and backfilled.

Unless otherwise shown on the plans or directed, joints between precast units shall be five (5) mm wide and grouted as specified. Joints shall be tooled to produce a smooth circular section not more than three (3) mm deep.

The vertical alignment of the finished curb shall not depart from true level by more than six (6) mm and at any point, maximum deviation of the tip of the curb under a straightedge shall be not greater than three (3) mm in three (3) meters. The horizontal alignment shall not depart from that shown on the plans by more than twelve (12) mm, nor deviate from a straight edge by more than three (3) mm in three (3) meters.

4. Finish. Unformed, exposed surfaces shall be finished in accordance with Paragraph 5.03.4.9, "Finishing" in these General Specifications.

Formed, exposed surfaces need not receive additional finishing except when air bubbles or other surface flaws require correction as determined by the Engineer.

5. Curing. Precast curb sections shall be cured in accordance with the provisions of Paragraph 5.03.4.10, "Curing and Protection" in these General Specifications using membrane, water, or steam curing.

6. Removal of forms. Forms may be removed from elements cast at the site as soon as practical as long as damage results.

6.02.3.4 Bituminous Curb. Immediately prior to placing bituminous curb, a tack coat of asphalt at the rate ordered by the Engineer shall be applied to the surface upon which bituminous curb is to be placed. The curb shall be placed, shaped, and compacted true to line and grade with extrusion or other equipment capable of shaping and thoroughly compacting the materials to the required cross section and uniform surface texture.

Construction of bituminous curbs, may be performed with automatic curbing machines which place, compact and finish straight or curved curbs, for streets, traffic islands and other roadside areas. In this case, no forms shall be used. Instead, interchangeable mold patterns shall be used to form the required shapes. For construction methods of asphalt curbs the latest Asphalt Institute Specification Series No. 3 shall apply. Typical details for installation of asphalt concrete curbs are provided in the Ministry's Standard Drawing CGS-5, which shall govern, unless otherwise directed by the Engineer.

6.02.4 QUALITY ASSURANCE PROCEDURES. The curbs and gutters will be inspected, sampled, tested and evaluated in accordance with Section 1.08, "Acceptance of Work" in these General Specifications as follows:

The materials incorporated into the curbs and gutters shall be sampled, tested and evaluated in accordance with the specifications and test methods referenced in Subsection 6.02.2, "Materials" in these General Specifications. The construction of the curbs and gutters will be accepted in accordance with Subsection 1.08.4, "Measured or Tested Conformance" in these General Specifications. For bituminous curbs the stability and density requirements will be waived.

6.02.5 METHOD OF MEASUREMENT. Precast Curb, Precast Channelization Curb, Precast Bridge Curb, Concrete Curb, Bituminous Curb, Combined Curb and Gutter, and Gutters, shall be measured by the linear meter of each type of Work authorized, completed, and accepted by the Engineer based on the dimensions shown on the plans or ordered by the Engineer. Symmetrical curbs and gutters shall be measured along the centerline. Asymmetrical sections shall be measured along the inside face (toward roadway centerline). Excavation for the various types of curbs and gutters shall not be measured separately for payment but will be considered as subsidiary Work, except when such excavation is a part of, and is measured in conjunction with, the roadway excavation. In such instances, the excavation shall be measured and included in the quantity of Roadway Excavation - computed as a pay item as provided in Section 2.03, "Excavation" in these General Specifications.

No separate measurement shall be made for concrete base for precast curb, nor will measurement be made for bedding material, except that excavation and backfill ordered and acceptably performed in excess of one hundred fifty (150) millimeters below the section shall be measured in accordance with Subsection 2.09.8, "Method of Measurement" in these General Specifications.

6.02.6 PAYMENT. **The amount of authorized, completed and accepted Work as measured above will be paid at the contract unit prices in the Bill of Quantities, which price shall be full compensation for furnishing all required materials, equipment, tools, labor, including reinforcement and joints, and all other items necessary for the proper completion of the Work as specified in Subsection 1.07.2, "Scope of Payment" in these General Specifications.**

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
60201	Precast Curb	Linear Meter
6020101	Precast Channelization Curb, Type ___	Linear Meter
6020102	Precast Bridge Curb, Type ___	Linear Meter
60202	Concrete Curb	Linear Meter
6020201	Concrete Curb, Type ___	Linear Meter
60203	Bituminous Curb	Linear Meter
6020301	Bituminous Curb, Type ___	Linear Meter
60204	Combined Curb and Gutter	Linear Meter
6020401	Combined Curb and Gutter, Type ___	Linear Meter
60205	Gutter	Linear Meter
6020501	Gutter, Type ___	Linear Meter

SECTION 6.03 - CATCH BASINS, MANHOLES, INLETS AND DRAINAGE GRATES

6.03.1 DESCRIPTION. This Work shall consist of the finishing and installing of precast or cast-in-place catch basins, manholes, inlets and outlets, including metal frames, grates, and covers, in accordance with the plan details and these specifications, at the locations and to the lines and grades shown on the plans or established by the Engineer.

This Work shall also consist of changing the elevation of manhole, catch basin or inlet covers or grates, including rebuilding of the existing manhole, catch basin, or inlet top, preparation of the seat and placement anew of the existing manhole cover or grate, in conformity with the lines and grades shown on the plans or established by the Engineer.

ITEMS IN BILL OF QUANTITIES
Catch Basins
Manholes
Inlets
Drainage Grate
Adjustment of Elevation of Manhole Cover and Drainage Inlet Grate

6.03.2 MATERIALS.

6.03.2.1 Concrete. Concrete shall conform to the requirements of Class C as specified in Subsection 5.01, "Portland Cement Concrete" in these General Specifications.

6.03.2.2 Reinforcing Steel. Reinforcing Steel shall conform to the requirements as specified in Section 5.02, "Reinforcing Steel" in these General Specifications.

6.03.2.3 Structural Steel. Structural steel shall conform to the requirements as specified in Section 5.05, "Steel Structures and Miscellaneous Metal Work" in these General Specifications.

6.03.2.4 Cast Iron. Gray-iron castings shall conform to AASHTO M 105, Class 25S. Castings shall be manufactured to conform to the sizes and dimensions shown on the plans.

1. Test Specimens. Two (2) test specimens shall be cast for each casting that will be subjected to traffic loads. The specimens may be cast attached to or separate from the casting. Specimens shall be of such size that a bar nineteen (19) millimeters in diameter and twenty (20) centimeters in length can be machined from each specimen.

6.03.2.5 Steel Castings.

1. General. Mild to medium-strength steel castings shall conform to AASHTO M 103. Unless otherwise shown on the plans or specified, castings shall be Grade 65-35 fully annealed in accordance with ASTM E 44. Steel castings shall conform to the dimensions, sizes and sections shown on the plans.

2. Test Specimens. Two (2) test specimens shall be cast for each casting. Test specimens shall be of such size that a bar nineteen (19) millimeters in diameter and twenty (20) centimeters in length can be machined for each specimen.

6.03.2.6 Wrought Iron.

1. General. Wrought iron bars, plates, and shapes shall conform to the sizes and dimensions shown on the plans or specified.

2. Requirements.

(1) Rolled Wrought Iron Shapes and Bars. Rolled wrought-iron shapes and bars shall conform to the requirements of ASTM A 207.

(2) Wrought-Iron Plates. Wrought-iron plates shall conform to ASTM A 42.

6.03.2.7 Bedding Course. Bedding Course material shall conform to the requirements of Subsection 3.02.2, "Materials," Grading I or Grading II in these General Specifications.

6.03.2.8 Precast Concrete Manholes. The Contractor may use any type of precast concrete manhole segments provided that they have been approved by the Engineer. The Contractor should submit with his Tender, full details and drawings of any alternative type which he proposes to use.

Precast concrete manhole chamber, taper and shaft sections and chamber and shaft cover slabs shall be BSS 556: Part 2, 1972.

6.03.2.9 Manhole Frames and Covers. All manhole frames and covers shall be of local Saudi Production and shall be of grey cast iron, of heavy duty design (forty tons test load) and on tensile strength conform to ASTM A48-76 Class 30A or better. Frames shall have a square base seventy-five (75) centimeters per side, a height of fifteen (15) centimeters, and have a clear circular opening of sixty (60) centimeters diameter. Covers shall be circular, and shall be equipped with a locking device, have prising slots, lifting holes and non-skid pattern top. The total weight of frame and cover shall be two hundred (200) kilograms minimum.

The word "STORM" in five (5) centimeter letters shall be cast on the cover in English and Arabic. Bearing surfaces between cast iron frames and covers shall be machined and fitted together to prevent rocking. All castings shall be coated with coal or tar pitch varnish to which sufficient oil has been added to make a smooth finish. When manholes are used as drop inlets, the manhole frame and cover will be replaced by a catchbasin frame and grate as per Paragraph 6.03.2.2, "Reinforcing Steel" in these General Specifications.

6.03.2.10 Safety Steps and Hand Bars. Safety steps and hand bars shall be manufactured of twenty (20) millimeters diameter mild steel deformed reinforcing bars and hot dip galvanized in accordance with ASTM A 153.

6.03.2.11 Catchbasins. Catchbasins shall be precast and constructed of Class C concrete, cast in steel watertight forms, thoroughly cured, all as detailed on the drawings and specified. Such units shall be cast in a casting yard prepared and fitted for this purpose at least three (3) weeks before they are used. Catchbasin shall be set on a fifteen (15) centimeters base of Class B concrete.

6.03.2.12 Catchbasin Frames and Grates. All catchbasin frames and grates shall be of heavy duty design (25 tons test load). The type shall be as indicated on the drawings.

Those for use on asphalted streets shall be of a grey cast iron and shall conform to DIN 1213. Frames and grates shall be square. The total grate opening shall be 1250 cm^2 minimum made up of rectangular opening three (3) centimeters wide at the top and slightly tapered (opening downward). The frames shall be fifteen (15) centimeters high and shall have a clear basin. The total weight of frame and grate shall be one hundred fifty (150) kilograms minimum.

6.03.2.13 Masonry. Bricks shall be from local manufacturer and should conform with local standards or BS 3921 1965.

6.032.14 Pipe Runners. Pipe Runners used for R.C.B.C. inlet and outlet drainage grates shall be ASTMA-53 steel. Steel plates, bolts and nuts shall conform to ASTMA 36 and ASTM 307 respectively.

The dimensions of the pipe runner standard and alternate design plates, size and length of bolts and nuts are to be checked and submitted to the Engineer for approval. They shall be compatible with the type and size of pipe runner adopted from the standard plan tabulation.

6.03.3 CONSTRUCTION REQUIREMENTS.

6.03.3.1 Alternate Designs. Unless otherwise designated, concrete manholes, catch basins, and inlets may be precast or cast-in-place at the option of the Contractor. Alternate designs may also be proposed for inlet frames and grates. Alternate designs shall conform to the plans. If alternate designs are not included in the plans, the Contractor may submit proposals to the Engineer for approval. Such designs shall be minimally equivalent to the specified design with respect to strength, hydraulic capacity, and other functional parameters. Alternate designs shall also be similar to the specified design in above ground appearance after installation. The approval of alternate designs for concrete manholes, catch basins, or inlets shall not result in increased costs to the Ministry for the construction of these or any related items.

6.03.3.2 Excavation and Backfill. Excavation and backfill shall conform to the requirements of Section 2.09, "Structural Excavation and Backfill" in these General Specifications.

When required by the plans or ordered by the Engineer, the structure shall be installed on a bedding course of the thickness shown on the plans or ordered by the Engineer. The bedding course shall be compacted to Type ninety (90) compaction.

6.03.3.3 Concrete Construction. Precast and cast-in-place concrete construction shall conform to the requirements of Section 5.03, "Concrete Structures" in these General Specifications.

6.03.3.4 Masonry. When so indicated on the plans, brick or concrete block masonry may be used for the walls of catch basins, manholes, or inlets. Masonry manholes may be constructed circular, with an inside diameter which is equal to the greater of the inside dimensions indicated on the plans.

When masonry is used for square or rectangular structures, the inside dimensions of the structure shall be of the dimensions shown on the plans, unless ordered otherwise by the Engineer. The mortar for masonry shall be as specified in Subparagraph 5.01.3.1.2, "Mortar" in these General Specifications. The brick or concrete block shall be laid with full mortared joints and with sufficient header courses to tie the masonry together properly as approved by the Engineer.

6.03.3.5 Placing Castings. Castings shall be set in full mortar beds or otherwise secured as shown on the plans and approved by the Engineer. Mortar for setting castings shall be as specified in Subparagraph 5.01.3.1.2, "Mortar" in these General Specifications. Casting shall be set accurately to correct elevations so that no subsequent adjustment will be necessary.

6.03.3.6 Welded Grates and Frames. Welded steel grates and frames shall be constructed in accordance with the plans. All materials, including miscellaneous hardware, shall be galvanized after fabrication in accordance with ASTM A 123 or ASTM A 153 as appropriate.

Frames or anchor bolts shall be set and firmly secured in place to grade before placement of concrete.

6.03.3.7 Cleaning. All catch basins, manholes, inlets and outlets shall be thoroughly cleaned of any accumulation of silt, debris or foreign matter of any kind and shall be free from such accumulations at the time of Provisional and Final Handover.

6.03.3.8 Manholes. Manholes, of precast concrete shall be constructed in accordance with the drawings. Channels in the bottom of the manholes shall be smooth and semi-circular in shape conforming to the inside of the adjacent pipe sections.

The channel shall be constructed of half pipe sections for straight through manholes. Changes in direction of flow shall be made with a smooth curve of as large a radius as the size of the manhole will permit.

Changes in size and grade of the channels shall be gradual and even. Manholes shall be constructed so that the top of the frame and cover is at road grade unless otherwise directed by the Engineer. The final position of the cover at the finished grade shall be attained by the installation of at least two courses of brick.

The types of manholes to be constructed are as follows:

- Manholes Type "A" shall be used where the vertical depth from the ground level to pipe soffit does not exceed two and eighty hundredths (2.80) meters.

- Manholes Type "B" shall be used where the vertical depth from the ground level to pipe soffit exceeds two and eighty hundredths (2.80) meters.

Precast concrete sections or rings used for all manhole construction shall have lengths of thirty (30), ninety (90) and/or one hundred twenty (120) cm conforming to BS 556: Part 2: 1972. The sections shall be of reinforced Class A concrete, cast in steel watertight forms, thoroughly cured, all as detailed in the drawings.

Such units shall be cast in a casting yard prepared and fitted for this purpose at least three (3) weeks before they are used.

The steps may be placed during or after casting, but no field installations shall be permitted. If the steps are installed after casting, correctly located holes shall be made during casting, and steps shall be placed later, properly blocked and mortared in to the satisfaction of the Engineer. Any section not fitted with the necessary number of steps will be rejected.

Steps shall not be used as lifting eyes and any such devices for lifting and handling shall be provided on the exterior surface only. Any units found cracked, defective or with edges broken or damaged shall be rejected.

Precast concrete units except where otherwise specified, shall be bedded and jointed with cement mortar of one part cement to three parts fine aggregate, true to line and level shown on the drawings, each unit being firmly pressed into position and the joints flush pointed as the Work proceeds.

6.03.3.9 Adjustment of Elevation of Manhole Cover and Inlet Drainage Grate. Where a manhole cover or inlet grate is to be raised or lowered to conform to a new elevation as shown on the plans or as directed by the Engineer, the Contractor shall carry out the following:

1. Remove the cover or grate along with its frame and store it on site.

2. Remove the top portion of the manhole or inlet to prepare for rebuilding; or to expose the embedded rebars, clean the rebars by sandblasting or wire-brushing, and weld new reinforcement to raise the structure elevation; or bend/cut the existing reinforcement to lower the structure elevation.

3. Dispose of removed materials as directed.

4. Rebuild the manhole/inlet top with new masonry units or concrete, as directed, place anew the frame and cover/grate, coat as directed, cure the structure, and clean the Work.

6.03.4 QUALITY ASSURANCE PROCEDURES.

6.03.4.1 General. The catch basins, manholes and inlets will be inspected, sampled, tested and evaluated in accordance with Section 1.08, "Acceptance of Work" in these General Specifications as detailed in the following paragraphs.

6.03.4.2 Concrete Products. Concrete products which are precast not in the vicinity of the project shall be tested by the manufacturer at the time of casting and such test results shall be presented to the Engineer along with Certificates of Compliance. The Engineer shall be advised of the manufacturer's proposed casting schedule at least thirty (30) days in advance of commencement. If so ordered by the Engineer, the Contractor shall arrange for an approved independent laboratory to perform verification testing at the casting site.

6.03.4.3 Steel and Iron Castings. Along with Certificates of Compliance, the Contractor shall submit all required test specimens to the Engineer for inspection. After inspection, the Engineer may order some or all of the test specimens to be machined and tested by an approved independent laboratory.

6.03.4.4 Other Materials. All other materials produced offsite shall be accompanied by Certificates of Compliance and test results as appropriate.

6.03.4.5 Construction. The installation of the catch basins, manholes, inlets and drainage grates will be accepted in accordance with Subsection 1.08.4, "Measured or Tested Conformance" in these General Specifications.

6.03.5 METHOD OF MEASUREMENT. Catch Basins, Manholes, Inlets, and Drainage Grates shall be measured by the unit of each based on the number of each type constructed, completed and accepted including furnishing and installation of all frames, grates, covers and steps.

Manhole cover or drainage grate shall be measured by the kilogram, to the nearest gram, of completed and accepted Work, regardless of size or type.

Manhole cover or drainage grate changing of elevation shall be measured by the number of units successfully restored as specified, regardless of size or type.

Excavation, bedding, backfill, replacing pavement where required, reinforcing steel, and disposal of surplus material will not be measured separately, but shall be considered subsidiary to the Item(s) of Work as shown in the Bill of Quantities.

6.03.6 PAYMENT. The amount of completed and accepted Work as measured above will be paid at the contract unit price(s) specified in the Bill of Quantities which price(s) shall be full compensation for furnishing all materials, for all labor, equipment, tools,

supplies and all other items necessary for the proper completion of the Work as specified in Subsection 1.07.2, "Scope of Payment" in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
60301	Catch Basin	Unit
6030101	Catch Basin, Type A	Unit
6030102	Catch Basin, Type ___	Unit
60302	Manhole	Unit
6030201	Manhole, Type A	Unit
6030202	Manhole, Type B	Unit
6030203	Manhole, Type ___	Unit
60303	Inlet	Unit
6030301	Inlet, Type 1	Unit
6030302	Inlet, Type 2	Unit
6030303	Inlet, Type 3	Unit
6030304	Inlet, Type ___	Unit
60304	Drainage Grate	Kilogram
6030401	Drainage Grate, R.C.B.C. Inlet and Outlet Pipe Runners	Kilogram
6030402	Drainage Grate, Type 1	Kilogram
6030403	Drainage Grate, Type 2	Kilogram
6030404	Drainage Grate, Type 3	Kilogram
6030405	Drainage Grate, Type ___	Kilogram
60305	Adjustment of Elevation of Manhole Cover and Inlet Drainage Grate	Unit

SECTION 6.04 - PIPE UNDERDRAIN AND IRRIGATION PIPE

6.04.1 DESCRIPTION. This Work shall consist of furnishing pipe underdrain and irrigation pipe of the type and sizes provided on the plans or in the proposal in accordance with the requirements of these specifications, and installing such pipe at the locations shown on the plans or designated and in conformity with the established lines and grades. The Work shall include the furnishing and construction of such joints and connections to other pipes, catch basins, endwalls, etc., as may be required to complete the Work, as shown on the plans or directed, together with granular backfill filter material and construction fabric, if required.

ITEMS IN BILL OF QUANTITIES
Pipe Underdrain
Irrigation Pipe

6.04.2 MATERIALS.

6.04.2.1 Plastic Pipe Underdrains. Plastic pipe underdrain shall be plastic conforming to ASTM 3033 or ASTM 3034 for polyvinyl chloride (PVC) or ASTM D 2751 for acrylanitrile-butadiene-styrene (ABS). The class of pipe may be modified to accommodate local Saudi manufactured products that meet appropriate Saudi Arabian Standards Organization (SASO) requirements.

6.04.2.2 Bituminous Coated Steel Pipe Underdrains. Bituminous Coated Steel pipe underdrain shall be bituminous coated, galvanized, corrugated steel conforming to AASHTO M-36, Type III, and AASHTO M-190, Type A. Coupling bands shall be fully coated.

6.04.2.3 Plastic Irrigation Pipe. Plastic irrigation pipe shall conform to ASTM D 1785, Schedule 40 (polyvinyl chloride), or ASTM D 1527, Schedule 40 (acrylonitrile-butadiene-styrene).

6.04.2.4 Steel Irrigation Pipe. Steel irrigation pipe shall be standard, circular, galvanized welded or threaded steel pipe conforming to ASTM A 53.

6.04.2.5 Perforations. All pipe underdrain shall be perforated except sections specifically designated as non-perforated by the Engineer. Perforated pipe may be sealed for nonperforated sections provided the perforations are sealed in a manner approved by the Engineer and provided the pipe is installed with the perforations on the top. Perforations may be circular holes or slots at the option of the Contractor. However, different filter requirements shall apply to each.

Plastic pipe underdrain circular perforations shall be between five (5) millimeters and ten (10) millimeters in diameter arranged symmetrically in a minimum of four (4) rows parallel to the axis of the pipe. All rows shall be in the lower half of the pipe but no row shall be closer than forty (40) grads to the invert. Perforations in each row shall be a maximum of ten (10) centimeters center to center.

Plastic pipe underdrain slotted perforations shall be between one and five tenths (1.5) millimeters and three (3) millimeters in width, and twenty-five (25) to forty (40) millimeters in length measured on the inside of the pipe. Perforations shall be in two (2) rows, parallel to the axis of the pipe on each side of the invert. Each row shall be approximately fifty (50) grads from the invert. Perforations shall be spaced between twenty (20) and thirty (30) times the average slot width along each row.

Bituminous Coated Steel pipe underdrain circular or slotted perforations shall conform to AASHTO M 36. Perforations shall be cut before bituminous coating but shall conform to the minimum size.

6.04.2.6 Granular Backfill Filter Material. Granular backfill filter material for pipe underdrain with circular perforations or slots greater than three (3) millimeters average width shall meet the requirements of and conform to one of the gradations in Subparagraph 5.01.2.2.2, "Coarse Aggregate" in these General Specifications.

Granular backfill filter material for pipe underdrain with slots up to three (3) millimeters in width shall meet the requirements of and conform to the gradation in Subparagraph 5.01.2.2.1, "Fine Aggregate" for concrete fine aggregate or one of the gradations in Subparagraph 5.01.2.2.2, "Coarse Aggregate" in these General Specifications.

6.04.2.7 Geotextile Fabric. If the granular backfill filter material is installed in trenches excavated in or backfilled with A-3, A-4, A-5, A-6, or A-7 soil, the filter material shall be encapsulated in Type II Geotextile fabric conforming to Table 6.018-2 "Type II Fabric Geotextiles for Underdrain" in these General Specifications.

6.04.3 CONSTRUCTION REQUIREMENTS.

6.04.3.1 Pipe Underdrain.

1. Perforated Sections. Trenches for perforated underdrain sections shall be excavated to a width equal to the outside diameter of the pipe plus three hundred (300) millimeters, and to a minimum depth of approximately one hundred fifty (150) millimeters below the grade established for the flow line of the pipe, unless otherwise directed.

When geotextile fabric is required, it shall be of sufficient width to accommodate the periphery of the granular coarse aggregate backfill filter material section plus a minimum thirty (30) centimeter lap. The fabric shall be placed in the trench before any filter material with the center of the fabric in the bottom of the trench. After installation of the bedding, pipe, and remainder of the filter material, the fabric shall be lapped at the top and the installation backfilled as required.

A minimum one hundred fifty (150) millimeters bedding layer of granular backfill filter material shall be placed and compacted in the bottom of the trench for its full width and length. Pipe of the size specified shall be embedded firmly in the bedding material with perforations down and the pipe sections joined securely with the appropriate coupling bands or joint filler. The high end of pipe installations shall be closed with suitable plugs to prevent entry of soil materials.

After the pipe installation has been inspected and approved, granular backfill material shall be placed to a minimum height of three hundred (300) millimeters above the top of pipe. The remainder of the trench shall be backfilled in accordance with Section 2.10, "Trench Excavation and Backfill" in these General Specifications.

2. Nonperforated Sections. Trenches for nonperforated sections for connections and outlets shall be excavated to the same width and depth required for perforated sections or as ordered by the Engineer. Pipe shall be laid in the trench with all ends firmly joined by applicable methods. After inspection of the pipe installation by the Engineer, the trench shall be backfilled in accordance with Section 2.10, "Trench Excavation and Backfill" in these General Specifications. Granular backfill filter material will not be required for nonperforated sections unless specified on the plans or ordered by the Engineer.

6.04.3.2 Irrigation Pipe.

1. General. In areas where the new roadway intercepts and blocks existing irrigation flow, it shall be the Contractor's responsibility to provide and maintain, as approved by the Engineer, adequate temporary irrigation flow to all the isolated areas originally under irrigation, until such time as the irrigation pipe is installed in the approved location.

2. Excavating, Trenching and Backfilling. Excavating, trenching and backfilling shall be as specified for pipe culverts in Section 2.10, "Trench Excavation and Backfill" in these General Specifications.

3. Laying Pipe. In general, irrigation pipe will be placed as specified for pipe culverts in Section 6.08, "Pipe Culverts" in these General Specifications. Steel pipes shall be laid with ends abutting, and joints coupled by welding or by means of threads, and true to line and grade. All pipes shall be fitted and matched so that, when laid, they will form a smooth, uniform invert with watertight joints. Backfilling shall not proceed until the installation is tested in the presence of and approved by the Engineer.

6.04.4 QUALITY ASSURANCE PROCEDURES. The pipe underdrain and irrigation pipe will be inspected, sampled, tested and evaluated in accordance with Section 1.08, "Acceptance of Work" in these General Specifications as follows:

The materials incorporated into the pipe underdrain and irrigation pipe shall be sampled, tested and evaluated in accordance with the specifications and test methods referenced in Subsection 6.04.2, "Materials" in these General Specifications. The installation of the pipe underdrain and irrigation pipe will be accepted in accordance with Subsection 1.08.4, "Measured or Tested Conformance" in these General Specifications.

6.04.5 METHOD OF MEASUREMENT.

6.04.5.1 Pipe Underdrain. The accepted length of perforated and nonperforated sections of pipe underdrain will be measured by the linear meter for each type and size of Pipe Underdrain authorized, completed and accepted. No separate measurement will be made for granular backfill filter material or for geotextile fabric which shall be considered subsidiary to the Pipe Underdrain item.

No separate measurement will be made for trench excavation and backfill required up to two (2) meters in depth. This Work will be considered subsidiary to Pipe Underdrain. For trenches ordered in excess of two (2) meters in depth, measurement will be made for quantities in excess of two (2) meters depth in accordance with Paragraph 2.09.2.3, "Structural Excavation for Culverts and Miscellaneous Structures" in these General Specifications.

6.04.5.2 Irrigation Pipe. Irrigation Pipe shall be measured by the linear meter of each type and size for all Work authorized, completed and accepted by the Engineer. Measurements shall be continuous along the longitudinal axis of each installation. No separate measurement will be made for fittings and hardware required explicitly or implicitly by the plans or Special Specifications. The furnishing and installation of these items shall be a subsidiary obligation of the Contractor. Excavation, bedding, and backfilling will not be measured and shall also be subsidiary obligation of the Contractor.

6.04.6 PAYMENT. The amount of authorized, completed and accepted Work as measured above will be paid at the contract unit price per linear meter for each type and size of Pipe Underdrain and Irrigation Pipe as they appear in the Bill of Quantities, which price shall include all required materials, equipment, tools, labor, and all other items necessary for the proper completion of the Work as specified in Subsection 1.07.2, "Scope of Payment" in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
60401	Plastic Pipe Underdrain, 100 mm diameter	Linear Meter
60402	Plastic Pipe Underdrain, 150 mm diameter	Linear Meter
60403	Plastic Piper Underdrain, 200 mm diameter	Linear Meter
60404	Plastic Pipe Underdrain, 250 mm. diameter	Linear Meter
60405	Plastic Piper Underdrain, 300 mm diameter	Linear Meter
60406	Plastic Piper Underdrain, ___ mm diameter	Linear Meter
60413	Steel Coated Pipe Underdrain, 100 mm diameter	Linear Meter
60414	Steel Coated Pipe Underdrain, 150 mm diameter	Linear Meter
60415	Steel Coated Pipe Underdrain, 200 mm diameter	Linear Meter
60416	Steel Coated Pipe Underdrain, 250 mm diameter	Linear Meter
60417	Steel Coated Pipe Underdrain, 300 mm diameter	Linear Meter
60418	Steel Coated Pipe Underdrain, ___ mm diameter	Linear Meter
60423	(Type) Underdrain, 100 mm diameter	Linear Meter

60424	(Type) Underdrain, 150 mm diameter	Linear Meter
60425	(Type) Underdrain, 200 mm diameter	Linear Meter
60426	(Type) Underdrain, 250 mm diameter	Linear Meter
60427	(Type) Underdrain, 300 mm diameter	Linear Meter
60428	(Type) Underdrain, ___ mm diameter	Linear Meter
60431	Plastic Irrigation Pipe, 300 mm diameter	Linear Meter
60432	Plastic Irrigation Pipe, ___ mm diameter	Linear Meter
60441	Steel Irrigation Pipe, 300 mm diameter	Linear Meter
60442	Steel Irrigation Pipe, ___ mm diameter	Linear Meter

SECTION 6.05 - STORM SEWERS

6.05.1 DESCRIPTION. This Works shall consist of the construction of "Storm Sewers" for the removal of water from collection points in accordance with these specifications and in conformity with the lines and grades shown on the plans or established by the Engineer.

ITEMS IN BILL OF QUANTITIES
Asbestos Cement Storm Sewer
PVC Storm Sewer Pipe
Reinforced Concrete Storm Sewer

6.05.2 TYPES OF PIPE FOR STORM SEWERS. Reinforced concrete, asbestos cement or PVC may be furnished for Storm Sewers, unless otherwise shown on the plans or in the Bill of Quantities.

6.05.3 REINFORCED CONCRETE BOX STORM SEWER. Reinforced concrete box storm sewer shall be constructed in place to conform to the location and dimensions shown on the plans and in accordance with the requirements of Sections 5.01 "Portland Cement Concrete," 5.03 "Concrete Structures," and 5.02 "Reinforcing Steel" in these General Specifications.

6.05.4 MATERIALS. Materials shall conform to the requirements of Sections 5.01 "Portland Cement Concrete," 5.02 "Reinforcing Steel" in these General Specifications.

6.05.4.1 Asbestos-Cement Pipes. All asbestos-cement pipes and fittings for storm water systems shall be made from sulphate resistant cement and shall be to BS 3656: 1973.

The pipes and asbestos cement fittings shall be given a double coat internally and externally or a bituminous solution at the place of manufacture.

Unless otherwise specified or ordered, the pipes shall be provided with approved flexible joints.

A crushing test shall be carried out on one percent (1%) of the total number of pipes, asbestos cement fittings and collars.

6.05.4.2 PVC Pipe. Pipes of synthetic materials for general drainage use shall be approved pipes of polythene, polypropylene, or polyvinylchloride. Unplasticised polyvinylchloride pipes shall conform to the requirements of Class 2 or 3 ASTM D3033 or BS 3506.

6.05.4.3 Granular Material for Pipe Bedding and Backfilling. Granular material for pipe bedding and backfilling shall be as specified in Section 2.10, "Trench Excavation and Backfill" in these General Specifications.

Flexible Joints in Concrete Beds, and Surrounds to Pipes shall be formed with suitable compressible fibrous board, or similar approved material, of a thickness of twenty (20) millimeters, unless otherwise specified or ordered.

6.05.4.4 Bitumen Emulsion. Bitumen emulsion shall be as provided for in Section 4.01, "Bituminous Materials" in these General Specifications and shall contain not less than fifty-three percent (53%) of prime bitumen.

6.05.5 CONSTRUCTION REQUIREMENTS.

6.05.5.1 Handling of Pipes. At every point of loading and unloading, pipes must be handled by approved lifting tackle. Unloading by rolling down planks or any other form of inclined ramp will not be allowed without the written approval of the Engineer.

6.05.5.2 Pipe Storm Sewer Requirements.

6.05.5.2.1 Excavation. The trench shall be excavated beginning at the outlet end and proceeding toward the upper end, true to line and grade shown on the plans or as established by the Engineer. The width of the trench shall be sufficient to lay and backfill the pipe satisfactorily but in no case shall be less than the external diameter of the pipe plus fifteen (15) centimeters on each side. When ordered by the Engineer, the trench shall be shored or sheeted to insure safe and satisfactory construction and backfilling. If tunneling under a railroad or existing street or highway is required, it shall be done using methods which will insure that the railroad, street, or highway is undisturbed during and after the construction and such methods shall be approved by the Engineer before Work is begun. If it is necessary to remove an existing street or highway surface in constructing the sewer, the surface shall be reconstructed with fully equivalent material as approved by the Engineer and at the expense of the Contractor unless provision for the removal and reconstruction is otherwise provided on the plans, or in the Bill of Quantities.

The foundation in the trench shall be so formed as to prevent subsequent settlement and must be approved by the engineer. If the foundation is in rock, an equalizing bed of well-compacted sand or other approved material at least fifteen (15) centimeters in thickness shall be placed upon the rock. If the foundation is in good firm earth, in the opinion of the engineer, the earth shall be pared or molded to give full support to each pipe for a depth at least equal to one-fourth (¼)the external diameter of round pipe, or ten percent (10%) of the overall height of arch pipe, notches being cut to receive the bell (when bell and spigot pipe is used). If the excavation has been made deeper than necessary, proper bearing shall be secured by means of a layer of sand or other suitable material, approved by the Engineer.

When indicated on the plans, or if ordered in writing by the Engineer, in order to provide a suitable foundation for the pipe, a concrete cradle or encasement shall be placed under or around the pipe. The dimensions and class of the concrete shall be as indicated on the plans or ordered by the Engineer.

Pipe trenches shall only be bottomed up immediately in advance of pipe laying but no pipes shall be laid until a distance of at least ten (10) meters along the trench has been prepared to receive the pipes, unless specially permitted otherwise by the Engineer. The trenches and joint holes shall be kept free from water until the pipes are laid, jointed and where specified surrounded with concrete.

Water from the trenches shall not be allowed to enter the pipes after jointing, and backfilling shall not commence until the pipe joints have been inspected by the Engineer.

Where the pipes are to be laid in rock cutting, the excavation shall be taken down to one hundred fifty (150) millimeters of granular bedding materials or with one hundred fifty (150) millimeters of Class A concrete as directed by the Engineer.

6.05.5.2.2 Laying. The laying of pipes in finished trenches shall be started at the outlet end so that the spigot ends (when bell and spigot pipe is used) point to the direction of flow. All pipes shall be laid with ends abutting and true to line and grade. They shall be laid in the beds so that the lower portion of each pipe is supported for its entire length to a depth at least equal to one-fourth (¼) the external diameter of round pipe, or ten percent (10%) of the overall height of arch pipe. They shall be fitted and matched so that when laid in the trench, they will form a sewer with a smooth, uniform invert. Bell ends (when bell and spigot pipe is used) shall be carefully cleaned before pipes are lowered into the trenches. Pipes shall be lowered in an approved manner so as to avoid unnecessary handling in the trench.

For pipe lines laid inside trenches, the permissible tolerance in line and level shall be determined by the Engineer, but unless otherwise specified or determined, shall be six (6) millimeter in level and twenty-five millimeters in line between manholes or other access points.

Asbestos-cement and reinforced concrete pipes shall have watertight and flexible joints sealed with approved rubber ring or flexible gasket, which shall be stored until needed in a cool place far from direct sunlight. Joints shall have a gap between the end of the spigot and the base of the bell of not less than six (6) millimeters and not greater than twenty (20) millimeters, this being achieved by approved positive means such as removable metal feelers or hardwood wedges.

Synthetic or rubber joint rings, shall be stored until needed in a cool place free from direct sunlight and protected from frost.

Joints of all other types of pipe shall be cemented with a cement mortar composed of one (1) part Portland cement and three (3) parts of fine aggregate mixed with sufficient water to form a plastic mortar. As each section of pipe is laid, the bell or hub of the preceding pipe shall be wetter and cleaned and the bottom portion filled with mortar. After the pipe is placed, the remaining portion of the joint shall be filled. The inside of the joint shall be finished smooth and wiped clean. The mortar on the outside shall, after its initial set, be protected from the sun with moist earth or other covering approved by the engineer.

Plastic joint compound may be used in lieu of the Portland cement mortar. If plastic joint compound is used, it shall be prepared and applied in accordance with the manufacturer's recommendations.

Where pipes are to be laid on solid ground, holes shall be cut in the bottom of the trench of such size and depth as to allow the joints to be properly made and for the barrel of the pipe to bear evenly on solid ground for its full length.

Granular material for pipe bedding shall be placed over the full width of the trench bottom in successive uniform layers not exceeding one hundred fifty (150) millimeters. Each layer shall be lightly compacted to give the following minimum bed thickness:

- Pipes not exceeding three hundred (300) millimeters ID - one hundred fifty (150) millimeter bed thickness [minimum one hundred (100) under sockets].

- Pipes exceeding three hundred (300) millimeters but not exceeding five hundred (500) ID - two hundred (200) millimeters minimum bed thickness.

- Pipes exceeding five hundred (500) millimeters but not exceeding seven hundred fifty (750) millimeters ID - two hundred fifty (250) millimeters minimum bed thickness.

- Socket holes shall be formed into the compacted material and the bedding graded so that pipe barrels bear evenly on the bed for their full length.

- Any leveling pegs shall be removed as pipe laying proceeds.

6.05.5.2.3 Backfilling. Granular material of the same type as that used for pipe bedding shall be carefully placed and thoroughly compacted above the bedding material in successive uniform layers and on both sides of the pipes simultaneously and over the top of the pipe as specified in Section 2.10, "Trench Excavation and Backfill" in these General Specifications.

Properly fitted temporary wooden stoppers shall be provided and constantly used to close the ends of all uncompleted pipe lines. The stoppers are only to be removed when pipes are being laid and jointed.

6.05.5.2.4 Cleaning and Inspecting of Storm Sewer Pipes. After backfilling pipe trenches and completing manholes, hatch boxes, etc., and before the trench surfaces are permanently reinstated, the interior of the pipelines shall be cleaned of silt and debris for inspection by the Engineer.

Pipelines of six hundred seventy-five (675) millimeters or more diameter will where practicable be inspected from the inside and where necessary the Contractor shall provide a suitable trolley for this purpose.

Where pipelines are less than six hundred seventy-five (675) millimeters diameter and where larger pipelines for special reasons cannot be inspected from the inside, a loose plug in the form of a cylinder of diameter twenty-five (25) millimeter smaller and of length not less than the internal diameter of the pipe shall be passed through each pipeline.

If required by the Engineer, a similar inspection will be repeated immediately before a certificate of completion is issued which includes that part of the Works.

On completion of work, or earlier if agreed by the Engineer, all drains and pipes shall be flushed from end to end with water and left clean and free from obstructions.

6.05.5.2.5 Testing of Pipelines Generally. Testing of pipelines shall in all cases be applied in the presence of the Engineer's Representatives. The Contractor shall provide complete plant and all struts, thrust blocks, etc., as may be necessary for effectively testing the pipelines to the specified pressures.

Should a test fail the Contractor shall at his own cost replace defective pipes or make good leaking joints, or otherwise re-execute defective work and cleaning, inspection and testing shall then be repeated. Payment will be made only for satisfactory tests.

6.05.5.2.6 Testing on Non-Pressure Pipelines. As soon as a length of pipe has been laid and before backfilling, it shall be subjected to the following Preliminary Test: air shall be pumped into the pipeline by suitable means until a pressure of one hundred (100) millimeter head of water is indicated on a water manometer and the test will not be considered satisfactory if the air pressure falls to less than seventy-five millimeters during a period of five (5) minutes.

Pipes shall be given a Final Test after they have been backfilled, cleaned and inspected. For the Final Test the pipeline shall be filled with water in a manner approved by the Engineer to a level one and one-quarter (1.25) millimeters above the highest point of that part of the pipeline under test. After standing for thirty (30) minutes the water shall be topped up if necessary and the test will not be considered satisfactory if the loss of water in the next sixty minutes exceeds seven and one-half (7.5) liters per thirty (30) meters of length per meter of diameter of the pipeline under test.

6.05.5.3 Reinforced Concrete Box Storm Sewer. Reinforced concrete box storm sewer shall be constructed of the class of concrete designated on the plans and Work shall conform to the requirements of Sections 5.01 "Portland Cement Concrete," 5.03 "Concrete Structures," and 5.02 "Reinforcing Steel," in these General Specifications.

Excavation and backfilling of reinforced concrete box storm sewer shall conform to the requirements of Section 2.09, "Structural Excavation and Backfill" in these General Specifications.

6.05.6 QUALITY ASSURANCE PROCEDURES. The storm sewers will be inspected, sampled, tested and evaluated in accordance with Section 1.08, "Acceptance of Work" in these General Specifications as follows:

The materials incorporated into the storm sewers shall be sampled, tested and evaluated in accordance with the specifications and test methods referenced in Subsection 6.05.2, "Materials" in these General Specifications. The installation of the storm sewers will be accepted in accordance with Subsection 1.08.4, "Measured or Tested Conformance" in these General Specifications.

6.05.7 METHOD OF MEASUREMENT.

6.05.7.1 Storm Sewer Pipes. Storm Sewer Pipes shall be measured by the linear meter of the various sizes and types of storm sewer pipe regardless of the depth to which they are to be laid. Measurements shall be along the centerline of the pipe complete in place from end of pipe to the inside face of walls of catchbasins, manholes, inlets, sumps, or from the inside face to inside face of walls of such structures, as the case may be.

No measurement shall be made for the excavation and preparation of trenches, the provision and installation of concrete bedding, cradles or surrounds and granular pipe bedding and for the backfilling and recompaction of trenches, all such work will be considered subsidiary to the appropriate storm sewer pipe item in the Bill of Quantities.

No measurement shall be made for breaking into existing pipes and manholes and making good afterwards as approved by the Engineer, but shall be considered subsidiary to the laying of the pipe.

6.05.7.2 Reinforced Concrete Box Storm Sewer. The quantities of the various items that constitute the completed and accepted structure shall be measured for payment. Only accepted Work shall be included and the dimensions shall be those shown on the plans or ordered in writing by the Engineer.

Concrete and reinforcing steel shall be measured as provided in Section 5.01, "Concrete Structures" and Section 5.02, "Reinforcing Steel" in these General Specifications.

Structural excavation shall be measured for payment as specified in Section 2.09, "Structural Excavation and Backfil" in these General Specifications.

6.05.7.3 Unauthorized Work. No measure shall be made of unauthorized Work as specified in Part One, "General" in these General Specifications.

6.05.8 PAYMENT. The amount of completed and accepted Work, measured as provided above, will be paid for at the contract unit price(s) per linear meter in the Bill of Quantities for storm sewer pipe of the various sizes and types, which prices shall be full compensation for all excavation, trimming and preparation of trenches, including any shoring or sheeting and other work required to deal with problems related to the high

water table, for the provision and installation of concrete or granular bedding, cradles or surround and for the laying, jointing and testing of the storm sewer pipes, including connections to existing pipes, manholes, chambers and headwalls, for the backfilling, recompaction, disposal of surplus materials, reinstatement of trenches and for all labor, equipment, tools and all other items necessary for the proper completion of the Work as specified in Subsection 1.07.2, "Scope of Payment"in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
60501	Asbestos Cement Storm Sewer, 300 mm dia	Linear Meter
60502	Asbestos Cement Storm Sewer, 400 mm dia	Linear Meter
60503	Asbestos Cement Storm Sewer, 500 mm dia	Linear Meter
60504	Asbestos Cement Storm Sewer, 600 mm dia	Linear Meter
60505	Asbestos Cement Storm Sewer, 750 mm dia	Linear Meter
60506	Asbestos Cement Storm Sewer, 900 mm dia	Linear Meter
60507	Asbestos Cement Storm Sewer, 1000 mm dia	Linear Meter
60508	Asbestos Cement Storm Sewer, 1200 mm dia	Linear Meter
60509	Asbestos Cement Storm Sewer, ___ mm dia	Linear Meter
60513	PVC Storm Sewer Pipe, 300 mm dia	Linear Meter
60514	PVC Storm Sewer Pipe, 400 mm dia	Linear Meter
60515	PVC Storm Sewer Pipe, 500 mm dia	Linear Meter
60516	PVC Storm Sewer Pipe, 600 mm dia	Linear Meter
60517	PVC Storm Sewer Pipe, 750 mm dia	Linear Meter
60518	PVC Storm Seer Pipe, 900 mm dia	Linear Meter
60519	PVC Storm Sewer Pipe, 1000 mm dia	Linear Meter
60520	PVC Storm Sewer Pipe, 1200 mm dia	Linear Meter
60521	PVC Storm Sewer Pipe, ___ mm dia	Linear Meter
60525	Reinforced Concrete Storm Sewer, 300 mm dia	Linear Meter
60526	Reinforced Concrete Storm Sewer, 400 mm dia	Linear Meter
60527	Reinforced Concrete Storm Sewer, 500 mm dia	Linear Meter
60528	Reinforced Concrete Storm Sewer, 600 mm dia	Linear Meter
60529	Reinforced Concrete Storm Sewer, 750 mm dia	Linear Meter
60530	Reinforced Concrete Storm Sewer, 900 mm dia	Linear Meter
60531	Reinforced Concrete Storm Sewer, 1000 mm dia	Linear Meter

60532	Reinforced Concrete Storm Sewer, 1200 mm dia	Linear Meter
60533	Reinforced Concrete Storm Sewer, ___ mm dia	Linear Meter
60536	(Type), Storm Sewer, 300 mm dia	Linear Meter
60537	(Type), Storm Sewer, 400 mm dia	Linear Meter
60538	(Type), Storm Sewer, 500 mm dia	Linear Meter
60539	(Type), Storm Sewer, 600 mm dia	Linear Meter
60540	(Type), Storm Sewer, 750 mm dia	Linear Meter
60541	(Type), Storm Sewer, 900 mm dia	Linear Meter
60542	(Type), Storm Sewer, 1000 mm dia	Linear Meter
60543	(Type), Storm Sewer, 1200 mm dia	Linear Meter
60544	(Type), Storm Sewer, ___ mm dia	Linear Meter

SECTION 6.06 - RIPRAP AND SLOPE PROTECTION

6.06.1 DESCRIPTION. This Work shall consist of the placement of riprap, concrete, gabions, wire mesh, or other forms of protection on slopes at the locations shown on the plans, or as ordered by the Engineer, in accordance with the specifications and in conformity with the lines, grades, thickness and typical cross sections shown on the plans or established by the Engineer.

ITEMS IN BILL OF QUANTITIES
Loose Stone Riprap
Grouted Stone, Riprap
Sacked Concrete Revetment
Gabions
Reinforced Concrete Slope Protection
Wire Mesh Slope Protection
Paving Tile Slope Protection
Wire Enclosed Riprap Slope Protection

6.06.2 MATERIALS.

6.06.2.1 Stone for Riprap. Stone for grouted and loose riprap shall be hard, sound and durable, furnished in broad flat shapes to the maximum extent practicable. Samples of the stone to be used shall be submitted to and approved by the Engineer before any stone is placed.

The minimum apparent specific gravity shall be two and five tenths (2.5) and the maximum absorption shall be six (6) percent when tested in accordance with MRDTM 304. The stone shall not have an abrasion loss greater than forty-five (45) percent when tested in accordance with MRDTM 309.

The weight of stone for the various classes of riprap shall be as follows:

TABLE 6.06-1

Size of Stone (Kilograms)				Percent of the Total Weight Smaller than Size Shown
Class A	Class B	Class C	Class D	
50	200	1,000	5,000	95-100
20	100	500	2,000	50-100
5	20	100	500	0-50
1	5	20	100	0-10

Stone for "Loose Stone Riprap" shall be quarried, fractured, or otherwise predominantly angular. Stone for other riprap and gabions may be rounded (boulders) or angular.

6.06.2.2 Grout. Grout for "Grouted Stone Riprap" shall conform to Subparagraph 5.01.3.1.2, "Mortar" in these General Specifications.

6.06.2.3 Concrete. Concrete for "Sacked Concrete Revetment" shall conform to Subsection 5.03.9, "Concrete for Minor Structures" in these General Specifications except that aggregates may be produced in and batched from a single stockpile and the minimum cement content shall be five and one-half (5½) sacks per cubic meter.

Concrete for "Reinforced Concrete Slope Protection" shall conform to Class A in Section 5.01, "Portland Cement Concrete" in these General Specifications.

6.06.2.4 Sacks. Sacks for "Sacked Concrete Revetment" shall be of minimum two hundred (200) grams per square meter burlap. They shall be approximately six hundred (600) millimeters by nine hundred (900) millimeters measured when empty. Relatively clean reclaimed sacks may be used if approved by the Engineer.

6.06.2.5 Gabions. Gabion baskets shall be constructed of galvanized steel wire mesh conforming to ASTM A 390, Class 3, and the requirement shown on the plans. The wire mesh shall be twisted to form hexagonal openings of uniform size. The maximum nominal opening size shall be one hundred (100) millimeters. The mesh shall be constructed so as to resist pulling apart at any of the twists or connections forming the mesh when a single wire strand in a section is cut.

Baskets shall be supplied in one or more of the sizes shown on the plans so as to be assembled forming the minimum dimensions, stability, and structural integrity of the type of installation specified.

Baskets shall be fabricated in such a manner that the sides, ends, lid (except for gabion blankets), and diaphragms can be assembled at the construction site into rectangular baskets of the specified sizes. Gabion baskets shall be of single unit construction-base, lid, ends, and sides shall be either woven into a single unit or one edge of these members connected to the base section of the gabion in such a manner that strength and flexibility at the point of connection is at least equal to that of the mesh.

All perimeter edges of the mesh forming the basket shall be securely clip bound or selvedged so that the joints formed by tying the selvedges have at least the same strength as the body of the mesh.

Perimeter (edge), tie, and connection wires shall conform to ASTM A 641, Class 3, Medium Temper, and the minimum diameters shown on the plans.

Alternate equivalent designs of gabion baskets may be submitted to the Engineer for approval.

Riprap fill material for gabions shall be Class A as shown in Table 6.06-1.

6.06.2.6 Reinforcing Steel. Reinforcing steel for "Reinforced Concrete Slope Protection" shall conform to Subsection 5.02, "Reinforcing Steel" in these General Specifications.

6.06.2.7 Wire Mesh Slope Protection. Wire mesh for "Wire Mesh Slope Protection" shall be chain-link fence fabric conforming to ASTM A 491 or ASTM A 392. Minimum wire size shall be four and eight tenths (4.8) millimeter diameter (6 AWG).

Galvanized wire rope shall conform to ASTM A 603 and shall be the size shown on the plans.

Rock bolts, fasteners, and hardware shall be galvanized and conform to the requirements shown on the plans.

6.06.2.8 Wire Enclosed Riprap Slope Protection. Wire fabric shall meet the requirements of ASTM A 116, Class 2, minimum four (4) millimeters diameters (No. 8 AWG). Tie wires shall conform to ASTM A 641, Class 3, soft or medium temper, minimum four (4) millimeters diameter.

Piles, deadmen, and other hardware shall conform to the requirements shown on the plans.

Riprap for "Wire Enclosed Riprap" shall be Class A as shown in Table 6.06-1.

6.06.2.9 Geotextile Fabric. Geotextile Fabric shall be a woven or nonwoven geotextile meeting the following requirements of Section 6.16, "Geotextile Construction" in these General Specifications for Type 1 Fabric-Geotextile for Slope Protection and Channel Lining.

6.06.2.10 Joint Filler. Preformed joint filler shall conform to the requirements of AASHTO M 33. Hot-poured joint filler shall conform to AASHTO M 282.

6.06.3 CONSTRUCTION REQUIREMENTS. The bed upon which the riprap or slope protection is to be placed shall be excavated to the required grades and lines as shown on the plans or as directed and approved by the Engineer. A footing trench shall be excavated along the toe of the slope as shown on the plans or as directed by the Engineer. All footing trenches and excavations shall be approved by the Engineer prior to placement of stones or concrete. Subgrade or base should be firm or compacted as approved by the Engineer. Stones shall be placed so as to provide a minimum number of voids; larger stones shall be placed in the footing trench and on the outside surface of the slope.

6.06.3.1 Loose Riprap. The loose riprap shall be placed by dumping and spreading in layers by a mechanical device or other methods approved by the Engineer, all to secure a stable mass. After the completion and approval of the riprap placement, the surface voids of the riprap in the footing trench and on the lower portions of the slope shall be filled with excavated material and dressed to the satisfaction of the Engineer.

6.06.3.2 Grouted Riprap. Riprap shall be arranged in such a way that the largest rocks are at the bottom of the slope. The surfaces of the rock shall be cleaned of adhering dirt and clay.

The space between stones of grouted riprap shall be filled with concrete mortar. After riprap placement, the grout shall be vibrated, spaded, and rodded into place until the voids are completely filled to a minimum depth of five hundred (500) millimeters from the face of the riprap. Excess material and spillage shall be cleaned from the front face of the riprap before hardening. The exposed mortar shall, immediately after completion of a section of riprap, be cured using clear curing compound in accordance with Subparagraph 5.03.4.10.1, "Membrane Curing" in these General Specifications.

6.06.3.3 Sacked Concrete Revetment. After the slopes have been prepared as shown on the plans, and have been approved by the Engineer, the sacked concrete riprap shall be placed thereon. The sacks shall be filled with concrete loosely placed so as to leave room for tying and sewing. Approximately thirty-five thousandths (0.035) cubic meter of concrete shall be placed in each sack. The sacks shall be closed by sewing tied with strong twine. Immediately after closing, the sacks shall be placed and trampled lightly to cause them to conform to the earth surface and the adjacent sacks already in place. The sacks shall be laid in accordance with the details shown in the plans. All dirt and debris shall be removed from the top of the sacks before the next course is laid. Sacks shall be placed so that the tied ends will not be adjacent to one another. No more than six (6) courses of sacks shall be placed in any tier until initial set in the first course of any such tier has taken place.

In placing sacks that are filled with concrete, care in shaping the sacks shall be exercised, to the end that the minimum dimensions shown on the plans will be obtained, and also that the finished sacked concrete revetment will have a minimum of voids.

6.06.3.4 Gabions. Each gabion unit shall be assembled by binding together all vertical edges with wire ties on approximately one hundred fifty (150) millimeter spacing or by a continuous piece of connecting wire stitched around the vertical edges with a coil about every one hundred (100) millimeters. Empty gabion units shall be set to line and grade as shown on the plans or as directed by the Engineer. Wire ties or connecting wire shall be used to join the units together in the same manner as described above for assembling. Internal tie wires shall be uniformly spaced and securely fastened in each cell of the structure.

Assembly details of gabions shall be as specified in the HDM, Volume 4, Standard Drawings SP-4 through SP-7.

Where the length of the gabion exceeds its horizontal width the gabion shall be equally divided by diaphragms, of the same mesh and gauge as the body of the gabions, into cells whose length does not exceed the horizontal width. The gabion shall be furnished with the necessary diaphragms secured in proper position on the base section in such a manner that no additional tying at this juncture will be necessary.

The last lift of stone in each cell shall be level with the top of the gabion in order to properly close the lid and provide and even surface for the next course.

All gabion units shall be tied together each to its neighbor along all contacting edges in order to form a continuous connecting structure. Empty gabions stacked on filled gabions shall be laced to the filled gabion at the front, side and back.

A standard fence stretcher, chain fall, or iron rod may be used to stretch the wire baskets and hold alignment.

The gabions shall be filled with stone carefully placed by hand or machine to assure alignment and avoid bulges with a minimum of voids. Alternate placing of rock and connection wires shall be performed until the gabion is filled. After a gabion has been filled, the lid shall be bent over until it meets the sides and edges. The lid shall then be secured to the sides, ends, and diaphragms with the wire ties or connecting wire in the manner described above for assembling.

6.06.3.5 Reinforced Concrete Slope Protection.

6.06.3.5.1 Surface Preparation. Slopes to be protected shall be compacted and finished to grade prior to the installation of reinforcing steel, bulkheads, and joint material. The Contractor shall furnish screed rails or other grade indicating devices to control the minimum depth of concrete and uniformity of the top surface.

6.06.3.5.2 Reinforcing Steel and Joints. Reinforcing steel shall be supported firmly so as not to be subject to displacement during construction. Joints shall be laid out or referenced accurately. Construction joints shall be placed at designated contraction joints, except they shall be expansion type whenever constructed more than five (5) meters from a free edge or another expansion joint.

6.06.3.5.3 Concrete Placement. Concrete shall be placed and finished in accordance with the requirements of Section 5.03, "Concrete Structures" in these General Specifications. The Contractor may select a uniform floated or broomed finish approved by the Engineer. Joint blockouts for poured joint filler may be formed in place or inserted in the fresh concrete.

6.06.3.5.4 Curing. Concrete shall be cured in accordance with the requirements of Paragraph 5.03.4.10, "Curing and Protection" in these General Specifications using membrane or water curing.

6.06.3.6 Wire Mesh Slope Protection. Wire Mesh Slope Protection shall be installed in accordance with the typical details shown on the plans, and at locations shown on the plans or ordered by the Engineer.

In particular, wire mesh slope protection shall be placed as shown in the HDM, Volume 4, Standard Drawing SP-1, depending on the slope, its nature, and to the sizes of loose boulders, if any.

Wire mesh shall be folded onto itself for thirty (30) centimeters minimum, and firmly anchored on the tope of the slope. Anchors may be expansion bolts or reinforcing bars, driven or bonded to the slope with non-shrink grout or encased in concrete. Type, size, length and spacing of anchors and anchor rods shall be as shown on the plans.

Before laying the wire mesh, all loose rock and boulders shall be removed and disposed of as approved. The cable grid shall be laid, the wire mesh sheets shall be rolled down the slope, secured to the cables, and laced together using galvanized steel wire two gauges heavier than that used in the main body of the mesh. Where overlapping occurs, the sheets shall be overlapped without cuts.

Where shown on the plans or directed by the Engineer, wire mesh shall be anchored to the slope, using one anchor every fifteen (15) square meters of mesh. The toe of the slope protection shall be anchored or left loose, as shown or as directed.

6.06.3.7 Paving Tile Slope Protection. Paving Tile Slope Protection shall be installed in accordance with the Plan details and as detailed in Paragraph 6.12.3.2 "Precast Tiled Sidewalks" in these General Specifications.

6.06.3.8 Wire Enclosed Riprap Slope Protection. Wire Enclosed Riprap Slope Protection shall be constructed in accordance with the typical details shown on the plans, and at locations shown on the plans or ordered by the Engineer.

6.06.3.9 Geotextile Fabric. Geotextile Fabric shall be furnished and installed, when required, by the typical details shown on the plans and as detailed in Section 6.16, "Geotextiles" in these General Specifications for Type I Fabric-Geotextile for Slope Protection and Channel Lining.

6.06.4 QUALITY ASSURANCE PROCEDURES. The riprap and slope protection will be inspected, sampled, tested and evaluated in accordance with Section 1.08, "Acceptance of Work" in these General Specifications as follows:

The materials incorporated into the riprap and slope protection shall be sampled, tested and evaluated in accordance with the specifications and test methods referenced in Subsection 6.06.2, "Materials" in these General Specifications. The installation of the riprap and slope protection will be accepted in accordance with Subsection 1.08.4, "Measured or Tested Conformance" in these General Specifications.

6.06.5 METHOD OF MEASUREMENT. Loose Stone Riprap, Grouted Stone Riprap, Sacked Concrete Revetment, Gabions, and Wire Enclosed Riprap Slope Protection shall be measured by the cubic meter based on the dimensions shown on the plans or ordered in writing by the Engineer, for all quantities authorized, constructed and accepted by the Engineer.

Reinforced Concrete Slope Protection, Wire Mesh Slope Protection and Paving Tile Slope Protection, Geotextile Fabric (if included in the Bill of Quantities) will be measured by the square meter based on the dimensions shown on the plans or ordered in writing by the Engineer, for all quantities authorized, constructed, and accepted by the Engineer. When Geotextile Fabric is required by the plans or specifications, but not included in the Bill of Quantities, it shall be considered subsidiary. When it is included in the Bill of Quantities it shall be as specified, measured, and paid for under Section 6.16, "Geotextiles" in these General Specifications. No separate measurement will be made for the anchorage system for Wire Mesh Slope Protection which shall be considered subsidiary to that Item of Work.

Excavation below original ground elevations for riprap and other forms of slope protection shall be measured in accordance with Paragraph 2.03.2.3 "Roadway Excavation - Channel and Ditch" in these General Specifications.

6.06.6 PAYMENT. The amount of completed and accepted Work as measured above will be paid for at the contract unit price(s) specified in the Bill of Quantities which price(s) shall be full compensation for furnishing all materials, for all labor, equipment, tools, supplies, and all other items necessary for the proper completion of the Work as specified in Subsection 1.07.2, "Scope of Payment" in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
60601	Loose Stone Riprap	Cubic Meter
6060101	Loose Stone Riprap, Class A	Cubic Meter
6060102	Loose Stone Riprap, Class B	Cubic Meter
6060103	Loose Stone Riprap, Class C	Cubic Meter
6060104	Loose Stone Riprap, Class D	Cubic Meter
6060105	Loose Stone Riprap, Class ___	Cubic Meter
60602	Grouted Stone Riprap	Cubic Meter
6060201	Grouted Stone Riprap, Class A	Cubic Meter
6060202	Grouted Stone Riprap, Class B	Cubic Meter
6060203	Grouted Stone Riprap, Class C	Cubic Meter
6060204	Grouted Stone Riprap, Class D	Cubic Meter
6060205	Grouted Stone Riprap, Class ___	Cubic Meter
60603	Sacked Concrete Revetment	Cubic Meter
60604	Gabions	Cubic Meter
60605	R.C. Slope Protection	Square Meter

60606	**Wire Mesh Slope Protection**	**Square Meter**
60607	**Paving Tile Slope Protection**	**Square Meter**
60608	**Wire Enclosed Riprap Slope Protection**	**Cubic Meter**

SECTION 6.07 - DITCH LININGS, WASH CHECKS, AND SLOPE DRAINS

6.07.1 DESCRIPTION. This Work shall consist of the construction of ditch linings, wash checks, and slope drains, including drainage chutes and waterways, in accordance with the specifications and in conformity with the lines, grades, and cross sections shown on the plans or established by the Engineer.

ITEMS IN BILL OF QUANTITIES
Ditch Lining
Wash Check
Embankment Slope Drain
Cut Slope Drain

6.07.2 MATERIALS. Materials shall conform to the requirements specified in the following sections:

6.07.2.1 Concrete. Concrete for drainage chutes, ditch lining, and wash checks shall conform to Minor Concrete in Subsection 5.03.9, "Concrete for Minor Structures" in these General Specifications.

6.07.2.2 Reinforcing Steel and Steel Mesh. Reinforcing steel and steel mesh shall be as specified in Section 5.02, "Reinforcing Steel" in these General Specifications.

6.07.2.3 Bituminous Mixture. The bituminous mixture for bituminous waterways for embankment slopes shall conform to the requirements for Bituminous Wearing Courses as specified in Section 4.05, "Bituminous Concrete Pavement" in these General Specifications an equivalent mixture, as may be approved by the Engineer. Additional asphalt cement may be required by the Engineer to reduce oxidation and the specified stability requirements will therefore be waived.

6.07.2.4 Riprap. The riprap for use with concrete drainage chute for cut slopes, overside drains, and bituminous waterways for embankment shall be the class shown on the plans and as specified in Section 6.06, "Riprap and Slope Protection" in these General Specifications.

6.07.2.5 Galvanized Sheet Metal. The galvanized sheet metal for the overside drain flume shall be fabricated from two (2) millimeter thick corrugated sheet metal and the tapered inlet assembly shall be fabricated from two (2) millimeter thick smooth sheet metal.

6.07.2.6 Anchor Stakes. The anchor stakes used to attach the overside drain to the slope shall be thirty-eight (38) millimeter galvanized steel pipe.

6.07.2.7 Stone. Stone for grouted stone ditch lining or grouted stone wash checks shall be hard, durable, and from a source approved by the Engineer. The stone shall be quarried or fractured in generally rectangular shapes suitable for laying in the required configurations.

6.07.2.8 Grout. Grout for grouted ditch linings or wash checks shall conform to Subparagraph 5.01.3.1.2, "Mortar" in these General Specifications.

6.07.2.9 Bedding Course. Bedding course material shall conform to the requirements of Subsection 3.02.2, "Materials" for Aggregate Subbase, Grading I or II in these General Specifications.

6.07.3 CONSTRUCTION REQUIREMENTS.

6.07.3.1 Excavation. The subgrade for the ditch linings, wash checks, and slope drains shall be excavated to a smooth surface parallel to the proposed finished surface and to a depth sufficient for the full thickness of the lining, wash checks, or slope drains. Soft, unstable subgrade material shall be removed and replaced with suitable materials approved by the Engineer. The subgrade shall be compacted to Type 95 compaction.

6.07.3.2 Concrete Ditch Linings, Concrete Wash Checks and Concrete Cut Slope Drains.

6.07.3.2.1 Bedding Course. The bedding course, if required by the plans, shall be placed to the minimum specified dimensions in layers not exceeding one hundred fifty (150) millimeters compacted depth and compacted to Type 90 compaction.

6.07.3.2.2 Forms. Forms for concrete ditch linings, concrete wash checks, and cut slope drains shall be full typical section depth constructed of metal, wood, or other suitable material. All forms shall be free from warp, and of sufficient strength to resist the pressure of the concrete without displacement. They shall be securely staked, and supported firmly to the required line and grade.

6.07.3.2.3 Concrete Placement. Concrete shall be placed in accordance with Section 5.03, "Concrete Structures" in these General Specifications. Placement of concrete for ditch linings and slope drains shall begin at the lower end of the portion of the ditch to be lined or slope to be drained and progress toward the upper end. If shown on the plans, the concrete shall be reinforced with the type of reinforcement and in the manner indicated.

The surface shall be finished with a wooden float. Facilities for workmen shall be provided to avoid them walking in the fresh concrete.

6.07.3.2.4 Curing. Immediately after the finishing operations are completed, the concrete shall be protected and cured in conformance with Paragraph 5.03.4.10, "Curing and Protection" in these General Specifications using membrane or water curing.

6.07.3.3 Grouted Riprap Stone Ditch Linings and Wash Checks. Grouted riprap ditch linings and wash checks shall be constructed in accordance with the requirements of Section 6.06, "Riprap and Slope Protection" in these General Specifications.

6.07.3.4 Bituminous Waterways and Slope Drains.

6.07.3.4.1 Bedding Course. The bedding course, if required by the plans, shall be placed to the minimum specified dimensions in layers not exceeding one hundred fifty (150) millimeters compacted depth and compacted to Type 95 compaction.

6.07.3.4.2 Forms. If shown on the plans, forms of a type satisfactory to the Engineer shall be staked securely into position at the correct line and elevation. Other approved equipment and methods may be used.

6.07.3.4.3 Placing Mixture. The mixture shall be placed on the prepared bed only when the bed is sufficiently dry and weather conditions are suitable. The mixture shall be placed in one or more courses of uniform thickness as shown on the plans. Each course shall be smoothed by raking or screeding, and shall be thoroughly compacted by rolling with a hand-operated roller weighing not less than one hundred fifty (150) kilograms, or with a small power roller of a type satisfactory to the Engineer. Areas that cannot be reached with rollers may be compacted with hand tampers. After compaction, the surfacing shall be of nominal thickness and cross section shown on the plans, shall be smooth and even, and of a dense and uniform texture.

6.07.3.5 Metal Slope Drains. The corrugated metal inlet assemblies and flumes and other appurtenances shall be installed in accordance with these specifications and in conformity with the standard drawings, design, grades, and at the locations shown on the plans or as established by the Engineer.

6.07.3.6 Backfilling and Finishing Work. For all ditch linings, wash checks, and slope drains, immediately after placement or curing, the installation shall be backfilled with suitable material and compacted to Type 95 compaction. The adjacent slopes and shoulders shall also be shaped and compacted to the required cross section and to provide a neat appearance to the drainage installation.

6.07.4 QUALITY ASSURANCE PROCEDURES. The ditch linings, wash checks, and slope linings will be inspected, sampled, tested and evaluated in accordance with Section 1.08, "Acceptance of Work" in these General Specifications as follows:

The materials incorporated into the ditch linings, wash checks, and slope linings shall be sampled, tested and evaluated in accordance with the specifications and test methods referenced in Subsection 6.07.2, "Materials" in these General Specifications. The construction of the ditch lining, wash checks and slope drains will be accepted in accordance with Subsection 1.08.4, "Measured or Tested Conformance" in these General Specifications.

6.07.5 METHOD OF MEASUREMENT. Ditch Linings shall be measured by the square meter for all Work authorized, completed and accepted by the Engineer based on the top surface area of each item as shown on the plans or authorized by the Engineer.

Wash Checks, Embankment Slope Drains, and Cut Slope Drains shall be measured by the linear meter for all Work authorized, completed and accepted by the Engineer.

Wash Checks shall be measured perpendicular to the wash along the top surface of the upstream face as shown on the plans. Embankment Drains and Cut Slope Drains shall be measured longitudinally based on the lengths ordered by the Engineer and limits shown on the plans.

There shall be no separate measurement of excavation, backfill bedding course, minor concrete, bituminous concrete, reinforcing steel, steel mesh, stone, riprap, grout and other quantities associated with these items. This Work shall be considered subsidiary to these items.

Loose riprap or grouted riprap required at the outlet ends of ditches and slope drains shall be measured separately in accordance with Subsection 6.06.4, "Method of Measurement" in these General Specifications.

6.07.6 PAYMENT. The amount of completed and accepted Work as measured above will be paid at the contract unit price(s) specified in the Bill of Quantities which price(s) shall be full compensation for furnishing all materials, for all labor, equipment, tools, supplies, and all other items necessary for the proper completion of the Work as specified in Subsection 1.07.2, "Scope of Payment" in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
60701	Ditch Lining	Square Meter
6070101	Concrete Ditch Lining	Square Meter
6070102	Grouted Stone Ditch Lining	Square Meter
6070103	Paving Tile Ditch Lining	Square Meter
6070104	(Type) Ditch Lining	Square Meter
60702	Wash Check	Linear Meter
6070201	Concrete Wash Check	Linear Meter
6070202	Grouted Stone Riprap Wash Check	Linear Meter
6070203	(Type) Wash Check	Linear Meter
60703	Slope Drain	Linear Meter
6070301	Concrete Embankment Slope Drain	Linear Meter
6070302	Bituminous Embankment Slope Drain	Linear Meter
6070303	Metal Embankment Slope Drain	Linear Meter
6070304	Concrete Cut slope Drain	Linear Meter
6070305	Bituminous Cut Slope Drain	Linear Meter
6070306	Metal Cut Slope Drain	Linear Meter

SECTION 6.08 - PIPE CULVERTS

6.08.1 DESCRIPTION. This work shall consist of furnishing and installing circular pipe culverts and elliptical pipe arch culverts. All units shall conform to the dimensions, fabrications, material, and strength requirements for the type, class, size, and shape in accordance with the plans and these specifications. Units shall be bedded and backfilled in accordance with applicable provisions included herein and shall be constructed to the lines and grades shown or established. When specified, concrete headwalls or anchors of the class concrete and dimensions shown shall be constructed on pipe culverts.

Where alternate types of pipe are shown in the contract, any of the alternates may be furnished provided that each continuous line of pipe is constructed of the same throughout. At locations where no alternates are shown, the specified type shall be installed.

ITEMS IN BILL OF QUANTITIES
Reinforced Concrete Pipe Culvert (Precast)
Reinforced Concrete Pipe Culvert (Cast-in-Place)
Reinforced Concrete Arch Culvert (Precast)
Reinforced Concrete Arch Culvert (Cast-in-Place)

6.08.2 MATERIALS.

6.08.2.1 Reinforced Concrete Pipe Culvert (Precast).

6.08.2.1.1 Description. This specification covers reinforced concrete round pipe to be used for culvert construction.

6.08.2.1.2 Requirements. Reinforced concrete round pipe shall meet all applicable requirements of the "Standard Specification for Reinforced Concrete Culvert, Storm Drain and Sewer Pipe," AASHTO M 170. Unless otherwise shown on the plans or in the Special Specifications, Class V pipe shall be furnished.

6.08.2.1.3 Basis of Acceptance. Acceptability of pipe in sizes less than one and eighty-three thousandths (1.083) meters in diameter shall be based on one (1) or more of the following items as may be deemed necessary by the Engineer.

1. The results of three-edge-bearing tests for the load to produce a twenty-five hundredths (0.25) millimeter crack and the ultimate load performed on not less than three percent (3%) of all pipes furnished (AASHO T33).

2. The loading to destruction of selected pieces of pipe to determine ultimate strength, area and placement of steel and absorption characteristics of the concrete (AASHO T33).

3. Absorption tests on selected samples from the wall of the pipe (AASHO T33).

4. By inspection of the finished pipe to determine its conformance with the design prescribed in this specification and its freedom from defects.

5. Crushing tests on concrete cores drilled from the wall of the pipe (AASHO T 33).

6. Absorption tests on concrete cores drilled from the walls of selected pipe (AASHO T 33).

7. By inspection of the finished pipe, including the amount and placement of reinforcement, to determine its conformance with the design prescribed in these specifications and its freedom from defects.

By mutual agreement between the producer and the Engineer, pipe one and eighty-three thousandths (1.083) meters in diameter and larger may be tested by three-edge-bearing to complete destruction to determine area and placement of steel.

6.08.2.1.4 Testing of Precast Reinforced Concrete Pipe. **If the Contractor elects to purchase reinforced concrete culvert pipe from a source off the project, all provisions of the specification shall apply. Pipe not available for testing and inspection during manufacture will be tested on the job site in accordance with the specifications.**

For test purposes, the Contractor shall at his expense, when directed by the Engineer, provide three (3) edge bearing test equipment (CT 230) or CT 230M). The test equipment shall remain on-site until such time as the Engineer releases it. The Contractor shall assist the Engineer in conducting the three-edge-bearing tests as directed by the Engineer.

6.08.2.1.5 End Sections. **Concrete for precast concrete end sections shall conform to the requirements of Class K in Paragraph 5.01.2.1 "Portland Cement Concrete" in these General Specifications. Reinforcing steel shall conform to the requirements of Section 5.02, "Reinforcing Steel" in these General Specifications. Materials for other end sections shall conform to the requirements shown on the plans in these General Specifications and in the Special Specifications.**

6.08.2.1.6 On-Site Fabrication. **If the precast pipe is not supplied by an approved manufacturer of reinforced concrete pipe and the Contractor elects to precast such pipe on site, the Contractor shall, in addition to the requirements specified herein, comply with all of the requirements of Sections 5.01 "Portland Cement Concrete," 5.03 "Concrete Structures" and 5.02 "Reinforcing Steel" in these General Specifications as deemed applicable by the Engineer. Pipe cast on the site shall be as detailed on the plans.**

The curing methods for on-site precast reinforced concrete pipe shall conform to the requirements of Paragraph 5.03.4.10 "Curing and Protection" in these General Specifications.

The acceptability of pipes manufactured on-site shall be determined from results obtained from laboratory cured compressive strength cylinders tested in accordance with AASHTO T22, and conforming to the general requirements for reinforced concrete culvert pipe as state herein.

Pipes represented by test cylinders that fail to meet the strength requirements for Class K concrete, but in no case below eighty percent (80%) of the specified design strength, shall be properly marked, and installed provided that the full length of the culvert in which they are used shall be carefully bedded in a concrete cradle of at least one hundred forty (140) kilograms per square centimeter, twenty-eight (28) day strength, having a minimum thickness under the pipe of one-fourth (¼)of the nominal internal diameter of the culvert pipe and extending up the sides of the pipe to a height equal to one-fourth (¼) the outside diameter of the culvert pipe. The concrete cradle shall extend the full width of the culvert trench unless otherwise directed by the Engineer, but in no case shall it extend, as its narrowest point, less than fifteen (15) centimeters from the outside of the pipe on each side. Concrete cradle bedding installed for the purpose of counter affecting under-strength pipe shall be at the expense of the Contractor. Pipes represented by test cylinders that fail to meet eighty percent (80%) of the specified design strength shall be destroyed and disposed of by the Contractor as directed by the Engineer.

There shall be no less than four (4) test cylinders made for each seventy-five (75) cubic meters of concrete placed or for each day's production, whichever is less.

6.08.2.2 Reinforced Concrete Arch Culvert (Precast).

6.08.2.2.1 Description. These specifications cover precast reinforced concrete arch pipe to be used for culverts.

6.08.2.2.2 Requirements. Pipe furnished under these specifications shall meet all applicable requirements of the "Specifications for Reinforced Concrete Arch Culvert, Storm Drain and Sewer Pipe" (AASHTO M 206). Unless otherwise shown on the plans or specified in the Contract Documents, Class A-IV shall be furnished for culverts up to one and thirty hundredths (1.30) meter times eighty hundredths (.80) meter and Class A-III for larger pipes.

6.08.2.2.3 Basis of Acceptance. Acceptability of pipe in sizes from forty-six hundredths (0.46) meter times twenty-eight hundredths (.28) meter through one and thirty hundredths (1.30) meter by eighty hundredths (.80) meter shall be based on one (1) or more of the following items, as may be deemed necessary by the Engineer.

1. The results of the three-edge bearing tests for the load to produce at twenty-five hundredth (0.25) millimeter crack and the ultimate load performed on not less than three percent (3%) of the pipe furnished (AASHO T 33).

2. The loading to destruction of selected pieces of pipe to determine ultimate strength, area and placement of steel and absorption characteristics of the concrete (AASHO T 33).

3. Absorption tests on selected samples from the wall of the pipe (AASHO T 33).

4. By inspection of the finished pipe to determine its conformance with the design prescribed in this specification and its freedom from defects.

Acceptability of pipe one and forty-nine hundredths (1.49) meter by ninety-one hundredths (.91) meter and larger shall be based on the following items as may be deemed necessary by the Engineer.

5. Crushing tests on concrete cores drilled from the wall of the pipe (AASHO T 33).

6. Absorption tests on concrete cores drilled from the walls of selected pipe (AASHO T 33).

7. By inspection of the finished pipe, including the amount and placement of reinforcement, to determine its conformance with the design prescribed in this specification and its freedom from defects.

By mutual agreement between the producer and the Engineer these sizes of pipe may be tested by three-edge bearing to complete destruction to determine area and placement of steel.

6.08.2.2.4 On-Site Fabrication. If the precast pipe is not supplied by an approved manufacturer of reinforced concrete arch pipe and the Contractor elects to precast such pipe on site, the Contractor shall, in addition to the requirements specified herein, comply with all the requirements of Sections 5.01 "Concrete," Section 5.03 "Concrete Structures" and Section 5.02 "Reinforcing Steel" in these General Specifications. Pipe cast on the site shall be as detailed on the plans.

The curing methods for on-site precast reinforced concrete arch culvert pipe shall conform to the requirements of Paragraph 5.03.4.10 "Curing and Protection" in these General Specifications.

The acceptability of pipes manufactured on-site shall be determined from results obtained from laboratory cured compressive strength cylinders tested in accordance with AASHTO T 22, and conforming to the general requirements for reinforced concrete culvert pipe as stated herein.

Pipes represented by test cylinders that fail to meet the strength requirements for Class K concrete, but in no case below eighty percent (80%) of the specified design strength, shall be properly marked, and installed provided that the full length of the culvert in which they are used shall be carefully bedded in a concrete cradle of at lease one hundred forty (140) kilograms per square centimeter, twenty-eight (28) day strength, having a minimum thickness under the pipe of one-fourth (¼)of the nominal internal span of the culvert pipe and extending up the sides of the pipe to fifteen (15) centimeters above the third (_) radius center. The concrete cradle shall extend the full width of the culvert trench unless otherwise authorized by the Engineer but in no case shall it extend as its narrowest point, less than fifteen (15) centimeters from the outside of the pipe on each side. Concrete cradle bedding installed for the purpose of counter effecting under-strength pipe shall be at the expense of the Contractor. Pipes represented by test cylinders that fail to meet eighty percent (80%) of the specified design strength shall be destroyed and disposed of by the Contractor as directed by the Engineer.

There shall be no less than four (4) test cylinders made for each seventy-five (75) cubic meters of concrete placed or for each day's production, whichever is less.

6.08.2.3 Reinforced Concrete Pipe (Cast-in-Place) and Reinforced Concrete Arch Culvert (Cast-in-Place).

6.08.2.3.1 Description. These specifications cover cast-in reinforced concrete round pipe and cast-in-place reinforced concrete arch pipe to be used for culvert construction.

6.08.2.3.2 Requirements. Cast-in-place reinforced concrete pipes shall be constructed as shown in the standard plans or as otherwise proposed by the Contractor and approved by the Engineer. Any deviation from the approved manner of construction, in the opinion of the Engineer, will be a basis for rejection, and the subsequent removal and reconstruction of the culvert. Cast-in-place pipe culverts shall conform to the requirements of Section 5.01 "Portland Cement Concrete," Section 5.03 "Concrete Structures," Section 5.02 "Reinforcing Steel" in these General Specifications.

6.08.2.3.3 Basis of Acceptance. Acceptability of cast-in place pipe culverts shall be determined from the conformance of the concrete to the requirement specified for Class K concrete, based on results obtained from laboratory-cured compressive strength cylinders tested in accordance with AASHO T22, conforming to the other requirements specified for reinforced concrete culvert pipe as stated herein. There shall be no less than four (4) test cylinders made for each seventy-five (75) cubic meters of concrete placed for each day's pour, whichever it less.

6.08.3 EQUIPMENT. Equipment shall be according to the type and number outlined in the Contractor's detailed Program of Work as approved by the Engineer.

6.08.4 CONSTRUCTION REQUIREMENTS.

6.08.4.1 Excavation and Forming Bed for Pipe. The excavation for pipe culverts shall be performed in accordance with the requirements of Section 2.10, "Trench Excavation and Backfill" in these General Specifications.

6.08.4.2 Laying Pipe.

6.08.4.2.1 General. No pipe culverts shall be placed until the excavations and foundations have been approved by the Engineer. Variations in the laying lengths of two (2) or more pipes forming a multiple culvert shall not exceed (2) centimeters. The laying length of any pipe shall not underrun the theoretical design length by more than two (2) centimeters.

6.08.4.2.2 Precast Concrete Pipe and Pipe Arches. The pipe shall be carefully laid true to lines and grades given, with hub, bell, or groove ends upstream, and with the spigot or tongue end entered the full length into the adjacent section of pipe. If the pipe is to be laid below the ground line, a trench shall be excavated to the required depth and of a width sufficient to permit thorough tamping of the backfill under the haunches and around the pipe. Any pipe which is not in true alignment or which shows any undue settlement after laying, but before the fill is placed, shall be taken up and relaid at the Contractor's expense. When shown on the plans, or as directed by the Engineer, sufficient camber shall be built into the pipe structure to allow for settlement from fill loads. All joints, shall be sealed with an approved cement mortar. Jointing mortar shall be one (1) part Portland cement to two (2) parts of sand, by volume. The quantity of water in the mixture shall be sufficient to produce a still workable mortar, but shall in no case exceed twenty-seven (27) liters per fifty (50) kilogram sack of cement. The sand shall conform to AASHO M 45 and cement shall conform to AASHO M 85. When approved by the Engineer, air entrained Portland cement conforming to AASHO M 134 or and admixture conforming to AASHO M 154 may be used. Rubber gasketed joints when approved by the Engineer, may be used at no additional cost to the Ministry. Where permissible lift holes have been used, the holes shall be carefully filled with an approved expansive mortar to provide a watertight section. The mortar shall be finished flush on the inside of the pipe and shall be properly cured on the outside. Lifting devices shall have sufficient bearing on the inside of the pipe to avoid damage resulting from a concentration of stresses around the lift holes.

6.08.4.2.3 Rubber Gasket Type Pipe. If rubber gasket type pipe is used, the joints shall be Installed in accordance with the manufacturer's recommendations to insure that the gasket has not been displaced.

6.08.4.2.4 Sealing Pipe. In sealing pipe with mortar, the mortar contact areas of all pipe ends shall be clean and damp when mortar is applied. After applying mortar to the entire interior surface of the bell or groove, the spigot or tongue end shall be forced into position. Any remaining void in the bell or groove shall be filled with a bed of mortar built-up around the groove-type joint. The interior joints of the pipe shall be finished flush with the surface of the pipe. Outside surface of mortar joints shall be cured with burlap, kept thoroughly moist for a minimum of three (3) days after the completion of the joint.

Multiple culverts, unless otherwise noted on the plans, shall be laid with one-half (½) span of the pipe, or a minimum of three hundred (300) millimeters, whichever is greater, between the pipes.

6.08.4.2.5 Cast-in-Place Concrete Pipe and Pipe Arches. The pipes shall be constructed in accordance with the details shown on the plans or in an alternate manner,

proposed by the Contractor and approved by the Engineer. The pipe shall be carefully formed true to the lines and grades given.

When the Contractor elects to construct the pipe in a trench with no external vertical forms, four (4) centimeters of additional reinforcing steel clearance shall be provided. No additional payment will be made for the increased quantity of concrete required as it shall be considered subsidiary to the bid items for "Cast-in-Place Reinforced Concrete Pipe and Pipe Arches."

Longitudinal construction joints will only be permitted as shown on the plans. Transverse construction joints will be permitted provided prior written approval is obtained from the Engineer. Continuance of such approval shall be contingent on the construction of the joints in a satisfactory and acceptable manner.

All forms for Cast-in-Place Reinforced Concrete Pipes shall be approved by the Engineer prior to their use. The inside pipe forms shall be of metal suitably stiffened and supported to be unyielding during the placement of the concrete. The face of the forms shall be such to provide a smooth and even interior pipe surface.

Interior arch forms may be removed after forty-eight (48) hours when approved by the Engineer. The Contractor shall use every precaution when removing forms to protect the culvert from damage. Damage caused by the removal for forms shall be immediately repaired by the Contractor at his own expense.

Multiple culverts shall be laid (or constructed) as shown on the plans.

Curing of Cast-in-Place Reinforced Pipe and Arch Culvert shall conform to the requirement of Paragraph 5.03.4.10 "Curing and Protection" in these General Specifications.

6.08.4.2.6 Bedding. The bedding of pipe culverts shall conform to the requirements of Section 2.10, "Trench Excavation and Backfill" in these General Specifications.

Concrete used for bedding, concrete cradles and concrete used to compensate for overdepth or overwidth trench excavation will not be paid for separately, but will be considered subsidiary to the items of pipe culverts appearing in the Bill of Quantities.

6.08.4.2.7 Backfilling. The backfilling of pipe culverts shall conform to the requirements in Section 2.10, "Trench Excavation and Backfill" in these General Specifications.

6.08.5 QUALITY ASSURANCE PROCEDURES. The pipe culverts will be inspected, sampled, tested and evaluated in accordance with Section 1.08, "Acceptance of Work" in these General Specifications as follows:

The materials incorporated into the pipe culverts shall be sampled, tested and evaluated in accordance with the specifications and test methods referenced in

Subsection 6.08.2, "Materials" in these General Specifications. The installation of the pipe culverts will be accepted in accordance with Subsection 1.08.4, "Measured or Tested Conformance" in these General Specifications.

6.08.6 METHOD OF MEASUREMENT. This work shall be measured by the linear meter, to the nearest centimeter, of the various types, classes and sizes of pipe culverts appearing in the Bill of Quantities.

For accepted pipe culverts without headwalls, the measurement shall be taken from end to end along the geometrical center of the pipe. For accepted pipe culverts with headwalls, the measurements, unless otherwise shown on the plans, shall be taken from the inside (roadside) face of parapet (hub-guard) to the inside face of parapet along the geometrical center of the pipe.

No measurement or payment shall be made for pipes ordered removed because of faulty construction.

The quantities of Work and material constituting headwalls which are part of a pipe culvert installation will be measured and paid for as provided in the several Sections involved.

6.08.7 PAYMENT. The amount of completed and accepted pipe culverts, measured as provided above, will be paid for at the contract unit price(s) per linear meter, as specified in the Bill of Quantities for the various types, classes and sizes of pipes, which price (s) shall be full compensation for furnishing and placing all materials, for all labor, structural excavation, removal of old pipes, shoring, draining water, jointing, bedding and all bedding materials, backfill, including concrete backfill, increased cement content, equipment, tools, and all other items necessary for the proper completion of the Work as specified in Section 1.07.2, "Scope of Payment" in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
60801	Reinforced Concrete Pipe Culvert (Precast), 300 mm	Linear Meter
60802	Reinforced Concrete Pipe Culvert (Precast), 400 mm	Linear Meter
60803	Reinforced Concrete Pipe Culvert (Precast), 500 mm	Linear Meter
60804	Reinforced Concrete Pipe Culvert (Precast), 600 mm	Linear Meter
60805	Reinforced Concrete Pipe Culvert (Precast), 750 mm	Linear Meter
60806	Reinforced Concrete Pipe Culvert (Precast), 1000 mm	Linear Meter
60807	Reinforced Concrete Pipe Culvert (Precast), 1200 mm	Linear Meter
60808	Reinforced Concrete Pipe Culvert (Precast), 1400 mm	Linear Meter
60809	Reinforced Concrete Pipe Culvert (Precast), ___ mm	Linear Meter

60812	Reinforced Concrete Pipe Culvert (Cast-in-Place),	Linear Meter
60813	Reinforced Concrete Pipe Culvert (Cast-in-Place), 400 mm	Linear Meter
600814	Reinforced Concrete Pipe Culvert (Cast-in-Place), 500 mm	Linear Meter
60815	Reinforced Concrete Pipe Culvert (Cast-in-Place), 600 mm	Linear Meter
60816	Reinforced Concrete Pipe Culvert (Cast-in-Place), 750 mm	Linear Meter
60817	Reinforced Concrete Pipe Culvert (Cast-in-Place), 1000 mm	Linear Meter
60818	Reinforced Concrete Pipe Culvert (Cast-in-Place), 1200 mm	Linear Meter
60819	Reinforced Concrete Pipe Culvert (Cast-in-Place), 1400 mm	Linear Meter
60820	Reinforced Concrete Pipe Culvert (Cast-in-Place), ___ mm	Linear Meter
60823	Reinforced Concrete Arch Culvert (Precast), 49 x 77 cm	Linear Meter
60824	Reinforced Concrete Arch Culvert (Precast), 61 x 96 cm	Linear Meter
60825	Reinforced Concrete Arch Culvert (Precast), 73 x 115 cm	Linear Meter
60826	Reinforced Concrete Arch Culvert (Precast), 85.5 x 134.5 cm	Linear Meter
60827	Reinforced Concrete Arch Culvert (Precast), 97.5 x 153.5 cm	Linear Meter
60828	Reinforced Concrete Arch Culvert (Precast), 109.5 x 173 cm	Linear Meter
60829	Reinforced Concrete Arch Culvert (Precast), 122 x 192 cm	Linear Meter
60830	Reinforced Concrete Arch Culvert (Precast), 134 x 211 cm	Linear Meter
60831	Reinforced Concrete Arch Culvert (Precast), ___x___ cm	Linear Meter
60835	Reinforced Concrete Arch Culvert (Cast-in-Place), 49 x 77 cm	Linear Meter
60836	Reinforced Concrete Arch Culvert (Cast-in-Place), 61 x 96 cm	Linear Meter
60837	Reinforced Concrete Arch Culvert (Cast-in-Place), 73 x 115 cm	Linear Meter
60838	Reinforced Concrete Arch Culvert (Cast-in-Place), 85.5 x 134.5 cm	Linear Meter
60839	Reinforced Concrete Arch Culvert (Cast-in-Place), 97.5 x 153.5 cm	Linear Meter
60840	Reinforced Concrete Arch Culvert (Cast-in-Place), 109.5 x 173 cm	Linear Meter
60841	Reinforced Concrete Arch Culvert (Cast-in-Place), 122 x 192 cm	Linear Meter
60842	Reinforced Concrete Arch Culvert (Cast-in-Place), 134 x 211 cm	Linear Meter
60843	Reinforced Concrete Arch Culvert (Cast-in-Place), ___ x ___ cm	Linear Meter

SECTION 6.09 - WATER WELL EXTENSIONS

6.09.1 DESCRIPTION. This Work shall consist of extending or construction of mortar uncoursed rubble masonry water wells above original ground level for protection against inundation from flood water in accordance with the specifications and in conformity with the dimensions and locations as shown on the plans or established by the Engineer.

ITEM IN BILL OF QUANTITIES
Water Well Extensions

6.09.2 MATERIALS. Stone for water well extensions shall be sound, durable stone, and, if possible, obtained locally during construction. Stone shall be similar in size to that used in the existing well or as approved by the Engineer. Mortar shall meet the requirements of Subparagraph 5.01.3.1.4, "Mortar" in these General Specifications.

6.09.3 CONSTRUCTION REQUIREMENTS. All live or active wells within the limits of new construction or at locations shown in the plans or directed by the Engineer to continue in service and which require extending shall be carefully protected during the placement of the embankment and all construction operations.

All stones shall be laid in mortar with all spaces between stones completely filled and with the stones carefully settled in the mortar beds before the mortar has set.

The masonry shall be constructed in an approved workmanlike manner and the top of the wall shall fit the embankment slope and/or be constructed to the elevation shown on the plans or designated by the Engineer.

The mortar shall be protected from the direct rays of the sun and shall be cured for three (3) days after placing with approved wet burlap or wet cotton mats.

The backfill, when required, around the wall shall be carefully placed and the finished construction shall present a neat approved appearance.

6.09.4 QUALITY ASSURANCE PROCEDURES. The water well extensions will be inspected, sampled, tested and evaluated in accordance with Section 1.08, "Acceptance of Work" in these General Specifications as follows:

The materials incorporated into the water well extensions shall be sampled, tested and evaluated in accordance with the specifications referenced in Subsection 6.09.2, "Materials" in these General Specifications. The construction of the water well extensions will be accepted in accordance with Subsection 1.08.4, "Measured or Tested Conformance" in these General Specifications.

6.09.5 METHOD OF MEASUREMENT. Stone masonry for water well extensions shall be measured by the cubic meter of masonry authorized, completed and accepted by the Engineer based on the minimum dimensions shown on the plans or ordered and subsequently verified by the Engineer.

6.09.6 PAYMENT. The amount of completed and accepted Work, measured as provided above, will be paid for at the contract unit price per cubic meter specified in the Bill of Quantities for Water Well Extensions, which price shall be full compensation for furnishing and placing all materials, for all excavation, for all labor, tools, equipment, and all other items necessary for the proper completion of the Work as specified in Subsection 1.07.2, "Scope of Payment" in these General Specifications.

PAYMENT WILL BE MADE UNDER:

ITEM NO.	PAY ITEM	PAY UNIT
60901	Water Well Extensions	Cubic Meter

SECTION 6.10 - DIKES

6.10.1 DESCRIPTION. This Work shall consist of reconstructing portions of existing farm dikes which were partially or totally removed in order to permit new construction, and constructing new diversion and spur dikes. Diversion dikes shall consist of placing material to the lines and grades required to intercept and divert the flow of surface water to an appropriate discharge or dispersion point. Spur dikes shall consist of placing material to the lines and grades required to channel flood waters away from bridge abutments.

This Work shall be in accordance with the specifications and in conformity with the lines and grades shown on the plans or established by the Engineer.

ITEMS IN BILL OF QUANTITIES
Reconstructing Existing Farm Dike
Spur Dike
Diversion Dike

6.10.2 CONSTRUCTION REQUIREMENTS. Only approved materials from the roadway excavation, drainage excavation, structural excavation, or borrow may be used to reconstruct existing farm dikes, or construct new diversion or spur dikes.

Reconstruction of existing farm dikes shall be the rebuilding of existing improvements, at or near the same location, to either new lines, grades, and cross sections, or to their original lines, grades and cross sections, as indicated on the project plans. Farm dikes shall be compacted in a manner approved by the Engineer and to a density fully equivalent to the original dike or as otherwise ordered by the Engineer.

Reconstruction of existing farm dikes, and construction of diversion and spur dikes shall be performed in accordance with the plans and Section 2.05, "Embankment" in these General Specifications. All material shall be compacted to Type 95 compaction unless otherwise specified.

Unless otherwise specified, the outer one and half (1.5) meter (horizontal) of dike faces subject to flooding and not otherwise protected by construction fabric and riprap shall be constructed of AASHTO M-145 Classification A-1 or A-2 materials.

Construction fabric and riprap shall be installed on spur dikes as required by the plans.

6.10.3 QUALITY ASSURANCE PROCEDURES. The dikes will be inspected, sampled, tested and evaluated in accordance with Section 1.08, "Acceptance of Work" in these General Specifications as follows:

The construction of the dikes shall be sampled, tested and evaluated in accordance with the specifications referenced in Subsection 6.10.2, "Construction Requirements" and in accordance with Subsection 1.08.4, "Measured or Tested Conformance" in these General Specifications.

6.10.4 METHOD OF MEASUREMENT. Reconstructing Existing Farm Dikes shall be measured by the linear method of authorized, completed and accepted Work by the dimensions ordered and subsequently verified by the Engineer.

Spur Dikes and Diversion Dikes shall be measured by the cubic meter of material authorized, placed, compacted, finished, and accepted by the Engineer based on the ordered and verified final dimensions of the dike(s).

Quantities of embankment measured as farm dikes, spur dikes, or diversion dikes will not be measured separately as embankment.

Riprap and Construction Fabric, if required, shall be measured as provided in Section 6.06, "Riprap and Slope Protection" in these General Specifications. Such quantities of riprap will not be included in the quantities of Spur Dikes or other dikes.

6.10.5 PAYMENT. The amount of completed and accepted Work, measured as provided, will be paid for at the contract unit price specified in the Bill of Quantities bid per linear meter for Reconstructing Existing Farm Dikes, and per cubic meter for Spur Dikes and Diversion Dikes, which price shall be full compensation for furnishing all material, water, equipment, tools, labor, and all other items necessary for the proper completion of the Work as specified in Subsection 1.07.2, "Scope of Payment" in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO.	PAY ITEM	PAY UNIT
61001	Reconstructing Existing Farm Dikes	Linear Meter
61002	Spur Dike	Cubic Meter
61003	Diversion Dike	Cubic Meter

SECTION 6.11 - FENCES, GATES AND GUARDS

6.11.1 DESCRIPTION. This Work shall consist of furnishing and installing fences, gates, and guards in accordance with the plans and specifications, at the locations and to the lines and grades shown on the plans or ordered by the Engineer.

ITEMS IN BILL OF QUANTITIES
Chain Link Fence
Industrial Fence
Wire Barbed Wire Fence
Wire Combination Fence
High Tension Wire Fence
Gate
Animal Guard

6.11.2 MATERIALS.

6.11.2.1 Chain Link Fence. Chain link fabric shall conform to ASTM A 491 (aluminum coated) or ASTM A 392 (galvanized). Mesh size shall be fifty (50) millimeters nominal, and wire size shall be three and seventy-six hundredths (3.76) millimeters diameter (No. 9 AWG) before galvanizing. If required by the plans or Special Specifications, fabric shall be plastic coated in accordance with Paragraph 6.01.2.5, "Glare Screens" in these General Specifications.

Materials shall conform to the requirements of this specification and shall be of the sizes, dimensions and types indicated in the HDM, Volume 4, Standard Drawings Nos. FAG-4 and FAG-5, according to the type(s) of chain-link fence(s) shown on the plans or directed.

6.11.2.2 Barbed Wire. Barbed wire shall conform to ASTM A 585 (aluminum coated), Class 1; or ASTM A 121 (galvanized), Class 1.0 Wire shall be composed of minimum two and five tenths (2.5) millimeters diameter (No. 12½AWG) wire and four (4) pointed barbs spaced not more than one hundred fifty (150) millimeters on center.

6.11.2.3 Combination Fence Fabric. Fabric for combination fences shall conform to ASTM A 584 (aluminum coated), Class 1; or ASTM A 116 (galvanized), Class 1.0 Minimum wire size shall be three and four tenths (3.4) millimeter diameter (No. 10 AWG). Mesh size and style shall be as shown on the plans.

6.11.2.4 Tension Wire. Tension wire shall conform to ASTM A 641, Class 1, Hard Temper. Tension wire for High Tension Wire Fence shall be a minimum of two and seven tenths (2.7) millimeters diameter. Tension wire for Chain Link Fence and Industrial Fence shall be a minimum of four and five tenths (4.5) millimeters diameter. Tension wire for other fences shall be of the minimum diameter shown on the plans.

6.11.2.5 Posts and Braces. Circular steel posts and braces shall be galvanized, conforming to ASTM A 53, Schedule 40, or ASTM A 120, Schedule 40, and shall be of the dimensions shown on the plans. At the option of the Contractor, alternate

galvanized steel shapes having the minimum equivalent bending strength in both directions may be substituted for circular posts and braces.

Rectangular hollow sections shall conform to ASTM A 501, BS 4360 Grade 43C or DIN 17100 St. 44.

End corner posts, straining posts and line posts, along with braces and stretcher bars thereof, shall conform to the requirements of this specification and shall be of the sizes and dimensions indicated in the Standard Drawings referred to in Paragraph 2.1 above. Line posts shall be spaced at three (3.0) meters on centers maximum, unless otherwise directed by the Engineer. Gate posts shall conform to the requirements of this specification and shall be of the sizes and dimensions specified in the HDM, Volume 4, Standard Drawing FAG-6.

Post tops shall be pressed steel, wrought iron, malleable iron, or plastic caps to manufacturer's standard as approved by the Engineer, designated as a weathertight closure cap for each post.

Posts and braces for High Tension Wire Fence shall conform to ASTM A 618, Grade 1.0 Material shall be of the shapes and dimensions shown on the plans and shall be galvanized in accordance with ASTM A 123.

6.11.2.6 Miscellaneous Hardware. All miscellaneous hardware shall conform to the requirements shown on the plans, and shall be galvanized in accordance with ASTM A 153.

6.11.2.7 Tie Wire. Tie Wire shall conform to ASTM A 112, and shall be minimum three and five tenths (3.5) millimeters diameter unless otherwise shown.

6.11.2.8 Structural Steel. Structural steel for Animal Guards shall conform to ASTM A 36, and shall be galvanized in accordance with ASTM D 123.

6.11.2.9 Concrete. Concrete for setting posts shall conform to the requirements of Subsection 5.03.9, "Concrete for Minor Structures" in these General Specifications. Concrete for Animal Guards shall conform to Class A in Section 5.01.0

6.11.2.10 Reinforcing Steel. Reinforcing steel shall conform to Section 5.02, "Reinforcing Steel" in these General Specifications.

6.11.2.11 Wire Rope. Wire rope for High Tension Wire Fence installed in the median shall conform to the requirements of AASHTO M 30, Type 11, Class A. Equivalent galvanized wire rope with a minimum breaking strength of nineteen thousand four hundred (19,400) kilograms will be acceptable.

6.11.2.12 Barbed Wire Supporting Arms. These items, where indicated, shall be manufacturer's standard as approved by the Engineer, consisting of metal and finish to match the framework, with provision for anchorage to posts and attaching three (3) rows of barbed wire to each arm. Supporting arms may be either attached to posts or integral with post top weather cap and must be capable of withstanding a maximum of one hundred fifteen (115) kg downward pull at the outermost end. Unless otherwise directed by the Engineer, provide single forty five (45) degree arm for three (3) strands barbed wire, one for each post, spaced as indicated on the plans.

6.11.2.13 Stretcher Bars. Stretcher bars shall be of one piece lengths to full height of fabric, with a minimum cross-section of twenty by five (20 x 5) mm. Provide one stretcher bar for each gate and end post, and two (2) for each corner and straining post.

6.11.2.14 Stretcher Bar Bands. Bands shall be steel, wrought iron, or malleable iron, spaced not over three hundred (300) mm on centers to secure stretcher bars to end, corner, straining and gate posts. Bands may also be used with special fittings for securing braces to end, corner, straining and gate posts.

6.11.2.15 Gates. Materials for gates shall conform to the requirements of this specification and shall be of the sizes, dimensions and types indicated in the HDM, Volume 4, Standard Drawing No FAG-6.

Gate perimeter frames shall be fabricated of tubular members. Additional horizontal and vertical members shall be provided to ensure proper gate operation and for attachment of fabric, hardware and accessories. Space so that frame members are not more than two and forty five hundreths (2.45) meters apart.

Gate frames shall be assembled by welding or with special malleable or pressed steel fittings and rivets for rigid connections. Same fabric as for the fence shall be used, unless otherwise directed by the Engineer. Fabric shall be installed with stretcher bars at vertical edges. Bars may also be used at top and bottom edges. Attach stretchers to gate frame at not more than three hundred eighty (380) mm on centers. Attach hardware with rivets or by other means which will provide security against removal or breakage.

Diagonal cross-bracing consisting of ten (10) mm diameter adjustable length truss rods shall be installed on gates, where necessary to ensure frame rigidity without sag or twist, as approved by the Engineer.

6.11.3 CONSTRUCTION REQUIREMENTS.

6.11.3.1 Fencing. The Contractor shall stake all sections of fence as shown on the plans or ordered by the Engineer prior to beginning Work. Top elevations of all posts shall be computed to follow a smooth grade with curves at transitions. Cutting the tops from posts after installation shall not be permitted.

The required line of the fence shall be cleared of all obstacles and debris which would interfere with the line of the fence. Minor grading may be required to achieve a smooth line.

Posts shall be set plumb to the required line and grade in concrete footings. No wire or fabric shall be strung taut until line posts have been set for at least one (1) day and corner posts for at least three (3) days. In sandy areas or other areas of poor soil support, the Contractor shall enlarge the footings as required by the Engineer to maintain adequate fence tension.

Wire or fabric shall be strung uniformly at the required tension and attached to corner posts and brace posts before permanently attaching to line posts. Any significant sags or detensioning which occurs after installation shall be corrected by the Contractor.

When fencing crosses ravines or other discontinuities in the terrain causing gaps under the fence, the Contractor, if so ordered by the Engineer, shall modify the installation to the extent practical by adding strands or additional fabric so as to provide the required access control without interfering with drainage.

Galvanized gates or fencing materials which are constructed or repaired by welding, cutting, or other Work which damages the coating shall be repaired by grinding smooth all damaged surfaces and painting with two (2) coats of paint No. 8 as specified in Section 5.13, "Painting of Structures" in these General Specifications.

6.11.3.2 Animal Guards. Concrete supports for animal guards shall be constructed in accordance with the requirements of Section 5.03, "Concrete Structures" in these General Specifications. Supports shall be set to support the guard at the design grade of the finished roadway surface. Anchor bolts shall be set precisely prior to and supported firmly during concreting.

Steel and hardware for animal guards shall be galvanized before assembly. Units shall be set on the supports after the concrete curing period.

6.11.4 QUALITY ASSURANCE PROCEDURES. The fences, gates and guards will be inspected, sampled, tested and evaluated in accordance with Section 1.08 "Acceptance of Work" in these General Specifications as follows:

The materials incorporated into the fences, gates and guards shall be sampled, tested and evaluated in accordance with the specifications and test methods referenced in Subsection 6.11.2, "Materials" in these General Specifications. The construction of the fences, gates and guards will be accepted in accordance with Subsection 1.08.4, "Measured or Tested Conformance" in these General Specifications.

6.11.5 METHOD OF MEASUREMENT. Chain Link Fence, Industrial Fence, Barbed Wire Fence, Combination Fence, and High Tension Wire Fence shall be measured by the linear meter for all Work authorized, completed, and accepted by the Engineer based on the horizontal length of each type and height fence ordered by the Engineer. Dimensions ordered shall be from center to center of end or corner posts. Gates and other gaps shall be excluded.

Gates shall be measured by the square meter for all gates of each type authorized, completed, and accepted by the Engineer, based on the nominal height of the gate ordered times the required distance between the adjacent fence end/gate support posts.

Animal Guards shall be measured by the unit of each for all Work authorized, completed and accepted by the Engineer for each width guard required.

There shall be no separate measurement for excavation, backfill, concrete footings, or for any other material and Work required explicitly or implicitly by the Plans and specifications for the proper completion of the Work. Such material and Work shall be considered subsidiary to these items.

6.11.6 PAYMENT. The amount of completed and accepted Work as measured above will be paid at the contract unit price(s) specified in the Bill of Quantities, which price(s) shall be full compensation for furnishing all materials, for all labor, equipment, tools, supplies, and all other items necessary for the proper completion of the Work as specified in Subsection 1.07.2, "Scope of Payment" in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
61101	Chain Link Fence	Linear Meter
6110101	Chain Link Fence, 1.0 m Height	Linear Meter
6110102	Chain Link Fence, 1.2 m Height	Linear Meter
6110103	Chain Link Fence, 1.4 m Height	Linear Meter
6110104	Chain Link Fence, 1.6 m Height	Linear Meter
6110105	Chain Link Fence, 1.8 m Height	Linear Meter
6110106	Chain Link Fence, 2.0 m Height	Linear Meter
6110107	Chain Link Fence, 2.2 m Height	Linear Meter
6110108	Chain Link Fence, 2.4 m Height	Linear Meter
6110109	Chain Link Fence, 2.6 m Height	Linear Meter
61102	Industrial Fence	Linear Meter
6110201	Industrial Fence, 1.0 m Height	Linear Meter
6110202	Industrial Fence, 1.2 m Height	Linear Meter
6110203	Industrial Fence, 1.4 m Height	Linear Meter
6110204	Industrial Fence, 1.6 m Height	Linear Meter
6110205	Industrial Fence, 1.8 m Height	Linear Meter
6110206	Industrial Fence, 2.0 m Height	Linear Meter
6110207	Industrial Fence, 2.2 m Height	Linear Meter
6110208	Industrial Fence, 2.4 m Height	Linear Meter
6110209	Industrial Fence, 2.6 m Height	Linear Meter

61103	Barbed Wire Fence	Linear Meter
6110301	Barbed Wire Fence, 2 Strand	Linear Meter
6110302	Barbed Wire Fence, 3 Strand	Linear Meter
6110303	Barbed Wire Fence, 4 Strand	Linear Meter
6110304	Barbed Wire Fence, 5 Strand	Linear Meter
6110305	Barbed Wire Fence, 6 Strand	Linear Meter
6110306	Barbed Wire Fence, 7 Strand	Linear Meter
61104	Combination Wire Fence	Linear Meter
6110401	Combination Wire Fence, 2 Wire	Linear Meter
6110402	Combination Wire Fence, 3 Wire	Linear Meter
6110403	Combination Wire Fence, 4 Wire	Linear Meter
6110404	Combination Wire Fence, 5 Wire	Linear Meter
6110405	Combination Wire Fence, 6 Wire	Linear Meter
61105	High Tension Wire Fence	Linear Meter
6110501	High Tension Wire Fence, Type 1	Linear Meter
6110502	High Tension Wire Fence, Type 2	Linear Meter
6110503	High Tension Wire Fence, Type 3	Linear Meter
6110504	High Tension Wire Fence, Type 4	Linear Meter
61106	Gate	Unit
6110601	Chain Link Fence Gate	Unit
6110602	Industrial Fence Gate	Unit
6110603	Combination Fence Gate	Unit
6110604	Metal Gate	Unit
6110605	(Type) Gate	Unit
61107	Animal Guard, 3 m Width	Unit
61108	Animal Guard, 4 m Width	Unit
61109	Animal Guard, 5 m Width	Unit
61110	Animal Guard, 6 m Width	Unit
61111	Animal Guard, 7 m Width	Unit
61112	Animal Guard, 8 m Width	Unit
61113	Animal Guard, 9 m Width	Unit
61114	Animal Guard, 10 m Width	Unit

SECTION 6.12 - SIDEWALKS, DRIVE PADS AND MEDIAN PAVING

6.12.1 DESCRIPTION. **This Work shall consist of the paving of sidewalks, drive pads, and medians in accordance with these General Specifications and in conformity to the locations, lines, grades, and typical sections shown on the plans or established by the Engineer.**

ITEMS IN BILL OF QUANTITIES
Cast-in-Place Sidewalk, Drive Pad or Median Paving
Precast (Tiled) Sidewalk, Drive Pad or Median Paving
Bituminous Sidewalk, Drive Pad or Median Paving

6.12.2 MATERIALS.

6.12.2.1 Concrete. **Portland cement concrete shall conform to the requirements of Class A in Section 5.01, "Portland Cement Concrete" in these General Specifications except that the concrete subcourse for precast sidewalks and median paving shall conform to Subsection 5.03.9 "Concrete for Minor Structures" in these General Specifications.**

6.12.2.2 Reinforcing Steel. **Reinforcing steel and wire mesh shall conform to the requirements of Section 5.02, "Reinforcing Steel" in these General Specifications.**

6.12.2.3 Mortar. **Mortar shall conform to the requirements of Subparagraph 5.01.3.1.4, "Mortar" in these General Specifications.**

6.12.2.4 Expansion Joint Filler. **Performed expansion joint filler shall conform to the requirements of AASHTO M 33.**

6.12.2.5 Bituminous Mixture. **Bituminous mixture shall conform to the requirements of Section 4.05, "Bituminous Concrete Pavement" for Bituminous Wearing Course in these General Specifications.**

6.12.2.6 Bedding Course. **Bedding course material shall conform to the requirements of Paragraph 3.02.2.2 "Materials" for Granular Subbase Course, Grading I or II in these General Specifications.**

6.12.3 CONSTRUCTION REQUIREMENTS.

6.12.3.1 Cast-in-Place Sidewalks, Drive Pads, Median Paving.

6.12.3.1.1 Excavation. **Excavation shall be made to the required depth and to a width that will permit the installation and bracing of the forms. The foundation shall be shaped and compacted to an even surface conforming to the section shown on the plans. All soft and yielding material shall be removed and replaced with acceptable material.**

6.12.3.1.2 Bedding Course. Bedding course material, if required, shall be placed in layers not exceeding one hundred fifty (150) millimeters in depth and each layer compacted to Type 95 compaction. The total bedding course thickness shall be as shown on the plans.

6.12.3.1.3 Forms. Forms shall be of metal, wood, or other suitable material and shall extend for the full depth of the concrete. All forms shall be straight, free from warp, and of sufficient strength to resist the pressure of the concrete without displacement. Bracing and staking of forms shall be such that the forms remain in both horizontal and vertical alignment until their removal. All forms shall be cleaned and oiled before concrete is placed against them.

6.12.3.1.4 Placing Concrete. The foundation shall be thoroughly moistened immediately prior to the placing of the concrete. The proportioning and mixing of the concrete shall be in accordance with the requirements for the class of concrete specified. The concrete shall be deposited in one course in such a manner as to prevent segregation and consolidation by vibrators.

6.12.3.1.5 Finishing. The surface shall be finished with a wooden float and light brooming. No plastering of the surface will be permitted. All outside edges of the slab and all joints shall be edges with a five (5) millimeter radius edging tool.

6.12.3.1.6 Joints. Expansion joints shall be of the dimensions specified, and shall be filled with the type of premolded expansion joint filler noted. The sidewalk shall be dived into sections by weakened plane joints formed by a jointing tool or other acceptable means as directed. These joints shall extend into the concrete for about one fourth (¼) to one fifth (1/5) of the depth and shall be approximately three (3) millimeters wide. Joints shall match as nearly as possible adjacent joints in curb or pavements. Weakened plane joints may be sawed in lieu of forming with a jointing tool.

Construction joints shall be formed around all appurtenances such as manholes, utility poles, etc., extending into and through the sidewalk, drive pad, or median. Premolded expansion joint filler one (1) centimeter thick shall be installed in these joints. Expansion joint filler of the thickness indicated shall be installed between concrete construction and any fixed structure such as a building or bridge. This expansion joint material shall extend for the full depth of the concrete construction.

6.12.3.1.7 Curing. Concrete shall be cured by membrane or water in accordance with Paragraph 5.03.4.10, "Curing and Protection" in these General Specifications.

6.12.3.2 Precast (Tiled) Sidewalk, Drive Pad and Median Paving.

6.12.3.2.1 General. Tiled sidewalks shall be constructed in accordance with the dimensions and levels shown on the drawings or as directed by the Engineer. All areas inside channelizing islands shall also be provided with a sidewalk pavement, unless otherwise shown on the Drawings or as directed by the Engineer.

Tiles sidewalks shall be formed of precast concrete tiles four hundred by four hundred (400 X 400) millimeters, with a seven (7) millimeter edge bevel. The tiles shall have sufficient roughness on the back surface to permit proper adhesion of the mortar.

6.12.3.2.2 Manufacture of Tiles. Precast tiles shall be manufactured by an automatic plant of the central batch high pressure type, erected in a special yard reserved specifically for this purpose. The plant shall be equipped with a double feeding system, one for the upper layer, and another for the lower layer of the tile. Manual intervention shall be a minimum.

Operation of the plant shall be such that it shall first discharge enough mortar materials into the form for the upper layer, and after preliminary vibration and uniform leveling, the coarse mixture for the lower layer shall then be discharged into the tile form. The high pressure automatic device shall be used only after a second vibration and leveling of the material has taken place. Tiles shall not be disturbed during setting of the concrete.

Curing of the tiles shall take place in a closed curing room where the Contractor shall provide an automatic steam curing system to be operated as and when approved by the Engineer. The capacity of the curing room shall permit acceptance and complete curing of the daily plant production of tiles.

The period of curing shall be at least one full day at a temperature of fifty-five to seventy-five degrees Celsius (55 to 75° C). This period may be subject to changes and adjustments after direct tests have been made on the production or as directed by the Engineer.

Tiles shall not be imperfectly finished, and shall be free from segregation, honeycombing, broken or damaged corners and imperfect plan faces. Correction of defects by polishing, retouching or any other means will not be permitted. Approval of the tiles given by the Engineer at any stage of the Work, shall not prejudice the Engineer's right to later discard any imperfect tiles. Final approval shall be given only after the tiles have been completely positioned in-situ. Rejected tiles shall be removed from the site and replaced.

6.12.3.2.3 Concrete Tiles. Concrete tiles shall consist of an upper layer formed of one (1) cm of 1:1 cement:sand mortar, and lower layer formed of three (3) centimeters of Class D concrete.

6.12.3.2.4 Tile Sidewalk Construction. The foundation for tiles shall consist of seven (7) centimeters thickness of compacted sand gravels.

Tiles shall be laid only after the gravel base has been compacted sufficiently and after approval has been given by the Engineer. Tiles shall be immersed in water immediately before laying. Tiles shall be bedded on a five (5) centimeter thickness of 1:3 cement:sand mortar.

Joints between tiles and between tiles and curbs shall be as per the Ministry's Standard Drawings wide and shall be completely filled with 1:2 cement/sand mortar or a grout for the full thickness of the tile by use of proper tools, during and after positioning of the tiles. All transverse and longitudinal joints shall be in proper line and in the correct pattern, to ensure a neat and workmanlike appearance.

As soon as the mortar or grout has partially set, the Contractor shall rake all mortar material from the groove formed by the two adjacent bevels, and from the first three mm. depth of the joint, using appropriate tools.

When the mortar has sufficiently set, the Contractor shall sprinkle the sidewalk with water and shall cover it with plastic or nylon sheets to avoid evaporation of water during the curing period. The sheets shall be left in place until completion of setting of the mortar and concrete, or as ordered by the Engineer. The Contractor shall then remove all foreign matter, wood, concrete or mortar lumps, etc., leaving the sidewalk in a neat, clean and tidy condition.

In cases where tiles are required to be cut, due to the presence of obstacles, poles, hydrants, etc., or in the construction of driveways or side roads, etc., the Contractor shall cut the tiles and/or substitute in-situ concrete of at least the same quality as the tiles. The Engineer shall decide, after trials, on the method to be adopted. This operation shall be kept to a minimum. The Contractor shall complete as much as practicable of the sidewalk using precast tiles.

The method of construction of the sequence of operations, for areas of sidewalks constructed using in-situ concrete shall be the same as those for sidewalks constructed using precast tiles. The Contractor shall ensure that the final appearance of the sidewalk surfaces, regardless of the method of construction adopted, shall be the same for both types of construction.

Where the sidewalk crosses the entrance to a shop or a house the level of which is higher than the sidewalk, the Contractor shall construct steps, formed by a curb and a complete or partial tile. The steps shall be backfilled with concrete of the same quality as specified for tile foundations.

A step shall be constructed wherever the difference in elevation between the entrance and the sidewalk is more than three hundred (300) millimeters. The Contractor shall submit to the Engineer, prior to commencing any sidewalk construction, a list of locations where steps will be required, together with design details for construction of such steps.

Driveway pavements shall be constructed to the same standards as specified for sidewalks.

6.12.3.2.5 Testing of Tiles. The following tests shall be carried out on sidewalk tiles to ascertain their suitability for the Work:

1. Impact Strength

2. Flexural Strength
3. Abrasion Resistance

The first two (2) tests shall be carried out on four (4) samples taking as a final result the average of the most homogenous results of the four (4). The abrasion resistance test shall be carried out on two (2) samples, the results of which shall be averaged.

1. Impact Strength

This test establishes the minimum height of fall of a steel ball weighing one kg. which, when striking the tile in the middle, breaks it. The product of the height of the fall by the weight of the ball is taken as the Impact Strength. Limiting value: 0.5 Kgs. - Meters minimum.

2. Flexural Strength

This test is carried out by placing a tile on two knife supports, with edges rounded with a radius of one (1) centimeter, arranged parallel to the side of the tile and ten (10) centimeters apart. The load is gradually transmitted to the tile top surface, along the centerline, by a third knife arranged parallel to the other two (2).

The unit maximum bending stress equals fifteen (15) Phb^2 where 'P' is the total breaking load in kilograms, 'b' is the width of the tile in centimeters, 'h' is the thickness of the tile in centimeters.

The limit acceptance value for Flexural Strength shall be thirty (30) kilograms per square centimeter minimum.

3. Abrasion Resistance

This test is carried out with a machine composed of a horizontal cast-iron disc, rotating about its vertical central axis at uniform speed; a horizontal diametrical cross-piece by means of which two samples are pressed on the disc, at such a distance from the center of the disc, that the relative speed with respect to the disc, is one meter per second; a second horizontal diametrical cross-piece orthogonal to the first, which is carried at either end appropriate devices to let the moistened abrasive flow onto the track; two pairs of conveniently arranged brushes to guide the abrasive that tends to escape under the samples.

The samples, pressed against the disc, rotate by means of a special mechanical device, around their own vertical central axis, at the rate of one turn of the specimen for fifty (50) turns of the disc. Carborundum grit sufficiently coated with liquid mineral oil with an Engler viscosity between five (5) and seven (7) at fifty degrees Celsius (50° C.) shall be used as an abrasive. The grit shall pass Sieve No. 60 and be retained on Sieve No. 100. Consumption of carborundum and oil should be approximately twenty (20) and twelve (12) grams, respectively, per minute.

The square sample, with a surface area of fifty (50) square centimeters shall be pressed against the disc by a total weight of fifteen (15) kilograms unit pressure of three-tenths (0.3) kilograms per square centimeter. The test is normally carried out with a distance run of the grinding wheel of five hundred (500) meters. For materials with a surface wearing layer different from the rest of the tile, the distance run must be such that the disc does not penetrate into the lower layer.

The thickness of the layer abraded in millimeters with a pressure of three-tenths (0.3) kilogram per square centimeter for a distance run of one thousand (1000) meters is taken as the Abrasion Factor. This factor is determined by assuming that the consumption is proportional to the distance run. The limit acceptance value for the Abrasion Factor shall be twelve (12) millimeters maximum.

6.12.4 SIDEWALK, DRIVE PAD AND MEDIAN PAVING TOLERANCES. The tolerances for sidewalk, drive pad and median paving construction shall be as follows:

Elevation of sidewalk and tiles: plus or minus six (6) millimeters from the designed grade elevation.

The Engineer shall check paving surfaces by use of a four (4) meter long straight edge. The deviation of the surface from the straight edge shall not exceed three (3) millimeters when the straight edge is applied transversely and longitudinally to the finished paving.

6.12.5 QUALITY ASSURANCE PROCEDURES. Sampling, testing and acceptance shall conform to the requirements of Section 1.04, "Control of Materials" and 1.08, "Acceptance of Work" in these General Specifications as follows:

The materials incorporated into the sidewalks, drive pads and medians shall be sampled, tested and evaluated in accordance with the specifications and test methods referenced in Subsection 6.12.2, "Materials" in these General Specifications. The construction of the sidewalks, drive pads and medians will be accepted in accordance with Subsection 1.08.4, "Measured or Tested Conformance" in these General Specifications.

The finished surface shall be such that, when tested with a three (3) meter straightedge, no portion of the finished surface shall vary more than ten (10) millimeters from its lower edge.

6.12.6 METHOD OF MEASUREMENT. Cast-in-Place, Precast (Tiled) and Bituminous Sidewalk, Drive Pad, or Median Paving shall be measured by the square meter for all Work of each type, authorized, completed, and accepted by the Engineer based on the horizontal dimensions on the plans or ordered by the Engineer. Depressed curb driveway entrances, unless otherwise specified, shall be measured inclusive with the adjacent sidewalk.

Excavation for sidewalk, drive pad, and median paving shall not be measured separately for payment but will be considered as subsidiary Work, except when such

excavation is a part of, and is measured in conjunction with, the roadway excavation. In such instances, the excavation shall be measured and included in the quantity of roadway excavation computed as a pay item as provided in Section 2.03, "Excavation" in these General Specifications.

Bedding course, if required, shall not be measured separately but shall be considered subsidiary to these Items of Work. Portland cement concrete, minor concrete, bituminous concrete, reinforcing steel and other miscellaneous materials shall not be measured separately but shall also be considered subsidiary to the items.

6.12.7 PAYMENT. **The amount of authorized, completed and accepted Work, measured as described above, will be paid at the contract unit price(s) shown in the Bill of Quantities, which price(s) shall include all required materials, equipment, tools, labor, and all other items necessary for the proper completion of the Work as specified in Subsection 1.07.2, "Scope of Payment" in these General Specifications.**

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
61201	Cast-in-Place Sidewalk, Drive Pad or Median Paving	Square Meter
61202	Precast (Tiled) Sidewalk, Drive Pad or Median Paving	Square Meter
61203	Bituminous Sidewalk, Drive Pad or Median Paving	Square Meter

SECTION 6.13 - MONUMENTS

6.13.1 DESCRIPTION. This Work shall consist of the construction or furnishing and placing of right-of-way, survey and reference monuments in accordance with the standard plans and these specifications in conformity with the lines, grades, and locations shown on the plans in the MOC's "Standards for Road Safety Features" or established by the Engineer.

ITEMS IN BILL OF QUANTITIES
Right-of-Way Monument
Survey Monument
Reference Monument

6.13.2 MATERIALS.

6.13.2.1 Concrete. Concrete used to fabricate monuments shall conform to the requirements of Section 5.03.9, "Concrete for Minor Structures" in these General Specifications.

6.13.2.2 Reinforcing Steel. Reinforcing steel shall conform to the requirements of Section 5.02, "Reinforcing Steel" in these General Specifications.

6.13.2.3 Metalwork. Monuments and marker hardware, steel plates, and pipe shall conform to the requirements shown on the plans. Anchor rail for monuments in sand dune areas shall be 5-20 or equivalent and shall conform to the requirements shown on the plans. Brass shall conform to the requirements of ASTM B 176.

6.13.3 CONSTRUCTION REQUIREMENTS.

6.13.3.1 General. Units shall be constructed in accordance with Standard Ministry Drawings. They shall be hydraulically pressed and cured to the satisfaction of the Engineer. They shall have a clean finish with smooth surfaces. Segregation, honeycombing or broken corners will not be allowed and remedial measures will not be accepted. Final approval of the monuments will be given by the Engineer only after proper incorporation in the Work.

6.13.3.2 Laying. Units shall be laid in the locations and to the levels shown on the drawings or as directed by the Engineer. Subgrade shall be compacted to provide a smooth surface of uniform density and shall be approved by the Engineer before placing the units. Excavation and backfilling with concrete or otherwise shall be considered subsidiary to the installation of right-or-way monuments and no additional payment will be made therefore. All monuments shall be set vertically to the depth shown on the plans and maintained in the vertical position while the holes are backfilled with approved material and thoroughly compacted.

One face of the monument shall be impressed with the kilometric distance. The method of inscribing the information on the unit shall be approved by the Engineer.

6.13.4 QUALITY ASSURANCE PROCEDURES. The monuments will be inspected, sampled, tested and evaluated in accordance with Section 1.08, "Acceptance of Work" in these General Specifications as follows:

The materials incorporated into the monuments shall be sampled, tested and evaluated in accordance with the specifications and test methods referenced in Subsection 6.13.2, "Materials" in this Section in these General Specifications. The installation of the monuments will be accepted in accordance with Subsection 1.08.4, "Measured or Tested Conformance" in these General Specifications.

6.13.5 METHOD OF MEASUREMENT. Monuments shall be measured by the unit for each monument furnished, installed and accepted.

6.13.6 PAYMENT. The amount of completed and accepted Work, as measured, will be paid for at the contract unit price(s) per unit as specified in the Bill of Quantities for each type of monument which price(s) shall be full compensation for furnishing all materials, for all labor, equipment, tools, supplies, and all other items necessary to complete the Work as specified in Subsection 1.07.2, "Scope of Payment" in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
61301	Monument	Unit
6130101	Right-of-Way Monument	Unit
6130102	Survey Monument	Unit
6130103	Reference Monument	Unit

SECTION 6.14 - SHOTCRETE (PNEUMATICALLY APPLIED MORTAR)

6.14.1 DESCRIPTION. This Work shall consist of applying one or more layers of pneumatically applied shotcrete to rock soil or concrete surfaces in ditches, channels, and tunnels, and cladding slopes in accordance with details and dimensions shown on the plans and as specified in the specifications.

The several classes of shotcrete shall be produced by a wet mix process which consists of mixing aggregates, admixtures, Portland cement and water and then feeding this mixture into suitable delivery equipment which will feed the mixture into a pressurized nozzle. Accelerating admixtures, if used, shall be added uniformly at the nozzle and the resulting mixture pneumatically sprayed onto a surface.

ITEMS IN BILL OF QUANTITIES
Shotcrete
Reinforced Shotcrete
Fiber Reinforced Shotcrete

6.14.2 MATERIALS.

6.14.2.1 General. Except as modified in this Subsection, Portland cement, fine aggregate, coarse aggregate, and mixing water shall conform to the quality requirements of Section 5.01, "Portland Cement Concrete" in these General Specifications. The mixture of coarse and fine aggregate for applications two hundred fifty (250) millimeters or thicker shall conform to the following gradation requirements:

Standard Sieve Size	Percent Passing by Weight
12.5 mm (½ inch)	100
9.5 mm (3/8 inch)	90-100
4.75 mm (No. 4)	65-82
2.36 mm (No. 8)	45-68
1.018 mm (No. 16)	30-53
0.600 mm (No. 30)	20-38
0.300 mm (No. 50)	7-22
0.150 mm (No. 100)	2-10
0.075 mm (No. 200)	0-3

When the application is less than two hundred fifty (250) millimeters thick, the gradation given in Subparagraph 5.01.2.2.1, "Fine Aggregate" in these General Specifications shall apply.

All Portland Cement used in shotcrete shall have a maximum sulfate expansion of 0.040 percent when tested in accordance with ASTM C 452.

Aggregates: Normal weight aggregate for shotcrete shall comply with the requirements of AASHTO M6 and M80. The minimum specific gravity for aggregates shall be 2.55. Light weight aggregate is not permitted.

Accelerating Admixtures: Accelerating admixtures shall only be used after acceptable compatibility testing as in Paragraph 6.14.2.3 "Mix Design Requirements" in these General Specifications. Admixtures shall conform to the following additional requirements:

1. Contain no water-soluble chlorides or materials corrosive to steel not be subject to other detrimental effects such as cracking, spalling or debonding.

2. Admixtures shall have a three-year minimum history of satisfactory performance in similar applications.

Silica Fume: The use of silica fume is subject to the approval of the Engineer. The silica fume shall have a minimum of Silicon Dioxide ($Si0_2$) content of ninety (90) percent and have previous acceptable performance on similar projects with shotcrete.

Reinforcement: Welded wire reinforcement shall be as shown on the plans and meet the requirements of Section 5.02, "Reinforcing Steel" in these General Specifications.

Fibers: Fibers shall comply with the requirements of ASTM A 820-90 and shall be cold drawn steel with a minimum tensile strength of one thousand (1000) N per square millimeter and with lengths at least eighteen (18) millimeters and an equivalent diameter between thirty-eight hundredths (.38) millimeters and sixty-four hundredths (.64) millimeter. The fibers shall have bent, deformed or enlarged ends or be continuously deformed throughout.

6.14.2.2 Applicable Publications. The publications listed below form a part of this Specification to the extent referenced. The publications are referred to in the text by the basic designation only.

1. American Concrete Institute (ACI)

ACI 506.2-77	Specification for Materials, Proportioning and Application of Shotcrete
ACI 506.3R-82	Guide to Certification of Shotcrete Nozzlemen
ACI 506R-85	Guide to Shotcrete

2. American Association of State Highway and Transportation Officials (AASHTO)

AASHTO M157	Standard Specification for Ready-Mixed Concrete
AASHTO M241	Standard Specification for Concrete Made by Volumetric Batching and Continuous Mixing
AASHTO T24	Standard Method of Obtaining and Testing Drilled Cores and Sawed Beams of Concrete

AASHTO T106	Standard Method of Test for Compressive Strength of Hydraulic Cement Mortar
AASHTO T154	Standard Method of Test for Time of Setting of Hydraulic Cement by Gilmore Needles

3. American Society of Testing Materials (ASTM)

ASTM A 820-90	Evaluation of Cold Drawn Steel Wire Fibers
ASTM C 452	Standard Test Method for Determination of the Sulphate Resistance of Cements
ASTM C 1018-92	Standard Test Method for Flexural Toughness and First Crack Strength of Fiber-reinforced Concrete

6.14.2.3 Mix Design Requirements.

6.14.2.3.1 General. All shotcrete shall be designed in accordance with the most current requirements of ACI 506.2 - Specification for Materials, Proportioning, and Application of Shotcrete taking into account all special requirements contained in this Subsection in these General Specifications. A separate mix design shall be submitted for each type of shotcrete. Each mix shall have a minimum cement content of four hundred (400) kilograms per cubic meter.

Maximum Water Cement Ratio. The maximum water-cement ratio is forty-five hundredths (0.45) for all wet mix applications.

Fiber-reinforced shotcrete mixes shall contain a minimum of fifty-five (55) kilograms per cubic meter of steel fibers and a minimum of five percent (5%) micro silica. The proposed shotcrete mixes shall be developed by the Contractor using accelerator compatibility tests and subsequent preconstruction tests as indicated herein at least thirty (30) days prior to the actual application of any shotcrete to any surface. The Engineer will witness the production of all test samples and supervise the testing on cored cylinder samples and sawed beam specimens.

Compatibility tests shall be performed to determine cements and additives to be used in field test mixes. Determine initial and final set for additive concentrations of varying percentages of cement content by weight expected to be used in the work. The actual proportion shall be determine by laboratory testing such that:

1. Setting times determined by AASHTO T154 using no greater than forty-five hundredths (0.45) water-cement ratio by weight.

   (1) Time of initial setting at not more than three (3) minutes.

   (2) Time of final setting at not more than twelve (12) minutes.

2. Compressive strength by AASHTO T106 (using fifty (50) millimeter cube specimens), using no greater than forty-five hundredths (0.45) water-cement ratio by

weight, shall be not less than five hundred sixty (560) kilograms per square centimeter at eight (8) hours.

To ascertain the compatibility of the ingredients and their optimum proportions, a shotcrete mix having the same strength and characteristics required for actual application shall be developed.

6.14.2.3.2 Acceptance of Design Mix. The Engineer will inform the Contractor, in writing, of his approval of mixes which meet the requirements. No shotcrete mix shall be used in preconstruction tests that has not been accepted by the Engineer.

The exact proportions of ingredients determined on the basis of preconstruction tests shall be used in the actual application of shotcrete and shall not be varied without the written approval of the Engineer.

6.14.2.3.3 Shotcrete Strengths. The minimum progressive core shotcrete compressive strengths and toughness requirements are as follows:

1. All shotcrete (preconstruction and construction) shall have the following minimum progressive core compressive strengths:

Age	Compressive Strength-psi
8 hours - unsoaked	60 kg./sq. cm. minimum
72 hours - unsoaked	200 kg./sq. cm. minimum
28 days - soaked	350 kg./sq. cm. minimum

2. All of the above minimum strengths are for test specimens with a seventy-five (75) millimeter diameter and having a length to diameter ratio (L/D) of at least two (2) with compressive strengths determined by AASHTO T24. For L/D ratios between one (1) and two (2), the compressive strength shall be reduced as indicated in AASHTO T24.

3. All preconstruction fiber-reinforced shotcrete shall have the following minimum requirements:

1.0 First crack flexural strength at seven (7) days = fifty (50) kilograms per square centimeter

2.0 Toughness Index at seven (7) days:
I_{10} = 5.0 and I_{30} = 14

The flexural strength and toughness index shall be determined according to ASTMC 1018-92. All test beams shall be extracted from panels according to AASHTO T24. All beams shall have dimensions of 350x100x100 millimeters for all preconstruction and construction testing.

6.14.3 PRECONSTRUCTION TESTING.

6.14.3.1 **Submittals.** The following, in accordance with Subsection 1.03.2, "Plans and Working Drawings" requirements in these General Specifications, shall be submitted by the Contractor prior to proceeding with preconstruction testing:

1. Specification for and description of proposed equipment for mixing and application of shotcrete, including the specified remote shotcreting boom. Include manufacturer's literature, operating and maintenance procedures.

2. Proposed mix design and preliminary test results following requirements in ACI 506.2 for each proposed shotcrete type. Include detailed gradations of all aggregates. This submission shall be accompanied by certified test results of samples tested in accordance with ASTM C 452 to verify adequate sulphate expansion resistance. The results of compatibility testing done in accordance with ACI 506.2 shall also accompany this submission to verify that any proposed admixtures to accelerate set are compatible with the cement to be used.

3. Proposed method of application and batching of shotcrete.

4. Certification of specified materials to the referenced standards.

5. Samples of all shotcrete ingredients and product supplier data. The Engineer shall have the opportunity to visit the proposed aggregate supplier(s) and obtain independent samples.

6. Brands, types and suppliers of admixtures.

7. Evidence of nozzlemen's qualifications.

8. Evidence of shotcrete supervisors' qualifications.

9. Name(s) and experience record of the firm(s) doing the work. References shall be provided.

10. Proposed preconstruction testing program plan showing, as a minimum, proposed test panel (shop drawing), location and method of anchoring test panels, date and time for test panel shotcreting, method of shooting test panel (e.g. vertical, horizontal, using remote boom) and number of test panels to be completed for each method.

11. Batch tickets. Submit a delivery ticket if ready mix delivery of materials is used. The information to be provided and the requirements shall be in accordance with Paragraph 5.01.8.1, "Quality Control of the Mixing Process" in these General Specifications.

12. Cold and hot weather protection and curing plans.

6.14.3.2 Personnel. The Contractor and/or Shotcrete Subcontractor shall have had previous shotcreting experience. The Engineer will quality nozzlemen for this project. Furthermore, the Contractor shall provide evidence that all proposed nozzlemen on this project have a minimum one year shotcrete application experience. Supervisors shall demonstrate and provide evidence of previous experience of training in shotcrete application of at least three (3) years experience on comparable projects. Evidence, for both nozzlemen and supervisors shall be provided prior to any preconstruction tests. The Engineer will then qualify the nozzlemen, using the ACI Certification (ACI-5063R-82 Guide to Certification of Shotcrete Nozzlemen). The qualification will be granted upon: a successful written exam based on questions in, but not limited to, Appendices B and E; workmanship demonstration and successful test panel completion as described herein. The qualification will be based on the scoring system in the publication and when the results of the twenty-eight (28) day strength tests are known. No shotcrete shall be placed by any personnel without the specific prequalification.

6.14.3.3 Preconstruction Tests. After completion of the laboratory tests and their acceptance, preconstruction tests shall be made on each approved design mix to demonstrate capability of equipment, workmanship, and materials under field construction at least thirty (30) days prior to actual application of shotcrete in permanent Work. The mixes selected for preconstruction tests shall be confined to those approved by the Engineer following the laboratory testing.

Test panels shall be shotcreted by each proposed nozzleman using the equipment, materials, mix proportions and procedures proposed for the applications. All test panels shall be shotcreted at the project site. Mixes that are to be applied using a remote boom shall have test panels made using the remote boom. Each nozzleman shall shotcrete one test panel for each mix design considered and for each shooting position which will be encountered with each mixture. As a minimum, a horizontal (overhead) and vertical shooting position shall be done.

A minimum of two (2) test panels shall be constructed for each mixture and bid item eight hundred (800) millimeters square by two hundred (200) millimeters deep constructed with a rigid bottom and sides. Each test panel must be fastened to a rigid object to prevent vibration during shotcreting. A minimum one hundred fifty (150) millimeter thickness of shotcrete shall be applied to permit proper core and beam dimensions and trimming. Test panels shall then be cured to approximate field conditions.

The Contractor shall core nine (9) seventy-five (75) millimeter diameter cores and cut three (3) beams from each test panel, in the presence of the Engineer, utilizing AASHTO T24 procedures. The Contractor shall seal the cylinders individually in plastic bags, identify them and transport them to the Engineer's testing facility at the project site. The Engineer will supervise the testing of the cylinders for compressive strength in accordance with MRD Test 525 and the testing of the beams for first crack flexural strength and toughness indices in accordance with ASTM C1018-92.

Core samples, for each panel, will be taken at different times, corresponding to the specified strength ages. A series of cores will be taken at six and one-half (6½)hours,

to allow time to test for eight (8) hour strength. The remaining series shall be cored at two (2) days for seventy-two (72) hour compressive strength and twenty-eight (28) day compressive strength. Three (3) beams shall be cut from the on site test panel at six (6) days of age. In addition to the compression testing, the cores and beams shall be carefully examined visually for soundness or evidence of nonuniformity in the consistency of the shotcrete. The Contractor shall saw one of the test panels into several pieces to allow visual inspection of the shotcrete density, void structure and coverage of any reinforcement.

All phases of the preconstruction testing will be done in the Engineer's presence. The average compressive strength of all cores from each test panel shall test to at least one hundred percent (100%) of the strength specified for each specified age with no individual core having a compressive strength of less than eighty eight percent (88%) of the specified strength. For the fiber-reinforced shotcrete, the first crack flexural strength and average toughness indices, for both I_{10} and I_{30} shall test to at least one hundred percent (100%) of the specified requirements. Cylindrical samples having a L/D of less than two (2), shall have the strength reduced in accordance with AASHTO T24.

6.14.3.4 Safety. Alkali hydroxides and other chemicals contained in shotcrete admixtures are toxic and can cause skin and respiratory irritation; adequate safety measures shall be undertaken. The Contractor shall maintain safety in all areas where shotcrete is to be handled or applied, including dust protection to the satisfaction of the Engineer. To ensure protection against detrimental effects from such caustic material, nozzlemen, operators, helpers, and any other nearby personnel, during application of shotcrete, shall wear gloves, adequate protective clothing, goggles or face shields, and approved respirators equipped with filters which prevent passage of caustic mists. The Contractor shall furnish and maintain at his own expense two additional sets of approved head and face protection equipment and toxic-free breathing apparatus for the exclusive use of the Engineer throughout the project.

After preliminary testing has shown that mix design process and workmanship are capable of providing a satisfactory product, the Engineer will authorize Work on the structure.

6.14.4 EQUIPMENT.

6.14.4.1 Proportioning and Mixing Equipment. The following shall apply: Aggregate and cement shall be proportioned on a weight basis conforming to the applicable provisions of AASHTO M157. Volumetric batching may be used, subject to the Engineer's approval, providing that a weight batching is done every four hours of shotcreting in accordance with AASHTO M241, Sections 6.4 (Yield Check) and 6.5 (Proportioning Check), except that the former may be checked by simple metered weight. Ready mixed shotcrete shall be delivered in transit mixers that comply with AASHTO M157.

The application of the mixture shall be done within sixty (60) minutes after adding cement to the mixer. This time allotment may be reduced by the Engineer if cement prehydration in the mixer results in significant rebound, insufficient bonding and/or reduced compressive strength.

Mixing and placing equipment shall be capable of continuous operation and shall deliver a uniform and uninterrupted material flow, without segregation or loss of any ingredients.

Any accelerating admixture shall be added immediately prior to final mixing, of in liquid form, shall be accurately proportioned into the water supply by metering at the application nozzle. Dry additive whether powder or finely ground from a solid at the mixer shall be accurately proportioned by mechanical means and shall be thoroughly mixed with the other ingredients.

6.14.4.2 Water and Air Supply Systems. The following shall apply:

1. Water Supply. The water supply, for the dry mix process, shall have three and one-half (3.5) kilograms per square centimeter or greater pressure in excess of the air pressure at the nozzle water ring.

2. Air Supply. The air supply shall be capable of supplying sufficient uniform constant pressure to convey shotcrete materials as recommended by the manufacture. An air supply system shall not be contaminated by oil or contain excessive moisture.

6.14.4.3 Delivery Equipment. The equipment shall be provided with a device which can be directly correlated to production (i.e. cubic meter) either by direct volume or a machine constant.

The delivery machine shall be capable of introducing materials to the delivery hose at a uniform rate, with ejection from the nozzle at velocities that will afford adherence of material to the treated surface with a minimum rebound and maximum adherence and density.

6.14.4.4 Placing Equipment. Placing equipment for wet-mix process shall be capable of handling and applying shotcrete containing the specified maximum size aggregate and accelerating admixture. If accelerating admixture is to be added at the nozzle, the placing equipment shall provide for accurate proportioning and adequate mixing of accelerator with the other shotcrete ingredients.

6.14.5 CONSTRUCTION.

6.14.5.1 Preparation of Surface for Shotcreting. Surfaces, which are to receive shotcrete whether new or previously shotcreted, shall be cleaned of all loose material. Loose rock, mud and other foreign matter shall be removed by a combination water and high velocity air jet. Surfaces shall be moist at the time of application. Surfaces are unacceptable if they are excessively dry, dusty or have frost.

Non-corrosive measuring pins or gage wires shall be installed on not greater than one (1) meter centers in all directions or depth check holes shall be drilled on a random basis in each four (4) square meters of shotcrete to verify that the requirement minimum thickness is being provided. When it is determined that the minimum thickness is not being provided, the Contractor shall drill additional core holes where and as directed by the Engineer, to determine the limits of the deficient shotcrete and to make additional placements of shotcrete in these areas to bring thickness up to the specified minimum. No additional payment will be made for these requirements.

When a layer of shotcrete is to be covered by a succeeding layer at a later time, it shall first be allowed to develop its initial set. All laitance, loose material, and rebound shall then be removed by brooming or scraping. Laitance which has been allowed to develop final set and which cannot be cleaned by brooming or scraping shall be removed by sandblasting.

6.14.5.2 Shotcrete Application. The Contractor shall coordinate shotcrete application with excavation and ground support installation.

Shotcrete shall be applied using the same equipment, techniques, and nozzlemen as used to place the accepted preconstruction test panels. The nozzle shall be held at a predetermined distance and position so that the stream of shotcrete shall flow as nearly as possible at right angles to the surface to be covered. When filling around any steel ground reinforcement, the nozzle shall be held at a slight angle so that the metal is completely encased. The shotcrete shall be applied from the lower part of the area upwards so that rebound does not accumulate on the portion of the surface that still has to be covered.

Shotcrete shall emerge from the nozzle in a steady uninterrupted flow. When, for any reason, the flow becomes intermittent, the nozzle shall be diverted from the Work until steady flow resumes. The velocity of materials ejected from the nozzle shall be such that with the clockwise rotation of the nozzle, the required compaction of the material with minimal rebound and segregation, and maximum placement density are achieved. Care shall be taken to ensure a product of uniform consistency and quality. Equipment shall be provided to allow application of shotcrete to surfaces at an appropriate range of one (1) to one and one-half (1.5) meters from the nozzle.

Acceptable shotcrete shall consist of a dense and uniform concrete without rebound inclusions, segregation, or discernible weakness of bond between layers. All laitance, loose material and rebound shall be removed and the surface layer sounded with a hammer for voids, rebound or aggregate pockets, and unbounded areas. Defective areas shall be removed and replaced as specified herein at the Contractor's expense.

Construction joints shall be tapered over a minimum distance of four hundred eighty (480) millimeters to a thin edge, and the surface of such joints shall be thoroughly wetted before any adjacent section is placed.

6.14.5.3 Shotcrete Curing. New shotcrete shall be cured for seven days by keeping its surface moist. Moisture may be applied by sprinkling, intermittent light hosing or other methods approved by the Engineer. The surface is not permitted to be dry at any time during the curing period.

6.14.6 QUALITY ASSURANCE PROCEDURES. The shotcrete will be inspected, sampled, tested and evaluated in accordance with Section 1.08 "Acceptance of Work" in these General Specifications.

6.14.6.1 Quality Assurance Sampling and Testing. An acceptance sample consists of three cores. Test cores shall be obtained from work and may be taken on partially applied shotcrete or completed shotcrete, at the Engineer's discretion. The Engineer will determine the locations and dates. The frequency of sampling shall be:

MINIMUM MANDATORY TESTING

Material	Test	Location	Frequency	Notes
Shotcrete, Reinforced Shotcrete and Fiber-Reinforced Shotcrete (all categories)	AASHTO T24	On-Site	1 set of 3 cores per 50 cubic meters placed.	Individually sealed in plastic bags, tagged for identification and delivered to project lab. Minimum forty (40) hours to break date as per T-24 specification.

An acceptance sample shall be obtained by the Contractor for each fifty (50) cubic meters of shotcrete placed. Each sample shall consist of three cores from the completed Work, cored at twenty-six (26) days of age. At the Engineer's option, the Engineer may require cores from the panels in lieu of cores from the Work.

Testing and core sampling shall be done utilizing AASHTO T24 procedures. The core samples shall be seventy-five (75) millimeters diameter. The Contractor shall perform the core sampling and test the samples under the supervision of the Engineer. Core lengths shall be the full thickness of the shotcrete or as otherwise directed by the Engineer and shall expose the bond between shotcrete and rock.

The voids caused by the coring operation shall be plugged by the use of material equal to the shotcrete in-place and workmanship to ensure continuity of the lining as to strength.

If the average strength of three cores from one area is less than eighty-five percent (85%) of the specified twenty-eight (28) day strength, corrective work shall be performed, including application of additional thickness of shotcrete or removal and replacement of the defective shotcrete as directed by the Engineer. Such corrective work shall be performed at no cost to the Ministry.

If any cores taken fail to show adequate bond with the rock, or bond between layers, or show obvious defects, or the strength or toughness requirements do not meet the minimums, the Engineer may direct the Contractor to do additional sampling/testing. This additional sampling/testing will be done at no cost to the Ministry.

If the shotcrete system selected by the Contractor fails to provide satisfactory in-place shotcrete in accordance with these Specifications, as determined by the Engineer, the Contractor shall modify his procedures, mix design, equipment or system accordingly, subject to approval of the Engineer.

6.14.6.2 Defective Shotcrete. Shotcrete that does not meet strength requirements or which lacks uniformity, exhibits segregation, honeycombing, or lamination, shows significant cracking, lacks reasonable watertightness, contains any dry patches, slugs, voids, or sand pockets, or is hollow shall be regarded as defective shotcrete.

The Engineer reserves the right to order removal of defective shotcrete and its replacement with acceptable corrective shotcrete as specified herein.

Any surface defects shall be repaired as soon as possible after any initial shotcrete placement. The Engineer will inspect all shotcrete visually and by hammer sounding. All shotcrete which sounds "hollow" or which exhibits defects noted above shall be removed and replaced with fresh shotcrete, at the Contractor's expense. Alternatively, the Engineer may allow application of an additional layer of full-thickness shotcrete.

Any corrective measure ordered by the Engineer to correct defective shotcrete shall be without cost to the Ministry.

6.14.7 METHOD OF MEASUREMENT. Shotcrete, Reinforced Shotcrete, and Fiber reinforced Concrete will be measured by the square meter when the depth is specified in the Pay Item description. Measurement of areas for payment will include only those areas where the full thickness called for on the plans is in place. Shotcrete, Reinforced Shotcrete, and Fiber Reinforced Shotcrete shall be measured by the cubic meter when the depth is not specified in the Pay Item description.

Adjustments to Shotcrete contract unit prices will be based on compressive strength for unreinforced, reinforced and fiber reinforced shotcrete.

6.14.8 PAYMENT. The accepted quantities determined as provided above will be paid for at the contract unit price per unit of measurement on the pay items listed below and the price and payment will be full compensation for the Work specified in Subsection 1.07.2, Scope of Payment" in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
61401	Shotcrete, 25 mm Depth	Square Meter
61402	Shotcrete, 50 mm Depth	Square Meter
61403	Shotcrete, 75 mm Depth	Square Meter
61404	Shotcrete, 100 mm Depth	Square Meter
61405	Shotcrete, 125 mm Depth	Square Meter

61406	Shotcrete, 150 mm Depth	Square Meter
61407	Shotcrete, 175 mm Depth	Square Meter
61408	Shotcrete, 200 mm Depth	Square Meter
61409	Shotcrete, ___ mm Depth	Square Meter
61412	Shotcrete	Cubic Meter
61413	Reinforced Shotcrete, 50 mm Depth	Square Meter
61415	Reinforced Shotcrete, 75 mm Depth	Square Meter
61416	Reinforced Shotcrete, 125 mm Depth	Square Meter
61417	Reinforced Shotcrete, 150 mm Depth	Square Meter
61418	Reinforced Shotcrete, 175 mm Depth	Square Meter
61419	Reinforced Shotcrete, 200 mm Depth	Square Meter
61420	Reinforced Shotcrete, ___ mm Depth	Square Meter
61423	Reinforce Shotcrete	Cubic Meter
61424	Fiber Reinforced Shotcrete, 50 mm Depth	Square Meter
61425	Fiber Reinforced Shotcrete, 75 mm Depth	Square Meter
61426	Fiber Reinforced Shotcrete, 100 mm Depth	Square Meter
61427	Fiber Reinforced Shotcrete, 125 mm Depth	Square Meter
61428	Fiber Reinforced Shotcrete, 150 mm Depth	Square Meter
61429	Fiber Reinforced Shotcrete, 175 mm Depth	Square Meter
61430	Fiber Reinforced Shotcrete, 200 mm Depth	Square Meter
61431	Fiber Reinforced Shotcrete, ___ mm Depth	Square Meter
61434	Fiber Reinforced Shotcrete	Cubic Meter

SECTION 6.15 - MODULAR RETAINING WALLS

6.15.1 DESCRIPTION. This Work shall consist of furnishing and installing cribwalls, binwalls, concrete panel walls, or other precast or prefabricated modular retaining wall systems as specified by the plans and Special Specifications.

ITEM IN BILL OF QUANTITIES
(Type) Modular Retaining Wall

6.15.2 MATERIALS.

6.15.2.1 Concrete. Concrete for precast concrete modules shall conform to Class C in Section 5.01, "Portland Cement Concrete" in these General Specifications. Concrete for footings shall conform to Section 5.03.9, "Concrete For Minor Structures" in these General Specifications.

6.15.2.2 Reinforcing Steel. "Reinforcement Steel" shall conform to Section 5.02 "Reinforcing Steel" in these General Specifications.

6.15.2.3 Steel Components. Steel components and hardware shall conform to the requirements shown on the plans. All components shall be galvanized in accordance with ASTM A 123 or A 153 as appropriate.

6.15.2.4 Geotextile Fabric. Geotextile fabric shall conform to the requirements for Type III Fabric - Geotextiles for Drainage Blankets in Section 6.16, "Geotextiles" in these General Specifications.

6.15.2.5 Underdrain. Underdrain shall conform to the requirements of Section 6.04, "Pipe Underdrain and Irrigation Pipe" in these General Specifications.

6.15.2.6 Drainage Layer. Drainage shall conform to the requirements of Section 6.21, "Drainage Layer" in these General Specifications and as detailed in the Special Specifications.

6.15.3 CONSTRUCTION REQUIREMENTS.

6.15.3.1 Preliminary. Prior to the fabrication of modules, the Contractor shall develop and submit to the Engineer for approval, detailed drawings of each wall section based on the typical drawings in the plans and onsite surveys conducted by the Contractor which confirm the dimensions of the design.

6.15.3.2 Foundation. The foundation for each section of wall shall be excavated, leveled, and compacted to Type 95 compaction. If required by the Engineer, the foundation shall be subexcavated and replaced with compacted Class A-1-a or A-1-b material or, if required, with concrete meeting the requirements contained in Subsection 5.03.9, "Concrete for Minor Structures" in these General Specifications.

6.15.3.3 Concrete Modules. Concrete modules shall be precast in accordance with the requirements of Section 5.03, "Concrete Structures" in these General Specifications. Modules shall not be placed in the structure until they have attained one hundred percent (100%) of their specified strength.

Modules, including all required hardware and miscellaneous components, shall be set in the structure in accordance with the plans and approved detailed drawings. Deflections due to backfilling shall be anticipated in setting the modules. After backfilling, the face of the wall shall not deviate from the theoretical design plane by more than one-half (½) of one (1) percent of the height of the wall at that point. Temporary wedges or clamps shall be used to hold modules in place during construction and backfill. Open joints shall be masked on the inside of the wall using three hundred (300) millimeter wide strips of geotextile fabric fastened to the wall with an approved adhesive.

6.15.3.4 Backfill. As construction progresses, the modular wall shall be backfilled in maximum fifteen (15) centimeter compacted lifts using Class A-1-a or A-1-b soil. Backfill material shall also contain not more than fifty percent (50%) rock fragments and boulders passing the fifteen (15) centimeter sieve and retained on the seven and five tenths (7.5) millimeter sieve. Backfill shall be compacted to Type 95 compaction.

6.15.3.5 Drainage. Adequate provisions shall be made for the thorough draining of the backfill to weep holes or to a separate underdrain system through a sheathing material or geocomposite sheet drain drainage layer as detailed in the Plans and Special Specifications for the specific type(s) modular retaining wall system listed in the Bill of Quantities.

6.15.4 QUALITY ASSURANCE PROCEDURES. The modular retaining walls will be inspected, sampled, tested and evaluated in accordance with Section 1.08, "Acceptance of Work" in these General Specifications as follows:

The materials incorporated into the walls shall be sampled, tested and evaluated in accordance with the General Specification Sections referenced in Subsection 6.15.2 "Materials" in this Section in these General Specifications. The construction of the walls will be accepted in accordance with Subsection 1.08.4, "Measured or Tested Conformance" in these General Specifications.

6.15.5 METHOD OF MEASUREMENT. (Type) Modular Retaining Wall shall be measured by the square meter based on the nominal dimensions of the front face of each section of wall as shown on the approved detailed drawings, completed and accepted by the Engineer.

Foundation excavation and backfill below the original ground elevation shall be measured in accordance with Subsection 2.09.8 "Method of Measurement" for "Structural Excavation-Other Structures" in these General Specifications. Backfill above the original ground elevation shall be included in the approved cross sections for Section 2.05, "Embankment" in these General Specifications.

Geotextile fabric and concrete for footings shall be considered subsidiary to the retaining wall.

Underdrain and drainage layers detailed in the Plans and Special Specifications will not be measured separately but will be considered subsidiary to the wall system(s) listed in the Bill of Quantities.

6.15.6 PAYMENT. The completed and accepted Work, measured as described above, will be paid at the contract unit price(s) shown in the Bill of Quantities, which price(s) shall include all required materials, equipment, tools, labor and all other items necessary for the proper completion of the Work as specified in Subsection 1.07.2, "Scope of Payment" in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO.	PAY ITEM	PAY UNIT
61501	Crib Wall Modular Retaining Wall	Square Meter
61502	Binwall Modular Retaining Wall	Square Meter
61503	Concrete Panel Modular Retaining Wall	Square Meter

SECTION 6.16 - GEOTEXTILES

6.16.1 DESCRIPTION. This Section covers requirements for erosion control (slope protection and channel lining), subsurface drainage (underdrains and drainage blankets) and subgrade restraint (subgrade or embankment foundation stabilization) construction using geotextile fabrics, when required elsewhere in the Contract Documents.

ITEMS IN THE BILL OF QUANTITIES
Geotextile Fabric, Type

6.16.2 MATERIALS.

6.16.2.1 General. Geotextiles shall be woven or nonwoven fabrics as specified and shall consist of long chain polymeric filaments or yarns such as polypropylene, polyethylene, polyester, polyamide, or polyvinylidene-chloride formed into a stable network such that the filaments or yarns retain their relative position to each other and be free of defects and tears. These fabrics shall be resistant to deterioration due to ultraviolet exposure, ambient temperatures, acid and alkaline conditions, oils, micro-organisms and insects.

During shipment and storage, the rolls of fabric shall be protected from exposure to the sun, or any light containing ultraviolet rays, heat, dirt and other detrimental conditions. The fabric shall be placed in a dry place off the ground in straight piles according to ASTM D 4873. Except for fabrics designed for slope stabilization and soil erosion control work, the geotextiles shall not be exposed to ultraviolet radiation for more than two (2) days.

The fabric, except wrapping placed directly against perforated pipe, shall be formed in widths of at least 2 meters. Sheets of fabric may be sewn together to form fabric widths as required. The sheets of fabric shall be sewn together at the point of manufacture or other approved locations. The geotextile manufacturer is responsible for establishing and maintaining a quality control program so as to assure compliance with the requirements of this specification.

6.16.2.2 Definitions. The following definitions apply to geotextiles:

1. Machine Direction. The long (or warp) direction of the geotextile. The cross-machine (or fill) direction is perpendicular to the machine direction.

2. Mean Roll Values. The mean roll value of any specific geotextile property is the average of the test results from any roll within a lot.

3. Nonwoven Geotextile. A textile produced by bonding or interlocking of fibers, or both, accomplished by mechanical, heat or chemical means.

4. Seam Allowance. The minimum distance from the edge of a geotextile to the stitch line nearest to that edge.

5. Seam Type. A designation relating to the essential characteristics of geotextile positioning and rows of stitching in a specified sewn seam, as shown on the plans.

6. Selvedge. The finished edge of a geotextile parallel to the machine direction.

7. Stitch Type. A designation relating to the essential characteristics of the interlacing of sewing thread(s) in a specified seam, as shown on the plans.

8. Woven Geotextile. A textile comprising of two or more sets of filaments or yarns interlaced in such a way that they result in a uniform pattern.

6.16.2.3 Materials Acceptance.

6.16.2.3.1 Source Approval. Prior to installation of the proposed fabric, the Contractor shall submit to the Engineer a copy of a mill certificate or affidavit signed by a legally authorized official from the company manufacturing the fabric.

The mill certificate or affidavit shall attest that the fabric meets the chemical, physical, and manufacturing requirements stated in this specification. The sample shall be labeled with the lot and batch number, date of sampling, project number, property specifications, manufacturer, and product name.

6.16.2.3.2 Control Testing. As soon as the fabric arrives at the project site, samples will be randomly selected by the Contractor under the supervision of the Engineer and submitted to an independent testing Materials Testing Laboratory for testing and to confirm that the correct fabric was received and that it meets the property values specified.

One sample from the inner wraps of each five (5) rolls or fraction thereof, up to a maximum of five (5) samples, shall be chosen at random from each shipment. Size of sample shall be one (1) meter by the full roll width of the fabric. The Contractor shall also furnish, with each shipment of fabric, a Certificate of Guarantee from the manufacturer of the fabric. The Certificate shall attest that the fabric meets the chemical, physical and manufacturing requirements stated in this General Specification and include actual test results for each physical requirement.

6.16.2.4 Physical Requirements. The fabric furnished may be either woven or non-woven, at the Contractor's option. The fabric shall meet the requirements of Table 6.16-1, Table 6.16-2, Table 6.16-3 or Table 6.16-4 as specified for each use.

6.16.2.5 Fastener Pins. Fastener pins for use when fabric is installed in underdrain systems shall be formed of No. 9 or heavier steel wire and shall be at least three hundred (300) millimeters long with a one hundred (100) millimeters right angle bend on one end.

Fastener pins for use when the fabric is used under slope protection or channel lining, for subgrade or embankment foundation stabilization, or is used to wrap aggregate drainage blankets, shall be steel, six (6) millimeters in diameter, pointed at

one end, fabricated with a head to retain a steel washer having an outside diameter of at least forty (40) millimeters, and at least forty (40) millimeters long.

Fastener pins will be accepted based on visual inspection by the Engineer on the project.

6.16.2.6 Other Materials. Aggregates, perforated pipe, and other materials that may be specified in the contract shall meet the requirements of the Standard Specifications or as provided elsewhere in the Contract.

TABLE 6.16-1 - TYPE I FABRIC
GEOTEXTILES FOR SLOPE PROTECTION AND CHANNEL LINING

PROPERTY	MINIMUM VALUE[1]	TEST METHOD
Grab Strength (kg.)	90	ASTM D 4632
Elongation (%)	15	ASTM D 4632
Sewn Seam Strength[2](kg.)	80	ASTM D 4632
Puncture Strength (kg.)	36	ASTM D 4833
Burst Strength (kg/cm^2)	22	ASTM D 3786
Trapezoid Tear (kg.)	22	ASTM D 4533
Apparent Opening Size	Hole size equal to or	ASTM D 4751
(U.S. Std. Sieve)	smaller than a U.S.#40	
Sieve (0.425 mm)		
Permeability (cm/sec.)	0.015	AASHTO M 288
Ultraviolet Degradation	70% strength retained	
at 150 hours	for all classes	ASTM D 4355

(1) Minimum. Use value in weaker principal direction. All numerical values represent minimum average roll value (i.e. test results from any sampled roll in a lot shall meet or exceed the minimum values in the Table)

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(2) Values apply to both field and manufactured seams.

TABLE 6.16-2 - TYPE I FABRIC
GEOTEXTILES FOR SLOPE PROTECTION AND CHANNEL LINING

PROPERTY	MINIMUM VALUE[1]	TEST METHOD
Grab Strength (kg.)	36	ASTM D 4632
Elongation (%)	N/A	ASTM D 4632
Sewn Seam Strength[2](kg.)	30	ASTM D 4632
Puncture Strength (kg.)	10	ASTM D 4833
Burst Strength (kg/cm^2)	9	ASTM D 3786
Trapezoid Tear (kg.)	10	ASTM D 4533
Apparent Opening Size (U.S. Std. Sieve) Sieve (0.425 mm)	Hole size equal to or smaller than a U.S.#40	ASTM D 4751
Permeability (cm/sec.)	0.025	AASHTO M 288
Ultraviolet Degradation at 150 hours	70% strength retained for all classes	ASTM D 4355

1. *Minimum. Use value in weaker principal direction. All numerical values represent minimum average roll value (i.e. test results from any sampled roll in a lot shall meet or exceed the minimum values in the Table)*

2. *Values apply to both field and manufactured seams.*

3. *The AASHTO 288-97 Geotextile Specification for Highway Applications TABLE 2. Subsurface Drainage Geotextile Requirements are in addition to the above Table 6.16-2 Type II Fabric Requirements*

TABLE 6.16-3 –TYPE III FABRIC
GEOTEXTILES FOR SUBGRADE OR EMBANKMENT STABILIZATION

Table 6.16-3 is composed of the following referenced three (3) Tables in ASSHTO M 288-97.

TABLE 1 - Geotextile Strength Property Requirements
TABLE 2 - Separation Geotextile Property Requirements
TABLE 3 –Stabilization Geotextile Property Requirements

(1) Minimum. Use value in weaker principal direction. All numerical values represent minimum average roll value (i.e. test results from any sampled roll in a lot shall meet or exceed the minimum values in the Table).
(2) Values apply to both field and manufactured seams.

TABLE 6.16-4 - TYPE IV FABRIC GEOTEXTILES FOR DRAINAGE BLANKETS

PROPERTY	MINIMUM VALUE[1]	TEST METHOD
Grab Strength (kg.)	80	ASTM D 4632
Elongation (%)	N/A	ASTM D 4632
Sewn Seam Strength[2](kg.)	70	ASTM D 4632
Puncture Strength (kg.)	36	ASTM D 4833
Burst Strength (kg/cm^2)	204	ASTM D 3786
Trapezoid Tear (kg.)	22	ASTM D 4533
Apparent Opening Size (U.S. Std. Sieve) Sieve (0.300 mm)	Hole Size Equal to or Smaller than a U.S.#50	ASTM D 4751
Permeability (cm/sec.)	0.020	AASHTO M 288
Ultraviolet Degradation at 150 hours	70% Strength Retained for All Classes	ASTM D 4355

(1) Minimum. Use value in weaker principal direction. All numerical values represent minimum average roll value (i.e. test results from any sampled roll in a lot shall meet or exceed the minimum values in the Table).
2) Values apply to both field and manufactured seams.

6.16.2.7 Acceptance Procedures for Non-Specification Fabric. It is intended that all geotextile fabric used in Ministry work shall meet the requirements of the applicable specifications. However, when geotextile fabric which fails requirements has been inadvertently incorporated into the work prior to completion of testing, the material may be accepted with a reduction in pay provided the failure(s) will not cause poor performance. When the failure is excessive, then the geotextile fabric shall be removed and replaced unless the Engineer determines that the geotextile fabric can remain in place. The largest payment reduction will be applied when the material fails to meet more than one specification requirement. The payment reduction will be calculated on the invoice cost of the material delivered at the project site. Geotextile fabric that fails and has not been incorporated into the Work will be rejected and shall not be used on the project.

AOS PAYMENT REDUCTION

% #35-#40 or % #45-#50 Glass Beads Passing Fabric as Applicable	0-5	6-10	11-15	16-20	21 or More
Reduction Rate	0%	20%	30%	40%	*

GRAB STRENGTH PAYMENT REDUCTION

% of Requirement	100% or more	90-99%	75-89%	74% or Less
Reduction Rate	0%	25%	40%	*

ELONGATION PAYMENT REDUCTION
TYPE I FABRIC ONLY

% of Requirement	100% or more	90-99%	75-89%	74% or Less
Reduction Rate	0%	25%	40%	*

SEWN SEAM STRENGTH PAYMENT REDUCTION

% of Requirement	100% or more	90-99%	75-89%	74% or Less
Reduction Rate	0%	25%	40%	*

**Fabric shall be removed and replaced unless the Engineer determines the fabric can remain in place at a 100% reduction rate.*

6.16.3 CONSTRUCTION REQUIREMENTS.

6.16.3.1 General. The fabric shall be placed in the manner and at the locations shown on the plans. At the time of installation, fabric will be rejected if it has defects, rips, holes, flaws, deterioration, or damage incurred during manufacture, transportation or storage. The surface to receive the fabric shall be prepared to a relatively smooth condition free of obstruction, debris or sharp objects that may puncture the fabric. Construction equipment will not be permitted to operate directly on the fabric.

The fabric shall be protected at all times during construction from contamination by surface runoff and any fabric so contaminated shall be removed and replaced with uncontaminated fabric.

Any fabric damaged during installation or during placement of filter materials, slope protection or other materials shall be repaired or replaced at no cost to the Ministry. Extensively damaged fabric shall be removed and replaced as directed. When the majority of the fabric is undamaged, individual isolated cuts, tears or punctures may be repaired by placing a patch of geotextile fabric over the damaged area. The patch shall extend at least one meter beyond the damage in all directions or the entire perimeter of the patch shall be fastened by sewing as specified in Paragraph 6.16.3.2 "Field Splices" in these General Specifications at the Contractor's option.

Fabric shall be covered with a layer of the specified material within fourteen (14) calendar days after placement of the fabric; fabric not covered within this time shall be removed and replaced at the Contractor's expense if damage or deterioration is evident as determined by the Engineer. Fabric not covered within thirty (30) calendar days after placement shall be removed and replaced at no cost to the Ministry.

6.16.3.2 Field Seams.

6.16.3.2.1 General. Field splices at edges or ends of the fabric made by sewing with a portable sewing machine which produces a lock stitch. The strength across the seam shall be least sixty percent (60%) of the fabric strength in that direction. The Contractor shall obtain the Engineer's approval before field seaming and stitching. Sew field seams with polymeric thread consisting of polypropylene, polyester, or kevlar, and as resistant to deterioration as the geotextile being sewn. Use a color of thread that contrasts with the geotextile being sewn so the stitches are exposed for inspection when the geotextile is placed.

6.16.3.2.2 Stitch Requirements. Use two (2) rows of lock-type stitching, Type 401, to make the seams, as shown. The two (2) rows of stitching shall be twelve (12) millimeters apart with a tolerance of ± six (6) millimeters and not cross except for restitching.

6.16.3.2.3 Minimum Seam Allowance. The minimum seam allowance, that is, the minimum distance from the edge of geotextile to the nearest stitchline is:

Seam Type (See Plans)	Minimum Seam Allowance, Millimeters
Flat or Prayer Seam Type SSa-1	38
"J" Seam, Type SSn-1	25
Butterfly-folded Seam, Type SSd-1	25

6.16.3.2.4 Seam Type. Obtain the geotextile manufacturer's recommendation for the type of seam and stitch to be used. If the Contractor does not obtain and provide the foregoing technical information, use a "J" seam with at least three (3) stitches per twenty-five (25) millimeters. The flat, or prayer, seam may be used for repair of damaged in-place geotextile.

6.16.3.3 Overlaps. Where appropriate, overlapping instead of sewn seams, will be allowed. Minimum overlap requirements for geotextiles are:

Geotextile Application	Minimum Overlap Requirements, Millimeters
Drainage Blankets	300
Embankment Stabilization	600
Underdrains	600
Slope Protection and Channel Lining	600
Roadbed Subgrade Stabilization	600

6.16.3.4 Slope Protection and Channel Lining. Type I fabric shall be placed with the long dimension parallel to the channel or toe of slope and shall be laid smooth and

free of tension, stress, folds, wrinkles or creases. Transverse laps shall be placed so the upstream strip laps over the downstream strip. Horizontal laps shall be placed so the lower strip laps over the upper strip. Laps may be eliminated provided the joint is sewn as specified in Paragraph 6.16.3.2, "Field Seams" in these General Specifications.

Fastener pins shall be installed through both strips of overlapped fabric at no less than two (2) meter intervals along a line through the midpoint of the overlap, and at any other locations as necessary to prevent any slippage of the fabric.

The fabric shall be protected from damage due to the placement of the slope protection or channel lining by limiting the height of drop of the material to no greater than three tenths (0.3) meter or no greater than one (1) meter when a cushioning layer of sand is placed on top of the fabric before dumping the material, at the Contractor's option. The Contractor shall demonstrate that the placement technique will prevent damage to the fabric. Placement of material shall begin at the toe and proceed up the slope.

6.16.3.5 Underdrains. Type II fabric shall be placed and shaped to the sides and bottom of the trench with suitable equipment, without stretching. Care shall be taken so that the required amount of fabric will be available for top lap. The filter aggregate shall be placed so as not to damage, displace, or dislodge the fabric, and shall be placed as specified in Section 6.04, "Pipe Underdrain and Irrigation Pipe," in these General Specifications. The fabric shall then be folded over the backfilled trench and secured with steel pins at intervals of two (2) meters to produce a double thickness of fabric over the full width of the top of the trench.

The fabric shall be ordered in lengths to minimize the number of splices necessary. When splices between rolls are necessary, the fabric shall be placed so that the upstream roll overlaps the downstream roll a minimum of six hundred (600) millimeters and shall be secured with fastener pins as directed. The lap and fastener pins may be eliminated provided the joint is sewn as specified in Paragraph 6.16.2.4, "Field Splices" in these General Specifications.

6.16.3.6 Subgrade or Embankment Foundation Stabilization. Type III fabric shall be placed with the long dimensions parallel to the long dimensions of the area to be covered and shall be laid smooth and free of tension, stress, folds, wrinkles or creases. The embankment foundation area to be stabilized shall be cleared of sharp objects which might damage the fabric during installation. Surface vegetation (grasses, weeds, etc.) shall be left in place. All laps, both longitudinal and transverse, shall be at least one-half (0.5) meters and shall be secured with fastener pins at two (2) meter intervals along a long through the midpoint of the overlap. This overlap is normally sufficient for a good joint, however, it may become necessary to sew the overlapped sections. When sewn joints are directed or approved, sewing shall be specified in Paragraph 6.16.3.2, "Field Seams" in these General Specifications.

During back dumping and spreading, the wheels of trucks, dozer blades and other equipment shall travel on previously placed fill and shall not make direct contact with the fabric. The material shall be spread in the direction of the fabric overlap. Large fabric

wrinkles which may develop during spreading operations shall be folded and flattened in the direction of the spreading. Occasionally, large folds may reduce the fabric overlap width. Special care shall be given to maintain proper overlap and fabric continuity. For the first lift, the thickness shall be the minimum that will support construction equipment with two hundred (200) to four hundred (400) millimeter ruts. A minimum of between two-tenths (0.2) meters and three-tenths (0.3) meters of fill shall be maintained between the structures and geotextile.

6.16.3.7 Drainage Blankets. Type IV fabric shall be placed with the long dimensions parallel to the long dimensions of the area to be covered and shall be laid smooth and free of tension, stress, folds, wrinkles or creases. All laps, both longitudinal and transverse, shall be at least one-half (0.5) meters except laps may be eliminated provided the joint is sewn as specified in Paragraph 6.16.3.2, "Field Seams" in these General Specifications.

The drainage blanket material shall be placed to present a reasonably even surface free from mounds or depressions. After the material is placed, the fabric shall be folded over the ends and sides of the material and additional fabric placed over the material so that the material is completely encased within the fabric. All laps that are not sewn shall be secured by fastener pins at one (1) meter intervals along a line through the midpoint the lap. Additional pins, regardless of the location, shall be installed as necessary to prevent any slippage of the fabric. The fabric shall be placed so that laps do not occur at the edges or ends of the drainage blanket. Embankment shall be placed in a manner to avoid damage or displacement of the completed drainage blanket.

Light equipment shall be used for spreading fill material over previously placed material.

6.16.4 QUALITY ASSURANCE PROCEDURES. Geotextile fabric shall be sampled, tested and evaluated in accordance with Section 1.08, "Acceptance of Work" of these General Specifications as follows: Fabric materials acceptance shall be in accordance with Paragraph 6.16.2.3 "Materials Acceptance" and 6.16.2.7 "Acceptance Procedures for Non-Specification Fabric" in these General Specifications. Construction of the Geotextile fabric shall be accepted in accordance with Subsection 1.08.4, "Measured or Tested Conformance" in these General Specifications.

6.16.5 METHOD OF MEASUREMENT. When fabric is used for underdrains, either to wrap perforated pipe or to wrap aggregate, measurement and payment will as specified in Section 6.04 "Pipe Underdrain and Irrigation Pipe" in these General Specifications as applicable. No separate measurement of payment will be made for fabric when the plans or proposal indicate the fabric is incidental to the Work, when the specifications for another item requires incidental installation of geotextile fabric, or when no separate bid item for fabric is listed in the proposal.

When a separate bid item for fabric is listed in the proposal, fabric of each type will be measured in square meters except where the Contract indicates the fabric is incidental to other Work or items.

When the fabric is used to completely enclose an aggregate drainage blanket, the area measured for payment will be the sum of (1) the area of the lower surface of the aggregate layer, (2) the area of the upper surface of the aggregate layer, and (3) the area of the sides and ends of the aggregate layer; dimensions used to calculate these areas will be the dimensions shown on the plans or as directed. When used for other purposes, the entire surface area covered as specified or directed will be measured. No allowance will be made for material in laps or seams. Fastener pins will not be measured for separate payment, but will be considered incidental to the fabric.

6.16.6 PAYMENT. The accepted quantity of fabric and geocomposite of each type will be paid for at the contract unit price per square meter, which payment shall be full compensation for all materials, labor, equipment, and incidentals necessary to acceptably furnish and place the fabric and complete the Work as specified in Subsection 1.07.2, "Scope of Payment" in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
61601	Geotextile Fabric, Type I	Square Meter
61602	Geotextile Fabric, Type II	Square Meter
61603	Geotextile Fabric, Type III	Square Meter
61604	Geotextile Fabric, Type IV	Square Meter
61605	Geotextile Fabric, Type V	Square Meter
61606	Geotextile Fabric, Type _	Square Meter

SECTION 6.17 - SOIL NAILED WALL

6.17.1 DESCRIPTION. This Work consists of constructing soil nailed walls by internally reinforcing the soil mass with cement grouted steel bars, and providing vertical drainage and a reinforced shotcrete facing in close conformity with the lines, grades, dimensions, and design parameters shown on the plans or directed by the Engineer. The wall shall be constructed from the top down as the soil and rock in front of the wall are removed and the nails are installed, grouted and the facing applied at each level. The soil nailed wall system shall provide permanent or temporary stabilization for the exposed slopes.

ITEMS IN BILL OF QUANTITIES
Soil Nail Wall No. __
Additional Length of Nails

6.17.2 MATERIALS. Materials shall conform to the following referenced Sections in these General Specifications and other referenced test methods:

Epoxy Coated Soil Nail Bars:	(threaded as necessary)
Steel:	AASHTO M31-Grade 60 thread as necessary. Only nails greater than 10 meters in length may be spliced using a mechanical splicer.
Epoxy Coating:	AASHTO M284. Bend Test requirements shall be waived.

The minimum coating thickness for epoxy shall be fourteen (14) mils and the maximum thickness shall be eighteen (18) mils.

Welded Steel Wire Fabric:	Section 5.02-"Reinforcing Steel"
Shotcrete:	Section 6.14- "Shotcrete"
Grout:	Paragraph 5.04.3.6 - "Grout"
Mortar:	Subparagraph 5.01.3.1.4
Plates:	AASHTO M183
Nuts:	AASHTO M291, Grade B, Hexagonal

Plates and nuts shall be epoxy coated with the same minimum and maximum thickness as the soil nail bars. At least two bar, plate, and nut assemblies shall be tested in accordance with ASTM F432. The results of these tests shall be submitted to the Engineer at least ten (10) days prior to the installation of any soil nail bars.

Centralizers: Minimum diameter twelve (12) millimeters less than the nominal diameter of the drill hole.

Centralizers shall be plastic and so constructed so to insure a minimum grout cover of at least twenty-five (25) millimeters around the soil nail bar.

Horizontal Drains. Provide as required and shown on the Plans, slotted and unslotted PVC pipe conforming to AASHTO M-278. The Contractor shall make provisions to assure that the hole does not collapse prior to the insertion of the slotted drain. Only the front three hundred (300) millimeters of drain pipe shall be unslotted.

Vertical Wall Drains. Provide as required and shown on the Plans, prefabricated, fully wrapped preformed geocomposite drains. The core, not less than six (6) millimeters thick or more than twelve (12) millimeters thick, shall be either a preformed grid of embossed plastic or a system of plastic pillars and interconnections forming a semirigid mat. The core material when covered with filter fabric shall be capable of maintaining a drain void for the entire height of permeable liner. Preformed drains shall be no wider than three hundred (300) millimeters unless special methods are used to insure adherence of the shotcrete to the fabric and to preclude the fabric from sagging under the weight of the shotcrete. They shall be suitably outletted or connected to a longitudinal drain at the bottom of the structure. When splicing of drains is required, full flow through the splice shall be maintained and splices shall be suitably protected from damage and contamination during subsequent shotcreting. The shotcrete shall be full thickness over the drain.

6.17.3 CONSTRUCTION REQUIREMENTS.

6.17.3.1 Submittals. Material certifications, instrumentation installation and connection details, personnel qualifications, and detailed excavation and construction procedures and sequencing plans shall be submitted to the Engineer for review and approval at least two weeks prior to the commencement of work under this item. This submittal shall include all details for the installation and load testing of test nails described in this Section of these General Specifications.

All necessary torque wrenches, hydraulic jacks, and related equipment for the installation and testing of soil nails shall be provided and maintained in good working order by the Contractor. The Contractor shall provide certified calibrations for each of these devices dated not more than thirty days prior to their first use on this project. The Contractor may be required to verify the calibration of any torquing or jacking equipment should any question arise concerning the accuracy of these devices.

Within thirty (30) days after the completion of each soil nailed wall, the Contractor shall provide as-built drawings, grouting records, and soil nail test results for all work on that wall. The drawings shall be compatible with, at a similar scale to, and similarly detailed as the contract drawings for this work. The grouting records and soil nail test results shall be compiled and summarized in a neat, logical and readable manner.

6.17.3.2 Qualifications. The Contractor shall submit proof of two projects on which he has constructed retaining walls using soil nails or ground anchors within the past five (5) years. The Contractor's staff on this project shall include a supervising engineer with at least three (3) years experience in the construction of soil nailed or ground anchored walls.

Drill operators and foremen shall have a minimum of two years experience in the installation of soil nails or ground anchors. Shotcrete nozzle operators shall have at least one year experience in the application of shotcrete or work under the immediate supervision of a foreman or instructor with at least two years of such experience. Shotcrete nozzle operators shall be qualified in accordance with ACI Test Panel Certification Procedures detailed in Paragraph 6.14.3.2 "Personnel" in these General Specifications. The Contractor shall submit resumes documenting that project personnel have the required experience and work shall not begin until the Engineer has approved the proposed personnel in writing. Changes to approved personnel shall not be made until approved in writing by the Engineer.

6.17.3.3 Sequence. The sequence of construction shall be as outlined in Paragraphs 6.17.3.4, Excavation" through 6.17.3.7, "Final Shotcreting'below unless otherwise proposed by the Contractor and approved by the Engineer, in these General Specifications. Consideration will be given to make the sequence more site specific including installing the nails before the face is shotcreted provided the cut face remains stable.

6.17.3.4 Excavation. Excavation shall proceed in stages with each stage exposing the minimum amount of soil or rock face which will allow the practical and expeditious application of the initial layer of shotcrete and the installation of soil nails while assuring stability of the excavated face and minimizing ground movements. The excavation should be within the limits and construction stages indicated in the Plans.

6.17.3.5 Initial Shotcrete. After each stage is excavated the cut surface shall be cleaned of all loose material, mud, rebound, and other foreign matter than could prevent or lessen the bond of the shotcrete to the soil or rock face. No exposed face will be allowed to stand for more than twenty-four (24) hours without applying the initial shotcrete layer. All surfaces shall be dampened and all permanent drainage and instrumentation for the exposed area shall be installed prior to the application of the initial shotcrete layer.

The Contractor shall install permanent drainage as specified in the submitted Plans. Connect drainage system at the bottom of the wall in such a manner as to carry the water away from the toe. Use weep holes, horizontal drains, or other methods to control seepage. Where used, weep holes shall be six-tenths (0.6) meter long, fifty (50) millimeter diameter, slotted drain pipe (Schedule 40 PVC) placed in pre-drilled holes sloped five percent (5%) to drain. During placement of shotcrete the weep holes shall be protected against contamination to insure proper functioning.

Apply shotcrete with the same equipment and the same technique as those used in the approved test panels. Nozzle operators performing the test panels to be the same operators used to place shotcrete in the work. Thickness measuring pins shall be installed on one and five-tenths (1.5) meter centers in each direction. The pins shall be non-corrosive. Other methods to establish if the required minimum thickness of shotcrete is being applied may be approved if Contractor can satisfactorily demonstrate the reliability of these other methods.

When any layer of shotcrete is to be covered by a succeeding layer, it shall first be allowed to develop its initial set. Then, all laitance, loose material, and rebound must be

removed by brooming or scraping. Remove laitance which has been allowed to take final set by sandblasting and thoroughly clean surface.

Firmly position the wire fabric to prevent movement and vibration while the shotcrete is being applied. Lap mesh one and one-half (1½) squares in both directions. Tie wires shall be bent flat in the plane of the mesh and not form large knots. A minimum cover of forty (40) millimeters of shotcrete shall be required.

Control thickness, method of support, air pressure and water content of shotcrete to preclude sagging or sloughing off.

The shotcrete shall be applied from the bottom up to prevent accumulation of rebound on the surface still be covered. Shotcrete shall emerge from the nozzle in a steady uninterrupted flow.

6.17.3.6 Nail Holes. Holes shall be drilled for soil nails at the location shown in the plans, or directed by the Engineer, to the minimum diameter and length shown. The Contractor shall provide soil nail length necessary to develop adequate load capacity to satisfy testing acceptance criteria for the design load required, but not less than the lengths shown on the plans. Core drilling, rotary drilling, percussion drilling, auger drilling, or driven casting may be used to advance the hole. Water or other liquids shall not be used as a cutting or flushing medium but air may be used. It will be the Contractor's responsibility to choose the drilling method that will maintain open drill holes and does not promote mining and loosening of the soil at the perimeter of the drill hole or fracture soil with weak stratification planes by using high flushing volumes and pressures. Each hole shall be located within one hundred fifty (150) millimeters of the location shown on the plans (measured at the collar) and the angle of entry shall be within three degrees (3°) of that shown on the plans. Subsidence or physical damage to the exposed soil face, or to areas intended to be undisturbed, by the Contractor's drilling operations, shall be cause for immediate cessation of these operations and repair of all damage at the Contractor's expense.

Grout shall be injected at the lowest point of each drill hole and the hole shall be filled with grout progressively from the bottom to the top. Grouting equipment shall be capable of thorough and continuous mixing and producing a grout with the required water-cement ratio that is free of lumps. Grout may be pumped through grout tubes, casing, hollowstem augers, or drill rods. The Contractor shall keep accurate and up-to-date records of the quantities of grout used for each soil nail.

Nails shall be placed in each drilled hole within fifteen (15) minutes of the grout injection. Mortar packing and secondary grouting shall be accomplished as soon as practicable after nail installation. Nominal nail stressing as shown on the plans shall not be accomplished until the grout and mortar pack have reached a compressive strength of at least 250 kg/cm^2. Nails shall not be stressed to more than twenty percent (20%) of design load.

The Contractor shall place centralizers at three (3) meter intervals in the total length with the last centralizer three hundred (300) millimeters from the end of each nail and insure that no less than forty (40) millimeters of grout cover is achieved along the nail.

Secondary grouting shall be provided to the small ungrouted zone at the face, place a bearing plate over the bar and dry pack with cement or a cement mortar to provide even bearing against the shotcrete face.

6.17.3.7 Final Shotcreting. Welded wire fabric for reinforcement of the surface layer shall be installed and held firmly in proper position while the final layer of shotcrete is applied. All requirements of Paragraph 6.17.3.5 "Initial Shotcrete" shall also apply to this shotcreting operation. Care shall be exercised to avoid allowing significant overspray or rebound to hit final and finished shotcrete or rock surfaces. Any finishing, brooming, or cleaning necessary to produce or maintain the required surface texture shall follow the shotcrete application as closely as possible.

Further Excavation. Further excavation shall not be accomplished until after the final layer of shotcrete has been applied to the proceeding lift. Each lift shall be completed using the sequence outlined in Paragraphs 6.17.3.4 'Excavation" through 6.17.3.7 'Final Shortcreting' in these General Specifications.

6.17.3.8 Tolerances. Shotcrete tolerances shown on the plans are minimum thicknesses. Greater thicknesses may be required locally to fill indentations left in the face by the excavation process. Areas overexcavated behind the theoretical excavation limit shall be backfilled with shotcrete at no additional cost to the Ministry. Careful excavation techniques will be necessary and some shotcrete backfill should be anticipated. The final wall surface shall fall within one hundred fifty (150) millimeters of the theoretical surface except within the bottom one and one-half (1.5) meters of the wall where the tolerance shall be three hundred (300) millimeters, toward the roadway and zero away from the roadway. All adjustments to meet these tolerances shall be made in the initial shotcrete application so that the fully reinforced final shotcrete layer shall have a relatively uniform thickness.

The Contractor shall provide field survey data comparing the theoretical and actual excavation limits with sufficient measurement points to assure compliance with these tolerances. These data shall be supplied to the Engineer for each excavation lift prior to the setting of thickness measurement pins or the application of the initial layer shotcrete on each lift.

6.17.4 NAIL INSTALLATION AND TESTING.

6.17.4.1 Test Nail Installation. The Contractor shall install, at the locations shown on the plans or as directed by the Engineer, approximately one (1) test nail per horizontal row of nails. These nails shall be installed using similar procedures as production nails and as soon as practicable in the excavation sequence. The length of each test nail will be chosen to insure pullout failure prior to yield of the steel tendon but will not be less than one (1) meter. The total number of test nails will not exceed three percent (3%) of the total number of production nails on this project.

Each test nail shall be grouted in place as part of a regular production grouting process, including primary grout, and if necessary and secondary grouting. Details for isolating the test nail from the shotcrete and determining the grouted length shall be provided by the Contractor. As soon as the grout has reached a cube strength of two hundred fifty (250) kilograms per square centimeter, the Contractor shall subject each test nail to a pullout test. This pullout test shall consist of incrementally tensioning the nail with a calibrated hydraulic jacking system. Each increment shall be equivalent to approximately twenty-five percent (25%) of the design load of the nail tendon and each nail test shall be conducted to ninety percent (90%) of the yield strength of the tendon.

Nail tendon deflection shall be measured with a dial gage capable of measuring movement of two hundredths (0.02) millimeters and recorded to the nearest 0.02 mm with respect to an independent fixed reference point at each increment of load. The jacking system shall be capable of maintaining a constant load for at least eight (8) minutes at each increment. Deflection readings shall be taken and recorded at times of ½, 1, 2, 4 and 8 minutes after each load increment has been applied. Each load increment shall be applied as rapidly as possible.

All nail testing shall be done in cooperation with and in the presence of the Engineer. Shorter load hold times at the low load increments may be individually approved during testing should no movement be occurring.

The reaction load for nail testing may be spread over the surface of the wall but no pressure shall be applied within one (1) meter of the nail being tested. Pressure from the reaction system against the wall shall not crack or otherwise damage partially or fully completed sections of the wall.

Test nails shall be cut off behind the finished surface of the wall when testing is complete.

Nail testing is included to verify the soil-tendon strength assumed in design. Should nail tests prove that the friction limit actually being obtained in field production is significantly different than the friction limit assumed in design, the Engineer will make design modifications to increase the nail length or decrease the nail spacing to insure a stable completed structure.

Should these design modifications become necessary, additional nails or nail length beyond those shown on the plans will be paid for under Item 6.17.3, "Additional Length of Nails" in these General Specifications.

6.17.4.2 Nail Testing.

6.17.4.2.1 Equipment. A dial gauge capable of measuring to twenty-five thousandths (0.025) millimeter shall be used to measure movement. A hydraulic jack and gauge calibrated as a unit shall be used to apply the test load. The pressure gauge shall be graduated in one hundred (100) pounds per square inch increments or less and used to measure the applied load. The test loads shall be applied incrementally.

6.17.4.2.2 Pullout Testing. Install one (1) nail per horizontal row but no more than three percent (3%) of the total number of nails as non-service nails and load test to pullout failure. Pullout failure is defined as movement in excess of one (1) millimeter between the one (1) minute and ten (10) minute reading of two (2) millimeters per log cycle of time over a maximum load hold period of sixty (60) minutes. The test nails shall be installed and tested at each level at a rate consistent with construction operations. The test length of nail shall be chosen to cause pullout failure prior to steel yield, but it shall not be less than two and five-tenths (2.5) meters. A minimum ungrouted or unbonded zone of nine-tenths (0.9) meters in length to the face shall be provided. The method of installation and size of drill hole shall be the same as for production nails.

Each test nail shall be grouted in place as part of a regular production grouting process. After grouting, the nail shall not be loaded for a minimum of three (3) days. Reaction frames should not bear on the shotcrete face within a nine-tenths (0.9) meter radius of the center of the drilled hole.

The pullout test shall be made by incrementally loading the nail. The nail movement shall be measured and recorded to the nearest twenty-five thousandths (0.025) of a millimeter with respect to an independent fixed reference point at each increment of load. The test shall be monitored with a pressure gauge. The load hold period shall start as soon as each test load is applied. Movement shall be recorded at 1 minute, 2, 3, 4, 5, 6 and 10 minutes. If the load hold is extended, the nail movement shall be recorded at 15, 25, 30, 45 and sixty (60) minutes. Each increment of load shall be no greater than twenty-five percent of the design load of the nail tested. The loading shall be terminated at failure or earlier at the option of the Contractor if the design ultimate unit bond stress is demonstrated.

6.17.4.2.3 Acceptance Criteria. The nail is deemed acceptable if the unit bond stress at a failure load is equal or greater than the design unit bond stress. Unacceptable test results shall result in modifications to design and/or construction procedures. Any modifications of design or construction procedures shall be at no change in the contract prices and the verification testing procedures shall be repeated as required by the Engineer. Graphs shall be plotted during the test of deflection against load.

6.17.5 QUALITY ASSURANCE PROCEDURES. Soil Nailed Wall shall be sampled, tested and evaluated in accordance with Section 1.08, "Acceptance of Work" in these General Specifications as follows:

Construction of the walls and nails shall be in accordance with Subsection 1.08.4 "Measured or Tested Conformance" and Paragraph 6.17.4.2 "Nail Testing" in these General Specifications. The Soil Nail walls materials shall be accepted in accordance with Subsection 1.08.3, "Certificate of Compliance" and the specifications and test methods referenced in Subsection 6.17.2, "Materials" in these General Specifications.

6.17.6 METHOD OF MEASUREMENT. Each soil nailed wall complete in place and accepted will be measured by the square meter of surface area to the pay limit shown on the plans or designated by the Engineer which will include the following:

1. **All Walls**
   - (1) shotcrete with coloring
   - (2) epoxy coated nails, nuts & plates, grout, mortar pack and grout pads
   - (3) wall drain and weep holes
   - (4) welded wire fabric holding devices

2. **Wall with 1.05 Meters H X 1.02 Meters V Nail Spacing**
   - (1) shotcrete thickness
     1st application - 80 millimeters
     2nd application - 100 millimeters
   - (2) welded wire fabric
     1st application - 70 millimeters X 70 millimeters - W12 x W12 (2' squares at nails only)
     2nd application - 100 millimeters X 100 millimeters - W7 x W7

3. **Wall with 1.08 Meters H X 1.02 Meters V Nail Spacing**
   - (1) shotcrete thickness
     1st application - 60 millimeters
     2nd application - 70 millimeters
   - (2) welded wire fabric
     1st application - 70 millimeters X 70 millimeters - W10 x W10 (2' squares at nails only)
     2nd application - 100 millimeters X 100 millimeters - W5.5 x W5.5

Additional length of nails will be paid by the linear meter of nail complete in place and accepted. This item will only be paid if modifications in nail length and/or nail spacing are necessitated by low pullout test results and are approved by the Engineer. If such modifications are made, payment under Pay Item 61701 will comprise full and final payment for any and all Work required to implement these modifications. No additional nails or longer nails will be added at a higher elevation that the test nail upon which design modifications are based.

6.17.7 PAYMENT. The accepted quantities, determined as provided above, will be paid for at the contract price per unit of measurement. For the soil nailed walls and additional lengths of nails is in the Bill of Quantities. The prices(s) shall be full compensation for furnishing all materials, labor, equipment, tools, supplies and all other items necessary for the proper completion of the Work as specified in Subsection 1.07.2, "Scope of Payment" in these General Specifications, which price shall be full compensation for all labor, equipment, and materials required by this Section. All work required by this Section and not specifically listed in the bid schedule shall be considered a subsidiary obligation of the Contractor under this Section.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
61701	Soil Nailed Wall No. ___	Square Meter
61702	Soil Nailed Wall, No. 2	Square Meter
61703	Soil Nailed Wall, No. 3	Square Meter
61704	Soil Nailed Wall, No. ___	Square Meter
61706	Additional Lengths of Nails	Linear Meter

SECTION 6.18 - REINFORCED EARTH STRUCTURES

6.18.1 DESCRIPTION. This Work shall consist of the construction of Reinforced Earth structures in accordance with these specifications and in conformity with the lines, grades, design and dimensions shown on the plans or established by the Engineer.

ITEMS IN BILL OF QUANTITIES
Concrete Facing
Reinforcing Strips

6.18.2 MATERIALS.

6.18.2.1 General. Since "Reinforced Earth" or its equivalent is normally a patented process, the Contractor shall make his own arrangements to secure the supplies and services needed for this Work from the patentee or his licensees through suitable legal agreement. A copy of such agreement shall be furnished to the Engineer. Materials not conforming to this section of the specification or from sources not listed in the contract documents should not be used without written consent from the Engineer.

6.18.2.2 Concrete Facing. All concrete materials shall conform to the requirements in Subsection 5.01.2, "Materials." Concrete shall conform to Class A as specified in Subsection 5.01.1, "Description." Reinforcing Steel shall conform to the requirements of Section 5.02, "Reinforcing Steel," for the type and grade specified on the plans or in the Special Specifications all in these General Specifications.

6.18.2.2.1 Casting. All reinforcing steel and inserts, including connection hardware, PVC tubes, tie strips, lifting and handling devices, etc., shall be set in place to the dimensions and tolerances shown on the plans prior to casting. The panels shall be cast on a flat level area with the exposed face cast against a correctly dimensioned and approved form. Each unit shall be identified by lightly marking in the fresh concrete on the rear face, the date of casting, the panel type, and any other information required by the Engineer. Any galvanized devices shall not contact or be attached to the face panel reinforcement steel.

6.18.2.2.2 Curing. The units shall be cured in accordance with the requirements of Paragraph 5.03.4.10, "Bridge Structure Curing and Protection" in these General Specifications. Curing shall continue as necessary beyond seven (7) days until the concrete develops the specified compressive strength as required herein.

6.18.2.2.3 Removal of Forms. The forms shall remain in place until test cylinders cured with the facing panels yield seventy (70) kilograms per square centimeter compressive strength, otherwise twenty-eight (28) days. Transportation of panels shall only be allowed at a minimum of two hundred forty (240) kilograms per square centimeter.

6.18.2.2.4 Concrete Finish. The front face of each unit shall have the finish as specified in the plans or Special Specifications.

The Contractor shall demonstrate his ability to produce the specified finish by constructing or supplying a minimum of three (3) test panels. The materials, including formwork, used in the construction of the test panels shall be the same as those proposed for use in the Work. The test panel finish must be approved by the Engineer prior to production of units for the Work. The approved test panels shall remain available on the site throughout the duration of the Work and shall not be incorporated into the Work unless or until released by the Engineer.

The rear face of each unit shall be left with a dense, rough texture with no open pockets of aggregate or honeycombed areas.

6.18.2.2.5 Tolerances. All units shall be manufactured within the following tolerances:

1. All dimensions shall be within five (5) millimeters of the corresponding plan dimensions.

2. The smoothness of the front face of each unit shall be within eight (8) millimeters when tested with a one and one-half (1.5) meter straightedge in any direction.

3. The difference in length between any two diagonal measurements on a single unit shall be no more than ten (10) millimeters.

4. The thickness of the unit shall be within fifteen (15) millimeters of the plan thickness.

6.18.2.2.6 Acceptance. Acceptance of each of the precast units shall be determined on the basis of compression tests and visual inspection. Sampling and testing for compressive strength shall conform to the requirements of Section 5.01, "Concrete," Section 1.04, "Control of Materials", and Section 1.08 "Acceptance of Work" in these General Specifications. An additional four (4) compressive specimens shall be cast with each acceptance sample set of specimens and shall be field cured in the same manner as the concrete facing units. Compressive tests on these additional specimens shall be used to determine the length of curing time required and acceptability for placement. Units will be considered acceptable for placement in the structure provided the compressive strength of field cured cylinders exceeds two hundred forty (240) kilograms per square centimeter. Units will be rejected by the Engineer due to defects that indicate imperfect molding, honeycombing, cracking, severe chipping, or open texture concrete. The Engineer may reject any unit which does not compare favorably with the approved front face panel.

6.18.2.2.7 Handling, Storage and Transporting. All units shall be handled, stored and transported in such a manner as to eliminate the danger of chipping, cracking, fracture, and excessive bending stresses. Units in transport or in storage shall be supported on firm blockings located adjacent to the tie strips. Connecting pins and tie strips shall be protected from bending and damage at all times.

6.18.2.3 Leveling Concrete. Concrete for placement in the leveling pad shall conform to the requirements of Subsection 5.03.9, "Concrete for Minor Structures" in these General Specifications. Curing shall be maintained for a minimum of twelve (12) hours or as ordered by the Engineer.

6.18.2.4 Reinforcing Strips and Tie Strips. Shapes and dimensions of these elements shall conform to the dimensions and tolerances shown on the plans and shall be shown on shop drawings produced by the Contractor and approved by the Engineer. Tie strips shall be shop fabricated of rolled steel conforming to the minimum requirements of ASTM A 570, Grade 33 except as modified in Subparagraph 6.18.2.4.1 'Physical and Mechanical Properties" in these General Specifications. Reinforcing strips shall be hot rolled form bars to the required shape and dimensions. Their physical and mechanical properties shall conform to the requirements of AASHTO M 183, except as modified in Subgraph 6.18.2.4.1 'Physical and Mechanical Properties" in these General Specifications. Reinforcing strips and tie strips shall be hot dip galvanized to conform to the minimum requirements of AASHTO M 111, except as modified in Subparagraph 6.18.2.4.2 'Weight of Coating" in these General Specifications. Holes for bolts shall be punched in the locations shown on the plans. All required cutting, bending, and hole punching shall be performed prior to galvanizing.

6.18.2.4.1 Physical and Mechanical Properties. Reinforcing strips and tie strips shall conform to the following:

Minimum Yield Point	2,400 kg/cm^2 (235 MPa)
Tensile Strength	3,700 to 4,500 kg/cm^2 (363 to 441 MPa)
Phosphorus	0.06 percent maximum
Sulfur	0.05 percent maximum

6.18.2.4.2 Weight of Coating. The weight of zinc coating shall conform to the following:

Minimum Weight	500 g/m^2

6.18.2.5 Fasteners. Bolts and nuts shall have hexagonal heads and shall conform to the requirements of AASHTO M 164, Type 2, except as modified hereunder. Bolts shall be twelve (12) millimeters in diameter, thirty (30) millimeters in length with twenty (20) millimeters of thread length. Fasteners shall be hot dip galvanized in accordance with the requirements of AASHTO M 232, Class C.

Minimum Yield Point	6,400 kg/cm^2 (627 MPa)
Minimum Tensile Strength	8,000 kg/cm^2 (784 MPa)
Minimum Elongation	12 percent

6.18.2.6 Joint Filler. Filler for vertical joints between units shall be flexible, open cell polyurethane foam. Filler for horizontal joints between units and where pads are used shall be resin-bonded cork strips conforming to the requirements of ASTM D 1752, Type II, or preformed EPDM rubber pads conforming to ASTM D-2000 for 4AA, 812 rubber or neoprene elastomeric pads having a Durometer Hardness of 55+5, and shall be approved by the Engineer. All joint covers between panels on the back side of wall shall be Type III Fabric conforming to the applicable requirements of Table 6.16-3 "Geotextile Subgrade and Embankment Stabilization."

6.18.2.7 Coil Embeds/Loop Imbeds. Coil Embeds/Loop Imbeds shall be fabricated of cold drawn steel wire conforming to ASTM-510, UNS G-10350 or ASTM A-82. Loop imbeds shall be welded in accordance with ASTM A-185. Both shall be galvanized in accordance with ASTm B-633 or equal.

6.18.2.8 Coil Embed Grease. The cavity of each coil embed shall be completely filled with no-oxid type grease or equal.

6.18.2.9 Coil Bolt. The coil bolts shall have two (2) inches of thread. They shall be cast of 80-55-06 ductile iron conforming to ASTM A-536. Galvanization shall conform to ASTM B-633 or equal.

6.18.2.10 Connector Pins. Connector pins and mat bars shall be fabricated from A-36 steel and welded to the soil reinforcement mats as shown on the Plans. Galvanization shall conform to ASTM A-123 (AASHTO M-111).

6.18.2.11 Backfill Materials. All backfill material used in the structural volume shall be reasonably free from organic or otherwise deleterious materials, and shall conform to the following mechanical and physico-chemical requirements.

6.18.2.11.1 Mechanical Requirements. Backfill material shall conform to the following gradation:

SIEVE SIZE	PERCENT PASSING
250 mm (10 inch)	100
100 mm (4 inch)	100-75
0.425 mm (No. 40)	0-60
0.075 mm (No. 200)	0-15
Plasticity Index	Less than 6

The angle of internal friction should not be less than thirty-four degrees (34°) as determined by the standard direct shear test (AASHTO T-236) on the portion finer that the #10 sieve, utilizing a sample of the material compacted to ninety-five percent (95%) of AASHTO T-99.

The Contractor may request that the acceptance limits be increased for material not meeting the above percent passing the 0.075 millimeter sieve requirement. However, he must include with his request an analysis showing (1) that the material passing the 0.075 millimeter sieve contains less than ten (10) percent smaller than fifteen thousandths (.015) millimeters, or (2) that the material contains less than twenty (20) percent smaller than fifteen thousandths (.015) millimeter and the minimum angle of internal friction as determined by ASTM D 2850 of twenty-eight (28) grads.

6.18.2.11.2 Physico-Chemical Requirements. Materials shall have a minimum resistivity when measured in accordance with ASTM G 57 of three thousand (3,000) Ohm centimeters. Materials having a resistivity less than the above but greater than one thousand (1,000) Ohm centimeters may be acceptable provided that the following requirements are met:

1. The pH value of the material measured in water extracted from a water-soil mixture is between five (5) and ten (10) when tested in accordance with ASTM G 51.0

2. The water extracted from the water-soil mixture contains a chlorides content of less than one hundred (100) parts per million and a sulphates content of less than two hundred (200) parts per million when tested in accordance with MRDTM 514.

6.18.3 CONSTRUCTION REQUIREMENTS.

6.18.3.1 Excavations. Excavations shall be in accordance with the requirements of Section 2.03, "Excavation" in these General Specifications and the Special Specifications. Limits and construction stages shall be as shown on the plans or approved by the Engineer.

6.18.3.2 Foundation Preparation. The foundation for Reinforced Earth structures shall be graded level for a width equal to the length of reinforcing strips plus three-tenths (.3) of a meter. Prior to wall construction, the foundation shall be fully compacted with a smooth wheel vibratory roller and shall meet the requirements of Type 95 compaction except where constructed on rock as specified in Section 2.05, "Embankment" in these General Specifications. Any foundation soils found to be unsuitable shall be removed and replaced in accordance with the procedures in Paragraph 2.03.2.2 Roadway Excavation - Unsuitable Material' in these General Specifications.

Where shown on the plans or directed by the Engineer, a concrete leveling pad shall be placed beneath the concrete facing panels.

6.18.3.3 Erection. Precast concrete facing panels shall be placed so that their final position is vertical or battered as shown on the Plans. Panels shall be placed in successive horizontal lift in the sequence shown on the plans as backfill placement proceeds. As fill material is placed behind a panel, the panels shall be maintained in position by means of temporary wooden wedges or braces according to the suppliers recommendations placed in the joint at the junction of the two (2) adjacent panels on the external side of the wall. Wedges or braces shall be kept in place for the three (3) top rows of panels during construction. As construction proceeds and a fourth row is erected, the lowest row of wedges or braces can be removed and so on.

External bracing may also be needed for the initial lift. The panels shall be handled by means of lifting devices connected to the upper edge of the panel.

Vertical tolerance and horizontal alignment tolerance shall not exceed twenty-five (25) millimeters when measured with a three (3) meter straightedge. The maximum offset in any panel joint shall be nineteen (19) millimeters.

6.18.3.4 Backfill Placement. Backfill placement shall follow closely the erection of each lift of panels. At each reinforcing strip level, backfill shall be roughly leveled before placing and bolting the strips. Reinforcing strips shall be placed normal to the face of the wall or as shown on the plans. The maximum layer thickness shall not exceed forty (40) centimeters. The Contractor shall decrease this thickness if necessary to obtain the specified density.

At the end of each day's operations, the Contractor shall shape the last level of backfill to permit runoff of rain water away from the wall face. Backfill shall be compacted to Type 95 compaction as defined by Paragraph 2.05.4.3 "Earth Embankment Lift Thickness and Requirements" in these General Specifications. Backfill in subgrade zones shall be compacted to Type 98 compaction. Backfill compaction shall be accomplished without disturbance or distortion of reinforcing strips and panels. Compaction of the one (1) meter wide strip adjacent to the backside of the wall facing shall be achieved by the use of a manually operated vibrating compactor.

The moisture content of the backfill material prior to and during compaction shall be uniformly distributed throughout each layer. Backfill optimum moisture content. Backfill material with a placement moisture content in excess of the optimum moisture content shall be removed and reworked until the moisture content is uniformly acceptable throughout the entire lift.

The maximum lift thickness after compaction shall not exceed three hundred (300) millimeters. The Contractor shall decrease this lift thickness, if necessary, to obtain the specified density.

6.18.4 QUALITY ASSURANCE PROCEDURES. The reinforced earth structures will be inspected, sampled, tested and evaluated in accordance with Section 1.08 "Acceptance of Work" in these General Specifications as follows:

The materials incorporated into the reinforced earth structures shall be sampled, tested and evaluated in accordance with the specifications and test methods referenced in Subsection 6.18.2, "Materials" in these General Specifications. The installation of the reinforced earth structures will be accepted in accordance with Subsection 1.08.4, "Measured or Tested Conformance" in these General Specifications.

6.18.5 METHOD OF MEASUREMENT.

6.18.5.1 Concrete Facing. Concrete Facing shall be measured by the square meter for all Work authorized, completed and accepted by the Engineer based on the front face surface area of each unit for the thickness shown on the plans and listed in the Bill of Quantities. There will be no separate measurement of concrete for concrete leveling pads. This Work and any excavation required to place the pads shall be considered subsidiary to this item.

6.18.5.2 Reinforcing Strips. Reinforcing Strips shall be measured by the linear meter of strip fixed in place and accepted by the Engineer. Lengths shall be based on those shown on the plans for each type of strip or as authorized by the Engineer.

6.18.5.3 Backfill. There will no separate measurement for excavation, backfill, or compaction required to complete the structural earthwork volume. This Work shall be considered subsidiary to these items.

6.18.6 PAYMENT. The amount of completed and accepted Work as measured above will be paid at the contract unit prices specified in the Bill of Quantities, which prices shall be full compensation for furnishing all materials, for all labor, equipment, tools, supplies, and all other items necessary for the proper completion of the Work as specified in Subsection 1.07.2, "Scope of Payment" in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
61801	Concrete Facing, 0.1 m thick	Square Meter
61802	Concrete Facing, 0.15 m thick	Square Meter
61803	Concrete Facing, 0.2 m thick	Square Meter
61804	Concrete Facing, 0.25 m thick	Square Meter
61805	Concrete Facing, 0.3 m thick	Square Meter
61806	Concrete Facing, 0.35 m thick	Square Meter
61807	Concrete Facing, 0.40 m thick	Square Meter
61808	Concrete Facing, ___ m thick	Square Meter
61811	Reinforcing Strips, 100 mm Width, 1 mm Depth	Linear Meter
61812	Reinforcing Strips, 100 mm Width, 2 mm Depth	Linear Meter
61813	Reinforcing Strips, 100 mm Width, 3 mm Depth	Linear Meter
61814	Reinforcing Strips, 100 mm Width, 4 mm Depth	Linear Meter
61815	Reinforcing Strips, 100 mm Width, 5 mm Depth	Linear Meter
61816	Reinforcing Strips, 100 mm Width, 6 mm Depth	Linear Meter
61817	Reinforcing Strips, 100 mm Width, 7 mm Depth	Linear Meter
61818	Reinforcing Strips, 100 mm Width, 8 mm Depth	Linear Meter
61819	Reinforcing Strips, 100 mm Width, 9 mm Depth	Linear Meter
61820	Reinforcing Strips, 150 mm Width, 1 mm Depth	Linear Meter

61821	Reinforcing Strips, 150 mm Width, 2 mm Depth	Linear Meter
61822	Reinforcing Strips, 150 mm Width, 3 mm Depth	Linear Meter
61823	Reinforcing Strips, 150 mm Width, 4 mm Depth	Linear Meter
61824	Reinforcing Strips, 150 mm Width, 5 mm Depth	Linear Meter
61825	Reinforcing Strips, 150 mm Width, 6 mm Depth	Linear Meter
61826	Reinforcing Strips, 150 mm Width, 7 mm Depth	Linear Meter
61827	Reinforcing Strips, 150 mm Width, 8 mm Depth	Linear Meter
61828	Reinforcing Strips, 150 mm Width, 9 mm Depth	Linear Meter
61829	Reinforcing Strips, 200 mm Width, 1 mm Depth	Linear Meter
61830	Reinforcing Strips, 200 mm Width, 2 mm Depth	Linear Meter
61831	Reinforcing Strips, 200 mm Width, 3 mm Depth	Linear Meter
61832	Reinforcing Strips, 200 mm Width, 4 mm Depth	Linear Meter
61833	Reinforcing Strips, 200 mm Width, 5 mm Depth	Linear Meter
61834	Reinforcing Strips, 200 mm Width, 6 mm Depth	Linear Meter
61835	Reinforcing Strips, 200 mm Width, 7 mm Depth	Linear Meter
61836	Reinforcing Strips, 200 mm Width, 8 mm Depth	Linear Meter
61837	Reinforcing Strips, 200 mm Width, 9 mm Depth	Linear Meter
61838	Reinforcing Strips, ___ mm Width, ___mm Depth	Linear Meter

SECTION 6.19 - ROCK BOLTS, CABLE BOLTS AND ROCK ANCHORS

6.19.1 DESCRIPTION. This work shall consist of cleaning and scaling slopes, drilling and redrilling slope reinforcement holes, placing rock bolts, cable bolts, and rock anchors, grouting, tensioning and testing the bolts and anchors. The location and inclination of each bolt and anchor will be determined by the engineer in the field. On new construction the installation and tensioning of rock bolts and rock anchors shall be done concurrently with rock excavation to allow this installation to proceed from benches or blasted rock.

The essential terms are defined as follows:

Rock bolt is a bolt made of steel rebar inserted into a hole drilled or bored in rock and grouted. Rockbolts can be tensioned or non-tensioned. Normally the maximum length of a rock bolt is six (6) meters. In special cases rock bolts may be twelve (12) meters long. (Long bolts are difficult to handle). Bolts are usually installed manually. In large projects special drilling jumbos with bolt installation capability may be used. The tensioning force of a bolt is usually fifty (50) to one hundred (100) kN.

Cable bolt is a bolt made of steel cable inserted into a hole drilled or bored in rock and grouted. The cable bolts can be tensioned or non-tensioned. Tensioning force of a cable bolt is usually less than two hundred (200) kN. The length of a cable bolt can be up to forty (40) meters. At longer lengths the installation becomes difficult and drilling accuracy decreases considerably beyond that length.

Rock Anchor is a rock bolt or cable bolt which is tensioned with high force (minimum two hundred (200) kN and even more than one thousand (1000) kN). Anchors may be equipped with special anchoring, tensioning, and corrosion protection fixtures.

Corrosion Protection. The most common corrosion protection of bolts and anchors is grout. Grout can be cement/water mixture, sand/cement/water mixture or resin. To improve corrosion protection of a bolt or anchor various kinds of fixtures can be used. The most useful are centralizing fixtures which keep the rock bolt or cable bolt in the center of the installation hole and do not allow it to touch the wall of the installation hole.

The bolt or anchor can be installed inside a corrugated plastic tube. The space between the tube and the rock bolt or anchor and tube shall be filled with grout.

ITEMS IN BILL OF QUANTITIES
Slope Cleaning and Scaling
Initial Boring of Slope Reinforcement Installation Holes
Cementation and Reboring of Slope Reinforcement Installation Holes
Rock Grouting Around Installation Hole
Tensioning of Rock Bolts or Cable Bolts including Tensioning Elements and Face Plates
Tensioning of Rock Anchors including Tensioning

Elements and Face Plates
Bare (Without Sheath) Rock Bolt or Cable
Bolt or Rock Anchor, Installed on Slope Height(s)
Sheathed Rock Bolt or Cable Bolt or Rock Anchor
Corrugated Plastic Tube for Bolt or Anchor

6.19.2 MATERIALS. Rock bolts, cable bolts, rock anchors and accessories shall conform to the following requirements and shall be of the type manufactured by companies regularly engaged in the production of rock bolts, cable bolts, rock anchors and accessories:

Resin Grouted and Cement Grouted Rock Bolts and StrandCable Bolts	AASHTO M31 - Grade 60. Nominal diameter of 20-35 millimeters. ASTM A-615-Grade 70 hollow-core groutable rebar. Nominal diameter of 20 to 51 millimeters.
Cement Grouted Rock Anchors	AASHTO M 31 - Grade 60 groutable steel rebar. Nominal diameter of 20 to 51 millimeters.
Nuts and Head Assemblies	AASHTO M 291, Grade B, hexagonal. Spin-lock head assembly.
Bearing and Keyhole Plates	AASHTO M 183, 200 millimeters by 200 millimeters by 10 to 15 millimeters thick.
Washers	AASHTO M 293 Carbon Steel
Resin Grout	Prepackaged high strength polyester resin cartridges with separated catalyst such as Celtite or Fasloc or an approved equal.
Cement Grout	The water/cement ratio of the grout shall not exceed nineteen (19) liters per sack. Chemical additives shall not be used unless approved in writing by the Engineer.

6.19.3 SUBMITTALS. At least two (2) bolt-plate-washer-nut assemblies shall be laboratory tested by the Contractor in accordance with ASTM F 432 for each different bolt and anchor proposed for use. At least two (2) weeks prior to any bolt or anchor installation, the Contractor shall furnish the results of these laboratory tests, copies of manufacturer's literature, and the Contractor's proposed method of installing and tensioning rock bolts, cable bolts, and rock anchors for review and approval by the Engineer.

All necessary torque wrenches, hydraulic jacks, and related equipment for installation and testing of bolts and anchors shall be provided and maintained in good working order by the Contractor. The Contractor shall provide certified calibrations for each of these devices dated not more than thirty (30) days prior to their first use on this project. The Contractor may be required to verify the calibration of any torquing or jacking equipment should any question arise concerning the accuracy of the equipment.

A minimum of four (4) resin grouted bolts and two (2) anchors of each length shall be installed with short anchor zones consisting of fast set resin and no slower setting resin. These bolts will be tested in increments, to ninety percent (90%) of the yield strength of the bolt, to verify the anchorage capacity. The Contractor shall supply all necessary tensioning and measuring devices and labor support to assist the Engineer in conducting these tests.

At least two (2) mechanically anchored bolts and anchors shall also be tested to verify the capacity of the Contractor's proposed mechanical anchorage and tested in increments to ninety percent (90%) of the yield strength of the bolt.

All acceptable anchorage tests shall hold at least eighty percent (80%) of the yield strength of the bolt without significant anchorage slip. Should the initial tests be unacceptable, anchorage modifications shall be submitted for review and approval by the Engineer, and further testing shall proceed until acceptable anchorage tests have been conducted with all proposed anchors. Bolts and anchors used for anchorage testing shall not be incorporated as mechanical stabilization for any final slope, and will not be measured for payment. All testing is a subsidiary obligation of the Contractor.

At least two (2) weeks before conducting these tests, the Contractor shall submit his proposed testing location and procedure to the Engineer for review and approval. Before conducting the tests, the Contractor shall submit certified calibration curves for all tensioning devices dated not more than thirty (30) days prior to their use on this project.

6.19.4 CONSTRUCTION REQUIREMENTS.

6.19.4.1 General. Bolt and anchor lengths specified are minimum embedded lengths. The Contractor shall allow extra length for appropriate end hardware. The length of anchors indicted shall be verified by pull-out tests and may require modification to achieve adequate bond.

The spacing and pattern of bolts and anchors shown on the plans are diagrammatic and approximate, and are not to be taken as definitive. The location, length, and inclination of each rock bolt and anchor in the side slopes shall be determined and located in the field by the Engineer.

Holes shall be drilled by rotary or percussion drilling methods. The type of drilling method selected shall not fracture or otherwise damage the rock which is being bolted. The drilled hole or cased hole shall be the diameter recommended by the bolt or epoxy resin grout manufacturer. Holes shall be drilled into the rock to the lengths and inclinations directed by the Engineer. Inclination of the bolt or anchor shall be such as to permit bolting generally normal to the rock surface, except when otherwise shown on the plans or directed by the Engineer. All alignment of the drilled holes shall be straight and allow easy entry of bolts and anchors without undue force.

Resin grouted bolts and anchors shall be installed in accordance with the manufacturer's recommended viscosities and setting times (fast and slow setting) for the expected temperature ranges.

The resin cartridges shall be stored in a well-ventilated, dry area and protected from excessive heat or cold during storage. The manufacturer's recommended shelf life shall not be exceeded. Resin cartridges that show signs of hardness or other indications of deterioration shall not be used.

All installation procedures of the resin grouted bolts and anchors shall be in accordance with the manufacturer's recommendations with the following requirements:

1. Sufficient fast setting resin shall be placed in the bottom of the hole for an adequate anchorage.

2. Sufficient cartridges of slower setting resin to completely fill the remainder of the hole when the bolt is inserted shall then be placed, the bolt inserted, and the resin mixed.

3. After the fast setting resin has set but before the setting time of the slower setting resin, the bolt shall be tensioned to fifty percent (50%) of the yield strength of the bolt and locked off at that stress.

Mechanically anchored cement grouted bolts and anchors shall be installed as shown on the plans and tensioned to fifty percent (50%) of the yield strength of the bolt.

Any installed bolt or anchor (either resin grouted or mechanically anchored) which cannot be tensioned to the specified loading without movement of the anchorage zone shall be replaced at the Contractor's expense. Location, length and inclination of replacement bolts will be determined by the Engineer.

Cement grout for encapsulation of bolts and anchors shall be pumped in from the lowest part of the hole. Holes which do not hold grout in the initial filling shall be regrouted from the lowest part of the ungrouted portion until the annular space is completely filled with grout.

All vertical and near vertical bolts and anchors shall be installed, grouted, and the grout allowed to reach a compressive strength of at least one hundred seventy-five (175) kilograms per square centimeter prior to blasting any adjacent lift below the topmost elevation of the bolts and anchors.

6.19.4.2 Installation Procedures.

6.19.4.2.1 Bolts.

1. Cleaning and scaling of the slope. The slope is cleaned and scaled. Scaffolding is erected where installation from the surrounding ground level is not possible.

2. Marking of bolt locations. The location and direction of individual bolts are marked on the slope surface.

3. Drilling of installation hole. Installation hole is bored or drilled. If the hole caves in it shall be filled with cement grout and redrilled after the grout has hardened. If the rock has open fractures it shall be injected through the installation hole by pumping cement grout into the hole through a packer installed at the mouth of the hole. The grouting pressure shall be specified in the design documents.

4. Bolt installation.

4.1 Installation of non-tensioned bolts. Non-tensioned bolt is installed by filling the hole with sand, water, and cement grout and then pushing rebar into the hole. If the hole is inclined upwards the hole needs to be plugged with a rubber plug to prevent the grout from flowing out of the hole.

Spacers can be used to centralize the rebar in the hole and prevent it from touching the wall of the hole.

4.2 Installation of tensioned bolts.

Tensioned bolts are installed in two (2) or three (3) phases depending on the type of anchoring. Bolts with mechanical anchoring are installed by making the anchor operational, expansion shell anchors are anchored by turning the rebar which make the anchoring mechanism expand and anchor itself against the walls of the hole. Wedge type anchor is hit against the bottom of the hole which makes the wedge expand and anchor itself.

Resin or cement grout anchored bolts are installed by installing first the grout anchor at the lower end of the hole. The grout is left to cure and harden.

After the anchoring is installed the bolt is tensioned by turning the tightening nut against the washer with a specified moment. After tightening the hole is filled with cement grout to reduce the risk of corrosion. Some mechanically anchored bolt types have a hole through which the grout is pumped into the hole. Others need to have a grouting hose pushed to the bottom of the hole. If the bolt needs to be tension tested the testing has to be done before grouting.

6.19.4.2.2 Anchors. The installation of rock anchors is similar to the installation of tensioned rock bolts. The anchoring and tensioning elements may be more elaborate for anchors than for bolts. Therefore, the anchoring procedures shall always be fully specified in the Special Specifications.

Fully bonded anchors are preferred for rock slope stabilization (Anchors with a free length are originally designed for soil anchoring where full bonding of the entire length of the anchor is not possible). Even if anchors with free lengths are used the installation hole has to be filled with cement grout to reduce the risk of corrosion as otherwise the empty hole may be filled with water.

6.19.5 QUALITY ASSURANCE PROCEDURES. The bolt and anchor installation including preparatory slope cleaning and boring will be inspected, sampled, tested and evaluated in accordance with Section 1.08, "Acceptance of Work" in these General Specifications.

Slope cleaning and scaling and drilling of slope reinforcement installation holes will be accepted in accordance with Subsection 1.08.2 "Visual Inspection" in these General Specifications. Installation and tensioning of bolts and anchors will be accepted in accordance with Subsection 1.08.04, "Measured or Tested Conformance" in these General Specifications as documented by the various anchorage and pull tests on the installations. The bolts and anchors will be accepted under Subsection 1.08.3, "Certification of Compliance" in these General Specifications based upon the Certificates of Guarantee and test reports on the materials including ASTM F432.

6.19.6 METHOD OF MEASUREMENT. Slope cleaning shall be measured by the square meter including the area of the slope cleaned to the satisfaction of the Engineer. Initial boring, cementation and reboring of slope reinforcement installation holes shall be measured by the linear meter based upon the actual length of holes bored and/or cemented and rebored except for the anchorage capacity test holes as they are subsidiary. Tensioning of bolts and anchors shall be measured by the unit for each bolt and anchor acceptably tensioned except that the anchorage capacity tests shall not be measured as they are subsidiary to the work under the tensioning items.

Bolts, anchors, and corrugated plastic tube shall be measured by the linear meter, complete in place and accepted. The linear meter measurement shall be taken from the collar of the hole to the furthest extent of the steel tendon. No measurement above the collar of the drill holes will be made.

6.19.7 PAYMENT. The accepted quantities, determined as provided above, will be paid for at the contract price per unit of measurement, respectively, for each of the pay items listed in the Bill of Quantities. Said prices and payments shall be full compensations for furnishing labor, equipment, materials, tools and all incidentals necessary for the completion of the Work as specified in Subsection 1.07.2, "Scope of Payment" in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
61901	Slope Cleaning and Scaling	Square Meter
6190101	Slope Cleaning and Scaling, Slope Height less than 5 meters	Square Meter
6190102	Slope Cleaning and Scaling, Slope Height 5 to 15 meters	Square Meter
6190103	Slope Cleaning and Scaling, Slope Height 15 to 25 meters	Square Meter
6190104	Slope Cleaning and Scaling, Slope Height more than 25 meters	Square Meter
61902	Initial Boring of Slope Reinforcement Installation Holes	Linear Meter
6190201	Initial Boring of Slope Reinforcement Installation Holes, 50 mm dia on Slopes less than 5 m high	Linear Meter
6190202	Initial Boring of Slope Reinforcement Installation Holes, 50 mm dia on Slopes 5-15 m high	Linear Meter
6190203	Initial Boring of Slope Reinforcement Installation Holes, 50 mm dia on Slopes 15-25 m high	Linear Meter
6190204	Initial Boring of Slope Reinforcement Installation Holes, 50 mm dia on Slopes more than 25 m high	Linear Meter
6190205	Initial Boring of Slope Reinforcement Installation Holes, 75 mm dia on Slopes less than 5 m high	Linear Meter
6190206	Initial Boring of Slope Reinforcement Installation Holes, 75 mm dia on Slopes less that 5 -15 m high	Linear Meter
6190207	Initial Boring of Slope Reinforcement Installation Holes, 75 mm dia on Slopes 15 -25 m high	Linear Meter
6190208	Initial Boring of Slope Reinforcement Installation Holes, 75 mm dia on Slopes more than 25 m high	Linear Meter
6190209	Initial Boring of Slope Reinforcement Installation Holes, 100 mm dia on Slopes less than 5 m high	Linear Meter
6190210	Initial Boring of Slope Reinforcement Installation Holes, 100 mm dia on Slopes 5-15 m high	Linear Meter
6190211	Initial Boring of Slope Reinforcement Installation Holes, 100 mm dia on Slopes less that 15-25 m high	Linear Meter
6190212	Initial Boring of Slope Reinforcement Installation Holes, 100 mm dia on Slopes more than 25 m high	Linear Meter
6190213	Initial Boring of Slope Reinforcement Installation Holes, 125 mm dia on Slopes less than 5 m high	Linear Meter
6190214	Initial Boring of Slope Reinforcement Installation Holes, 125 mm dia on Slopes 5-15 m high	Linear Meter
	Initial Boring of Slope Reinforcement Installation Holes, 125 mm dia	

6190215	on Slopes 15-25 m high	Linear Meter
6190216	Initial Boring of Slope Reinforcement Installation Holes, 125 mm dia on Slopes more than 25 m high	Linear Meter
61903	Cementation and Reboring of Slope Reinforcement Installation Holes	Linear Meter
6190301	Cementation and Reboring of Slope Reinforcement Installation Holes, 50 mm dia on Slopes less than 5 m high	Linear Meter
6190302	Cementation and Reboring of Slope Reinforcement Installation Holes, 50 mm dia on Slopes 5-15 m high	Linear Meter
6190303	Cementation and Reboring of Slope Reinforcement Installation Holes, 50 mm dia on Slopes 15-25 m high	Linear Meter
6190304	Cementation and Reboring of Slope Reinforcement Installation Holes, 50 mm dia on Slopes more than 25 m high	Linear Meter
6190305	Cementation and Reboring of Slope Reinforcement Installation Holes, 75 mm dia on Slopes less than 5 m high	Linear Meter
6190306	Cementation and Reboring of Slope Reinforcement Installation Holes, 75 mm dia on Slopes 5-15 m high	Linear Meter
6190307	Cementation and Reboring of Slope Reinforcement Installation Holes, 75 mm dia on slopes 15-25 m high	Linear Meter
6190308	Cementation and Reboring of Slope Reinforcement Installation Holes, 75 mm dia on Slopes more than 25 m high	Linear Meter
6190309	Cementation and Reboring of Slope Reinforcement Installation Holes, 100 mm dia on Slopes less than 5 m high	Linear Meter
6190310	Cementation and Reboring of Slope Reinforcement Installation Holes, 100 mm dia on Slopes 5-15 m high	Linear Meter
6190311	Cementation and Reboring of Slope Reinforcement Installation Holes, 100 mm dia on slopes 15-25 m high	Linear Meter
6190312	Cementation and Reboring of Slope Reinforcement Installation Holes, 100 mm dia on Slopes more than 25 m high	Linear Meter
6190313	Cementation and Reboring of Slope Reinforcement Installation Holes, 125 mm dia on Slopes less than 5 m high	Linear Meter
6190314	Cementation and Reboring of Slope Reinforcement Installation Holes, 125 mm dia on Slopes 5-15 m high	Linear Meter
6190315	Cementation and Reboring of Slope Reinforcement Installation Holes, 125 mm dia on Slopes 15-25 m high	Linear Meter
6190316	Cementation and Reboring of Slope Reinforcement Installation Holes, 125 mm dia on slopes more than 25 m high	Linear Meter
61904	Rock Grouting Around Installation Hole	Kilogram
6190401	Rock Grouting Around Installation Hole on Slopes less than 5 m high	Kilogram
6190402	Rock Grouting Around Installation Hole on Slopes 5-15 m high	Kilogram

6190403	Rock Grouting Around Installation Hole on Slopes 15-25 m high	Kilogram
6190404	Rock Grouting Around Installation Hole on Slopes more than 25 m high	Kilogram
61905	Tensioning of Rock Bolts or Cable Bolts including Tensioning Elements and Face Plates	Unit
61906	Tensioning of Rock Anchors including Tensioning Elements and Face Plates	Unit
61907	Bare (Without Sheath) Rock Bolt or Cable Bolt or Rock Anchor	Linear Meter
6190701	Bare (Without Sheath) Rock Bolt or Cable Bolt or Rock Anchor, Capacity 50 kN	Linear Meter
6190702	Bare (Without Sheath) Rock Bolt or Cable Bolt or Rock Anchor, Capacity 100 kN	Linear Meter
6190703	Bare (Without Sheath) Rock Bolt or Cable Bolt or Rock Anchor, Capacity 200 kN	Linear Meter
6190704	Bare (Without Sheath) Rock Bolt or Cable Bolt or Rock Anchor, Capacity 400 kN	Linear Meter
6190705	Bare (Without Sheath) Rock Bolt or Cable Bolt or Rock Anchor, Capacity ___ kN	Linear Meter
61908	Sheathed Rock Bolt or Cable Bolt or Rock Anchor	Linear Meter
6190801	Sheathed Rock Bolt or Cable Bolt or Rock Anchor, Capacity 50 kN	Linear Meter
6190802	Sheathed Rock Bolt or Cable Bolt or Rock Anchor, Capacity 100 kN	Linear Meter
6190803	Sheathed Rock Bolt or Cable Bolt or Rock Anchor, Capacity 200 kN	Linear Meter
6190804	Sheathed Rock Bolt or Cable Bolt or Rock Anchor, Capacity 400 kN	Linear Meter
6190805	Sheathed Rock Bolt or Cable Bolt or Rock Anchor, Capacity ___ kN	Linear Meter
61909	Corrugated Plastic Tube for Bolt or Anchor	Linear Meter
6190901	Corrugated Plastic Tube for Bolt or Anchor, 50 mm dia	Linear Meter
6190902	Corrugated Plastic Tube for Bolt or Anchor, 75 mm dia	Linear Meter
6190903	Corrugated Plastic Tube for Bolt or Anchor, 100 mm dia	Linear Meter
6190904	Corrugated Plastic Tube for Bolt or Anchor, ___ mm dia	Linear Meter

SECTION 6.20 - EXPLORATORY DRILLING

6.20.1 DESCRIPTION. This work shall consist of exploratory drilling for soil and rock samples and recording boring log data as specified. The various sampling methods are designated as follows:

ITEMS IN BILL OF QUANTITIES
Split Spoon (SPT) Sampling of Soils
Thin-Walled Tube Sampling of Soils
Rock Core Drilling NX Cores, 53 mm Min. Dia. Double Barrel
Rock Core Drilling NX Cores, 53 mm Min. Dia. Triple Barrel

6.20.2 MATERIALS. Materials for this work shall meet the requirements of the following Paragraphs:

6.20.2.1 Drive Pipe. Drive pipe shall be extra-strength steel pipe one hundred (100) millimeter nominal diameter as specified, with threaded ends in random one and one-half (1.5) meter lengths and shall conform to the requirements of ASTM A120, Schedule 40.

6.20.2.2 Casing. The casing shall be diamond drill flush-joint or flush coupled type, fabricated from high quality seamless steel tubing conforming to the requirements of the Diamond Core Drill Manufacturer's Association (DCDMA) Standards. The design shall permit any size casing to telescope into the next larger size.

6.20.2.3 Samplers. Samplers shall be of the split barrel, ball check design and have a minimum length of five-tenths (0.5) meter and outside diameter of fifty (50) millimeters. Samplers with flap valve or spring type retainers shall be permitted only with special permission of the Engineer.

6.20.2.4 Thin Wall Sample Tubes. Tubes for undisturbed soil samples shall be fabricated from Type 304 stainless steel tubing meeting the requirements of ASTM A276 as specified for a nominal eighty-three (83) millimeter O.D. seamless or welded tubing with nominal sixteen hundred twenty-five ten thousandths (0.1625) millimeter wall thickness.

6.20.2.5 Diamond Core Drill Bits. Diamond drill bits shall be one type: NX bits. NX bits shall produce an eighty-three (83) millimeter diameter core and shall have a 0.134 millimeter wall thickness. The bits shall meet the requirements specified by the National Bureau of Standards and Diamond Core Drill Manufacturer's Association Standards.

6.20.2.6 Sample Storage Bags. Sample storage bags shall be moisture-proof, transparent, plastic bags with minimum dimensions two hundred (200) millimeters length, two hundred fifty (250) millimeters width and five hundredths (0.05) millimeter thickness.

6.20.2.7 Sample Jars. Sample jars shall be glass, wide-mouthed jars of one-quart capacity with air-tight screw covers fitted with rubber compo-lined caps.

6.20.2.8 Jar Cartons. Jar cartons shall consist of corrugated Kraft paper cardboard fabricated into a box with overall nominal dimensions three hundred (300) millimeters wide, three hundred ninety-three (393) millimeters long and one hundred seventy-five (175) millimeters deep. The box shall be partitioned and have sufficient strength to safely support twelve (12) sample jars in a three by four (3 x 4) array.

6.20.2.9 Boulder and Rock Core Boxes. Boxes shall be fabricated of white pine, grade No. 1 common lumber or better, twenty-five millimeter minimum thickness stock. Overall box dimensions for NX core boxes shall be one hundred twenty (120) centimeters long, two hundred eighty-three (283) millimeters wide and ninety-four (94) millimeters deep. Core rows shall be separated by wooden or tempered hardboard, three (3) millimeter thick strips recessed to nine (9) millimeter depth at the bottom and ends of box. Box covers shall be hinged with two (2) fifty (50) millimeter steel butt hinges and arranged to be securely fastened with two (2) thirty-seven (37) millimeter hooks and eyes.

6.20.3 CONSTRUCTION DETAILS. The Contractor shall carry out all field work associated with subsurface investigations as shown in the plans or as directed by the Engineer. Such investigations may include boring, sampling, logging, and field testing, and shall be performed as specified herein and in accordance with the methods outlined in the HDM, Section 2.06-Geotechnical Engineering, Appendix I - Ground Investigations.

6.20.3.1 Drilling Procedures. Auger borings and diamond core drilling shall be performed as specified in MRDTM 223 and 226, respectively.

Special precautions shall be taken when protection of existing structures is required. Precautions shall be at the Contractor's responsibility and expense and as directed by the Engineer.

6.20.3.1.1 Soil Samples. Drill holes for split-spoon (SPT) samplers shall be progressed and cased by means of flush-joint casing, flush-coupled casing, one hundred (100) millimeter diameter, extra-strength drive pipe or where permitted, by a drilling mud process or by using a hollow flight auger. If the drilling mud process is approved and used, the minimum hole diameter shall be one hundred (100) millimeters.

Drill holes for thin-walled tube samplers shall be progressed and cased using minimum one hundred (100) millimeter diameter drive pipe or casing.

Prior to sampling, the drill hole shall be cleaned to the sampling elevation by using equipment that will not disturb the material to be sampled. Bottom discharge chopping or fishtail bits will not be allowed. Jetting through an open sampler and subsequently sampling when the desired depth is reached will not be permitted. Samples shall be removed from material which is not disturbed or contaminated from drilling operations. When sampling with a thin-walled tube, the last seventy-five (75) millimeters of soil directly above the sampling elevation shall be removed with a clean-out jet auger.

6.20.3.1.2 Rock Samples. Continuous rock core samples shall be taken in boulders exceeding one hundred fifty (150) millimeters in penetration thickness and in ledge rock at locations and depths designated by the Engineer. Rock samples shall be drilled with a Double or Triple Tube, Swivel Type Core Barrel using a diamond bit that will drill a rock core not less than fifty-three (53) millimeters in diameter for one hundred (100) millimeters casing.

6.20.3.2 Sampling. Soil samples may be disturbed or undisturbed as directed. Split-barrel sampling shall conform to MRDTM 224 and piston or open tube thin-walled sampling shall conform to MRDTM 225.

6.20.3.2.1 Split-Spoon Barrel. Samples shall be taken at every obvious change in stratum and in no case at intervals greater than one and five-tenths (1.5) meters. The split-spoon barrel sampler shall be placed on the bottom of the cleaned-out hole and then driven with blows from a one thousand six hundred sixty (1660) kilogram ± hammer falling freely forty-five (45) centimeters. The sampler shall be driven a minimum of forty-five (45) centimeters but not farther than the length of the split barrel, a variable to be determined for the individual split barrel being used.

The number of blows required to drive the sampler each increment of one hundred fifty (150) millimeters shall be recorded. If refusal of penetration is encountered before the desired sample length is attained, the sampler shall be removed from the hole and core drilling started. Refusal shall be assumed when fifty (50) hammer blows advance the sampler less than twenty-five (25) millimeters.

A recovery of less than three hundred (300) millimeters of sample in a sampler drive a minimum of four hundred fifty (450) millimeters is not acceptable, and another sample is to be taken after advancing the hole into undisturbed soil. Should this second sample also be similarly short, a sampler equipped with a basket shoe or other springtype retainer shall be used for the third attempt. Flap or trap valves will be allowed only with special permission of the Engineer. When sampling fine granular materials below the water table, the casing or drive pipe shall be kept full of water to prevent "blow-back" unless otherwise directed by the Engineer.

6.20.3.2.2 Thin-Walled Tube. Undisturbed soil samples shall be taken with a thin-walled tube sampler in the strata designed by the Engineer. Samples shall be recovered with a stationary piston type sampling tube, a self-contained, hydraulically operated piston sampler, or a casing-actuated piston sampler, modified to accept the thin-walled tubes specified in Subsection 6.20.2, "Materials" in these General Specifications. Samples with piston rods extending to the ground surface must be provided with locks which positively lock the piston against upward travel during lowering of the tube until the sampling depth is reached. In addition, the sampler shall be provided with positive locks to secure the piston rods to the drill rod prior to removal of the sampler tube after penetration. All samplers must be approved by the Engineer before use.

With the sample tube resting on the bottom of the hole, the tube shall be pushed into the soil with a continuous motion and without impact or rotation for a maximum distance of four hundred fifty (450) millimeters. Care must be taken to allow air and water to flow freely through the vent thus preventing compression of the soil sample. Time and pressure for penetration, whenever measured, must be recorded. After pressing to the required depth and setting for five (5) minutes to allow the soil to swell and adhere to the sides of the tube, the sampler with its contained soil sample shall be carefully rotated to shear off the sample, then removed from the hole. The piston rod shall be backed off to admit air past the flattened threads and thus relieve the vacuum which would distort the sampling during removal of the piston. For other approved types of equipment, the necessary vacuum breaking measures shall be taken.

The length of sample in the tube and also the distance pressed, shall be measured and recorded.

The bottom of the sample shall be carefully squared at least twenty-five (25) millimeters back from the end of the tube and a wax seal, approximately twenty-five (25) millimeters thick, shall be poured in the bottom end of the tube. The soil at the top of the tube shall be carefully squared up and a wax seal, approximately twelve (12) millimeters thick, shall be poured. Any space remaining between the top or bottom of the sample tube and the wax seal shall be filled with damp sawdust after the was has hardened. Wax shall be a mixture of equal parts of microcrystalline wax and white paraffin. The ends of the tubes shall be sealed with snugly fitting metal or plastic caps which shall be secured in place with friction tape. No was shall be placed on the outside of the tube.

Rock cores shall be obtained by use of rotary drilling methods in accordance with MRDTM 226. The procedure to be followed shall be that which brings about the highest percent recovery and shall be determined in the field. Under no circumstances shall coring be continued when it is obvious that the core barrel is blocked. In zones that are highly fractured or where the barrel continually becomes blocked, either short runs shall be used or a wire line core barrel shall be utilized. Core barrels may be single-tube (restricted to hard rock), double-tube (conventional or M-design, for fractured or broken formations), or wire line (formations prone to caving or blocking, increased recovery), as directed in the field as the work progresses.

Rock core recoveries of less than eighty-five percent (85%) will generally not be considered satisfactory. Except for deliberately serving the continuous core, care shall be taken to avoid blocking the bit or core barrel.

When the core is broken off, the core barrel shall be raised to the ground surface and the core withdrawn.

6.20.3.3 Testing. Testing shall be performed by the Contractor under the supervision of the Engineer, as indicated in the HDM, Section 2.06 - Geotechnical Engineering, Appendix I - Ground Investigations, Paragraphs B.5 - Field Tests and C.1 - Laboratory Tests. Tests shall be carried out in accordance to the Highway Materials Manual Part 2 - Soils, and the requirements of the project as determined by the Engineer.

6.20.3.4 Backfilling Boreholes. Open boreholes that are no longer required shall be backfilled. Backfilling materials shall be locally available soil tamped in place, except at locations where it is essential to prevent the movement of water from one stratum to another and to preclude piping of material to the surface through the borehole. Included in this category are all borings downstream of proposed embankments and at proposed locations of structures. In such cases, the boreholes shall be backfilled with grout, placed from the bottom of the hole upward by means of a pipe so that all of the drilling fluid be displaced. Grout shall consist of Portland cement and water, Portland cement and hydrated lime in proportions about 5:8 by weight, or a mixture of Portland cement with about ten (10) percent bentonite by volume.

6.20.4 BORING LOG DATA. Data obtained in borings shall be recorded in the field and shall include the following:

Date of Boring
Job Identification
Boring Location by Stations and Offset or Coordinates
Structure Number or Name when Pertinent
Elevation of Ground Surface at Boring Locations
Sample Depths
Limits of Strata
Ground Water Data
Soil Description
Penetration Records (blows)
Other Pertinent Remarks

The data thus obtained shall be presented on boring logs furnished by the Engineer. Two (2) copes of the preliminary log for each boring shall be submitted to the Engineer on the working day following completion of the boring.

A complete record of all significant information pertaining to the drilling and sampling operations within each borehole shall be maintained, concurrent with the advancement of the hole. Each soil boring or rock coring shall be logged in the field by the Contractor as specified in the HDM, Section 2.06, Figures 2.06.2, 2.06.3, unless more stringent requirements are established by the Engineer, and submitted to the Engineer in three copies upon completion of a hole.

A similar record may be prepared independently by the supervisor assigned to oversee the operations in the borehole, when so directed. Duplicate records may be needed to insure that all observations are recorded and to provide a check in the event of the discovery of some discrepancy after the work has been completed.

Final logs shall be prepared by the Contractor as a condensation of the field logs, refined on the basis of laboratory test results, in an approved format. The final logs shall present a clear, concise, accurate picture of subsurface conditions and shall be readily usable for preparation of geologic sections. Geologic sections shall be submitted by the

Contractor to the Engineer in three copies, along with the final logs for approval and evaluation.

Final typed logs shall be submitted to the Engineer within one (1) week after an "approved" preliminary log is returned to the Contractor by the Engineer.

6.20.5 GROUND WATER LEVELS. The level at which ground water is first encountered in the borings shall be noted. When water is introduced into the hole, water level readings shall be taken at the end of each day after the hole is prepared to the next sampling depth. The casing or drive pipe shall be filled with water and covered at the end of the working day and the drop, if any, recorded when the work is resumed. Ground water levels shall be measured before and after the casing or drive pipe is pulled. Each water level reading shall be recorded showing the date and time the reading is made, the depth of the drive pipe or casing, and the depth to water. Any loss or gain of water in the boring, except that caused by deliberately introducing water and/or inserting or removing tools shall be recorded. This record shall show the date and time the loss or gain is noted, the depth of the casing and the depth of the water. If flowing, the height of artesian rise above the ground surface shall be recorded.

All water level readings and related data shall be recorded on the boring logs under "Remarks." If necessary, additional forms shall be used for recording ground water data.

Artesian heads shall be effectively and permanently sealed. This seal shall be satisfactory to the Engineer.

6.20.6 MARKING AND PACKAGING SAMPLES.

6.20.6.1 Driven Soil Samples. Samples shall be placed in tied plastic storage bags placed in wide-mouth quart-size jars in such a manner so as to maintain a representation of the sample's natural structure. The jar top shall be self-sealing (compo-lined) to retain the natural moisture and the jar shall be labeled to show the project, sample number, the hole number, and the depth of original of the sample. Jars shall be placed in Kraft corrugated cartons with spacers for twelve (12) jars. Samples must be protected from temperature extremes of freezing and sun.

6.20.6.2 Undisturbed Soil Samples. Undisturbed soil samples shall be clearly, accurately and indelibly marked to show the date, hole number, location, the depth and elevation from which the sample was taken, kind of material and depth of stratum the sample represents, and all other information which may be helpful in determining the character of the subsurface conditions. Undisturbed samples shall be handled, stored and transported using extreme care to absolutely prevent the samples from being subjected to freezing, drying, jarring and any other disturbance that would make the samples unsuitable for detailed laboratory testing. The tubes properly packaged to prevent any disturbance to the samples, shall be stored and transported in the correct upright position at all times.

6.20.6.3 Rock Samples. Samples shall be labeled in accordance with "Instructions for Labeling Rock Cores." This information is available upon request to the Ministry of Communications Materials and Research Department.

The rock cores shall be placed for shipment in boxes meeting the requirements of Paragraph 6.20.2.9 "Boulder and Rock Core Boxes" in these General Specifications.

Rock cores shall be preserved and stored as specified in MRDTM 226. Core boxes pertaining to each hole shall be numbered in sequence with box one number (1) containing the core of the highest elevation. Wooden blocks shall also be used to indicate core loss. These blocks shall be marked with the elevations of top and bottom of loss, as well as amount of loss, on twelve-millimeter wide tape with embossed lettering. If the loss can be pinpointed, the block shall be inserted at the depth of the loss; otherwise, it shall be placed at the end of the run in which the loss occurred.

When directed by the Engineer, some rock cores may require sealing. In such instances, the method shall be to wrap waxed paper or foil around the core and seal the entire core by dipping in microcrystalline wax.

Samples and boxes shall be clearly labeled so as to leave no doubt as to their exact source. Labeling information shall be as specified in MRDTM 224, 225 and 226 and as directed. In addition, sampling tubes or liners shall be marked to indicate the top and the level of the top and bottom of the sample contained. All markings shall be weather - and wear - proof.

6.20.7 DELIVERY OF SAMPLES. When directed, samples shall be transported for testing to the laboratory, or to such other location within one-hundred (100) kilometers from the source as the Engineer may direct, in a motor vehicle to be provided by the Contractor and under the custody of a supervision staff member. Loading, handling and unloading of the samples shall be carried out by the Contractor's staff under the direction of the Engineer or his authorized representative.

6.20.7.1 Soil Samples. The Contractor shall deliver, with all charges prepaid, the properly labeled, packaged and protected undisturbed samples and split barrel samples immediately following the completion of each boring from which Thin-Walled Samples were extracted. The samples shall be delivered to a location designated by the Engineer.

The container in which the undisturbed soil samples are delivered shall be marked with the wording, "UNDISTURBED SOIL SAMPLES" "HANDLE WITH SPECIAL CARE" in large lettering.

The tubes containing acceptable undisturbed samples shall become the property of the Ministry.

6.20.7.2 Rock Samples. Samples shall be delivered to the Engineer's or Ministry Office which is delegated the responsibility and authority to execute the prescribed work.

6.20.8 QUALITY ASSURANCE PROCEDURES. The exploratory drilling will be inspected, sampled, tested and evaluated in accordance with Section 1.08, "Acceptance of Work" in these General Specifications as follows:

The materials incorporated into the exploratory drilling shall be sampled, tested and evaluated in accordance with the specifications and test methods referenced in Subsection 6.20.2, "Materials" in this Section in these General Specifications. The exploratory drilling will be accepted in accordance with Subsection 1.08.4, "Measured or Tested Conformance" in these General Specifications.

6.20.9 METHOD OF MEASUREMENT.

6.20.9.1 Split-Spoon Sampling of Soils. The quantities to be measured shall be the actual number of linear meters of acceptable holes measured from the ground surface at each hole. For holes progressed in water, the mean level of the water surface during the time the boring is made shall be considered as the starting datum. All measurements will be made by or in the presence of the Engineer.

6.20.9.2 Thin-Walled Sampling of Soils. The quantities to be measured shall be the number of individual acceptable samples taken.

6.20.9.3 Rock Core Drilling. The quantities to be measured shall be the actual number of linear meter drilled in the presence of the Engineer as listed in the Bill of Quantities and as substantiated by core length obtained, properly labeled, described and boxed.

6.20.10 PAYMENT.

6.20.10.1 Split-Spoon Sampling. The contract unit price bid per linear meter shall be based on twenty (20) meter incremental depths as follows:

0-20	Linear Meter
20-40	Linear Meter
over 40	Linear Meter

The contract unit price shall include the cost of furnishing all labor, materials and equipment necessary to complete the work.

6.20.10.2 Thin-Walled Tube Sampling. The contract unit price for each sample shall include the cost of furnishing all labor, materials and equipment necessary to complete the work, including the cost of the stainless steel tube which shall become the property of the Ministry. Payment for progressing the borings shall be paid for under their respective items.

6.20.10.3 Rock Core Drilling. The contract unit price per linear meter shall include the cost of furnishing all labor, materials and equipment necessary to complete the work including core boxes which shall become the property of the Ministry.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
62001	Splt Spoon Sampling of Soils	Linear Meter
6200101	Split Spoon Sampling, 0-20 m Depth Range	Linear Meter
6200102	Split Spoon Sampling, 20-40 m Depth Range	Linear Meter
6200103	Split Spoon Sampling, over 40 m Depth Range	Linear Meter
62002	Thin-walled Tube Sampling of Soils	Unit
62003	Rock Core Drilling NX Cores, 53 mm Min. Dia., Double Barrel	Linear Meter
62004	Rock Core Drilling NX Cores, 53 mm Min. Dia., Triple Barrel	Linear Meter

SECTION 6.21 - DRAINAGE LAYER

6.21.1 DESCRIPTION. This work consists of furnishing and placing sheathing material or geocomposite against the backfilled faces of retaining walls, wing walls, and abutments. This Work shall also consist of furnishing and placing geogrid mats on a prepared earth, aggregate or other surface, in accordance with the specifications and in conformity with the lines, grades and cross-sections shown on the plans or established by the Engineer.

ITEMS IN BILL OF QUANTITIES
Sheathing Material
Geocomposite Sheet Drain
Geocomposite Pavement Bridge Drain
Geogrid

6.21.2 MATERIALS. Materials shall conform to the following Subsections:

6.21.2.1 Geocomposite Drains. Geocomposite drains consist of a polymeric drainage core with a geotextile conforming to TYPE IV fabric in Table 6.11-4 attached to or encapsulating the core. The geocomposite drain shall include all necessary fittings and material to splice one sheet, panel, or roll to the next and to connect the geocomposite drain to the collector and outlet piping.

The drainage core shall be fabricated in sheet, panel, or roll form of adequate strength to resist installation stresses and long term loading conditions. The core material shall consist of long chain synthetic polymers composed of at least eighty-five percent (85%), by weight, polypropylene, polyester, polyamide, polyvinyl chloride, or polystyrene. The core shall be built up in thickness by means of columns, cones, nubs, cusps, meshes, stiff filaments or other configurations.

Geocomposite drains shall have a minimum compressive strength of two hundred seventy-five (275) kPa when tested according to ASTM D 1621, procedure A. All splices, fittings, and connections shall have sufficient strength to withstand construction handling and permanent loading and shall not impede flow or damage the core.

The geocomposite drains shall be identified, shipped, and stored according to Section 7 of AASHTO M 288. Elevate and protect sheets, panels, or rolls with a waterproof and ultraviolet resistant cover if stored outdoors.

When using a geocomposite drain for a permanent installation, limit the geocomposite exposure to ultraviolet radiation shall be limited to less than ten (10) calendar days.

6.21.2.2 Geocomposite Sheet Drains. The horizontal and vertical flow of water within the sheet drain shall interconnect at all times for the full thickness of the core. The drainage core with the geotextile in place shall provide a minimum flow rate of one (1)

L/s/m of width when tested according to ASTM D 4716 under the following test conditions:

1. A three hundred (300) millimeter long specimen
2. An applied load of sixty-nine (69) kPa
3. A gradient of 1.0
4. A 100 hour seating period
5. A closed cell foam rubber between platens and geocomposite

If core construction separates the flow channel into two (2) or more sections, only the flow rate on the in-flow face is considered in determining the core's acceptability.

The geotextile fabric shall be firmly attached to the core so folding, wrinkling, or other movement cannot occur either during handling or after placement. Bonding shall be achieved using nonwater soluble adhesive, heat sealing, or other method recommended by the manufacturer. Adhesive shall not be used on areas of the geotextile fabric where flow is intended to occur.

If heat sealing is used, it shall not weaken the geotextile below the required strength values. The geotextile shall be extended below the bottom of the core a length sufficient to completely encapsulate a one hundred twenty-five (125) millimeter diameter collector pipe.

6.21.2.3 Geocomposite Pavement Edge Drains. The geotextile shall tightly encapsulate the geocomposite edge drain. The edge drain shall permit in-flow from both sides. The drain core with the geotextile in place shall provide a minimum flow rate of three (3) L/s/m of width when tested according to ASTM D 4716 under the following test conditions:

1. A three hundred (300) millimeter long specimen
2. An applied load of sixty-nine (69) kPa
3. A gradient of 0.1
4. A 100 hour seating period
5. A closed cell foam rubber between platens and geocomposite

If the geocomposite polymer core separates the flow channel into two (2) or more parts, only the tested flow rate of the channel facing the pavement shall be considered.

All pipe and pipe fittings used for an outlet to the edge drain shall be non-perforated plastic pipe conforming to Section 6.04 "Pipe Underdrain and Irrigation Pipe" in these General Specifications.

The solvent cement for the outlet pipe and fittings shall be according to ASTM D 2564. The material composition of the outlet fittings shall be compatible for direct solvent welding to PVC.

6.21.2.4 Sheathing Material. Sheathing material shall meet the requirements for either concrete fine aggregate conforming to Subparagraph 5.01.2.2.1 "Fine Aggregate" in these General Specifications or coarse aggregate consisting of sound, durable particles of gravel, slag, or crushed stone conforming to Table 6.21-1.

TABLE 6.21-1 SHEATHING MATERIAL GRADATION	
Sieve Designation	Percent by Weight Passing Standard Sieves (AASHTO T 11 and T 27)
75 mm (3 in.)	100
19.00 mm (¾ in.)	50-90
4.75 mm (No. 4)	20-50
0.075 mm (No. 200)	0.0-2.0

6.21.2.5 Geogrid. Geogrids shall be single-layered or multi-layered, made from high density polyethylene or polypropylene in a continuous extrusion process. Geogrids used in conjunction with bituminous concrete construction shall have a melting point over one hundred seventy degrees Celsius (170° C) and a service temperature range extending at least between zero and eighty degrees Celsius (0-80° C).

Geogrid shall have adequate tensile strength and extensibility, compatible with its intended use and the soil and site conditions. The material shall be physically and chemically durable, and resistant to mildew, insects, naturally occurring acids and alkalis, and to certain building materials, when present, such as lime, cement or asphalt. When specified on the plans or directed by the Engineer, geogrid shall be treated for resistance to ultraviolet radiation. Geogrid may be of the following types.

1. Type A; monooriented grid/mat, exhibiting considerable tensile strength along one direction, the primary direction, suitable for unidirectional reinforcement of soil or other materials.
2. Type B; bioriented grid/mat, exhibiting considerable tensile strength along both directions, primary and secondary, suitable for bidirectional reinforcement of soil or other materials.
3. Type C; bioriented grid/mat, exhibiting considerable tensile strength along both directions, primary and secondary, suitable for bidirectional reinforcement of soil or other materials.
4. Type D; tridimensional grid/mat of cellular construction, exhibiting moderate tensile strength along both directions, suitable for containing soil, or other material, within its cells.

When shown on the plans or directed by the Engineer, multi-layered geogrid mats shall be factory-sewn or factory-extruded, to manufacturer's standard. Site assembly of single-layered geogrids into multi-layered composite systems shall not be permitted.

Performance requirements shall be as shown on the plans, and shall address all or part of the physical and chemical characteristics itemized in the foregoing paragraphs, based on intended use. Depending on the plan requirements and the primary function of the geogrid, the Contractor shall submit test results of the proposed material, as outlined in Table 6.21-2 herein.

Table 6.21-2
Minimum Quality Assurance Test Requirements

Test	Test Method	Unit	Primary Function			
			Reinforcement	Filtration	Drainage	Erosion Control
Polymer material	ASTM D1248, D4101	-	x	x	x	x
Mass per unit area	ASTM D1910	gr/m2	x	x	x	x
Thickness	ASTM D1777	mm	x	x	x	x
Strip tensile strength (main/secondary direction)	ASTM D4595	kN/m	x			
Elongation at max. Load (main/secondary direction)	ISO 5081	%	x			
U.V. Properties (carbon black content)	ASTM D4218	%				x
Transmissivity under pressure 2 kN/m2*	EMPA Testing Institute, Switzerland	m2/sec		x	x	

*Transmissivity tests shall be accompanied by graphs, illustrating transmissivity curves for applied pressures ranging from zero to one thousand (0 to 1000) kPa and hydraulic gradients ranging from five tenths to two (0.5 to 2.0).

Depending on application, the Engineer reserves the right to require that all tests listed in this table or additional tests not listed therein, be carried out, prior to approval of any material.

Tests shall be carried out on a sample of five specimens cut out randomly from each lot of five thousand (5,000) square meters of the proposed geogrid, or fraction thereof. Test results shall be the average of five specimens, with no individual value varying more than twenty percent (20%) from the average.

All materials furnished under this specification shall be accompanied by the manufacturer's certificate of guarantee. The certificate shall guarantee compliance to the specification requirements, give the quantity of the geogrid in the shipment, and identify the geogrid by order number, project location and destination. Materials not accompanied by a certificate of guarantee, shall be sampled in the field and samples submitted to an approved independent laboratory for testing.

The Engineer may approve materials on the basis of the certificate of guarantee and/or laboratory tests, but reserves the right to resample and have retested any materials used during the progress of the work. Should the geogrid not conform to the specifications, it shall be rejected, previous approval notwithstanding.

6.21.3 CONSTRUCTION REQUIREMENTS. Sheathing material or geocomposite shall not be placed against a mortar course less than four (4) days old.

6.21.3.1 Sheathing Materials. The inlet end of each weep hole and drain shall be covered with a geotextile extending a minimum of three hundred (300) millimeters beyond the weep hole or drain. Sheathing material shall be placed against the surface to be backfilled. Backfill shall be according to Subsection 2.09.4, "Backfill Structures" in these General Specifications using methods which prevent the backfill from mixing with the sheathing material.

6.21.3.2 Geocomposite Sheet Drain. When a geocomposite is used in conjunction with a waterproof membrane, install drainage panels compatible with the waterproofing using methods recommended by the membrane manufacturer. Assembly and placement of the geocomposite drain against the surface to be backfilled according to the manufacturer's recommendations.

Geocomposite drains are to be spliced so the flow across the edges is continuous. The geotextile shall overlap a minimum of seventy-five (75) millimeters in the direction of water flow. For vertical splices, the geotextile shall be overlapped in the direction backfill proceeds.

The geocomposite drain shall be connected to the perforated pipe underdrain or weep holes so the flow is continuous from the drainage core into the perforated collector pipe or weep holes. The geotextile shall extend from the bottom of the geocomposite drain to over the collection pipe.

Backfill and compaction shall be according to Subsections 2.09.4 "Backfilling Structures" and 2.09.5 "Compaction of Structural Backfill" in these General Specifiations. The backfill shall not be allowed to enter the geocomposite drain system at any point.

Any portion of the geocomposite drain damaged during installation or backfilling shall be repaired or replaced according to the manufacturer's recommendations.

Galvanized No. 17 gage hardware cloth screen having approximately thirteen by thirteen (13 x 13) mesh openings shall be placed and securely attached over the outlet ends or all exposed pipes or weep holes to prevent rodent entry.

6.21.3.3 Geogrid. The surface whereupon the geogrid will be laid shall be smooth, level and compacted as specified on the plans or specifications for each particular application. The surface shall be free of obstructions, depressions or debris that may adversely affect the installation of the geogrid.

The geogrid shall be placed smoothly and stretched over the prepared surface, parallel or perpendicular to the centerline of the facility, as shown on the plans or directed for each particular application. Individual mats shall be secured in place using 8-mm diameter, U-shaped pegs made from reinforcing steel bars. When directed, adjacent mats shall overlap with each other. Overlapping shall follow a shingle-like pattern, with the uphill or upstream mat overlapping the downhill or downstream mat, respectively. Lap widths shall be not less than 15 cm and mats shall be tied to each other with plastic ties, as per the manufacturer's standard.

Geogrid mats shall be unrolled as close as possible to their final locations and shall not be dragged around nor subjected to unnecessary abuse prior to placement. Backfill shall be back-dumped on the geogrid and spread in a loose thickness between 15 and 25 cm, without driving trucks or other construction equipment directly on the geogrid. If, in the opinion of the Engineer, the geogrid is damaged or displaced to the extent that it cannot function as intended, he will order the Contractor to remove any backfill, regrade the area, and replace the geogrid, all at the Contractor's expense. Backfill shall be compacted to the density required by the purpose of the backfill, as specified elsewhere in the specifications.

Geogrids shall be placed in conjunction with the placement of the backfill or overburden material, in order to minimize the time of exposure of the unprotected geogrid to the sunshine. Such lag time shall not exceed two weeks.

In slope-protection applications, the geogrid shall be anchored at the top of the slope by means of folding the geogrid into a small trench and backfilling with the excavated material, and compacted. Slope-protection materials, such as riprap, shall be placed from the bottom upward.

When underwater installation is necessary, laps shall be pre-sewn and the geogrid shall be weighted by tying reinforcement bars to it, either transversely or longitudinally, to secure against floatation, and then lowered in position.

When geogrids are used in conjunction with bituminous concrete construction, the mats shall be laid on the prepared surface immediately after the tack coat has been sprayed. The geogrid shall be unrolled under tension and rolled with a manual roller onto the bituminous surface for full adhesion. In curves, the geogrid shall be cut across its full width as frequently as directed and overlapped 15 to 20 cm in the direction of subsequent laying of the bituminous layer. While the bituminous concrete layer is being placed, braking and unnecessary maneuvering on the fabric shall be avoided. On gradients, the bituminous concrete layer shall be placed uphill, so as to avoid direct braking of trucks pushed by the paving machine on the geogrid.

6.21.4 QUALITY ASSURANCE PROCEDURES. Drainage layer work will be inspected, sampled, tested, evaluated and accepted in accordance with Section 1.08, "Acceptance of Work" in these General Specifications as follows:

Geocomposites will be accepted under Subsection, 1.08.3 "Certification of Compliance" in these General Specifications. When samples are required, the Contractor shall provide a one (1) meter square sample from products supplied as sheets or panels or a one (1) meter length full roll width sample from products supplied in rolls. The sample shall be labeled with the lot and batch number, date of sampling, project number, item number, manufacturer, and product name.

The installation of the geocomposites and sheathing material shall be inspected, sampled, and evaluated in accordance with Subsection 1.08.4, "Measured or Tested Conformance" in these General Specifications.

6.21.5 MEASUREMENT. Sheathing material will be measured by the cubic meter to the neat lines shown on the Plans.

Geocomposite sheet drain will be measured by the square meter of front face in final position, excluding overlaps.

Geocomposite pavement edge drain will be measured by the linear meter acceptably installed excluding splices.

Geogrid shall be measured by the square meter of completed and accepted Work of the various types and strength grades placed as specified. Measurement shall be based on the theoretical dimensions shown on the plans or directed by the Engineer. No allowance shall be made for anchoring, overlaps or seams or for other materials, such as reinforcing bars for weighting. No measurement shall be made of unauthorized Work as specified in Subsection 1.07.6, "Unauthorized Work," in these General Specifications. This Work shall include furnishing all materials and placing the geogrid as specified.

6.21.6 PAYMENT. The accepted quantities, measured as provided above, will be paid at the contract unit price per unit of measurement for the pay items listed below that are shown in the Bill of Quantities. Said prices and payments will be full compensation for furnishing labor, equipment, materials, tools and all incidentals necessary for the completion of the work as specified in Subsection 1.07.2, "Scope of Payment" in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
62101	Sheathing material	Cubic Meter
62102	Geocomposite sheet drain	Square Meter
62103	Geocomposite pavement edge drain	Linear Meter
62104	Geogrid	Square Meter
6210401	Geogrid Type A, Tensile Strength ___kN/m	Square Meter
6210405	Geogrid Type B, Tensile Strength ___ kN/m	Square Meter
6120410	Geogrid Type C, Tensile Strength ___ kN/m	Square Meter
6120415	Geogrid Type D, Tensile Strength ___ kN/m	Square Meter
6120420	Geogrid Type ___, Tensile Strength ___ kN/m	Square Meter

SECTION 6.22 - JOINT SEALANT AND JOINT FILLER

6.22.1 Description. This Work covers joint sealing and caulking materials and expansion joint fillers and gaskets for use where shown on the plans and specified in other sections of these General Specifications and at locations directed by the Engineer.

6.22.2 Materials.

6.22.2.1 General. Manufacturer's specifications, recommendations, and installation instructions for each type of sealant, caulking compound, joint filler, gasket, and associated miscellaneous materials required, shall be submitted by the Contractor for approval by the Engineer. Each submittal shall be accompanied with a letter by the manufacturer stating which of the materials proposed comply with the requirements and is intended for each specific application shown or directed.

Elastomeric sealant materials shall be obtained only from manufacturers who will, if required, send a qualified technical representative to the site, for the purpose of advising the Contractor of proper procedures and precautions for the use of the materials.

Sealant materials specified by the manufacturer as having an application temperature range of eight to fifty degrees Celsius (8 to 50° C) shall be given preference.

When so directed by the Engineer, the Contractor shall submit three hundred (300) mm long samples of each color required (except black) for each type of sealant, caulking compound, joint filler, or gasket exposed to view. The sample shall be installed between two strips of material similar to or representative of typical surfaces where the sealant or filler will be used, held apart to represent typical joint widths. Samples will be reviewed by the Engineer for color and texture only. Compliance with all other requirements is the exclusive responsibility of the Contractor.

When so directed by the Engineer, the Contractor shall prepare a mock-up installation of each major type and use of sealant. Sealant shall be installed between materials matching those used on the project, complying with conditions similar in every respect to the anticipated project conditions. Mock-ups shall be prepared well in advance of scheduled installation, so that nominal cure time is allowed and final adjustments can be made, if necessary, before proceeding with the actual Work.

Sealant hardnesses shown on the plans, specified or directed, are intended to indicate the general range necessary for overall performance. The manufacturer's technical representative shall be consulted to determine the actual hardness recommended for the conditions of installation and use. Except as otherwise indicated or recommended, compounds within the following ranges of hardness (Shore A, fully cured, at 24 degrees C) shall be provided:

1. Five (5) to twenty (20) for high percentage of movement and minimum exposure to weather, with no exposure to abuse.

2. Fifteen (15) to thirty-five (35) for moderate percentage of movement and moderate exposure to weather and abrasion.

3. Thirty (30) to sixty (60) for low percentage of movement and maximum exposure to weather and abrasion, including foot traffic on horizontal joints.

For joints subject to movement, either thermal or dynamic elastomeric sealants, where approved, having the lowest modulus of elasticity consistent with exposure to abrasion or abuse shall be provided. For horizontal joints subject to traffic, sealants with high modulus of elasticity, as required to withstand indentation by impressed stones, etc., shall be provided. Manufacturer's recommendations shall be complied with, wherever no other requirements are indicated.

Before purchase of each specified sealant, filler or gasket, the Contractor shall investigate its compatibility with the joint surfaces and other materials in the system. Only materials as herein specified which are known to be fully compatible with the actual installation conditions, as shown by manufacturer's published data or certification, shall be provided.

Size and shape of preformed sealant or filler units shall be as shown in the plans or, if not shown, as recommended by the manufacturer, either in his published data or upon consultation with his technical representative for the joint size and site location conditions.

Pressure sensitive adhesives, compatible with each material in the joint system, may be applied to one face of joint fillers and gaskets to facilitate installation and permanent anchorage. Adhesives shall not be allowed to contaminate sealant bond surfaces, if any, in the joint system.

6.22.2.2 Joint Sealing Compounds.

6.22.2.2.1 Hot Type Joint Sealing Compounds.

1. Compositions. This type shall be a mixture of virgin synthetic rubber or reclaimed rubber, or a combination of the two with asphalt plasticizer and tactified. Ground cured rubber scrap shall not be used.

2. Physical Requirements. The joint sealing compound, after heating and applications, shall form a resilient and adhesive compound capable of effectively sealing joints in concrete against the infiltration of moisture and foreign material through repeated cycles of expansion and contraction. It shall be for completely filling the joints and without damage to the material. It shall not flow from the joints or be picked up and tracked by vehicle tires at summer temperatures.

This material shall comply with the following:

(1) Pour Point. The pour point shall be at least eleven degrees Celsius (11° C) lower than the safe heating temperature. The safe heating temperature

is defined as the highest temperature to which the material can be heated and still meet all requirements of this specification. No sample of the material will be tested until the manufacturer furnishes his recommended safe-heating and pouring temperatures.

(2) Prolonged Heating. After six (6) hours of continuous heating, with constant mixing the laboratory melter at the manufacturer's recommended pouring temperature, the joint sealer shall meet all requirements of this specification. (For initial qualifying tests and subsequently as directed by the Engineer.)

(3) Penetration. The penetration at twenty-five degrees Celsius (25° C), one hundred fifty (150) grams, five (5) seconds, shall be not less than fifty (50) nor more than ninety (90) millimeters.

(4) Flow. The flow at sixty degrees Celsius (60° C) and at a seventy-five (75) degree angle shall not exceed one (1) centimeter in five (5) hours.

(5) Ductility. The ductility at twenty-five degrees Celsius (25° C) shall be not less than thirty-five (35) centimeters.

(6) Bond. The material when tested at minus seventeen and eighth-tenths (-17.8) degrees C to one hundred (100) percent extension (1.27 centimeters extended to 2.54 centimeters) shall, after five (5) cycles, show no surface checking, cracking, separation or other opening in the material or between the material and the block. At least two (2) test specimens in a set of three (3) specimens representing a given sample shall meet this requirement.

(7) Resilience. Recovery shall be not less than twenty-five (25) percent.

(8) Compression Recovery. Compression recovery of bond specimens shall be not less than one (1) centimeter within fifteen (15) minutes.

(9) Impact. No failure in cohesion or adhesion shall occur.

(3) Methods of Sampling and Testing.

(1) Sampling. Samples for testing shall consist of not less than a four and five tenths (4.5) kilogram sample from each batch of the joint sealer. A batch shall be considered as all finished material that was manufactured simultaneously or continuously as a unit between the time of compounding and the time packaging or placing in shipping containers. Each package or container shall be marked properly to indicate clearly the batch of which it forms a part. The material shall be sampled in accordance with the requirements of the "Standard Methods of Sampling Bituminous Materials" (ASTM Designation: D 140) for solid materials in cakes.

(2) Testing. Testing shall be in accordance with AASHTO T 187 except that the tolerances on dimensions of test specimens, Article 6.3 shall be plus or minus thirteen hundredths (0.13) centimeters and the temperature tolerances, Article 6.4 shall be plus or minus two and two tenths (2.2) degrees C.

6.22.2.2.2 Cold Type Joint Sealing Compounds.

1. Composition. This type shall be homogeneous material of such consistency that it can be applied by means of a high pressure pump through suitable nozzles to completely fill the joints. The compound may be blended with a suitable solvent or solvents by the manufacturer to provide better workability during installation in the joints. The volatility of these solvents must be such that they will evaporate within a short time after installation leaving a material that is adhesive and resilient.

2. Physical Requirements.

(1) Flow. The flow during a five (5) hour period at sixty degrees Celsius (60° C) shall not exceed five-tenths (0.5) centimeters.

(2) Penetration. After evaporation of the solvent, the penetration at twenty-five (25) degrees C, one hundred fifty (150) seconds, shall not exceed two hundred twenty (220) millimeters.

(3) Bond. When the compound is tested at minus seventeen and eight tenths (-17.8) degrees C, the development at any time during the test procedure of a crack, separation or other opening which is at any point over sixty-four (64) millimeters deep in the material or between the material and concrete block, shall constitute failure or the test specimen. The failure of more than one (1) test specimen in a group of three (3) specimens representing a given sample of joint-sealing compound shall be cause for rejection of the sample on the basis of this requirement.

3. Methods of Sampling and Testing. Cold-type joint compound shall be tested in accordance with ASTM D 1851, except that the material for test specimens, Article 7 ©will be stirred manually rather than mechanically.

6.22.2.2.3 Two-Component Elastomeric Sealants.

1. Two-component Polysulfide Sealant: Polysulfide-based, two-part elastomeric sealant, non-sag or self-leveling as recommended by the manufacturer for the application shown in the plans or directed.

2. Two-component Polyurethane Modified Sealant: Proprietary two-component primerless sealant.

3. Two-component Polyurethane Sealant: Polyurethane-based, two-part elastomeric sealant, self-leveling or non-sag as recommended by the manufacturer for the application shown in the plans or directed.

6.22.2.2.4 One-Component Elastomeric Sealants.

1. One Part Silicone Rubber Sealant: Silicone rubber based, one-component elastomeric sealant compounds.

2. One Part Polyurethane Sealant: Polyurethane based, one-component elastomeric sealant compound.

6.22.2.2.5 Preformed Elastomeric Sealants. Butyl Rubber Sealant Tape: A partially-vulcanized, self-adhesive, non-staining, elastomeric butyl rubber type, recommended by the manufacturer for waterproof construction when compressed up to 35% in dynamically-moving joints; not less than ninety eight percent (98%) solids; no deterioration after 3000 hours test in Atlas Weatherometer.

6.22.2.2.6 Non-elastomeric Sealants.

1. One-component Acrylic Sealant: Acrylic terpolymer, solvent-based, one part, thermoplastic sealant compounds; solids not less than ninety five percent (95%) acrylic; recommended by manufacturer for general use as an exposed construction sealant.

2. Acrylic-latex Sealant: Latex-rubber-modified, acrylic-emulsion polymer sealant compound; permanently flexible, non-staining and non-bleeding; recommended by manufacturer for protected exterior exposure.

3. Butyl Rubber Sealant: Polymerized butyl rubber and inert fillers (pigments), solvent-based with minimum seventy five percent (75%) solids, non-sag consistency, tack-free time of twenty four (24) hours or less, paintable, non-staining.

4. Preformed Butyl Rubber Sealant: Preformed ribbon or tape (coiled with release paper) of polymerized butyl rubber and inert fillers (pigments), solvent-based with minimum ninety five percent (95%) solids, non-sag thread or fabric to prevent stretch (as required to facilitate proper application).

6.22.2.2.7 Non-skinning Mastic Sealants.

1. Polybutene Mastic Sealant: Either liquid or preformed ribbon (coiled with release paper) of polybutene-based mastic, non-drying, non-skinning, non-hardening, of low viscosity, as recommended by the manufacturer for joints subject to shear movement but not subject to normal joint movement.

2. Polyisobutylene Mastic Sealant: Either liquid or preformed ribbon (coiled with release paper) of polyisobutylene-based mastic, non-drying, non-skinning, non-hardening, non-migrating, heavy-bodied as recommended by manufacturer for large joints subject to shear movement but not subject to normal joint movement.

6.22.2.3 Miscellaneous Materials.

6.22.2.3.1 Joint Cleaner. Type of joint cleaning compound recommended by the sealant or caulking compound manufacturer, for the joint surfaces to be cleaned.

6.22.2.3.2 Joint Primer/Sealer. Type of joint primer/sealer recommended by the sealant manufacturer, for the joint surfaces to be primed or sealed.

6.22.2.3.3 Bond Breaker Tape. Polyethylene tape or other plastic tape as recommended by the sealant manufacturer, to be applied to sealant-contact surfaces where bond to the substrate or joint filler must be avoided for proper performance of sealant; Self-adhesive tape wherever applicable.

6.22.2.3.4 Sealant Backer Rod. Compressible rod stock polyethylene foam, polyethylene jacketed polyurethane foam, butyl rubber foam, neoprene foam or other flexible, permanent, durable non-absorptive material as recommended for compatibility with sealant by the sealant manufacturer.

6.22.2.4 Preformed Expansion Joint Filler.

6.22.2.4.1 Description. This type of fillers and gaskets shall be as herein specified and shall have relatively little extrusion and a moderate to high amount of recovery after release from compression.

6.22.2.4.2 Requirements. Nonextruding and resilient type of expansion joint filler shall conform to all the requirements of the Standard Specifications for 'Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)," AASHTO Designation M 213 and as herein specified.

6.22.2.4.5 Concrete Control/Expansion Joint Fillers.

1. Self-expanding Cork Joint Filler: Resilient and non-extruding type premolded cork units, complying with ASTM D1752 Type III, and AASHTO M153, Type III.
2. Cork Joint Filler: Resilient and non-extruding type premolded cork units, complying with ASTM D1752, Type II, and AASHTO M153, Type II.

3. Sponge Rubber Joint Filler: Resilient, non-extruding, open-cell type premolded rubber, gray to match concrete, complying with ASTM D1752, Type I and AASHTO M153, Type I.

4. Bituminous and Fiber Joint Filler: Resilient and non-extruding type premolded bituminous impregnated fiberboard units, complying with ASTM D1751 and AASHTO M213.

6.22.2.4.4 Cellular Foam Expansion Joint Fillers.

1. Closed-cell Neoprene Joint Filler Expanded neoprene complying with ASTM D1056, Class SC (oil-resistant and medium swell), of thirteen (13) kPa to thirty four (34) kPa compression deflection (Grade SCE 41); except provide ninety (90) kPa to one hundred seventeen (117) kPa compression deflection (Grade SCE 44), wherever filler is applied under sealant exposed to traffic.

2. Closed-cell PVC Joint Filler: Flexible expanded polyvinyl chloride complying with ASTM D1667, Grade VE 41 B1 (24 kPa compression deflection); except

provide higher compression deflection grades as may be necessary to withstand installation forces and provide proper support for sealants, if any.

3. Expanded Polyethylene Joint Filler: Flexible, compressible, closed-cell polyethylene of not less than sixty eight (68) kPa compression deflection twenty five percent (25%); except provide higher compression deflection strength as may be necessary to withstand installation forces and provide proper support for sealants; surface water absorption of not more than four hundred ninety (490) gr/sq.m.

4. Open-cell Polyurethane Joint Filler: Flexible, highly compressible, open-cell polyurethane foam of not less that twenty (20) kg/cu m density and not less than thirteen (13) kPa compression deflection twenty five percent (25%) with not more than ten percent (10%) compression set for twenty five (25) hours at fifty percent (50%) compression; comply with ASTM D1564.

6.22.2.4.5 Gaskets.

1. Hollow Neoprene Pavement Gasket: Hollow or compartmentalized neoprene extrusion, designed to withstand compression to forty percent (40%) of normal width without extrusion from joint, and with full recovery; with heavy, durable top member, suitable for long-term exposure to severe traffic abrasion and contamination; hardness of approximately 66 Shore A; comply with ASTM D2628.

2. Molded Neoprene Gasket: Extruded neoprene gaskets complying with ASTM D2000, designation 2BC 415 to 3BC 620, black, of 40 to 60 Shore A durometer hardness; of the profile shown in the plans or, if not shown, as required by the joint shape, size and movement characteristics to maintain a watertight and airtight seal.

3. Exposed Closed-cell Neoprene Gasket: Extruded or molded expanded neoprene complying with ASTM C509, Grade 4, black; formed with durable self-skin to the profile shown in the plans or, if not shown, as required to maintain a watertight and airtight seal.

4. Concealed Closed-cell Neoprene Gasket: Extruded or molded expanded neoprene gaskets complying with ASTM D1056, Class SC, of the compression deflection required to perform properly; self-skinned and of the profile shown in the plans or, if not shown, as required to maintain a watertight and airtight seal.

5. Closed-cell PVC Gasket: Closed-cell, flexible, non-exuding, polyvinyl chloride foam gaskets complying with ASTM D1667, Grade VE 41 BL; except provide a higher compression deflection grade if necessary to maintain a watertight seal; provide pressure-sensitive adhesive on one face.

6.22.2.5 Miscellaneous Materials. Oakum Joint Filler: Untreated hemp or jute fiber rope, free of oil, tar and other compounds which might stain surfaces, contaminate joint walls, or not be compatible with sealants.

6.22.3 Certificate of Guarantee. The Contractor shall furnish the Engineer with a Manufacturer's Certificate of Guarantee for each type of joint material delivered to the site. The certificate shall note compliance to the appropriate specifications and shall state the results of the tests performed on the material, as required by the specifications. The Contractor shall, unless otherwise directed by the Engineer, have the joint material tested for conformance to the applicable specifications at an approved testing laboratory. All costs connected with Certificate of Guarantee and any subsequent quality testing shall be at the Contractor's expense.

The Contractor shall submit a special guarantee indicating that for a period of two (2) years from final acceptance he shall repair or replace sealants which fail to perform as watertight joints; or fail in joint adhesion; cohesion, abrasion, weather, extrusion, migration, or stain resistance; general durability; or appear to deteriorate in any other manner not clearly specified by the submitted manufacturer's data, as an inherent quality of the material for the exposure indicated. The guarantee shall include an agreement to remove and replace other work which has been superimposed on or otherwise placed against the sealants and caulking work, to the extent required to repair or replace the sealants and caulking work.

6.22.4 Construction Requirements. Joints shall be placed and sealed as specified in other sections of the specifications pertaining to items of Work to be jointed and sealed and as herein specified, when more stringent.

6.22.4.1 General. Joint surfaces of units to receive fillers, gaskets or sealants, and the conditions under which the work is to be performed shall be examined, and surfaces shall be prepared as recommended by the manufacturer and as herein specified for the intended use.

Work shall not proceed until unsatisfactory conditions have been corrected.

6.22.4.2 Joint Sealing Compounds.

6.22.4.2.1 Weather Limitations. Installation of sealants shall not proceed under adverse weather conditions, or when forecasted weather conditions are unfavorable for proper cure and development of high early bond strength. Wherever joint width is affected by ambient temperature variations, elastomeric sealants shall be installed only when temperatures are in the lower third of the manufacturer's recommended installation temperature range, so that the sealant will not be subjected to excessive elongation and bond stress.

6.22.4.2.2 Joint Surface Preparation. Joint surfaces shall be cleaned immediately before installation of the sealant or caulking compound. Dirt, insecure coatings, moisture and other substances which would interfere with bond of sealant or caulking compound shall be removed.

Sealants shall not be installed over joint surfaces which have been painted, lacquered, waterproofed or treated with water repellent or other treatment or coating, unless a test for durability (adhesion) has successfully demonstrated that the sealant bond is not impaired by the coating or treatment. If the test has not been performed, or shows bond interference, the coating or treatment shall be removed from the joint surfaces before installing the sealant.

Concrete and masonry joint surfaces shall be etched to remove excess alkalinity, unless the manufacturer's printed instructions indicate that alkalinity does not interfere with sealant bond and performance. Etching shall be performed with 5% solution of muriatic acid; neutralize with dilute ammonia solution, rinse thoroughly with water and allow to dry before sealant installation.

6.22.4.2.3 Installation. The sealant manufacturer's printed instructions shall be complied with except where more stringent requirements are shown or specified, and except where the manufacturer's technical representative indicates otherwise.

The joint surfaces shall be primed or sealed wherever shown or recommended by the manufacturer. Primer/sealer shall not be allowed to spill or migrate onto adjoining surfaces.

Sealant backer rod for liquid elastomeric sealants shall be installed, except where shown to be omitted or recommended to be omitted by the manufacturer for the intended application.

Bond breaker tape shall be installed wherever shown and wherever required by manufacturer's recommendations to ensure that elastomeric sealants will perform properly.

Only proven installation techniques shall be employed which will ensure that sealants will be deposited in uniform, continuous ribbons without gaps or air pockets; with complete "wetting" of the j joint bond surfaces equally on opposite sides. Except as otherwise indicated or directed, sealant rabbet shall be filled to a slightly concave surface, slightly below adjoining surfaces. Where horizontal joints are between a horizontal surface and a vertical surface, the joint shall be filled to form a slight cove, so that the joint will not trap moisture and dirt.

Sealants shall be installed to depths as shown or, if not shown, as recommended by the sealant manufacturer; but within the following general limitations measured at the center (thin) section of the bead.

1. For sidewalks, pavements and similar joints sealed with elastomeric sealants and subject to traffic and other abrasion and indentation exposures, joints shall be filled to a depth equal to seventy five percent (75%) of joint width, but not more than sixteen (16) mm deep or less than ten (10) mm deep.

2. For normal moving joints sealed with elastomeric sealants, but not subject to traffic, joints shall be filled to a depth equal to fifty percent (50%) of joint width, but not more than twelve (12) mm deep or less that six (6) mm deep.

3. For joints sealed with non-elastomeric sealants and caulking compounds, joints shall be filled to a depth in the range of seventy five to one hundred twenty five percent (75% - 125%) of joint width.

Sealants or caulking compounds shall not be allowed to overflow or spill onto adjoining surfaces, or to migrate into the voids of adjoining surfaces. Masking tape or other precautionary devices shall be used to prevent staining of adjoining surfaces, by either the primer/sealer or the sealant/caulking compound.

Excess and spillage of compounds shall be removed promptly as the work progresses. Adjoining surfaces shall be cleaned with a solvent recommended by the manufacturer, to eliminate evidence of spillage; without damage to the adjoining surfaces or finishes.

Polysulfide sealant installation shall comply with standards recommended by the sealant manufacturer.

6.22.4.2.4 Cure and Protection. Sealants and caulking compounds shall be cured in compliance with the manufacturer's instructions and recommendations to obtain high early bond strength, internal cohesive strength and surface durability. All procedures required for the curing and protection of sealants and caulking compounds during the construction period shall be provided, so that they will be free of deterioration or damage (other than normal wear and weathering) at the time of acceptance.

6.22.4.3 Preformed Expansion Joint Filler. The manufacturer's instructions and recommendations shall be complied with for the installation of each type of joint filler or gasket required, unless more stringent requirements are shown in the plans or directed.

Units shall be set at proper depth or position in the joint to coordinate with other work, including the installation of bond breakers, backer rods and sealants. Voids or gaps between the ends of joint filler units shall not be accepted.

Exposed edges or faces of gaskets and exposed joint fillers shall be slightly recessed behind adjoining surfaces, unless otherwise directed, so that compressed units will not protrude from the joint.

Ends of gaskets shall be bonded together with adhesive or by other means as recommended by the manufacturer to ensure continuous watertight and airtight performance. Ends at corners shall be mitercut and bonded, unless molded corner units are provided.

6.22.5 Quality Assurance. Acceptance of joint materials shall be in accordance with Subsection 1.08.4 - "Measured or Tested Conformance," in these General Specifications. At the Engineer's discretion, acceptance of any or all of the materials specified herein, may be carried out as specified in Subsection 1.08.3 - "Certification of Compliance," in these General Specifications.

Acceptance of the completed work shall be carried out as specified in Subsection 1.08.2 "Visual Inspection," in the General Specifications, and as detailed below.

After nominal cure of exterior joint sealants which are exposed to the weather, a test for water leaks shall be performed. Horizontal joint exposures shall be tested by flooding with water to a depth of fifty (50) mm for twenty four (24) hours. Vertical joint exposures shall be tested by flooding the joint with water directed from a twenty (20) mm garden hose held perpendicular to the wall face, six hundred (600) mm from the joint, connected to a water system with two hundred (200) kPa minimum normal water pressure. The stream of water shall be moved along the joint at an approximate rate of six (6) meters per minute.

Approximately five percent (5%) of total joint system shall be tested, in locations which are typical of every joint condition, and which can be inspected easily for leakage on the opposite face. The test shall be conducted in the presence of the Engineer who will determine the actual percentage of joints to be tested and the actual period of exposure to water, based upon the extent of observed leakage, or lack thereof.

Sealant installation shall be repaired at leaks or, if the leakage is excessive, the sealant installation shall be replaced as directed.

Where the nature of observed leakage indicates the possibility of inadequate joint bond strength, the Engineer may direct that additional testing be performed at a time when joints have been fully cured, followed by natural exposure through both extreme temperatures and returned to the lowest range of temperature in which it is feasible to conduct testing. Repair or replace work shall be carried out as directed.

6.22.6 Method of Measurement. No part of this section is a Bill-of-Quantity item. Measurement may be made for project records only, when so directed by the Engineer.

6.22.7 Payment. The materials provided for in this section shall not be paid for directly, but will be considered subsidiary to other items or Work appearing in the Bill of Quantities.

KINGDOM OF SAUDI ARABIA
MINISTRY OF COMMUNICATIONS

GENERAL SPECIFICATIONS
FOR
ROAD AND BRIDGE CONSTRUCTION

November 1998

PART SEVEN
ROADWAY LIGHTING AND TRAFFIC SIGNALS

PART SEVEN: ROADWAY LIGHTING AND TRAFFIC SIGNALS

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PART SEVEN: ROADWAY LIGHTING AND TRAFFIC SIGNALS

SECTION 7.01 - GENERAL

7.01.1 DESCRIPTION. These specifications are considered as General Specifications. The Lighting and Power Installations to be supplied and installed under contract shall be as required by the Project Drawings and Contract Bill of Quantities.

7.01.2 SCOPE OF WORK. Work related to the electrical installation provided for in this Specification shall include the supply, installation, testing, commissioning and putting into satisfactory operation any or all of the following systems as required by the Project Drawings and Contract Bill of Quantities:

1. 33 kV System
2. 13.8 kV System
3. LV Cables
4. LV Pillar
5. Lighting Installation
6. Earthing
7. Installation Testing
8. Equipment Data
9. Electrical Civil Works
10. Traffic Signals.

The work shall include the provision of shop drawings and the calculations required by the specification, as well as the provision of all literature and samples in connection with the approval of proposed equipment.

The equipment supplied shall include all necessary items for a complete installation which will give satisfactory operation not withstanding errors and omissions. The equipment listed in the documents is, therefore, indicative and not limitative.

7.01.3 TECHNICAL REQUIREMENTS.

7.01.3.1 General. All work carried out on the installation shall be in accordance with the requirements of these Specifications, so that their true meaning and intent are fulfilled. Minor deviations from the drawings may be made to accomplish this, but no changes shall be made without the written approval of the Engineer.

These specifications, and the design drawings are complementary documents, intended for the selection of equipment having the general and specific characteristics as detailed in the documents.

7.01.3.2 Regulations and Standards. All electrical work shall comply with all applicable Government Rules and Regulations and carried out in accordance with the recommendations of the International Electrotechnical Commission (IEC) together with reference to the following:

1. Relevant Standards and Specifications issued by the appropriate Authorities in the Kingdom of Saudi Arabia, including the "Design Principles for Roadway Lighting" issued by the Ministry of Communications.

2. IEE Wiring Regulations (UK) as published by the Institute of Electrical Engineers, London.

3. National Electric Code (USA) as published by National Fire Protection Association.

4. BSS published by the British Standards Institution.

5. DIN (German) Standards and VDE Regulations as published by the German Electrotechnical Commission.

6. NEMA National Electrical Manufacturers Association (USA)

7. I.E.C. Recommendations.

All equipment and materials supplied for this project shall be manufactured in compliance with the latest relevant standards of the IEC and NEMA, BSS or DIN and hereinafter referred to as "Standards."

Acceptance tests shall conform with the above mentioned "Regulations" and "Standards."

7.01.3.3 Basic Design Consideration. MV power will be supplied to the package sub-stations either by underground cable networks or by overhead lines, 3-phases, 60 HZ, as shown on the Project Drawings.

LV power will be distributed from the substation transformers at 400/230V nominal, 3-phases, 4-wires, 60 HZ.

Single phase equipment shall be connected between phases and neutral in a way to balance the three (3) phases.

The component parts of each electrical system or piece of equipment shall be the latest standard product of a single manufacturer unless otherwise specified, and provided such components, manufactured by different manufacturers, are of standard design and dimensions, and interchangeability is possible and shall normally have been in satisfactory service for at least two (2) years.

All work shall be installed in a neat workmanlike manner so as to be readily accessible for operation, maintenance and repair. Minor deviations from the Drawings may be made to accomplish this but no changes shall be made without the approval of the Engineer.

Unless otherwise specifically mentioned, all equipment shall be designed and rated for a continuous and trouble-free service at fifty degrees Celsius (50° C.) ambient temperature and one hundred percent (100%) relative humidity with temperature reaching seventy degrees Celsius (70° C.) in direct sunlight with a high content of ULTRA-VIOLET rays. The equipment shall be able to withstand full load operation exposed to sun, dust storms, corrosive agents and the like.

7.01.3.4 Approval of Equipment. The Contractor shall not order any equipment before receiving approval in writing. Approval procedures shall be as follows:

1. Contractor submits his proposal to the Engineer in triplicate. This submission shall be comprehensive and clearly state any manufacturer's deviations from the specification. Manufacturers' literature with the submission shall be originals and not photocopies.

2. The submission shall be reviewed by the Engineer. Approval procedure shall be as follows:

(1) If the submission is from local manufacturers and complies with specification requirements, the Engineer will issue his written approval to the Contractor. A copy of the submission with the Engineer's approval letter is to be submitted to the M.O.C. for information.

(2) If the submission is from local manufacturers but there are minor deviations from the specification requirements which shall not affect the performance of the equipment, the Engineer will clarify the deviation and submit it to the M.O.C. for approval. The Engineer shall transmit the approval to the Contractor in writing only after receipt of the M.O.C. approval.

All submissions shall give clear detailed characteristics of the equipment proposed, together with calculations where necessary, including catalogue identification references. Documents shall be in the Arabic and English languages.

The Engineer reserves the right to direct the Contractor to provide equipment of a make and type which is essential to achieve the designed criteria.

The Contractor shall at his own expense, present a sample to the Engineer of each type of luminarie to be used, complete with its auxiliary equipment which shall exactly conform to the specified items. The luminaries should only be submitted after approval of their technical characteristics.

The approval of the proposed luminaries shall be given after the Contractor submits his detailed calculation of the illumination levels as required by this Subsection.

The Engineer reserves the right to verify the performance and quality of the samples by instructing that tests of his choice be carried out at the Contractor's expense, before granting approval of the sample.

Approval of samples by the Engineer does not in any way relieve the Contractor of his contractual obligations in respect of the suitability of the equipment or its final performance once installed, and the coordination of the elements into a fully operational installation.

The Contractor shall not be entitled to claim in any way whatsoever because of a sample rejection considered by the Engineer as not complying with the Specification and the Contractor shall be wholly responsible for any delay resulting from the rejection of a sample.

7.01.3.5 Contractor's Drawings. The Tender Drawings detailed in the "List of Drawings" are design drawings, describing all the installation deemed to achieve the required performance.

The Contractor shall submit for approval by the Engineer detailed construction drawings before starting work. These drawings shall comply with and complement the tender drawings in showing physical layout of all equipment, exact location of columns, construction and installation details, wiring diagrams, etc. No work shall be started on site until approval of the Drawings has been given in writing by the Engineer.

Upon completion of the Works the Contractor shall provide the Engineer with one (1) transparency and six (6) prints of each of the layout and detail drawings and wiring diagrams showing "As-installed" together with any other information and documentation and operation of the equipment.

All Contractor's documents and drawings presented shall be in the Arabic and English languages.

7.01.3.6 Maintenance Literature. Prior to the final acceptance of the installation the Contractor shall submit to the Engineer six (6) sets of manuals for all equipment supplied under the Contract. The manuals shall be A4 size bound in loose leaf binders or booklets suitably enclosed and including the following:

1. Single line diagram of the complete work
2. Control, protection and circuit diagrams for all equipment
3. Setting-up, commissioning and operating instructions
4. Trouble shooting procedures
5. Maintenance instructions including schedules for preventative maintenance
6. Complete recommended spares list including manufacturers' name and catalogue number
7. Name, address and phone number of manufacturers' local authorized representatives and service agent.

7.01.3.7 Manufacturers. The detailed descriptions of equipment appearing in the following sub-divisions, indicate the minimum quality and standard of equipment to be accepted. Products of manufacturers having good repute and standard shall be considered by the Engineer on an equal basis. In this respect the Engineer's decision shall be final and not subject to any justification whatsoever.

7.01.4 DESIGN CRITERIA FOR THE LIGHTING INSTALLATION.

7.01.4.1 General. It is the intention of these Specifications and the attached Drawings to obtain a lighting installation which provides luminance levels according to the design criteria detailed below. The installation detailed on the drawing has been designed tentatively on the basis of actual light distribution curves of existing luminaries similar to those specified to achieve the required levels.

The Contractor shall be responsible and confirm in writing that his selection of equipment will ensure on the road and sign surfaces luminance levels and uniformities equal or better than those defined in the "Lighting Design Criteria."

7.01.4.2 Lighting Design Criteria. The road surface on which the lighting levels shall be measured is defined as the width of all the traffic lanes of all roadways, underpasses and ramps of the interchanges.

The luminance and illumination levels of the roadways and ramps as specified below are the initial average level which shall be calculated and substantiated by measurements of the Contractor, after one hundred (100) hours of operation. The Contractor shall specify the anticipated lamp lumen and luminarie dirt depreciation factors after two (2) years of operation recommended by the manufacturers, to assist the Engineer in assessing the maintained lighting levels in the installation.

The luminance and illuminance levels and uniformities shall be calculated by the Contractor for the interchanges, travel lanes and service roads. The Contractor shall take account of the different elevations of roadways and ramps in his lighting calculations. The Contractor shall include for the luminaries manufacturer to carry out the final setting of all lights after site erection to ensure maximum utilization of light output.

Within six (6) weeks after award of the Contract, the Contractor shall submit the technical details of the luminaries and having obtained conditional approval thereof, submit in duplicate, full details of the calculated results for the levels and uniformity of luminance and illumination on all road surfaces. These details should be submitted in the format as described in the relevant IEC Publication and the Ministry of Communications Highway Design Code and after initial approval by the Engineer, the Contractor shall erect on site along typical stretches of the road, at least four (4) consecutive spans of masts equipped with the specified number of the submitted luminaries, and the Contractor shall prove by measurement that the lighting criteria have been met. The results shall be fully tabulated. The results will be analyzed and submitted to the M.O.C. Engineer for approval. No final approval will be given until the tests have been completed and the test results are accepted by the M.O.C. Engineer. The execution of the Contract shall then proceed upon the basis of these levels and uniformities being achieved, throughout the whole extent of the Contract.

Upon completion of the installation the Contractor shall be required to carry out measurements of the lighting levels on site in accordance with Design Code Section

7.16, Paragraph C (f) and to submit the results as proof that the approved calculated levels and uniformities have been achieved.

The following initial lighting design criteria should be applied:

	Travel Lanes
Luminance (L) cd/m^2	As shown on Design Manual TABLE for the type of road under construction
Overall Uniformity (Uo) (Uo = L min./L avg.)	0.4
Uniformity of each lane (Ul) (Ul = L min./L max.	0.7
Threshold increment not exceeding	10%

Calculations shall show the installation is satisfactory using Road Surface characteristics IEC classification. Type R2 with qo = 0.07 and also Type R4 with qo = 0.08.

Reference Horizontal Illumination (E avg. #)	As shown in Design Manual TABLE for the type of road under construction

Illuminance Uniformities

E. min./E. Avg.	1:3
E. min./E. Max.	1:6

7.01.4.3 Light Distribution Pattern. The Contractor shall select fixtures generally similar to IEC classification.

Luminaries shall be of the cut-off or semi cut-off type of distribution.

The luminaries shall be of purpose built design incorporating the specified size and type of lamps.

The light distribution characteristics of the luminarie as mounted shall be better than:

Direction of Maximum intensity zero to sixty-seven degrees (0-67°) for cut-off type. Maximum permissible value of intensity at:

90 degrees from nadir - 25 cd/1000 lumens
80 degrees from nadir - 100 cd/1000 lumens

7.01.5 ENERGY SAVING. Partial cut-off of the street lighting after mid-night is required in roads and interchanges. This shall be achieved by putting off one-half (½) of the installed luminaries on high masts and columns.

This shall be made by Timer installed in the Packaged S/S and contactors installed in the high masts and columns. The connection between the timer and contactor shall be by pilot cables.

Specifications of timer, contactor and pilot cables to be submitted for approval by the Engineer.

7.01.6 SAFETY CLEARANCE. Prior to start of construction, the Contractor must check all drawings and to ensure that all obstacles have been taken into account and to submit to the Engineer a list of obstacles at site including existing O/H power lines, water and drainage pipes, underground power and telephone lines.

Clearances (vertical and horizontal) required by the authorities to be achieved. Construction drawings showing all services and the new installations to be signed by both Contractor representatives and the Engineer before commencement of the construction of bases of High Mast, Lighting Columns, Traffic Signals Poles, Overhead Gantry Signs, Sign Boards, Packaged Sub-Stations, uPVC Ducts, Trenches, etc.

SECTION 7.02 - 33 KV SYSTEM

7.02.1 33 KV DISTRIBUTION NETWORK.

7.02.1.1 DESCRIPTION. The distribution shall consist of 33 KV overhead line 3 phases and earth wire shall be installed along the roads to feed the 33/0.4 KV sub-stations installed in the positions shown on the drawings. The work and structure shall consist of the following: foundations and steel tubular pole, pole extension, angle steel crossarm, angle braces, hardware, ACSR conductors, earth wire, surge arrestors, fuse disconnect, porcelain insulators, guys, earthing, steel accessories, cut out with fuses, etc. The Contractor shall supply all materials and labor installation testing and putting into satisfactory operation the 33 KV network, including connecting the new 33 KV lines to the existing SCECO overhead lines. It is the Contractor's responsibility to obtain full specification from SCECO to ensure full compliance with their requirements.

The positions of connection points shall be determined by SCECO. The line conductor size shall be in accordance with SCECO requirements.

ITEMS IN BILL OF QUANTITIES
33 KV Overhead Electrical Line, Copper Conductor
33 KV Overhead Electrical Line, Aluminum Conductor

7.02.2 MATERIALS.

7.02.2.1 Poles. Octagonal Steel poles of different heights and working loads are classified as follows:

ULTIMATE LOAD	HEIGHT	CLASS
1490 Kg	12M	12 OC1/1490
1900 Kg	12M	12 OC2/1900
3750 Kg	12M	12 OC3/3750
4960 Kg	12M	12 OC4/4960
4917 Kg	13M	13 OC5/4917

Poles will be limited to a deflection of five percent (5%) of their exposed height by using the following formula:

The exposed height is the total pole length less one and three-quarters (1.75) meters for High Voltage poles and less one and one-half (1.5) meters for Low Voltage Poles.

Thus, for a twelve (12) meter HV pole, the deflection is (12 - 1n.75) x 5/100 - 512.5 millimeters.

In order to determine the deflection, poles will be tested at Working Load. Working Load will be defined as Ultimate Load divided by a safety factor of one and one-half (1.5) or WL=UL/1.5.

The analysis and design of the poles shall include the effect of deflection at the top. Local buckling criteria shall be in accordance with provisions of "Design of Steel Transmission Pole Structures" by ASCE.

Poles are required to be supplied with holes predrilled in order to attach crossarms, braces and eye bolts, etc., according to the type of structure required, in conformity with SCECO construction standards. Manufacturer shall supply poles with plugs installed to seal off all holes. These may be plastic and must be a fine fit within the hole.

Manufacturer shall supply caps or plugs to cover the top of each pole. Such caps may be made of durable plastic or composition materials and shall be tight fitting, with an air hole in each cap.

The pole shall be of octagonal cross-section. It shall be of taper design and aesthetically pleasing. It shall be manufactured from sheet steel or grade as specified by the relevant standard. It shall preferably be made in one (1) piece. When more than one (1) piece is needed, the Contractor will give details of the method of joining the pieces. The octagonal sections will be made by cold forming.

The Contractor shall submit to the Engineer the details of his calculations to evaluate the working stresses in the steel poles for the specified loading and dimensions.

The calculations shall include sketches of applied loads and indicate the breaking stress of the pole and pole top deflection.

The welding process used will conform to the CSA Standard W59-1977 for the grade of steel to be used.

All welds will be performed, ground to a smooth finish, and tested before galvanizing.

Quality control method specified by SCA Standard W59-1966 shall be used to check the quality of all the welds.

All poles, cross arms, braces, brackets, etc. after manufacture will be hot-dip galvanized in accordance with the ASTM standard No. A123-73.

No further manufacturing, touching or modifications will be performed on them after they have been galvanized.

Each item will be checked for adherence, mass of zinc deposited, continuity of coating, after the process of galvanizing.

All holes shall be drilled before galvanizing.

The holes will have specified dimensions as measured after galvanizing.

The poles shall be provided with a permanently fixed metal tag at five thousand (5000) millimeters from the built-end with the following information punched on it:

- Class, working load in kilograms
- The year of manufacture
- The length of pole in meters

All poles will be color coded by placing two (2) sets of specific spectral bands of color, one (1) set at the build-end of the pole and the second set at a distance of four thousand five hundred (4500) millimeters from the built-end of the pole. Each band will be one hundred (100) millimeters wide and shall be separated by one hundred (100) millimeters. This code will give immediate identification of the Pole's application in the field.

Color coding shall be carried out as per SCECO requirements.

The manufacturing tolerance on the overall dimensions of the items of material will be as follows:

± 1.0% - on overall height of the pole
± 0.5% - on overall length of crossarms and braces
± 0.5 mm - on hole diameters
± 0.8 mm - on the centers of the holes

7.02.2.2 Pole Extensions. Pole extensions must be made to fit precisely into their parent pole. They must be capable of rapid and easy assembly in the field. The composite pole must be capable of carrying the load normally carried by the parent pole. They shall be manufactured to the same specifications.

7.02.2.3 Crossarms. Crossarms shall be fabricated from angle sections of ASTM grade A36 steel with minimum tensile strength 42.186 kilograms per square millimeter. (60,000 pounds per square inch).

The crossarms shall be supplied with holes predrilled to attach it to poles and for installation of insulators, etc.

The required size and location of holes in the Crossarm shall be as specified in SCECO construction standard drawings. Crossarms of different length are classified as follows:

X-Section	Length
L 100 x 100 x 10 mm	2000 mm
L 100 x 100 x 10 mm	3000 mm
L 100 x 100 x 10 mm	1500 mm
L 100 x 100 x 10 mm	2500 mm
L 100 x 100 x 10 mm	3000 mm
L 150 x 100 x 10 mm	3000 mm

7.02.2.4 Braces. Braces shall be fabricated from equal angle sections of ASTM grade A36 steel with minimum tensile strength 42.186 kilograms per square millimeter (60,000 pounds per square inch).

Braces shall be supplied with holes pre-drilled to attach it to pole end crossarm. They are classified as follows and shall have the dimensions, size and location of holes as detailed in SCECO construction standard drawings:

X-Section	Length
L 40 x 40 x 6mm	800 mm
L 40 x 40 x 6mm	800 mm one end clipped
L 40 x 40 x 6mm	1500 mm
L 40 x 40 x 6mm	1500 mm one end clipped
L 40 x 40 x 6mm	1460 mm
L 40 x 40 x 6mm	1460 mm one end clipped left hand
L 60 x 60 x 5mm	2370 mm
L 40 x 40 x 6mm	1460 mm one end clipped right hand
L 40 x 40 x 8mm	1270 mm

7.02.2.5 Bracket, Plate and Strap. These shall be fabricated from ASTM grade A36 steel with a minimum tensile strength of 42.185 kilograms per square millimeter (60,000 pounds per square inch).

They shall be supplied with pre-drilled holes wherever specified. The material items are described as follows and in conformity with SCECO construction standard drawings:

Item Description

Flat Steel Bracket
Double Arming Plate
Back Strap
Pole bearing plate five (5) millimeters thick for light pole
Pole bearing plate ten (10) millimeters thick for heavy pole

7.02.2.6 Saddles. Saddles are required to be installed on poles of round section to provide a flat surface for crossarms of angle iron specified in the crossarm section.

Two (2) types of saddles are required: bold-on and wrap-on type. The wrap-on type saddle will, in addition, provide a means of attaching crossarms and brace to pole by means of locking type steel wraps. The wraps shall be of stainless steel or galvanized steel. It shall be of dimensions to meet the mechanical strength specified below. It shall be supplied in lengths of thirty (30) meters. Locking clamps and tool for locking wraps shall also be supplied.

The saddles shall be galvanized steel and have the following mechanical strengths.

	Mechanical Strength
1. Bolt-on type saddle for x-arm	2500 kilograms
2. Bolt-on type saddle for brace	2500 kilograms
3. Wrap-on type saddle for x-arm	7000 kilograms
4. Wrap-on type saddle for brace	500 kilograms

7.02.2.7 Porcelain Insulators. The entire porcelain surface of the insulators that will be exposed after assembly shall be glazed, so as to ensure zero (0) moisture absorption and relative freedom from imperfections. The glaze shall be of a type to minimize radio and TV interference and corona discharge. Retaining pins and locking devices shall be of phosphor bronze high quality galvanized steel, galvanized in accordance with ASTM specification for zinc coating (hot-dip) on iron and steel hardware. Each insulator unit shall bear symbols identifying the manufacturer and giving the year of manufacture. The marking shall be visible and durable. The cement sealing between insulator porcelain and base shall be so processed to avoid any surface cracking. The top groove radius of insulators shall be suitable for aluminum stranded conductors up to a size of two hundred twenty-five (225) square millimeters.

7.02.2.8 ACSR Conductor. Sizes of ACSR conductor to be used shall be specified by SCECO and are classified as follows:

1. One hundred twenty-five and one-tenth (125.1) square millimeters or equivalent, with six (6) strands of aluminum and one (1) strand of steel, rated tensile strength of three thousand eight hundred twenty (3820) kilograms. It shall be of code name "PENGUIN."

2. Two hundred fifty-five and one-tenth (255.1) square millimeters or equivalent, with eighteen (18) strands of aluminum, and one (1) strand of steel, rated tensile strength of five thousand five hundred eighty-three kilograms. It shall be of code name "PELICAN."

The aluminum conductor shall be hard-drawn aluminum wire and the steel core wire shall be of zinc coated hard-drawn steel. The weight of zinc coating shall be not less than as specified in CSA standard C49-65.

The wires used in the construction of the stranded conductor shall, before stranding, have the mechanical and electrical properties specified in CSA Standard C49-65.

The aluminum shall be of highest purity commercially obtainable and shall not be less than ninety-nine and one-half percent (99.5%). It shall be Electrical Conductor Grade EC having a minimum conductivity of sixty-one percent (61%) IACS. If requested by the Engineer, the Contractor shall submit a certificate of analysis giving the percentage and nature of any impurities in the metal from which the wire is made.

The wires of the stranded conductor shall be smooth and free from all imperfections consistent with good commercial practice.

The stranding of the conductor shall be round concentric and lay factor as per CSA Standard C49-65.

Joints in wires shall only be made as specified CSA Standard C49-65.

7.02.2.9 Tie Wire. Tie wire, line guard and preformed line ties.

1. Tie wire. The Tie wire shall be five (5) millimeters diameter round annealed dead soft aluminum wire suitable for binding fourteen and three-tenths (14.3) millimeter bare ACSR and twenty and sixty-seven hundredths (20.67) bare ACSR to line post insulation EEI/NEMA class 57-35 F neck.

2. Line Guards. The line guards shall be preformed aluminum alloy type suitable for conductor diameters fourteen and three-tenths (14.3) millimeter bare ACSR and twenty and sixty-seven hundredths (20.67) millimeter bare ACSR and having suitable abrasion characteristics, and of suitable lengths for use on signal and double insulator supports. The line guard for double insulator support shall be suitable for insulator spacing of two (2) millimeters. The ends shall be so shaped as to give the minimum acceptable corona characteristics. They shall be center marked for proper alignment during installation.

3. Line Ties. The preformed line ties for top and side groove shall be suitable for binding the following two (2) sizes of conductors to EEI/NEMA class 57-3SF neck post insulators:

(1) One hundred twenty-five and one-tenth (125.1) square millimeter ACSR with line guard giving an overall diameter of twenty and eighty-three hundredths (20.83) millimeters.

(2) Two hundred fifty-five and one-tenth (255.1) square millimeter ACSR with line guard giving an overall diameter of twenty-eight (28) millimeters.

The preformed line ties shall be made of alumoweld wire to tie and fit exactly insulator-conductor lie guard, eliminating the movement of conductor relative to insulator and to wind, which can create the unbalanced pull. They must have suitable lengths for use on single and double insulator support. They shall be color coded for proper identification.

4. Preformed Dead-End for Messenger. This is required for dead ending the ACSR messenger of quadruplex cable. It shall be of aluminum alloy, suitable for one hundred twenty-five and one-tenth (125.1) square millimeter ACSR fourteen and three-tenths (14.3) millimeter diameter bare conductor. It shall be suitable to fit standard hardware such as thimbles, eye nuts, clevises. They shall be color coded for proper identification.

7.02.2.10 Ground Wire (Earth Wire). The ground wire shall be forty-two and forty-one hundredths (42.41) square millimeters stranded Class A, as per ASTM B8-72, soft drawn bare copper. Technical date pertaining to this class of wire :

- Stranding	7/2.76 mm
- Conductor diameter (mm)	8.43
- Conductor weight (Kg/km)	377
- Resistance B.C. at 20° C. (Ohms/km)	0.415

The ground wire supplied shall be manufactured in accordance with ASTM Standard B8-72 and all values specified shall be considered minimum guaranteed values.

7.02.2.11 Guy Wire. The guy wire shall be made up of seven (7) strands and the overall diameter shall be about nine and two tenths (9.2) millimeters. The grade of wire shall be CSA Grade 160 as specified by CAS G12-1970. The guy wire shall have a guaranteed minimum breaking of not less than five thousand four hundred sixty (5460) kilograms. The individual wires before stranding shall meet the physical properties such as tensile strength, elongation and ductility strength as specified by CSA G12-1970. The zinc coating on wires before stranding shall be by hot dip galvanizing. The weight of zinc coating and adherence of coating will meet the requirement of CSA G12-1970. The method of stranding the wire shall be as specified in CSA G12-1970. No splicing or joining of strands shall be permitted after manufacture. Welds made prior to wire drawing are permitted. Joining of individual wires by welding during stranding operation is permissible and such joints shall be dispersed sufficiently so as to maintain the minimum breaking strength specified. Such joints, however, will be recoated in a workmanlike manner with zinc or lead-zinc compound containing a minimum of fifty percent (50%) zinc.

7.02.2.12 Dropout Power Fuse. The dropout power fuse shall have the following characteristics:

1. It shall be used for protection of the distribution transformer and the 33/0.4 KV package substations. The transformers MV voltage level and size shall be as specified in the project Special Specifications.

2. The Dropout Fuses specifications; nominal voltage, maximum design voltage, continuous current rating, symmetrical interrupting rating, insulator creepage distance to ground, shall strictly follow the latest SCECO requirements.

3. It shall be expulsion, drip out type with single element, open, with solid power fuse suitable for the protection of distribution transformers.

4. It shall be single insulator style, suitable for direct vertical mounting on angle steel crossarms.

5. Terminals and hardware shall be suitable for clamping.

(1) One hundred twenty-five and one-tenth (125.1) square millimeter ACSR stranded conductor.

(2) Two hundred fifty-five and one-tenth (255.1) square millimeter ACSR stranded conductor.

6. The fuse links for power fuse shall be EEI-NEMA standard. Fuse links shall be rated to the requirements or as recommended by SCECO.

They shall be suitable for mounting on steel crossarms and shall be supplied complete with mounting accessories and hardware.

7. Mounting brackets and accessories shall conform to applicable EEI-NEMA Standards and galvanized in accordance with Standards specificized.

They shall be constructed for outdoor, pole top application.

They shall be mild exhaust, low arc energy construction, suitable for heavy duty application.

7.02.2.13 Pole Line Hardware. The pole line hardware listed below shall be of galvanized steel, galvanized in accordance with ASTM Standard A 123-71 for steel parts and A 153-71 for hardware.

Cotter pins shall be of stainless or bronze.

7.02.2.13.1 Shoulder Eye Bolts. These are required for LV dead end and angle poles. It shall be of sixteen (16) millimeter (_") diameter and made with a snug fitting washer welded into place suitable to the pole section. The eye shall be thirty-eight (38) millimeters by fifty (50) millimeters and the thickness should be twelve and seven-tenths (12.7) millimeters. Length shall suit the installation equipment. Shoulder eye bolts shall have a mechanical strength of fifty three thousand four hundred N (12,000 pounds) in accordance with CSA Standard C83-1970.

7.02.2.13.2 Eye Nut. Eye nut shall be manufactured in accordance with CSA Standard C83-1970 and have a mechanical strength of fifty-three thousand five hundred (53,500) N (12,000 pounds). The eye nut shall have a tapped hole for sixteen (16) millimeter (_ inch) diameter bolt. The oval eye shall be thirty-eight (38) by fifty (50) millimeters (1½"x 2") thickness twelve and seven-tenths (12.7) millimeters (½ inch) to fit the standard NEMA clevis opening of seventeen and forty-six hundredths (17.46) millimeters (1.46 inches).

7.02.2.13.3 Bolts. Bolts shall be of carbon steel grade "A" in accordance with ASTM standard A 307-74. Bolts dimensions and strength shall be to SCECO requirements. The thread shall be coarse thread series as per ANSI standard having a class 2A tolerance for bolts and class 2B tolerance for nuts. All bolts shall be supplied with nuts.

7.02.2.13.4 Expansion Anchors. Anchors shall be threaded, expansion type, suitable for attaching fittings to masonry wall. It shall be suitable for use with stud (double arming bolt) of diameter sixteen (16) millimeters (_") and length as required, at least sixty-three and one-half (63.5) millimeters (2½").

7.02.2.13.5 Square Washers. Three (3) types of washers are required:

1. Flat square galvanized washers shall be of six and thirty-five hundredths (6.35) millimeters (½") and nine and one-half (9.5) millimeters (_") thicknesses and one hundred two (102) millimeters (four inches (4") area suitable for bolts of diameters sixteen (16) millimeters (_") and twenty-five and four-tenths (25.4) millimeters (1").

2. Curved square galvanized washers for round poles shall be of four and seventy-six hundredths (4.76) millimeters (3/16") thickness and sixty-three and one-half (63.5) millimeters (2½") area suitable for bolt or diameter sixteen (16) millimeters (_").

3. Bevel washer shall be used with transformer platform. It shall be of hot dip galvanized suitable for bolt of diameter sixteen (16) millimeters (_"). All washers will conform to CSA standard G164 after galvanizing.

7.01.2.13.6 Suspension Clamps. The clamps are required to permit turning angles of up to one hundred twenty degrees (120°) without the need of dead ending the conductor.

1. Suitable for clamping one hundred twenty-five and one-tenth (125.1) square millimeter, stranded conductor (code name "PENGUIN") together with the line guard, which will have an overall diameter of approximately twenty-eight (28) millimeters. It shall have a minimum mechanical strength of 54779 N.

2. Suitable for clamping twenty-five and one tenth (25.1) square millimeters, stranded conductor (code name "PELICAN" together with the line guard, which will have an overall diameter of approximately twenty-eight (28) millimeters. It shall have a minimum mechanical strength of 54779 N.

It shall be suitable for use with suspension insulators EEI/NEMA class 52-4. It shall be of cast aluminum and supplied complete with aluminum keeper, Ubolts, cotter bolt, cotter pin and hardware for clamping the specified conductors. Suspension clamp shall be in accordance with CSA Standard C83-1970.

7.02.2.13.7 Strain Clamp Straight Type. The straight line strain clamps with clevis ends are required for dead-ending one hundred twenty-five and one-tenths (125.1) square millimeters. ACSR messenger having a diameter of fourteen and three-tenths (14.3) millimeters (.563"). The clamp body shall be manufactured from forged aluminum alloy which has been heat treated. All connector fittings, will be of forged steel, hot-dip galvanized. U-bolts, nut and lockwashers will be of galvanized steel. Cotter pins will be of stainless steel. Clamp shall have a mechanical strength of 37473N.

7.02.2.13.8 Strain Clamps, Quadrant Type. These are required for clamping the overhead conductors in dead ends. It shall be of one (1) piece cast aluminum type, with clevis opening suitable for eye nut of thickness twelve and seven-tenths (12.7) millimeters. They shall be:

1. Suitable for clamping ACSR stranded conductor one hundred twenty-five and one-tenth (125.1) square millimeters and shall have minimum mechanical strength of 37474 N.

2. Suitable for clamping ACSR stranded conductor two hundred fifty-five and one-tenth (255.1) square millimeters and shall have minimum mechanical strength of 54779 N.

It shall be supplied complete with cotter bolt and cotter pin and shall be suitable for hot line maintenance.

7.02.2.13.9 Messenger Suspension Clamp. Messenger clamps are required for messenger attachment to poles in straight runs and small angles up to five degrees (5 °). It shall be of two (2) pieces, with curved ends, suitable for clamping ACSR messenger of size one hundred twenty-five and one-tenth (125.1) square millimeters. It shall be supplied complete with two (2) bolts and a hole in the center of nineteen (19) millimeters and have a mechanical strength of 82974 N.

7.02.2.13.10 Wedge Grip. Wedge grips are required to dead end quadruplex services. The shell of wedge shall be of aluminum. The wedge and wire bail shall be of stainless steel. The wire bail shall be of stainless steel and of detachable type. The wedge grips shall have the minimum mechanical strength as listed below and suitable for use with the size of conductors specified.

The following sizes of wedge grips are required:

1. Wedge grip for dead ending quadruplex cable service with full size neutral messenger of one hundred twenty-five and one-tenth (125.1) square millimeters ACSR, having a mechanical strength of 11125 N.

2. Wedge grip for dead ending quadruplex cable service with full size neutral messenger of thirty-three and six-tenths (33.6) square millimeters ASC, having a mechanical strength of 4450 N.

3. Wedge grip for dead ending quadruplex cable service with full size neutral messenger of thirteen and three-tenths (13.3) square millimeters ASC, having a mechanical strength of 4450 N.

7.02.2.13.11 Straight Clevis Extension with Eye. Two (2) lengths of straight clevis with eye are classified to SCECO requirements to connect the suspension insulator to the pole structure.

1. Total length of clevis with eye shall be two hundred fifty-four (254) millimeters (10").

2. Total length of clevis with eye shall be three hundred fifty-five (14") millimeters.

The clevis shall be manufactured from steel and be hot dip galvanized. It shall have a minimum mechanical strength of 54779 N (12,300 lbs) and be manufactured in accordance with CSA standard C83-1970.

The clevis shall have an opening of seventeen and forty-six (17.46) millimeters (11/16") and will be complete with a sixteen (16) millimeter (5/8") diameter cotter belt, nut and cotter pin. Cotter pin shall be of bronze or stainless steel. The clevis eye shall have an opening of seventeen and forty-eight hundredths (17.48) millimeters (11/15") and an eye thickness of twelve and seven-tenths (12.7) millimeters (½") suitable for use with a clevis type insulator EEI/NEMA class 92-4.

7.02.2.13.12 Y-Clevis Extension. Y-Clevis extension is required to connect the suspension insulators to the pole structure.

The Y-Clevis shall have forty-five degree (45°) clevis opening, with sixteen (16) millimeters (5/8") diameter cotter bolt complete with nut and cotter pin and an overall length of two hundred fifty-four (254) millimeters (10"). Cotter pin shall be of bronze or stainless steel.

The Y-Clevis shall have a minimum mechanical strength 54779 N (12,300 pounds), and be manufactured in accordance with CSA standard C83-1970. The clevis eye shall have an opening of seventeen and forty-six (17.46) millimeters, and the eye thickness shall be twelve and seven-tenths (12.7) millimeters, suitable for use with the clevis type suspension insular EEI/NEMA class of 52.4.

7.02.2.13.13 Y-Clevis Eye. Y-Clevis with eye is required for connecting pole guy straps to guy wire. The Y-clevis shall have a forty-five degree (45°) opening with a nineteen and one-tenth (19.1) millimeter (½")cotter bolt complete with nut and cotter pin. The cotter pin shall be of bronze or stainless steel.

The overall nominal length of Y-clevis eye shall not exceed one hundred fifty-two (152) millimeters (6"). The eye of the Y-clevis shall have a diameter of twenty and six-tenths (20.6) millimeters (13/16") and a width of nineteen and one-tenth (19.1) millimeters (½").

The Y-clevis eye shall be manufactured in accordance with CSA standard C83-1970 and shall have a mechanical strength of 133,492 N, 13,608 kilograms or thirty thousand (30,000) pounds.

7.02.2.13.14 Anchor Shackle. It shall be used in part with items (f) or/and (k) specified above. It shall be a hot dip galvanized steel piece, ninety (90) turning, complete with cotter bolt and cotter pin. Shackle shall be of twelve (12) millimeter thickness, and be of eye dimensions of seventy and six-tenths (70.6) millimeters length and sixteen and seven-tenths (16.7) per seventeen and three-tenths (17.3) millimeter radius.

7.02.2.14 Guy Accessories. Guy fittings shall be suitable for nine and fifty-two (9.52) millimeter (3/8") diameter galvanized steel stranded guy wire with breaking strength of 53562 N conforming to CSA grade 160, and be manufactured in accordance with CSA standard C83-1970.

All guy fittings shall be galvanized in accordance with ASTM stranded A 123-71 and hardware in accordance with ASTM standard A 153-71 and are classified as below:

1. Guy Dead-End Fittings. These are required for attaching the guy strand to steel tubular pole. It shall be suitable for guying angles of thirty degrees to forty degrees (30-40°).

Two (2) types of guy dead and fittings are required:

(1) Bolt-on Type. It shall be an angle guy attachment with thimble eye fitting provided with a bolt hole for bolting to steel pole using a bolt of diameter sixteen (16) millimeters (5/8").

The guy eye shall be shaped into a smooth thimble to prevent injury to the guy strand.

(2) Pole Band. The pole band is required for attaching guys and suspension insulators to poles without drilling holes in poles.

It shall consist of a four (4) piece pole band, a pair of connecting links with holes and one (1) end for nineteen (19) millimeters (½") diameter bolt and holes at the other end of forty-four and four-tenths (44.4) millimeters (1½") diameter suitable for the guy thimble to be used.

Two (2) sizes of pole bands are required:

- for strapping to pole diameters between one hundred ninety (190) millimeters (7½") to three hundred four (304) millimeters (12").

- for strapping to pole diameters between two hundred eighty (280) millimeters (11") to four hundred six (406) millimeters (16").

Each pole band shall be supplied with 4-bolts of nineteen millimeter (½") diameter, each bolt with 4-nuts. The bolts shall be of steel as per ASTM standard A-325 and hot dip galvanized.

2. Side Walk Guy Fittings. These are required for use in place of ordinary head guy in congested areas. It shall consist of pole plate, unthreaded steel pipe and clamp fitting. The fitting on plate and clamp shall be by means of set screw to avoid the use of threaded pipe.

(1) Pole Plate: It shall be provided with pipe fitting for fifty and eight-tenths (50.8) millimeters (2 inch I.P.S.) diameter pipe. Pole plate shall be strapped to steel tubular poles by means of two (2) piece pole bands.

Pole plate and bands shall be of one (1) piece construction or means provided on bands to bolt plate on to the pole bands. Pole bands are required to strap the pole plate to poles of diameter two hundred sixty-five (265) millimeters and three hundred ten (310) millimeters. The dimensions of pole diameter are preliminary and shall be confirmed by the Engineer at the time of order.

(2) Clamp Fitting: It shall be provided with pipe fitting for fifty and eight-tenths (50.8) millimeters (2 inch I.P.S.) diameter pipe.

It shall also be provided with clamps with grooves to accommodate guy strand of size specified above.

(3) Steel Pipe: The pipe shall be of galvanized steel, unthreaded, fifty and eight-tenths (50.8) millimeters (2 inch I.P.S.) diameter and length one and one-half (1½) meter. The side walk guy fitting shall be supplied complete with all necessary hardware.

3. Guy Thimble. Half oval guy thimble shall be grooved to fit the guy wire of nine and fifty-two hundredths (9.52) millimeters (3/8") diameter.

4. Anchor Rod. The rod shall be of hot-dip galvanized steel, with double thimble eye. It shall be supplied complete with hardware for attaching the rod to steel cross plate anchor specified below in item (e). These sizes are required:

(1) 25.4 mm (1") dia. and 2.44 m (8 ft.) long
(2) 19 mm (3/4") dia. and 2.44 m (8 ft.) long
(3) 19 mm (3/4") dia. and 1.83 m (6 ft.) long

5. Steel Cross-Plate Anchors. The cross-plate anchor shall be of hot-dip galvanized steel. The anchor shall comprise of two (2) steel plates, heavy duty, welded at right angles. It shall be suitable for use with anchor rods of diameters nineteen (19) millimeters (3/4") and twenty-five and four-tenths (25.4) millimeters (1").

Two (2) sizes are required:

(1) 1612 square centimeters (250 square inch) area
(2) 2580 square centimeters (400 square inch) area

6. Preformed Guy Grip. It shall be suitable for dead-ending CSA grade one hundred sixty (160) guy wire to the above specified dead ends and guy rods. It shall be of galvanized steel strands and breaking strength not less than 53562 N.

The guy strand shall not slip through the grip at load equal to or less than 53562N.

7. Guy Guard. Guy guards shall be of tapered half round section, made of steel sheet or aluminum of high impact resistance and yellow in color. It shall be two thousand four hundred forty (2440) millimeters in length.

It shall be provided with galvanized bolted clamps for attaching it to guy wire of diameter nine and fifty-two (9.52) millimeters (3/8") or anchor rods of diameter twenty-five and four-tenths (25.4) millimeters (1").

8. Link Stick. It shall be used as an insulated extension link on guys at the locations where the jumper clearance is inadequate. It shall consist of a fiber glass rod with eye fittings at both ends, suitable for a guy wire of nine and fifty-two (9.52) millimeters diameter. The eye fittings shall be of malleable iron, hot dip galvanized and shall be supplied complete with hardware.

It shall be used on a system of the following characteristics:

Nominal system voltage	33 KV
Maximum system voltage	36 KV
Bill	170 KV
Impulse flashover positive	210 KV
Impulse flashover negative	260 KV

It shall have minimum breaking strength of 53562 N.

7.02.2.15 Energy Meter. This standard applies to induction type kilowatt hour meters for the measurement of electrical energy at a frequency of sixty (60) Hz.

The kilowatt hour meter will comply in all respects with IEC publication No. 521 (latest edition). Maximum demand indicators shall be as per IEC 211 (latest edition). Reactive energy meters will comply with IEC publication No. 145 (latest edition). Acceptance and testing by SCECO general will be carried in accordance with IEC 514 (latest edition). SCECO will carry out an additional accuracy test on polyphase meters with one (1) phase loaded.

7.02.2.15.1 System Condition.

Three (3) phase, earthed neutral system, frequency sixty (60) Hz. for HV.

Three (3) phase, four (4) wire system, frequency sixty (60) Hz. for LV.

7.02.2.15.2 Terminals.

1. The clearance of the terminal block and between the terminals and surrounding parts shall be not less than three (3.0) millimeters.

2. Terminal cover shall be short and sealable.

3. The order of the phases at the terminals shall be, looking from the front, from left to right.

Incoming Red	Outgoing Red
Incoming Yellow	Outgoing Yellow
Incoming Blue	Outgoing Blue
Incoming Neutral	Outgoing Neutral

7.02.2.15.3 Register.

1. The register shall be of the cyclometer type. For 5(6)A, transformer operated meters, it shall have six (6) digits including two (2) decimals. For direct connection meters, it shall have six (6) digits including one (1) decimal.

2. For 6(6)A, transformer operated meters a removable blank plate, to be engraved by SCECO Central, shall be fixed adjacent to the register to indicate the necessary multiplication factor.

3. The figures shall be clearly and indelibly marked or engraved in old Arabic on the drums. The figures shall not be less than four (4) millimeters high; they shall be in white on a black background.

The decimal(s) shall be encircled in red on the plate. As an alternative, the figures can be printed on white on a red background. For the decimals, the European script is also acceptable.

The fast moving drum shall be subdivided and marked on the edge in one hundred (100) divisions.

7.02.2.15.4 Arrangement. The nameplate of the meter shall have all information in Arabic and English and should indicate that the meter is the property of SCECO, Central Region. All meters will be suitable for surface mounting on a plain surface or adjustable rails. Fixing will be from the front with one (1) hole at the top center and two (2) at the bottom. The meters shall have maximum dimensions of:

Width	180 millimeters
Depth	150 millimeters
Length	270 millimeters

A sample should be supplied in any type of meter not previously approved by SCECO Central. If the type is approved, the sample shall remain the property of SCECO and the material to be supplied shall correspond in all respects to that sample.

7.02.2.15.5 Current and Voltage Transformers.

1. Current Transformers: To IEC publication No. 185 (latest edition) Burden 10 VA, accuracy class 0.5.

(1) High Voltage CTs

Ratios 800/5; 600/5; 400/5; 300/5; 150/5; 75/5
When applicable.

(2) Low Voltage CTs
Ratios 3000/5; 1500/760/5; 500/250/5
When applicable.

They shall be encapsulated with base fixings and busbar fixings, independently removable.

2. Voltage Transformers: To IEC publication No. 186 (latest edition).

Burden 100 VA, accuracy class 0.1.

Ratios 13800/110; 13800/120; 33000/115; 33000/110; 132000/115 Volts.
When applicable.

7.02.2.16 GRP Cabinet.

1. Three (3) neon lamps, green color is requested. An average life of forty thousand (40,000) hours is expected.

They should be easily visible from the outside, without removing the cabinet cover, through a window. Any alternative device with the same expected average life shall be considered.

2. Internal wiring shall be of two and one-half (2.5) square millimeters stranded copper, black PVC insulated cable, as per SCECO drawings. Cables shall be numbered at each end. At the meter brackets, the cables shall be equipped with flat blade type crimp terminals.

3. One (1) sealed cable bushing shall be provided in the base of the cabinet to accommodate the incoming cable. In addition, cable clamp fitting shall be provided inside the cabinet to support the cable.

A knock-out in the back of the cabinet shall also be provided to accept a cable coming through the wall directly into the cabinet.

4. Provision shall be made for bonding any metallic part inside the cabinet to the armoring of the cable.

5. The meter cabinet shall be of impact proof and high temperature heat resistant self extinguishing hot molded glass fiber reinforced polyester insulating material with at least twenty-five percent (25%) of fiber-glass (weight).

6. It shall be vermin, dust and weather-proof and suitable for surface mounting. The front shall take the form of a cover complete with fittings such that it can be locked or sealed in position.

7. Two (2) unbreakable and heat resistant windows shall be fitted in the front cover, one (1) for meter reading, one (1) for seeing the lamps. The meter window shall be at the top of the cabinet cover.

8. An unbreakable, heat resistant and transparent pocket with a hinged lid, shall be provided in the front cover to accommodate the Electricity Account.

9. There should be sufficient space to make off the cables and to install the meter within the cabinet.

10. The finished color of the cabinet is preferably green but a suitable somber alternative color such as gray would be sufficient.

11. Four (4) fixing brackets shall be provided as per SCECO standard construction drawings.

12. A sample should be supplied to SCECO for checking and approval. The sample will correspond in all respects with the cabinets to be supplied.

As an alternative, two (2) samples could be submitted: one (1) for checking the internal arrangement of the cabinet and one (1) for checking the quality of the material itself. If specifically requested by SCECO central the KWh meter 5(6)A shall be supplied.

7.02.2.17 Surge Arrestor. The surge arrestors supplied shall be:

- **Suitable for use on 33 KV system, with equipment Bill 170 KV.**
- **Distribution class and intermediate class.**
- **Ten (10) kA standard duty cycle operations.**
- **Complete with clamp type terminals for line conductor and ground leads.**
- **Intermediate class surge arrestors are to be installed at both source side and load sides of the recloser and at the cable termination structure.**

Each surge arrestor supplied shall be furnished with a galvanized steel mounting bracket suitable for mounting the arrestor on steel cross arms complete with hardware. Mounting brackets and accessories shall conform to applicable EEI-NEMA standards. The surge arrestors shall be of time-proven valve type construction, using high quality ceramic valve blocks, scaled in one (1) piece ceramic housing.

The surge arrestors shall be supplied with high speed dropout or lockout feature, permitting isolation of the arrestor in the event of failure and also providing visible indication of the faulted arrestors.

The line terminals shall be positive clamp type for copper stranded conductor up to forty-two and four-tenths (42.4) square millimeters.

The ground terminals shall be positive clamp type suitable for copper standard conductors up to forty-two and four-tenths (42.4) square millimeters.

All terminals shall be supplied complete with hardware, ready for connecting the specified conductors. A protective cover of suitable material shall be provided with each arrestor.

Each arrestor shall be provided with a permanent, weatherproof name plate giving arrestor type, voltage minimum creepage distance style and date of manufacture mounted for ease of identification. The name plate shall be both in the Arabic and English languages.

7.02.3 CONSTRUCTION REQUIREMENTS. The Contractor shall verify with the successful manufacture of the steel poles and conductors details of the necessary civil works which must be completely suitable for the equipment. All sizes and details must be checked before concrete is poured and revised with the approval of the Engineer and SCECO. It is the Contractor's sole responsibility to supply all materials and to construct in the correct site location the concrete bases for the poles and to connect with SCECO authorization the new installed 33 KV lines to the existing overhead lines.

Typical atmospheric conditions are as follows:

Isokeraunic level	10 to 2 days/annum
Maximum average air temperature per 24hours	38° C
Minimum air temperature	-2°
Maximum air temperature	45°
Relative humidity	100%
Annual precipitation	30 to 100 mm in the form of drizzle
Maximum wind velocity	110 km/hour
Air pollution	Sand, grain sized, dust and traces of salt laden spray
Solar radiation constant	120 watts/square centimeter
Elevation above sea level	1000 meters

N.B. The Contractor shall verify with the concerned authorities in the area of the project to ensure that the above typical atmospheric conditions are applicable otherwise the actual atmospheric conditions shall be applied.

7.02.4 METHOD OF MEASUREMENT. The 33 KV overhead lines shall be measured by linear meter, put into operation after testing and acceptance as meeting these General Specifications in all respects and being acceptable to the supply authority.

7.02.5 PAYMENT. The completed and accepted quantities, measured as provided above, will be paid at the contract unit price for the pay items listed below that are

specified in the Bill of Quantities. Payment will be full compensation for supplying all materials, installation, testing and putting in operation, for all labor, equipment, tools, supplies and other items necessary for the proper completion of the work as specified in Subsection 1.07.2, "Scope of Payment" in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
70201	33 kV Overhead Electrical Line, Copper conductor, 125 mm^2 ACSR Penguin with Earth Cable, 85 mm^2	Linear Meter
70202	33 kV Overhead Electrical Line, Copper Conductor, 255 mm^2 ACSR Pelican with Cable, 85 mm^2	Linear Meter
70203	33 kV Overhead Electrical Line, Aluminum Conductor, 125 mm^2 ACSR Penguin with Earth Cable, 85 mm^2	Linear Meter
70204	33 kV Overhead Electrical Line, Aluminum Conductor, 255 mm^2 ACSR Pelican with Cable, 85 mm^2	Linear Meter
70205	33 kV Overhead Electrical Line, Copper Conductor ___mm^2 Penguin with Earth Cable, 85 mm^2	Linear Meter
70206	33 kV Overhead Electrical Line, Copper Conductor, ___ mm^2 ACSR Pelican with Earth Cable 85 mm^2	Linear Meter
70207	33 kV Overhead Electrical Line, Aluminum Conductor ___mm^2 ACSR Penguin with Earth Cable 85 mm^2	Linear Meter
70208	33 kV Overhead Electrical Line, Aluminum Conductor ___ mm^2 ACSR Pelican with Earth Cable 88 mm^2	Linear Meter

SECTION 7.03 - 33/0.4 KV PACKAGED SUB-STATIONS

7.03.1 DESCRIPTION. This work shall consist of supplying, installing the necessary bases, testing and putting into satisfactory operation, factory assembled package sub-stations at the locations indicated upon the drawings and connecting to the medium voltage electrical supply and to the Low Voltage distribution network.

The MV supply shall be extended from the 33 KV overhead lines installed under this Contract. The Contractor shall include for all necessary work on existing roads to facilitate the extension of the MV supply. The Contractor shall also supply all materials and labor for connecting the station base with the existing duct runs.

ITEMS IN BILL OF QUANTITIES
33000/400V KVA Electrical Substation

7.03.2 MATERIALS. The packaged sub-station shall be completely self-contained, mounted upon integral base and factory assembled in a totally enclosing, aesthetically acceptable cladding, vandalproof and weatherproof housing ready for placing into position upon a concrete or similar base pad.

The substation shall comprise: Transformer with LV and MV cable boxes, LV switchgear and control panel.

The substation shall be suitable in all respects for continuous operation or rated load in direct sun with surface temperatures reaching seventy degrees Celsius (70° C.).

Finish: The substation final finish and final color shall be to the approval of the Engineer.

All live parts shall be completely enclosed in lockable compartments, which shall be adequately segregated for maximum safety, giving all necessary access. Compartments shall be ready to accept cables from the bottom side. (A safety fence and concrete crashworthy safety barrier shall be provided around the substation with a lockable gate).

7.03.2.1 Transformer Compartment. The transformer compartment containing a transformer which shall have the following characteristics based on an ambient temperature of fifty degrees Celsius (50°):

Rated KVA	**As specified.**
Voltage Ratio	**33,000 volts primary, 400/230 volts secondary, no load.**
Winding connections	**Primary - delta three (3) wires, Secondary - star with neutral point brought out insulated for earthing externally.**

Phases/Frequency Tappings	**Three (3) phase/60 HZ MV off-circuit at plus five percent (+5%) to minus five percent (-5%) in two and one-half percent (2½ %) steps.**
Tapping Method	**Externally operated off-circuit tap change switch with indicator plate and facilities for locking in any operating condition.**
Phase Notation	**DYn 11**
Impedance	**Five percent (5%) minimum.**
Noise Level	**Less than forty-eight (48) DB**
Allowable temperature	**Fifty degrees Celsius (50° C.) measured by increase rise in resistance of windings.**
Cooling	**Oil natural with radiator sealed type ONAN to give full rated output in fifty degrees Celsius (50° C.) ambient temperature.**
Fittings	**Lifting lugs, skid base, earthing terminal, dial type thermometer, rating and connection plate, pressure relief disc.**

Permanent continuous oil temperature reading is required.

A vent shall be provided to prevent rupturing of the transformer. This shall be capable of withstanding the variations in pressure in normal service.

An oil level indicator shall be fitted with the sight glass fitted to the same side of the transformer as the tap change control handle.

MV & LV cable boxes shall be located on opposite sides of the transformer with the cable entry coming vertically from below.

Boxes shall have a removable front and bottom cover.

Dry type terminations shall be used for both MV and LV cables and palms of brushing shall be flat and vertical in order to facilitate easy termination of cables which shall be fitted with crimped or compression lugs and covered with heat shrinkable shrouds.

The bottom cover of the MV cable box shall be designed to accommodate standard compression glands; A M10 stud with nut shall be provided to earth the cable armor.

Where deemed suitable for a compact design, the input and output connections shall be by means of purpose made copper busbars designed to fit the two (2) package substation compartments and of adequate rating and fault level.

7.03.2.2 Low Voltage Switchboard. The low voltage switchboard shall be a separate enclosed metal compartment complete with lockable doors within the housing and comprising:

A triple pole and neutral earth leakage type, manual operated main circuit breaker of the molded case pattern rated as detailed on the drawings, 500 volt, of adequate rupturing capacity not less than the available short circuit current from the substation transformer, and complete with overload and short circuit release mechanisms thermal and magnetic trips. It shall be of the current operated type.

A triple pole contactor rated as indicated on the drawings.

Electronic Timer (Quartz) type for energy saving installation: timer shall be capable to operate without interruption in case of power supply loss for at least two hundred (200) hours.

An ammeter with selector switch and current transformers. Ammeter to be fitted with maximum demand indicator.

A voltmeter with selector switch and protection fuse.

A KWh meter, current transformer and accessories with a glass window to be mounted on the S/S frame (enclosure) to SCECO Specifications (if required).

The layout, rating and number of outgoing triple and single pole circuit breakers, shall be as detailed on the drawings, 500 volt 10,000 ampere rupturing capacity and complete with overload and short circuit release mechanism comprising thermal and magnetic trips.

All breakers shall be molded case circuit breakers type, calibrated at fifty degrees Celsius (50° C.) for setting the magnetic trip coils.

A single phase socket outlet of 16-250 DIN rating range complete with plug top and a twelve (12) watt fluorescent lighting fittings of the integral battery/inverter emergency type with switching facility to allow emergency light to be initiated shall be mounted adjacent to the LV and MV switchgear panels and shall be prewired in the factory.

The substation shall have the following facility:

Photo Electric Control: The LV panel circuits serving the street lighting and signs shall be supplied through triple pole contactors which shall be photo-electric controlled. An override facility shall be provided for maintenance. The photo-electric controls shall consist of an omni-directional cadmium cell thermal relay of high quality employing solid state photo-variable conductance elements giving a 2:1 on/off ratio with sensitivity to switch on lights when the daylight illumination reduces to seventy (70) lux. This allows for the high pressure sodium lights striking time, taking account of the rather fast rate of daylight intensity drop off in the region. The photo-electric cell shall be mounted at the top of the substation on a three (3) meter high post.

7.03.2.3 Accessories. Each substation shall be fitted with a compartment housing the accessories to form a complete operating installation including the following:

One (1) pair of rubber gloves.
One (1) set of spare fuses.
One (1) set of safety and operating instructions.
MV line diagram.
LV circuit diagram with designations.

7.03.3 CONSTRUCTION REQUIREMENTS. The Contractor shall agree with the successful manufacturer of the packaged substation on the details of the necessary civil works which must be completely suitable for the equipment and all sizes and details must be checked before concrete is poured and revised with the approval of the Engineer where necessary. It is the Contractor's sole responsibility to supply all materials and to construct in the correct site location the concrete base, and to connect it to the cable duct system and subsequently to carry out the installation, cabling and connecting up of the packaged substation, including making off the ends of the MV supply cables.

The Contractor shall install the packaged substation unit from the concrete base supplying and using the appropriate lifting gear to ensure that no damage occurs. When correctly located, the unit shall be anchored in position and tested before and after connecting up of the incoming and outgoing cables is carried out.

Approved Manufacturers:

Saudi Manufacturers - Saudi Arabia.

7.03.4 METHOD OF MEASUREMENT. The 33000/400 V electrical substation shall be measured as a complete unit furnished, installed, including safety barriers and fencing and put into operation after testing and acceptance as meeting these General Specifications in all respects. No separate measurement will be made for New Jersey Barriers or safety fence as this work is considered subsidiary to the substation item.

7.03.5 PAYMENT. The completed and accepted quantities, measured as provided above, will be paid for at the contract unit price for pay items listed below as specified in the Bill of Quantities. Payment will be full compensation for supplying all materials, installation of the substation, testing and putting into operation, for all labor, equipment, tools, supplies and other items necessary for the proper completion of the work as specified in Subsection 1.07.2, "Scope of Payment" in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
70301	33000/400 V (100) KVA Electrical Substation	Unit
70302	33000/400 V (160) KVA Electrical Substation	Unit
70303	33000/400 V (200) KVA Electrical Substation	Unit
70304	33000/400 V (300) KVA Electrical Substation	Unit
70305	33000/400 V (500) KVA Electrical Substation	Unit
70306	33000/400 V (600) KVA Electrical Substation	Unit
70307	33000/400 V (____) KVA Electrical Substation	Unit

SECTION 7.04 - 13.8 KV INTAKE SWITCHING STATIONS

7.04.1 DESCRIPTION. The Electric Power Company (SCECO) and suburbs shall give a supply at 13.8 KV 3 phase, 3 wire, 60 Hz to the MV Intake Switching Stations which will be positioned as shown on the Drawings.

This work shall consist of installing foundations and constructing the necessary building, roofing and putting into satisfactory operation and Medium Voltage switching station. Supplying, installing and testing the contained switchgear. The Contractor shall supply all materials and labor for connecting the building to the existing cable duct systems.

ITEMS IN BILL OF QUANTITIES
13.8 KV Intake Switching Station

7.04.2 MATERIALS.

7.04.2.1 The Enclosure. The enclosure will house the switchgear as detailed and in addition contain adequate space for the Power Company equipment. It shall consist of a concrete block built building cement rendered internally and externally with concrete roof and foundation containing cable trench for the power company distribution cabling. Doors shall be steel lockable and adequate louvers with sand traps where applicable for natural cooling shall be provided. The complete building to conform to the requirements of the Power Company and generally as shown on the Drawings.

Enclosed lighting fittings, self-contained emergency lighting fittings (switched battery inverted type), general purpose socket outlet and plug, together with all associated wiring from a central distribution unit shall be included and supplied from a voltage transformer installed on the network circuit breaker cubicle.

7.04.2.2 Equipment. The MV intake and switching units shall comprise panels containing the following equipment as shown on the Drawings:

MV Switching Station at the location shown on the drawings.

Space only for two (2) incoming circuit breakers provided by power company.

Space only for one (1) metering panel provided by the power company.

Network control - One (1) circuit breaker.

Outgoing circuit breakers - Number as indicated on the drawings.

The MV equipment shall consist of standard panel extensible type units suitable for mounting within the purpose built station. Equipment shall be suitable in all respects for an ambient temperature of fifty-five degrees Celsius (55° C.) and forming a completely integrated self-supporting assembly.

The MV panel shall be equipped with floor mounting framework, skid base, internal wiring, labels and cable sockets all as required for the complete installation. The assembly shall be arranged for cubic access from below without dismantling any structural members.

Circuit Breakers: These shall be manually and motor charged mechanisms suitable for local and remote control fitted with integral earthing.

Type	**SF6 or Vacuumor Minimum Oil or Bulk Oil metalclad.**
System Nominal Voltage	**13,800 Volts.**
Rated Current at 55° C.	**630 Amps.**
Basic Impulse Level	**95 KV.**
Power Frequency Withstand Voltage	**38 KV.**
Frequency	**60 Hz.**
Short Circuit Rating	**500 MVA.**
Busbar	**Shall be electrolytic grade copper rated 1200 Amperes at fifty-five degrees Celsius (55° C.) The entire busbar shall be made of individual module sections. The busbar system shall be suitable to withstand the mechanical stress for the rated short circuit currents. The busbars, connections and their insulated supports shall be of approved construction and mechanically strong with molded insulation completely encasing each busbar and connections.**
Indication	**Compensations for expansion and contraction of the busbar and enclosure arrangement due to temperature changes shall be provided.**
Protection 1. Network Control (Incoming C.B.)	**Neon indicator connected to voltage capacitator divider indicating voltage presence.** **In order to achieve discrimination with the outgoing circuit breakers, tripping of the breakers shall be by current transformer**

energized trip coils operated from a direct acting inverse definite minimum time relay activated from primary current transformers for overcurrent and earth fault protection. Protection to be suitable for a normal load current of approximately 150/200 Amps. Protection relay shall be flush mounted on the front panel and shall meet from all respects with SCECO relevant standard and specifications.

2. Outgoing C.B.s

Tripping of the breakers shall be by direct acting primary trip coil or by means of current transformer operated direct acting trip coils for overcurrent and earth fault protection. Protection to be suitable for a normal load current of approximately 50/100 Amps and discriminate with network circuit breakers. Protection relays shall be flush mounted on the front panel and shall meet from all respects with SCECO relevant specifications.

Voltage Transformer

The Network Control Panel shall be provided with A 5000 to 10,000 VA voltage transformer connected at the primary side of the circuit breaker. This VT shall be fitted with fuses and supply the lighting, socket outlets and any auxiliaries needed to serve the switching station building. Specifications for a separate transformer may be proposed by the Contractor for the Engineer's review and approval.

Cable Boxes and Cable Glands

For incoming cables from SCECO to the Network Control Panel, cable box and cable gland shall be in accordance with the power company requirements.

For outgoing cables, cable boxes and cable glands shall be suitable for the use with the type and cross section of the cables used as specified or indicated on the drawings.

Accessories.

Each injection and switching station shall be supplied with all necessary accessories to form a complete operating installation including the following:

- One (1) pair of rubber gloves.
- One (1) 13.8 K volt potential tester.
- One (1) set of spare fuses for each fuse switch.
- One (1) set of safety and operating instructions.

The above equipment excluding the rubber mat shall be supplied within a special purpose made wall mounted cupboard and shall be painted white inside and outside and be complete with a mortise type lock and three (3) keys.

Each intake switching station shall be equipped with a framed and glazed MV line diagram indicating the breakers, switches, etc

7.04.3 CONSTRUCTION REQUIREMENTS. The Contractor shall verify with the successful manufacturers of the Medium Voltage intake and switching station that the civil works as described are suitable for each equipment. All sizes and details must be checked and revised where necessary. It is the Contractor's sole responsibility to ensure compatibility of civil and electrical work.

The units of equipment shall be lifted into position within the station upon prepared foundations. The station switchboards shall be complete or in sections as necessitated for transportation. They shall be fixed into position and all equipment connected up as required. The units shall then be tested before and after incoming and outgoing cables are terminated.

7.04.4 METHOD OF MEASUREMENT. The intake switching station shall be measured as the number of units acceptably furnished and put into operation after testing and accepted as meeting the General Specifications in all respects and being acceptable to the Supply Authority. This unit measurement shall include complete construction and equipping of the buildings including cells, service transformer, connections, fees and the cost of power connection from SCECO.

7.04.5 PAYMENT. The completed and accepted quantities, measured as provided above will be paid for at the contract unit prices for the pay items listed below that are as specified in the Bill of Quantities. Payment will be full compensation for supplying all materials, installation, testing and putting into operation, all labor, equipment, tools, supplies, including any fees or cost whatsoever due to the Local Supply Authority for supply connection, and any other items necessary for the proper completion of the work as specified in Subsection 1.07.2, "Scope of Payment" in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO.	PAY ITEM	PAY UNIT
70401	13.8 kv Intake Switching Station including cells, service transformer, reinforced concrete building and connections, fees and the cost of power connection from SCECO.	Unit

SECTION 7.05 - 13,800/400 VOLT PACKAGED SUBSTATIONS

7.05.1 DESCRIPTION. This work shall consist of supplying, installing the necessary bases, testing and putting into satisfactory operation, factory assembled package substations at the locations indicated upon the drawings and connecting to the medium voltage electrical supply and to the Low Voltage distribution network.

The MV supply shall be extended from the MV switching station or MV overhead line installed under the Contract or from the existing substations installed under previous Contracts, as specified or shown on the Drawings. The Contractor shall include for all necessary work on the existing roads to facilitate the extension of the MV supply. The Contractor shall also supply all materials and labor for connecting the substation base with the existing duct runs.

ITEMS IN BILL OF QUANTITIES
13,800/400V KVA Electrical Substation

7.05.2 MATERIALS. Packaged substations shall be completely self-contained, mounted upon integral base and factory assembled in a totally enclosing, aesthetically acceptable cladding, vandalproof and weatherproof housing ready for placing into position upon a concrete or similar base pad.

The substation shall comprise: MV switchgear (ring main unit), transformer, LV switchgear and control panel. The MV switchgear (RMU) either to be incorporated in the substation enclosure or to be separately mounted on separate concrete base to SCECO requirements (if required).
The substation shall be suitable in all respects for continuous operation or rated load in direct sun with surface temperatures reaching seventy degrees Celsius (70° C.).

Finish: The substation final finish and final color shall be to the approval of the Engineer.

All live parts shall be completely enclosed in lockable compartments, which shall be adequately segregated for maximum safety, giving all necessary access. Compartments shall be ready to accept cables from the bottom side.

7.05.2.1 Medium Voltage (MV) Switchgear. The medium voltage switchgear shall consist of the following units:

1. Two (2) ring main oil switches

2. One (1) fuse oil switch with fuses mounted in a separate compartment.

The ring main oil switches shall be fitted with cable boxes and glands suitable to receive the incoming three (3) core copper conductors, XLPE insulated steel or aluminum armored cable 15 KV rated of cross section as specified. The cables shall be connected to the fixed mating contacts by flexible connectors which shall be provided with a slotted hole to compensate for manufacturing and installation tolerances.

The ring main switches and the fuse switch shall have operating positions at the front of the unit and the fuses shall be capable of withdrawal by direct pull from this position for replacement. The fuse access shall be interlocked to prevent it being opened unless the fuse switch is "OFF" and earthed. The switching mechanisms shall be "independent manual" type with a quick "make and break" feature, speed of operation being independent of the operator.

The fuse switch shall have a trip button or trip automatically by fuse operations. In the event of any fuse "blowing" all three (3) phases of the fuse shall trip open and an interlock shall be provided to ensure that the fuse switch cannot be put back into service until the faulty fuse has been replaced.

The MV switchgear shall have the following characteristics:

1. Main Unit:

Rated voltage	13.8 KV
Impulse withstand	95 KV
Power Frequency Test Voltage	38 KV for 1 minute
Short circuit rating	500 KVA
Busbar current rating	630 Amps
Frequency	60 Hertz

2. Switch Fuse:

Normal Current	150 Amps with fuses rated to requirements.
Making Capacity	47 KA peak prospective at 13.8 KV (500 MVA)
Breaking Capacity	21 KA symmetrical prospective (500 MVA at 13.8 KV).

3. Oil Switches:

Normal Current	630 Amps
Making Capacity	47 KA at 13.8 KV (500 MVA)
Short Time Current	21 KA for three (3) seconds.

4. The RMU shall be equipped with sensitive earth fault indicator.

7.05.2.2 Transformer Compartment. The transformer compartment containing a transformer which shall have the following characteristics based on an ambient temperature of fifty degrees Celsius (50° C.).

Rated KVA	As specified.
Voltage Ratio	13,800 volts primary 400/230 volts secondary, no load.
Winding Connections	Primary - delta three (3) wires, Secondary - star with neutral point brought out insulated for earthing externally.
Phases/Frequency Tappings	Three (3) phase/60 Hz.
Tapping Method	MV off-circuit at plus five percent (+5%) to minus five percent (-5%) in two and one-half percent (2½%) steps. Externally operated off-circuit tap change switch with indicator plate and facilities for locking in any operating condition.
Phase Notation	DYn 11
Impedance	Five percent (5%) (minimum).
Noise Level	Less than forty-eight (48) DB
Allowable temperature	Forty-five degrees Celsius (45° C.) measured by increase rise in resistance of windings.
Cooling	Oil natural with radiator sealed type ONAN to give full rated output in fifty degrees Celsius (50° C.) ambient temperature.
Fittings	Lifting lugs, skid base, earthing terminal, dial type thermometer, rating and connection plate, pressure relief disc.

Permanent continuous oil temperature reading is not required, however, provision shall be made for the use of a thermometer, as and when required, by the fitting of a thermometer pocket. This shall be fitted with a weather-proof removable cap.

A vent shall be provided to prevent rupturing of the transformer. This shall be capable of withstanding the variations in pressure in normal service.

An oil level indicator shall be fitted with the sight glass fitted to the same side of the transformer as the tap change control handle.

7.05.2.3 Low Voltage Switchboard. The low voltage switchboard shall be a separate enclosed metal compartment complete with lockable doors within the housing and comprising:

A triple pole and neutral earth leakage type, manual operated main circuit breaker of the molded case pattern rated as detailed on the drawings, 500 volt, of adequate rupturing capacity not less than the available short circuit current from the substation transformer, and complete with overload and short circuit release mechanisms thermal and magnetic trips. It shall be of the current operated type.

A triple pole contactor rated as indicated on the drawings.

Electronic Timer (Quartz) type for energy saving installation: Timer shall be capable to operate without interruption in case of power supply loss for at least two hundred (200) hours.

An ammeter with selector switch and current transformers. Ammeter to be fitted with maximum demand indicator.

A voltmeter with selector switch and protection fuse.

A KWH meter, current transformer and accessories with a glass window to be mounted on the S/S frame (enclosure) to SCECO Specifications (if required).

The layout, rating and number of outgoing triple and single pole circuit breakers, shall be as detailed on the drawings, 500 volt 10,000 ampere rupturing capacity and complete with overload and short circuit release mechanism comprising thermal and magnetic trips.

All breakers shall be molded case circuit breakers type, calibrated at fifty degrees Celsius (50° C.) for setting the magnetic trip coils.

A single phase socket outlet of 16-250 DIN rating range complete with plug top and a twelve (12) watt fluorescent lighting fittings of the integral battery/inverter emergency type with switching facility to allow emergency light to be initiated shall be mounted adjacent to the LV and MV switchgear panels and shall be prewired in the factory.

The substation shall have the following facility:
Photo Electric Control: The LV panel circuits serving the street lighting and signs shall be supplied through triple pole contactors which shall be photo-electric controlled. An override facility shall be provided for maintenance. The photo-electric controls shall consist of an omni-directional cadmium cell thermal relay of high quality employing solid state photo-variable conductance elements giving a 2:1 on/off ratio with sensitivity to switch on lights when the daylight illumination reduces to seventy (70) lux. This allows for the high pressure sodium lights striking time, taking account of the rather fast rate

of daylight intensity drop off in the region. The photo electric cell shall be poled mounted at a height of three (3) meters and fitted to the top of the substation.

7.05.2.4 Accessories. Each substation shall be fitted with a compartment housing the accessories to form a complete operating installation including the following:

One (1) pair of rubber gloves.

One (1) set of spare fuses.

One (1) set of safety and operating instructions.
MV line diagram.

LV circuit diagram with designations.

7.05.3 CONSTRUCTION REQUIREMENTS. The Contractor shall agree with the successful manufacturer of the packaged substation details of the necessary civil works which must be completely suitable for the equipment and all sizes and details must be checked before concrete is poured and revised with the approval of the Engineer where necessary. It is the Contractor's sole responsibility to supply all materials and to construct in the correct site location the concrete base, and to connect it to the cable duct system and subsequently to carry out the installation, cabling and connecting up of the packaged substation, including making off the ends of the MV supply cables.

The Contractor shall install the packaged substation unit from the concrete base supplying and using the appropriate lifting gear to ensure that no damage occurs. When correctly located, the unit shall be anchored in position and tested before and after connecting up of the incoming and outgoing cables is carried out.

Approved Manufacturers:

Saudi Manufacturers - Saudi Arabia.

7.05.4 METHOD OF MEASUREMENT. The 13,800/400 volt electrical substation shall be measured as the number of units acceptably furnished, installed, including safety barriers and fencing, and put into operation after testing and accepting as meeting these General Specifications in all respects. No separate measurement will be made for safety barriers or fencing as this work is considered subsidiary to the substation item.

7.05.5 PAYMENT. The completed and accepted quantities, measured as provided above, will be paid for at the contract unit price for the pay items listed below specified in the Bill of Quantities. Payment will be full compensation for supplying all materials, testing and putting into operation, for all labor, equipment tools, supplies and other items necessary for the proper completion of the work as specified in Subsection 1.07.2, "Scope of Payment" in these General Specifications. No separate payment for safety barriers or fencing will be made as this work is considered subsidiary to the substation item.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
70501	13,800/400 V (100) KVA Electrical Substation	Unit
70502	13,800/400 V (160) KVA Electrical Substation	Unit
70503	13,800/400 V (200) KVA Electrical Substation	Unit
70504	13,800/400 V (300) KVA Electrical Substation	Unit
70505	13,800/400 V (500) KVA Electrical Substation	Unit
70506	13,800/400 V (1000) KVA Electrical Substation	Unit
70507	13,800/400 V (___) KVA Electrical Substation	Unit

SECTION 7.06 - 13.8 KV MEDIUM VOLTAGE CABLES

7.06.1 DESCRIPTION. This work shall consist of supplying and installing of cables and tray including all necessary jointing, terminating and testing. The cables shall be pulled into the ducts and draw-pits provided or installed directly buried in ground, as specified or shown on the drawings.

ITEMS IN BILL OF QUANTITIES
13.8 KVA Medium Voltage Cables

7.06.2 MATERIALS. Cables shall be single or three (3) cores of cross section as specified with stranded copper phase conductors, cross-linked polyethylene insulated (XLPE), semiconductive layer, copper foil PVC inner sheath, aluminum wire or strip armored, PVC outer sheath and rated 8.7/15 KV, in compliance with IEC 502:1983. The cable shall be suitable for a maximum conductor operating temperature of ninety degrees Celsius (90° C.). The armoring on all cables shall be bonded to the metalwork and to the earthing system.

The semiconductive layer shall be capable of being removed without the use of tools to ensure that the XLPE core insulation is unscratched or damaged in any way.

7.06.3 CONSTRUCTION REQUIREMENTS. Power shall be distributed to the transformer substations at 13,800 volts, three (3) phases, three (3) wires, 60 Hertz, by one (1) of the following procedures:

1. From the MV intake station and fed out from the outgoing circuit breakers then looped into the packaged substations installed under the project. MV cables shall be single or multi cores of the type and cross-sections as specified on the drawings.

   or

2. From the existing packaged substation installed under previous contracts, then looped into the substations installed under the project. MV cables shall be single or multi cores of type and cross-sections as specified on the drawings.

or

3. From the existing 13.8 KV SCECO cable networks to the packaged substations installed under the project. Type, cross-sections and method of installation for the MV cables shall be in accordance with SCECO requirements.

4. Before any cable is installed, duplicate copies of the test certificate giving details of the results of tests made in accordance with the "Standards" shall be submitted to the Engineer for approval. For XLPE cable these tests shall include the application of voltage tests minimum twenty-five percent (25%) above the working voltage level and checking the permitted discharge level in pico-Coulombs (maximum 20 PC's).

5. Cable Jointing and Terminating.

(1) All cable joints and terminations shall be complete with the correct specified materials, tapes, stress cones, glands and bonds.

(2) All joints whether terminations to or through joints shall be carried out strictly in accordance with the cable manufacturers recommendations.

(3) Only skilled jointers shall be employed for the jointing of cables. The qualifications of the jointers shall be submitted to the Engineer prior to the work commencing on site. Joints shall be filled with epoxy resin after taping unless this is contrary to the chosen cable manufacturers recommendations. A sample site constructed cable termination and through-joint shall be submitted to the Engineer prior to any jointing commencing on site. The samples shall be constructed in the presence of the Engineer and shall be available to the Engineer for any manufacturer's test and inspection.

(4) Termination of cables shall be either crimped or soldered. Use of either method shall be verified with the Engineer prior to commencement.

(5) All through-joints shall be complete with manufacturer's recommended metal sleeves and shall be filled with recommended type compound.

(6) All through-joints shall be located in a cable draw-pit.

6. After completion of the installation, draw-pits should be cleared out and the covers correctly refitted.

Approved Manufacturers:

Saudi Manufacturers - Saudi Arabia.

7.06.4 METHOD OF MEASUREMENT. Medium voltage cables shall be measured by the linear meter installed in ducts or clipped on tray or run directly into the ground as specified in these General Specifications.

Where three (3) single core cables are run laid in trefoil these shall be measured as installed per linear meter including three (3) single core cables suitably taped and installed.

7.06.5 PAYMENT. The completed and accepted quantities, measured as provided above, shall be paid for at the contract unit prices for the pay items listed below that are specified in the Bill of Quantities. Payment will be full compensation for furnishing all materials, including tray where required, installation, testing and putting into operation, for all labor, equipment, tools and supplies and all other items necessary for the proper

completion of the work as specified in Subsection 1.07.2, "Scope of Payment" in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
70601	13.8 kVA Medium Voltage Cables, single wire armored, PVC/XLPE Insulated (3x185) mm^2	Linear Meter
70602	13.8 kVA Medium Voltage Cables, single wire armored, PVC/XLPE Insulated (3x95) mm^2	Linear Meter
70603	13.8 kVA Medium Voltage Cables, single wire armored, PVC/XLPE Insulated (size) mm^2	Linear Meter

SECTION 7.07 - LOW VOLTAGE CABLES

7.07.1 DESCRIPTION. This work shall consist of supplying and installing of cables and tray including all necessary jointing, terminating and testing. The cables shall be pulled into the ducts and draw-pits provided.

ITEMS IN BILL OF QUANTITIES:
Low Voltage Cable

7.07.2 MATERIALS. Unarmored Cables. The LV cables shall be single or multicore cables of cross section as specified with stranded copper conductors, PVC or XLPE insulated, PVC outer sheath.

Armored Cables. The LV cables shall be multicore cables of cross section as specified with stranded copper conductors, PVC or XLPE insulated, single wire armored, extruded PVC outer sheath.

Cables shall be 600/1000 volts grade in compliance with the standards. Color coding of the different phases and neutral or L-N and E shall be in conformity with the standards. The cable shall be suitable for a maximum conductor operating temperature of seventy degrees Celsius (70° C.).

The cable voltage designation and manufacturer shall be embossed on the cable oversheath.

Cable Accessories.

Cable Glands. Cable glands shall be made of brass, bright dipped and the gland shall consist of the gland body with polychloroprene inner sheath sealing ring, armor clamping cone, armor nut and captive polychloroprene outer sheath sealing ring, brass solid washer and earth tag to which the separate earthing conductor shall be attached.

The gland shall be of such a design that during assembly no torque will be induced in the cable sheath or armor. Also, overtightening of the seals when clamping armor wires shall be prevented.

Each gland shall be locked onto equipment with suitable brass backnuts. Also, at every gland a polychloroprene shroud shall be fitted over the gland for additional protection.

Cable Tray and Supports. All cable trays used throughout the project shall be galvanized, flanged with heavy duty folded reinforced edge, and slotted to British Admiralty pattern.

Cable channel used throughout shall be galvanized.

7.07.3 CONSTRUCTION REQUIREMENTS.

1. From the substations power shall be distributed at a declared voltage of three hundred eighty (380) volts three (3) phase and neutral, four (4) wire, 60 Hertz.

2. The LV distribution 380/220 Volt shall be installed using PVC insulated, PVC sheathed cable. A separate green PVC insulated cable shall be run alongside the supply cable within the ducts and connected to the earth studs of the equipment.

3. The distribution shall be generally routed as shown on the Drawings and consist of final sub-circuits from each packaged substation or feeder pillar.

4. The LV cables shall be pulled into a duct system in the ground as indicated and routed through the draw-in pits at each position of equipment via the sleeves from the pit to the base of the equipment.

5. The low voltage cable for the amenity lighting shall be run in the underground duct system. From a drawpit located in the base of the abutment wall a rising duct will be provided to route the cables up to a final drawpit via sleeves passing through the abutment wall into the box structures of the viaduct. It shall be run in ducts to the first amenity light position where it will be terminated in a metal clad junction box with a three (3) pin waterproof socket mounted in the lid for recessed hingeable type luminarie.

6. No through joints shall be allowed in LV cables where adequate manufacturers length are available.

7. All through-joints, where allowed, shall be complete with the manufacturer's recommended metal sleeves and shall be filled with recommended type compound. Joints shall be located in a cable drawpit.

8. All cable joints and terminations shall be complete with the correct specified materials, tapes, stress cones, glands and bonds. All joints whether terminations to or through joints shall be carried out strictly in accordance with the cable manufacturers recommendations.

9. Only skilled jointers shall be employed for the jointing of cables. The qualifications of the jointers shall be submitted to the Engineer prior to the work commencing on site. Joints shall be filled with epoxy resin after taping unless this is contrary to the chosen cable manufacturer's recommendations. A sample site constructed cable termination and through-joint shall be submitted to the Engineer prior to any jointing commencing on site. The samples shall be constructed in the presence of the Engineer and shall be available to the Engineer for any manufacturer's test and inspection.

10. Termination of cables shall be either crimped or soldered. Use of either methods shall be verified with the Engineer prior to commencement.

11. After completion of the installation, drawpits should be cleared out and the covers correctly refitted.

Before any cable is installed, duplicate copies of the test certificate giving details of the results of tests made in accordance with the "Standards" shall be submitted to the Engineer for approval.

Approved Manufacturers:

Saudi Manufacturers - Saudi Arabia.

7.07.4 METHOD OF MEASUREMENT. Low voltage cables shall be measured by the linear meter installed in ducts or clipped on cable tray or supports as specified in these General Specifications.

7.07.5 PAYMENT. The completed and accepted quantities, measured as provided above, shall be paid for at the contract unit prices for the pay items listed below that are as specified in the Bill of Quantities. Payment will be full compensation for furnishing all materials, including cable tray where required, installation, testing and putting into operation, for all labor, equipment, tools and supplies and all other items necessary for the proper completion of the work as specified in Subsection 1.07.2, "Scope of Payment" in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
70701	Low Voltage Cable, PVC/PVC Insultated Stranded Copper Wires, (4x6) mm^2	Linear Meter
70702	Low Voltage Cable, PVC/PVC Insultated Stranded Copper Wires, (4x10) mm^2	Linear Meter
70703	Low Voltage Cable, PVC/PVC Insultated Stranded Copper Wires, (4x16) mm^2	Linear Meter
70704	Low Voltage Cable, PVC/PVC Insultated Stranded Copper Wires, (4x25) mm^2	Linear Meter
70705	Low Voltage Cable, PVC/PVC Insultated Stranded Copper Wires, (4x35) mm^2	Linear Meter
70706	Low Voltage Cable, PVC/PVC Insultated Stranded Copper Wires, (Size) mm^2	Linear Meter

0

SECTION 7.08 - LOW VOLTAGE FEEDER PILLAR

7.08.1 DESCRIPTION. This work shall consist of supplying, complete with necessary base, mounting, testing and putting into satisfactory operation of feeder pillars which shall generally be used to feed underpasses electrical lighting and power installation and other installations as required.

ITEMS IN BILL OF QUANTITIES
Low Voltage Feeder Pillar

7.08.2 MATERIALS. The feeder pillar shall be totally enclosed, fully self-contained, dustproof, weatherproof, and suitable for mounting outdoors exposed to dust, rain and sunlight.

The cabinets shall be reinforced free standing structure, manufactured from three (3) millimeters nominal thickness steel with bolted reinforcement corner construction and shall be of the dwarf type with a bolting down root for mounting on a pre-formed concrete base suitable for all incoming and outgoing cables from below ground level on a duct system. Cabinets shall have two (2) hinged lockable opening doors to provide full front access to the cabinet which shall be sized according to the equipment being installed. The roof of the cabinet shall be slanted and shall have water drip edges provided.

The feeder pillar shall be complete with all equipment and fittings incorporating molded case circuit breakers controlling the main supply in and the outgoing circuits. The pillar shall have the following main characteristics:

Voltage	**1000 volts.**
Molded Case Circuit Breakers (MCCB)	**Triple-pole rated as shown on the project drawings.**
Interrupting Capacity	**25,000 amperes RMS symmetrical.**
Contactors	**Triple-pole, inductive type, rates as shown on the project drawings.**
Busbars	**Fully insulated, rates as shown on the drawings.**
Metering	**Ammeter with selector switch and current transformers. Ammeter to be fitted with maximum demand indicator.**
	Voltmeter with selector switch and protection fuse.
	KWH meter, current transformer and

	accessories with a glass window to be mounted on the F.P. frame (enclosure) to SCECO specifications (if required).
Internal Cabling	PVC/PVC single core 1000 volt grade with copper conductors and rated as required taking into account manufacturers recommended temperature and"bunching" derating factors. All internal wiring shall be suitably "laced" or clipped.
Photo Electric Control	The LV panel circuits serving the street lighting and signs shall be supplied through triple-pole contactors which shall be photo-electric controlled. An override facility shall be provided for maintenance. The photo-electric controls shall consist of an omni-directional cadmium cell thermal relay of high quality employing solid state photo-variable conductance elements giving a 2:1 on/off ratio with sensitivity to switch on lights when the daylight illumination reduces to seventy (70) lux. This allows for the high pressure sodium lights striking time, of daylight intensity drop off in the region. The cell shall be pole mounted at a height of three (3) meters and fitted to the top of the feeder pillar.

All equipment, busbars, conductors, etc., within the pillar shall be fully insulated such that there are no live parts of connections exposed all to the complete satisfaction of the Engineer.

The feeder pillar shall have a fifty (50) millimeters by six (6) millimeters high conductivity copper main earth bar for grounding purposes complete with test link (see "earthing"). Also, permanently fixed to the inside of the door there shall be a distribution diagram showing all circuit connections, MCCB ratings, cable sizes and references, etc.

The Feeder Pillar shall be secured against unauthorized access by means of wedge locks protected by brass plugs and operated by a special key to be agreed with the Engineer.

Finish. The Pillar final finish and final color shall be to the approval of the Engineer.

7.08.3 CONSTRUCTION REQUIREMENTS. The Contractor shall agree with the successful manufacturer of the feeder pillar, details of the necessary civil works which must be completely suitable for the equipment and all sizes and details must be checked before concrete is poured and revised with approval of the Engineer where necessary. It is the Contractor's sole responsibility to supply all materials and to construct in the correct site location the concrete base, and to connect it to the cable duct system and subsequently to carry out the installation, cabling and connecting up of the feeder pillar.

The Contractor shall install the feeder pillar unit upon the concrete base supplying and using the appropriate lifting gear to ensure that no damage occurs. When correctly located, the unit shall be anchored in position and tested before and after connecting up of the incoming and outgoing cables is carried out.

Approved Manufacturers:
Saudi Manufacturers - Saudi Arabia.

7.08.4 METHOD OF MEASUREMENT. The low voltage feeder pillar shall be measured as a complete unit, furnished, installed, including safety barriers and fencing, and put into operation after testing and accepting as meeting these General Specifications in all respects. No separate payment for safety barriers or fencing shall be made as this work is considered subsidiary to the feeder pillar item.

7.08.5 PAYMENT. The completed and accepted quantities measured, as provided above, shall be paid for at the contract unit price for the pay items listed below that are specified in the Bill of Quantities. Payment will be full compensation for supplying all materials, installation, testing and putting into operation, for all labor, equipment tools, supplies and other items necessary for the proper completion of the work as specified in Subsection 1.07.2 "Scope of Payment" in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
70801	Low Voltage Feeder Pillar, IP54, (100) Amp Main C.B., (60) Amp Main Contactor	Unit
70802	Low Voltage Feeder Pillar, IP54, (150) Amp Main C.B., (150) Amp Main Contactor	Unit
70803	Low Voltage Feeder Pillar, IP54, (200) Amp Main C.B., (200) Amp Main Contactor	Unit
70804	Low Voltage Feeder Pillar, IP54, (300) Amp Main C.B., (300) Amp Main Contactor	Unit
70805	Low Voltage Feeder Pillar, IP54, (400) Amp Main C.B., (3500) Amp Main Contactor	Unit
70806	Low Voltage Feeder Pillar, IP54, (___) Amp Main C.B., (___) Amp Main Contactor	Unit

SECTION 7.09 - HIGH MASTS

7.09.1 DESCRIPTION. This work shall consist of the supply, installation upon prepared foundations the connection, commissioning and putting into satisfactory service the high masts complete with operating mechanisms, luminarie support ring or bracket, luminaries, control gear, energy saving contactor, wiring and distribution equipment.

The mast luminarie support ring shall be designed to provide appropriate distribution of lighting either in one (1) direction or in many directions thus making it possible to concentrate the required number of luminaries on any zone and fix them rigidly in any direction desired.

High mast earthing requirements are specified in Section 7.16 "Earthing" in these General Specifications.

The high masts shall be installed on fixed foundations and/or bases which together with the necessary ducts, drawpits, excavation and similar civil works shall be provided by the Contractor in conformity with the requirements outlined in Section 7.19 "Civil Works for Electrical Installation" and as further detailed in this Section of these General Specifications.

ITEMS IN BILL OF QUANTITIES
High Mast Lighting Including Control Gear and Power Distribution Box

7.09.2 MATERIALS.

7.09.2.1 Mast. The mast shall be of the height specified on the Drawings, hot dipped galvanized of multi-sided or circular cross-section with a continuous taper made of formed sheet steel in accordance with BS 4360 and electrically welded. They shall be delivered to the site in manageable sections and be joined by means of pressure over-lapping or slip joints which shall have a minimum length of one and one-half (1½) times the diameter of the joint. Site welding will not be allowed.

The walls of the Masts shall have a minimum thickness of three (3) millimeters and the steel used shall have a minimum tensile strength of five hundred ten (510) MN per square meter and a minimum yield strength of three hundred fifty five (355) MN per square meter.

The Mast and Mast Foundations shall be designed, manufactured and installed in accordance with Technical Report No. 7 of the Institution of Public Lighting Engineers (UK). The design shall be based upon Section 2 of Report No. 7 giving guidance on the selection of the three (3) second gust wind speed, in this case of not less than one hundred sixty (160) kilometers per hour, blowing in the most unfavorable direction at a height of ten (10) meters above ground level. Appropriate reinforcement shall be provided where necessary to increase the strength. Its behavior under wind induced oscillation shall be such that it shall not fail due to fatigue and its oscillation shall be damped to zero (0).

The maximum deflection at the top of the mast shall not exceed two and one-half percent (2½%) of the mast height with the wind speed detailed.

A steel flange of adequate thickness and free from laminations shall be welded to the base of the mast developing fully the strength of the section. In addition, supplementary gussets shall be provided between bolt holes where deemed necessary.

An access door shall be provided in the base of the mast of adequate dimensions to permit clear access to the back plate installed for the mounting of the MCCB and the junction box, winch, etc. The backboard shall be made of steel or other non-hygroscopic material. The door shall be completely weatherproof fitted with a hidden hinge and a heavy duty lock. The door area shall have appropriate reinforcement.

A stainless steel twelve (12) millimeter diameter earthing bolt shall be welded inside the mast near the access door and shall be complete with cadmium plated steel washers and nuts.

7.09.2.2 Luminarie Support Ring. The high mast luminarie support ring or carriage shall be constructed of hot dipped galvanized steel channel fitted with the appropriate number of luminaries, lamp gear mounting brackets, wiring chamber and mounting plate. Where necessary it shall be in two (2) halves joined by bolted flanges to permit removal from the erected mast.

The luminarie shall be mounted on the luminarie ring by means of a specially designed bracket allowing it to be swivelled in any desired direction. It shall be possible to lock it firmly in its position, thus preventing any rotation or falling while moving the luminarie ring.

The head frame shall be covered by a shaped protective aesthetic canopy to give a coordinated appearance of head frame and luminarie ring as detailed in the Plans or Standard Drawings. If the details are included in the Plans or Standard Drawings the Contractor shall submit his proposed details to the Engineer for approval as part of his Electrical Shop Drawings submitted.

For masts fitted with a mobile luminarie ring, rollers with a centering mechanism shall be provided to ensure a perfect alignment of the luminarie ring both axially and in azimuth, while ascending or descending the mast. Rollers shall be made of water-resistant, non-marking composition material with oil-impregnated bronze brushings. All shafts and washers shall be stainless steel.

A weatherproof wiring chamber shall be provided and installed on the luminarie ring and shall be equipped with the proper terminal blocks and neutral bar and shall include facilities on the luminarie ring to allow testing of luminaries while in the lowered position. The wiring chamber shall be fitted with an earthing stud accessible from inside and out for earthing connections.

The cable connecting the MCCB assembly at the base of the mast to the wiring chamber on the luminarie ring, shall be flexible multicore copper conductor cable with neoprene or approved equivalent high temperature insulation and sheath in accordance with BS 6977 or IEC 277-6.

For mobile luminarie rings a multi-pin type plug and socket shall be fitted in the flexible cable adjacent to the power control and distribution unit housing in the base, for disconnection of the rising cable.

Color coding of the different phases shall conform to the standards. Each luminarie shall have its own neutral conductor connected to the neutral bar.

The cables installed within the luminarie ring connecting each luminarie to the wiring chamber shall be factory pre-wired avoiding the need for field wiring, and shall have single core copper conductors with neoprene or cross-linked polyethylene or approved equivalent insulation and sheath. Cables shall have two and one-half (2½) square millimeter copper conductors with color coding of different phases being in conformity with BS 6004, BS 6007, IEC 227 and IEC 245 or other equivalent standards.

7.09.2.3 Raising and Lowering Equipment. The head frame shall be hot-dipped galvanized steel attached to the mast by means of a steel slip-fitter and secured by at least four (4) stainless steel set screws. It shall be composed of a spun aluminum or other approved weatherproof cover, housing the required number of steel rope pulleys and associated accessories for the operation and powering of the luminarie ring.

Pulleys shall be of non-corrosive material grooved to suit the steel rope and cable diameter, and fitted with stainless steel shafts. The pulleys shall be housed in a chassis integral with a sleeve which slopes over the top of the mast and is secured axially and in azimuth. The complete chassis assembly shall be manufactured from steel and hot dipped galvanized. Arrangements shall be provided to ensure that the electric cables and steel ropes are separated before passing over their respective pulleys, and close fitting guides shall ensure that the cables and ropes cannot disengage the pulley during operations.

The luminarie ring shall be supported by three (3) steel ropes coupled to two (2) steel ropes and suspended from the double drum winch by means of a manufactured steel coupling unit. A divider bar shall ensure the separation of the steel ropes during raising and lowering.

Flexible stainless steel stranded wire ropes in accordance with BS 302 suitable for the application, with a factor of safety of five (5) times the Safe Working Load of the winch, shall support the luminarie ring assembly. Stops installed on the steel ropes or alternatively welded to the mast shall support the luminarie ring assembly in the lower position to within one and six-tenths (1.6) meters above the base of the mast. The electric cable shall be prevented from winding around the steel hoisting ropes.

A multicore electrical power cable as specified shall be provided, terminating in the base compartment with a multi-pin plug and socket coupler fitted with a guard ring for

the disconnection of the rising cable and at the mast head connected to the wiring chamber fixed to the luminarie ring.

A steadying system shall keep the luminarie ring in the correct top position avoiding any rotation around its vertical axis.

The luminarie ring shall be raised and lowered for installation and maintenance purposes by means of a winching system specially designed to be installed and removed through the access door at the base of the mast.

The luminarie ring shall be raised and lowered for installation and maintenance purposes by means of a winching system specially designed to be installed and removed through the access door at the base of the mast.

The winching system shall have a lifting capacity of at least twice the weight of the luminarie ring assembly. The maximum winding torque during operation shall be specified. The winching system shall employ double drums as a safeguard against a single suspension steel wire rope failing.

Winches shall be capable of normal operation using a portable power tool which shall be a multispeed reversible type incorporating a torque limiting device which can be readily adjusted and locked. The power tool shall be equipped with a remote control switch to allow the operator to stand clear of the moving head frame and using push-button controls at the end of a five (5) meter long flexible lead. A mounting or support frame shall be provided for locating and securing the power tool during operations.

Terminations of steel wire ropes on which drums shall not involve distortion or twisting of the rope structure. One (1) full layer of turns shall remain on the drum when the luminarie ring is full or lowered or alternatively the drums shall be grooved to ensure a tidy lay.

Manually operated winches shall be provided with handles and shall incorporate a torque limiter which can be readily adjusted and locked. Winches shall be completely self-sustaining. Brakes or clutches which require adjustment or which can be affected by moisture or lubricant shall not be used.

Winch gears shall be totally enclosed and self-lubricating by means of an oil bath. Only lubricant recommended by the supplier shall be used. The gear ratio shall take into account operational safety and speed.

An MCCB providing overload protection shall be incorporated to stop the luminarie ring when the effort required by the winch exceeds the nominal load.

The winch shall be fitted with suitable equipment to allow it to stop in a safe manner, without damage to the mast finish, in the event of a supply failure to the power tool. The winding mechanism should then be capable of being operated by hand.

7.09.2.4 Finish. All welds shall be smooth with spatter removed and the interior and exterior surfaces of the mast and ring shall be cleaned by pickling or blasting and shall be free of any grease.

All components shall be hot dipped galvanized by total immersion in a bath of molten zinc after completion of the fabrication. No further leveling up, finishing or modifications shall be carried out after completion of the galvanizing process. The minimum thickness of zinc coating shall be four hundred fifty (450) grams per square meter on the inside and outside surfaces of the mast and ring. The galvanizing shall conform with BS 729:1971.

Any damage to the galvanizing shall be rectified during erection by wire brushing the affected area and treating with an approved zinc restorative. Sufficient material shall be applied to provide a zinc coating at least equal in thickness to the galvanized layer.

The flange plate and bottom of the pole to a height of one-half (0.5) meters shall be given an internal and external coating on all surfaces of heavy duty bitumen paint prior to erection.

7.09.2.5 High Mast Distribution Equipment. The high mast base compartment shall be fitted with a power control and distribution assembly installed in a pre-wired weatherproof box opposite the access door inside the base of the mast.

The assembly shall consist of a surface mounting sheet steel weatherproof box with a cover enclosing:

- One (1) three-pole MCCB together with a neutral link for luminarie circuits. The ratings of the MCCB shall be in accordance with the Regulations and Standards and suitable to the connected load and cable.

- One (1) single pole MCCB with neutral link for each luminarie circuit of a suitable current rating.

- One-pole MCCB with neutral link connected to the incoming supply and serving a 16A-250 V DIN socket outlet complete with a three (3)-pin plug to suit the raising and lowering mechanism.

- A multi-pin plug and socket coupler with guard ring fitted with cable outlet for connection to the multi-core electric power cable provided from the MCCB to the luminarie ring wiring chamber.

The MCCB's shall be derated and calibrated to provide over-current and short circuit protection when used in an ambient temperature of fifty degrees Celsius (50° C.) and shall have the required breaking capacity. The incoming side of the triple pole MCCB with neutral link shall be fitted with a four (4)-way, line-tap type terminal block, with each terminal capable of accepting 2 x 35 square millimeter copper conductors.

The multi-pin coupler for supply to the portable raising and lowering power tool shall be connected to the MCCB via a flexible connection to ensure accessibility.

A contactor of the normally closed type, rated at fifty degrees Celsius (50° C.) adequate for two and one-half (2½) KW and shall comply with the standards. The contactor shall be used to control the partial cut-off operation of the street lighting after midnight. The contactor shall be installed inside the H. Mast distribution box or inside a separate weatherproof box opposite the access door inside the base of the mast.

Note:

Where MCCBs are referred to in this Specification it shall be taken to mean Molded Case Circuit Breakers (MCCBs) conforming to IEC 57 or BS 4752 and suitable for uninterrupted duty, having a rated current short circuit breaking capacity exceeding three (3) KA.

7.09.2.6 Aircraft Obstruction Light. Where required by Civil Aviation Authorities, two (2) red luminaries within cast aluminum bodies shall be fitted at the top of each high mast attached to the movable luminarie ring with a purpose made bracket and arranged to project through the canopy.

The luminaries shall be provided with a change over relay such that, in the event of lamp failure, the second lamp is automatically connected. Lamps shall be GLS Rough Service 100 watt suitable for an E.S. (#27) lampholder.

7.09.2.7 Lightning Protection. High masts shall be equipped with an air terminal of the correct height to provide the required zone of protection for the mast headframe and fixtures. The air terminal shall be bonded to the mast to ensure the discharge is dissipated via the earth connection and system without damage to the steel winch ropes or the electrical cables.

7.09.2.8 High Mast Approval. For the approval of the Engineer before manufacturing commences the Contractor shall submit detailed calculations and supporting data to show the mast meets the design criteria detailed and shall include the following information:

- **The deflection at the top of the Mast at the designed wind speed.**
- **The natural frequency of the mast.**
- **The critical wind speed for resonance.**
- **The damping stresses under resonant conditions.**
- **The steel stresses under resonant condition.**
- **The acceleration at the top of the mast under resonant conditions.**

- Welding procedure.

- Procedure to ensuring that the flange plate is not laminated.

- Details of the joints between the mast sections and between the bottom section and the flange plate.

- Details of the joints between the mast sections and between the bottom section and the flange plate.

- Details of the base compartment with the method of reinforcement at the door area and means adopted for making the door weather and tamperproof.

7.09.3 CONSTRUCTION REQUIREMENTS. High masts shall be installed on concrete foundations as shown on the Drawings and described under another section of the Specification. The erection of high masts and the assembly of the luminarie headframe and raising and lowering gear shall be carried out strictly in accordance with the manufacturer's instructions using workmen who have had experience in the installation of high masts. The Contractor shall confirm before commencement of the erection and assembly work, that the foundations are suitable for use with the high mast installation proposed.

Each high mast metal work shall be bonded to a separate earth rod as indicated on the Drawings and also to the separate earthing cable connected to the distribution system earth bar.

Masts shall be of specified height capable of carrying the specified number of luminaries as indicated on the Drawings. The luminarie ring shall be oriented to give the correct illumination at designated locations along the road surfaces.

The high mast system incorporating mobile luminarie rings shall be installed to be suitable for utilizing a purpose-made portable cage for maintenance purposes. The cage shall be obtained from the high mast supplier and shall be capable of carrying two (2) persons plus servicing equipment. A safety device shall be provided for use within the cage in the event of a hoisting rope failure.

A portable power tool shall be provided as necessary for raising and lowering the headframe or maintenance cage respectively from a remote position. Manual raising and lowering equipment where appropriate shall also be provided.

Approved Manufacturers:
Saudi Manufacturers - Saudi Arabia.

7.09.4 METHOD OF MEASUREMENT. High masts shall be measured as the number of masts completely capable of fixing the number of luminaries specified including control gear, distribution board, contactor and earthing, erected and put into operation in accordance with these General Specifications.

7.09.5 PAYMENT. Luminaries will not be measured for payment under this Section as they are covered in Section 7.11, "Street Lighting Luminaries" in these General Specifications. The completed and accepted high mast assemblies, as measured above, shall be paid for at the contract unit price for the high mast pay items listed below that are specified in the Bill of Quantities. Payment will be full compensation for supplying all materials, installation, testing and putting into operation, for all labor, equipment, tools, supplies and other items necessary for the proper completion of the Work as specified in Subsection 1.07.2, "Scope of Payment" in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
70901	High Mast Lighting capable of fixing 2 luminaries, including control gear and power distribution box, 20 m height	Unit
70902	High Mast Lighting capable of fixing 2 luminaries, including control gear and power distribution box, 25 m height	Unit
70903	High Mast Lighting capable of fixing 2 luminaries, including control gear and power distribution box, 30 m height	Unit
70904	High Mast Lighting capable of fixing 2 luminaries, including control gear and power distribution box, 35 m height	Unit
70905	High Mast Lighting capable of fixing 2 luminaries, including control gear and power distribution box, 40 m height	Unit
70906	High Mast Lighting capable of fixing 2 luminaries, including control gear and power distribution box, ___ m height	Unit
70911	High Mast Lighting capable of fixing 4 luminaries, including control gear and power distribution box, 25 m height	Unit
70912	High Mast Lighting capable of fixing 4 luminaries, including control gear and power distribution box, 25 m height	Unit
70913	High Mast Lighting capable of fixing 4 luminaries, including control gear and power distribution box, 30 m height	Unit
70914	High Mast Lighting capable of fixing 4 luminaries, including control gear and power distribution box, 35 m height	Unit
70915	High Mast Lighting capable of fixing 4 luminaries, including control gear and power distribution box, 40 m height	Unit
70916	High Mast Lighting capable of fixing 4 luminaries, including control gear and power distribution box, ___ m height	Unit
70921	High Mast Lighting capable of fixing 6 luminaries, including control gear and power distribution box, 20 m height	Unit
70922	High Mast Lighting capable of fixing 6 luminaries, including control gear and power distribution box, 25 m height	Unit
70923	High Mast Lighting capable of fixing 6 luminaries, including control gear and power distribution box, 30 m height	Unit
70924	High Mast Lighting capable of fixing 6 luminaries, including control gear and power distribution box, 35 m height	Unit

70925	High Mast Lighting capable of fixing 6 luminaries, including control gear and power distribution box, 40 m height	Unit
70926	High Mast Lighting capable of fixing 6 luminaries, including control gear and power distribution box, ___ m height	Unit
70931	High Mast Lighting capable of fixing 9 luminaries, including control gear and power distribution box, 20 m height	Unit
70932	High Mast Lighting capable of fixing 9 luminaries, including control gear and power distribution box, 25 m height	Unit
70933	High Mast Lighting capable of fixing 9 luminaries, including control gear and power distribution box, 30 m height	Unit
70934	High Mast Lighting capable of fixing 9 luminaries, including control gear and power distribution box, 35 m height	Unit
70935	High Mast Lighting capable of fixing 9 luminaries, including control gear and power distribution box, 40 m height	Unit
70936	High Mast Lighting capable of fixing 9 luminaries, including control gear and power distribution box, ___ m height	Unit

SECTION 7.10 - LIGHTING COLUMNS

7.10.1 DESCRIPTION. This work shall consist of supplying, installing upon prepared bases, and putting into satisfactory operation lighting columns complete with luminaries, brackets, wiring, distribution equipment, control gear and associated materials as located on the Drawings.

ITEMS IN BILL OF QUANTITIES
Lighting Columns (Poles) Complete With Arms, Power Distribution Box, Bolts and Cables

7.10.2 MATERIALS.

7.10.2.1 Columns. Columns shall be of the height specified and be multi-sided or circular section, tapered type, made of formed sheet steel electrically welded.

Columns up to twelve (12) meters height shall be supplied as a one (1) piece section.

Columns above twelve (12) meters in height may be supplied in more than one (1) piece, with the base section being a minimum of twelve (12) meters in length. Multi-section columns shall be of the slip joint type with sufficient overlap to ensure correct vertical alignment for the whole column after assembly.

Columns shall have a minimum wall thickness of three (3) millimeters for the lowest section and shall be made of sheet steel with a minimum rupturing resistance of thirty-seven (37) kilograms per square millimeter and a minimum yield strength of twenty-four (24) kilograms per square millimeter.

The column tops shall be designed to receive the single or double arm brackets, as required, to support the specified number of luminaries. The bracket arrangement shall be so designed as to ensure that failure due to wind induced oscillations does not occur, nor shall the wind rotate the bracket from the desired alignment.

The Contractor shall calculate the column cross-section thickness of steel sheet, etc., so that the columns once installed and fully equipped shall be able to withstand a gust wind velocity of one hundred sixty (160) kilometers per hour blowing in the most unfavorable direction, at a height of ten (10) meters above ground level taking into account the effect of the maximum resistance provided by a minimum of two (2) luminaries plus any special bracketing for each type of pole. Appropriate reinforcement shall be provided where needed to increase the strength.

The fatigue of the steel shall in no case exceed half (½) ofthe elasticity limit, taking into account the dynamic stresses due to vibrations.

A steel flange plate of adequate thickness shall be solidly welded onto the lower edge of the pole as shown on the Drawings. The plate shall have the specified number of holes for the columns for accepting the holding down bolts together with clearance hole in the center of not less than one hundred fifty (150) millimeters diameter.

Columns shall be provided with one (1) weatherproof access door positioned at the base. The access shall be suitably sized to insert and service the supply cable terminations and switchgear. The door shall be flush fitting with a retaining mechanism and a positive locking arrangement having a removable hexagonal key. Appropriate reinforcement shall be provided in the column at the door openings. Internally positioned opposite to each door shall be fitted non- hygroscopic baseboards of suitable size to accept the appropriate equipment. The baseboards shall be fixed to the inside of the column by means of purpose-made brackets. A stainless steel earthing stud shall be welded inside the pole near the access door and shall be complete with stainless steel washers and nuts.

7.10.2.2 Finishing. All welds shall be smooth with spatter removed, the interior and exterior surfaces of the columns shall be cleaned by means of pickling or blasting and shall be free of any grease trace.

All components of the column shall be hot dipped galvanized after completion of the fabrication. No further touching up, finishing or modifications shall be carried out after galvanizing. The minimum thickness of zinc coating shall be five hundred (500) grams per square meter on both the inside and outside faces of the column. The galvanizing shall be carried out by total immersion in a bath of molten zinc.

The galvanizing standard used shall be at least equal to French Standard NFA 91 121 (June 1958) or UK Standard BS 729/71.

Any damage to the galvanizing shall be rectified during erection by wire brushing the affected area, treating with an approved rust converter to the satisfaction of the Engineer.

The flange plate and bottom of the pole to a height of half (½)meter shall be given an external and internal coating of heavy bitumen paint prior to erection.

7.10.2.3 Distribution Equipment. Distribution equipment shall be mounted in a weatherproof enclosure on the baseboards of the lower compartment of the columns and shall comprise a back plate chassis complete with:

For either one or two luminaries per column	1 x 15 amperes single pole molded case circuit breaker and neutral assembly.

The breakers shall be calibrated at fifty degrees Celsius (50^{0} C.). The incoming side of the breakers shall be fitted with a terminal kit capable of accepting 2 x 16 square millimeter three (3) phase and neutral copper conductors. The breakers shall have a current interrupting capacity exceeding three (3) KA.

A contactor of the normally closed type, rated at fifty degrees Celsius (50° C.) adequate for one (1) KW and shall comply with the standards. The contactor shall be used to control the partial cut-off operation of the street lighting after midnight. The

contactor shall be installed inside the column distribution box or inside a separate weatherproof box opposite to the access door inside the base of the column.

Columns with three (3) or more individual luminaries shall have them wired over the three (3) phase and neutral. Columns carrying one (1) or two (2) single lamp luminaries shall be connected over one (1) phase and neutral.

7.10.3 CONSTRUCTION REQUIREMENTS. Columns shall be installed upon concrete bases as detailed on the Drawings. The Contractor shall, before commencement of the construction work, confirm that the foundations are suitable for use with the column installation he proposes to install. Holding down and plumb adjusting nuts, washers, locknuts or nyloc nuts shall be stainless steel or cadmium plated.

Erection of lighting columns along the roadways shall be such that the luminaries shall be located on a line parallel to the theoretical profile of the road. The alignment of the columns both horizontally and vertically must be secured to the satisfaction of the Engineer.

At each column the separate earthing cable associated with the circuit supplying it shall be bonded to the metalwork. Where the supply cable is looped at the column breaker panel, the earthing cable shall not be cut but looped into the terminal. The final column in each LV distribution circuit shall have its metalwork bonded to a separate earth rod as detailed.

Approved Manufacturers:

Saudi Manufacturers.

7.10.4 METHOD OF MEASUREMENT. Lighting columns shall be measured as the number of columns as specified above complete with wiring, control gear, distribution board, contactor and internal cabling for luminaries and earthing as necessary commencing at the termination of incoming cable supplied, erected and put into operation in accordance with these General Specifications.

Luminaries will not be measured for payment under this Section as they are covered in Section 7.11, "Street Lighting Luminaries" in these General Specifications.

7.10.5 PAYMENT. The completed and accepted lighting column assemblies, measured as provided above, shall be paid for at the contract unit price for the Lighting Column items listed below that are specified in the Bill of Quantities. Payment will be full compensation for all materials, installation, testing and putting into operation, for all labor, equipment, tools, supplies and other items necessary for the proper completion of the work as specified in Subsection 1.07.2, "Scope of Payment in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
71001	Lighting Columns (Poles) complete with arms, power distribution box, bolts and cables, 4 m height	Unit
71002	Lighting Columns (Poles) complete with arms, power distribution box, bolts and cables, 6 m height	Unit
71003	Lighting Columns (Poles) complete with arms, power distribution box, bolts and cables, 8 m height	Unit
71004	Lighting Columns (Poles) complete with arms, power distribution box, bolts and cables, 10 m height	Unit
71005	Lighting Columns (Poles) complete with arms, power distribution box, bolts and cables,12 m height	Unit
71006	Lighting Columns (Poles) complete with arms, power distribution box, bolts and cables, 14 m height	Unit
71007	Lighting Columns (Poles) complete with arms, power distribution box, bolts and cables, 16 m height	Unit
71008	Lighting Columns (Poles) complete with arms, power distribution box, bolts and cables, 18-19.9 m height	Unit

SECTION 7.11 - STREET LIGHTING LUMINARIES

7.11.1 DESCRIPTION. This work shall consist of supplying, installing and putting into satisfactory operation the street lighting luminaries to be installed on the High Mast or Lighting Columns as specified under other sections of this Specification.

ITEMS IN BILL OF QUANTITIES
Street Light Luminarie Complete With Control Gear and Lamp

7.11.2 MATERIALS.

7.11.2.1 Luminarie. The luminaries shall be totally enclosed, dust and watertight, shock resistant and specially designed to house the specified lamps, electrical gear and accessories. The body shall be made of extruded or pressure die-cast or fabricated aluminum alloy of the corrosion resistant type. The lamp housing shall be dust, watertight, in compliance with IP 54 of IEC Publication 144.

Mirror reflectors shall be of ninety-nine and one-half percent (99½%)purity, glazed, and anodized aluminum, or die-cast, super-purity aluminum vapor deposited type, coated with a transparent layer of silicon as a protection against wiping.

The protector shall be made of heat and shock resistant glass, and mounted into a suitable frame. The protector frame assembly shall be fixed to the body by means of captive screws and secured by extra safety clamps to allow the replacement of the protector and reflector. An ozone resistant ethylene propylene or approved equivalent rubber shall ensure sealing of the front glass.

The lamp socket shall be made of high grade porcelain mounted in a support bracket with provision to adjust the lamp both vertically and axially. A lamp support and a locking system shall grip and prevent the lamp moving in operation.

Ballast and control gear shall be mounted within the luminarie in a separate compartment isolated from the lamp and with enclosed terminal blocks fitted with quick-disconnect electrical leads. Where required the control gear shall be contained within a prewired box having an enclosure of IP at least twenty-three (23) and mounted on the luminarie ring separately from the luminaries.

The luminarie shall be provided with a line HRC fuse carrier and holder with a suitably rated fuse to conform with IEC 269 or BS 88 to provide fault protection to the luminarie. The fuse shall also be rated to withstand the starting current and be preferably located in the control gear enclosure.

A specially designed louver shall be proved to screen the lamp from direct view and limit glare where necessary.

Special precautions shall be given to the choice of materials which shall be able to support without damage or aging or alteration in its structural or physical properties, severe climatic conditions (tropical climate) in addition to the heat emitted by the lamp.

Utilization of aluminum is imposed, polyester, plastics and other similar organic matters are not acceptable.

A suitable terminal block shall be provided to allow connection of the supply cables and shall be clearly marked. Special arrangements shall be taken to facilitate maintenance, quick replacement and easy disconnection of individual components.

The exposed metallic parts of the luminarie shall be factory finished, stove enameled with a suitable corrosion resisting paint capable of resisting the heat emitted by the map during continuous operation, even if necessary under full sunlight conditions. Color to be agreed upon with the Engineer.

7.11.2.2 Lamps. Each luminarie shall be provided with the specified lamp or lamps as selected from the following list and having the characteristics detailed.

Type	Nominal lamp Wattage	Minimum Lumen output after 100 hours	Average Life Burning Hours
SONT	250	27,000	12,000
SONT	400	48,000	12,000
SONT	1000	135,000	12,000

7.11.2.3 Control Gear. Shall be of the plug in type for operation at A.C. 220 volts, single phase, 60 Hertz. The ballast shall be specially selected for the particular type of lamps selected. The lamp shall be able to start with at least plus or minus ten percent (±10%) variation of the nominal voltage and continue in normal operation with dips attaining twenty percent (20%) for four (4) seconds.

The compression provided shall ensure there is no large increase in the current during starting.

The control gear losses shall not exceed ten percent (10%) of the normal lamp wattage. A device shall be provided for the suppression of radio and television interferences.

The ballast shall be equipped with energy savings components which will guarantee savings of not less than thirty percent (30%) of the lamp wattage. Electronic ballasts are also acceptable if submitted and approved with the luminarie.

7.11.3 CONSTRUCTION REQUIREMENTS.

- The luminarie shall be arranged on the mast head frame and oriented to give the recommended illumination at the designated locations along the road surface.

- The luminaries shall be mounted at the top of the lighting columns upon purpose made bracket. The angle of luminarie inclination shall be in accordance with the design

requirements. The luminaries shall be set at ninety degrees (90°) to the longitudinal axis of the roadway.

Approved Manufacturers:

Saudi Manufacturers - Saudi Arabia.

7.11.4 METHOD OF MEASUREMENT. The street lighting luminaries shall be measured by the unit complete with lamps, all fittings and fixing including wiring, control gear and installed and put into operation in accordance with these General Specifications.

7.11.5 PAYMENT. The completed and accepted street lighting luminaries, measured as provided above, shall be paid for at the contract unit price for the luminarie pay item specified in the Bill of Quantities. Payment will be full compensation for the furnishing of all materials, installation, testing and putting into operation, and all labor, equipment, tools, supplies and other items necessary for the proper completion of the Work as specified in Subsection 1.07.2 "Scope of Payment" in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
71101	Street Lighting Luminarie, IP54, complete with control gear and lamp, 150 W.H.P.S.	Unit
71102	Street Lighting Luminarie, IP54, complete with control gear and lamp, 250 W.H.P.S.	Unit
71103	Street Lighting Luminarie, IP54, complete with control gear and lamp, 400 W.H.P.S.	Unit
71104	Street Lighting Luminarie, IP54, complete with control gear and lamp, 1000 W.H.P.S.	Unit
71105	Street Lighting Luminarie, IP54, complete with control gear and lamp, ___ W.H.P.S.	Unit

SECTION 7.12 - AMENITY LIGHTING LUMINARIES

7.12.1 DESCRIPTION. The work shall consist of the supplying and installing in prepared cutouts in the structure of the viaduct and ramps, the recessed amenity lighting complete with all supports, fittings and fixings and connected to the low voltage distribution system.

ITEMS IN BILL OF QUANTITIES
Amenity Lighting, Luminaries Complete with Lamp

7.12.2 MATERIALS.

7.12.2.1 Luminaries. The luminaries shall be recessed hingeable or fixed type flush mounted complete with lamp and control gear. The luminaries shall be of the totally enclosed type, dust, watertight, shock resistant in compliance with IP 54 of IEC Publication 144. The luminarie shall be designed to house the specified HPS lamp and accessories and suitable for fitting into a preformed opening in the underside of the viaduct to provide a flush finish.

The luminarie shall consist of three (3) principal parts as follows:

1. **Luminarie (body and diffuser)**
2. **Frame for concrete opening**
3. **Control gear housing**

The luminarie shall consist of the luminarie body, lamp-holder and flat sheet glass diffuser. The body shall be made from galvanized sheet steel epoxy powder coated silver-grey after construction. The interior of the body shall be white epoxy powder coated.

The refractor shall be high impact heat and shock resistant glass specially treated to avoid any build up of electrostatic charges and mounted into a metal frame. The frame assembly shall be fixed to the body by means of stainless steel captive screws and secured by additional safety clamps to allow replacement. An approved gasket shall ensure a thorough weathertight sealing of the front glass assembly.

Access into the body of the luminarie shall be from the back or top. The lamp socket shall be made of high grade porcelain fixed in a rigid support bracket. A lamp supporting and locking system shall grip and prevent the lamp from loosening.

Luminarie Frame: The luminarie shall be fixed flush with the underside of the viaduct into a preformed opening. To achieve this the luminarie shall be complete with a frame for "trimming" the concrete opening. The frame shall be made from steel angle of suitable section galvanized after manufacture and finished the same as the luminarie body. The frame shall allow for taking up constructional tolerances in the concrete opening.

Each luminarie shall have an integral fuse to protect the luminarie and associated cabling.

Luminaries shall be complete with a one and one half (1½)square millimeter three (3) core cable high temperature PVC flexible cable and a five (5) pin waterproof plug for connection into a socket outlet mounted on an adaptable conduit box, suitably sealed against the ingress of moisture and into which will be terminated the incoming supply cable. This arrangement shall afford rapid removal of the luminarie for maintenance or replacement.

Hinged type luminarie shall hinge onto the frame on one (1) side and shall swing up into the vertical position. Access for maintenance personnel shall be gained to the viaduct "boxes" using the luminaries as access points. The frame shall have a vertical upstand onto which the luminarie body shall automatically clip and rest in the raised position. The control gear shall be housed in a self-contained sealed box which shall be fixed to the rear of the frame upstand. Connection from the control gear to the lamp holder shall be by means of a three (3) core two and one-half (2½)square millimeter flexible copper cable butyl insulated and sheathed with cable glands at each end.

7.12.2.2 Lamps. Lamps shall have the following characteristics:

Type	Nominal lamp Wattage	Minimum Lumen output after 100 hours	Average Life Burning Hours
SONT	150	14,500	12,000
SONT	250	27,000	12,000

7.12.2.3 Control Gear. Control gear shall be of the plug-in type for operation at 220 volts, 60 Hertz, power factor compensated to at least nine-tenths (0.9). The ballast shall be of a type specially adapted for the particular make of lamps selected. The lamp shall be able to start with at least plus or minus ten percent (±10%) of the voltage value and continue in normal operation with dips attaining twenty percent (20%) for four (4) seconds.

The compensation provided shall ensure that there is no large increase in the operating current during starting. The control gear losses shall not exceed ten percent (10%) of the nominal lamp wattage. A device shall be provided for the suppression of radio and television interference. The ballast shall be equipped with energy savings components which will guarantee savings of not less than thirty percent (30%) of the lamp wattage. Electronic ballasts are also acceptable if submitted and approved with the luminarie.

7.12.3 CONSTRUCTION REQUIREMENTS. Recessed fittings shall be fixed square in the preformed openings and finished flush with the underside of the viaduct.

Cabling for the recessed hingeable type luminaries shall be run inside the viaduct boxes suitably clipped and shall loop in and out of the adaptable conduit boxes housing and sockets serving the luminaries.

Each adaptable box shall be equipped with terminals to terminate the two (2) or three (3), sixteen (16) square millimeter four (4) core cable and earth cable depending upon the position in the circuit.

The cabling for the recessed fixed type luminaries shall pass from the duct system through the bridge abutment at high level and shall be embedded looping in and out of the adaptable conduit boxes' recess left for the luminarie.

Approved Manufacturer:

Saudi Manufacturers - Saudi Arabia.

7.12.4 METHOD OF MEASUREMENT. The amenity lighting luminaries shall be measured by the unit complete with lamps, all fittings and fixings including flexible cable and plug supplied and installed and put into operation in accordance with these General Specifications.

7.12.5 PAYMENT. The completed and accepted amenity lighting luminaries, measured as provided above, shall be paid for at the contract unit price for the pay items specified in the Bill of Quantities. Payment shall be full compensation for furnishing all material, installation, testing and putting into service, for all labor, equipment, tools, supplies and other items necessary for the proper completion of the work as specified in Subsection 1.07.2, "Scope of Payment" in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
71201	Amenity Lighting Luminaries, IP 54, complete with lamp, 70 W.H.P.S.	Unit
71202	Amenity Lighting Luminaries, IP 54, complete with lamp, 150 W.H.P.S.	Unit
71203	Amenity Lighting Luminaries, IP 54, complete with lamp, 250 W.H.P.S.	Unit
71204	Amenity Lighting Luminaries, IP 54, complete with lamp, 400 W.H.P.S.	Unit
71205	Amenity Lighting Luminaries, IP 54, complete with lamp, ___ W.H.P.S.	Unit

SECTION 7.13 - SIGN ILLUMINATION

7.13.1 DESCRIPTION. This work shall consist of supplying, installing and putting into satisfactory operation the floodlights for lighting the road signs which are supplied and installed under a separate section of this Contract.

ITEMS IN BILL OF QUANTITIES
Overhead Sign Lighting Luminaries, Including Fixtures, Cables, Distribution Box, Switch, and Control Gear and Installation on Supporting Steelwork.

7.13.2 MATERIALS.

7.13.2.1 Floodlight. The wide angled floodlights for overhead signs shall be of the totally enclosed type, weather, dust and shock resistant designed to house the specified lamps.

The body of the floodlight shall be made of extruded or pressure die-cast aluminum alloy box closed on the front by a protector of very high resistance glass capable of withstanding thermic and mechanical shocks and set into grooves in the box by special gasketting. The reflector shall be of high purity (99.9 percent) anodized aluminum secured in precision aligned internal tracks to provide wide beam distribution. The side covers of injected light shall allow easy access to the optical block and shall secure tightness of the whole enclosure to IP 54 in accordance with IEC Publication 144.

A connection box shall be located at the rear of the floodlight body with gland connection to accept four (4) square millimeter PVC/SAW/PVC two (2) core cable. The lamp and control gear shall be mounted in two (2) different and isolated compartments, or alternatively the central gear may be housed remotely. Floodlights shall be provided with an earthing terminal.

7.13.2.2 Lamps. Metal halide shall have the following characteristics:

Nominal lamp watts	250 watts
Minimum lumen output after 100 hours burning	19,000 lumen
Average life	10,000 hour

7.13.2.3 Control Gear. Control gear shall be of the plug-in type, for operation at 220 volts, 60 Hertz, power factor compensated to at least nine tenths (0.9) lagging. The ballast shall be of a type specially adapted for the particular make of lamps selected.

The lamp shall be able to start with at least plus or minus ten percent (±10%) line voltage, and normal operation with dips attaining twenty percent (20%) for four (4) seconds. Compensation shall be such to ensure that there is no large increase in the operating current during starting. The control gear losses shall not exceed ten percent (10%) of the nominal lamp wattage. A device shall be provided for the suppression of radio and television interference. The ballast shall be equipped with energy savings components which will guarantee savings of not less than thirty percent (30%) of the lamp wattage. Electronic ballasts are also acceptable if submitted and approved with the luminarie.

The cables for the internal wiring in the control gear compartments, shall have single core two and one-half (2½) square millimeter copper conductors, with neoprene or cross-linked polyethylene or approved equivalent insulation and sheath.

The exposed metallic parts of the luminarie shall be painted with a corrosion and heat resistant paint and equipped with radio interference suppression equipment.

7.13.3 CONSTRUCTION REQUIREMENTS. The Contractor shall check that the sign is adjusted and set correctly relative to the vertical plane and the road axis, and shall then proceed with the electrical installation and fitting of the floodlights.

Overhead Signs. The floodlights shall be located as shown on the Drawings and mounted on the front edge of the platform. A specially designed mounting bracket shall be provided for each floodlight allowing it to be swivelled in any desired direction and enabling it to be locked firmly in its final position. The feeder cable shall be routed via the duct in the supporting frame up to platform height where it shall be glanded into a suitable metal clad waterproof box and will be terminated into a non-automatic T00PO and N 40 ampere miniature circuit breaker isolator. A two-way three (3) phase five (5) ampere miniature circuit breaker board within the enclosure shall distribute power to the individual floodlights using four (4) square millimeter two (2) core PVC/SWA/PVC cable. The earth of the cables shall be bonded to the earth terminal of each enclosure.

On no account should the floodlights or associated bracketry and fixings obstruct the view of the sign face. Additional screening where required shall be added to the top or bottom edges of the sign in the event of excess glare to oncoming traffic.

The Contractor shall be responsible for the final setting and locking in position of the floodlights after demonstrating to the Engineer that the specified sign lighting requirements has been met.

Approved Manufacturers:

Saudi Manufacturers - Saudi Arabia.

7.13.4 METHOD OF MEASUREMENT. Sign illumination shall be measured as the number of overhead sign lighting luminaries including fixtures, distribution box, supporting steelwork, switchgear, control gear, interconnecting cabling and earthing as necessary, supplied, erected and put into operation in accordance with these General Specifications.

7.13.5 PAYMENT. The completed and accepted sign illumination floodlight assemblies as provided above shall be paid for at the contract unit price(s) for "Overhead Sign Lighting Luminaries" as specified in the Bill of Quantities. Payment will be full

compensation for furnishing all materials, installation, testing and putting into operation, for all labor, equipment, tools, supplies and other items necessary for the proper completion of the work as specified in Subsection 1.07.2, "Scope of Payment" in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
71301	Overhead Sign Lighting Luminaries, IP54, 250 Watt H.P.M.V. (Size), including fixtures, cables, distribution box, switch and control gear and installation on supporting steelwork	Unit

SECTION 7.14 - UNDERBRIDGE FITTING

7.14.1 DESCRIPTION. The work shall consist of the supply, installation on the ceiling or on the walls of the bridges and putting into satisfactory service the fittings for the specified high pressure sodium lamps, including control gear and lamp, wiring and associated materials.

ITEMS IN BILL OF QUANTITIES
Underbridge Fitting, Complete with Lamp

7.14.2 MATERIALS.

7.14.2.1 Fitting. The fitting shall have a robust body constructed from pressure die-cast aluminum finished with polyurethane paint. A front refractor shall be applied with gasket with a mechanical protection to IP 54 in compliance with IEC Publication 144. The refractor shall be one (1) piece made from thermal and mechanical shock-resistant borosilicate glass. The fitting shall be completely factory assembled and prewired with heat-resistant silicone insulated flexible cable. The reflector shall be of the high purity anodized aluminum giving asymmetrical distribution of the light.

The control gear shall be housed in a separated compartment isolated from the lamp compartment.

Through wiring shall be provided making use of watertight cable glands.

7.14.2.2 Lamps. Lamps shall have the following characteristics:

Type	Nominal lamp Wattage	Minimum Lumen output after 100 hours	Average Life Burning Hours
SONT	150	14,500	12,000
SONT	250	27,000	12,000

7.14.2.3 Control Gear. Control gear shall be suitable for operation at 220 volts, 60 Hertz, power factor compensated to at least nine-tenths (0.9). The ballast shall be of a type specially adapted for the particular make of lamps selected. The lamp shall be able to start with at least plus or minus ten percent (±10%) of the voltage value and continue in normal operation with dips attaining twenty percent (20%) for four (4) seconds. The ballast shall be equipped with energy savings components which will guarantee savings of not less than thirty percent (30%) of the lamp wattage. Electronic ballasts are also acceptable if submitted and approved with the luminarie.

The compensation shall ensure that there is no large increase in the operating current during starting. The control gear losses shall not exceed ten percent (10%) of the nominal lamp wattage. A device shall be provided for the suppression of radio and television interference.

7.14.3 CONSTRUCTION REQUIREMENTS. The fitting shall be mounted on the ceiling or on the walls of the bridges, at the instructions of the Engineer, by means of galvanized steel brackets specially designed for the purpose and well fixed to the concrete of the bridge structure.

Approved Manufacturers:

Saudi Manufacturers - Saudi Arabia.

7.14.4 METHOD OF MEASUREMENT. Underbridge fittings shall be measured as the number of fittings complete with lamp, control gear, wiring, fixing brackets and other accessories, mounted and put into operation in accordance with these General Specifications.

7.14.5 PAYMENT. The completed and accepted fittings, measured as provided above, shall be paid for at the contract unit price for the pay items listed below specified in the Bill of Quantities. Payment shall be full compensation for the furnishing of all material, installation, testing and putting into service, for all labor, equipment, tools, supplies and other items necessary for the proper completion of the work as specified in Subsection 1.07.2, "Scope of Payment" in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
71401	Underbridge Fitting, IP54, complete with lamp, 70 W.H.P.S.	Unit
71402	Underbridge Fitting, IP54, complete with lamp, 150 W.H.P.S.	Unit
71403	Underbridge Fitting, IP54, complete with lamp, 250 W.H.P.S.	Unit
71404	Underbridge Fitting, IP54, complete with lamp, 400 W.H.P.S.	Unit
71405	Underbridge Fitting, IP54, complete with lamp, ___ W.H.P.S.	Unit

SECTION 7.15 - UNDERPASS LIGHTING LUMINARIES

7.15.1 DESCRIPTION. This work shall consist of supplying, installing and putting into satisfactory operation a luminarie lighting system to light vehicle underpasses.

ITEMS IN BILL OF QUANTITIES
Underpass Lighting Luminaries

7.15.2 MATERIALS.

7.15.2.1 Luminaries. The luminaries shall be a modular unit modified by the manufacturer to accommodate the lamp and light distribution arrangement required for the scheme.

All luminaries shall have the following principal features and details:

1. Aluminum (magnesium - silicon alloy) one (1) piece extruded body having a wall thickness of not less than two and one-half (2½) millimeters.

2. Polished aluminum reflector.

3. The optical system, electrical control gear and lamp shall be mounted on a "plug-in" type gear tray which shall have locating pins to ensure alignment when being fitted into the body. The ground wire connection shall be taken through the plug and socket connector to ensure that the ground potential is maintained on the gear tray when it is being removed from the luminarie for maintenance purposes.

4. The luminarie shall have a hinged front glass assembly which shall comprise of a clear toughened glass plate, not less than five and one-half (5½) millimeters thick, fixed into an aluminum frame which shall have a full length closing device. The front glass assembly shall seat on to a neoprene non-rotting type gasket and once seated shall provide a fully jet-proof and dustproof seal to IP 65.

5. The whole assembly shall be treated against corrosion by anodizing the aluminum.

6. The luminarie shall be complete with their own mounting accessories and shall be supported from the underpass structure.

7.15.2.2 Lamps. Each luminarie shall be provided with the specified lamp or lamps as selected from the following list and having the characteristics detailed.

Type	Nominal lamp Wattage	Minimum Lumen output after 100 hours	Average Life Burning Hours
(a)			
SONT	250	27,000	12,000
SONT	400	48,000	12,000
(b) Fluorescent lamps			
TL	58	4,500	7,500
TL	65	4,800	7,500

7.15.2.3 Control Gear:

1. For high pressure sodium lamps

Lamps shall have a ballast incorporated of the plug-in type, for operation at 220 volts, power factor compensated to at least nine-tenths (0.9) lagging. The ballast shall be of the type specially adopted for the lamps selected. The lamp shall be able to start with at least plus or minus ten percent (±10%) line voltage and continue in normal operation with dips attaining twenty percent (20%) for four (4) seconds. Compensation shall be such as to ensure that there is no great increase in the operating current during starting and gear losses shall not exceed ten percent (10%) of the normal wattage.

The luminarie circuits shall be provided with a suppressing device for prevention of radio interference. The ballast shall be equipped with energy savings components which will guarantee savings of not less than thirty percent (30%) of the lamp wattage. Electronic ballasts are also acceptable if submitted and approved with the luminarie.

2. For fluorescent lamps

Fluorescent luminaries shall be equipped with rapid start (starterless) control gear, which shall be tropicalized for use in temperature in excess of fifty degrees Celsius (50° C.) ambient and shall be suitable for operation as a 220V, 60 Hertz supply.

Fluorescent circuits shall have a power factor of not less than nine-tenths (0.9).

7.15.2.4 Lighting Control System. The nighttime lighting fluorescent fixtures shall be controlled from the section of the LV switchboard busbar inside the compact substation which feeds the street lighting masts. These will be switched on when the photo-electric cell controlling the street lighting contactor actuated.

The daytime lighting HPS fixtures will be fed from a separate busbar of the LV switchboard of the compact substation and which will be controlled from a second set of photo-electric cell and contactor. These shall be interlocked with the nighttime lighting contactor such that when one is "ON" the other will be "OFF".

7.15.3 CONSTRUCTION REQUIREMENTS.

7.15.3.1 General. Sub-circuit lighting cables from the substation to the lighting fixtures shall be routed via PVC ducts into the underpass.

7.15.3.2 Luminaries. Luminaries shall be fixed using Unistrut or approved equal cable channel together with luminarie mounting accessories as provided by the luminarie manufacturer.

The interconnection between fittings shall be by a conduit coupling approximately twenty five (25) millimeters length, twenty (20) millimeters diameter through which the interconnecting wiring will be passed.

Luminaries shall be through wired with a five (5) core or five (5) single core heat resistant flexible copper cable, rubber insulated and/or sheathed. The earth wire shall be solidly bounded to the earthing stud inside the luminarie. Cable cross sections shall be as specified on the drawings.

Luminaries shall be installed throughout the underpass in a neat continuous line. Luminaries shall be aligned to the satisfaction of the Engineer and any necessary realignment to the satisfaction of the Engineer and any necessary realignment shall be made without additional cost.

Luminaries shall be complete with their own mounting accessories as shown on the electrical and structural drawings. Fixings shall be agreed with the Engineer and all bolts used shall be stainless steel painted after installation with a two (2) pack epoxy anti-corrosion paint again to be agreed with the Engineer.

The Contractor shall place emphasis on aligning the luminaries level and true to the satisfaction of the Engineer.

Approved Manufacturers:

Saudi Manufacturers - Saudi Arabia.

7.15.4 METHOD OF MEASUREMENT. Underpass lighting luminaries complete with lamps, control gear, wiring and all fittings, fixings and shall be measured as the number furnished, installed and put into operation after testing and acceptance as meeting these General Specifications in all respects.

7.15.5 PAYMENT. The completed and accepted quantities, measured as provided above, shall be paid for at the contract unit prices for the pay items listed below that are specified in the Bill of Quantities. Payment will be full compensation for supplying all

materials installation and putting into operation, all labor, equipment, tools, supplies and other items necessary for the proper completion of the work as specified in Subsection 1.07.2, "Scope of Payment" in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
71501	Underpass Lighting Luminaries, IP65, daytime lighting, complete with lamp, 150 W.H.P.S.	Unit
71502	Underpass Lighting Luminaries, IP65, daytime lighting, complete with lamp, 2 x 150 W.H.P.S.	Unit
71503	Underpass Lighting Luminaries, IP65, daytime lighting, complete with lamp, 250 W.H.P.S.	Unit
71504	Underpass Lighting Luminaries, IP65, daytime lighting, complete with lamp, 2 x 250 W.H.P.S.	Unit
71505	Underpass Lighting Luminaries, IP65, daytime lighting, complete with lamp, 400 W.H.P.S.	Unit
71506	Underpass Lighting Luminaries, IP65, daytime lighting, complete with lamp, 2 x 400 W.H.P.S.	Unit
71507	Underpass Lighting Luminaries, IP65, daytime lighting, complete with lamp, ___ W.H.P.S.	Unit
71511	Underpass Lighting Luminaries, IP65, nighttime lighting, complete with lamp, 40 Fluorescent	Unit
71512	Underpass Lighting Luminaries, IP65, nighttime lighting, complete with lamp, 58 Fluorescent	Unit
71513	Underpass Lighting Luminaries, IP65, nighttime lighting, complete with lamp, 65 Fluorescent	Unit
71514	Underpass Lighting Luminaries, IP65, nighttime lighting, complete with lamp, ___ Fluorescent	Unit

SECTION 7.16 - EARTHING

7.16.1 DESCRIPTION. This work shall consist of the supply, installation, connection, testing and any additions or adjustments to make the earthing installation comply with the standards specified and to the approval of the Engineer.

ITEMS IN BILL OF QUANTITIES
Earthing Installation

7.16.2 MATERIALS. Materials shall be in accordance with the requirements and standards.

7.16.3 CONSTRUCTION REQUIREMENTS. All exposed non-current carrying metallic parts of the installation and the neutral point of the distribution system shall be earthed. The earthing of the distribution system shall be made at the neutral point of the transformers.

A separate fifty (50) millimeter by six (6) millimeter high conductivity earth bar shall be mounted on porcelain connectors in each substation housing. The bar shall be pre-drilled with a minimum distance of seventy-five (75) millimeters between holes. The following conductors shall be connected to the bar where relevant:

1. Transformer Neutral - insulated cable
2. Transformer frame earth - bare conductor
3. MV switchgear frame earth - bare conductor
4. LV switchgear frame earth - bare conductor
5. Earth mat connection - insulated cable
6. Earth mat connection - insulated cable

The insulated cable shall be fifty (50) square millimeter single core PVC green insulated cable fixed at regular intervals with PVC cleats and terminating with suitably sized lugs.

The bare conductors shall be thirty-five (35) millimeters by six (6) millimeters high conductivity copper tape fixed at regular intervals with purpose made brass saddles.

Each substation earth mat shall have two (2) separate earth paths, each comprising of two (2) sixteen (16) millimeter diameter copper covered steel rods of two and one-half (2½) meter length driven into the ground in the corners of enclosure. The rods shall be fitted with inspection covers and connected together and to the earth bar with inspection covers and to the earth bar with insulated cable. The resistance to earth for each path should not exceed ten (10) ohms giving a network earth of maximum five (5) ohms excluding any earthing external to the substation.

Each earth bar shall have a label fitted over and shall identify the connections together with the wording "Main Earth Bar."

The separate earthing cables for the high masts and lighting column circuits shall be bonded to the earth at the LV supply position, every high mast and last column on each circuit shall be bonded via the earthing bolt to a sixteen (16) millimeter diameter copper covered steel rods of sufficient length driven into the ground adjacent to the mast or column. The bonding shall be a sixteen (16) square millimeter stranded copper, single core, insulated cable. A similar system shall be installed at the relevant position of the sign lighting installation. The resistance to earth for the earth path shall not exceed ten (10) ohms excluding any other earthing. Additional rods shall be installed if necessary to achieve this reading.

All connections between rods and earthing tape or cables shall be made by the Cadweld process which produces a fused joint. Bolted connections may be used for connection to removable items of equipment only.

All lighting fittings distribution boards, isolators, ... etc., together with all extraneous metalwork shall effectively be bonded to the main earth bar in the substation via separate earthing leads and sub-main cables; armoring, etc.

Where single wire armored is used for earthing purpose, earth tags shall be fitted to the cable glands and a separate bonding lead shall be taken from the tag to the earth terminal of the fused switch, breaker, isolator or switchboard.

EARTHING TESTS. After installation of the individual earthing system in accordance with the above for the various parts of the Specification and after the whole installation has been connected up, an earth resistance test shall be carried out on the earth bar at each substation and the readings obtained officially recorded. Three (3) readings shall be obtained or each substation relating to the two (2) earth paths connected individually and in parallel. An Evershed and Vignoles or similar earth tester shall be used and all results tabulated and handed to the Engineer.

7.16.4 METHOD OF MEASUREMENT. Earthing shall be measured as the number of completed sets of earthing supplied, installed, and put into operation after testing and acceptance as meeting these General Specifications in all respects.

7.16.5 PAYMENT. The completed and accepted quantities, measured as provided above, will be paid at the contract unit price(s) for the pay items listed below that are specified in the Bill of Quantities. Payment will be full compensation for furnishing all materials, installation, testing and putting into operation, for all labor, equipment, tools, supplies and other items necessary for the proper completion of the work as specified in Subsection 1.07.2, "Scope of Payment" in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
71601	Earthing Installation, Highmast	Unit
71602	Earthing Installation, Sub-Station	Unit
71603	Earthing Installation, Switching Station	Unit
71604	Earthing Installation, Columns and Amenity Lighting	Unit
71605	Earthing Installation, Gantry Sign or Overhead	Unit
71606	Earthing Installation, (Type)	Unit

SECTION 7.17 - TESTING AND ADDITIONAL REQUIREMENTS

7.17.1 DESCRIPTION. The work included in this section is of a general subsidiary type associated with that carried out in the relevant sections of these General Specifications.

7.17.2 LABELING. All items of equipment shall be adequately and clearly labeled in English and Arabic. Labeling shall be in accordance with the schematic diagram, a copy of which shall be incorporated in the Operation and Instruction Manual.

1. General. Each item of switchgear, and all other items of plant whether individual or forming part of a switch or control panel shall be clearly labeled on the exterior of the casings.

2. Lighting columns and masts shall be fitted with "Traffolite" or similar labels to give black lettering on a whole background of sufficient size to be visible from a passing vehicle. These labels shall be attached to the columns by means of stainless steel nuts and bolts positioned just above the access openings. The columns shall be identified strictly in accordance with the coding and locations shown on the Plan - Electrical Installation Drawings.

3. Switchgear. All control switchgear labels shall be engraved on "Traffolite" to give black lettering on a white background, and shall indicate the voltage, current rating and phase color, together with the manufacturer's distinguishing mark. A separate label shall include the service controlled.

4. Overall Scheme. All switchgear, distribution boards and apparatus shall be included in an overall identification scheme and labeled accordingly.

5. Phase Markers. The interior of each item of electrical equipment shall be clearly marked to show the phases by means of colored plastic sleeving or discs.

6. Circuit Lists. Circuit lists shall be mounted on the inside of distribution or doors, so placed that they are easily readable. The list shall comprise a printed sheet sealed into a semi-rigid clear plastic cover provided by specialist supplier.

7. Cable Core Identification. AC power cable cores shall be identified at their terminations by colored sheaths of the heat or chemically shrinkable type to indicate the respective phases and neutral. Where the core insulation is suitably colored during manufacture the colored sleeve may be omitted.

8. Accessory Identification. All accessories such as local switches, switch-fuses and isolators used for the control of equipment, lighting fittings, etc., shall carry engraved identification plates to indicate the circuit number and phase to which the accessory is connected as shown on the drawings.

Prior to final testing the Contractor shall confirm that all labeling is intact over the whole site and that all cables have been fitted with circuit markers wherever the cable emerges from the duct system.

7.17.3 TESTING AND COMMISSIONING.

7.17.3.1 General. **Testing and inspection of the installation shall be carried out in accordance with the regulations and standards listed in the documents after completion of the work to prove compliance with the Specifications. The tests will be carried out in the presence of and to the satisfaction of the Engineer.**

Manufacturer's test certification for appropriate equipment shall be handed to the Engineer prior to the site testing being carried out.

All results of the tests shall be recorded on site and signed by all witnessing parties. Subsequently, three (3) copies of all such documents shall be submitted to the Engineer.

The Contractor shall furnish all equipment, measuring apparatus, labor, etc., to facilitate the tests. This equipment shall be sealed and have current calibration certificates issued by an official laboratory, approved by the Engineer.

Prior notice shall be given to the Engineer of proposed tests together with a list of the equipment to be used. In particular the Contractor shall submit his proposals for measuring the luminance and illumination levels and for calculating the average levels as specified elsewhere in this specification.

All tests including where applicable, insulation tests, continuity tests, effectiveness of earthing, measuring of earth electrode resistance, shall be carried out under the responsibility of the Contractor.

The Contractor shall be responsible for all costs involved in testing and commissioning and shall re-test at his own expense any item that fails. No repeat test shall be carried out until the cause has been established and rectification of the failure has been carried out.

7.17.3.2 Site Testing. **The Contractor shall include for the following tests to be carried out on site:**

7.17.3.2.1 Substation Tests. **Insulation resistance test with 1000 volts megger. Phasing out and polarity check. Operation and protection tests.**

7.17.3.2.2 Cables.

MV Cables

- **Insulation resistance tests taken between conductors and between conductors and cable metallic sheath taken with a 1000 volt megger.**

- **High potential Test**

This shall be carried out in accordance with the IEC 502:1983 recommendations for Electrical Test after installation. Test voltage shall be agreed with and recognized by the cable manufacturer.

LV Cables

- **Insulation resistance tests taken between conductors and between conductors and separate earthing cable taken with a 500 volt megger**

- **Continuity Tests**

The Contractor shall obtain approval from the Engineer, after completion of all tests, for authorization of connection of the power supply to the installation.

7.17.3.2.3 Visual Inspection. The Contractor shall include for carrying out the following tests in addition to those previously called for:

- **Condition of the equipment and quality of the workmanship.**

- **Level, perpendicularity and alignment of the high masts, poles and luminaries.**

- **Actual characteristics of the equipment.**

7.17.3.2.4 Measurement of Insulation Resistance. Insulation resistance tests on the various LV circuits. The tests shall be performed after installation, in accordance with approved standards to determine the adequacy of insulation between phases and also between phases, neutral and earth (lamps shall be removed during the test where applicable).

Resistance tests of the earthing of all metallic frames.

7.17.3.2.5 Operational Tests. Normal functioning of all lamps. Operational tests on all switchgear and power equipment including recording the voltage at the terminals of each ballast on the final column in each circuit, together with the voltage existing simultaneously at the feeder pillar outgoing LV terminals.

7.17.3.2.6 Performance Tests. Performance tests shall be performed after one hundred (100) hours normal functioning. Measurement of the lighting levels and uniformities on the road surfaces. The results of which shall be submitted to the Engineer in tabulated form.

The Resident Engineer will reserve the right to take any action he may consider necessary, in the event of the measure values not conforming with the lighting design criteria as specified under the relevant section of these Specifications. Any other tests found necessary by the Engineer to verify conformity of the installation with these Specifications.

7.17.4 HANDLING OF EQUIPMENT. The Contractor shall provide all slings, lifting tackles and cranes required for the safe handling, off-loading and installation of all items supplied and shall be responsible for obtaining and maintaining up-to-date the necessary test certificates for such equipment. Protection of surfaces and floors during installation shall be the responsibility of the Contractor together with any making good required. Programming of deliveries shall be coordinated to ensure accessibility of equipment at the appropriate stage of construction.

The Contractor shall be fully responsible for protection and maintenance in good condition of all equipment included in his supply during storage, delivery, installation and until hand over completion.

SECTION 7.18 - ELECTRICAL INSTALLATION EQUIPMENT DATA

7.18.1 GENERAL. The information and data on the principal items of equipment must be submitted by the Contractor with his Tender.

The Contractor shall supply all the information and data proving compliance of the equipment with the Specifications as listed in the Summary of Equipment Manufacturers and required by the Detailed Equipment Data. The Engineer reserves the right to request any further information he may need to check compliance of the proposed equipment with the Specifications.

The Contractor shall supply information from the Manufacturer's Equipment lists with the characteristics indicated in his Tender unless otherwise specifically agreed to in the following format:.

SUMMARY OF EQUIPMENT MANUFACTURERS

Bill of Quantity Item No.	Description	Manufacturer	Country of Orgin	Catalogue Reference

7.18.2 DETAILED EQUIPMENT DATA.

7.18.2.1 33 KV Overhead Lines Network.

1. Manufacturers of all parts of the system
2. Type with manufacturers catalogue and descriptive leaflet and catalogue number
3. Details of construction with detailed specifications, grade, strength and ratings of the materials used
4. Calculations showing details of stresses under maximum wind loading
5. Calculations and sizes of necessary concrete support bases

7.18.2.2 High Masts/Lighting Columns.

1. Manufacturers
2. Type with manufacturers' catalogue and descriptive leaflet
3. Details of construction with detailed specification of materials used for column and holding down bolts
4. Calculations showing details of stresses under maximum wind loading and gusting
5. Calculations and sizes of necessary concrete support bases

7.18.2.3 Intake Switching Station/Packaged Substation/Feeder Pillar.

1. Manufacturer
2. Specifications with manufacturer's catalogue
3. Construction drawings
4. Characteristics of each component
5. Foundations block detail
6. General Arrangement

7.18.2.4. Cables (MV and LV).

For each type of cable:

1. Manufacturer
2. Specification
3. Standard to which it complies
4. Rated voltage
5. Manufacturer's catalogue, with indications of cable proposed

7.18.2.5 Luminaries.

7.18.2.5.1 Luminaries Details.

1. Manufacturer
2. Type with manufacturer's catalogue and description leaflet
3. Details of construction with detailed specification of materials used
4. Total electrical load of luminarie
5. Lighting characteristics of the luminarie:
   - Total luminous output in percent of lamps output
   - Isocandela diagrams in all azimuths
   - Isolux curves on a horizontal surface
   - Coefficient of utilization
6. Weight of complete fitting
7. Luminarie dirt depreciation curves

7.18.2.5.2 Lamp Control Gear.

1. Ballast

   (1) Manufacturer
   (2) Type with manufacturer's catalogue and descriptive leaflet
   (3) Operating design characteristics of lamp (starting and normal)
   (4) Losses in normal operation
   (5) Minimum starting voltage
   (6) Variation of lamp lumen output with voltage
   (7) Starting current (with cold and hot lamp)

(8) Minimum voltage for lamp correction
(9) Power factor before and after correction
(10) Conductor temperature when the ballast is operating inside the luminarie, placed in an ambient temperature of fifty degrees Celsius (50° C.)
(11) Wiring diagram and characteristics of each component

2. Condenser for Power Factor Correction

(1) Manufacturer
(2) Type with manufacturer's catalogue
(3) Characteristics: capacity, voltage and temperature rating
(4) Maximum operating temperature when installed inside the luminarie, operating in an ambient temperature of fifty degrees Celsius (50°C.)

3. The ballast shall be equipped with energy savings components which will guarantee savings of not less than thirty percent (30%) of the lamp wattage. Electronic ballasts are also acceptable if submitted and approved with the luminarie.

7.18.2.5.3 Lamps.

1. Manufacturer
2. Type with manufacturer's catalogue
3. Lamp operating characteristics (starting and normal)
4. Starting time and starting current in cold and hot conditions
5. Minimum voltage for lamp extinction
6. Spectral distribution of the light emitted
7. Lumen output after 100 and 200 hours operation
8. Variation of lumen output with voltage variation
9. Variation of lumen output with ambient temperature variation
10. Variation of lumen output with lamp life
11. Average lamp life, under defined conditions
12. Lamp temperature, while operating in the proposed fixture in an ambient temperature of fifty degrees Celsius (50° C.). The critical spot location of lamp temperature shall be identified.

7.18.2.6 For all Other Equipment.

1. Manufacturer
2. Type
3. Catalogue, with indication of equipment proposed
4. Detailed Specification
5. Construction drawings and wiring drawings

SECTION 7.19 - CIVIL WORKS FOR ELECTRICAL INSTALLATION

7.19.1 DESCRIPTION. The work shall consist of furnishing and installing of the complete duct system for all cables, construction of reinforced concrete foundations for packaged substations, distribution feeder pillars, high mast and conventional lighting columns, construction of drawpits for ducts, and installation of breakaway support coupling, transformer base and multi-direction slip base assemblies all as shown on the Plans or as established by the Engineer. This work also includes the installation of breakaway support coupling assemblies on existing foundations.

ITEMS IN THE BILL OF QUANTITIES
uPVC Ducts
Drawpits
Reinforced Concrete Foundations for High Mast/Lighting Columns
Reinforced Concrete Bases for Substations
Reinforced Concrete Bases for Feeder Pillars
Breakaway Support Coupling Assembly for Lighting Columns
Breakaway Multi-direction Slip Base Assembly for Lighting Columns
Breakaway Cast Aluminum Transformer Base Assembly for Lighting Columns

7.19.2 MATERIALS.

7.19.2.1 Polyvinylchloride (uPVC) Duct. Polyvinylchloride (uPVC) duct shall be of the non-sparking type and suitable for direct burial in the ground. Minimum tensile strength shall be four hundred (400) MN per square meter. Impact strength shall be forty (40) MN per square meter.

The nominal outside diameters shall be as noted on the Drawing and comply with S.A.S. for Class II having wall thickness of two and two-tenths (2.2) millimeters for one hundred ten (110) millimeters diameter and three and two-tenths (3.2) millimeters for one hundred sixty (160) millimeters diameter.

7.19.2.2 Concrete. Concrete shall be Class B as specified and shall conform to the relevant requirements of Section 5.01, "Portland Cement Concrete" in these General Specifications.

7.19.2.3 Reinforcing Steel. Reinforcing steel shall be mild steel and shall conform to the relevant requirements of Section 5.02, "Reinforcing Steel" in these General Specifications.

7.19.2.4 Drawpit Covers. Covers for drawpits shall be cast iron and of the heavy duty (35 tons test load) type, Grade A, to BSS 497 (1976) and shall conform to the relevant requirements of these General Specifications.

7.19.2.5 Backfill Material. Sand and sieved backfill material free from stones or other debris shall be provided for reinstating the trenches after the laying of cables and ducts. Interlocking concrete cable tiles to give fifty (50) millimeters minimum overlap each side of the outer cables and/or ducts. An indicating tape or mesh shall be buried two hundred (200) millimeters below the finished ground surface and above each duct run.

7.19.2.6 Breakaway Support Coupling, Transformer Base and Multi-direction Slip Base Assemblies. Breakaway support coupling, transform base and multi-direction slip base assemblies shall meet the materials requirements contained in the latest edition of the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries, and Traffic Signs.

7.19.2.6.1 Breakaway Support Coupling Assembly. Breakaway support coupling assembly (longitudinally grooved) shall comply with the following additional materials requirements:

Minimum Tensile Strength	10,900 kilograms
Restrained Shear	1.64 kg min. - 2.95 kg max
Nut Torque	(237 ± 34 Newton meters)
Coupling Coating:	External surface: Phosphate per Mil. Std TTC-490 Method 3, Type 2, prime using cathodic epoxy electrocoat and fusion bond coat with black nylon #11, 7-15 mil thick Internal Threads: Dry Film Lubricant per Mil-L-23398
Anchor Bolt:	Min. 500 mm length, 27 mm diameter, (3 mm pitch) threaded and galvanized per ASTM 153, 64-76 mm maximum above foundation

Miscellaneous washers are to be heavy duty galvanized per ASTM A153. Heavy Hex Nut per ASTM A563 Grade DH shall be mechanically galvanized per ASTM B695.

Sheet metal skirt to be two-piece corrosion resistant AASHT T3003 aluminum 1.5 mm thick, 13.3 cm high sections long enough to be held together by three (3) stainless steel self tapping slotted sheet metal screws.

Electrical wiring and electrical breakaway quick disconnects are to be provided as indicated on the Drawings.

7.19.2.6.2 Breakaway Cast Aluminum Transformer Base Assembly. Unless otherwise indicated on the contract drawings, conventional lighting columns shall incorporate a cast aluminum breakaway transformer base and electrical breakaway quick-disconnect. The base shall be constructed so that when used with the size and weight of pole proposed, the assembly shall meet the safety and strength requirements of AASHTO Standard Specification for Structural Supports for Highway Signs, Luminaries and Traffic Signals.

The contractor shall furnish a certification from the base manufacturer to this effect:

Cast aluminum transformer bases shall meet the following requirements:

Base - ASTM B108 allow 5G70A - T6 or alloy 356-T6.

Door - The high density plastic door shall be fabricated using Noryl SE1 CFM3 resin, or approved equal. The vandal resistant door fastener shall be a stainless steel socket button head cap screw.

Connecting and hold down hardware for cast aluminum transformer bases shall be: bolts ASTM A-325, nuts ASTM A-563 Grade A, and both galvanized to ASTM A-153 (AASHTO M-232).

The transformer base and pole combination shall be designed to withstand the wind loads described in the referenced AASHTO Standard Specifications.

Electrical wiring and electrical breakaway quick disconnects are to be provided as indicated on the Drawings.

7.19.2.6.3 Breakaway Multi-direction Slip Base Assembly. Breakaway multi-direction slip base assembly shall conform following additional materials requirements, and to the standard drawing details and notes.

1. All washers shall be AASHTO M164 (ASTM A325).

2. Clamping bolts shall be new AASHTO M164 (ASTM A325) or ASTM A449 bolts with clean undamaged threads.

3. The galvanized surfaces of the two slip plates and the 22 guage stainless steel or galvanized keeper plate shall be smooth and without irregularities, to reduce friction and to prevent slackening of bolt tension due to flattening of the irregularities.

Electrical wiring and electrical breakaway quick disconnects are to be provided as indicated on the Drawings.

7.19.3 CONSTRUCTION REQUIREMENTS.

7.19.3.1 Underground Duct System.

1. UPVC duct shall be supplied in lengths with a fitting socket provided at one (1) end of each length, and jointed using the manufacturer's recommended adhesive to form a watertight joint.

2. Routing of duct as shown on the Drawings is schematic but no major change of alignment will be allowed unless approved by the Engineer. In all cases

where unremovable obstructions are met, the directions of the Engineer shall govern the routing of duct past such obstacles. All routing of duct shall be of such nature and in accordance with good practice to allow the minimum of difficulty in subsequent installations of cable within the conduit. Only smooth bend elbows (Electrical Elbows) to be used, bend of ducts by heating is not acceptable.

3. Excavation shall be of sufficient depth to allow the duct to be installed as shown on the Project Drawings.

4. A pull wire shall be placed in all ducts stretching the complete length between all drawpits.

5. The duct runs shall be inspected by pulling a steel mandrel, or other approved device, of a diameter equal to seventy-five percent (75%) of the inside diameter of the duct and five hundred (500) millimeters long. The mandrel shall pass through the entire run of the duct from one (1) end to the other without binding. All ducts which will not allow the mandrel to be pulled through, shall be repaired or replaced to the satisfaction of the Engineer at the Contractor's expense.

6. After the duct run has been accepted the Contractor shall furnish and install a three (3) millimeter diameter galvanized steel pull wire in the ducts for the future pulling of cables. The steel wire shall be cut at a distance of one (1) meter outside the duct head into the drawpit and be securely fixed so that the wire will not be lost inside the duct.

7. Ducts run not terminated in drawpits shall be properly capped.

8. Identification markers to be placed at both sides of road to indicate utilities ducts.

7.19.3.2 Drawpits, Bases and Foundations.

1. All structural excavation and backfill shall conform to the requirements of Section 2.05, "Excavation for Structures"in these General Specifications.

2. The excavation shall be well cleaned and a waterproof membrane lining placed in the bottom and on the sides before the concrete is poured.

3. Walls and roof slabs of drawpits shall be properly formed.

4. Mild steel reinforcement shall be provided and placed as shown on the Drawings, PVC ducts shall be installed all as detailed.

5. Where duct openings are provided in the drawpit walls are unused, they shall be fitted with a three hundred (300) millimeter length of capped stub duct.

6. Foundation for packaged substations/feeder pillars shall be in accordance with the manufacturer's detailed drawings.

7. Foundation for high masts and conventional lighting columns shall be in accordance with the dimensions, details and technical requirements as shown on the project relevant drawings.

7.19.3.3 Trenching for Duct Laying.

1. Trenches shall be excavated to the depth shown on the project drawings in any material including soil, sand or rock, in level or sloping ground in the locations shown. The trenches shall be wide enough to accommodate the ducts at the spacing indicated. Excavation to link the trenches with every location into ducts at road crossings and into enclosures shall be included.

2. A bed of sand two hundred (200) millimeters thick shall be laid in the bottom of the trench prior to the ducts being laid.

3. After laying of the ducts, a surrounding and covering layer of sand two hundred (200) millimeters deep shall be placed over the ducts, followed by the interlocking cable tiles, then the backfill incorporating the marker tape and the whole then compacted. The marker tape shall be provided as part of the item covering the duct. These operations shall be carefully coordinated with the duct layer who shall supervise the duct covering operations to ensure there shall be no damage to the ducts.

7.19.3.4 Breakaway Support Coupling, Transformer Base and Multi-directional Slip Base Assemblies. The construction of support coupling, transformer base and multi-slip base assemblies shall be in accordance with the recommended practices of the manufacturers as supplemented by the following additional installation instructions:

The type of breakaway assembly used (support coupling, transformer base, or multi-direction slip base) shall be the Transformer Base unless otherwise indicated in the Contract Plans and listed in the Bill of Quantities. If the weight of luminarie and pole exceed 590 kilograms, breakaway support coupling assembly cannot be used.

Where the lighting column flange plate is in contact with a breakaway transformer base the contacting surfaces shall be thoroughly coated with an aluminum-impregnated caulking compound, or a synthetic rubber gasket may be placed between the two surfaces, as approved by the Engineer.

7.19.3.4.1 Breakaway Support Coupling Assembly Installation. Breakaway support coupling assembly shall be installed on new and existing foundations in accordance with the recommended practices of the manufacturer as supplemented by the following installation instructions:

1. The coupling manufacturer shall have a representative present during initial installation.

2. At existing foundations the anchor nuts, pole, grout pad and leveling nuts shall be removed and the conduits cut to a maximum height of fifty (50) mm above the foundation.

3. Area around the anchor bolts shall be cleaned of debris or dirt.

4. Heavy duty galvanized (HDG) anchor bolts must be installed min. sixty four (64) mm to max. seventy six (76) mm above the new foundation or cut off to the same elevation above on existing foundations.

5. Remove excess zinc or other foreign material from HDG anchor bolts by chasing the threads with a standard HDG twenty seven (27) mm diameter three (3) mm pitch nut to within twenty five (25) mm of the foundation. Thread couplings onto the anchor bolts by hand.

When threading coupling onto the anchor bolt, take precautions so as not to damage the black coating on the surface.

6. Level couplings after positioning. There should be a minimum of three (3) mm and a maximum of nine (9) mm gap between the bottom surface of the coupling and the top of the anchor.

7. Remove the nut, small washer and the cardboard sleeve.

8. Set the pole in place on top of couplings and large washers.

9. Install small washers and hand tighten the nuts.

10. Plumb the pole using the couplings as required. Pole should sit firmly on all four (4) couplings before starting to tighten the nuts.

11. To complete the installation, tighten the nuts to the manufacturer's specified torque or use torque control nuts. Do not over torque the nut as it may crack the coupling.

Note: Torque control nuts should not be used in highly corrosive environment.

7.19.3.4.2 Breakaway Multi-direction Slip Base Assembly Installation. Construction of the breakaway multi-directional slip base assembly shall be in accordance with the recommended practices of the manufacturer as supplemented by the following installation instructions:

1. The slip plane shall be free of obstructions such as protruding conduit or anchor bolts. The conduit, anchor bolts, and other obstructions shall terminate at a height at or below the elevation of the top of the bottom slip plate.

2. Washers in the slip plane shall be placed between the bottom plate and the keeper plate to reduce friction.

3. The clamping bolts for the slip base assembly shall be tightened to 200 Newton Meters or to the specified torque, plus or minus two percent (2%), in two stages using an accurately calibrated torque wrench before erecting the light standard onto the foundation bolts.

4. Anchor bolts shall extend through the top heavy hex nut two full threads.

5. Anchor bolts damaged after the foundation concrete is placed shall not be repaired by bending or welding. The Contractor's repair procedure is to be submitted to the Engineer for approval prior to making any repairs. The procedure is to include removing the damaged portion of the anchor bolt, cutting threads on the undamaged portion to remain, the installation of an approved threaded sleeve nut and stud, and repairing the foundation with epoxy concrete repair.

6. Where used, the grout pad shall not extend above the elevation of the bottom of the slip base.

7. Anchor bolts shall be installed plumb, ± 1 degree.

8. The lighting column flange plate, where in contact with the pole foundation, shall be coated externally with black bituminous paint.

7.19.3.4.3 Breakaway Cast Aluminum Transformer Base Assembly Installation.

1. Cast aluminum transformer bases shall meet the requirements of the latest version of AASHTO's and "Standard Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals."

2. Cast aluminum transformer bases shall be marked for easy identification as to compliance with the above specifications.

3. All connecting and hold down washers shall be supplied and installed in accordance with the base manufacturer recommendations.

4. The contractor shall furnish to the Engineer a certification that the base meets AASHTO requirements for all types of breakaway bases.

5. All connecting and anchor bolts shall be torqued to a minimum 257 N-M or as specified by the pole and breakaway base manufacturer.

6. If shimming is necessary to install the light poles straight and level, on its longitudinal axis, the contractor shall install "U" shaped shims or bound flat washers. The washers/shims shall be installed around the anchor bolts.

7.19.4 QUALITY ASSURANCE PROCEDURES. The uPVC ducts, drawpits, reinforced concrete bases and foundations, and breakaway assemblies will be inspected, sampled, tested and evaluated in accordance with Section 1.08 "Acceptance of Work" in these General Specifications.

The materials incorporated into the uPVC ducts, drawpits, reinforced concrete bases and foundations and breakaway assemblies shall be sampled, tested and evaluated in accordance with the specifications and test methods referenced in Subsection 7.19.2 "Materials" and Subsection 1.08.3 "Certification of Conformance" in these General Specifications. The installation of these materials and construction of the ducts, drawpits, bases, foundations and assemblies will be inspected and accepted in accordance with Subsection 7.19.3 "Construction Requirements" and Subsection 1.08.4 "Measured or Tested Conformance" in these General Specifications.

7.19.5 METHOD OF MEASUREMENT. Bases, foundations and breakaway assemblies shall be measured by the number of units acceptably constructed. uPVC duct shall be measured by the linear meter of completed and backfilled trench in which the specified number of ducts have been installed. Ducts shall be measured along the axis of the duct from terminus to terminus and shall include all bends. Breakaway support coupling assemblies installed on existing foundations shall also be measured by the unit.

Reinforced concrete drawpits and cast iron covers shall be measured by the number of completed and accepted drawpits of each type and size.

7.19.6 PAYMENT. The completed and accepted quantities, measured as provided above, will be paid for at the contract unit price(s) for the pay items listed below that are specified in the Bill of Quantities. Payment shall be full compensation for furnishing all materials, for all labor, equipment, tools, supplies and all other items necessary for the proper completion of the work as specified in Subsection 1.07.2, "Scope of Payment" in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
71901	uPVC Duct, installed, 50 mm dia	Linear Meter
71902	uPVC Duct, installed, 80 mm dia	Linear Meter

71903	uPVC Duct, installed, 100 mm dia	Linear Meter
71904	uPVC Duct, installed, 150 mm dia	Linear Meter
71905	uPVC Duct, installed, 200 mm dia	Linear Meter
71906	uPVC Duct, installed, 250 mm dia	Linear Meter
71907	uPVC Duct, installed, 300 mm dia	Linear Meter
71908	uPVC Duct, installed, 350 mm dia	Linear Meter
71909	uPVC Duct, installed, ___ mm dia	Linear Meter
71915	Drawpit with Heavy Duty Steel Cover, 90 x 900 x 1200 mm	Unit
71916	Drawpit with Heavy Duty Steel Cover, 900 x 1800 x 1200 mm	Unit
71917	Drawpit with heavy Duty Steel Cover, 600 x 600 x 1200 mm	Unit
71918	Drawpit with Heavy Duty Steel Cover, (Size) mm	Unit
71925	Drawpit with Medium Duty Steel Cover, 900 x 900 x 1200 mm	Unit
71926	Drawpit with Medium Duty Steel Cover, 900 x 1800 x 1200 mm	Unit
71927	Drawpit with Medium Duty Steel Cover, 600 x 600 x 1000 mm	Unit
71928	Drawpit with Medium Duty Steel Cover, (Size) mm	Unit
71935	Drawpit with Light Duty Steel Cover, 900 x 900 x 1200 mm	Unit
71936	Drawpit with Light Duty Steel Cover, 900 x 1800 x 1200 mm	Unit
71937	Drawpit with Light Duty Steel Cover, 600 x 600 x 1000 mm	Unit
71938	Drawpit with Light Duty Steel Cover, (Size) mm	Unit
71945	Reinforced Concrete Foundation for (6) meter lighting column	Unit

71946	Reinforced Concrete Foundation for (8) meter lighting column	Unit
71947	Reinforced Concrete Foundation for (10) meter lighting column	Unit
71948	Reinforced Concrete Foundation for (12) meter lighting column	Unit
71949	Reinforced Concrete Foundation for (14) meter lighting column	Unit
71950	Reinforced Concrete Foundation for (16) meter lighting column	Unit
71951	Reinforced Concrete Foundation for (20) meter high mast/lighting column	Unit
71952	Reinforced Concrete Foundation for (25) meter high mast/lighting column	Unit
71953	Reinforced Concrete Foundation for (30) meter high mast/lighting column	Unit
71954	Reinforced Concrete Foundation for (35) meter high mast/lighting column	Unit
71955	Reinforced Concrete Foundation for (___) meter high mast/lighting column	Unit
71960	Breakaway Support Coupling Assembly for (6) meter lighting column	Unit
71961	Breakaway Support Coupling Assembly for (8) meter lighting column	Unit
71962	Breakaway Support Coupling Assembly for (10) meter lighting column	Unit
71963	Breakaway Support Coupling Assembly for (12) meter lighting column	Unit
71964	Breakaway Support Coupling Assembly for (14) meter lighting column	Unit
71965	Breakaway Support Coupling Assembly for (16) meter lighting column	Unit
71966	Breakaway Support Coupling Assembly for (___) meter lighting column	Unit
71970	Breakaway Multi-Direction Slip Base Assembly for (6) meter lighting column	Unit

71971	Breakaway Multi-Direction Slip Base Assembly for (8) meter lighting column	Unit
71972	Breakaway Multi-Direction Slip Base Assembly for (10) meter lighting column	Unit
71973	Breakaway Multi-Direction Slip Base Assembly for (12) meter lighting column	Unit
71974	Breakaway Multi-Direction Slip Base Assembly for (14) meter lighting column	Unit
71975	Breakaway Multi-Direction Slip Base Assembly for (16) meter lighting column	Unit
71976	Breakaway Multi-Direction Slip Base Assembly for (___) meter lighting column	Unit
71980	Breakaway Cast Aluminum Transform Base Assembly for (6) meter lighting column	Unit
71981	Breakaway Cast Aluminum Transform Base Assembly for (8) meter lighting column	Unit
71982	Breakaway Cast Aluminum Transform Base Assembly for (10) meter lighting column	Unit
71983	Breakaway Cast Aluminum Transform Base Assembly for (12) meter lighting column	Unit
71984	Breakaway Cast Aluminum Transform Base Assembly for (14) meter lighting column	Unit
71985	Breakaway Cast Aluminum Transform Base Assembly for (16) meter lighting column	Unit
71986	Breakaway Cast Aluminum Transform Base Assembly for (___) meter high mast/lighting column	Unit
71990	Reinforced Concrete Base for substations in accordance with substation supplier design	Unit
71991	Reinforced Concrete Base for Feeder Pillars	Unit

SECTION 7.20 - TRAFFIC SIGNALS

7.20.1 DESCRIPTION. These Works shall consist of the supply, installation and putting into satisfactory service of the Traffic Signal system complete with controller, detectors, traffic signal masts and poles, signal heads complete with lamps and pedestrian facilities where required, cabling and connection and all necessary services for the complete installation.

The controller, signal masts and poles shall be installed on fixed foundations or bases and the supply and construction of these, together with all necessary ducts, drawpits, trenches, excavations and similar civil works shall be provided by the Contractor in conformity with the requirements outlined in Section 7.19, "Civil Works for Electrical Installation" and as further detailed in this Section of these General Specifications.

Placement of the signal poles and controller cabinet shall minimize the possibility of their being struck by errant vehicles.

ITEMS IN BILL OF QUANTITIES
Signal Controller, (No.) Phase
Traffic Signal Head
Pedestrian Traffic Signal Head
Pedestrian Traffic Signal Head, Push Button
Traffic Signal Support
Traffic Loop Detectors

7.20.2 DEFINITIONS. For this Section of the General Specifications the following definitions shall apply. Where applicable, the meanings of the terms are detailed in BS 892:1967 Glossary of Highway Engineering Terms and BS 6100 Section 2.4.1:1986 Highway Engineering.

1. Full-vehicular actuated traffic signals. Traffic signaling equipment in which the duration of green signals and the time of the cycle vary in relation to the traffic flow into and through the controlled area.

2. Fixed time traffic signals. Traffic signaling equipment in which the duration of the red and green signals are fixed in relations to each other and together form a fixed cycle.

3. Semi-vehicular actuated traffic signals. Traffic signaling equipment which provides vehicular actuated control of the minor roads including Vehicular Extension Periods up to the Maximum Green Period.

4. Pedestrian demand traffic signals. Traffic signaling equipment actuated by push button and providing right-of-way for pedestrians, who when the request is made, do not have the right-of-way.

5. Traffic signal sequence. Traffic signal head aspects to provide the following facilities:

Option 1 (Vehicle/Vehicle)

VEH A	G A R R R
VEH B	R R RA G G

Option 2 (Vehicle/Pedestrian)

VEH	G A R R R RA G
PED	R R R G FG R R

If specified the flashing green (FG) pedestrian right-of-way may be complete with audible signal.

6. Right-of-way. The condition which applies when a green signal is displayed to traffic at the approach to a primary signal face and which permits traffic to proceed if the way is clear, but with special care to turning traffic, giving way to pedestrians who are crossing.

7. Traffic stream. Vehicles in one (1) or more lanes on the same approach to the controlled area which, when they have the right-of-way, will move in the same direction.

8. Stage. A condition of signal lights during a period of the cycle which gives right-of-way to one (1) or more particular traffic movements.

A stage may be considered as starting at the point at which all phases that will have right-of-way during the stage have been set to green, and all phases terminating have been set to red and ending at the point at which the phase loses the right-of-way.

Stages may be considered as being separated by interstage timing periods during which phases loses and gain right-of-way to establish a new stage.

9. Interstage period. The period between the end of one (1) stage and the start of the next stage.

10. Phase. The sequence of conditions applied to one (1) or more streams of vehicular traffic and, where required combinations of vehicular traffic and pedestrians, which always receive identical signal light indications throughout the complete cycle.

11. Minimum green run period. The minimum duration of the phase green signal before it is allowed to be terminated.

12. Vehicular extension period. Additional duration of green signal indication secured by operation of a detector by vehicles having the right-of-way.

13. Maximum green run period. The maximum time for which a phase can continue to be extended by its associated detection equipment after a demand has been made by traffic on another phase.

14. Early cut-off. A condition in which one (1) or more traffic streams are permitted to move after the stoppage of one (1) more of the traffic streams which during the preceding stage have been permitted to run with them.

15. Late release. A condition in which one (1) or more traffic streams are permitted to move before the release of one (1) or more of the traffic streams which during the subsequent stage are permitted to run with them.

16. Cycle. The sum of all stages from the beginning of the green on a reference major street until the return of green to the reference approach.

17. Staggered ambers. A condition where on a change of right-of-way the warning to traffic streams about to start commences during the warning to traffic streams called upon to stop.

18. All red. A condition where on a change of right-of-way the commencement of a warning to traffic streams about to start commences after the termination of the warning to traffic streams called upon to stop.

19. Normal clearance period. A fixed inter-stage period giving staggered ambers.

20. Fixed extra clearance. A fixed inter-stage period longer than the normal clearance period.

21. Turning traffic. Vehicles turning left or right after passing the stop line or primary signal face.

22. Demand. A request for right-of-way by traffic during a phase which has no right-of-way when the request is made.

23. Forced change. A condition which shall cause a change to a selected stage, unless the controller is in an inter-stage or a minimum green period, in which case the change to the selected stage shall be deferred until the expiry of the minimum green period providing the condition is still present at that time.

7.20.3 SUBMITTALS. Material and equipment listings along with shop drawings of poles, mast arms, controller, cabinet, wiring schematics, harnesses and pin connectors, etc., shall be furnished the Engineer for approval within sixty (60) days after signing the Contract. Partial listings and shop drawings will not be accepted for consideration.

Submissions shall be clear, complete, and in quadruplicate. Material and equipment lists shall, in addition to a summary, include catalog cutouts or published data sheets. Unacceptable submittal data will be returned for corrective action. A copy of the approved material and equipment listings along with approved shop drawings will be returned to the Contractor.

Any changes to the approved material or equipment lists must be requested in writing. If requested by the Engineer, the Contractor shall submit for inspection and approval samples of both the specified and proposed substitute item at no cost to the Ministry. Manufacturer's warranties and guarantees, furnished on equipment used in the Work, shall be delivered to the Engineer; likewise, instruction sheets and parts lists supplied shall be delivered to the Engineer upon receipt of the equipment. For each type of equipment used in the Work, spare units reflecting ten percent (10%) of the equipment used with a minimum of one (1) shall be provided to the Engineer.

Throughout the entire project, all units of any one (1) item, such as poles, signal heads, detectors, controllers, cabinets, etc., shall be made by the same manufacturer unless otherwise approved in writing by the Ministry.

Inasmuch as certain items and/or equipment furnished for use under this Section will be standard production type products, acceptance will be made by the Engineer, based on selected confirmation tests, the manufacturer's certification of the material and/or design conforming to the requirements, noted hereinafter or on the plans, and visual inspection at the job site. The manufacturer shall make available to the Ministry data and material samples from the production runs for use in evaluation of their product.

7.20.4 MATERIALS.

7.20.4.1 General. Materials employed in the manufacture of the equipment shall be the best of their respective kinds and the workmanship shall conform to the best modern practice. Material shall be selected or treated so that no corrosion will occur during the lifetime of the installation.

The equipment shall be designed to operate on A.C. 220 volts single phase 60 Hz. The equipment shall function satisfactorily should the voltage vary within the plus fifteen percent (+15%) or minus twenty percent (-20%) and should the frequency vary within plus or minus four percent (±4%). If the equipment is sensitive to voltage fluctuations within the above stated limits an automatic voltage stabilizer shall be incorporated in the system.

Electronic equipment shall use components of assessed quality in accordance with the system outlined in BS 9000 General Requirements For A System For Electronic Components Of Assessed Quality or other approved equal.

All equipment shall be designed and derated for continuous operation at fifty degrees Celsius (50°C.) ambient temperature and one hundred percent (100%) relative humidity with temperatures reaching eighty-five degrees Celsius (85°C.) in direct sunlight with a high ultra violet content. The equipment shall be suitable for uninterrupted full load operation exposed to sun, dust storms, corrosive elements and similar adverse climatic conditions.

All wiring shall be neatly and securely fixed in position in an approved manner. The wiring, except loop detector wire, shall be in high temperature PVC insulated cables, color coded for ease of identification. All terminals shall be of adequate size.

All equipment and associated service requirements shall comply with BS 505:1971 Road Traffic Signals, or approved equal and with local requirements covering timing, sequence, phasing detectors, modes, facilities and other options as may be detailed.

7.20.4.2 Concrete and Footings. Concrete for footings and pedestals shall conform to Subsection 5.03.9, "Concrete For Minor Structures" in these General Specifications.

Concrete for prestressed poles shall be Class K conforming to Paragraph 5.04.3.1 "Prestressed Concrete" in these General Specifications.

Reinforcing steel shall conform to Section 5.02, "Reinforcing Steel" in these General Specifications.

Prestressing steel shall conform to Paragraph 5.04.3.3 "Prestressing Reinforcement" in these General Specifications.

Piling shall conform to Section 5.06 "Piling" in these General Specifications.

7.20.4.3 Steel Products. Steel products shall conform to the following:

Structural Steel Tubing	ASTM A 501 or ASTM A 595, Grade A
Steel Castings	ASTM A 27, Grade U-60-30
Galvanizing	ASTM A 123 or ASTM A 153
Low Carbon Anchor Bolts, Bolts, Nuts, and Washers	ASTM A 307
High-Strength Bolts, Nuts, and Washers	ASTM A 325
Stainless Steel Bolts, Screws, and Washers	ASTM A 193
Stainless Steel Nuts	ASTM A 194

7.20.4.4 Aluminum Products.

1. Aluminum tubing, support components, bases and miscellaneous support hardware shall conform to ASTM B 108, B 209, B 211 or B 221, as appropriate. Aluminum alloys shall have a minimum tensile strength of two thousand five hundred (2,500) kilograms per square centimeter, and a minimum yield strength of two thousand (2,000) kilograms per square centimeter.

2. Miscellaneous non-structural aluminum castings shall conform to ASTM B 108, alloy optional.

7.20.4.5 Cable and Duct.

1. Conductor Cable, High Voltage. The voltage rating of the conductor cable supplying primary electrical power shall be five (5) KV for primary voltages less than five (5) KV, and fifteen (15) KV for voltages of five (5) KV and above. The specific type of conductor cable shall be as recommended and approved by the Kingdom.

2. Conductor Cable and Wire. Conductor cable shall be six hundred (600) volt cable, single conductor, thermoplastic insulated and sheathed. The conductor cable shall be plainly marked on the outside with the manufacturer's name and identification in accordance with industry practice.

3. Duct. Duct shall consist of polyvinyl chloride (PVC) plastic pipe conforming to ASTM F 512, Type DB-120, or ABS plastic pipe conforming to ASTM D 2750, Type II. Duct for jacking may be galvanized steel as approved by the Engineer.

7.20.5 CONTROLLERS.

7.20.5.1 General. Controllers shall be completely solid state, digital micro-processor controllers. Solid state shall mean that electronic devices such as transistors, diodes, resistors, and capacitors are used to perform the functions of the controller or other mechanism. They shall be capable of providing the number and sequence of intervals, phases, overlapping phases, and special operational features required by the plans and specifications.

The manufacturer shall program each controller to operate as required by the plans and specifications. All logic circuit inputs shall be internally buffered to withstand transients and electrical noise resulting from normal use, without damage to the circuits. All controller timing shall be fully programmable using keyboard units located on the front panel of each controller. Memory storage shall be non-volatile EPROM under a main power-off condition for at least thirty (30) days.

It shall be possible to advance the controller through the normal cycle by a hand-operated (police) switch. This switch shall control all intervals except the yellow change and red clearance intervals which shall be timed by the controller as programmed. Controllers shall be designed for operation at a nominal power input of two hundred twenty (220) volt, single phase, sixty (6) hertz alternating current. The controller and all associated electrical equipment shall operate satisfactorily at any voltage between one hundred eighty (180) and two hundred forty-five (245) volts. They shall also operate satisfactorily within a power mains frequency range of sixty (60) hertz plus or minus three (±3) hertz.

A diagnostic and interrogation control unit shall be supplied with each controller which shall provide means of changing the intersection parameters and give visual displays

of circuit functions to enable a rapid maintenance service, and indicate stage in operation, termination or running of minimum green time, signal state for each phase and stored demands.

The time clock shall be of real time quartz type having the same accuracy and monitoring as that of the mains frequency with which it shall be synchronized. The time clock module shall be programmed to provide the time plan dependent control and to be used in dedicated intersection or in the area or group coordinated system as required, it shall accept, operate and pass on the green signal hurry calls and to provide any other time based requirement as specified.

The module shall be provided with a battery operated "stand by" unit for use in the event of a main failure which shall function for a minimum of two hundred (200) days and arranged so that when supply is returned the signals will reestablish without loss of function.

Controllers shall be capable of being fitted with modules to provide priority facilities for emergency or other public vehicles fitted with the necessary equipment. In no case shall the introduction or cancellation of a priority signal override a normal minimum green period on any stage sequence specified for safety reasons but the priority signal may convert a running signal to a minimum green run period.

The controller shall be fitted with adjustable auto transformer signal dimming facilities to reduce the intensity of the aspect signals to between five to fifty percent (5-50%) of full intensity during the night hours. All signals shall be reduced by the same amount which shall be adjustable and capable of being set between the limits specified.

The reduced intensity shall not affect the color of the light signal which shall comply with the limits set out in BS 1376:1985.

Switching of the reduced signal aspect intensity of each intersection shall be provided by photo electric control relay supplying the traffic signals through a tapped auto transformer controlled by a change-over Contractor to IEC 158:1 or a solid state contactor to IEC 158:2.

The photo-electric controls shall consist of two (2) omni-directional cadmium cell thermal relays connected in series using solid state photo-variable conductance elements giving a 2:1 on/off ration with sensitivity to switch on lights when the daylight illumination reduces to seventy (70) lux. The photo-electric cells shall be mounted at the top of the nearest traffic signal mast or other purpose designed high mounting and connected to the controller via the duct system.

The photo-cell control module shall be capable of adjustment to permit switching levels between thirty (30) and eighty (80) lux. The exact settings between these limits is to be determined on Site and approved.

Series connection of the two (2) photo cells shall ensure that failure of one cell (in the closed position) will allow the other to control the circuit.

An on-off switch shall be installed in the controller arranged so that in the "on" position the traffic signal dimming system is functional and the "off" position shall ensure that the contactor and hence the dimming remains de-energized whilst the control system remains functional.

Two (2) or more power interruptions separated by power restoration of fifteen hundred (1,500) or more milliseconds shall be considered as separate interruptions. When power to the controller is interrupted and then restored, the controller shall react as follows:

1. When the interruption is five hundred (500) milliseconds or less, the controller shall continue to operate as though the interruption had not occurred.

2. When the interruption is one thousand (1,000) milliseconds or more, the controller shall revert to its start-up sequence.

3. When the interruption is more than five hundred (500) milliseconds and less than one thousand (1,000) milliseconds, the controller shall react in accordance with either Subparagraph 1 or 2 above.

Three (3) or more power interruptions of three hundred (300) milliseconds or less separated by power restoration of three hundred (300) milliseconds or more shall not cause the controller to revert to its start-up sequence. Whenever power is restored after a power interruption, as defined in Subparagraphs 2 and 3 above, the initial signal indications shall be those which are programmed to be displayed to traffic at the beginning of the green interval for the major traffic movement on the major street. The manufacturer shall program each controller to restart at that point in the cycle. The restart program shall also place a call on each actuated phase of a traffic-actuated controller.

The programmed timing of any interval by the controller shall not deviate at any time by more than plus or minus one hundred (±100) milliseconds from the set value related to the power frequency. The controller and all associated electrical equipment shall operate satisfactorily in a temperature range of from minus twenty-five degrees Celsius (-25°C) to eighty-five degrees Celsius (85°C). They shall also operate satisfactorily at a relative humidity of not over ninety-five percent (95%) over the temperature range of five degrees Celsius (5°C) to forty-five degrees Celsius (45°C).

Non-varying controller functions shall be contained in a programmable read-only memory (PROM) (or EPROM), or similar device. The manufacturer shall program this memory as required by the plans and specifications prior to delivery of the controller. This memory shall be unaffected by a power outage. It shall be alterable only by being reprogrammed by an external device or by replacement of the memory. The controller functions which shall be contained in this memory include (but are not limited to):

1. Permissible sequences of indications, intervals, and phases;

2. Minimum allowable timing of Yellow Clearance, Green, Walk and Don't Walk intervals;
3. Initial indications upon start-up after power interruption;
4. Prohibited simultaneous signal combinations.

Controllers shall not accept nor operate upon any manual input or stored timing parameters shorter than the following:

1.	Yellow Clearance	2.0 seconds
2.	Minimum green	5.0 seconds
3.	Minimum "Walk"	4.0 seconds
4.	Minimum pedestrian clearance	6.0 seconds

Controllers shall not allow any of the following conditions:

1. Green signal indications which cause two (2) or more traffic movements to be in conflict.
2. The appearance of indications, intervals, or phases which the Manual on Uniform Traffic Control Devices states shall not follow other specified indications, intervals, or phases.
3. The simultaneous appearance of combinations of indications which are prohibited by the MUTCD.

Controllers shall require, in accordance with the MUTCD, that designated indications, intervals, and phases shall follow specified indications, intervals, and phases.

7.20.5.2 Controller Enclosure. Each controller shall be housed in a dust tight and weatherproof enclosure conforming to IP 65 of IEC 529. The housing shall be made from aluminum alloy, galvanized sheet steel or glass-reinforced polyester as specified. The surface shall be treated light grey with paint having high ultra-violet reflective and corrosion inhibiting qualities and so designed as to minimize the effect of solar radiation on the equipment.

The housing shall be constructed of material not less than two (2) millimeters thick and internally ribbed where necessary to provide a rigid structure and support framework for the necessary internally mounted equipment. All external corners and edges, excepting the lower edges, shall be rounded.

The front and rear of the enclosure shall be fully accessible through one (1) side or two (2) center opening doors fitted with gaskets and compression type recessed hinges and center mounted cylinder locks with three locking points.

Where specified the enclosure may be fitted with access doors on one side only and the internal equipment shall be hinge mounted on a frame for access to front and rear. The housing shall be adequately braced and supported to carry the weight of the equipment when moved to the open position.

Provision shall be made for manual control of the traffic signal control system by means of either a "built-in" flap type access door or a separate "bolt-on" unit as specified. The "bolt-on" manual control unit shall have an enclosure to a similar specification to that of the controller Access to the controller and manual controls shall be protected with locks with keys of different patterns, two (2) keys for each lock. Corresponding locks and keys for each controller or manual control shall be identical for enclosures of the same make and pattern.

The controller and manual control enclosure for each intersection shall provide sufficient space to house all standard equipment including vehicle detector modules, local interface and master equipment for use in a cabled or cable less system, and shall be capable of operating as an isolated intersection or as linked system.

7.20.5.3 Controller Electrical Equipment. All circuit wiring shall have a current carrying capacity in accordance with design requirements.

Traffic signal head wiring and switching equipment shall be suitable for a normal maximum lamp load of two (2) kilowatts to allow for uprated signal lamps where used on high speed motor road intersections.

All components and accessories shall be adequately derated and sufficiently sized so as to ensure reliability in operation and require only routine maintenance for a minimum of five (5) years operation.

A separate switched 13A BS 1363 power socket outlet shall be provided for maintenance purposes.

A heavy duty (HD) master switch and fuse shall be provided to isolate all equipment in the controller from the mains supply. The master switch shall be DP and rated at not less than twenty (20) amps.

An HD switch and fuse shall be provided to isolate the power from the controller logic. The controller fuse shall be rated at ten (10) amps.

A separate HD switch rated at not less than ten (10) amps shall be provided to control traffic signal lamps. The operation of this switch shall not affect the controller logic.

A fault on any signal feeder or a short circuited lamp shall not cause any major damage to the controller which cannot be easily repaired, i.e. fuse replaced, plug-in lamp switching module replaced etc.

To enable the controller to be used in a future wide area control system a separate switch fuse outlet shall be provided to supply electrical power to the associated equipment. The mains to this switch will not be disconnected by the controller switch.

Where deemed preferable or if otherwise specified the HD switches and fuses may be substituted with Molded Case Circuit Breakers (MCCB's) conforming to IEC 157 or

BS 4752. The MCCB's shall be of equivalent rating and provide over current and fault protection.

All HD switches, fuses, or MCCB's shall be derated for use in the climatic conditions detailed. All control and protection equipment shall be properly labeled showing the purpose and function of the equipment controlled.

The controller shall be fitted with a voltage monitor and in the event of a supply loss of less than fifty (50) milliseconds the controller shall continue to function normally. Should the supply failure exceed 50 milliseconds the controller shall shut down without malfunction and the control logic shall be retained without loss.

Where specified the controller shall be fitted with a mains failure standby unit which shall comprise a fixed thirty-two (32) amp three (3) pin plug suitable for the connection of a portable thirty-two (32) ampere socket and flexible cable connected to a mobile generating set.

The fixed plug and portable socket shall be in accordance with BS 4343:1968 or IEC 309 or approved equal standard and located in an IP 65 enclosure within the base of the enclosure.

7.20.5.4 Pre-timed Controllers. Pre-timed controllers, without any physical change in or addition to the controller or terminal facilities, shall be capable of operating:

1. As an isolated intersection controller, or
2. As a unit in a non-interconnected coordinated progressive system, or
3. As either a secondary or master controller in an interconnected coordinated progressive system.

The controller may be either:

1. Modular with plug-in circuit boards, or
2. An integral, single unit, or
3. A combination of the above.

All controllers furnished shall be identical and shall have the following features as a minimum:

1. Four (4) separate and distinct signal sequences (operating plans)
2. Three (3) cycle lengths
3. Three (3) offsets for each cycle
4. Four (4) splits per cycle
5. Thirty-six (36) intervals per cycle
6. Thirty-six (36) signal circuits
7. The capability to accept a command for automatic transfer to and from flashing operation. The time of transfer within the signal cycle shall conform to the requirements of the Manual on Uniform Traffic Control Devices.

Switches of keyboard units shall be provided on the front of the controller to permit manual programming of the following functions:

1. Any one (1) of the four (4) signal sequences (operating plans)
2. Any one (1) of the three (3) cycle lengths
3. Any one (1) of the four (4) splits
4. Any one (1) of the three (3) offsets
5. Turn ON or OFF the power to the controller only
6. Select the mode of operation:

   (1) Automatic (normal)
   (2) Stop-timing
   (3) Manual advance of intervals

The controller status shall be displayed by dials or electro-luminous devices for the following functions:

1. Signal interval
2. Signal plan (sequence of phases)
3. Length of cycle, split, and offset
4. Status of back-up battery

Each controller shall be readily interchangeable with other similar controllers. The wiring harness and pin connector shall be wired in accordance with the U.S. National Electrical Manufacturers Association (NEMA) specifications. Controllers shall be connected to the associated electrical equipment by the wiring harness terminating in an enclosed plug, with a socket in the controller.

7.20.5.5 Traffic-Actuated Controllers. The controller shall be a fully traffic-actuated controller which is also capable of functioning as a semi-traffic actuated controller or as a pretimed controller. It shall also be capable of operation as a unit in a progressive coordinated signal system.

The controller may be either:

1. Modular with plug-in printed circuit boards, or
2. An integral, single unit, or
3. A combination of the above.

All controllers furnished shall be identical and shall have indicator lights on the front panel to show as a minimum:

1. The phase which is being timed
2. The interval which is being timed
3. The next phases to which the controller will advance
4. The presence of vehicle and pedestrian detector actuations in the controller.
5. The status of the back-up battery.

The following external inputs to and outputs from the controller shall be provided as a minimum in addition to power input, grounding (earthing) and signal circuits:

1. Vehicle and pedestrian detectors
2. Stop timing (which may be activated at any point in the cycle)
3. Hold (to prevent transfer of right-of-way at the end of a phase)
4. Inhibit maximum timing
5. Force-off (to cause immediate transfer of right-of-way without regard to timing status)
6. Manual control
7. Switches to insert:

(1) One (1) artificial demand without extensions on all phases having detectors
(2) Continuous artificial demands on all phases (which would result in pre-timed operation)

If the controller has a keyboard entry device, the front panel shall contain an electronic character display panel. When information is put into or requested from the controller memory and operating circuits, the information shall be shown on the display panel. The number of characters which can be displayed shall be adequate to show all data and parameters in decimal format together with a data descriptor.

A diagnostic program shall be furnished by the manufacturer of the controllers. The program shall show the proper operation of all inputs, outputs, controls, and indicators. It shall provide visual confirmation on the front panel of the controller. The diagnostic program may be in the controller memory or may be in a separate plug-in module. An instruction and maintenance manual, including a diagnostic routine, circuit diagrams, and parts list, shall be furnished with each controller.

Each four (4) phase traffic-actuated controller called for by the contract shall have the following characteristics:

1. It shall be capable of providing four (4) phase operation.
2. It shall provide for four (4) programmable overlaps.
3. The above features shall be provided by the controller whether or not preemption, coordination, or other special programming is utilized.
4. Sequential timing of phases (single ring, dual entry)
5. Separate vehicle and pedestrian timing shall be provided on all four (4) phases.
6. Volume-density timing shall be provided on all timed and vehicle-actuated phases.

This shall include a combination of:

(1) Increasing the length of the initial part of the Green interval on the basis of the number of vehicle actuations during the Yellow and Red intervals, and
(2) A reduction in the allowable time gap between actuations by vehicles having the Green indication based on the time after an actuation on a conflicting phase.

Each eight (8), sixteen (16), or thirty-two (32) phase traffic-actuated controller which is required by the plans and estimate of quantities shall be identical to the other eight (8), sixteen (16), or thirty-two (32) phase controllers furnished under this contract. These controllers shall have the following characteristics:

1. They shall be capable of providing from two (2) to eight (8), sixteen (16), or thirty-two (32) phase operation as required by the plans and Bill of Quantities. It shall be readily possible to increase the phase capability of the controller to eight (8), sixteen (16), or thirty-two (32) sequential phases by reprogramming through the keyboard.
2. They shall provide for four (4) programmable overlaps whether or not preemption, coordination, or other special programming is utilized.
3. Concurrent timing of phases (dual ring) shall be provided.
4. The controller shall be programmable for both single and dual entry. (This means that an actuation may cause transfer of right-of-way to only one (1) phase (single entry) or to two (2) or more concurrent, non-conflicting phases.)
5. Volume-density timing shall be provided on all vehicle-actuated phases. This shall include a combination of:

(1) Increasing the length of the initial part of the Green interval on the basis of the number of vehicle actuations during the Yellow and Red intervals, and
(2) A reduction in the allowable time gap between actuations by vehicles having the Green indication based on the time after an actuation on a conflicting phase.

When a phase is terminated by expiration of the maximum green interval timing, a demand for return of the right-of-way to that phase shall be automatically placed.

When operating in the semi-actuated mode, the signal shall revert to and rest with the green indication displayed to the major street. When operating in the full traffic-actuated mode, the signal shall rest with the green indication being shown to the street on which the last actuation occurred.

7.20.6 MONITORS. Either internal or external to each controller there shall be a device (monitor) which will detect conflicting signal indications, unsatisfactory controller or monitor voltage, or the absence of a required red indication. If included in the controller, the monitor function shall have a separate power supply.

The monitor shall have twelve (12) input channels. Four (4) inputs per channel shall be provided. For the purpose of conflict determination, a signal on the Green, Yellow, or Walk inputs of the channel shall be considered to indicate that the channel is in service. The signal inputs shall be taken at the field terminals in the control cabinet so that the load switches as well as the controller output are monitored. For the purpose of detecting the absence of a required Red indication, a signal on any of the Green, Yellow, Walk, or Red inputs or a channel shall be considered to show that the channel is in service.

When voltages concurrently exist on any conflicting channels for five hundred (500) milliseconds or more, the monitor shall trigger. When the monitor triggers due to conflicting Greens or the absence of a Red indication, it shall place the signal in a flashing mode. The desired mode shall be indicated on the plans and shall be user programmable by jumpers on the terminal facilities. It may either cause the signal indications to flash Yellow on the main street and Red on the minor street, or to flash Red on both streets. This flashing mode shall continue until manually reset. Power interruption and subsequent restoration after the monitor is triggered by conflicting Greens or the absence of Red shall not reset the conflict monitor. The absence of the required voltage at any of the Red signal field terminals for one (1) second or more shall trigger the monitor. When the direct current input voltage from its power supply to either the monitor or the controller drops below seventy-five percent (75%) of the rated voltage, the monitor shall trigger. When this occurs, the monitor shall place the signal in the selected flashing mode as detailed in Paragraph 6, above. Upon resumption of normal voltage, the monitor shall cause the controller to resume normal operation without the necessity of manual resetting.

The wiring between the controller and the monitor shall be designed so that the signal installation will revert to and remain in flashing mode whenever either the controller or the monitor is disconnected. Indicator lights to display the status of the monitor and the signal operations which it is monitoring shall be placed in its front panel or on the controller front panel if it includes the monitor function. These lights shall indicate that the monitor is operating and the reasons for its being triggered if that occurs.

7.20.7 TERMINAL FACILITIES AND CABINET EQUIPMENT.

7.20.7.1 Terminal Facilities. Terminal facilities consist of all devices and materials in the control cabinet which are external to the controller and monitor, except time switches.

Terminal facilities shall be protected by dual thirty (30) ampere common-trip, solid neutral circuit breakers, or acceptable equivalent means for circuit protection which will de-energize all signal indications simultaneously. These circuit breakers shall supply power through separate bus relays and radio interference line filters to two (2) signal busses (load strips) having essentially equal load. The bus relays shall have mercury contactors and shall not be jack-mounted. These relays are needed to disconnect normal power circuits from the signal indication field terminals during flashing operation.

Load switch panels shall have sufficient capacity for twelve (12) three (3) circuit load switches, the necessary number of flash transfer relays, and two (2) double-circuit flashers. Load switches shall be solid-state and shall be compatible with the controller. Their contacts shall have a minimum rating of not less than one hundred fifty percent (150%) of the load (in amperes) which will be required by the signal indications called for by the plans. The minimum rating shall be ten (10) amperes for a tungsten lamp or gas-tubing-transformer load at eighty to one hundred ten percent (80-110%) of rated voltage. Solid-state current switching devices shall be derated to not more than fifty percent (50%) of their rated maximum capacity.

Cabinet wiring shall be neat and firm. Signal circuit wiring shall have a current-carrying capacity of not less than ten (10) amperes. Control circuit wiring shall be capable of carrying the required current without significant voltage drop or heating.

Control circuit wiring shall have a cross sectional area of four-tenths (0.4) square millimeters (22 AWG) or more. All cabinet wiring shall have heat-resistant insulation. To ensure reliability during the life of the installation, all wiring shall be sized to have good mechanical strength and to carry the required current. The wiring shall be of sufficient size so that it will not be damaged by a brief shorting of a light circuit.

Terminal strips shall be used to terminate mechanism wiring, and signal light, detector and interconnection cables. All cabinet wiring shall be attached to the terminal strip with spade or eyelet lugs. Terminal strips shall have strong, positive screw pressure connectors well separated for safe and easy connection of wires. Each incoming line on interconnection cable shall have a fuse. Flexible cable shall be furnished for connecting the controller and other components to each other and to the terminal strips.

7.20.7.2 Cabinet and Cabinet Equipment. Each controller shall be housed in a strong weatherproof and dustproof metal cabinet designed to be fastened with interior anchor bolts to a concrete base. The anchor bolts shall be furnished with the cabinet. Doors and base shall be adequately sealed to prevent the entry of rain, sand, or dust (IP 65). The cabinet shall be of pleasing and functional design and appearance. It shall be large enough to provide ample space for housing the controller and all of the other electrical and mechanical devices which must be in the cabinet. This will include the monitor, detector amplifiers, local interface and master control equipment, flashers, load switches, circuit breakers, and fuses.

The cabinet shall have a door in the front which is nearly the full height of the cabinet. A similar door shall be provided in the rear of the cabinet if necessary to give access to equipment and wiring. The front cabinet door shall contain a small door for access only to a separate compartment with switches and controls of concern to the police. Cabinet doors shall be secured by a tumbler lock identical for all cabinets of the same make. The police door shall be secured by a tumbler lock for standard police keys. Two (2) keys for each controller door and one (1) police key shall be furnished for each cabinet.

The cabinet shall be designed to limit the temperature of the air inside the cabinet to not more than seventy degrees Celsius (70°C) under any ambient outside temperature without forced ventilation. Shelves or frames shall be provided within the cabinet to support the controller and all associated equipment. Such supports shall be spaced to give adequate air circulation. It shall not be necessary to rest one (1) piece of equipment upon another. Relays, flashers, load switches, circuit breakers, electrical interference filters, and other auxiliary equipment shall be located in a manner consistent with the intersection plan. Equipment layout shall allow easy field inspection and maintenance accessibility without extensive disassembly or special tools. The inner and outer surfaces of the cabinet shall be properly painted or enameled to resist corrosion, abrasion, and the effects of solar radiation. White, light grey, or aluminum are desirable colors to improve visibility inside the cabinet and to reduce the temperature in it by reflecting rather than absorbing the sun's rays.

The cabinet shall contain the following in addition to the controller, detector modules, monitor, and interconnection equipment (where required):

1. An automatic variable resistor type of power surge protector in the power mains input.
2. Radio interference filters in the power mains input.
3. A separately fused duplex power receptacle.
4. A light socket protected by a screen, with switch, for illuminating the interior of the cabinet for servicing the equipment at night.
5. Two (2) double-circuit solid state or motor-driven flashers and bases. Flashers shall have contacts rated for at least ten (10) amperes per circuit.
6. Intersection master switch to remove power from the entire installation.
7. Switch to remove power only from the controller.
8. Switch to remove power from the signal indications without removing it from the controller and monitor.
9. Emergency flash switch, manual/automatic mode switch, and manual pushbutton control cord, all accessible only through the door keyed for police use.

The control cabinet shall be placed on and bolted to a concrete base not less than seventy-five (75) centimeters thick, of which ten (10) centimeters is above ground line. The concrete base shall extend at least (10) centimeters beyond the control cabinet on all sides. One (1) three (3) centimeter and at least one (1) ten (10) centimeter fiber or plastic duct shall be placed in the concrete base. The duct shall extend approximately five (5) centimeters above the top of the base and shall exit from the side of the base not less than fifty (50) centimeters below ground level.

The controller cabinet shall be factory wired for the controller, monitor, detector amplifiers, and all auxiliary equipment called for by the plans and specifications. A cabinet wiring diagram shall be placed in a heavy plastic envelope attached to the inside of the door. A maintenance and operations manual shall also be placed in the envelope. An additional copy of the wiring diagram and manual for each cabinet shall be furnished to the Ministry.

7.20.8 DETECTORS.

7.20.8.1 Vehicle Detectors.

1. Detector Loop Roadway Unit

Detection of vehicles shall be accomplished by a loop of multiple turns of wire placed in the roadway not less than fifty (50) millimeters below its surface in accordance with the plans.

The detector loop shall be formed from stranded copper wire having a minimum cross sectional area of three (3) square millimeters (12 AWG), with cross-linked polyethylene insulation. The loop wire shall then be encased for physical protection in neoprene tubing having an inside diameter slightly greater than the loop wire and a wall thickness of approximately one and six-tenths (1.6) millimeter. As an alternative, the loop wire may be placed in a polyvinyl chloride (PVC) duct having a nominal inside diameter of twenty-five (25) millimeters laid in a slot cut into the pavement.

The detector loop shall not be spliced in the loop and shall be brought out from the loop to a splice box indicated on the plans. The cable run from the splice box to the controller cabinet shall be #14 AWG, THHN type. The output from the loop shall be compatible with the detector amplifier. The location, configuration, and installation of the loops shall be as shown on the plans and for high speed may be up to one hundred fifty (150) meters from the intersection.

The width of the slots for loop cables shall be the diameter of the encased cable and twenty-five (25) millimeters deeper than the encased loop cable diameter multiplied by the number of turns in the loop. All debris shall be blown from the slots with compressed air prior to installation of the cable. A stick or non-metallic object with a broad face (rather than a sharp tool) shall be used to push the loop cable into the slot. The cable shall be sealed into the slot with one component rubberized sealant, and the slot shall then be filled to pavement level. The cable shall be held in place in the slot while it is being filled.

Detector loops shall cover the total width of the carriageway with individual loops for each traffic lane. Loops shall be installed to provide signals for right filter vehicles and may be required, if specified, for left turning vehicles.

Detectors and control modules shall be arranged to detect presence and estimated speed of vehicles within the active loop area, two (2) or three (3) detection loops shall be installed and spaced apart in appropriate traffic lanes if required, for speed detection and for signal extension times as required. Parked vehicles within or adjacent to the detector loop shall not affect the detector operation.

2. Detector Amplifiers. The detector amplifiers shall be housed and powered in the controller cabinet. They may be modular units with a common power supply or separate self-contained units. All outputs from detector amplifiers shall be isolated from equipment ground (earth). Detector amplifiers shall be self-tuning. The detector shall automatically adjust to normal environmental changes. The detector amplifier shall be capable of proper operation with a loop having an inductance range of from twenty (20) to two thousand (2,000) microhenries.

In the event of a power failure, detector amplifiers shall automatically retune upon power restoration. The circuit design of detector amplifiers shall protect the amplifier from damage from voltage surges on the amplifier input due to lighting or other high voltage. Detector amplifiers which are separate modular units shall have a fuse or circuit breaker in the mains power supply lead which is accessible from the front panel. Detector amplifiers shall have a lamp or other device to give visual indication of each actuation of each detector channel by a vehicle.

Detector amplifiers shall provide delay and extension timing as follows, and shall have suitable controls on the front of the amplifier for these functions:

1. In delay timing, detector output to the controller occurs from one (1) second to thirty (30) seconds after detector actuation. The amount of delay can be selected

and shall be adjustable in not more than one (1) second increments. Each new detection shall restart the timing of delay.

2. In extension timing, detector output to the controller is continued for a maximum period of about seven (7) seconds after vehicle passage. This allows the vehicle passage-time to be shortened, which increases the efficiency of the signal. The extension timing shall be adjustable in increments or not more than one-fourth (¼) second.

3. Green Gating. The delay and extension timing functions of detectors shall be modified by the presence or absence of Green signal outputs from the controller as follows:

- When the Green signal is being shown to a phase, the detector amplifier delay timing shall not operate on that phase.

- When the Green signal is not being shown to a phase, the detector amplifier extension timing shall not operate on that phase.

A permanent demand shall be registered by the detector as if a vehicle were present over the loop when:

1. **A loop or loop lead-in becomes an open circuit, or**
2. **The power supply to the detector amplifier fails.**

Each detector amplifier shall be separately fused. They shall have front controls or switches to select the detector sensitivity, to adjust frequency and inductance and operational mode such as pulse or presence operation. There shall be a lamp or other device on the front of the detector to indicate the operation of the output device. Detector amplifiers shall be capable of proper operation under the same conditions of temperature and humidity as are specified for signal controllers. Detector amplifiers which are separate units shall be furnished with suitable cable to connect them to the cabinet terminal block.

7.20.8.2 Pedestrian Detectors. A pedestrian detector shall be a manually-operable normally-open switch (push button). These detectors shall be capable of being operated by any pedestrian.

Pedestrian detectors shall be designed for fastening to a metal or wood pole or post. Any hardware necessary for the purpose shall be furnished.

The pedestrian push button unit shall be a cast aluminum or galvanized sheet level fabricated box fitted with a glass or acrylic display mounted adjacent to the pedestrian access. Provision shall be made to illuminate internally that part of the display marked with the legend "WAIT" (in Arabic and English) white on a blue background, the lamp shall be sixty (60) watt E27 cap in accordance with IEC 64 or BS 161.

Push buttons shall be plastic, with plungers and mountings designed to minimize the effect of jamming. Enclosures shall be dust protected and weatherproof conforming to IP 54 of IEC 529. The push button circuits shall operate at voltages less than AC sixty (60) volts.

7.20.9 VEHICLE TRAFFIC SIGNAL HEADS.

7.20.9.1. Optical Unit Lenses.

7.20.9.1.1 General. Vehicle traffic signal lenses shall be made either from glass or a plastic stabilized to ultra-violet light. They type, quality, and processing of the material shall be the best for the purpose. Lenses shall remain in satisfactory condition after prolonged exposure to weather, including blowing sand. Plastic lenses shall not be deformed by the head from the lamp, nor shall their chromaticity or transmittance change materially due to heat or aging.

Lenses shall be uniformly colored throughout the body of the material. They shall be true to required dimensions and form. They shall be free from streaks, wrinkles, chips, or bubbles which in any way detract from their efficiency or use. Each lens, when used in a standard traffic signal with approved lamp and proper reflector, shall produce the appearance, light distribution, brightness, and chromatic characteristics required by this specification. The chromaticity of each color of vehicular traffic signal lens shall be between the following boundaries as defined by the Commission Internationale d'Enclairage (C.I.E.) 1931 (ASTM E 308).

The minimum relative luminous transmittance of traffic signal lenses with illuminate between two thousand eight hundred fifty degrees K (2,850° K) and three thousand degrees K (3,000° K) shall be:

1. Red - ten percent (10%)
2. Yellow - forty-four percent (44%)
3. Green - nineteen percent (19%).

The manufacturer shall furnish certification from the supplier satisfactory to the Ministry, stating that the lenses meet the requirements of these General Specifications.

The following information shall be pressed on the flange of each lens:

1. The word "TOP" at the proper point to indicate the correct orientation of the lens in the head.

2. The manufacturer's trademark.

3. On plastic lenses, the maximum wattage of the lamp which may be used in an optical unit with that lens.

4. On a three hundred (300) millimeter lens, a word or symbol to show whether it is narrow or wide beam, if applicable.

There shall be two (2) nominal lens sizes--two hundred (200) millimeter and three hundred (300) millimeter. All lenses of each size shall fit readily but closely into position with its gasket so as to make a water and dust-proof joint.

7.20.9.1.2 Arrow Lenses.

1. Arrow lenses shall be round and shall be three hundred (300) millimeter in nominal dimensions.

2. Arrow lenses may use prismatic diffusion or the equal thereof for diffusion of the transmitted light.

3. Arrow lenses shall be red, green, or yellow as specified. The chromaticity and minimum relative luminous transmittance of the translucent part of the lens shall be the same as for other lenses of the same color.

4. All of the lens, except for the arrow, shall be covered by an opaque dull black or dark grey enamel. Alternatively, the lens may be a composite of glass, colored plastic and filter, with the symbol on an internal surface. The material forming the symbol shall be of sufficient opacity to totally hide the light from the largest lamp used behind the lens. The covering material shall not separate from the lens due to heat from the lamp, weathering or washing during signal maintenance.

5. The shape of the arrow shall be in accordance with the MUTCD.

6. The lighted arrow indication shall appear to be uniformly illuminated over that portion of the signal which is not opaque.

7.20.9.2 Optical Unit Reflectors. Reflectors may be either silvered glass or specular-finished anodized aluminum. They shall be so shaped that, with the lamp in the correct position, its light will be directed by the reflector and lens to provide the light distribution required by these General Specifications.

Reflectors shall be mounted in such a manner that they are held firmly in the proper optical relation to the lens and socket when the optical unit door is closed. The mounting shall allow easy access without tools to the reflector and the back of the lens for cleaning and replacement of the lamp. The reflector shall have provision for a lamp receptacle. There shall be a gasket between the reflector and the lamp receptacle to exclude dust.

Glass reflectors shall have the following characteristics:

1. They shall be made from the best quality clear glass.

2. They shall have a uniform coating of metallic silver deposited over the entire back surface of the glass. No other substance shall be allowed between the silver and the glass. The silver shall adhere tightly to the glass.

3. A coat of metallic copper at least thirteen one-thousands (0.013) millimeters in thickness shall be applied over the silver. The copper coating shall extend over the edge of the reflector one-fourth (¼) of the thickness of the glass.

4. One (1) or more coats of enamel, conforming to Paint No. 9 in Section 9.13, "Painting of Structures" in these General Specifications shall be placed over the copper backing to prevent entrance of injurious gasses or moisture.

Aluminum reflectors:

1. The metal of the reflector shall be spun or drawn from aluminum not less than six-tenths (0.6) millimeters in thickness with a strengthening bead or flange.

2. The specular anodized aluminum reflecting coating shall be not less than twenty-five ten thousandths (0.0025) millimeters in thickness. The reflecting surface shall be totally free from flaws, scratches, defacement, or distortion.

The minimum values of luminance for Green Arrows and for pedestrian indications shall not be less than shown in Table 7.20-3.

Unless otherwise specified, there shall be a means of reducing the light output at night from lenses having a diameter of three hundred (300) millimeters, except for arrow lenses. The light output shall decrease proportionally as the ambient light level decreases. The output shall decrease to not less than thirty percent (30%) nor more than fifty percent (50%) of the light output at full rated voltage.

Table 7.20-1
Minimum Values of Luminance from Red and Green Lenses (Candelas)
Ordinary Highways

Vertical	On Geometric Axis	Horizontal 11^{G} on Either Side of Geometric Axis	28^{G} on Either Side of Geometric Axis
On geometric axis	400	150	25
1.1^{G} below geometric axis	475	200	30
11^{G} below geometric axis	200	100	25

7.20.9.3 Distribution of Light from Vehicle Traffic Signal Optical Units. When viewed from normal angles, the lighted signal lens shall appear to be reasonably uniformly illuminated over its entire surface. The ratio of maximum to minimum luminance shall not exceed five (5) to one (1). Each optical unit shall be so designed such that each lens will be illuminated independently. The unit shall be assembled so that no light can escape from one unit to another. Optical units shall be designed to minimize the appearance that the lamp is illuminated when the light rays from the sun enter the lens at low angles.

The distribution of light from red and green signal units shall be not less than that given in Tables 7.20-1 and 7.20-2 under the following conditions:

1. A standard lamp used at proper voltage.

2. Transmittance as set forth in Subparagraph 7.20.9.1 "Optical Unit Lenses" in these General Specifiifications.

3. Visor removed.

The light distribution for yellow signal units shall not be less than two (2) times the values in Table 7.20-2.

Table 7.20-2
Minimum Values of Luminance from Red and Green Lenses (Candelas)
High-Speed Highways

Vertical	On Geometric Axis	Horizontal 11^G on Either Side of Geometric Axis	28^G on Either Side of Geometric Axis
On geometric axis	800	380	50
11^G below geometric axis	475	200	40

Table 7.20-3
Minimum Values of Luminance for Green Arrows and for Pedestrian Signals (Candelas Per Square Meter)

Vertical	On Geometric Axis	Horizontal 11^G on Either Side of Geometric Axis	33^G on Either Side of Geometric Axis
On geometric axis	3500	2200	700
11^G below geometric axis	2500	1350	600
17^G below geometric axis	1500	1000	400

7.20.9.4 **Traffic Signal Lamps.** Traffic signal lamps shall be a standard design for use in traffic signal optical units. Lamps shall be designed for an average burning time of not less than six thousand (6,000) hours. The nominal operating voltage, rated watts, size, light center length, and base type shall be as required by the design of the optical unit.

The nominal operating color temperature of the lamps shall be between two thousand eight hundred fifty degrees K (2850° K) and two thousand eight hundred fifty-four degrees K (2854° K). Lamps may be either the tungsten or tungsten-halogen type. Lamps with a nominal minimum light output of six hundred (600) lumens shall be used with two hundred (200) millimeter lenses for ordinary conditions. Lamps with a nominal minimum light output of one thousand seven hundred fifty (1,750) lumens shall be used with larger lenses except polycarbonate arrow, special visibility limiting, and pedestrian lenses for which the lamp size recommended by the manufacturer shall be used. Transformers for the halogen lamps shall be furnished and shall be placed in each signal section.

7.20.9.5 Lamp Holders. Lamp holders shall be suitable for use in the type of optical unit furnished. The length of the lamp holder shall be such that the light center length of the lamp to be used in that optical unit is placed at the proper distance from the reflector as specified by the manufacturer. The metal socket of the lamp holder shall be compatible with brass or copper. The insulating parts of the lamp holder shall be strong and resilient and shall not burn nor soften when heated to a temperature of two hundred fifty degrees Celsius (250° C.). The lamp holder shall be designed to ensure that the lamp does not become loose and displaced due to vibration.

If tungsten lamps are furnished, the design of either the lamp holder or the reflector holder shall allow the rotation on the lamp holder so that the lead wires in the lamp may be properly oriented. It shall be possible to easily rotate the holder without changing the relative positions of the holder and the optical light center length of the reflector. After rotation, the holder shall be securely clamped in proper position without the use of tools.

Each lamp holder shall have two (2) lead wires, one of which shall be color-coded red, yellow, or green to correspond to the color of the lens which it is to be used. The other lead shall be white. Other appropriate colors shall be used for pedestrian indications, and for arrow indications. Each lead wire shall have a cross sectional area of at least two (2) square millimeters (14 AWG) and shall have at least six hundred (600) volt, one hundred five degrees Celsius (105°C.) thermoplastic insulation. Leads shall be long enough to reach from the lamp holder to the terminal block in the signal head with the door fully open.

7.20.10 VEHICLE TRAFFIC SIGNAL HEAD ASSEMBLIES.

7.20.10.1 General. Each vehicle traffic signal head shall consist of an assembly of one (1) or more signal faces. Signal head units shall be joined by bolts or similar devices capable of developing the full strength of the signal head and making a waterproof joint. Each signal face shall consist of an assembly of a sufficient number of signal sections to provide the required indications. Signal heads when assembled, generally in a group of three aspect units mounted vertically with red at the top, amber (yellow), and green at the bottom shall be capable of individual adjustment in respect to each other and the assembly shall be dust protected and splashproof with an enclosure conforming to IP 54 of IEC 529. Housings, doors, visors, and backplates for signal heads shall be made from suitable flame-resistant polycarbonate structural plastic which is ultra-violet light and heat stabilized. The visors, housings, doors, and backplates shall be matte black.

Each signal face consisting of three (3) sections, either all with two hundred (200) millimeter or all with three hundred (300) millimeter lenses, as specified, and with a standard backplate, shall perform satisfactorily under the following test:

1. The face shall be rigidly supported solely from the top or bottom section.

2. The laboratory equivalent of a sustained wind load of one hundred twenty (120) kilograms per square meter shall be applied perpendicularly to the face and backplate.

3. The face and backplate shall withstand the above loading without damage or permanent deformation sufficient to adversely affect their performance.

4. Upon request of the Ministry, the Contractor shall submit the results of the test performed by a laboratory approved by the Ministry, showing that the signal face and backplate conform to this requirement.

Signal heads assemblies shall be available in the various configurations allowing filter left or right aspects and alternative traffic symbols as required for specific intersections. Masks for inclusion in specific aspects with the specified symbol shall be available if required by the intersection design. Each configuration shall be a complete unit and fitted with the appropriate polypropylene backing sheet to complete the assembly. Signal aspect optical units shall be fitted with a pre-focus tungsten halogen signal lamp mounted within an aluminum reflector and fitted with a wide-angled self-colored acrylic lens. Each aspect shall be fitted with a visor and an anti-phantom light insert to prevent false signals from incident sunlight.

7.20.10.2 Signal Sections. Each signal section shall consist of a housing, door, visor, and optical assembly. Joints between housing, door, lens, reflectors, and lamp holder shall be adequately gasketed. Gasketing of outside joints shall be weatherproof, and gasketing of joints inside the housing shall be dustproof. The devices to secure the joints shall be simple, positive, and easily operated without special tools.

Each two hundred (200) millimeter signal section shall be square or round and between two hundred fifty (250) millimeters, and two hundred and eighty (280) millimeters along each side. Each three hundred (300) millimeter signal section shall be square or round and between three hundred fifty-five (355) millimeters, and three hundred eighty-five (385) millimeters along each side.

Each signal section and its associated optical system shall be capable of operating satisfactorily with the section's axis either vertical or horizontal. The optical system or the lens or both shall be capable of being turned to place the top of the lens in the proper position. Each signal section shall have an opening at either end to fit a mounting device. Unused openings shall be closed with an appropriate gasketed plug. Openings between sections shall be of adequate size to easily accommodate necessary wiring.

The signal lamp shall be low voltage supplied from a "built-in" encapsulated transformer for each aspect. The lamps shall be fifty (50) watt for use on normal intersections but where high speed roads (speeds above eighty (80) kilometers per hour) form part of the whole of the intersection, one hundred (100) watt lamps shall be used.

Light signals for vehicles shall be directed towards the vehicles at a point approximately fifty to one hundred (50-100) meters (200-400 meters for high speed roads) from the signal face at a point one and one-half (1½)meters above and along the center line of the carriageway, where light signals are used for individual traffic lanes the signal shall be directed along the center line of that lane.

The light intensity along this axis shall be four hundred (400) Candelas (800 Candelas for high speed roads) for the Red and Green Aspects and at least twice these values for the Amber (yellow) signal.

Each aspect shall be uniform in appearance within the core of the viewing angle and without secondary maxima and the colors of the light transmitted shall comply with the limits specified in BS 1376 or approved equal standard.

Where specified, traffic light signals shall be duplicated and displayed in miniaturized format mounted at driver eye level in a position adjacent to primary signal face or "Traffic Stopped" line.

All bolts, hinge pins, and similar hardware exposed to the weather shall be stainless steel or other non-corrosive material. The attachment hardware for each signal face shall be designed so that each face without visor may be rotated four hundred (400) grads about its axis. The attachment shall allow the face to be securely locked at approximate six (6) grad intervals. Locking shall be accomplished by engaging integral serrations on the housings and the attachment hardware. Alternative means of accomplishing the same result may be accepted by the Ministry.

7.20.10.3 Visors. The length of standard visors shall be a minimum of two hundred forty (240) millimeters for nominal three hundred (300) millimeter round or rectangular lenses. The length of visors for nominal two hundred (200) millimeter lenses shall be a minimum of one hundred seventy-five (175) millimeters.

Each visor shall be attached to the door in such a way that no light from the lens is visible between the visor and the door. Visors shall be securely fastened to the door so that they will not be detached by the wind loading specified in Paragraph 7.20.10.1 "General" in these General Specifications. Visors shall be made from the same material as the signal heads unless prior written approval for another material is given by the Ministry.

The lens opening in doors shall provide a visible lens diameter in Table 7.20-4.

TABLE 7.20-4

NOMINAL LENS SIZE	LENS OPENING	
	Minimum	Maximum
200 mm	195 mm	210 mm
300 mm	290 mm	300 mm

7.20.10.4 Mounting and Miscellaneous Assemblies. Signal head assemblies shall be mounted on straight or cantilever masts by brackets supporting both top and bottom of the signal head assembly. One (1) or a combination of the mounting methods may be used at any given intersection as indicated on the Drawings.

Signal head assemblies shall be attached by means of stainless steel clamps and mounting brackets which shall incorporate a wiring duct for the signal head wiring. The attachment shall allow vertical and angular adjustment of the signal head assembly and shall be suitable for the signal head presentation.

Gasketing shall be made from neoprene, silicone rubber, or an equivalent material. Gasketing material shall be resistant to heat, permanent deformation, and weather. The gasketing shall be compatible with the materials of the door, housing, and lens. The door, housing, or other parts to which the gasket is attached shall be designed to hold it in the correct position whether the joint is open or closed.

Unless otherwise specified, a backboard shall be provided with each signal face, or pair of signal faces which are mounted essentially back-to-back on the same support. Backboards shall extend not less than two hundred (200) millimeters beyond each edge of the signal face.

Mounting Assemblies. All mounting brackets and fittings which attach signal heads to their supports shall be water-tight when assembled. Brackets and other mounting hardware shall be of sufficient strength to safely support the weight of all signal heads which they carry. This shall include stress resulting from the horizontal wind loading described in Paragraph 7.20.10.1 "General" in these General Specifications. Brackets, slip-fitters, and other attachment devices shall provide a wireway free from sharp edges and protrusions which might damage the wiring insulation. The wireway shall be of sufficient size to accommodate at least ten (10) wires of the type used to energize the signal indications. Mast arm slip-fitters shall provide a means of adjusting the signal face to the proper vertical alignment.

7.20.11 PEDESTRIAN SIGNAL HEADS.

7.20.11.1 Physical Characteristics. Pedestrian signal lenses shall be of the two (2) aspect type and shall be rectangular with three hundred (300) millimeter sides. When not illuminated, the symbols shall not be readily distinguishable by pedestrians at the far end of the crosswalk. The luminance of the signal head along the directed axis shall be thirty-five hundred (3500) candelas per square meter.

Backplates are not needed on pedestrian signals unless specifically required by the contract. The physical characteristics of the housing, doors, lamp holders, visor, support brackets, gaskets, reflectors, lamps, and wiring shall comply with the requirements of this specification for the same device or material in vehicle signal head components.

7.20.11.2 Optical Characteristics. The chromaticity of each color of pedestrian signal lens shall be between the following coordinates as defined by the Commission Internationale d'Enclairage (C.I.E.) 1931 (ASTM E 308). The minimum luminous transmittance of the red color shall be three hundred thousandths (0.300), and of the green shall be two hundred ninety thousandths (0.290).

The lighted indication shall appear to be uniformly illuminated over that portion of the surface which is not opaque. When viewed from the usual angles encountered in service, the lens shall not show any shadows or bright spots which reduce the legibility of the message.

A complete pedestrian signal face shall consist of two (2) signal sections. The upper section shall have the red "standing man" symbol. The bottom section shall have the green "walking man" symbol.

Pedestrian indications shall be sufficiently bright and legible to be effective under all normal atmospheric conditions. They shall attract the attention of and be understandable by pedestrians (both day and night) at all distances from three (3) meters to the full width of the roadway which the pedestrian must cross.

7.20.12 TRAFFIC SIGNAL HEAD SUPPORTS.

7.20.12.1 General. Traffic signal pedestals, poles, and bridges shall be placed on concrete foundations as shown on the plans. Each such foundation shall have a cable duct not less than ten (10) centimeters inside diameter extending from eight (8) centimeters above the top of the foundation to a point on the side of the foundation at least sixty (60) centimeters below ground level. The conduit shall exit the top of the foundation between the anchor bolts.

The combined strength of pedestal or pole and base shall be as shown on the plans. Each pedestal or pole shall have an access opening with a cover plate. The opening shall be not less than two hundred (200) millimeters by fifty (50) millimeters. If in a pedestal or pole, it shall be not less than fifty (50) centimeters above ground level. The cover plate shall extend not less than ten (10) millimeters beyond the opening on all sides and shall be attached with stainless steel screws. A grounding lug, complete with stainless steel hardware, shall be provided inside the pole or base opposite the access door.

When required by the contract, pile foundations for poles shall be constructed in accordance with Section 5.06, "Piling" in these General Specifications.

Signal Bridges. Signal bridges, when required, shall be designed and fabricated to conform to the plans unless an equivalent design is approved by the Engineer.

7.20.12.2 Pedestals and Bases (for roadside signals). Standard pedestals to support traffic signal heads at the side of the street or on a median traffic island shall be galvanized steel or aluminum and shall have a minimum outside diameter of eleven (11) centimeters.

Bases for signal pedestals may be octagonal or round. If specified or required by the design, they shall each have an access opening at least one hundred fifty (150) millimeters square with a cover which is securely fastened with two (2) or more bolts.

The pedestal may be screwed into the base, or it may be fastened with epoxy into a socket in the base. The screw shall be in a readily-accessible location within the base. The base shall be fastened to the concrete footing with four (4) anchor bolts as shown on the plans. Ferrous pedestals, bases, and hardware shall be galvanized.

An assembly consisting of a three (3) section, single-face vehicle signal or a two (2) section pedestrian signal may be supported on the top of a signal pedestal using a suitable slip-fitter. When more or large signal heads are to be supported on a pedestal, they shall be attached to the side of the pedestal with suitable brackets and clamps. The pedestal shall extend beyond the upper signal head support. All bolts, nuts, and washers used with mounting hardware shall be stainless steel.

The top of a signal pedestal shall be covered by an acceptable polyethylene or metal cap or plug. Signal pedestals and bases shall be covered with at least three (3) coats of deep-yellow enamel conforming to Paint No. 9 in Section 5.13, "Painting of Structures" in these Generalthe roadway). The length and design of each traffic signal pole, base, and mast arm shall be in accordance with the plans and specifications. The cantilever section shall be not less than one hundred sixty-eight (168) millimeters diameter dependent upon the length of the outreach and as indicated on the Drawings. Masts shall be designed and constructed to provide adequate support and stability for the signal head and shall be suitable to support more than one (1) assembly. The masts specified are of tapered construction for aesthetic reasons for both the vertical and cantilever sections. The masts shall be complete with weather-proof cap and bolt down baseplate.

Galvanized steel, aluminum, or prestressed concrete poles shall be furnished as specified. The base shall be welded to the pole. Poles and mast arms shall provide for a wiring entrance from the pole to the arm, with a protective grommet for the wire at

the joint. Mast arms shall also provide for wiring entrances directly from the mast arm to the signal head or heads. There shall be no exposed wiring.

Masts shall be constructed from seamless steel, conical shape with a wall thickness not less than four and one-half (4½)millimeters and a tensile strength of five hundred ten (510) MN per square meter. Masts and mast components shall be hot dipped galvanized finish conforming to BS 729:1971 and the minimum thickness of zinc coating shall be four hundred fifty (450) grams per square meter on the inside and outside surface. No machining operation shall be allowed after completion of the galvanizing process. Masts shall be painted with two (2) coats of epoxy resin paint to an approved color finish after completion of the galvanizing process. Anchor bolts for signal poles shall be galvanized steel.

7.20.13 CABLE.

7.20.13.1 Signal Cable. Underground cables for signals shall have six-hundred (600) volt copper conductor having a cross-sectional area at least two (2) millimeters (14AWG). The conductors shall be stranded.

Underground cables shall have heat-resistant, long-life, cross-linked polyethylene insulation around each conductor. The cables shall have a tough, abrasion-resistant insulating sheath and a jacket of either neoprene or polyethylene over all conductors. The thickness of the insulation around the conductor at any point shall not be less than six-tenths (0.6) millimeter. The thickness of the sheath or jacket of the cable at any point shall not be less than shown in Table 7.20-5.

TABLE 7.20-5

DIAMETER OF CABLE UNDER JACKET (MM)	JACKET THICKNESS (MM)
10 or less	0.1
10 to 18	0.15
18 to 40	0.20

The Contractor shall verify the number of conductors required in all cable runs. Conductors shall be installed in continuous lengths without splices between terminals. Splicing is not permitted. Each connection of an electrical conductor to another conductor shall be made with the highest quality of the type of connector and insulation required by this specification. During the installation of each cable, a minimum of one (1) meter of cable shall be left in each handhole for connections.

Waterproof identification markings (colors) in the insulation shall be used for tracing and identifying wires. The green (tracer) conductor in the cable shall be used for green signal indications, the yellow (tracer) conductor for yellow indications, and the red

(tracer) conductor for red signal indications. Each conductor in the cable shall have a different tracer color or color combination.

Single core cables for use in controllers or signal masts, aspects or pedestrian or manual controllers shall be 450/750 volt flexible PVC insulated copper in accordance with BS 6004:1984 or approved equal standard with HT PVC insulation where operating in high ambient temperature conditions. The conductor size shall be in accordance with the circuit requirement. Cables shall be bunched, clipped and properly secured to form a complete wiring loop.

Multi-core cables to signal masts and equipment shall be stranded copper PVC insulated and sheathed 600/1000 volt to BS 6346:1977 or approved equal standard. Where multi-core cables are installed directly in the ground, they shall be single wire armored and sheathed overall.

Wires that extend from the cable in the signal base to the terminal strips in the signal heads shall be of the same gauge and tracer colors as the conductors in the cable. The white neutral conductor from each signal head terminal block shall be (30) centimeters longer than the other conductors.

A separate minimum five (5) square millimeters (10 AWG) single conductor white (tracer) current-carrying neutral conductor shall be connected to all other current-carrying neutral conductors in each base, handhole, and manhole. It shall be insulated from ground (earth) and other conductors. These white wires shall be connected to the current-carrying neutral terminal strip in the control cabinet. This terminal strip shall be isolated from the cabinet and from the equipment ground. The terminal strip shall be connected to the ground rod or rods through the neutral ground lug in the cabinet.

The minimum two (2) square millimeter (14 AWG) white insulated conductor in each cable shall be stripped bare for its entire length outside of the cable sheath. This is termed the equipment ground. It shall be attached for a short base, minimum two (2) square millimeters (14 AWG) wire from the grounding connector in each signal base with an approved electrical connector. The equipment ground shall terminate at the equipment grounding strip in the controller cabinet. The equipment grounding strip shall be isolated from the cabinet and the current-carrying neutral wire. The equipment ground strip shall terminate at the current-carrying neutral grounding lug in the control cabinet.

All cable grounding shields and any spare or unused conductors shall be effectively grounded in the control cabinet by connection to the equipment grounding terminal strip. They shall be grounded only in the control cabinet.

The Contractor shall verify that the maximum current load on any two (2) square millimeter (14 AWG) conductor to signal indications shall not exceed six and one-fourth (6¼)amperes. He also verify that the maximum current in a current-carrying neutral from signal indications does not exceed twelve and one-half (12½) amperes.

The current carrying neutral ground lug in the control cabinet shall be connected to two (2) copper-clad ground rods driven full length not less than two (2) meters apart. The ground (earthing) rods shall be at least fifteen (15) millimeters in diameter and two and one-half (2½)meters in length. The ground lug shall be connected to the ground rods with a single continuous length of bare stranded copper wire at least thirteen (13) square millimeters (6 AWG) in area.

7.20.13.2 Detector Lead-In Cable. Detector lead-in cable shall be shielded, and shall have two (2) minimum two (2) square millimeter (14 AWG) conductors with cross-linked polyethylene insulation. The cable shall have a drain wire.

The lead from the detector loops shall be spliced to the lead-in cable wire in the nearest appropriate splice box. All such splices shall be soldered and fully insulated from one another and from atmospheric conditions. Weather proofing can be accomplished with an epoxy splice kit, shrink fit plastic splice or by placing the soldered end of the splice in a paper cup and filling the cup with loop sealant to a level at least twenty-five (25) millimeters above the bare wire. The lead wire from the splice-box to the controller cabinet shall not exceed six hundred (600) meters. Each loop or adjoining loop pair, unless otherwise indicated on the plans, shall have a separate lead-in cable to the control cabinet. From the splice box to the control cabinet the lead-in cable shall be installed in the trench or duct with other cables.

Adjoining paired loops may be wired either in series or in parallel when being connected to the lead-in cable in the splice box. The Contractor shall measure the combined loop and lead-in inductance at the control cabinet end of each lead-in cable. The inductance of the loop detector circuit shall be determined by the equation:

$$L = \frac{17.6\ PN^2 + 75\ l}{11 + N}$$

Where L = inductance in microhenries
P = loop perimeter in meters
N = number of turns of wire in the loop
l = hundreds of meters of loop lead wire.

The calculated inductance of the loop and lead wire shall be between 50uh and 500 uh.

When wired in series the system inductance shall be determined as:

$$L_s = L_1 + L_2 + \text{--} + L_N$$

Where L_s = System Inductance
L_1, L_2 & L_N = Inductance of Loops 1, 2 through N

When wired in parallel the system inductance shall be determined as:

Where L_s = System Inductance in uh

L_1, L_2 thru L_N = Inductance in uh of loop 1,2, through N that are in the center.

When both series and parallel corrections are made in one loop detector system, each group of loop inductance or equivalent loop inductance shall be combined in accordance with the equations above. The resulting system inductance measured at the controller cabinet shall be between fifty (50) and five hundred (500) microhenries. The ratio of loop inductance to system induction shall be a minimum value of twenty-five hundredths (0.25).

Following completion of the detector/lead wire connection at the splice-box, the inductance of the loop/lead wire system shall be measured. The resulting value must 1be between fifty (50) uh and five hundred (500) uh. Should the measured value fall outside this range, the Contractor shall repair or replace the loop at no additional cost until the measured inductance is within the specified range.

7.20.13.3 Interconnecting Cable. When called for by the plans, interconnecting cable having the required number of conductors shall be installed. Shielded multiconductor cable with conductors shall be not less than two (2) square millimeters (14 AWG) in area, and have a cross-linked polyethylene insulation shall be used. The cable sheath shall also be polyethylene.

7.20.14 DUCT. Duct shall be assembled from sections of plastic pipe. It shall have a nominal diameter of seventy-five (75) millimeters. It shall be suitable for direct burial in the ground. The joints between sections shall be water-tight. If the duct is designed so that a tapered end of one duct is fitted into the end of the succeeding duct, the overlap of the joint shall be at least six (6) centimeters. The installed wire shall not fill more than one-half (½) the area of the conduit. When this limit is reached, an additional conduit or a larger conduit shall be used.

Ducts shall not be installed by cutting across the finished road surface. Where this operation is required ducts shall be installed by approved "thrust boring" techniques.

Ducts shall be made of high-impact, acid and alkali resistant (uPVC) type, and shall be of the specified class, diameter, wall thickness, all as detailed in the Standards and on the Drawings. They shall be of the non-sparking type and suitable for direct burial in the ground. The minimum tensile strength shall be four hundred (400) MN per square meter and impact strength shall be four hundred (400) MN square meter and impact strength shall be forty (40) MN per square meter. Each section of the duct shall have one end tapered. The joined part shall be equal or longer than eighty (80) millimeters in length. The junction shall be waterproof and sandproof.

Trenching and backfilling for duct and underground cable shall be to not less than the depth shown on the plans. No duct or cable shall be placed in a trench prior to inspection of the trench by the Engineer. The Contractor shall remove, store, and relay sod, and shall furnish and place topsoil and sod at locations as directed by the Engineer. Where excavation is made across parkways or driveways, the sod, topsoil, and crushed stone or gravel shall be replaced as nearly as practicable to its former condition. Concrete or bituminous surfaces and stabilized bases shall be restored to their former condition. The entire area involved shall be left in a neat presentable condition. Duct trenching shall be performed to a depth not less than fifty (50) centimeters below the ground line or top of subgrade and shall slope to drain at a rate not less than one-half percent (½%).

Ducts shall not be placed under the paved travel surface except in extreme cases. Excavation and backfill shall be performed in accordance with Section 2.10 "Trench Excavation and Backfill" in these General Specifications. All trenches shall be backfilled as soon as practicable after the installation of conduit, cable, or cable-conduit. Cinders, broken concrete, and other hard or objectionable materials which might cause mechanical damage to duct or cable shall not be used for backfilling to an elevation thirty (30) centimeters above the top of duct or cable. Backfill material shall be deposited in layers not exceeding fifteen (15) centimeters deep, and each layer shall be compacted to Type 95 compaction. If the trench is to be located under a shoulder which is to be stabilized, the trenching, installation of duct or cable, and backfilling the trench shall be completed before the shoulder stabilization construction is started. Unless the poles are in place, a coil of cable of sufficient length to reach the proposed handhole shall be buried near each pole location. The coil shall be covered with planks, a box, or other approved means so that it will not be damaged.

A minimum three (3) square millimeter (12 AWG) galvanized steel wire shall be left inside of any empty duct, or elsewhere as called for by the plans, for future pulling of cables. At least (1) meter of such wire shall extend beyond the end of the duct at each end, and shall be fastened securely to a wooden block or other object which cannot be drawn into the duct. A rigid object nearly the diameter of the duct shall be drawn through each such empty duct to ensure that it is clear of obstruction, after which both ends shall be plugged to prevent entry of dirt.

Duct shall extend approximately twenty-five (25) centimeters beyond paved areas at either end. Bends in duct shall have a minimum radius of thirty (30) centimeters for a duct having an inside diameter of five (5) centimeters and a proportionately greater radius for larger conduits.

7.20.15 INFORMATION AND DOCUMENTS TO BE SUPPLIED PRIOR TO ISSUE OF HANDING-OVER CERTIFICATE. The Contractor shall arrange to supply in triplicate and in the ENGLISH language the following information and documents and unless these are handed over, a taking-over certificate will not be issued:

1. Manufacturers catalogues of the actual equipment installed for each and every item.

2. Instruction manuals for the installation, operation and maintenance of each and every type of equipment installed.

3. Priced parts lists clearly indicating the part number of each component used in the equipment, reference to which will enable the Manufacturer to identify readily the

exact component required. Drawings showing the exploded view of major equipment should also be provided.

4. As fitted drawings of the completed Traffic Signal installation of the particular intersection complete with exact routes of all cables, their number of cores and sizes and the location of all signals. One transparent mother print on stable plastic film from which reproductions can be made in the future shall also be provided.

5. Any other information relating to the installation and which in the opinion of the Engineer and the Ministry of Communications is required for the future maintenance of the system.

7.20.16 TESTING AND COMMISSIONING PRIOR TO HANDING-OVER. As soon as the work at any one intersection is completed, the Contractor shall notify the Engineer and the Ministry of Communications of its readiness to test and commission the system.

All testing instruments and tools like Oscillograms, meters, recorders, etc., required and indicated as necessary by the Manufacturer of the testing of the equipment shall be provided free of charge by the Contractor.

After the system has been tested successfully, the Contractor shall commission the installation in the presence of the Ministry's representative and demonstrate that the entire system operates as required by the Specification and as indicated in the accepted offer.

7.20.17 METHOD OF MEASUREMENT. Measurement will be made of the number of units of Signal Controllers, Traffic Signal Heads, Traffic Signal Head Supports, Pedestrian Traffic Signal Heads, Pedestrian Signal Head Push Buttons, and Traffic Loop Detectors furnished and accepted in accordance with the plans and specifications, and as directed or approved by the Engineer.

7.20.18 PAYMENT. The completed and accepted quantities, measured as provided above, will be paid at the contract unit price(s) for the pay items listed below that are in the Bill of Quantities. Payment will be full compensation for furnishing all materials, for all labor equipment, tools, supplies and all of the other items necessary for the proper completion of the Work as specified in Subsection 1.07.2 "Scope of Payment" in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
72001	Signal Controller, 4 Phase	Unit
72002	Signal Controller, 8 Phase	Unit
72003	Signal Controller, 16 Phase	Unit
72004	Signal Controller, 32 Phase	Unit
72005	Signal Controller, (No.) Phase	Unit
72010	Traffic Signal Head, Size 3 x 100 mm	Unit
72011	Traffic Signal Head, Size 3 x 200 mm	Unit
72012	Traffic Signal Head, Size 3 x 300 mm	Unit
72013	Traffic Signal Head, Size ___ x ___ mm	Unit
72020	Pedestrian Traffic Signal Head, Size 2 x 200	Unit
72021	Pedestrian Traffic Signal Head, Size 1 x 300	Unit
72022	Pedestrian Traffic Signal Head, Size 2 x 200, with Flashing Arrows	Unit
72023	Pedestrian Traffic Signal Head, Size 1 x 200, with Flashing Arrows	Unit
72024	Pedestrian Traffic Signal Push Button	Unit
72025	Traffic Signal Support, Cantilever	Unit
72026	Traffic Signal Support, Pedestal	Unit
72027	Traffic Signal Support Short Bracket	Unit
72028	Traffic Loop Detectors	Unit

KINGDOM OF SAUDI ARABIA
MINISTRY OF COMMUNICATIONS

GENERAL SPECIFICATIONS
FOR
ROAD AND BRIDGE CONSTRUCTION

November 1998

PART EIGHT

LANDSCAPING AND IRRIGATION

PART EIGHT: LANDSCAPING AND IRRIGATION

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SECTION 8.01 LANDSCAPING

8.01.1 SCOPE AND REQUIREMENTS

8.01.1.1 Description. The works shall consist of furnishing and planting palms, trees, shrubs, creepers, succulents, grass, sod, ground cover and other plants. It shall also include excavation for planted areas and provision of agricultural soil, preparing and finishing planting bed. The work shall also include maintenance and other incidental planting procedure work, all as necessary to complete the planting operations in a workmanlike manner, according to the provisions of this Specification and in conformity with the lines shown on the Drawings or established by the Engineer.

ITEMS IN BILL OF QUANTITIES
Trees
Palms
Shrubs
Creepers
Ground Cover
Succulents
Climbing Plant
Grass
Hydroseeding Mixes
Gravel Mulch
Precast Concrete Tiling
Sod

8.01.1.2 Submittals. The Contractor shall submit to the Engineer information and certificates for materials to be used for this Contract. Such submittals shall include, but not be limited to, the following:

1. Manufacturer's certified analysis of all standard products, including fertilizers.

2. Certificates confirming the origin, size and age of all plant materials.

3. Health certificates for all imported plant material.

4. A laboratory analysis of agricultural soil mix, having the characteristics indicated in Paragraph 8.01.2.1 "Agricultural Soil" in these General Specifications with additives such as pH adjusters, fertilizers and other soil amendments.

5. Landscape construction schedules indicating mobilization, equipment, personnel, preparatory work and planting schedules.

The Contractor shall be responsible for the quality of all items purchased and shall submit a Supplier Quality inspection plan for review. The inspection plan shall cover those items intended for shop inspection and the procedures for carrying out the same.

8.01.1.3 Rubbish. All rubbish and litter as it accumulates within the landscape boundary, shall be cleared and carted away daily. The areas shall be kept in a clean and tidy condition with all driveways, paths, edges, curbs, gutters, and gullies swept and kept clear of debris at all times. All rubbish and debris shall be carted away to a dump as directed by the Engineer.

8.01.1.4 Oil and Petrol Storage. All oil and petrol containers are to be kept in suitable sheds provided by the Contractor, who is to observe all regulations regarding the storage of inflammable liquid. If any areas of soil are affected by oil or petrol spillage, the contaminated soil is to be dug up until uncontaminated ground is reached, and carted away and such areas made good as directed by the Engineer, all at the Contractor's expense.

8.01.1.5 Approved Chemicals. Only chemicals approved by the Ministry of Agriculture in the Kingdom of Saudi Arabia will be used. All chemicals shall be non-toxic to human beings, birds and animals and subject to the approval of the Engineer.

The Contractor shall be liable for ensuring that all chemicals are stored, handled and supplied strictly in accordance with the manufacturer's instructions.

8.01.1.6 Season. All work shall be carried out during the appropriate season and in weather conditions suitable for the operation. In particular, planting shall not be carried out before October or after March without the specific approval of the Engineer.

8.01.1.7 Work by Machine or by Hand. All operations may be executed by suitable approved machines or by hand. Any work in confined spaces, around existing trees or in the vicinity of major utility services must be executed by hand and the Contractor shall include for this in his rates.

8.01.1.8 Existing Plants. No existing trees, shrubs or other plants shall be removed without instructions from the Engineer. The Contractor shall take all measures to protect all plants from malicious or accidental damage during the execution of his work. He shall ensure that no branches are lopped and no tree roots exceeding fifty (50) millimeters in diameter are severed from growing trees except for pruning and training operations approved by the Engineer.

No soil, spoil, construction material or rubbish shall be stored, or deposited within three (3) meters of existing trees, shrubs or hedges. No bonfires shall be lit within the landscape contract boundaries.

Any damage that may be incurred shall be made good by the Contractor at his own expense.

8.01.1.9 Storage. All materials to be used in the landscape contract and stored at the Contractor's yard shall be kept covered and protected. In particular any plants held for planting shall be kept in a special compound, sheltered from the direct sun and drying winds and watered regularly.

8.01.2 SOFT LANDSCAPE: MATERIALS

8.01.2.1 Agricultural Soil.

8.01.2.1.1 Composition.

Agricultural soil shall be approved imported agricultural soil obtained from local sources and defined as follows:

PH:	6.0 - 8.0 saturated soil
Electro-Conductivity: (EC x 10^3)	Less than 4 mmhos/cm saturation extract at twenty-five degrees Celsius (25° C.)
Free Carbonates:	Less than 0.5 percent air-dried soil
Chlorides:	Less than 200 ppm in saturation extract
Sulphates:	Less than 200 ppm in saturation extract
Nitrates	Less than 75 ppm in saturation extract.
Phosphorus	10-25 ppm in 1.5 ammonium nitrate extract: 0.5 hour shake.
Potassium	100-400 ppm in 1.5 ammonium nitrate extract: 0.5 hour shake.
Magnesium	25-100 ppm in 1.5 ammonium nitrate extract: 0.5 hour shake.
Exchangeable Sodium:	Less than fifteen percent (15%) in neutral normal ammonium acetate
Boron:	Less than 1.5 ppm, hot water soluble
Physical Characteristics:	Sandy loam made up as follows: Sand 2 mm - 0.05 mm: 45-65% Silt 0.05 - 0.002 mm: 20-40%

Clay less than 0.002 mm: 5-15%

In case naturally occurring agricultural soil to the above physical characteristics is not available, the Contractor is allowed to mix soil constituents to achieve the above required characteristics.

8.01.2.1.2 Soil Analysis.

The Contractor shall arrange for an approved independent analyst to prepare a physical and chemical analysis of the proposed imported agricultural soil and irrigation water together with recommendations and report on fertilizer adjustments to the rates specified.

Soil samples shall be taken as follows:

Upon identification of every source of soil, representative samples of soils shall be analyzed as detailed below and results submitted to the Engineer for approval before any of the soil has been used.

Following this, further representative soil samples shall be taken at the rate of one (1) in every twenty (20) loads or as may be otherwise directed by the Engineer, analyzed and the results compared with those from the original sample (so as to ensure consistency and compatibility of supply).

The tests shall be:

- Total salts (EC of soil solution)
- Soil pH
- Exchangeable sodium, calcium, magnesium, potassium
- Available phosphates
- Organic matter as a percentage
- Available zinc, manganese, iron, boron
- Total sulphates.

8.01.2.1.3 Storage.

Agricultural soil shall be stored in heaps less than one (1) meter height. Soil heaps shall be protected from undue compaction and no construction material or waste shall be stored on or mixed in with the soil.

Approval shall be obtained of a sample load of agricultural soil of not less than five (5) cubic meters ($5m^3$). This sample shall be retained for comparison with subsequent loads.

8.01.2.1.4 Peat Humus.

Peat Humus shall be natural peat consisting of sedge, sphagnum or reed peat and of such a physical condition that it will pass through a twelve (12) millimeter screen. The humus shall be free from sticks, stones, roots or other objectionable matter. It shall have an acidity range from pH four (4) to seven and one-half (7.5) and the minimum organic content shall be eighty-five percent (85%) on a dry weight basis. Peat humus shall be delivered in undamaged commercial bales in an air-dry condition.

8.01.2.1.5 Fertilizers.

Inorganic fertilizers shall be applied to the irrigation water by the fertilizer injection equipment. Fertilizers shall be approved soluble NPK fertilizers in the ratio twenty:twenty:twenty (20:20:20) applied at a dilution rate of one (1) kilogram of fertilizer to one thousand (1000) liters of water.

Alternative dilutions

Appendix "1" attached shows the names of the most popular trees, shrubs, ground covers and succulents widely planted in the Kingdom of Saudi Arabia.

8.01.2.3.4 Range of Sizes.

No plant shall be less than minimum size, as specified herein after and at least fifty percent (50%) of the plants are to be as large as the upper half of the specified range. Measurements specified are minimum sizes acceptable after pruning (where pruning is required). Plants that meet measurements specified but do not possess normal balance between height and spread will not be acceptable.

8.01.2.3.5 Planting Stock.

All planting stock shall be well-branched and well-formed, sound, vigorous, healthy and free from disease, sunscald, abrasion and harmful insects or insect eggs and with a healthy and unbroken root system. Trees shall be symmetrically developed, their structure and habit of growth typical of the species or variety with straight stems free from objectionable disfigurements.

Plants delivered to the Work shall be either balled and burlapped or container stock. Bare rooted stock will not be permitted. Plant roots shall not be allowed to dry out during transport, storage, or transplanting, and the ball of earth surrounding the roots shall be kept wet at all times. Any plant that has a damaged root ball or is dry or in a wilted condition, as determined by the Engineer, when delivered to the Work, shall be rejected and shall be replaced by the Contractor at his own expense. Each plant shall be handled and packed in the approved manner for that species or variety, and all necessary precautions shall be taken to ensure that the plants will arrive at the Work in proper condition for successful growth. Root condition of plants furnished by the Contractor shall be determined by removing the earth from around the roots of not less than two (2) plants nor more than two percent (2%) of the total number of plants of each species or variety. If the sample plants inspected are found to be defective, the Engineer may reject the entire supply of plants represented by the sample plants. Sample plants deemed unsuitable for use in the Work due to the inspection shall be replaced by the Contractor at his own expense.

Trees shall be of a minimum height of one and one-half (1.5) meters above planting level, stem diameter shall be two (2) centimeters minimum and branches shall be at least twenty-five (25) centimeters. Where trees of the specified species are unavailable, and subject to the submission of evidence to that effect, the Contractor may, with the Engineer's approval, substitute alternative species trees of one and one-half (1.5) meters minimum height.

Palms shall be balled and burlapped unless container grown plants are available. Offshoots will not be accepted. The height of the palm shall be not less than one (1) meter from planting level to the base of the growing tip. Palms of one (1) to one and one-half (1.5) meters height shall have a root-ball diameter of seven hundred fifty (750) to nine hundred (900) for two (2) to three (3) meters height, the root-ball diameter shall

be one and one-half (1.5) to two (2) meters. Ninety percent (90%) of the palms shall be females.

Shrubs shall have a minimum height of five hundred (500) millimeters. Where shrubs of this size are not available, and subject to the submission of evidence to that effect, the Contractor may be allowed, with the approval of the Engineer, to use other substitutes of the same size. The shrubs are to be of good form, and their structure and habit of growth typical of species or variety.

Ground cover species shall be well rooted, and of not less than one (1) year's full growth and a minimum length of four hundred (400) millimeters.

Climbing plants shall have a minimum length of seven hundred fifty (750) millimeters. The growth shall be symmetrical and balanced. They should have been grown in one (1) kilogram containers and shall be of at least one (1) year's growth.

Grass seed shall comprise of the following mixture of species:

Cydomon dactylon:	**Fifty percent (50%)**
Roa annua:	**Fifty percent (50%)**

Before delivery to site, all plants shall be dipped in anti-desiccant.

8.01.2.4 Stakes

8.01.2.4.1 Stakes For Trees.

All stakes shall be of timber, straight, free of projections and pointed at one end. The lower ends shall be coated with a non-injurious wood preservative, to a minimum height of one hundred fifty (150) millimeters above ground level, to be applied at least two (2) weeks before use. Stakes shall be fifty (50) millimeters thick, the length below ground to be one thousand three hundred (1300) millimeters and the length above to be for full height of clear stem or half full height of feathered species.

Alternatively, tree stakes shall be mild steel tubes protected by a PVC coating in mid-green or similar approved color. The top and bottom of the steel tube shall be sealed with plastic caps. The external covering shall have horizontal ridges at regular intervals to facilitate the fixing of tree ties. The steel tube shall have a diameter of thirty-five (35) millimeters and a length of two thousand five hundred (2500) millimeters. Tree ties shall be patent plastic ones appropriate to the steel stake.

8.01.2.4.2 Stakes For Palms.

Stakes for palms shall be rough sawn timber, free from knots, rot, cross-grain or other defects that would impair strength. The size shall be fifty (50) by one hundred (100) by two hundred (200) millimeters minimum, depending upon palm size.

Alternatively, palm trees shall be stabilized with three (3) No. galvanized steel seven (7) strand wire ropes of ten (10) gauge, set out at one hundred twenty degrees (120°) round the stem. The wire shall be looped around the palm stem and protected by a neoprene tube. The wires shall be connected via a galvanized steel turnbuckle to an eight (8) millimeter diameter reinforcing road ground anchor. The ground anchor shall be one thousand (1000) meters long and shall be given in flush to the ground. The rods shall be at forty-five degrees (45°) to the ground surface.

8.01.2.5 Irrigation Water. Water shall be provided by the Contractor from off-site sources approved by the Engineer as being suitable for irrigation, free from substances harmful to plant life. Water sources shall not exceed the following parameters:

pH: 6.7

Total dissolved solids: less than 1000 parts per million (ppm)

The Contractor shall supply certified laboratory water quality test reports from an independent testing laboratory approved by the Engineer. These water quality test reports shall show evidence that the water to be utilized meets with the water quality criteria established above. Water quality reports shall be submitted:

- Two (2) weeks prior to the beginning of the first watering/irrigation operations

- Once per month throughout the maintenance period.

8.01.2.6 Hydroseeding Materials.

8.01.2.6.1 Soil Stabilizer. Products of the following composition are acceptable:

1. Stabilization material consisting of natural petroleum resin, wetting agents, water and sequestering agents not subject to breakdown.

The stabilization material shall be a free flowing, stable emulsion to the extent that the diluted emulsion shall not break down when stored in clean, closed containers at temperatures zero to eighty degrees Celsius (0° to 80° C.), for a minimum of three (3) months.

2. Product conforming to Table 4.01-5, Grade CSS-1 for Cationic Emulsified Asphalt in Section 4.01 "Bituminous Materials" in these General Specifications.

3. Product conforming to Table 4.01-5, Grade CMS-2 for Cationic Emulsified Asphalt in Section 4.01 "Bituminous Materials" in these General Specifications.

4. Product shall be non-toxic to plants, animals, humans and soil organisms and shall not be injurious to clothing. It shall positively immobilize sand to such an extent that it will not be disturbed by normal wind action from prevailing directions.

The material as purchased shall carry a warranty that if applied in accordance with the manufacturer's instructions it will provide effective stabilization for a period of one year after application.

Color of the chemical agents shall be as selected by the Engineer. Type of pigment shall be as recommended by the manufacturer of the chemical agent and mixed according to its instruction.

8.01.2.6.2 Super Absorbent Humectant. Super absorbent humectant shall be a hydrolyzed starch copolymer absorbent that swells into a clear gel capable of absorbing hundreds of times its weight in water.

8.01.3 SOFT LANDSCAPE: WORKMANSHIP

8.01.3.1 Soil Grading and Preparation. Subsoil shall be excavated to achieve tolerances specified for finished level of soil, and when reasonably dry and workable, graded to smooth flowing contours with all minor hollows and ridges removed. Non-cohesive, light subsoils shall be loosened with a three (3)-tine ripper, three hundred (300) millimeters deep at six hundred (600) millimeter centers; stiff clays and other cohesive subsoils shall be treated with herbicide, and the period of time recommended by the manufacturer shall be allowed to elapse before grading.

Finished ground levels shall be thirty (30) millimeters below adjoining paving or curbs after settlement except for any median strip where New Jersey Barriers are specified. Here, the finished level shall be one hundred (100) millimeters below the top of the New Jersey Barrier after settlement.

Between Concrete Crashworthy Safety Barriers (New Jersey Barriers) in the central median the areas shall be brought up to finished levels by spreading agricultural soils approximately four hundred fifty (450) millimeters deep that are reasonably dry and workable. The agricultural soil shall be graded to remove all hollows and ridges. In the outer separators and interchanges the Contractor shall excavate the planted areas to a depth of four hundred fifty (450) millimeters and backfill the excavated areas with agricultural soil.

Any rock projections and/or boulders should be removed off site to dump areas.

8.01.3.2 Drainage. The Contractor shall ensure that all planting positions are well drained.

8.01.3.3 Planting Sequence.

I. Grade soil as specified.

2. Stake out the outline of soft landscaping areas for approval by the Engineer.

3. For shrub, ground cover or creeper, excavate the planting pits to forty-five hundredths (0.45) meters depth. Excavated material shall be removed from the Site.

4. For trees, palms, shrubs, and ground covers. Dig the planting pit to the sizes specified. Excavated material shall be removed from the Site.

5. Ensure that the irrigation system is functioning properly.

6. Backfill planting pits with planting medium.

7. Preirrigate and ensure that the excess water can drain away.

8. Position the plant at the approved locations and fill around it with planting medium as specified.

9. Where specified, tie plant to stakes.

10. Check all plants one (1) week after planting for signs of wind shake and loosening due to soil subsidence. Firm and make good as necessary. Then similarly check all plants at a maximum of monthly intervals until the end of the defects liability period.

11. Remove wrapping from the buds of palm trees.

8.01.3.4 Tree Planting Medium. Planting medium for tree pits shall consist of approved agricultural soil as specified well mixed with fertilizers at the rate of two-tenths (0.2) kilograms P_20_5, two-tenths (0.2) kilograms K_2O, two-tenths (0.2) kilograms N and five (5) kilograms of fermented animal manure approved by the Engineer per cubic meter of agricultural soil.

8.01.3.5 Planting Trees. Tree pits shall be excavated to the dimensions shown on the Drawings, and the pit bottoms shall be broken up to a further depth of three hundred (300) millimeters. All trees shall be placed in the center of the pits and at the original soil depth and watered thoroughly after backfilling. All trees shall be surrounded by a water-holding depression, one hundred fifty (150) millimeters deep and six hundred (600) millimeters minimum in diameter.

Before planting, any broken or damaged roots shall be cut back to sound growth; any cut ends over twenty-five (25) millimeters in diameter shall be treated with tree wound dressing.

For bare-rooted trees, backfilling shall be placed in one hundred fifty (150) to two hundred fifty (250) millimeter layers to ensure close contact with roots and to eliminate air pockets. Firming shall take place as backfilling proceeds, so as not to damage roots; the soil shall be heeled in firmly around the root collar. For root-balled trees, backfilling shall be firmed around the root-ball in one hundred fifty (150) millimeter layers, so as not to disturb the roots.

8.01.3.6 Supporting Trees. To support a tree, a single stake shall be positioned close to the tree on the windward side and driven vertically into the pit bottom until the stake top is at its specified height.

Soil shall be consolidated around the stake during backfilling. The tree shall be secured firmly, but not rigidly, to the stake with at least two (2) ties, to prevent the tree from touching the stake. If necessary, chafing guards to be used to prevent abrasion between the tree and the stake. The top tie shall be positioned twenty-five (25) millimeters from the top of the stake and the lower tie approximately halfway down. Tree ties shall be approved proprietary ties, canvas or rubber hose.

8.01.3.7 Planting Palms. All suckers, flowering and fruiting parts and approximately thirty percent (30%) of fronds shall be removed from the palms before digging with sufficient fronds left to enclose and protect the growing bud. The remaining fronds shall be trimmed to sixty-five percent (65%) of their original length, lifted to surround the growing bud, burlap wrapped, securely tied in position. Special attention is required to protect palm roots from being bruised during digging and burlapping. Palms shall be planted according to specifications for trees above.

8.01.3.8 Supporting Palms. Palms are to be supported as shown on the detail drawing and in accordance with either method described in Subparagraph 8.01.2.4.2 "Stakes for Palms."

8.01.3.9 Shrub, Ground Cover and Creeper Planting Medium. Planting medium for shrub, ground cover and creeper shall consist of approved agricultural soil as specified well mixed with fertilizers at the rate of twenty (20) grams P_2O_5, twenty (20) grams K_2O, twenty (20) grams N and two (2) kilograms of fermented animal manure approved by the Engineer per plant.

8.01.3.10 Planting Shrubs, Ground Cover and Creepers. All weeds and rubbish shall be removed from planting areas. Before planting, all non-perishable containers shall be removed and all badly damaged roots pruned.

All shrubs shall be planted upright and well balanced with the best side to the front and at a density as specified on the Drawings. Planting medium shall be carefully packed around evenly spread roots or rootball in one hundred fifty (150) millimeter layers and well heeled in. The finished level shall be at the original soil mark on the shrubs. All shrubs irrigated by spray heads shall be surrounded by a water-holding depression one hundred fifty (150) millimeters deep by six hundred (600) millimeters minimum in diameter.

Climbers shall have their leading growths trained around the supporting wire mesh if specified.

Immediately after planting, (1.) carefully cut back any damaged, dead or diseased branches, remove weak or malformed growth and treat with tree wound dressing and (2.) water thoroughly, using a fine hose and (3.) spray with anti-desiccant (not during rainy weather).

8.01.3.11 Climber Mesh Embankments & Interchanges. Wherever required, supply and fix Polyethylene mesh to interchange embankments and outer median embankments steeper than 1V:2H. The mesh shall be green and shall be secured with Steel Pins, to the manufacturer's specifications, driven into the embankment at six hundred (600) millimeter vertical spacings and one (1.0) meter horizontal spacings. The top edge shall be secured with pins at five hundred (500) millimeter horizontal spacings. The base shall be buried in a trench four hundred fifty (450) millimeters by four hundred fifty (450) millimeters deep. The Contractor shall allow for all necessary excavation and backfilling.

8.01.3.12 Pruning. Immediately after planting, all plants are to be pruned as directed by the Engineer and in accordance with accepted horticultural practices. Pruning shall consist of carefully cutting back any damaged, dead or diseased branches; the removal of any weak or malformed growth, with the aim of forming each type of stock to the standard shape for its species. All pruning cuts greater than nineteen (19) millimeters shall be treated with an approved tree wound dressing.

8.01.3.13 Mulch. Gravel mulch shall be laid sequentially with the plant material and to a thickness of fifty (50) millimeters. Gravel mulch shall consist of washed gravel that is free from dirt, organic matter, clays, clay film or other deleterious matter. Grading shall be eighteen (18) to twenty-five (25) millimeters diameter. Gravel mulch shall be kept away from all drain inlets, pedestrian and vehicular surfaces.

Rock mulch used to stabilize the large open areas and planting beds shall be crushed stone or gravel, clean and free from sand, clay, dirt, organic matter or other deleterious matter. Grading shall be twenty-five (25) to fifty (50) millimeters diameter.

8.01.3.14 Watering. The Contractor shall ensure that sufficient water is applied to maintain healthy growth of all trees and plants. All plants shall be watered immediately after planting. If an irrigation system is required, water may be obtained from such facility. When an irrigation system is not required, the Contractor shall make his own arrangements for furnishing and applying water and shall be responsible for all costs involved.

Water shall be applied in a moderate stream until the backfill soil throughout the depth of each plant is saturated. Where watering is done with a hose, a pressure reducing device approved by the Engineer shall be used. Under no circumstances shall the full force of the water from the open end of a hose be allowed to fall within the basin around any plant.

8.01.3.15 Protection. Newly planted trees and plants shall be protected where necessary until plants are established. Any damage to planting shall be made good and the ground reinstated if disturbed, at the Contractor's expense.

8.01.3.16 Preparation and Maintenance of Grass Areas. Agricultural soils shall be placed to a minimum depth of one hundred fifty (150) millimeters to establish an acceptable seed medium. The seeding area shall be graded to line and grade and all weeds, sticks and stones more than twenty-five (25) millimeters diameter removed. Fertilizer shall be incorporated at the following rate: one hundred (100) kilograms P_20_5, one hundred (100) kilograms K_20 and fifty (50) kilograms N per hectare. The soil shall be cultivated to a minimum depth of one hundred (100) millimeters resulting in a lightly firm but friable seedbed.

The seeding area is to be thoroughly moistened before seeding and mulched with either straw or hay mulch within twenty-four (24) hours of seeding. The mulched seeded areas shall be kept moist until at least ten (10) days after seed germination.

8.01.3.17 Grass Seeding. Grass areas shall be recultivated immediately prior to planting if so required by the Engineer.

Seeding shall be carried out at the appropriate state in the Contract. The Contractor shall ensure that the seed bed is thoroughly irrigated before seeding. Seed shall be applied at the rate of one (1) kilogram per one hundred (100) square meters, spread evenly in two (2) equal sowings in transverse directions and areas lightly harrowed or raked.

8.01.3.18 Hydroseeding.

8.01.3.18.1 General. The Contractor shall furnish labor, materials, equipment and transportation to plant and stabilize by hydroseeding all the areas that are designated on the Contract Drawings and described herein to be hydroseeded. Included as part of the work in this Section but not necessarily limited by it are the following:

Soil Stabilization and Hydroseeding
Materials
Hydroseeding Installation
Maintenance Procedures
Irrigation as required.

8.01.3.18.2 Quality of Work.

The hydroseeding work shall be performed by a competent, trained individual or by use of an approved hydroseeding Subcontractor in accordance with the best standards and practices relating to the trade and under the continuous supervision of a competent foreman capable of interpreting the Contract Drawings and Specifications.

8.01.3.18.3 Inspection of Conditions.

The Contractor shall examine related work including irrigation and grading surfaces before proceeding with work and inform the Ministry in writing on conditions which will prevent the proper execution of his work. Failure to report unsuitable conditions will constitute acceptance of performing all work caused by the unsuitable conditions.

8.01.3.18.4 Soil Stabilization and Hydroseeding Materials.

All materials shall be approved and first grade quality and shall be in prime condition when installed and accepted. Any commercial process or packaging material shall be undisturbed and materials delivered to the site in the original, unopened condition bearing the manufacturer's guaranteed analysis. They shall be applied at the rates given below:

1. Fertilizer - three hundred thirty-six (336) kilograms per hectare of 16-20-20+ micronutrients, inorganic commercial fertilizer.

2. Fiber Mulch - at the quantity per hectare of cellulose fiber or paper mulching fiber as indicated on the Special Specifications.

3. Super Absorbent Humectant - at the quantity per hectare indicated on the Contract Drawings.

4. Soil Stabilant - four hundred seventy (470) liters per hectare of soil stabilant.

5. Seedmix - Seedmix for the contract area as specified in Subsection 8.01.2.3, "Plants" and Paragraph 8.01.5.1.1 "Grass Seeding" in these General Specifications or as specified in the Special Specifications.

Each type of seed shall be delivered to the site in separate sacks labeled with proper Latin names per variety and pure live seed count per kilogram on each sack. Any deviation from procedures, pure live seed rates, varieties or quantities must be authorized in writing by the Engineer. Written verification of seed components for each mix shall be supplied to the Engineer along with copies of certified seed analysis reports and respective lot numbers. Certified seed analysis shall be by a licensed seed laboratory.

8.01.3.18.5 Hydroseeding Equipment.

1. The above specified components shall be mixed together in the hydroseeding machine to allow for a homogenous slurry which is thoroughly mixed with potable water and can be applied easily without clogging. The machine type must be approved by the Ministry.

2. The equipment shall have a built-in agitation system and operating capacity sufficient to agitate, suspend and homogeneously mix a slurry containing not less than five (5) kilograms of fiber mulch plus fertilizers and chemical additives and solids for each one hundred (100) liters of potable water.

3. The hydroseeding equipment shall meet the minimum requirements of a slurry distribution line large enough to prevent stoppage and shall be equipped with a set of

hydraulic spray nozzles which will provide a continuous nonfluctuating discharge at the end of the spray nozzle.

8.01.3.18.6 Hydroseeding Installation and Planting Schedule.

1. The hydroseeding shall be applied in the form of a slurry consisting of organic soil amendments, commercial fertilizers, fiber, mulch, super absorbent humectant, potable water and seeds. When hydraulically sprayed onto the soil, the hydroseeding SHALL NOT FORM A BLOTTER LIKE MATERIAL. Instead, the spray operation should be so directed that the slurry spray will penetrate the soil surface as to drill and mix the slurry components into the soil, thus ensuring maximum impregnation and coverage of the sand particles with soil stabilizing material. The impregnation and mixing of the components will help in retaining moisture while preventing soil erosion.

2. The slurry shall be prepared at the site and its components shall be mixed to supply the rates of application as outlined in these specifications.

Slurry preparation should begin by adding potable water to the tank when the engine is at one-half (½)throttle. When the water level has reached the height of the agitator shaft and good recirculation has been established, the fertilizers shall be added to the mixture (the tank shall be at least one-third (_) filled with water at this time).

The engine throttle shall be opened to full speed when the tank is one-half (½) filled with water. All organic amendments and soil stabilants shall then be added by the time the tank is two-thirds (_) full. At this time the seedmix shall also be added.

Spraying shall commence immediately after the tank is full and the slurry is mixed.

3. Application - The operator shall spray the areas with a uniform coat using the dark color of the dye in the fiber as a visible guide. The slurry shall be applied in a downward drilling motion via a fan stream nozzle. It is important to ensure that all the components enter and mix with the soil to a depth not greater than ten (10) millimeters. The hydroseed materials have a tendency to build upon themselves. Therefore, it is important that the Contractor employs only qualified personnel to ensure uniformity of the hydroseed application.

4. Time Limit - The hydroseeding slurry components are not to be left in the hydroseed machine for more than two (2) hours for fear of destruction of the seeds. The Contractor shall add fifty percent (50%) more of the originally specified seedmix to any slurry which has not been applied within two (2) hours after mixing. The Contractor shall add seventy-five percent (75%) more of the original seedmix to any slurry which has not been applied within six hours after mixing. Any mixture which has not been applied within eight (8) hours shall be rejected and disposed of off-site at the Contractor's expense.

5. Protection - Special care is to be exercised by the Contractor to prevent any slurry from being sprayed onto any hardscape areas including concrete walks, fences,

walls, buildings, etc. Any slurry sprayed onto these areas shall be removed at the Contractor's expense.

6. Hydroseeding Schedule - The hydroseeding and soil stabilization installation should be timed to take advantage of the natural precipitation during the winter rainy season. As an added precaution, the area shall be presoaked by potable water truck or irrigation to a depth of seventy-five (75) millimeters immediately prior to the hydroseeding installation.

7. The hydroseeding areas shall be sealed with a soil stabilant immediately following the completion of the hydroseeding application. The time lapse between the first application of hydroseed and the sealing with soil stabilant shall not exceed twenty-four (24) hours.

8. Irrigation at the rates and frequency required for germination and establishment shall begin not more than twenty-four (24) hours after the completion of the hydroseeding and soil stabilant application.

8.01.3.19 Sod. This work consists of furnishing and placing living sod of perennial turf-forming grasses. Sod placement is designated as solid or spot as outlined below.

Sod shall be a living vigorous growth of the type of grass and thickness specified in the contract. The grass shall have a dense root system contained in suitable sod and reasonably free from noxious weeds and grasses. When the sod is cut, its top growth shall not be more than seventy-five (75) millimeters in height. Sod shall be cut and placed during the local growing season. Sod shall be placed only when weather and soil moisture conditions are favorable.

Pegs for sod shall be fabricated from sound wood, at least two hundred (200) millimeters long, square or round, and having a cross-sectional area of approximately six hundred forty-five (645) millimeters.

The area to be sodded shall be cleared and graded. The grade shall be cultivated, disked, harrowed or otherwise loosened to a depth of not less than one hundred (100) millimeters. Stones larger than twenty-five (25) millimeters in any diameter, sticks, stumps, and other debris that might interfere with the proper placement or subsequent growth shall be removed. The area to be sodded shall be cultivated like a grass area per Paragraph 8.01.3.16 "Preparation and Maintenance of Grass Areas" in these General Specifications.

The Contractor shall provide the Engineer at least three (3) days notice before cutting sod. The Engineer will inspect and approve the sod in its original position before cutting. The Contractor shall not deliver sod until the soil is prepared. The prepared sod bed shall be thoroughly moistened. The sod shall be placed within twenty-four (24) hours after cutting or within five (5) calendar days after cutting when the sod is stored in moist stacks, grass-to-grass and roots-to-roots. Protect sod against drying and from freezing.

1. Solid Sod. Sod shall be placed perpendicular to drainage flows. Sections of solid sod shall be placed edge to edge with staggered joints. Openings shall be plugged with sod or openings filled with acceptable loamy seeded topsoil. Sod shall be rolled or tamped to eliminate air pockets and provide an even surface. On slopes 1V:2H or steeper and in channels, sod shall be pegged on six-tenths (0.6) meter centers after rolling or tamping.

2. Spot Sod. Sod is to be placed in blocks. The blocks shall be rolled or tamped into the soil until the sod surfaces are slightly below the surrounding ground surface. The sod shall be watered when placing and kept moist for a minimum of ten (10) days. Erosion shall be avoided when watering.

The Contractor shall erect warning signs and barriers to protect newly sodded areas. Wheeled vehicles shall not be allowed on newly sodded areas.

Sodded areas shall be mowed and sodded areas that are damaged or fail to show a uniform growth of grass shall be repaired or replaced. Sodded areas shall be maintained until final acceptance of the project.

8.01.4 COMPLETION AND MAINTENANCE. This item shall be read in conjunction with the General Requirements for Maintenance of Irrigation and Landscaping in the attached Appendix "2".

8.01.4.1 After Planting. All soils areas shall be forked and/or raked to a fine tilth with approved cambers and no hollows.

8.01.4.2 Cleanliness. Soil and rubbish shall be removed from hard surfaces and the works left in a clean and tidy condition.

8.01.4.3 Maintenance Period. The Contractor shall be responsible for the maintenance of the planted areas, their irrigation and all operations necessary to keep the plants in a healthy condition for a period of two (2) years following the satisfactory completion of landscaping.

The maintenance shall include, but not be limited to watering, watering, weeding, pruning, mowing, fertilizing, removing rubbish, replacing plants, applying approved chemicals to counter insect attack, disease and weeds and any other horticultural operations recognized as necessary for the proper growth of plants and for keeping the contract area neat in appearance.

8.01.4.4 Maintenance Program. Visits shall be made at approximately daily intervals during the growing season and as necessary to fulfill the requirement of the Contract. The Contractor shall keep accurate records as to the operations conducted and keep such records available for inspection by the Engineer.

8.01.4.5 Watering. Irrigation should be conducted regularly. Irrigation duration should be scheduled to provide sufficient water for plants' growth based on the monthly plant water requirement. Once per month throughout the maintenance period, the Contractor shall supply certified laboratory water quality test reports as mentioned in Paragraph 8.01.2.5 "Irrigation Water" in these General Specifications.

8.01.4.6 Weed Control and Debris Removal. Weed and debris removal from an area of two (2) meter diameter around each tree and one (1) meter diameter around each ground cover or shrub shall be routinely performed by the Contractor. Grass and weeds shall not be allowed to reach a height of fifty (50) millimeters (two (2) inches) in any tree basin or around any plant before being completely removed, including root growth.

8.01.4.7 Pruning. Plants shall be pruned at an appropriate time to remove any dead, dying or diseased wood and suckers in order to promote healthy growth and natural shape. Cut ends exceeding twenty-five (25) millimeters in diameter shall be treated with tree wound dressing.

8.01.4.8 Fertilizing. Throughout the maintenance period the Contractor shall apply a soluble NPK fertilizer in weak solution through the injector mechanism located at each pump station. The fertilizer shall also include traces of zinc, iron and manganese.

Every two (2) months the Contractor shall take one (1) soil sample per half a hectare in each separate planting area serviced by fertilizer injection unit as directed by the Engineer. The soil samples shall be tested for agricultural nutrients and fertility suitable for arid plant growth.

The soil sample shall be tested by an approved agricultural soil testing laboratory from the Ministry of Agriculture to determine the levels of nutrients and obtain recommendations for the rate of application of nitrogen, phosphorus and exchangeable potassium together with the need for trace elements.

The dilution rate shall be as per the injector and manufacturer's recommendations and as directed by the Engineer. Fertilizer material and application rate shall be performed by the Contractor, and will be monitored and certified by the Engineer at the time of injection.

8.01.4.9 Plant Replacement. From a field review of completed sections of planting works thirty (30) days after installation, the Engineer will direct the Contractor to remove and replace all plants determined by the Engineer as dead, from the Contract Site. Plants reviewed that, though not dead but which exhibit questionable abilities to survive will be marked by the Contractor in the presence of the Engineer that require subsequent review after an additional thirty (30) day period.

The Contractor shall make every effort to stabilize the quality of all plants identified by the Engineer as questionable well in advance of any additional field reviews. Plants reviewed as not being in a healthy condition one hundred and twenty (120) days from installation will be noted by the Contractor for removal and replacement. As soon as seasonal planting conditions are appropriate the Contractor shall replant any areas containing unhealthy and dead plants at his own expense. The replanted species shall be as close as possible in size, shape and species as already growing on site.

8.01.4.10 Pest and Disease Control. Specific checks for pests and disease are to be carried out every week by the trained technical specialist of the Contractor's staff.

Spraying and dusting with approved insecticides and fungicides to control pests and to ensure healthy plant growth and survival, shall be performed as directed by the Engineer. The Contractor shall submit for the Engineer's review and approval manufacturer's product information with a sample one (1) liter of all proposed chemical insecticides and fungicides and a minimum thirty (30) calendar days prior to their anticipated use. Spraying with pesticides and fungicides shall be performed as required to control pests and disease and as approved by the Engineer. The Contractor shall maintain a supply of recognized and approved horticultural chemicals in sufficient quantities to combat recurring pests and/or disease infestation that might occur during the length of the contract.

The Contractor shall follow the manufacturer's recommendations in handling and storage of chemicals. Certain chemicals such as potassium nitrate must be separated from other chemicals. The ventilated storage area of the Contractor's chemicals must be locked when not in use and toxic hazard notices shall be posted in both Arabic and English, and suitable protective clothing and washing facilities shall be furnished by the Contractor, together with first aid equipment immediately adjacent to the storage area. The Contractor shall conduct training sessions in first aid and site safety, in English and Arabic, ensuring staff awareness to any precautionary measures that may be required for handling chemicals.

All equipment should be surface sterilized with methylated spirits after use on the plants which are known, or suspected to be diseased. All diseased wood, fungi, pruning, etc. to be disposed of after removal from diseased plants. The Contractor's methods and location of disposal shall be reviewed and approved by the Engineer prior to initiating the work.

8.01.4.11 Tree Stakes. The condition of all stakes, ties and guards shall be checked and any broken or missing items replaced. Ties shall be adjusted to prevent bark from being rubbed. Any damaged bark shall be cut back and treated with tree wound dressing.

8.01.4.12 Burlap Wrapping. Wrapping shall be removed from the palm growing buds when the turgor in the bud has been completely restored.

8.01.4.13 Grass Area Maintenance. The Contractor shall perform all required soil tests, mowing, trimming, irrigation, aeration, thatching, top dressing, and fertilization at frequencies required to maintain a healthy vigorous turf with a well kept appearance. The Contractor will overseed with rye grasses in areas approved by the Engineer to maintain a vigorous green color during winter months. The Contractor shall continuously reseed thin or dead areas and top dress lawn areas as required during the maintenance period.

8.01.5 GENERAL INSPECTION AND ACCEPTANCE REQUIREMENTS.

8.01.5.1 Defects. Any trees, shrubs or plants which are dead, dying or otherwise defective at substantial completion of the Works or six (6) weeks after first leafing out, whichever is later, shall be regarded as defects due to materials or workmanship not in accordance with the Contract. These must be replaced by approved equivalent trees, shrubs or plants unless otherwise instructed or unless defects are caused by malicious damage after substantial completion.

At the end of the maintenance period, all planted areas shall be free from weeds, trash, debris, and shall appear neat and clean. All plants shall be in good growing condition and shall be pruned, as directed by the Engineer, to present a well shaped and natural appearance. After pruning, all remaining wood shall be alive. All cut surfaces of twenty-five (25) millimeters or more in diameter shall be treated with an approved tree paint. Replacement plants shall be in place at least fifteen (15) days prior to the end of the maintenance period and shall exhibit no signs of damage or failure. The maintenance period shall be extended as required to ensure full compliance with the specifications.

Failure of the Contractor to adequately perform maintenance during this period shall be cause for extension of the maintenance period.

8.01.5.2 Manufacturer's Recommendations. Recommendations for the storage, handling and application of fertilizers, herbicides and other chemicals shall be strictly followed.

8.01.5.3 Storage. All trees and plants which are not to be planted on the day of delivery to the site shall be stored as follows, or by any other approved method:

1. Root-balled trees and plants shall be placed close together and root-balls covered with sand, moist peat or wet straw.

2. Bare-rooted trees and plants shall be heeled in, in prepared trenches, covered with sweet soil and watered thoroughly.

8.01.5.4 Planting Time. Plants and trees shall only be moved or planted into permanent positions during the period mid February to mid May and mid September to mid November every year and only when ground and weather conditions are suitable. The Engineer's approval must be obtained to vary the planting period if special conditions so warrant.

8.01.5.5 Weather Conditions. No planting shall be carried out when persistent cold or drying winds are likely to occur, or if the soil is water logged or excessively dry.

8.01.5.6 Planting Outside Specified Conditions. If the Engineer requires or approves of planting outside the above season or hours or during adverse weather conditions, the Contractor is not relieved of his obligations regarding plant replacement during the Defects Liability Period.

The Contractor is to allow for all measures necessary to reduce fatalities in the plant material by, for example, additional watering and the use of anti-desiccants and shading, as he considers appropriate.

8.01.5.7 Notice. The Contractor must give forty-eight (48) hours notice to the Engineer before commencing planting, maintenance or replacement work.

8.01.5.8 Meaning of Drawings. The drawings, specifications and other documents are intended to convey accurate descriptions of the nature and standard of quality of the work to be performed by the Contractor. Should the tenderer be in any doubt regarding the true meaning and intent of any Clause in the Specification, etc., he is invited to have these fully resolved before submitting his tender.

8.01.5.9 Planting Designs. Three (3) weeks prior to the commencement of excavation, the Contractor shall submit to the Engineer for approval, shop drawings indicating all the planting positions, species sizes. They shall be prepared in accordance with the planting plans supplied by the Engineer and shall be liable to in-situ adjustments as required.

8.01.5.10 "As Planted" Record. Before issuing of the Certificate of Substantial Completion, the Contractor shall furnish the Client with a bound set of layout Drawings to a scale 1:1000 which record the actual species used in the planted areas, including all approved substitutes.

8.01.6 METHOD OF MEASUREMENT. Trees, palms, shrubs, creepers, ground cover, succulents and climbing plants are all measured by number. Grass, hydroseeding mixes, gravel mulch and concrete tiling wherever specified shall be measured by the square meter. These measurements are taken to include all necessary works such as preparation of planting areas, excavation of pits, furnishing of all plants, stakes, ties, agricultural soil and fertilizers and all labor and maintenance.

8.01.7 PAYMENT. The quantities, measure as provided above, shall be paid for at the contract unit price(s) for the several pay items as specified in the Bill of Quantities, which prices shall be full compensation for furnishing, preparation of planting areas including plants, soil, fertilizers, stakes, chemicals and placing all materials, for all labor and maintenance, equipment and all other items described in the specifications necessary for the proper completion of the work.

The supply of water required will not be paid for directly but shall be considered subsidiary work pertaining to the several items contained in the landscape works.

The Contractor shall supply water for his own Contract and for any additional adjacent Contracts which are served by his pumping station.

For guarantee of perfect maintenance of works according to the Specifications, an amount equivalent to twenty-four percent (24%) of total amount of landscape items shall be reserved to be paid during maintenance period (24 months) at equal monthly payments of one percent (1%) according to performance of maintenance or works as required.

Prices and payment made under this section shall cover and be full compensation for furnishing labor, equipment, materials, tools and incidentals for completing the work as specified in Subsection 1.07.2, "Scope of Payment" in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
80101	Trees, Acacia arabica	Unit
80102	Trees, Albizzia lelbbek	Unit
80103	Trees, Casuarina	Unit
80104	Trees, Delonix regia	Unit
80105	Trees, Eucalyptus camaldulensis	Unit
80106	Trees, Prosopis juliflora	Unit
80107	Trees, Schinus molle	Unit
80108	Trees, Schinus terebinthifolius	Unit
80109	Trees, Ficus nitida	Unit
80110	Trees, Ficus altissima	Unit
80111	Trees, Pithecellobium dulce	Unit
80112	Trees, Aiziphus mauritiana	Unit
80113	Trees, (Type)	Unit
80120	Palms, Phoenix dactylifera	Unit
80121	Palms, (Type)	Unit
80125	Shrubs, Acacia farnesiana	Unit
80126	Shrubs, Bougainvillea spectabilis	Unit
80127	Shrubs, Bougainvillea glabra	Unit
80128	Shrubs, Caesalpina pulcherrima	Unit
80129	Shrubs, Dodonia viscosa	Unit
80130	Shrubs, Callistermon viminalis	Unit

80131	Shrubs, Atriplex halimus	Unit
80132	Shrubs, Tecoma stans	Unit
80133	Shrubs, Tehvitia nereifolia	Unit
80134	Shrubs, (Type)	Unit
80140	Creepers, (Type)	Unit
80145	Ground Cover, Carissa grandiflora	Unit
80146	Ground Cover, Clerodendron inerme	Unit
80147	Ground Cover, Ipomoea pes-capre	Unit
80148	Ground Cover, Ipomoea carica	Unit
80149	Ground Cover, (Type)	Unit
80155	Succulents, Aloe vera	Unit
80156	Succulents, Agava americana	Unit
80157	Succulents, Opuntia	Unit
80158	Succulents, Yucca alofolia	Unit
80159	Succulents, (Type)	Unit
80165	Climbing Plant, (Type)	Unit
80170	Grass, Bermuda	Square Meter
80171	Grass, Cydomon Dactylon/Roa Annua	Square Meter
80172	Grass, (Type)	Square Meter
80175	Hydroseeding Mixes, Bermuda	Square Meter
80176	Hydroseeding Mixes, (Type)	Square Meter
80180	Gravel Mulch, Class 18-25 mm dia	Square Meter
80181	Gravel Mulch, Class ___ - ___ mm dia	Square Meter
80185	Precast Concrete Tiling	Square Meter
80186	Sod	Square Meter

SECTION 8.02 IRRIGATION

8.02.1 SCOPE AND REQUIREMENTS

8.02.1.1 Scope. This work shall consist of supplying, installing, testing and maintaining an irrigation system complete in all respects, all in accordance with the specifications and in conformity with the details shown on the Drawings or established by the Engineer.

All irrigation water used by the Contractor for watering shall be of an approved quality and the Contractor shall provide the Engineer with complete physical and chemical analyses of this water and shall obtain necessary approvals prior to its use.

ITEMS IN BILL OF QUANTITIES

Irrigation Pipework
Plastic Irrigation Pipe
Steel Irrigation Pipe
Valve, Butterfly
Valve, Air Type
Valve, Globe
Valve, Silent Check
Valve, Remote Control
Valve, Pressure Reducing
Valve, Pressure Relief, Check
Valve, Penstock
Valve, Gate
Combination Valves
Electricity Supply
Mechanical Plant for Irrigation Pumping Station
Electrical Installations for Pumping Station
Civil Works for Pumping Station
Suction and Header Pipes for Pumping Station
Pumping Station Chain Link Fence and Gates

8.02.1.2 Abbreviations.

BS British Standards

SAS Saudi Arabian Standards

U/L Underwriters Laboratory

8.02.1.3 Shop Drawings and Approval of Equipment. The Contractor shall prepare shop drawings showing the detailed and accurate construction of every element of the Works. The shop drawings shall cover but not be limited to:

1. Reinforced concrete details and bar bending schedules.

2. The accurate setting out plans of all irrigation pipelines presented on 1/500 scale over one (1) meter contour background as obtained from actual field survey, indicting the pipe diameter, the location and size of all valves, fittings, and irrigators.

3. Installation details of valves, risers, pumping units and accessories.

4. Irrigation schedule showing the reference number of every valve, time of irrigation and length of the irrigation period.

5. Wiring layout of all remote control valves including the size and length of wires used.

Shop drawings for a specific location shall be submitted in triplicate to the Engineer at least two (2) weeks prior to commencement of construction in that location. No permanent work shall proceed in a location until the relevant shop drawings have been approved by the Engineer.

The Contractor shall submit full details in triplicate of all materials and equipment to be supplied for the approval of the Engineer. Firm orders for equipment shall not be placed until equipment has been approved in writing.

8.02.1.4 Record Drawings. The Contractor shall provide record drawings, to a scale not less than one one-thousandth (1/1000), showing the locations, dimensions and details of the Works as built. The drawings can be prepared by making amendments to the Contract Drawings; the Engineer will provide the Contractor with one (1) set of reproducible transparencies of the Contract Drawings for this purpose.

The record drawings shall be prepared not later than twenty (20) days after completion of the corresponding part of the Works. Upon completion of the whole of the Works, the completed record drawings shall be submitted to the Engineer for approval before the substantial Completion Certificate is issued. After approval, the Contractor shall provide three (3) bound sets of prints and one (1) reproducible transparency to the Employer.

Record drawings shall give the exact location, with respect to the road section, other pipelines and other permanent features, of all standard and special pipes, fittings, valves, irrigators and all other items incorporated in the Works, including diameters, pressure class or rating, and the actual pressures as measured on the highest and lowest irrigators commanded by each pressure regulating valve.

8.02.1.5 Maintenance and Operation.

8.02.1.5.1 General. The Contractor shall operate and maintain the irrigation system throughout the Maintenance Period as defined under Section 8.01, "Landscaping" in these General Specifications and shall provide staff in full time attendance throughout the period.

This item to be read in conjunction with the General Requirements for Maintenance of Irrigation and Landscaping in the attached Appendix "2".

8.01.1.5.2 Works. Maintenance of the works included in this Section shall cover all work necessary to adequately operate and keep all irrigation equipment, valves, pipelines and appurtenances in a proper operating condition, all to the satisfaction of the Engineer.

The maintenance program shall in general include but not be limited to the following:

1. Supply of irrigation water of suitable quality and in adequate quantities to meet the irrigation requirements. The Contractor shall arrange to obtain water from an adequate source, subject to the approval of the Employer and the Engineer, and shall pay all expenses incident thereto. Ground water may be exploited for this purpose and the Employer will provide assistance for obtaining approval by the relevant authorities.

The Contractor shall submit to the Engineer for approval, a full analysis of the water from each source prior to its use for irrigation, and at one (1) month intervals thereafter.

2. Irrigation at a frequency and depth as required for every season.

3. Maintenance and repair of all irrigation equipment, pipes, valves, pumping stations, and all appurtenances.

4. Provision of a detailed maintenance program to be submitted to the Engineer for approval at least two (2) months before any irrigation system is operated. This program shall include the Operation and Maintenance organization chart, the regular Maintenance works, the irrigation scheduling the means of providing water to the site and all other activities incident thereto.

5. Keeping a record of all maintenance, repair and operation activities throughout the maintenance period. This record shall show the date, location and type of work performed, all repairs and replacements, the amount of water applied at every irrigation and the duration of the application, results of the water analyses and all works, activities and equipment relevant to the operation and maintenance works. This record shall be complete to the approval of the Employer and the Engineer and shall revert to the Employer so that it can be used by the authority in charge following the expiry of the Maintenance Period.

8.02.1.6 Operation and Maintenance Literature. Prior to the final acceptance of the installation, the Contractor shall submit to the Engineer six (6) sets of manuals for all equipment supplied under the Contract. The manuals for all equipment supplied under the Contract. The manuals shall be A4 size bound in loose leaf binders or booklets suitably enclosed and shall include the following in Arabic and English languages:

1. Single line diagrams of the complete electrical installations.

2. Control, projection and circuit diagrams for all equipment.

3. Setting up, commissioning and operating instructions.

4. Trouble shooting procedures.

5. Maintenance instruction including schedules for preventative maintenance, recommended lubricants and equivalents.

6. The manufacturers catalogues and spare parts numbers of all permanent works together with a recommended spares list.

7. A description of the regular maintenance activities and the proper operating methods of the system in both the Arabic and English languages.

8. Name of Manufacturers' local or nearest authorized representative(s) and service agent(s).

8.02.2 PIPING AND APPURTENANCES

8.02.2.1 Scope. PIPING AND APPURTENANCES cover all pipes, fittings valves, irrigation equipment and accessories relevant to the irrigation network and also the Pumping Stations and Water Tanks.

8.02.2.2 Special Requirements. Notwithstanding the specific standards relevant to every pipe material, the following general requirements shall apply to all pipe materials:

8.02.2.2.1 Manufacturer's Certificate.

Every shipment shall be accompanied by an original statement from the manufacturer certifying that the products have been subject to the tests specified in the relevant standards, have been found to meet the requirements thereof and are manufactured in complete accordance with the specified standards.

Records of all tests carried out at the factory shall be kept and made available to the Engineer.

8.02.2.2.2 Marking.

Products shall have the following marks legibly cast, stamped or indelibly painted on, as appropriate:

1. Trade name, or manufacturer's name, monogram or identification mark.

2. Relevant standard(s).

3. Nominal diameter and pressure class designation.

4. Length of pipe is shorter than standard length.

5. Angle of bends in degrees.

6. Date of manufacture.

7. Shift of manufacture or lot reference.

8. Material used.

8.02.2.2.3 Retests.

For the purpose of this Specification, the term "batch" shall be deemed to include products of the same material, size and pressure class only.

The Engineer reserves the right to require additional tests or retests on selected products and the Contractor shall defray all costs. These tests when required shall be carried out an independent testing organization approved by the Engineer through the offices of the Contractor, in accordance with the latest applicable standards. The samples to be tested shall be selected by the Engineer with at least one (1) from every batch, and shall be subjected to any or all of the tests specified in the applicable standards.

If a sample shall fail to pass a given test, two (2) additional samples of the same batch shall be subjected to the same test. The failure of one (1) of these additional samples to pass this test shall be cause for rejection of that size, pressure class and type of manufacture during the same shift as the test samples.

8.02.2.3 Handling. All products shall be delivered to and distributed at the site by the Contractor. The Contractor shall follow the manufacturer's recommendations for handling, repairing, laying, jointing, anchoring, testing and other works with due respect to the following:

1. Loading and unloading shall be carried out by lifting with hoists, using ropes or slings in order to avoid shock or damage. Fittings shall be loaded and unloaded individually. Under no circumstances shall such materials be dropped. Pipes handled

on skidways shall not be skidded or rolled against pipes or other materials already on the ground. No dragging on the ground will be allowed.

2. Pipes shall be stacked by placing the first layer on level timber. Pipes shall not rest on sockets or joint faces. Pipes of the same diameter shall be stacked together with suitable labels, on which shall be entered the stack reference number, date of dispatch, date of delivery at the Site and the number of pipes. Height of stack shall be to the manufacturer's instructions. Rubber rings, plastic materials and any other materials as recommended by the manufacturers, shall be stored in shaded locations in their original packing.

3. Each pipe shall be unloaded on Site opposite or near the place where it will be installed.

8.02.2.4 Pipes, Fittings and Accessories. The pressure class of the pipes, fittings and accessories shall be as indicated in the Specifications that follow unless otherwise specifically indicated on the Drawings:

8.02.2.4.1 Ductile Iron Pressure Pipes.

Flexibility jointed pipes shall be to BS 4772 Class K9, with NP10 joints, flanged pipes to BS 4772 Class K12, fittings to BS 4772 K12 except for fittings with branches which shall be Class K14, and flanges to BS 4504. All flanges shall be rated at NP25.

Factory protection shall consist of:

Internally: cement mortar lining to BS 4772 Appendix C with sulphate resisting Portland cement to BS 4027.

Externally: coating with bitumen to BS 3416, thickness one (1) mil.

8.02.2.4.2 Unplasticised PVC Pressure Pipes.

Pipes shall be to SAS 14 Class 5 and SAS 15 unless otherwise indicated on the Drawings and in the Bill of Quantities. All sizes shown on the Drawing and the Bill of Quantities are for nominal internal diameter.

Fittings shall be injection molded to SAS 14.

Joints shall be injection molded to SAS 14.

8.02.2.4.3 Asbestos Cement Pressure Pipes.

Pipes shall be to SAS 5 and SAS 6 Class 18 manufactured with sulphate resistance cement conforming to BS 4027.

Ductile iron fittings to BS 4772, protected internally with cement mortar and externally with bitumen shall be used with asbestos cement pipes. End combinations

shall be as shown on the Drawings. Spigot or plain ended fittings shall have their ends shaped to suit specified asbestos cement joints.

Joints between pipes and between pipes and fittings shall be of the sleeve type utilizing gasket retaining grooved asbestos cement couplings. Rubber sealing rings shall be to BS 2494.

8.02.2.4.4 Steel Tubes and Tubulars.

Tubes shall be to BS 1387 Medium Class with screwed joints to BS 21. Factory protection shall consist of dipping in molten zinc containing not less than ninety-eight and one-half percent (98.5%) by weight of zinc at a temperature suitable to produce a complete and uniform adherent coating.

8.02.2.4.5 Flexible Pipe Couplings.

Flexible couplings are to be of the correct type and class recommended by the manufacturer for the specific pipe material and pressure. They must be fixed exactly in accordance with the manufacturer's recommendations. Factory protection shall consist of external and internal coating with bitumen to BS 3416, thickness one (1) mil.

Flexible pipe couplings shall be of the straight type to connect two (2) plain ended pipes of the same outside diameter or of the stepped type for large diametrical differences. Coupling is to be with center register. Material shall be malleable iron to BS 300 Grade 20/10 or rolled steel to BS 970-060 A12. Bolts to BS 90-EN3A. Rubber rings to BS 2494.

Allowable angular deflection shall not be less than six degrees (6°) for sizes up to six hundred (600) millimeters diameter.

8.02.2.4.6 Flanged Adaptors.

Material shall be cast iron body to BS 1452 grade 14 or mild steel plate to BS 4360 - 4SA and malleable cast iron flanges to BS 310 grade 20/10 or rolled steel to BS 970-060 A12. Bolts to BS 970-EN3A. Rubber rings to BS 2494.

Length of adaptor shall be two hundred (200) millimeters for diameters up to one hundred fifty (150) millimeters, two hundred fifty (250) millimeters for diameters between two hundred (200) and three hundred (300) millimeters and as approved for diameters larger than three hundred (300) millimeters. Factory protection shall consist of external and internal coating with bitumen to BS 3416, thickness one (1) mil.

8.02.2.4.7 Jointing Materials.

1. Gaskets shall be elastomeric full face three (3) millimeter thick joint rings to BS 2494 with dimensions to BS 3063.

2. Rings shall be elastomeric to BS 2494. Dimensions shall be to manufacturer's recommendations to suit type of joint.

3. Bolts and nuts shall be ISO metric black hexagon to BS 4190 minimum tensile strength four hundred thirty-three (433) MN per square meter, maximum elongation seventeen percent (17%). After fixing, bolt projection shall be maximum six (6) millimeters, minimum three (3) millimeters.

4. Washers shall be black steel conforming to BS 4320.

8.02.2.4.8 Field Testing.

1. General.

The Contractor shall provide pumping equipment, pressure gauges, instruments and water needed for hydrostatic field testing. Tests shall be carried out in the presence of the Engineer's representative.

Fittings and joints shall be permanently anchored before testing and left exposed for checking. All pipework is to be cleaned and swabbed, prior to field testing, to remove any material that may have collected during installation. Pipelines shall be partially backfilled before testing.

Each section shall be limited to five hundred (500) millimeters or the length between valve positions, whichever is shorter. No testing shall be carried out against a closed valve.

Ends of test sections shall be securely plugged and strutted.

Ends of risers shall be plugged and all air purged.

No testing shall be carried out against or through the pressure reducing valves. The setting of the pressure reducing valves shall not be changed for testing purposes. Pressures shall be applied by manually operated or motor driven test pumps approved by the Engineer.

Exposed joints shall be examined for visible leaks and appropriately repaired where necessary. Should a test fail, leaks shall be located and defective pipes or joints made good or replaced and the pipeline retested.

Test records shall be kept in an approved form, and the original copy shall be handed over to the Engineer immediately after completion of each test.

2. Hydrostatic Test.

The pipeline shall be filled slowly with water from the lowest point. After filling with water, absorbent pipes shall be allowed to stand for at least twenty-four (24) hours before testing to allow complete absorption.

Entrapped air shall be bled before pressurizing. Pressurizing is to continue until the specified test pressure is reached in the lowest part of the section under test. Further quantities of entrapped air shall be bled while pressure is being raised.

Unless otherwise specifically indicated, the test pressure shall be thirteen kilograms per square centimeter (13 kg/cm^2) for all pipelines upstream of pressure regulating valves and seven kilograms per square centimeter (7 kg/cm^2) for all pipelines downstream of pressure regulating valves.

The test pressure shall be maintained for one (1) hour by pumping. Pumping shall then be stopped for two (2) hours, at the end of which time, the line shall be repressurized to the original test pressure and the volume of water pumped into the line recorded.

The pipeline will be deemed to have failed the test if:

- Visible leaks are detected, regardless of leakage being within the allowable specified limit.

- Volume of water pumped to restore original test pressure after the period when pumping was stopped exceeds the allowable leakage of:

- Eight-tenths (0.8) liters per day per kilometer of pipe per millimeter of pipe diameter for each three (3) kilograms per square centimeter (3 kg/cm^2) of applied pressure for other pipe material.

- One-tenth (0.1) liters per kilometer of pipe per millimeter of pipe diameter for each three (3) kilograms per square centimeter of applied pressure for other pipe material.

8.02.2.4.9 PVC Ducts.

Ducks are to high impact resistant, acid resistant, high resistance to heat self extinguishing, low coefficient of expansion PVC compound. The size of ducts shall be as indicated in the Drawings.

Each section of duct is to have one (1) end tapered with jointed part being equal or longer than eight (8) millimeters and joined using adhesive recommended by manufacturer. Joint is to be waterproof and sandproof.

Ducts running under streets or paved areas are to be encased in concrete with minimum thickness as shown on the Drawings.

Ducts are to be cleaned by rubber or leather mandrel slightly larger than duct inside diameter.

A pull wire is to be placed in all ducts stretching the complete length and fixed to wooden block.

8.02.2.5 Valves.

8.02.2.5.1 General.

Unless otherwise indicated, valves shall comply with the following:

1. Valves shall be rated at sixteen kilograms per square centimeter (16 kg/cm^2) (NP 16).

2. Size fifty (50) millimeter (2 inch) and smaller shall have screwed ends to BS 21.

3. Size sixty-five (65) millimeter (2½ inch) and larger shall have flanged end connections to BS 4504 - NP 16.

4. The construction of the valve shall allow for complete servicing without removing the valve body from the line.

5. Factory protection of cast iron valves shall consist of an initial coat of protective paint applied immediately after shot blasting and a second coat on assembly.

6. For cast iron valves that will be installed exposed indoors the protective coating shall consist of two (2) coats of zinc primer. Two (2) coats of oil paint shall be applied one (1) before and one (1) after assembly. For cast iron valves that will be directly buried or installed inside valve chambers, the protective coating shall consist of two (2) coats of cold applied coat tar based primer. Two (2) coats hot applied coat tar based coating shall be applied after assembly.

7. After testing, each valve shall be drained, cleaned and closed. Valves shall be prepared for dispatch in such a way as to prevent the possibility of damage to inside or outside parts during transit. All machined parts shall be protected against rusting by painting or by other approved means.

8. For all underground valves the Contractor shall provide a valve support, the necessary ductile iron flanged/spigot pipes for connecting to pipes and all necessary fittings, tapers, flanged adaptors, bolts, nuts, gaskets, etc., for a complete valve installation as shown on the Drawings.

9. The valve box shall be constructed in accordance with the Drawings.

10. Valve markers shall bear suitable identification marking in accordance with details given on the Drawings or as instructed.

8.02.2.5.2 Gate Valves.

1. Size fifty (50) millimeter (two (2) inch) and smaller shall be to BS 5154 with solid wedge disk, non-rising stem, and screwed bonnet.

2. Size sixty-five (65) millimeter (two and one-half (2½)inch) and larger shall be to BS 5163 cast iron with inside screw, solid wedge, resilient seated, bolted bonnet and non-rising stem suitable for NP 16.

Materials of component parts shall be from the basic or alternative materials listed in BS 5163 Table 6.

Valves shall be supplied with either handwheels, valve caps or extension sockets as shown.

8.02.2.5.3 Butterfly Valves.

Butterfly valves shall be to BS 5155, cast iron and carbon steel, double flanged, resilient seated.

Operation key to be as indicated on the Drawings.

8.02.2.5.4 Globe Valves.

1. Size fifty (50) millimeter (two (2) inch) and smaller shall be to BS 5154 with integral seat, revolving seat and disk, inside screw, rising stem and screwed bonnet.

2. Size sixty-five (65) millimeter (two and one-half (2½)inch) and larger shall be to BS 5152 cast iron with bronze trim, renewable seat and disk, outside screw, rising stem and flanged bonnet.

8.02.2.5.5 Silent Check Valves.

1. Silent check valves shall be non-slam, spring loaded, suitable for installation in any position. They shall have straight guided disc with two-point bearing, wearing parts including disc, seat and other guide bushing shall be replaceable. They shall also have flow area in excess of pipe for minimum pressure drop.

2. Size fifty (50) millimeter (two (2) inch) and smaller shall be screwed, with bronze body, seat and disc, 18-8 stainless steel spring, with body having three hundred pounds per square inch (300 psi) working pressure rating.

3. Size sixty-five (65) millimeter (two and one-half (2½)inch) and larger shall be flanged, with cast iron body, bronze seat and disc, 18-8 stainless steel spring, with body having two hundred fifty pounds per square inch (250 psi) working pressure rating.

8.02.2.5.6 Remote Control Valves (RCV).

Remote control valves shall be provided with a twenty-four (24) volt, two (2) watt solenoid coil for remote open/close operation and shall be normally closed. It shall have a bleed off screw arranged to allow manual operation of the valve without energizing the solenoid coil. It shall have an adjustable flow control with manual shut-off.

Valves shall be of the slow-closing type suitable for the indicated low flow/low operating capacity at an operating pressure of five-tenths (0.5) to ten (10) kilograms per square centimeter.

Valves shall be fitted with nylon screens.

Valves shall be provided with all necessary pilot valves, copper tubes and contacts for remote indication of the valve status position open or closed at the irrigation program controller.

Valves shall be of corrosion resistant construction.

The valve body shall be glass filled nylon. The bonnet shall be A.B.S. The diaphragm shall be reinforced nylon. Valves shall be fitted with a nylon screen.

8.02.2.5.7 Pressure Reducing Valves.

Pressure reducing valves (PRV) shall automatically reduce a higher inlet pressure to a steady lower downstream pressure regardless of changing flow rate and/or varying inlet pressure. They shall also prevent slamming or water hammer through effective cushioning devices. Each PRV shall incorporate an orifice/strainer block and a plugged outlet on the downstream end for measuring the reduced pressure.

Each PRV shall have a control accuracy of ± two and one-half percent (2½%) of the preset reduced pressure value and shall have a drop tight shut-off, full face seating. The PVR shall be hydraulically operated and of the self-contained differential piston or pilot controlled diaphragm or piston type.

Setting of the controlled downstream pressure and its testing shall be done at the factory. Field tests shall be carried out to confirm the controlled pressure. This pressure is indicated on the Drawings. The maximum upstream pressure that the PVR shall be able to reduce to the indicated downstream pressure shall not be less than ten kilograms per square centimeter (10 kg/cm^2). The valve shall close drop tight when the downstream pressure exceeds the inlet pressure.

The valve body brass or cast iron shall be tested at sixteen kilograms per square centimeter (16 kg/cm^2).

The main valve shall be of the globe or angle type as specified. The pilot controls, the trim or both main valve and pilot controls and all springs shall be of stainless steel 303. The diaphragm shall be of nylon reinforced Buna-N.

Internal coating shall consist of epoxy resin.

One (1) portable pressure gauge suitable for fitting to the plugged outlet shall be supplied with every batch of 25 PRV or fraction thereof exceeding twelve (12) units. The number of pressure gauges thus supplied shall not be less than two (2) nor shall it exceed five (5) units. Pressure gauges shall comply with the Specifications set forth elsewhere in these General Specifications.

8.02.2.5.8 Remote Controlled Pressure Reducing Valves (RCPRV).

Remote Controlled Pressure Reducing Valves shall be solenoid valves each provided with a pressure reducing module. Performance is similar to the pressure reducing valve specified elsewhere in these General Specifications.

8.02.2.5.9 Pressure Relief Check Valves (Pump Control Valves).

This valve shall operate to automatically maintain a constant maximum system pressure, regardless of varying demand rates, by relieving excess pressure to pump suction. It shall also control excess pressure within the system and prevent back flow in case of pressure reversal.

The valve shall operate when the system pressure exceeds a certain preset maximum. This maximum pressure shall be coordinated with the pump characteristics, particularly the shut-off head, to avoid over-heating of the pump motor at low demands.

The valve shall have a control accuracy of plus or minus two and one-half percent (± 2.5 %) of the preset maximum system pressure and shall have a drop tight shut-off whenever the system pressure is below the preset relief pressure. Setting of the relief pressure and its testing shall be done at the factory. Field tests shall be carried out to conform the relief pressure.

The main valve shall be of the globe type as specified. The pilot controls, the trim of both main valve and pilot controls and all springs shall be of stainless steel 303. The diagram shall be of nylon reinforced Buna-N.

Internal coating shall consist of epoxy resin.

8.02.2.5.10 Air Valves.

1. General.

Valves shall have cast iron body and bolted cover to BS 1452 Grade 14 minimum, rubber outlet seat, plastic or ebonite ball, forged bronze screws and guide for ball acting under pressure. Valves shall be of the dynamic type where there is no

possibility of the ball being drawing into the orifice due to high air velocities. Valves shall be factor tested to sixteen kilograms per square centimeter (16 kg/cm^2).

Air valves shall be isolated from the mainline with a brass or gunmetal male screwed stop valve.

2. Combination air valves shall be used for relieving air under vacuum or pressure and in bulk and shall consist of a large orifice to release or admit air during charging or emptying of mains and of a small orifice to release air accumulated at summits of mains under pressure. The large orifice area shall be equal to or greater than inlet of valve. Each combination air valve shall be fitted with nitrile rubber lined butterfly valve with nylon coated disc on stainless steel shaft operated by lever handle with indicator and locking thumb screw.

3. Air and Vacuum Valves.

Type I (large orifice) shall be used for releasing or admitting air during filling or emptying of pipes.

Type II (small orifice) shall be used for automatically releasing, under pressure, accumulated air at summits of mains and where necessary at gradient changes.

8.02.2.5.11 Penstocks.

Penstocks shall be of sluice gate type to AWWA C501 non-rising stem having a faced back, studded for connecting to the discharge pipe flange and suitable for on-seating pressure with conventional closure and circular aperture. The stem shall be a continuous single piece - no couplings will be allowed.

Unless otherwise specified on the Drawings, any of the materials listed in Section 2 of the AWWA Standard may be used in manufacture except that materials identified as being subject to dezincification or dealumination are not to be used.

Sluice gates are to be operated by a handwheel without gears. Maximum operating head from surface of water to centerline of gate will not exceed ten (10) millimeters.

A leakage test, meeting the requirements of Section 6.3 of the AWWA Standard, is to be carried out at the factory on all sluice gates and test certificates and results shall be supplied in triplicate.

Surfaces of castings shall be factory protected as specified for cast iron valves.

8.02.2.5.12 Jointing Materials.

Gaskets shall be elastomeric full face three (3) millimeters thick joint rings to BS 2494 with dimensions to BS 3063.

Rings shall be elastomeric to BS 2494. Dimensions as per manufacturer's recommendation to suit type of joint required.

Bolts and nuts shall be ISO metric black hexagon to BS 4190, minimum tensile strength 433 KN per square meter maximum elongation seventeen percent (17%). After fixing bolt projection is to be maximum six millimeters, minimum three (3) millimeters.

Washers shall be black steel to BS 4320.

8.02.2.5.13 GRP Valve Boxes. GRP valve boxes are to be designed to suit the site conditions and loadings.

The glass reinforced plastic is to be manufactured from E-glass type fibers and thermosetting resin and is to incorporate a corrosion resistant liner. The glass fibers are to be compatible with the resins used. The liner is to comprise an inner face being a smooth hard suitably reinforced resin rich layer. The exterior surface of the valve box is to be resin rich.

The inside surface of each valve box is to be hard, durable, free of tackiness and free of bulges, dents, ridges or other defects that result in a variation of inside dimensions of more than three (3) millimeters from that obtained in adjacent unaffected portions of the surface.

No glass fiber reinforcement is to penetrate the interior surface of the valve box wall, and any glass fiber reinforcement on the exterior surface must be thoroughly impregnated with resin.

The glass content will be determined by ignition loss analysis in accordance with Method D 2584 or ISO Recommendation R 11172.

8.02.2.5.14 Plastic Valve Boxes. Plastic valve boxes are to be high impact resistant, acid resistant, high resistance to heat, self extinguishing, hard, durable, low coefficient of expansion PVC compound.

Valve boxes are to be designed to suit the site conditions and loadings.

8.02.2.5.15 Valve Accessories.

1. Handwheels.

Handwheels shall be to BS 5163, cast iron to BS 1452 Grade 10. Handwheels shall be marked "CLOSE" with an arrow to indicate clockwise direction of closure. Diameters and other construction details shall be to the manufacturer's standards. One (1) handwheel shall be supplied for each hand operated valve in pumping stations.

2. Valve Caps and Operation Keys.

Valve caps shall be to BS 5163, cast iron or malleable iron to BS 1452 grade 12 or BS 310 respectively. Set screws of valve caps shall be mild steel M12.

Operation keys shall be of the combination prising bar and lifting key type, one and one-half (1.5) meter vertical bar, one-half (0.5) meter horizontal bar. Keys shall be supplied at rate of one (1) for every five (5) valves with a minimum of three (3) and a maximum of ten (10).

3. Extension Spindles for Gate Valves.

Extension spindles shall be to BS 2470 - M12, hot dip galvanized to BS 1387, size 18 x 18 millimeters for valves up to two hundred (200) millimeter diameter and 24 x 24 millimeters for valves two hundred (250) millimeters to four hundred (400) millimeters diameter. Length, for each valve size shall suit excavation requirements. Spindles shall have cast iron or malleable iron caps and couplings to BS 1452 grade 12 and BS 310 respectively, on both ends of extension spindles (cap for operating spindle and coupling for connecting to valve). Set screws of caps and couplings shall be mild steel M12.

4. Protection Tubes.

Protection tubes shall be either uPVC or cast iron. Shape, sizes and other construction details shall be to manufacturer's standards and/or as shown on the Drawings. Tubes shall have caps encircling extension spindles.

5. Surface Boxes.

Surface boxes shall be to BS 1426. Frames and lids shall be cast iron to BS 1452 Grade 10. Studs, bolts, nuts and hinge pins shall be mild steel M12. Chains shall be mild steel or wrought iron. Lids shall be of the medium grade type B.

Lifting keys shall be malleable iron, supplied at the rate of one (1) per five (5) covers.

8.02.2.5.16 Workmanship.

Prior to installation, valves shall be inspected for cleanliness of bore, seating surfaces, etc., and for handling damage, cracks, missing parts and tightness of pressure containing bolting.

Valves, gates and hydrants shall be in closed position before installation.

Valves and hydrants shall be operated through one (1) complete opening and closing cycle in the position in which they are to be installed to ensure proper functioning.

8.02.2.5.17 Installation.

1. Valves. Valves shall be set and jointed to pipe in the manner specified for laying and jointing pipe and/or to manufacturer's instructions.

Each valve shall be provided with concrete pad as shown on the Drawings so that the pipe does not support the weight of the valve.

Valves shall not be used to bring misaligned pipe into alignment during installation.

All pressure-containing bolting (bonnet, seal plate and end connections) shall be inspected for adequate tightness after installation but prior to field testing.

2. Penstocks. For each penstock, the wall thimble, operating mechanism, stem and stem guides shall be installed in accordance with manufacturer's drawings and recommendations. Tolerances between seating faces shall be maintained and any warping avoided.

Tapped holes in thimbles shall be protected during concreting and setting.

Surfaces of thimbles and gates shall be protected from concrete spillage, paint, oil and debris. Thimbles shall be supported to prevent shifting during pouring and braced horizontally and vertically to prevent distortion.

Nuts shall be tightened in sequence after setting.

The entire assembly shall be cleaned, adjusted and lubricated after installation. Penstocks shall be operated through one (1) complete cycle on installation to ensure proper functioning.

8.02.2.5.18 Field Protection.

Valves shall be protected against the action of external agents by a coat of approved bituminous compound, applied cold by brush after pressure tests on pipelines have been completed.

Penstocks shall be protected against action of external agents with one coat of approved bituminous compound applied cold by brush after installation.

Buried bolts shall be protected against corrosion, with approved paint or by polyethylene wrapping.

8.02.2.6 Irrigators.

8.02.2.6.1 Irrigation Program Controllers.

The irrigation program controller shall be of the computer type capable of fully automatic or manual operation of the system. It shall be housed, as required, in either a pedestal mounted or a wall mounted corrosion proof and weatherproof lockable cabinet. The cabinet shall have a reset circuit breaker to protect it from power overload.

The controller shall be capable of operating the number of stations indicated in the Bill of Quantities. Each station shall be capable of controlling three (3) No. 24 volt AC remote control or remote control pressure reducing valves and shall have a time setting control capable of being set for one-tenth (0.1) hour increments from zero (0) to nine and nine-tenths (9.9) hours unless otherwise specifically indicated or set to omit the station from the irrigation cycle.

The controller shall have a selector for not less than an eight (8) day program for each station with up to twenty-three (23) start times per day on each program.

The controller shall have a switch for fully automatic or manual operation or to allow valve power output to be interrupted without affecting the controller timers.

The controller shall have a remote pump start circuit to activate a remote pump start relay to run the pump during the irrigation cycle. The controller shall allow for opening the first remote control valve before operating the pump and also for closing the last remote control valve within fifteen (15) seconds after stopping the pump. The controller shall be suitable for receiving controlled signals from a remote computer-assisted control center (through an interface to be installed at a later date by others) to supervise the operation of the remote control valves.

8.02.2.6.2 Spray Heads (for spray and stream spray).

Each spray head shall be of the fixed, non-rotating spray or stream spray type and adaptable for full circle or part circle wetting patterns. It shall be made of rugged brass or durable heat resistant plastic as determined in the Bill of Quantities and suitable for rough handling.

The spray nozzles shall be so manufactured as to provide a precise and uniform spray pattern at the specified pressure and precipitation rate.

Spray head discharge rate, spray radius and operating nozzle pressure are indicated on the Drawings.

- Shrub spray heads, shall be installed at a fixed height above the finished ground level as indicated on the Drawings.

- Grass spray heads shall be of the pop-up type that retract flush with the finished ground level when out of operation. During operating, the net pop-up height shall be fifteen (15) centimeters. The pop-up extension shall be totally enclosed - when out of operation - in a sealed plastic tube, and shall be so designed as to prevent intrusion of debris, and its possible clogging or jamming.

The Contractor shall provide the test results carried out at the factory substantiating the required performance (discharge and radius of throw at the prescribed operating pressure and height above ground) and giving the actual precipitation rate and its uniformity as obtained from the uniformity test carried out using catch cans. The uniformity test shall be carried out on single spray heads selected at the rate of one (1) out of every batch of one thousand (1000) spray heads.

The tested spray heads shall be so labelled and shall accompany the test results.

Every shipment of spray heads shall be accompanied by a statement from the manufacturer certifying that the spray heads are manufactured in accordance with and meet the requirements of the Specification and are similar to the tested spray heads.

The Contractor shall include in his rates for carrying out single uniformity tests on a maximum of two (2) spray heads per shipment selected by the Engineer for every type of spray head at an independent testing organization approved by the Engineer. If the results of these tests prove to be in discordance with the results supplied by the manufacturer, as the Engineer may judge, testing shall be carried out on another four (4) spray heads at the Contractor's expense. Failure of any of these spray heads to meet the manufacturer's results will be cause for rejection of the whole shipment.

8.02.2.6.3 Bubblers. Bubblers shall be of either the adjustable flow type or the pressure compensating type, both constructed of hard durable heat resistant plastic. The discharge rate and operating pressure shall be as indicated on the Drawings. The bubblers shall have an inlet screen.

The adjustable flow bubbler shall be provided with a tamper proof adjusting brass screw that allows throttling the flow down to complete shut-off.

The pressure compensating bubbler shall consist of an integral rubber device that automatically modulates pressure and discharges the specified flow at varying operating pressure conditions, within the range of one (1) to five (5) kilograms per square centimeter.

8.02.2.6.4 Hose Bibs. Hose bibs shall be twenty-five (25) millimeters (one (1) inch) brass bib taps to BS 1010 with stepped tapered hose connections, as shown on the Drawings.

8.02.2.6.5 Drip Emitters and Tubing.

8.02.2.6.6 Polyethylene Tubing and Fittings.

Polyethylene manifold pipe and fittings shall be in accordance with BS 1972, low density Type 32 and shall be Class C (nine kilograms per square centimeter (9 kg/cm^2).

Pipe shall have welded or compression fittings to BS 864 Part 3, such that thrust blocks are not required.

Polyethylene tubing for use as drip lateral shall be extruded from virgin low density polyethylene resin, free of splits and kinds and resistant to stress cracking and rolling. The working pressure shall be three kilograms per square centimeter (3 kg/cm^2).

Drip lateral fittings shall be sturdy and durable construction with minimum flow resistance. Couplings shall be of the compression type. Connection of lateral to manifold shall be achieved using compression fittings or insert barbs with external retaining champs or collars. The fitting shall attache to the manifold by solvent cement for uPVC and by threaded connection or rubber grommet for polyethylene. Ends of laterals shall be folded over and held in place by a slide collar.

8.02.2.6.7 Emitters. The emitter shall be of the multi outlet pressure compensating type. It shall be of the continuous flushing type. The number of outlets is as indicated on the drawings. Each outlet shall be individually chambered for uniform flow. The pressure compensating feature shall be separate for each outlet and shall allow the emitter to operate over the pressure range specified on the drawings with a pressure - discharge response allowing a constant discharge over the operating pressure range.

The emitter body shall be constructed of durable heat resistant plastic suitable for direct burial or exposed application. Outlets shall have an internal barb appropriate for the diameter of the distribution tubing.

Flow regulating diaphragm shall be of high consistency silicone resistant to dilute Hydrochloric and Sulfuric acids. Flow orifices shall be able to pass one hundred fifty (150) mesh particles and bioslime produced by soil-borne organisms.

8.02.2.7 Construction Requirements.

8.02.2.7.1 Earthworks.

1. Excavation. Excavation shall not be commenced on any section of work until a full supply of pipes and fittings is available on site for that section.

Trench width up to three hundred (300) millimeters above crown of pipe shall not exceed the following:

- **for pipes not exceeding sixty-five (65) millimeters diameter: three hundred (300) millimeters.**
- **for pipes over sixty-five (65) millimeters and not exceeding five hundred (500) millimeters diameter: nominal diameter plus four hundred fifty (450) millimeters.**
- **for pipes over five hundred (500) millimeters diameter: nominal diameter plus six hundred (600) millimeters.**

Where required by the Engineer, and due to excavation being taken wider than specified, the Contractor shall provide at no additional cost an increased pipe strength or additional pipe protection.

Where excavations have been taken deeper than required, the Contractor shall bear the cost of this excessive excavation and its backfill with the required Subsection 5.03.9, "Concrete for Minor Structures" in these General Specifications unless otherwise instructed.

Excavation with battered sides shall not be permitted in public highways, private gardens or within thirty (30) meters of any building or other structure.

Embankments and other areas of fill shall be filled and compacted as specified to a height of at least six hundred (600) millimeters above top of pipe before trench is excavated.

Excavation in existing pavements shall be executed carefully and to minimum widths. Methods which will give a straight and vertical face shall be used. Pavement shall be maintained at original level.

In common trenches and where one (1) pipe is at a lower level than an adjacent pipe in a common trench, the following shall apply:

- a sub-trench is permissible provided soil is stable.
- if a sub-trench is not permissible, the whole trench shall have a depth related to the lower pipe, with increased thickness of bedding to upper pipe as necessary.
- lower pipe shall be backfilled with thoroughly compacted granular material up to a level not less than half way up the higher pipe.

2. Formation of Beds.

Excavation shall be carried out immediately before laying beds or pipes.

Unstable material, rock projections, boulders and hard spots shall be removed and replaced with approved filling material, well consolidated.

Local soft spot shall be hardened by tamping in bedding material.

In rock, excavation shall be carried out to two hundred (200) millimeters below bed level and replaced with granular material or Subsection 5.03.9, "Concrete for Minor Structures" in these General Specifications as directed.

Excavated subsoil required for backfilling shall be stock-piled in temporary spoil heaps along sides of excavations or elsewhere on the Site as instructed.

3. Bedding Materials.

Bedding shall be placed as indicated on the Drawings. Materials for bedding shall consist of the following, the appropriate type to use being indicated on the Drawings:

- Graded aggregates - granular material
  for pipes not exceeding one hundred (100) millimeters diameter: graded fourteen (14) millimeters to five (5) millimeters with not more than twenty percent (20%) passing five (5) millimeter sieve.

  for pipes over one hundred (100) millimeters and not exceeding one thousand two hundred (1200) millimeters diameter: graded twenty (20) millimeters to five (5) millimeters with not more than twenty percent (20%) passing five (5) millimeter sieve.

- Nominal single - sized aggregates - granular material
  for pipes not exceeding one hundred (100) millimeters diameter: ten (10) millimeter size.

  for one hundred fifty (150) millimeter diameter pipe: ten (10) or fourteen (14) millimeter size.

  for two hundred (200) millimeter diameter pipe and over: ten (10), fourteen (14) or twenty (20) millimeter size.

- Sand.

  Sound, clean, uncontaminated granular material, uniformly graded from three (3) millimeter maximum size, free from organic and deleterious matter, not containing more than ten percent (10%) by weight of clay or silt individually or in combination.

- Concrete Bedding, Surrounds, Arches and Haunches

  In-situ concrete Subsection 5.03.9 "Concrete for Minor Structures" in these General Specifications.

4. Workmanship.

Granular bedding shall be placed in bottom of prepared trench and carefully hand tamped to minimum thicknesses. After pipe has been laid, additional material or haunching shall be placed in successive layers not exceeding one hundred fifty (150) millimeters thick on both sides simultaneously. Spaces between pipe and side of trench shall be completely filled and carefully hand tamped without disturbing pipe.

Concrete as required shall be placed after pipe is placed, and shall be worked under pipe and joint on both sides to provide a solid and uniform bedding.

Vertical construction joints shall be formed in concrete beds, surrounds, etc., at face of pipe joints with compressible board and shall be finished to profile of concrete and pipe. Any gap between spigot and socket shall be filled with approved resilient material.

5. Backfilling.

Materials shall be as specified on the Drawings.

Initial backfill shall be brought to the level indicted on the Drawings by laying and hand compacting in one hundred fifty (150) millimeter layers.

Final backfill, unless otherwise specified, shall be material excavated from the trench, laid and well compacted in layers not exceeding three hundred (300) millimeters thick. Use of heavy compactors shall not be allowed until there is six hundred (600) millimeters cover over pipes.

When backfilling to pipes with concrete beds and surrounds, the following shall be observed:

- Backfilling shall not be started within twenty-four (24) hours of placing concrete.
- Heavy compactors and traffic loads shall be prevented within seventy-two (72) hours of placing concrete.

Temporary bridges shall be provided over trenches to prevent construction traffic damaging pipes after backfilling.

Where pipelines are laid in planted areas the upper forty-five hundredths (0.45) meters backfilling shall be of Agricultural soil.

6. Reinstatement.

Reinstatement of asphalt, concrete and gravel pavements and the like shall be with materials and to thicknesses to match the existing pavement. Materials and workmanship shall be in accordance with local authority requirements and as directed by the Engineer.

Existing pavement shall be made good and new pavement shall be the same level and profile as the existing to provide a uniform surface.

In unsurfaced areas, surface of trench and any adjoining disturbed areas shall be graded after backfilling to provide a level, smooth surface.

Reinstatement of surfaces shall be started as soon after completion of other work as is practicable, but in no case more than ten (10) days after backfilling of trenches and other excavated areas and shall be completed within a further twenty (20) days.

For road crossings reinstatement shall be initiated within twenty-four (24) hours of backfilling.

Any settlement shall be made good by the Contractor to the Engineer's satisfaction.

8.02.2.7.2 Pipe Laying and Jointing.

1. General.

Pipes shall not be lowered into trench until the pipe bed has been brought to correct grade and approved.

Pipes two hundred fifty (250) millimeters in diameter and smaller may be lowered into the trench by sliding, using two (2) ropes. Lowering shall be done using ropes, wire slings, band slings, spreader beams, etc., as recommended by the manufacturer for each type of pipe.

Before laying, pipes shall be carefully examined for damage, and tested for soundness in accordance with the manufacturer's instructions. Damaged lining or coating shall be made good or the material disposed of as directed.

Dirt and foreign mater shall be removed before lowering and construction debris shall be cleared from the inside of each pipe before jointing.

Pipes shall be laid on even formation true to grade and line with sockets (where applicable) facing up the gradient.

Bedding shall be scooped out locally to allow proper jointing and for the barrel of each pipe to bear evenly on solid ground over its full length.

After field testing, further granular material shall be laid and compacted in one hundred (100) millimeter layers to levels shown on the Drawings.

Where pipe is to be laid on a concrete bed or surround, rectangular blocks of Concrete for Minor Structures made in approved molds at least fourteen (14) days before use, shall be provided at the rate of two (2) blocks for each pipe. The blocks shall then be set and boned to the correct level on the formation bottom and the pipe shall then be properly centered and socketed. Two (2) approved hardwood folding wedges of width equal to width of concrete block shall be inserted between the body of pipe and block and driven together until pipe is brought to the exact level required. Blocks and wedges shall be left undisturbed while pipes are being jointed and concrete bed or surround is being placed. The blocks and wedges shall be of sufficient size and strength to prevent settlement of pipes. Sufficient space shall be left to enable joints to be made, tested and inspected.

When pipe laying is not in progress, open ends of pipes shall be closed with properly fitted temporary wooden plugs or standard caps as directed.

2. Jointing.

Manufacturer's instructions shall be followed regarding cleanliness of joint surfaces, lubricant or solvent used, correct location of components, provision of correct gaps between end of spigot and back of socket for flexible joints, etc.

Flexible joints shall not be deflected beyond maximum permissible angles given by manufacturer and/or relevant standard, whichever is less.

Special instructions issued by a manufacturer of proprietary joints - e.g. patent detachable flexible joints - shall be strictly complied with when laying and jointing.

Different pipe and fitting materials shall be jointed with appropriate adaptors as recommended by the pipe manufacturer.

Unless otherwise detailed on the Drawings, joints on spigot and socket pipes other than plastic pipes shall be flexible and sealed with a rubber ring or flexible gasket which shall be approved by the Engineer's Representative and shall withstand the various tests specified herein for pipelines. For pipes up to and including sixty-seven and one-half (67.5) millimeters nominal bore, the joints shall be capable of withstanding a deflection of not less than one and one-half degrees (1.5 $^{\circ}$) in any direction and for pipes over sixty-seven and six-tenths (67.6) millimeters nominal bore, one half degree (½°) in any direction. All pipes shall be capable of withstanding a "draw" of thirteen (13) millimeters over and above the initial jointing allowance. The initial jointing allowance is the gap between the spigot and the shoulder of the socket measured parallel to the center line of the pipeline and shall not be less than six (6) millimeters or greater than thirteen (13) millimeters.

3. Line and Gradient.

In open excavation, sight rails and boning rods properly painted shall be provided and maintained to ensure correct alignment of pipe runs. Sight rails shall be positioned either vertically above the lines of pipes or immediately adjacent thereto. At no time during pipe laying shall there be less than three (3) sight rails in position on each length of pipeline to one (1) gradient.

A uniform gradient shall be achieved between consecutive air valves and/or washouts.

4. Thrust Blocks.

At every fitting causing a change in the direction of flow, the Contractor shall construct a thrust block of Subsection 5.03.9 "Concrete for Minor Structures" in these General Specifications to the dimensions shown on the Drawings.

Thrust blocks shall be provided for fittings of one hundred (100) millimeters in diameter and over unless the manufacturer recommends thrust blocks for smaller diameters giving the corresponding details and dimensions.

The additional excavation required to obtain a firm thrust face against undisturbed soil shall be made after the pipeline has been jointed. The concrete for the thrust block shall be placed the same day as the excavation is carried out.

No pressure is to be applied to thrust blocks until the concrete has matured for at least three (3) days.

5. Floatation.

Where flotation of pipes may occur due to floodwater or otherwise, water shall be excluded from the interior of the pipe and sufficient backfill shall be placed above the pipe to prevent its flotation. Open trenches shall be kept clear of water.

Any pipe that has floated shall be removed and its bedding shall be corrected prior to relaying.

6. Pipes Built into Structures.

The outside surfaces of pipes to be built-in shall be cleaned immediately before installation. Protective coatings to metal pipes shall be removed as ordered. Plastic pipes shall be painted with appropriate solvent cement and sprinkled with dry coarse sand while wet.

Two (2) flexible joints or flexible patented joints shall be provided adjacent to structures. The first joint shall be placed not more than one (1) pipe diameter from the face of structure and the second not more than the following distances away from the first:

- Two (2) pipe diameters or six hundred (600) millimeters minimum for pipe diameters not exceeding four hundred fifty (450) millimeters.

- One and two-tenths (1.2) meters for pipe diameters over four hundred fifty (450) and not exceeding one thousand (1000) millimeters.

8.02.3 MECHANICAL PLANT

8.02.3.1 Scope. The Mechanical Plant covers all mechanical equipment relevant to the pumping station and water tanks, including pumping units, flow meters, extract fans, control equipment, etc., that are not covered elsewhere in these General Specifications.

The pumping station is intended for the operation of the irrigation system and shall be able to supply the design flow at the required discharge head.

The specified duty of the pumping units is based on providing the reduced pressure levels specified for the downstream end of the pressure reducing valves with a safety margin of ten percent (10%) of the required pressure. The supplied pumping units shall be able to actually provide these reduced pressure and safety margins. It is the Contractor's responsibility to check the specified duty of the pumping units against the actual hydraulic characteristics of the supplied valves, pipes and fittings taking into consideration the final elevations of all components and to modify this duty, if need be, prior to ordering the pumping units and after approval of the Engineer.

The Contractor shall coordinate the operation of all equipment and controls to ensure the adequate running of the system.

8.02.3.2 Labels, Tags and Charts. Equipment, instruments, controls, electrical devices, valves, etc., shall be labelled in both the Arabic and English languages as to duty, service or function. Labels shall be of ivorine with black surface, white incised lettering, and attached to equipment or to adjacent permanent surfaces in an approved manner.

Aluminum tags (fifty (50) millimeters diameter, one and one-half (1.5) millimeters thick) with stamped filled with black print and provided with heavy aluminum or brass hooks and chains shall be provided in lieu of labels wherever the latter cannot easily identify the equipment.

Charts indicating the schedules for equipment lubrication, maintenance and essential operating instructions shall be prepared, mounted on protected wooden plaques or six (6) millimeter Masonite boards, covered with heat bonded clear plastic laminate or framed under glass. These charts shall be permanently fixed with four (4) brass screws at approved locations to the approval of the Engineer.

Prior to preparing labels and tags, a schedule shall be submitted for approval, showing the equipment to be labelled or tagged with suggested nomenclature. Similarly a draft of the charts shall be submitted for approval.

8.02.3.3 Workmanship Generally. Work shall be executed in accordance with the conditions of the Institution of Mechanical Engineers (IME) of Britain and with equipment fully accessible for operation, maintenance and repair.

Manufacturer's recommendations on handling, loading, unloading, installing, testing and other works shall be strictly followed.

The Contractor shall submit for approval a statement giving details of the proposed method of installation prior to commencing installation.

Machinery shall be mounted on steel packings ground flat on both sides. Packing thickness shall be so selected as to take up variations in concrete foundation level. Packing shall be bedded by chipping or grinding concrete surfaces. One (1) steel packing shall be used at each location adjacent to each holding down bolt.

Machinery shall be aligned, levelled and secured by holding down bolts.

8.02.3.4 Equipment and Materials Generally. Should any equipment prove unsatisfactory or not in compliance with the Specification and the Drawings, such equipment shall be corrected, repaired or replaced at no extra expense to the Employer. Subsequent tests shall be carried out until equipment is proved to fulfil specified requirements to the satisfaction of the Engineer.

Each piece of equipment shall have a certified nameplate at a conspicuous location, permanently attached at the factory, printed or stamped clearly with the name and address of the manufacturer, equipment model number, serial number, date of manufacture, electrical characteristics, performance rating or duty, pressure, temperature, or other limitations and other pertinent data.

Bearings shall be rated and sized to ensure satisfactory and stable running without vibration under all conditions of operation for a minimum life of one hundred thousand (100,000) hours running. They shall be lubricated and protected from ingress or moisture and sand and from the climatic conditions prevalent at the site. Bearings shall be to ISO standard SI unit dimensions where practicable.

Lubrication of bearings, etc. shall be by either splash or forced systems. Oil cooling facilities shall be provided as necessary. The machinery supplier shall ensure the lubricant used for initial filling and specified in the maintenance manual is adequate for prolonged operation in the specified ambient temperatures without overheating.

The plant shall be designed to minimize routine lubrication. Lubrication intervals of not less than seven (7) days are considered acceptable. Type of lubricant and intervals of lubrication for each individual item of plant shall be entered on a working schedule, forming part of the Operation and Maintenance Literature. A list of recommended lubricants and their equivalents shall be entered in the Operation and Maintenance Literature.

Flexible couplings shall be rated to cover full range of duty, and shall be of the flexible multi pin and bush type having not less than six (6) bushes and each having an inner sleeve to allow rotation on the pin (bushes shall not be in direct contact with pin). Pins shall have shoulders for positive location and securing to bosses. Bosses shall fit tight on the shafts and shall be secured with hand fitted keys.

Couplings shall be supplied in matching balanced sets and shall be machined, balanced and marked before leaving the manufacturer's works.

Unless otherwise specified, flanges and connections provided on equipment and associated piping shall be to BS 4504: Table 10.

Fixing bolts used for fixing steel to concrete shall be ordered and supplied with the equipment and are to be self-drilling anchor bolts. Bolts, nuts and washers which will be totally or periodically submerged shall be stainless steel unless otherwise specified or shown on the Drawings.

Electrical work shall comply with the appropriate requirements of the ELECTRICAL INSTALLATIONS Section of this General Specification.

Pipework, fittings, valves and other products not specifically mentioned shall comply with the appropriate requirements of the PIPING AND APPURTENANCES Section of this General Specification.

8.02.3.5 Spares. The Contractor shall provide spares suitable for a period of two (2) years operation in accordance with the manufacturer's recommendations. Contractor shall hand-over these spares to the Ministry of Communications stores or as directed upon the final handing-over of the works.

Lists of the spares for each pumping station shall accompany the Tender.

8.02.3.6 Pumping Units.

8.02.3.6.1 General.

1. Materials.

Materials for pumps shall be suitable for pump operating conditions and adequate for total heads to which pumps are subjected. Corrosion resistant materials shall be used. Assembly arrangements shall include isolation of dissimilar metals to avoid galvanic interaction.

Pumps shall have factory plugged connections for casing vents, drains and suction and discharge pressure gauges. Pumps shall have shaft packing or mechanical seals compatible with pump design and nature of liquid pumped in accordance with manufacturer's recommendations or as specified.

Impellers and rotating assemblies shall be statically and dynamically balanced at the factory.

Packing rings shall be installed in alternate layers to staggered ninety degrees (90°). Packing shall be tightened to seal while permitting the prescribed amount of leakage for lubrication.

Operating characteristics, pump point of specified flow and head shall fall near the point of maximum efficiency as obtained from manufacturer's published data. The pump shall be able to supply in head not exceeding fifty percent (50%) of the range between specified and shut-off heads.

Horse power rating of pump drive motor shall ensure non-overloading of motor throughout capacity range of pump for impeller diameter selected.

Electric motors shall be suitable for the available electric voltage and frequency. Motor speeds shall not exceed one thousand seven hundred fifty (1750) RPM for the sixty (60) Hz.

Pumps shall be provided from the factory complete with electric motors mounted on a common cast iron or steel base and properly aligned.

2. Installation.

Pumps and motor base shall be supported where applicable on an isolated reinforced concrete foundation as detailed on the Drawings and shall be aligned and level throughout their length and width.

Piping shall be supported independently of pump connections.

Drains for packing glands and machine bases shall be piped to the nearest floor drain or sump.

Before operation the Contractor shall ensure that the pump is properly lubricated, rotating element rotates freely by hand, casing is vented and full of water, direction of rotation is correct, strainer is clean and suction and discharge valves are open.

3. Shop Drawings.

Shop drawings shall be submitted for each pump for approval prior to shipment from the factory as follows:

- **Certified performance curves showing job number, customer and customer order number, pump designation number shown on the Drawings, date of manufacture, model number, pump size, impeller diameter pump can accommodate, speed, flow-head characteristic curve, consumed horsepower curve, pump efficiency curve and NPSH curve.**

- **Pump cross-sectional drawings showing major components with parts numbers and parts list.**

- **Pump outline dimensional drawing showing overall dimensions, location of foundation bolt holes and sizes, location and rating of suction and discharge nozzles.**

- **Recommended list of spare parts.**

- **Installation, operation and maintenance instruction manual.**

- **Details and wiring diagrams of factory supplied pump controllers, starters, controls or other electrical devices or accessories.**

- Special instructions for field installation and connection of each factory or field supplied electrical device, control or accessory.

4. Shop Tests.

Certified results of shop tests made by the manufacturer for each pump shall be submitted, prior to shipment from the factory, as follows:

- Performance test throughout capacity range of pump with specified design operating point clearly indicated on the pump flow-head characteristic curve.

- Hydrostatic pressure test to one and one-half (1½)times the shut-off pressure of the pump.

The pump test report shall include the following information:

- Pump data: pump designation number shown on the Drawings, model number, serial number, customer order number, flow, suction and discharge pressures, shut-off pressure, speed, and brake horsepower.

- Motor data: make, type, model number, serial number, horsepower rating, speed, voltage, phase, frequency, class of insulation, allowable temperature rise, full load amperes, locked rotor amperes and actual voltage and amperes at all test points.

- Starter data: make, model number, size, heater size, ampere rating, line voltage, control voltage and frequency.

8.02.3.6.2 Split Case Horizontal Pumping Unit.

1. Pump.

Pump shall be base mounted, double suction, single stage, centrifugal type, directly connected to motor through a heavy duty flexible coupling, with heavy gauge coupling guard.

Pump casing shall be high tensile strength alloy case iron, designated for a working pressure of sixteen kilograms per square centimeter (16 kg/cm^2), fitted with easily removable bronze wear rings dowelled to casing. Casing shall be divided at the horizontal centerline and the two (2) halves accurately machined, dowel aligned and bolted together.

Impeller shall be bronze, enclosed double suction type, fastened to shaft by stainless steel key and screw locked adjustable shaft sleeves.

Suction and discharge nozzles shall be of in-line piping design, cast integrally with lower half of pump casing to allow rotating element to be removed without disconnecting suction and discharge flanges.

Shaft shall be high strength steel, sized to carry axial and radial thrust with minimum deflection and protected against corrosion by full length bronze shaft sleeves. Teflon gaskets shall be provided between impeller hub and shaft sleeves.

Pump rotating element shall be supported by two (2) heavy duty grease lubricated ball bearings for both radial and thrust loads, mounted in machined moisture and dustproof cast iron housings, bolted to pump casing with register fits to ensure permanent alignment. Bearing housing supports shall be cast integrally with lower half of pump casing. Bearings shall be provided with grease seals and water slingers to protect bearings from contamination, and with easily accessible grease fittings for positive bearing lubrication.

Mechanical seal shall be non-resist face, carbon washer and stainless steel parts.

Pump and motor shall be mounted on a common base reinforced against deflection, with drip rim, drain tapping, bolt holes and grouting hole.

Impeller and pump outer casing shall be factory treated by shot blasting and priming with epoxy. Casing shall then be given one (1) undercoat and one (1) top coat of chlorinated rubber of approved color to three (3) mils thickness each coat.

2. Motor.

Motor shall be supplied by the manufacturer of the pumping equipment and shall be specified for pump concerned and specifically rated for the available supply voltage and frequency and for operational ambient temperature of fifty degrees Celsius (50 °C.).

Motor shall be to IEC 34 and shall have class F insulation. It shall be tropicalized and derated for satisfactory operation.

Motor protection shall be not less than IP 54, to IEC 144.

Motor shall be sized to drive the pump without being overloaded throughout the capacity range of the pump. Maximum continuous rating shall be not less than ten percent (10%) above the calculated maximum power requirement. Efficiency and power factor shall be high over a wide range of load conditions.

Motor shall be capable of delivering full rated power within voltage and frequency fluctuations of plus or minus five percent (± 5%) of their value and for simultaneous fluctuation of both within the specified range.

Starting and torque characteristics of the motor shall be as required by the driven pump.

Motor shall be silent in operation, free from vibration. Rotors shall be perfectly balanced both statically and dynamically. They shall run on ball or roller bearings with the weight of the rotating unit carried out ball thrust bearings incorporated in the body.

Noise level of pump-motor set in dBA at one (1) meter from the enclosure shall be submitted prior to approval.

Terminal boxes shall be provided with suitable dimensions to accept incoming cables with glands for PVC armored cable.

Final motor data shall be obtained from the equipment supplier and shall be approved before any motor control center is ordered.

Motor nameplates shall be checked for full load current rating and allowable temperature rise to select the proper overload heater element to be installed in each starter.

8.02.3.6.3 Submersible Pumping Unit.

1. Pump.

The pump shall be of the submersible, centrifugal type that shall form with its electric motor, one (1) single compact unit on a combined base and suction strainer. A threaded discharge elbow shall form an integrally cast part of the pump casing. The pump shall be provided with clamp for discharge pipe and with a watertight cable entry.

The pump shall be supplied from the factory complete with the necessary low level cut-out switch, the electric control panel, all necessary lengths of durable multi-conductor electric cables between the pump, level switch and control panel, special holder for level switch and lifting chain.

The pump shall have cast iron casing, impeller, and motor starter housing. The shaft and all bolts and nuts shall be stainless steel, the impeller shall be of bronze. The pump shall have two (2) double face mechanical seals. An oil casing shall be provided within the pump to lubricate and cool the seal rings. The pump shall be fitted with bronze case wear rings and a bronze terminal cover.

The whole unit shall be externally finished in black, non-hardening, corrosion-resistant, rubber-bitumen paint or in the manufacturer's standard finish, if approved by the Engineer.

2. Motor.

The motor shall be as specified for the split case horizontal pumping unit except that it shall be of the submersible type with a degree of protection not less than IP 68 to IEC 144.

8.02.3.6.4 End Suction Centrifugal Pump.

1. Pump.

The end suction centrifugal pump shall be horizontal, base mounted, end suction, single stage, centrifugal type, directly connected to the motor through a heavy duty flexible coupling, with heavy gauge coupling guard.

The pump and motor shall be mounted on a common cast iron base adequately reinforced against deflection, with drip rim, drain tapping, bolt holes and grouting hole.

The pump casing shall be high tensile strength close grain cast iron with smooth waterways, register fitted and bolted to the bearing frame for permanent alignment. It is to be fitted with bronze wear rings and with tapped and plugged bottom drain and top vent connections.

The impeller shall be cast iron, bronze, stainless steel, enclosed type, fitted to shaft with a key and locked in place.

The shaft shall be one (1) piece stainless steel, sized to carry axial and radial thrust with minimum deflection.

The mechanical seal shall be Ni-resist face, carbon washer and stainless steel metal parts.

The pump rotating element shall be supported by two (2) heavy duty grease lubricated ball bearings mounted in a heavy iron frame with adequate supports to the base for maximum rigidity.

2. Motor.

The electric motor shall be totally enclosed, drip-proof, squirrel cage, induction type, with permanently lubricated and sealed ball bearings.

8.02.3.6.5 Motor Control Panel.

The motor control panel shall include, but not necessarily be limited to the following:

1. Starters for the main and drainage pumps and for the exhaust fans.
2. Necessary control relays and timers
3. Indicating lamps for pump in operation and "TRIP" lamp for pump out of order
4. Rotary switches and relays

5. Distribution equipment of the MCCB pattern including a main earth leakage circuit breaker to give individual circuits for pumps, lighting and LV socket outlets, ventilation fans, etc.

6. Triple pole hand operated isolating switch mechanically interlocked in front door

7. Stop/start push buttons mounted on the front door

8. Accessories required for automatic operation of pumps as described

9. Interconnecting and interlock wiring.

The panel shall be complete with all wiring and fitting with fixed terminals suitably identified for all incoming/outgoing cables.

The panel shall be a purpose made heavy gauge welded sheet steel manufactured item with protection to IP 51 as a minimum category. The panel shall be fully vermin proof, with non lift-off front door, concealed hinges, weatherproof and tropicalized construction, baked-on enamel finish and wall mounted.

The pumping system shall be interlocked with the irrigation controller, pump control valve and low level switches in the water tanks.

Pump shall be started and stopped by the irrigation program controllers. Level switches shall override the irrigation program controller to stop pump at preset minimum water level in the tank(s) through the motor control center.

The controls shall prevent the stand-by pump being started, even manually, when the duty pump is operating.

Starting sequence of pumps shall be automatically alternated through the action of the change-over relay in the motor control panel. In the event of a fault in one (1) pump, the controls shall switch off the defective pump and start stand-by pump and put on the TRIP lamp to indicate that pump is out of order. Means shall be provided for permitting manual selection of duty and stand-by pumps.

All starters shall be fitted with circuit breakers rated for the necessary short circuit protection. The protection shall be independent of the controller and overload projection.

The control voltage for all starters and for all control circuits shall not be higher than one hundred twenty (120) volts. Step-down control transformers shall have two (2) windings and be of the isolating type. HRC fuses shall be used for control circuitry protection. Auxiliary supply for controls other than from the main power circuit, shall be effectively isolated by auxiliary contacts on a main isolator.

Contactors for star-delta starters shall comply with IEC 292 and shall be type AC-3.

Overload relays for starters shall be to IEC 292-1, and inherently compensated for variations in ambient temperature.

Unless otherwise required by the driven system, magnetic starters shall be as follows:

- Three (3) phase motors above fifteen (15) horse power (up to and including fifty (50) horse power) starter shall be star-delta, non-reversing magnetic type, with a 3-pole overload relay, and one (1) adjustable low voltage relay.

- Three (3) phase motors above fifty (50) horse power, starter shall be reduced voltage, auto-transformer type.

Unless otherwise required by the driven equipment all starters shall be provided with the following control devices:

- Start-stop push buttons
- One red pilot light
- One green pilot light
- One blue "TRIP" light
- One reset push button.

It shall not be possible to open the enclosure door without putting the isolator in the open position.

8.02.3.7 Pressure Switches. Each pump other than the sump drainage pumps, shall be provided with an independent pressure switch that overrides the regular operation of the pump to shut off the pump when the system pressure has exceeded the setting of the pressure relief - check valve or pump control valve by the accuracy range of this valve, and before it reaches the shut-off head of the pump.

This switch shall be as specified by the pump manufacturer.

8.02.3.8 Water Level Controls. Level controls shall be of the fixed electrode type.

The level controls shall override the regular operation of the pump and stop all pumping when the minimum water level has been reached and shall also give audible warning of high water level. The control panel mounted button to turn off the audible warning shall also automatically reset the warning system to operate next time the water level rises above full level.

Drainage pump shall be controlled by float switches.

8.02.3.9 **Electromagnet Flowmeters.** Plant-mounting enclosures for signal converters shall be to IEC 144, standard IP 65 or better. Rack mounting enclosures shall be to IEC 144, standard IP 20 or better.

8.02.3.10 **Pressure Gauges.** Pressure gauges shall be to BS 1780, constructed in stainless steel, bronze or other corrosion resistant material. No plastic materials shall be used in construction.

Fixed pressure gauges shall be fitted with isolating valve. Gauges and transmitters shall have over range protection.

Where compensation of more than two percent (2%) of the instrument span is required for the difference in level between the instruments and the tapping point, the reading shall be adjusted and the amount of compensation marked on the dial.

The sensitivity of the gauge shall be at least five-hundredths (0.05) bar. Every pressure gauge whether forming part of the permanent works or supplied for used by the Engineer's Representatives to test any item of the permanent works shall be accompanied by a calibration and testing certificate from the manufacturer or from an independent testing laboratory.

At each pressure gauge tapping point in pumping stations, a second tapping point shall be provided to allow pressure measurement by an independent hand held pressure gauge (for further re-calibration of the fixed gauge). One (1) hand held pressure gauge shall be supplied unused in its original wrapping for each pumping station.

8.02.3.11 **Strainers.** Size fifty (50) millimeter (two (2) inch) and smaller shall be screwed Y-type, bronze body, one hundred fifty pounds per square inch (150 psi) steam working pressure rating, with 20-mesh stainless steel screen and screwed cap with one-half (½) inch tapped hole with blowdown valve installed.

Size sixty-five (65) millimeter (two and one-half (2½) inch) and larger shall be flanged, basket type, cast iron body, one hundred twenty-three pounds per square inch (123 psi) steam working pressure rating, with 20-mesh stainless steel basket screen, bolted cap and three-fourths (3/4) inch tapped hole at the bottom with blowdown valve installed.

8.02.3.12 **Electrical Indicators and Integrators.** Electrical indicators and integrators shall be for use with analogue signal transmission systems and comply with BS 89 with accuracy class index one (1.0). Indicator movements shall be critically dampened (dead-beat).

Indicators shall have circular scales or shall be of the vertical edgewise type and shall be designed to avoid parallax error. Scale shall be clearly marked in SI units and shall comply with BS 3693. All instruments mounted on one (1) panel on board or in adjacent groupings, shall have similar styles of figures and letters. Dials shall be white with black scales and lettering, not subject to fading.

The materials for scales shall be such that no peeling or discoloration will take place with age under environmental conditions.

Major scale marks and numerals shall be of the same size and thickness and shall be separated by more than twenty-five (25) minor marks. Pointers shall interpret to the width of the minor scale marks.

Integrators shall be of the multi-digit cyclometer type. Each integrator shall have an integral or separate current-to-pulse converter with sufficient adjustment of the pulse rate to avoid the use of any multiplying factor except in integer power of ten (10). Each integrator shall incorporate an adjustable limiter whereby any input below a preset value is inoperative. Integrators shall have the number of digits shown on the appropriate instrument data sheet. A decimal point shall be provided to the right of the units digit.

8.02.3.13 Fertilizer Injector Equipment. Fertilizer injection equipment shall be of the Venturi type bypassed on the main pipeline and consist of a fertilizer tank with a minimum capacity of one hundred kilograms (100 kg.) of dry chemical fertilizer, having a hinged pressure-tight cover. The connections from the tank to the pipeline shall be sized so as to allow twenty-five kilograms (25 kg.) of fertilizer to be dissolved and dispersed in forty-five (45) minutes with normal pump operation.

All parts in contact with the fertilizer shall be in corrosion resistant material.

8.02.3.14 Axial In-Line Exhaust Fans. Axial in-line exhaust fans shall be direct driven single stage cylindrical fans with bell-shaped inlets capable of changing air at the rate shown on the Drawings. Housings shall be spun from heavy gauge aluminum or hot-dip galvanized steel and be provided with heavy aluminum supporting brackets for wall mounting. The impellers shall be aerofoil made of die-cast aluminum alloy. The shaft shall be of hot rolled steel, ground polished and keyed to the wheel.

8.02.3.15 Roof Cowls. Roof cowls shall be of the spun dome type designed for roof curb mounting. Relief vents shall be fully weatherproofed and of all aluminum construction. All materials used in construction shall be solid non-ferrous.

The cowl cover shall be constructed of heavy gauge aluminum and shall comprise a square spun hinged type dome. It shall be connected to the square curb with a smooth spun venturi. The cowl cover shall be provided with wire mesh bird screen.

The damper shall be the multi-blade type.

8.02.3.16 Flexible Connectors. Flexible connectors shall be expansion joints of the stainless steel packless bellows type suitable for sixteen (16) bar water pressure. Sizes shall be the same as the pipes on which they are to be installed, with screwed ends for sizes fifty (50) millimeters (two (2) inch) or smaller, and flanged ends for sizes sixty-five (65) millimeters (two and one-half (2½) inch) and larger.

8.02.3.17 Filters. Filters shall be installed where required and as indicated on the Drawings.

The purpose of the filters shall be the removal of suspended solids from the pumped water at a flow rate equal to the capacity of the pumping station.

The capacity of each filter unit as well as the mesh size of the screen are indicated on the Drawings and in the Bill of Quantities.

The filter unit shall be of the screen type and composed of the filter housing, the screen or filter cartridge, the flush valves, the isolation valves and the pressure gauges. The filter housing shall be of the type suitable for horizontal installation manufactured from stainless steel.

The inlet and outlet connections shall be of a size and type suitable for connecting to the pump(s) discharge header on which the filter unit is to be installed. Inlet and outlet shall be provided with gate valves for isolating the filter unit from the system.

The screen or filter shall consist of a stainless steel screen for a perforation size suitable for the proper performance of the used emitters and manufacturer's recommendations. The support of the screen or filter shall consist of a stainless steel cartridge that allows an easy field replacement of the screen or filter.

The flush port shall be controlled by a solenoid operated isolation valve linked to the irrigation program controller and set to open for at least one (1) minute (or the smallest time increment of the controller) at the beginning of every irrigation cycle, to thoroughly flush the retained particles. Flushing of the filter unit shall also be automatically operated when the pressure differential across the filter has reached or exceeded three-tenths kilograms per square centimeter (0.3 kg/cm^2). This pressure differential shall be sensed by a set of pressure gauges suitably located and adequately linked to the solenoid operated valve of the flush port.

The discharge from the flush port shall be conveyed in a uPVC pipe, of adequate size, to the sump of the pumping station.

8.02.4 ELECTRICAL INSTALLATIONS

8.02.4.1 Scope. This work shall consist of the complete electrical installation to be supplied and installed for all components of the Works as detailed in the following sections and shown on the Drawings.

Work shall include the supply, installation, testing, commissioning and putting into satisfactory operation of the following:

- Pumping station electrical installation complete including electricity supply, cables and level controls.

- Irrigation control equipment including all cables to pumping stations, irrigation program controllers and remote control valves.

The work shall include the provision of shop drawings and the calculations required by the specification, as well as the provision of all literature and samples in connection with the approval of proposed equipment.

The equipment supplied shall include all necessary items for a complete installation which will give satisfactory operation, notwithstanding errors and omissions. The equipment listed in the document are therefore, indicative and not limitative.

8.02.4.2 Technical Requirements.

8.02.4.2.1 General.

All work carried out on the installation shall be carried out in a neat, workmanlike and efficient manner, so as to be accessible for operation, maintenance and repair. The work shall be in accordance with the requirements of this Specification, so that its true meaning and intent are fulfilled. This Specification and the Drawings are complementary documents, intended for the selection of equipment having general and specific characteristics as detailed in the documents.

8.02.4.2.2 Regulations and Standards.

All electrical work shall comply with the applicable government rules and regulations in the requirements of the Electric Supply Authority and carried out in accordance with the recommendations of the International Electrotechnical Commission (IEC) with reference to the following:

- Relevant standards and specifications issued by the appropriate authorities in the Kingdom of Saudi Arabia.

- IEE Wiring regulations (UK) as published by the Institution of Electrical Engineers, London.

- National Electrical Code (USA) as published by the National Fire Protection Association.

- BSI as published by the British Standards Institution.

Acceptance tests shall conform with the above mentioned "Regulation" and "Standard."

8.02.4.3 Pumping Station Installation. The supply for each pumping station shall be taken from the nearest substation/feeder pillar.

The pumping system shall be interlocked with the irrigation controller, pump control valve and low level switches in water tanks.

Wiring to motors and level switches shall be PVC/SWA/PVC multi-core cables clipped to the concrete with copper clips. Cables shall terminate adjacent to the equipment with galvanized adaptable boxes and final connections to equipment enclosed in flexible conduit. All equipment shall be bonded to earth with a separate earthing conductor. The flexible conduit shall not be used as the earthing conductor.

The lighting shall consist of waterproof bulkhead fluorescent type luminaries controlled by a waterproof switch positioned adjacent to the access ladder. Wiring shall be PVC/SWA/PVC multi-core cable. Wiring shall terminate in adaptable boxes with fixed porcelain connectors and directly to the luminaries, with heat resistant cable connecting the luminaries. Ventilation fans shall be operated by a micro switch fitted to the pump room access hatch, such that on opening, the fans automatically switch on. In addition, a timer incorporated in the panel shall operate the fans for fifteen (15) minutes in every two (2) hours. The timer shall be capable of being adjusted to vary running and operating time.

8.02.4.4 Irrigation Control. **The twenty-four (24) volt electrically operated irrigation remote control valves shall be controlled by the irrigation program controllers positioned as shown on the Drawings. A separate electricity supply shall be taken from the nearest sub-station/feeder pillar to operate each controller.**

The controllers shall be interlocked with the pumping system to ensure that the pumps operate when any of the irrigation valves is open.

The irrigation control electric cables, connecting the irrigation program controllers to the remote control valves shall be single core copper wires PVC insulated and PVC sheathed. The sizes of cables shall be commensurate with the distances between the controllers and valves, operating pressure and the manufacturer's recommendations. The cables shall be U/L approved for ground feeders directly buried and rated for six hundred (600) volts. They shall be clipped to the water pipework where practicable. Multi-runs of cables shall be tied together at one (1) meter intervals using PVC tape and clipped to the underside of the water pipework at two (2) meter intervals using plastic straps.

To allow full flexibility of the system, each valve shall have a separate control cable such that any valve sequence control may be re-adjusted.

Where required, cable junction boxes shall be fitted. These shall be purpose made boxes fitted with fixed connectors and suitable labelled. The boxes shall be fitted with glands and gasketted lid to ensure fully waterproof and dust tight conditions.

Each remote control valve shall be fitted with a fixed connector inside a waterproof box and suitable for cable tails from the valve to be connected.

All cable cores shall be fitted with marker ferrules at each end for each of identification, and all valves shall be fitted with identification labels.

8.02.5 METALWORK, PAINT AND PAINTING AND WATER RETAINING STRUCTURES

8.02.5.1 Metalwork.

8.02.5.1.1 General.

Metalwork covers all purpose-made items shown on the Drawings. These items shall be fabricated to the design shown on the Drawings and according to the material and Workmanship specified in Section 5.05 "Steel Structures and Miscellaneous Metalwork" in these General Specifications.

8.02.5.1.2 Ladders and Safety Cages.

Ladders and safety cages shall be fabricated galvanized mild steel to BS 4211 or aluminum alloy as approved.

8.02.5.1.3 Pipe Supports.

Piping shall be supported independently of equipment at close enough intervals to avoid air pockets and dirt traps.

Supports shall be located in such a way as to carry weight of pipe, valves, fittings, insulation, appurtenances and contents without sagging.

In addition to the maximum spans specified, location of supports and hangers shall take into account concentrated loads, elimination of overhung sections or bends, load reaction on terminal connections, pipe expansion and contraction, vibrations, hydrostatic thrust, hydrostatic testing, water hammer and seismic forces.

Spacing of supports shall be reduced to less than three-quarters (3/4) of maximum spans specified where changes in direction or branch connections occur.

Supports shall be located immediately adjacent to changes in direction of piping, branch connections, and concentrated loads, irrespective of maximum spans specified. Supports shall be fixed to structures with masonry expansion bolts without causing overstress to the structure.

Risers shall be supported independently of adjacent horizontal hangers.

Intermediate steel shall be provided where required to transfer loads to areas of the structure where they can be safely accommodated.

Masonry expansion bolts shall be installed in accordance with manufacturer's instructions.

Where inverts of pipelines are approximately at time level multiple piping runs can be supported in groups on trapeze hangers. Pipes shall be kept in position with U-bolts. Lines subject to extreme thermal expansion shall be free to slide or roll.

For trapeze hangers, the maximum spacing shall be that for the smallest pipe supported. Spring cushions shall be used where a horizontal pipe is subject to considerable vertical movement or vibration.

Embedded inserts shall be installed during concreting.

U-bolts shall be welded to pipes at points of contact and bolted to structural angle frame securely fixed to structure.

Temporary hangers and supports are not allowed. Wire, metal bands, rope, wood, chain, strap, or perforated bar shall not be used.

8.02.5.2 Paint and Painting. Paint and painting shall comply with Section 5.13 "Painting of Structures" in these General Specifications unless otherwise specified in the Special Specifications.

The color of the final paint shall be approved by the Engineer's Representative.

8.02.5.3 Excavation. Excavation shall conform with Section 2.09, "Structural Excavation and Backfill" in these General Specifications.

8.02.5.4 Concrete. Concrete shall conform with Section 5.01, "Portland Cement Concrete" and Section 5.03, "Concrete Structures" in these General Specifications.

8.02.5.5 Reinforcement. Reinforcement shall conform with Section 5.02, "Reinforcing Steel" in these General Specifications.

8.02.5.6 Bituminous Primer to Buried Surfaces. Shall conform with Section 5.12, "Waterproofing for Structures" in these General Specifications.

8.02.6 METHOD OF MEASUREMENT

Irrigation pipework shall be measured by linear meter for the various types and sizes of pipe specified, installed, tested, completed and accepted. Lengths of pipe shall be measured along with their centerlines and shall include lengths occupied by valves and accessories.

Valves and Irrigation Equipment. Valves and irrigation equipment shall be measured by the number for the various types and sizes of valves and items of irrigation equipment as specified, installed, completed, tested and accepted.

Electricity supply as specified shall be measured by linear meter for the various types and sizes of cables specified or as a lump sum as specified in the Bill of Quantities.

Mechanical plant for the irrigation pumping station and storage tanks including the supply, installation, test and commission shall be measured by the sets.

Electrical installations for the irrigation pumping station and storage tanks including the supply, installation, test and commission shall be measured by the set.

Civil works for the irrigation pumping station and storage tanks including the supply, installation, test and commission shall be measured for the various items as specified in the Bill of Quantities.

Suction and header pipes of the irrigation pumping station and storage tanks including the supply, installation, test and commission shall be measured by the set.

Chain link fence around each pumping station and its appurtenant storage tank(s) including the supply, erection, excavation, concrete work, one (1) double gate and one (1) single gate and all other materials, equipment, labor maintenance, as shown on the Drawings, shall be measured by linear meter.

Other irrigation items not appearing in the Bill of Quantities shall not be measured but shall be considered subsidiary to other items in the Bill of Quantities.

8.02.7 PAYMENT. The quantities, measured as provided above, shall be paid for at the contract unit prices for the several pay items as specified in the Bill of Quantities, which prices shall be full compensation for furnishing, installing, handling and testing all materials, for all labor and maintenance, equipment and all other items described in the specifications necessary for the proper completion, acceptance and maintenance of the work.

The supply of water required will not be paid for directly but shall be considered subsidiary work pertaining to the several items contained in the landscape works.

The Contractor shall supply water for his own Contract and for any additional adjacent Contracts which are served by his pumping station.

For guarantee of perfect maintenance of works according to Specification, an amount equivalent to twenty-four percent (24%) of the total amount of irrigation items shall be reserved to be paid during the maintenance period (twenty-four (24) months) at equal annual payments of twelve percent (12%) according to performance of maintenance of works as required at the end of each twelve (12) month period.

The above price and payment shall cover and be full compensation for furnishing labor, materials, equipment, tools and incidentals necessary to completing all work as specified in Subsection 1.07.2, "Scope of Payment" in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
80201	Irrigation Pipework, Cast Iron, 25 mm dia	Linear Meter
80202	Irrigation Pipework, Cast Iron, 40 mm dia	Linear Meter
80203	Irrigation Pipework, Cast Iron, 50 mm dia	Linear Meter
80204	Irrigation Pipework, Cast Iron, 80 mm dia	Linear Meter
80205	Irrigation Pipework, Cast Iron, 100 mm dia	Linear Meter
80206	Irrigation Pipework, Cast Iron, 150 mm dia	Linear Meter
80207	Irrigation Pipework, Cast Iron, 200 mm dia	Linear Meter
80208	Irrigation Pipework, Cast Iron, 250 mm dia	Linear Meter
80209	Irrigation Pipework, Cast Iron, ___ mm dia	Linear Meter
80215	Plastic Irrigation Pipe, 50 mm dia	Linear Meter
80216	Plastic Irrigation Pipe, 80 mm dia	Linear Meter
80217	Plastic Irrigation Pipe, 100 mm dia	Linear Meter
80218	Plastic Irrigation Pipe, 150 mm dia	Linear Meter
80219	Plastic Irrigation Pipe, 200 mm dia	Linear Meter
80220	Plastic Irrigation Pipe, 250 mm dia	Linear Meter
80221	Plastic Irrigation Pipe, 300 mm dia	Linear Meter
80222	Plastic Irrigation Pipe, ___ mm dia	Linear Meter
80225	Steel Irrigation Pipe, 50 mm dia	Linear Meter
80226	Steel Irrigation Pipe, 80 mm dia	Linear Meter
80227	Steel Irrigation Pipe, 100 mm dia	Linear Meter
80228	Steel Irrigation Pipe, 150 mm dia	Linear Meter
80229	Steel Irrigation Pipe, 200 mm dia	Linear Meter
80230	Steel Irrigation Pipe, 250 mm dia	Linear Meter
80231	Steel Irrigation Pipe, 300 mm dia	Linear Meter
80232	Steel Irrigation Pipe, ___ mm dia	Linear Meter
80240	(Type), Irrigation Pipe, 50 mm dia	Linear Meter
80241	(Type), Irrigation Pipe, 80 mm dia	Linear Meter

80242	(Type), Irrigation Pipe, 100 mm dia	Linear Meter
80243	(Type), Irrigation Pipe, 150 mm dia	Linear Meter
80244	(Type), Irrigation Pipe, 200 mm dia	Linear Meter
80245	(Type), Irrigation Pipe, 250 mm dia	Linear Meter
80246	(Type), Irrigation Pipe, 300 mm dia	Linear Meter
80247	(Type), Irrigation Pipe, ___ mm dia	Linear Meter
80301	Valve, Butterfly, 300 mm	Unit
80302	Valve, Butterfly, 250 mm	Unit
80303	Valve, Butterfly, 200 mm	Unit
80304	Valve, Butterfly, 150 mm	Unit
80305	Valve, Butterfly, 100 mm	Unit
80306	Valve, Butterfly, 80 mm	Unit
80307	Valve, Butterfly, 50 mm	Unit
80308	Valve, Butterfly, 40 mm	Unit
80309	Valve, Butterfly, 25 mm	Unit
80310	Valve, Air-Type I, 300 mm	Unit
80311	Valve, Air-Type I, 250 mm	Unit
80312	Valve, Air-Type I, 200 mm	Unit
80313	Valve, Air-Type I, 150 mm	Unit
80314	Valve, Air-Type I, 100 mm	Unit
80315	Valve, Air-Type I, 80 mm	Unit
80316	Valve, Air-Type I, 50 mm	Unit
80317	Valve, Air-Type I, 40 mm	Unit
80318	Valve, Air-Type I, 25 mm	Unit
80319	Valve, Air-Type II, 300 mm	Unit
80320	Valve, Air-Type II, 250 mm	Unit
80321	Valve, Air-Type II, 200 mm	Unit
80322	Valve, Air-Type II, 150 mm	Unit
80323	Valve, Air-Type II, 100 mm	Unit
80324	Valve, Air-Type II, 80 mm	Unit

80325	Valve, Air-Type II, 50 mm	Unit
80326	Valve, Air-Type II, 40 mm	Unit
80327	Valve, Air-Type II, 25 mm	Unit
80328	Valve, Globe, 300 mm	Unit
80329	Valve, Globe, 250 mm	Unit
80330	Valve, Globe, 200 mm	Unit
80331	Valve, Globe, 150 mm	Unit
80332	Valve, Globe, 100mm	Unit
80333	Valve, Globe, 80 mm	Unit
80334	Valve, Globe, 50 mm	Unit
80335	Valve, Globe, 25 mm	Unit
80336	Valve, Silent Check, 300 mm	Unit
80337	Valve, Silent Check, 250 mm	Unit
80338	Valve, Silent Check, 200 mm	Unit
80339	Valve, Silent Check, 150 mm	Unit
80340	Valve, Silent Check, 100 mm	Unit
80341	Valve, Silent Check, 80 mm	Unit
80342	Valve, Silent Check, 50 mm	Unit
80343	Valve, Silent Check, 40 mm	Unit
80344	Valve, Silent Check, 25 mm	Unit
80345	Valve, Remote Control, 300 mm	Unit
80346	Valve, Remote Control, 250 mm	Unit
80347	Valve, Remote Control, 200 mm	Unit
80348	Valve, Remote Control, 150 mm	Unit
80349	Valve, Remote Control, 100 mm	Unit
80350	Valve, Remote Control, 80 mm	Unit
80351	Valve, Remote Control, 50 mm	Unit
80352	Valve, Remote Control, 40 mm	Unit
80353	Valve, Remote Control, 25 mm	Unit
80354	Valve, Pressure Reducing, 300 mm	Unit

80355	Valve, Pressure Reducing, 250 mm	Unit
80356	Valve, Pressure Reducing, 200 mm	Unit
80357	Valve, Pressure Reducing, 150 mm	Unit
80358	Valve, Pressure Reducing, 100 mm	Unit
80359	Valve, Pressure Reducing, 80 mm	Unit
80360	Valve, Pressure Reducing, 50 mm	Unit
80361	Valve, Pressure Reducing, 40 mm	Unit
80362	Valve, Pressure Reducing, 25 mm	Unit
80363	Valve, Pressure Relief Check, 300 mm	Unit
80364	Valve, Pressure Relief Check, 250 mm	Unit
80365	Valve, Pressure Relief Check, 200 mm	Unit
80366	Valve, Pressure Relief Check, 150 mm	Unit
80367	Valve, Pressure Relief Check, 100 mm	Unit
80368	Valve, Pressure Relief Check, 80 mm	Unit
80369	Valve, Pressure Relief Check, 50 mm	Unit
80370	Valve, Pressure Relief Check, 40 mm	Unit
80371	Valve, Pressure Relief Check, 25 mm	Unit
80372	Valve, Penstock, 300 mm	Unit
80373	Valve, Penstock, 250 mm	Unit
80374	Valve, Penstock, 200 mm	Unit
80375	Valve, Penstock, 150 mm	Unit
80376	Valve, Penstock, 100 mm	Unit
80377	Valve, Penstock, 80 mm	Unit
80378	Valve, Penstock, 50 mm	Unit
80379	Valve, Penstock, 40 mm	Unit
80380	Valve, Penstock, 25 mm	Unit
80381	Valve, Gate, 300 mm	Unit
80382	Valve, Gate, 250 mm	Unit
80383	Valve, Gate, 200 mm	Unit
80384	Valve, Gate, 150 mm	Unit

80385	Valve, Gate, 100 mm	Unit
80386	Valve, Gate, 80 mm	Unit
80387	Valve, Gate, 60 mm	Unit
80388	Valve, Gate, 40 mm	Unit
80389	Valve, Gate, 25 mm	Unit
80390	Combination Valve, Pressure and Gate, 300 mm	Unit
80391	Combination Valve, Pressure and Gate, 250 mm	Unit
80392	Combination Valve, Pressure and Gate, 200 mm	Unit
80393	Combination Valve, Pressure and Gate, 150 mm	Unit
80394	Combination Valve, Pressure and Gate, 100 mm	Unit
80395	Combination Valve, Pressure and Gate, 80 mm	Unit
80396	Combination Valve, Pressure and Gate, 60 mm	Unit
80397	Combination Valve, Pressure and Gate, 40 mm	Unit
80398	Combination Valve, Pressure and Gate, 25 mm	Unit
80401	Electricity Supply, Pumping Station	Linear Meter
80402	Electricity Supply, Irrigation Equipment	Linear Meter
80403	Electricity Supply, Pumping Station	Lump Sum
80404	Electricity Supply, Irrigation Equipment	Lump Sum
80501	Mechanical Plant for Irrigation, Pumping Station	Lump Sum
80502	Electrical Installations for Pumping Station	Unit
80503	Civil Works for Pumping Station	Lump Sum
80504	Suction and Header Pipes for Pumping Station	Lump Sum
80601	Pumping Station Chain Link Fence and Gates, 1 m Height	Linear Meter
80602	Pumping Station Chain Link Fence and Gates, 1.5 m Height	Linear Meter
80603	Pumping Station Chain Link Fence and Gates, 2 m Height	Linear Meter
80604	Pumping Station Chain Link Fence and Gates, 2.5 m Height	Linear Meter
80605	Pumping Station Chain Link Fence and Gates, 3.0 m Height	Linear Meter
80606	Pumping Station Chain Link Fence and Gates, ___ m Height	Linear Meter

PART 8 - LANDSCAPING AND IRRIGATION
APPENDIX 1

COMMON NAMES AND SPECIES OF THE MOST POPULAR PLANTS WIDELY PLANTED IN THE KINGDOM OF SAUDI ARABIA

Common names and species of the most popular plants widely planted in the Kingdom of Saudi Arabia.

TREES

Acacia Arabica

Albizzia lebbek

Casuarina

Delonix regia

Eucalyptus camaldulensis

Prosopis juliflora

Schinus molle

Schinus terebinthifolius

Ficus nitida

Ficus altissima

Pithecellobium dulce

Ziziphus mauritiana

SHRUBS

Acacia farnesiana

Bougainvillea spectabilis

Bougainvillea glabra

Caesalpinia pulcherrima

Dodonia viscosa

Callistemon viminalis

Atriplex halimus

Tecoma stans

Thevitia nereifolia

GROUND COVER

Carissa grandiflora

Clerodendron inerme

Ipomoea pes-capre

Ipomoea carica

SUCCULENTS

Aloe vera

Agava americana

Opuntia

Yucca alofolia

PALMS

Phoenix dactylifera

PART 8 - LANDSCAPING AND IRRIGATION
APPENDIX 2

GENERAL REQUIREMENTS FOR MAINTENANCE OF IRRIGATION AND LANDSCAPING

Part One: Maintaining and Watering Trees, Earth Covering, and Irrigation Network

Plant Maintenance Section

1. Replacement of Plants

The replacement operation means changing the dead, weak, bent, or slow growing plants with similar types of plants or any other type agreed on by the Ministry.

The most important reasons which require plants to be replaced are the following:

(1) Death of Plant

The Contractor has to preserve all plants and find the suitable method to guarantee their safety whether the cause is weather conditions, vandalism, as a result for a third party work in the site, or because of animals.

(2) Weakness of Some Plants, Slenderness, and their Inability for Continuous Growth:

A disease might affect plants and cause their slenderness and slow down their growth, or that the type of plant may not be suitable to the soil. Other reasons may also lead to growth weakness. Therefore, it becomes better to replace certain plants with another of the same type or any other type agreed on by the Ministry.

(3) There is a defect in the plant as a twist in the stock, irregular growth, or any other reason lead to be removed.

2. Specifications of Replaced Plants

The Contractor is required to change dead or slow growing plants with new ones of the same type or any other type agreed on by the Ministry including the following specifications:

(1) Trees

1) After plantation, the main stock length has to be not less than one (1) meter above earth level.

2) The main stock has to be straight and without twist and its diameter is not less than three (3) centimeters.

3) It should be free of diseases and insects.

(2) Shrubs

1) After plantation, the shrubs length should be not less than seventy-five (75) centimeters above earth level.

2) It has many branches.

3) The green growth has to be satisfying.

4) It has to be free from diseases and insects.

(3) Earth Cover

1) The level of greenery growth has to be satisfying.

2) It should be free from diseases and insects.

3) It has to be from the existing type or any other type agreed on by the Ministry.

(4) Transplant Flowers

1) To grow the planted types in the site of the project transplant.

2) During plantation, it has to be almost flowering.

3) It has to be ready for plantation any time within the project duration.

(5) Palms

Period inspection of palms occurs every three (3) months to replace the dead palms; and time has to be suitable for palm plantation. The dead palms have to be removed one (1) week before plantation to enable soil airing and to remove the dead roots and molds, if any. The planting should be performed by adding new sand around the root area.

The planted palms shall be with the following specifications:

1) To choose Arabic palms.

2) The female palms should be not less than ninety percent (90%).

3) The stock should be free of defects and within the same length of the dead palm, and not less than one (1) meter by any means. The diameter of the stock should be not less than sixty (60) centimeters and without twists or bends.

4) The palm ball diameter size is not less than one (1) meter and the roots shall be vital; and its parts shall be cleaned before plantation.

5) The outsider leaves shall be green and within two (2) to three (3) meters of length, and its number is not less than twelve (12). The inside leaves shall be green and free of any mold.

6) Palms shall be free of diseases and insects.

7) To import the palms in the site after cleaning, and to perform the planting operation. The palm shall be wrapped with sackcloth including stock and leaves to protect the core from dryness and from the effect of heat and cold.

3. Obligations for the Replacement Operation

(1) The Contractor is required to prepare for the replacement operation as excavation, filling, additional improvements, bitumen, and fertilizers.

(2) The Contractor is prohibited, by any means, to remove any plants from its spot before informing the supervising engineer and obtaining his written approval. If the Contractor removes a tree from its place without notifying the Ministry, he will pay the estimated costs of the removed plan.

(3) During the replacement operation if it was found that some plants were not planted in their sport because of the Contractor carelessness, the Contractor will replace the plants in the right place, and the size shall equal the other plants.

(4) If the Contractor plants are different from the mentioned specifications, he will be obligated to replace them with others in accordance to the mentioned specifications on his own expense.

4. Tumbling

Tumbling operation is turning over the soil around the roots and airing it and removing accumulations and leftovers. This operation is performed as follows:

(1) It occurs every sixty (60) days and the supervising engineer identifies the tumbling and becomes included in the work schedule.

(2) The turning over is performed in the upper level in order not to hurt the roots.

(3) Remove the leftover and accumulated material before tumbling.

(4) The soil should be left without watering for two (2) days after the soil turning over for the purpose of airing it.

(5) The Contractor has to fight back worms.

(6) To remove decayed plants during the tumbling operation or by using an appropriate herbicide in accordance with the supervising engineer's instructions.

5. Fertilizing Operation

(1) Organic Fertilizers are fertilizers that originate from organic material. They are important because they include the food elements needed for the plant and improve the soil. The organic fertilizer is added once a year in early winter.

The rates for adding organic fertilizers:

1) Palms: Five (5) kilograms for each palm tree.

2) Trees: Two (2) kilograms for each tree.

3) Shrubs, flowers, and grass: Two (2) kilograms for each square meter.

The specifications of organic fertilizers:

1) It should be free of harmful material in plants or soil.

2) It should be free of decayed grass seeds.

3) Humidity shall not exceed fifteen percent (15%).

4) pH should be within six (6) to seven (7).

5) Each gram should include not less than 5000 million of bacteria.

(2) Chemical Fertilizers are divided into the following types:

1) Chemical fertilizer compounds:

It includes the main food elements as Nitrogen, Phosphore, Potassium, etc.

2) Monism fertilizers:

It includes one (1) element as uric, and is added to compensate for low iron. This fertilizer is added when one (1) element appears to be low in big quantities. It spreads out and compensates the low rate of food elements quickly.

(3) Times for Adding Chemical Fertilizers

1) The monism fertilizers shall be added when a specific soil element appears to be low.

2) Chemical fertilizer compounds shall be added periodically once every month and in accordance to the fertilizing schedule.

3) The azoic fertilizer shall be added if needed to encourage the greenery growth.

4) The fertilizer shall be added to grass after mowing.

(4) Rates of Chemical Fertilizer

1) Palms: Two hundred (200) grams for each palm.

2) Trees: One hundred fifty (150) grams for each tree.

3) Grass, flowers, and shrubs: Fifteen (15) grams for each square meter.

(5) The Method for Adding Fertilizers

1) The fertilizer shall be spread under the stock in the area surrounding the roots.

2) Organic fertilizer is added to flowers before it is planting. The chemical fertilizer is added periodically and is turned over until flowering time.

6. Applying the Trimming and Forming Operations

(1) Trimming Trees and Shrubs is based on the plant type and its purpose. It is prohibited to trim trees without obtaining the supervising engineer approval about the trimming method including the following:

1) The Contractor has to trim one (1) tree as a sample and in accordance to what is specified by the supervising engineer.

2) The trimmed sample shall be inspected, and needed modification shall be done, if any.

3) The sample shall be photographed after performing the trimming operation for the tree. The supervising engineer and the project manager shall sign on the photograph.

4) The Contractor shall obtain the written agreement to complete trimming operation to the rest of the trees in accordance with the sample.

5) Time for trimming trees:

1. Trees will falling leaves shall be trimmed after the falling by cutting the diseased and dead branches only.

2. Formation, smoothing, and removal of unusual growth shall be performed any time in the year except for the periods when temperature reaches its climax of either high or low degrees.

3. Old trees which appear to be slow in growth shall be identified and inspected by the supervising engineer to obtain his approval for severe trimming for growth renewal.

4. Shadow trees shall be trimmed very little and the branches shall be cut when necessary.

5. As for trees hindering traffic movement, it should be trimmed by removing the branches causing this problem, and after obtaining the written agreement from the supervising engineer.

(2) Cutting and Forming Gates and Fences

Plants planted for this purpose will need continuous cutting to identify their form because such cutting will renew its growth and preserve fence appearance. Plant cutting is performed in accordance with the following:

1) It is prohibited to perform the cutting operation at a low temperature, greenery slow growth during winter season, or when temperature degrees reaches its highest rates.

2) Flowering fences shall be cut before blooming with an adequate period to allow flowering buds to bloom. It should be cut after flowering in order not to form seeds.

3) When perform cutting, the fence foot shall be thicker in comparison with the top to enable reinforcing the fence.

4) Fences and gates shall be formed differently, straight and others; and designs of different forms of cutting shall be prepared. These designs are shown to the supervising engineer to choose the appropriate locations for such forms.

5) If there is a reason that affects the fences and weaken them that becomes naked from the bottom part, in this case, the fence shall be cut unto half meter in early spring, or in early autumn after the bad conditions cease. It is fertilized with organism fertilizers to encourage bottom growth and forming new branches.

(3) Trimming Individual Shrubs

1) Individual shrubs shall be trimmed yearly and when needed for the following reasons:

1. Reduce shrubs size and organize its form to suit the purpose of its plantation.

2. To get rid of unwanted growth.

3. To remove diseased, dry, and dead branches.

4. To assist in making the sun light reaches all parts of the shrubs in order to encourage flower blooming.

2) Trimming Time

1. Winter trimming shall be performed on shrubs which has flowers and bloom at summer season.

2. Shrubs that have flowers on old branches and bloom in winter should be trimmed late spring and early summer.

3. Small shrubs should not be trimmed, and it is enough to cut the dead branches.

4. Cone shrubs should never be trimmed and are left for normal growth.

7. Trees Hold and Support

(1) Purpose of Holding and Supporting Operation

1) To assist in focusing trees vertical growth in full straightness and without any twisting or bending in the main stock.

2) To assist the main stock, by different means, to carry the greenery weight if the stock is unable of carrying it.

(2) Methods of Hold and Support

Hold and supporting are two (2) escorted operations performed on all trees. The method is different in regard to the trees age, size, and purpose.

1) Trees Newly Planted

These trees would not be exceeding one (1) year of age. At this phase, there is a need to encourage the main stock growth in thickness, straightness in regard to the following:

1. Leave the lower branches without trimming and let them grown normally unless it is extremely necessary. In case of disease, the branch shall be removed after obtaining a written approval from the supervising engineer.

2. To support the plants by setting wood support in an appropriate way for trees, and in regard to the tree's case, holder, type, numbers, and method of holding. What follows is an explanation of this operation:

(1) Holders shall be made of a good type white Swedish wood that is strong and dry; its measure is five by five (5 x 5) centimeters.

(2) Holders faces shall be soft to avoid harming the plant's stock when it moves as a result of wind blowing.

(3) The wood, which the holder is made of, should not have branching pose to avoid easy breaking.

(4) The supporting holder shall be pointed from the lower part in order to get through the soil easily, and it shall be painted with the bitumen to protect the wood from water.

(5) The upper part of the supporting holder shall be painted with a green color.

(6) The supporting holders shall be of an appropriate length of the tree's stock. These holders shall be replaced with others, when needed.

2) Tree Binding

1. The binding shall be simple, and the material shall be strong to avoid continuous cutting or stock bending.

2. When binding, the stock shall be paralyzing the supporting holder, and an appropriate space shall be in-between. The stock shall not be bound strongly to the support holder to avoid hindering the stock growth.

3. Means of Binding

The binding shall be performed by the following method:

(1) A thin string of two (2) mm. and it is performed on newly planted trees. This string is soft that would not hinder its growth or harm its stock. This string is cut easily, and needs continuous rebinding.

(2) Polyethylene binders: This binder is performed for such purpose. The binding opening shall be widened or control the binding circle around the stock.

(3) String bindings of three to five (3-5) mm. wrapped with a plastic material to protect the stock. This string surrounds the stock in many ways in accordance to the binding and supporting method. The supervising engineer shall choose the best used materials in binding and in accordance to what he believes is appropriate.

3) **Method of Supporting**

The method of supporting shall be identified by the stock length, number of branches and the method approved by the supervising engineer.

4) **Trees Newly Planted**

1. A tree is supported by one holder placed during plantation and is attached to the main stock. Three holes have to be made in the holder at top, middle, and bottom with an equal distance. The stock shall be bound to the supporting holder from these three locations.

2. To support with two wood holders limiting the tree in-between with an adequate distance. In this case, three holes are made in each supporting holder and with an appropriate distance. Binding shall be made with a wire covered by a plastic cover and leaving an appropriate opening that the stock can get through during binding.

3. To support using three holders in a triangle method around the stock. The stock is located in the middle with an equal distance from each holder. The binding is made by a lean wire with a plastic cover that forms a ring around the stock of three branches. Each of the three branches are fixed to each holder.

5) **Medium Size Trees**

These trees exceed one year of age and the top branches are huge that the stock fails to carry them without a supporting holder. Wood holders will be broken as a result of the heavy top weight.

In this case, an iron pipe of thirty eight to fifty (38-50) millimeters (1.5 to 2") diameter and in accordance to the tree size, it should be fixed in the earth, and shall be bound to the stock in a straight and paralyzed direction. The bottom part of the pipes shall be painted with bitumen and a green color for the top.

6) **Huge Trees**

The main stock is unable to carry the greenery. Such trees should be supported in regard to the following:

1. Minimize the top greenery weight by cutting the branches which cause the bending of the stock.

2. Trees shall be bound with one iron wire or more in an opposite direction to the bending wide, working on vertical appearance of the tree. The wire shall be fixed to the appropriate spot in the earth.

3. Supporting and holding style shall be changed in the following conditions:

(1) When the support holders are worn out.

(2) When the support holder is not suitable to the plant's length.

(3) When the support holder is unable to assist the plant for vertical growth.

(4) When the greenery growth of the plant reaches a size that such method is not suitable for, or if the plant inclines in one of the directions. In this case the contractor should perform the following:

1) To perform a study on a group of trees to choose the most suitable supporting way to its case.

2) To work on a resupporting program in accordance to the needs of every group, and to specify its final date.

3) To demonstrate the program for the supervising engineer. After fulfilling the needed discussion and modification, the contractor shall perform the work within the specified duration.

4) If the contractor is not committed to the program, he is subject to cash deduction which is specified in the deduction statement as SR 5.00 for each tree for each day of delay.

5) In case of broken trees and as a result for the carelessness of the contractor to support the trees, the contractor has to pay the expenses of these trees since plantation.

8. Fighting Insects and Diseases

Plants are sprayed with herbicide in the following cases:

(1) Protective Herbicide

The maintenance program has to include protective herbicides to spray the insects and avoid diseases. The maintenance engineer shall perform this project in regard to the following:

1) To specify the sprayed types of herbicide.

2) To specify the used percentage of herbicide.

3) To specify the protective spraying periods; it has to be not less than three (3) yearly.

4) To perform a schedule in accordance to the different project sites. The supervising engineer shall study the protective schedule with the maintenance engineer. He has to adjust the necessary modification and approve the program before spraying. This operation has to be in regard to the special specifications and project plans.

(2) Spraying in Case of Disease

The contractor shall be committed to the following in disease cases:

1) To specify disease type.

2) To specify the used herbicide.

3) To perform spraying diseased plants twice, and the second spray is fulfilled after ten days.

4) To perform an immediate spraying program for all plants in the diseased area. The contractor shall execute this operation after obtaining the supervising engineer approval regarding the herbicide type and spray schedule.

9. Washing Operations

(1) Soil Washing

It is an operation to dissolve precipitation salt as a result of spray or drip watering. This operation is summarized by overflowing the soil with clean washing water for few days that the precipitation salt is removed. The percentage of salt in the washing operation does not exceed more than one thousand (1000) parts per million.

The contractor has to perform this operation on separate periods in the following cases:

1) To use spraying or dripping system.

2) The appearance of salt in soil, or in case of analyzing it and finding a high percentage of salt. This operation has to be performed every two months in case of using the spraying or the dripping water system, appearance of salt in the soil, and when required by the supervising engineer in accordance to the project special specification and construction plans.

(2) Washing Trees and Shrubs

Plants in streets and intersections are exposed to dust accumulations on leaves as a result of dust spreading, wind blowing, soil falling on plants when crashed with. In addition, there is the drizzle sprayed out from cars which include carbon. With accumulation of all dust and harmful material on plants leaves causing the closure of leaves openings and hindering the plants of performing vital physiological operations.

Therefore, such accumulation shall be removed by washing the plants with a strong water spray to remove the dust and to refresh the plants.

Plants shall be washed once every six months, or whenever necessary, such as after wind blowing of dust or sand. The used water in the washing operation shall be treated and clean. The operation is performed by motors that pushes the water strongly towards the plants.

10. Specifying Soil Height

The height or level of soil toward the concrete barricade would cause hindering the maintenance and the watering operations which will lead to the weakness of plant growth. The soil level height below the top of the different types of concrete barricades to provide for sufficient amounts of water; it shall be ten (10) cm. The maintenance operation has to be performed simply and easily; and the contractor has to remove soil if it exceeds the above mentioned limits, and he should add new soil if it becomes less than the specified limits. In case of replacing some plants, the Ministry has the right to ask the contractor to change the soil more or less and with a depth not exceeding twenty (20) cm. The prices shall be carried on the maintenance item in a way that the added soil is a mixture of agriculture and sand soil in accordance with the project Special Specifications and construction plans.

11. Watering

(1) Watering Periods

Watering periods shall be specified for all of the four seasons. The contractor shall present an annual and monthly program submitted five days before the end of the Higri month. The supervising engineer shall review and discuss this program with the contractor and approve it before the beginning of the next following month.

(2) Situations for Changing the Watering Schedule

1) Watering operation shall be stopped during the raining period of winter and spring. Therefore, the watering schedule shall be subject to change during this period. In this case, there is no need to obtain the supervising engineer approval to change the schedule. Watering shall be stopped since commencing rain, and the contractor has to coordinate with the supervising engineer in regard to the following:

1. To specify the retained period; and this is determined in regard to adequate rain amounts for watering plants.

2. To receive the instructions regarding water pumping as a re sult of floods.

2) If the hot temperature increases to its highest rates which will affect the plants and harm them if things are not handled immediately.

In such case, the contractor is required to increase the watering percentage to avoid damage. This will also obligate the contractor to change the watering schedule in accordance with the new estimations regarding the weather temperature, low moisture, and plants demand of water at this stage.

3) In case of reducing watering periods in regard to the Ministry request, the contractor is obligated to perform this reduction. This reduction will cause modifying the watering schedule.

4) As for the cases that the Ministry find it necessary to change the watering schedule for any particular reason and in regard to the plant's benefit, the contractor has to be obligated to follow the Ministry instructions.

12. Maintaining Palms

Palms shall be provided with a special care in all operations, and in regard to its vitality and growth.

(1) Watering

It is one of the important matters, and it should take care of the following:

1) Palms Newly Planted

Successful growth of new planted palms depend on the watering method in accommodation to the following:

<u>1</u>. The watering operation shall continue daily and for the first forty (40) days.

<u>2</u>. Palms shall be flooded with water to the area surrounding the roots and to assure the nonexistence of air around the roots.

<u>3</u>. The watering operation shall occur in moderate weather circumstances. Watering shall be avoided during hot noon time, and watering should be at early morning or at night when temperature is high at summer time.

2) Palms at the Project Site

Palms shall be watered due to the earlier mentioned quantities and periods and in accordance to the project watering schedule.

3) There are some periods that palms would demand more and special care in regard to the watering operation. These periods are the following:

<u>1</u>. Before pollination season in order to activate the pollen and to speed up early pollination.

2. Immediately after flowering because palms need of water for dates to ripen.

3. When performing the curving operation.

4. During date ripen.

5. After collecting dates because watering helps in palm vitality and assist in forming new pollen.

4) Less watering is demanded in the following periods:

1. Palms planted in an area of high water rates.

2. After completion of the majority of date ripen because watering after full ripen would lower its good qualities.

3. At winter season and during the decrease of temperature.

5) Watering operation shall not be overdone in order not to have bad palms quality of causing roots to mold.

6) At summer time and during the hot weather, watering shall not be performed during noon time when the temperature would be in its maximum. The watering operation shall be performed during early morning or late evening.

(2) Palms Replacement

Dead or slow growing palms shall be replaced with new ones and in accordance to these specification of size, greenery, and being free of insects and diseases.

Under the supervision of the supervising engineer, the contractor shall examine the palms once every three months to remove dead ones and to plant new palms in accordance with the General Specifications.

The following shall be performed when replacing the palms:

1) To provide sufficient treatment before plantation in regard to the following:

1. To clean the excavation hole and to remove the mold.

2. To leave the excavation hole exposed to the sun for the purpose of cleaning and airing it.

2) Treatment during plantation is performed in accordance to the following:

1. The planted palm shall be addressed towards sunrise direction and shall lean to sunset area.

2. Adding agriculture sand around the palm roots during plantation.

3. During the plantation, the contractor has to bury the roots and part of the main stock under the soil level without burying the core to avoid causing mold.

4. To reserve the palm core and avoid its exposure to any hits during transportation or plantation.

5. If the palms leaves are long and huge, a part shall be removed and the rest shall be cut from the top in order not to cause palm bend.

(3) Protecting Newly Planted Palms

1) Protecting newly planted palms means to cover it in a sackcloth; the area where the greenery group meet the main stock. This protection is performed for the following reasons:

1. To protect the grown top (palm core) from dryness as a result of high temperature caused by direct sun rays and therefore, its chances to live become low.

2. To protect newly planted palms from severe cold weather during the first phase of plantation.

2) Method of Protection

1. Cover fifty (50) cm. of height around the main stock and one hundred (100) cm. of height around the greenery group to assure full protection for the palm core.

2. To bind protected area, it shall be bound from top, middle, and bottom, two un-tight binds in order to avoid affecting the palm core.

3) To remove the sackcloth cover from palms after the growth of new leaves and being confident of successful plantation after the growth of new leaves. The cover shall be removed so that the grown top is exposed to sun and air. Continuous covering shall cause lots of damages as follows:

1. Slow growth of the top part as a result of not being exposed to sun light.

2. Continuity of cover shall lead to insects gathering and which will cause palm disease and death.

(4) Trimming of Palms

Palms shall be trimmed once a year to remove dry leaves.

1) Periods for performing the trimming and smoothing operation.

There are two times to perform this operation and they are:

1. Before performing pollination.

2. After collecting dates at the end of the fruit season.

The trimming and smoothing shall be specified in accordance to work schedule.

2) Trimming and Smoothing Provisions

1. The trimming operation shall be limited to dry leaves only which have ceased to function. It is prohibited to remove any green leaves unless it is really necessary and after obtaining the supervising engineer approval.

2. When trimming, the dry leaves shall be removed from the base and the cutting shall be regular and in one level.

3. Dry leaves foot shall be trimmed and smoothed; this operation shall form the palm and give it a good appearance.

(5) Palms Pollination

Work shall be performed on fertile palms at the project location by transporting the male palm seeds to the female ones. Therefore, special care shall be provided to make this operation successful at a very high percentage. The following should be performed:

1) Pollination shall be performed under the sun rays.

2) This operation shall be avoided during rain falls, clouds, and fogs.

3) To put in the date bunch the pollination seeds which will pollinate the female flowers in it.

4) The pollination seeds shall be taken from a male palm tree that has the following specifications:

1. Pollination seeds shall be vital and of strong smell.

2. The male palm shall produce a number of big size flower sleeves.

3. The pollination shall be taken from a palm known of its fertility and vitality.

4. The flowers shall not fall down when it dries.

5) Method of Pollination

1. After completion of the spadix growth, the pollination man shall climb up to the palm to perform the pollination by putting an adequate quantity of the pollination seeds from 1-5 in each female date bunch. It shall be put upside down to enable the pollination seed to fall down on the female flowers, and it shall be bound around the date bunch for a few days.

2. The pollination operation shall be performed immediately after the opening of the female date bunch because any delay would cause less fertility.

(6) Palm Curving

This operation means to modify the palm case after completion of the pollination and fruit clutch to take its normal position in curving down.

This operation is performed when dates begin to be big in order to avoid disorder with the leaves which will hinder its growth and dates collection after ripen.

1) Curving Time

This curving operation shall be performed in accordance with the palm case and with the following:

1. After the dates begin to be big.

2. Before the palm case is dry and becomes broken.

3. Before intertwisting with the leaves.

2) Curving Method

The date branch shall fall down and pull its neighboring leaves in accordance to its case.

(7) To Adjust the Curved Palms

Some facts would cause the palm to bend and form a lean position as a result of uneven growth or car accidents which will cause the palm inclination from its straight position.

Therefore, the contractor has to adjust curved palms, or he has to inform the supervising engineer to adjust such palms to form a straight position without any bending or inclination.

(8) Fertilizing Palms

A great care shall be provided to fertilization in order to substitute the soil food elements by applying organic and chemical fertilizers that were mentioned before.

(9) Protection Against Insects and Diseases

1. Protective spraying in accordance to the project spraying schedule.

2. Treatment spraying in case of disease shall be done by spraying all the palms in the area with the appropriate herbicide twice within an interval of seven or ten days.

(10) To collect the palms dates and submit it to the Ministry under the supervision of the supervising engineer.

13. The contractor has to remove the water which will be gathered in some of the areas and which will hurt the plant that is caused by rain fall or any other.

Part Two: Irrigation System

The irrigation system contains several units; they are as follows:

1. Main Line

(1) To assure the nonexistence of any leaking; there are two types of leaking.

1) The First Type

Simple leaking, and it is usually found at the joints. This leaking would not be clarified in the main water pressure of distribution.

2) The Second Type

Severe leaking is a result of a break in the main line, and this will be clear in the pumping station that the pressure would go down less than the required measure limits. The pumping machine will stop automatically as well as the substitute one. An additional light shall be exposed to indicate low pressure and cease of the pumping work.

(2) To be certain of the working of the valve air vacuous:

The leaking shall exist as a result of the blemish.

2. Tube Boxes

(1) To be sure of the box safety of any break.

(2) To be sure of the good work (go back to the factoring instructions and the design plans) and to be sure of reducing the pressure.

(3) The overall inside and outside cleaning of the box, and to be sure of no water leaking to the inside of the box.

3. The Minor Line and Holders

(1) To be sure of the nonexistence of any leaking in the minor lines.

(2) To be sure of the right direction for the sprayers (go back to the design plans).

(3) To clean the filter periodically, and this filter is located inside the sprayers. As for the water dripping, the following has to be noted:

1) To clean the main filter periodically and to assure it is clean and undamaged.

2) To be sure of opening the dripping holes.

3) To be sure of the tubes joints safety between the dripping and the plants.

4. Maintaining the Drippings

The contractor has to perform the periodical maintenance for the drippings, and especially for the following:

(1) To be sure of nonexistence of any breaks in the dripping body and to replace the damaged ones.

(2) To be sure of the nonexistence of any breaks in the tube (flexible tube) and to replace the damaged one, if any. Also, to be sure the tube is clean and the nonexistence of any obstructions.

(3) To disconnect the dripping from the main watering tube and then wash the dripper with clean water and to remove the salt settled on it.

(4) To replace the damaged filter of drippers.

(5) To install the final drippers and make a test to be sure of the work accuracy and the quantity of water coming out of each dripper.

5. Maintaining the Sprayers

The periodical maintaining schedule is performing the following:

(1) To assure the nonexistence of any leaking out from the sprayer. This is clear if there is a water gathering around the sprayer area.

(2) To maintain the sprayer:

1) To disconnect the sprayer and clean the water drainage. It has to be noted not to use an iron material as iron wires in cleaning the drainage which will cause it to widen and lead to a change in the watering design. The cleaning is executed by pressured air and water.

2) The sprayer filter shall be cleaned periodically to preserve the appropriate water and that the sprayers shall last longer.

6. Maintaining the Operation Controlling Machines

The following shall be taken care of:

(1) To be sure of the control machine box safety and the nonexistence of any damage or rust to the outside body and the box door.

(2) To be sure of the safety of all electrical joints and make sure of its good condition and replacing the damaged ones.

(3) To be sure of the machine operating keys and its being in good condition and that the machine is working accurately. Also, the damaged keys shall be replaced .

KINGDOM OF SAUDI ARABIA
MINISTRY OF COMMUNICATIONS

GENERAL SPECIFICATIONS
FOR
ROAD AND BRIDGE CONSTRUCTION

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PART NINE
TRAFFIC CONTROL DEVICES
AND WORK ZONES

PART NINE TRAFFIC CONTROL DEVICES AND WORK ZONES

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PART NINE: TRAFFIC CONTROL DEVICES AND WORK ZONES

SECTION 9.01 - INTENT OF THE CONTRACT

Section 9.01 Intent of Contract. The intent of the contract is to provide for the safe construction and completion of the work described. It is also the intent of the contract that the work be performed in a manner that assures the safety and convenience of the road users and protects the residents and property adjacent to the project.

The contract contains both temporary and permanent Traffic Control work items to safely accommodate public traffic through construction and maintenance work zones and upon completion of the construction and maintenance works.

SECTION 9.02 - TRAFFIC CONTROL THROUGH WORK ZONES

9.02.1 DESCRIPTION. **This Work shall consist of the safe accommodation and protection of traffic through or around construction and maintenance work zones; the establishment, construction, maintenance, and obliteration of detours; and the furnishing, erection, moving, replacing, cleaning, and removing of all traffic control devices, in reasonably close conformity with these General Specifications, the Special Specifications, the plans, including Traffic Control Plans (TCP's), the MOC Manual on Uniform Traffic Control Devices (M.U.T.C.D.), and Work Zone Traffic Control Handbook.**

ITEMS IN BILL OF QUANTITIES

Traffic Control Management
Flashing Warning Arrow Panels
Barricades
Traffic Cones and Tubular Markers
Temporary Signs
Plastic Traffic Drums
Flaggers
Pilot Cars
Portable Crashworthy Safety Barriers
Moving Crashworthy Safety Barriers
Remove and Reset Portable Impact Attenuators
Temporary Guardrail
Truck Mounted Attenuators
Portable Impact Attenuators
Temporary Pavement Markings
Temporary Raised Pavement Markers
Temporary Rumble Strips
Temporary Speed Bumps
Pavement Marking Removal
Vertical Panels
Chevrons
Warning Lights
Hazard Identification Beacons
Temporary Variable Message Signs
Temporary Traffic Signals
Channelizing Devices on Flexible Supports
Detour Bridge

9.02.2 WORKSITE TRAFFIC SAFETY SUPERVISOR. **The Contractor shall provide a competent worksite traffic safety supervisor for the project who is someone other than the Project Manager. This supervisor shall be identified no later than at the preconstruction conference and the supervisor's address and phone numbers provided. The worksite traffic safety supervisor shall be responsible for and coordinate the safe handling of traffic through the work zone and shall have the following minimum qualifications:**

1. Have completed an approved training course in the safe handling of traffic through highway work zones.

2. Understand the contract and M.U.T.C.D. requirements.

The worksite traffic safety supervisor shall perform the following:

1. Inspect and correct the condition and position of traffic control devices in use each work day and night.

2. Review equipment operation and storage, and material handling and storage relative to traffic safety.

3. Hold traffic safety meetings with the engineers and superintendents of the Contractors prior to beginning Construction and periodically thereafter as necessary or as directed by the Engineer.

4. Furnish a weekly written certification to the Engineer that daily and nightly inspections were conducted and that project traffic control devices met or exceeded the contract requirements. Report all changes or corrective actions taken to maintain and protect traffic through the project.

5. Prepare and submit traffic control plans and working drawings and alternate traffic control proposals according to Subsection 1.03.2, "Plans and Working Drawings" in these General Specifications.

6. Prepare or obtain from Police and submit to the Engineer accident reports on all accidents occurring within the Project limits for the duration of the project.

If the plans or Special Specifications do not contain traffic control plans and working drawings, it is the contractor's responsibility to prepare them, including geometric, pavement structural section and cross section detour layouts, sign and other traffic control device locations and traffic handling schemes. They shall be submitted to the engineer and forwarded, with the consultant's recommendations, to the Ministry Road Services Department for final review and approval.

9.02.3 MATERIALS, EQUIPMENT AND INSTALLATION. Traffic control devices shall conform to the material requirements in the contract provisions. Cases, conditions, and details not covered in the plans, in these General Specifications or the Special Specifications shall conform to the applicable provisions of the Ministry's latest M.U.T.C.D., STANDARDS FOR ROAD SAFETY FEATURES, HIGHWAY DESIGN MANUAL VOLUME 4 - STANDARD DRAWINGS, AND OTHER MINISTRY ROAD SERVICES DEPARTMENT STANDARD APPLICATION MANUALS including their Work Zone Traffic Control Handbook.

9.02.3.1 Sign Faces. All sign faces, barricades, vertical panels, tubular markers and flaggers paddles shall use sheeting meeting the requirements of Paragraph 9.05.2.9, "Retro-reflective Sheeting" in these General Specifications. These devices shall be maintained at no less than fifty percent (50%) of their original reflectivity throughout the period of the contract. Installation shall be in accordance with M.U.T.C.D. Section 5.02.

9.02.3.2 Sign Plates. Sign plates, one side of which is less than one and one-tenth (1.1) meter, shall have a three (3) millimeter thickness. For plates, one side which is more than one and one-tenth (1.1) meter, the thickness shall be five (5) millimeters. All sign plates shall conform to the requirements of Paragraph 9.05.2.8 "Sign Panel Materials" in these General Specifications.

9.02.3.3 Sign Posts. Sign posts for temporary signs may be standard industrial billet or rail steel pipe, flanged U-channel, or I channel (I.P.E.) as detailed in Paragraphs 9.05.2.4 "Steel Channels," 9.05.2.5 "Standard Industrial Sign Supports" and 9.05.2.6 "Object Marker and Delineator Posts" in these General Specifications except that galvanizing of sign posts for temporary signs is not required. Steel pipe and I.P.E. sign supports shall have a slip base breakaway support in accordance with the M.O.C. Sign Erection Standards Manual (TS-O2). Signs requiring two (2) or three (3) posts shall use I.P.E. posts in accordance with the M.O.C. Road Services Department "DIMENSIONING OF SIGN POSTS AND FOOTINGS FOR DIRECTIONAL SIGNS."

9.02.3.4 Barricades. Type I or II barricades shall be constructed of wood, metal, or plastic. The Type I barricades shall collapse when tipped over. Plastic pipe for Type II barricades shall conform to ASTM D2729. Installation shall conform to M.U.T.C.D. Section 5.03.

9.02.3.5 Traffic Cones and Tubular Markers. Cones and tubes shall be manufactured of a material capable of withstanding vehicle impact without damage to the cones or tubes. Red shall be the predominant color of cones and tubes. The cones shall be a minimum of seven hundred (700) millimeters high and have a retro-reflectorized yellow band at least one hundred fifty (150) millimeters in width placed no more than seventy-five (75) millimeters from the top of the cone. This increased cone height supersedes the shorter minimum cone height shown in the M.U.T.C.D. Subsection 5.03 B. Cones and tubes shall be capable of remaining upright during normal traffic flow and wind conditions in the area where they are used. Installation shall conform to M.U.T.C.D. Sections 5.06 and 5.07.

9.02.3.6 Vertical Panels. Vertical panels shall be constructed of wood, metal or plastic with retro-reflectorized red stripes on a retro-reflectorized yellow background. They shall be three hundred (300) millimeters in width and shall have a vertical dimension of nine hundred (900) millimeters. Installation shall be on a post or other non-flexible support and conform to M.U.T.C.D. Subsection 5.03C.

9.02.3.7 Plastic Traffic Drums. Traffic Drums shall be commercially constructed out of plastic. They shall be a minimum of approximately eight hundred (800) millimeters high and a minimum of approximately five hundred (500) millimeters wide with stepped taper shape for ease of stacking and transportation. The markings on each drum shall consist of at least two horizontal retro-reflecting yellow and two red bands which completely encircle the drum. Bands shall be between one hundred (100) millimeters and two hundred (200) millimeters in width. Installation shall conform to M.U.T.C.D. Subsection 5.03D. Metal barrels are not acceptable and are not to be used.

9.02.3.8 Temporary Guardrails. Temporary guardrail shall generally conform to Section 6.01, "Crashworthy Safety Barriers" in these General Specifications and the M.U.T.C.D. for posts and steel rail. Used guardrail material will be permitted providing it is neat in appearance, straight and is approved by the Engineer. Certificates of Guarantee will not be required for used rail if the rail apparently meets the dimensional and other physical requirements of Section 6.01 "Crashworthy Safety Barriers" in these General Specifications.

9.02.3.9 Portable Crashworthy Safety Barriers. Portable crashworthy safety barriers shall conform to the requirements of Section 6.01, "Crashworthy Safety Barriers" in these General Specifications and the M.U.T.C.D. for the Type specified; modified, if necessary, for temporary installation. They may be new or used, provided they are in good condition. Use and placement shall meet the requirements of the M.U.T.C.D., Subsections 5.03F and 5.06D3. Polyethylene water-filled portable crash worthy safety barriers may be used in lieu of concrete if approved by the engineer as meeting all performance requirements.

In every case, individual Portable Crashworthy Safety Barriers shall have provisions for full strength connection between adjacent barrier sections and proper crashworthy end treatments such as portable impact attenuators, or safe tapers used in accordance with the M.U.T.C.D. and safe clear zone requirements. These connection and end treatments must be established in every installation of Portable Crashworthy Safety Barriers.

9.02.3.10 Moving Portable Crashworthy Safety Barriers. Moving Portable Crashworthy Safety Barriers must be done using equipment (transfer vehicle) that has been inspected and demonstrated to produce satisfactory performance in a safe manner.

9.02.3.11 Remove and Reset Portable Impact Attenuators. When portable impact attenuators are no longer required as crashworthy end treatments for crashworthy safety barriers or to shield other hazards they shall be removed and reset as crashworthy end treatments on other temporary work zone crashworthy barriers or hazards as directed by the engineer. New portable impact attenuators shall not be used when existing portable impact attenuators can be removed and reset. The removal and resetting shall be done in a safe manner and include the replacement of any parts lost or damaged in the removal process.

9.02.3.12 Truck Mounted Attenuator (TMA). Truck Mounted Attenuators which meet the U.S. National Cooperative Highway Research Program (NCHRP) 350 requirements for one hundred (100) kilometers per hour (kph) impacts shall be provided.

9.02.3.13 Portable Impact Attenuators. Portable Impact Attenuators which meet the U.S. NCHRP 350 requirements for one hundred (100) kilometers per hour (kph)

impacts shall be used at all barrier ends with tapers away from traffic of less than 15:1, and when the end will not be outside the required clear zone. The majority of the Portable Impact Attenuator must be reusable after a design impact.

9.02.3.14 Battery Operated Warning and Delineation Lights (Flashing or Steady). Types A, B and C warning and delineation lights shall meet the minimum requirements of and be used as specified in the M.U.T.C.D. Section 5.05. Steady lights shall be used to outline intended traffic paths on safety barriers, plastic traffic drums and other channelization devices.

9.02.3.15 Warning Flashing Arrow Panels. Types A, B and C Warning Flashing Arrow Panels shall meet the minimum requirements and be installed to conform to M.U.T.C.D. Subsection 5.05C.

9.02.3.16 Hazard Identification Beacon. The beacons shall be installed and have a yellow lens with a visible diameter of at least two hundred (200) millimeters and preferably three hundred (300) millimeters. It shall give a yellow round traffic signal indication and flash at a rate of not less than fifty (50) or more than eighty (80) times per minute in accordance with the M.U.T.C.D. Subsection 5.05B.

9.02.3.17 Temporary Variable Message Sign. The Contractor shall provide and operate variable message signs where shown on the plans and as directed by the Engineer. The signs shall be self-contained and trailer mounted.

The sign system shall consist of a three-line matrix panel assembly, controller, power source and structural support system. The message display shall be visible and legible from a distance of not less than three hundred (300) meters. Messages shall be cycled so that three message cycles are displayed to the driver while approaching the sign at ninety (90) kilometers per hour from three hundred (300) meters. The trailer and sign support system shall be painted red and/or yellow.

The unit shall be capable of operating on a continuous basis for not less than five days. The unit shall be capable of raising and lowering the message panel electrically and manually in the vertical axis and rotating it thirty (30) degrees in a horizontal axis. While in the raised position the bottom of the sign panel shall be a minimum of two and four-tenths (2.4) meters above the pavement surface. The sign panel shall be capable of rotating three hundred sixty (360) degrees and be stopped in any position.

The sign panel shall be three lines in height, and shall contain at least eight modular and interchangeable matrix assemblies per line. Each modular matrix assembly shall be capable of displaying a character.

The controller shall be easily located and accessible to allow the entry of all sign and message functions from a control cabinet on the trailer mounted unit.

A keyboard shall be incorporated into the controller to allow the user to generate and store a minimum of twenty (20) preprogrammed messages and any message

entered by operator. The controller shall have the capability of retrieving all messages stored in the temporary memory for as long as the sign panel is in operation.

A START/STOP switch shall be provided on the controller to activate the power supply and sign panel. An entry code shall be required to gain entry to the controller to access the memory and display messages on the exterior sign panel.

The sign shall be either bulb or dot matrix. Other types such as flipdisk, LED and fiberoptic will be considered for acceptance only if they meet all the sign system requirements contained in this paragraph.

Bulb Matrix Variable Message Sign - The sign panel assembly shall contain eight lamp bank matrices of a minimum of 7 X 5 lamps per line. The lamp bank shall display up to eight characters minimum, forty-five (45) centimeters minimum in height.

The lamps shall be rugged, high performance, high fluorescent yellow, fifty (50) millimeters in diameter, sealed beam units. The lamps shall be rated at twenty-four (24) volts, twenty (20) watts with a light output of eight hundred (800) foot-candles minimum.

Dot Matrix Variable Message Sign - Each dot matrix assembly shall contain electromagnetically activated dots. Dot color shall be fluorescent yellow. Illumination of the sign panel shall be by internal backlight. Activation of the backlight system shall be by photo cell system to measure both vertical and horizontal ambient lighting. A manual over-ride switch shall be provided to deactivate the photo cell system.

The Contractor shall operate the variable message signs including setup, computer program, placing (or moving as directed), and maintenance of the signs. All fuel or refueling costs shall be included. The signs may be partially solar powered or even totally solar powered if sufficient power can be generated and stored for day and nighttime operation.

9.02.3.18 Temporary Raised Pavement Markers. Temporary raised pavement markers shall be retro-reflective or non-reflective. The retro-reflective markers shall comply with the requirements contained in Subparagraph 9.03.2.5.4, "Type C Markers" (Plain Prismatic Retro-reflectors) in these General Specifications. The non-retro-reflective markers shall comply with the requirements contained in Paragraph 9.03.2.6 "Ceramic Raised Pavement Markers" in these General Specifications. Installation and application shall conform to Paragraph 9.03.3.5 "Retro-reflective and Ceramic Raised Pavement Markers" and Subparagraph 9.03.4.2.4 "Retro-reflective and Ceramic Raised Pavement Markers" in these General Specifications.

9.02.3.19 Temporary Pavement Marking and Markers. Temporary traffic markings may be retro-reflectorized or thermoplastic retro-reflectorized or epoxy thermoplastic retro-reflectorized traffic paint or pressure sensitive preformed marking tape. It may also be supplemented with Type C temporary retro-reflective raised pavement markers (Plain Prismatic Retro-reflectors). Preformed tapes shall be removable or non-removable. Removable tape shall be capable of being removed intact or in large strips. Non-removable tape is designed to remain in place. Tape shall consist of glass spheres of a high optical quality imbedded into a binder on a suitable backing that is precoated with a pressure sensitive adhesive. The spheres shall be of uniform gradation and distributed evenly over the surface of the color standards for pavement markings and shall be readily visible when viewed under automotive headlights at night. The marking tape, when applied in accordance with manufacturer's recommended procedures, shall be weather resistant and shall show no appreciable fading, lifting, or shrinkage during the useful life of the marking. The tape, as applied, shall be of good appearance, free of cracks, and the edges shall be true, straight, and unbroken.

Temporary markings shall be placed each day before traffic is allowed to use the section during nighttime. Very short sections may utilize temporary raised reflectorized markers only, if approved by the engineer.

Painted markings shall conform to Section 9.03 "Traffic Markings" in these General Specifications. Retro-reflective raised pavement markers shall also conform to Section 9.03, "Traffic Markings" in these General Specifications. They shall be white (crystal), yellow, or red, or a combination thereof, as required by the Plans or M.U.T.C.D. Installation shall conform to M.U.T.C.D. Section 5.04.

9.02.3.20 Temporary Delineators. Temporary delineators shall conform to the requirements of Section 9.05 "Highway Signing" in these General Specifications and the M.U.T.C.D. Installation shall conform to M.U.T.C.D. Subsection 5.04C.

9.02.3.21 Temporary Speed Bumps and Type B Rumble Strips. Temporary speed bumps and rumble strips shall comply with the materials and installation requirements contained in Paragraphs 9.04.3.1, "Speed Bumps" and 9.04.3.3, "Type B Rumble Strips" in these General Specifications.

9.02.3.22 Channelizing Devices on Flexible Supports. Channeling devices on flexible supports shall be used in work zone areas where channelization devices are frequently impacted by errant vehicles on high or low speed roadways. Theses devices shall be fabricated to withstand repeated impacts with minimal maintenance to devices and damage to vehicles. Devices shall be erected on a fixed, portable or driveable flexible base as detailed in the traffic control plans (TCP) or as approved by the Engineer. Fixed bases shall be surface mount or driveable type.

All sign panels for channeling devices on flexible supports shall be manufactured from polyethylene that have excellent resistance to temperature extremes and ultraviolet degradation.

Portable bases shall be fabricated from a flexible material such as virgin rubber and/or recycled rubber with an approximate weight of seventeen (17) kilograms.

Pavement surfaces shall be prepared in a manner that will insure proper bonding of adhesives and surface mount bases to the pavement surfaces. Adhesives shall be prepared and applied as per manufacturers recommendations.

Application and removal of devices shall not cause detrimental effects to the final pavement surfaces including pavement surface discoloration or surface integrity. Driveable bases shall not be permitted on final pavement surfaces. All application and removal procedures of fixed bases shall be approved by the Engineer.

Channeling devices on flexible supports shall generally be of five (5) types: Opposing Traffic Lane Divider, Construction Object Panel, Vertical Panel, Chevron Alignment and Channelizer.

The Opposing Traffic Lane Dividers are delineation devices used as center lane dividers to separate opposing traffic on a minimum two-lane, two-way operation. The rectangle upright double panels shall be approximately three hundred (300) millimeters wide by five hundred (500) millimeters set on a flexible support with the top approximately one (1) meter above the road surface as shown in the M.O.C. Road Services Department Work Zone Traffic Control Handbook. The legend on the panels shall be two opposing retro-reflectorized arrows on a retro-reflectorized yellow background with a red border similar to those on the two-way traffic sign (W18-1 in the M.O.C. Manual on Uniform Traffic Control Devices Subsection 5.02.F.3).

The Construction Object Panels (COP) are rectangular upright single or double panels approximately three hundred (300) millimeters wide by five hundred (500) millimeters high having one hundred (100) millimeter wide retro-reflectorized red stripes on a retro-reflectorized yellow background set on a flexible support with the top of the panel approximately one (1) meter above the road surface as shown in the M.O.C. Road Services Department Work Zone Traffic Control Handbook. They shall be used to delineate construction objects or areas such as gore areas.

The vertical panels are rectangular upright single panels approximately three hundred (300) millimeters wide and nine hundred (900) millimeters high having the same legend as those described in the M.O.C.M.U.T.C.D., paragraph 5.03.C except that it shall be set on a flexible support with the top of panel approximately one and five-tenths (1.5) meter above the road surface as shown in the M.O.C. Road Services Department Work Zone Traffic Control Handbook.

The chevron alignment panels shall have the same legend and size as those described in M.O.C.M.U.T.C.D. paragraph 5.02.F.11 except that it shall be set on a flexible support with the top of the panel one and five-tenths (1.5) meters above the road surface as shown in the M.O.C. Road Services Department Work Zone Traffic Control Handbook. Chevron alignment panels may also be set on the top of plastic traffic drums and concrete crashworthy safety barriers on shortened bases but with the top of the panel still one and one-half (1½) meters above the ground surface.

The tubular channelizer is a flexible surface mounted tubular channelizer specifically designed for channelization of construction work zone traffic through Two (2) Lane-Two (2) Way detours. The vertical tubes shall be made of polymer alloy weighing a minimum of one and seven-tenths (1.7) kilograms (with base). The tubes shall have a diameter of seventy-five (75) millimeters and a minimum height of nine-tenths (0.9) meters. They shall be of red color with a minimum of three (3) retro-reflective yellow

stripes with a height of seventy-five (75) millimeters each as shown in the M.O.C. Road Services Department Work Zone Traffic Control Handbook.

9.02.3.23 Detour Bridge Materials. Detour bridge materials shall be as specified in the plans and Special Specifications. Other than new materials may be used if approved by the Engineer, provided they can be properly identified and exhibit no detrimental damage.

9.02.3.24 Safety Vests. All workers, supervisory personnel, supervising consultants and Ministry officials involved in work zone traffic control or work zone construction operations must wear safety vests for their protection and identification by passing traffic. The color of the vests shall be retro-reflective red.

9.02.3.25 Aggregate Subbase for Detours. The aggregate subbase materials used in the construction of detours shall comply with the requirements for Grading I or II in Subsection 3.02.2, "Materials" in these General Specifications.

9.02.3.26 Aggregate Base for Detours. The aggregate base materials used in the construction of detours shall comply with the requirements for Grading I, II or III in Subsection 3.03.2, "Materials" in these General Specifications.

9.02.3.27 Bituminous Concrete for Detours. The bituminous concrete used in the construction of detours shall comply with the material requirements for Subsection 4.05.9, "Minor Bituminous Concrete" in these General Specifications.

9.02.4 CONSTRUCTION REQUIREMENTS.

9.02.4.1 General. The Contractor shall install and maintain temporary traffic control devices adjacent to and within the project according to the approved traffic control plans and working drawings, the M.O.C. M.U.T.C.D and the M.O.C. Road Services Department Work Zone Traffic Control Handbook. The Contractor shall install and maintain traffic control devices as follows:

1. Furnish and place traffic control devices before the start of construction operations.
2. Install only those traffic control devices needed for each stage or phase.
3. Relocate temporary traffic control devices as necessary.
4. Remove devices that no longer apply to the existing conditions.
5. Immediately replace any device that is lost, stolen, destroyed, inoperative, or damaged or when its retro-reflectivity is reduced by fifty percent (50%) of its required initial retro-reflectivity.
6. Keep temporary traffic control devices clean and their reflectivity well maintained.
7. Remove all temporary traffic control devices upon contract completion or when approved.
8. Cover or remove all conflicting permanent signs during the work period.
9. Provide acceptable Truck Mounted Attenuator (TMA) protection for all shadow and barrier vehicles.

The provision of an adequate supply of electrical power for the proper operation of warning lights, flashing arrow boards, temporary traffic signals, and temporary lighting in connection with the performance of the Work shall be the responsiblity of the Contractor.

All costs involved in the supply of electrical power are to be included in the prices entered in the Bill of Quantities relating to the Works, in which power is to be used. No separate payment whatsoever shall be made for supply of electrical power or for issuance of the necessary permits thereof.

The Contractor shall liaise and coordinate with the Municiplaities or other local Authorities regarding approval procedures and other formalities related to supply of power or shall provide the necessary electrical power by his own means. Whichever the case, the source of power supply shall be approved by the Engineer.

9.02.4.2 Traffic Handling Responsibility. The M.U.T.C.D. includes standard drawings which indicate typical layouts of the traffic control devices for various situations. The plans include standard drawings of traffic control devices, and may also include special drawings indicating a method of handling traffic through special work areas or activities which are not covered by the M.U.T.C.D. The combination of the M.U.T.C.D., the contract plans, General Specifications, and Special Specifications relative to control of traffic through work zones will be referred to as the Traffic Control Plan (TCP). It shall be the responsibility of the Contractor to thoroughly understand the requirements of the Traffic Control Plan for the project. The arrangement of traffic control signs, markings, and devices shall be in accordance with the M.U.T.C.D. and the contract, modified to meet actual field conditions and the Contractor's method of operation. Such modifications shall be subject to the approval of the Road Services Department, M.O.C. The Contractor may propose, in writing, alternate traffic control proposals for the handling of traffic through and around the work zone. The Engineer will recommend to the Road Service Department approval, disapproval or approval with modification of the Contractor's proposal. Such alternative Traffic Control Plans shall have the written approval of the Ministry, based on an equivalent level of service and safety to the public, prior to their implementation.

Access across and through the construction area shall be provided at the minimum necessary for the convenience of the public. Access shall be controlled or limited when appropriate, by the barriers together with signs guiding the public to approved access points. The Engineer shall be the final authority in approving or designating access points.

The safe and satisfactory movement of traffic through the project is of paramount importance and shall be a prime responsibility of the Contractor.

The Contractor shall be responsible for evaluating, planning for, and setting up all traffic control arrangements in connection with each construction or maintenance operation. The Contractor shall immediately recognize any extreme hazard to the public and correct the hazard. The Engineer shall identify deficiencies in the

Contractor's procedures and order correction, but the Contractor is primarily responsible for managing the traffic control on the project.

9.02.4.3 Traffic Control Devices and Services.

9.02.4.3.1 General. Traffic control devices and services shall be provided and maintained both inside and outside the project limits as needed to facilitate traffic guidance in accordance with the fundamental principles contained in the M.O.C. M.U.T.C.D. Part 5, "Traffic Controls For Work Areas." All signs and devices shall be kept in good repair. The Contractor shall keep reserve devices reflecting ten percent (10%) of the devices in use with a minimum of one (1) each in order to quickly provide replacements when needed.

Prior to start of construction or maintenance operations, the Contractor shall place such signs, barricades, portable crashworthy safety barriers, markings, and other traffic control devices as may be required by the Traffic Control Plan. During nonworking hours and following completion of a particular construction or maintenance operation, all warning signs, except those necessary for the safety of the public, shall be removed or entirely covered with either black plastic sheeting or plywood sheets so that the entire sign panel will not be visible.

Retro-reflective materials on signs, drums, barricades, and other devices shall be kept clean, free from dirt, mud, and other roadway grime. Scratches, rips and tears in sheeting shall be promptly corrected by the Contractor to the Engineer's satisfaction. Retro-reflective sheeting material shall be replaced when the Engineer determines that the reflectivity is less than fifty percent (50%) of the retro-reflectivity of new material.

Nighttime operations, if permitted by the Traffic Control Plan (TCP), shall be illuminated by a lighting system approved by the Engineer. The lighting system shall be positioned and operated to preclude glare to the approaching traveling public. The lighting system shall not include incandescent lights. Floodlights shall be used to mark flagger stations during the hours of darkness.

Gas or oil lanterns, or open-flame torches shall not be used on any construction or maintenance project.

9.02.4.3.2 Portable Crashworthy Safety Barriers. Portable crashworthy safety barriers shall be used to separate public traffic from construction and maintenance equipment, workmen and work areas. They shall be placed end-to-end and connected using acceptable pins or otherwise acceptable connectors to form a continuous safe barrier with acceptable tapers or crashworthy end treatments on each end. Isolated or unconnected barriers will not be permitted as they are safety hazards by themselves. Portable crashworthy safety barriers shall not be used to form channelization tapers of any less than fifteen to one (15:1).

Where two-way traffic must be maintained on one roadway of a normally divided highway, opposing traffic shall be separated either with portable crashworthy safety barriers, plastic drums, or opposing traffic lane dividers and tubular channelizers throughout the length of two-way operations. Where possible the portable crashworthy safety barrier shall be tied to an existing structure. Otherwise, the barrier shall be tapered, and fitted with a terminal section, if this can be done safely, or fitted with a portable impact attenuator.

9.02.4.3.3 Temporary Pavement Marking and Markers. Temporary retroreflectorized pavement marking and markers shall be used in combination with appropriate warning signs, channelizing devices, and delineation to clearly indicate the required vehicle paths. When a paved temporary roadway (detour) is required to reroute traffic to bypass a construction or maintenance zone, temporary retroreflectorized pavement markings (paint lines symbols, letters and raised pavement markers) and channelizing devices shall be placed on the approaches to and throughout the length of the temporary pavement.

The Engineer shall direct removal by a specific method or may require an overlay if he deems the Contractor's removal and obliteration unsatisfactory. Warning signs with legend UNMARKED PAVEMENT AHEAD shall be used only on a short-term basis when temporary or permanent pavement markings are obscured and new markings have not been placed. It is intended that temporary markings or markers be in place each day before traffic is allowed to use a section at night.

9.02.4.3.4 Signs and Barricades. All barricades and signs shall be placed for best visibility and legibility, maintained in good condition, and kept clean and free of dirt at all times. Contractor's and Engineer's vehicles and equipment must be parked so that barricades and signs are visible to approaching traffic at all times.

Where traffic is maintained through or over any part of the project, the Contractor will be required to mark all hazards within the limits of the project (including connecting roads) with barricades, warning, regulatory and guide signs.

Warning signs are to be placed well in advance of the hazard; the distance depending on topography and existing approach speeds.

Restricted speed zones, when authorized in the Traffic Control Plan (TCP), or by the Engineer, shall be maintained over only the minimum length of road which is practicable for the proper protection of traffic and the satisfactory prosecution of the Work. Any reduction in speed should be consistent with the project requirements.

Signs with more than ninety (90) centimeters length of horizontal side shall be mounted on two posts. Sign plates of more than two hundred twenty (220) and up to three (300) centimeters horizontal length shall be fixed on three (3) posts with suitable bracing. Sign plates of bigger widths than three hundred (300) centimeters shall be constructed with one (1) extra post for each extra meter of width with suitable bracing's. Crashworthy support posts are required.

Portable or removable mountings for signs which are frequently moved may be used. Such mounting shall be heavy enough not to turn over in the wind, and the base shall not be appreciably wider than the sign. The bottom of the sign shall be at least two (2) meters above the ground.

Rocks, asphalt or concrete pieces, construction materials, or other debris shall not be used as weighing device for portable signs, barricades or drums. Sandbags will be permitted as long as they are not more than thirty (30) centimeters above the ground.

9.02.4.3.5 Detours. Detours shall be constructed as shown on the plans or as directed by the Engineer to the required lines and grades.

Prior to opening a detour to traffic, all warning signs, barricades, portable crashworthy safety barriers, markings, channelizing devices, truck mounted attenuators and other required traffic control devices shall be in place and approved by the Engineer. Guide signs, detour signs, or route markers shall be installed throughout the length of the detour to provide adequate guidance to the motoring public.

The Contractor shall maintain the detour and traffic control devices in a satisfactory condition for traffic as directed by the Engineer,

9.02.4.3.6 Flaggers and Pilot Car Operators. Flaggers and pilot car operators shall be physically and mentally qualified, trained in their duties, efficient, and courteous, as outlined in the M.U.T.C.D. Each flagger on duty shall be identified with appropriate and distinctive apparel, including red retroreflective vest and hat, and shall be equipped with a highly visible, retroreflective "Stop/Slow" hand sign conforming to the M.U.T.C.D. Flags will not be permitted unless approved by the Engineer.

Pilot cars shall be identified with an appropriate informative sign mounted on the rear thereof and with a rotating amber beacon, and shall be operated at prudent speeds. Strobe light beacons will not be permitted.

9.02.4.3.7 Hazard Identification Beacons. The hazard identification beacon shall be used only to supplement an appropriate warning sign used in or in advance of work areas.

9.02.4.4 Limitation of Operations. The Contractor's operations shall be limited as follows:

1. No contract Work shall be performed during the hours of darkness unless authorized by the Engineer.

2. The Contractor's equipment shall be operated in the direction of the traffic, where practical.

3. The paving of adjacent traffic lanes shall be completed to the same elevation each workday to the extent practicable.

4. The Contractor will coordinate his activities in such a way as to maintain traffic flow on one lane of pavement on a two-lane road and on one-lane of pavement in each direction of travel on a four-lane road. Two-way traffic shall be provided whenever practicable and all operations shall be conducted in a sequence that will reduce the necessity for one-way traffic to a minimum.

5. The Contractor will coordinate with the Engineer on a location for a storage and parking area. Selection of all storage and parking areas is subject to the approval of the Engineer. The boundary of all such areas shall be located at least ten (10) meters from the edge of pavement. Access and egress from each area is subject to the approval of the Engineer.

6. During nonwork hours, pavers and rollers shall be parked in the storage areas, or at least ten (10) meters from the edge of any pavement open to traffic. When it is not feasible to meet these restrictions due to land features or ROW restrictions, pavers and rollers may be parked a minimum of three (3) meters from the pavement edge, as approved by the Engineer. Three (3) or four (4) Type I barricades, with Type A warning lights, shall be placed on the pavement side of the parked pavers and rollers. All other equipment shall be stored at approved storage and parking areas. Points of access and egress from all staging areas shall have adequate sight distance.

7. Contractor's material shall be stored only at the approved Contractor's storage and parking area (or at locations approved by the Engineer).

8. During periods of inclement weather, or during periods of unusually heavy traffic, the Engineer may require all affected operations to cease in order that traffic may be adequately accommodated.

9. The Contractor shall not switch lane closure during a work shift to accommodate changes in operations except as approved by the Engineer. Prior to switching traffic to a completed lane, the Contractor shall have the following:

(1) Adequate personnel and equipment to remove and set up all traffic control devices as required by the Traffic Control Plan (TCP).

(2) Adequate communications to safely control traffic.

(3) Paving and related equipment removed from the travel lane.

9.02.4.5 Detour Bridges. Detour bridges shall be constructed in accordance with the Plans and Special Specifications. At the completion of the permanent bridge, the detour bridge shall be removed and disposed of by the Contractor. The approaches and footings to the detour bridge shall be leveled or restored as approved by the Engineer to eliminate all visible evidence of its presence.

9.02.4.6 Aggregate Subbase for Detours. The aggregate subbase used for detours shall be constructed in accordance with Subsection 3.02.5, "Construction" in these General specifications.

9.02.4.7 Aggregate Base for Detours. The aggregate base used for detours shall be constructed in accordance with Subsection 3.03.5, "Construction" in these General Specifications.

9.02.4.8 Bituminous Concrete for Detours. The bituminous concrete used for detours shall be constructed in accordance with Subsection 4.05.9, "Minor Bituminous Concrete" including the placement of a prime coat in accordance with Section 4.02, "Bituminous Prime Coat, Tack Coat and Fog Seal" in these General Specifications.

9.02.5 MAINTAINING ROADWAYS DURING WORK. The Contractor shall perform roadway maintenance as follows:

1. Construct, maintain and remove detour roads and bridges.
2. Maintain intersections with trails, roads, streets, businesses, parking lots, residences, garages, farms and other features.
3. Maintain public roadways for public traffic during all work suspensions.
4. Maintain a reasonably dust-free traveled way.
5. Remove piles of soil and other material from traveled way.

The Contractor shall maintain the roadway in a safe and acceptable condition. If corrective action is requested by the Engineer and the corrective action is not taken to provide a safe roadway situation, the Engineer shall impose Paragraph 9.02.7.3 "Deductions for Non-Compliance" in these General Specifications including issuing "Stop Work" orders until the deficiency is corrected. The Contractor shall not be paid for any work accomplished while the "Stop Work" order is in effect. Written notice of the lifting of the "Stop Work" order shall be provided to the Contractor by the Engineer before any work on the job is restarted.

If necessary to insure the safety of the motoring public, the Engineer shall arrange for the correction of the deficiency in a manner he deems appropriate, the cost of which will be the responsibility of the Contractor.

9.02.6 METHOD OF MEASUREMENT. Traffic control devices will be measured based on the Items listed in the Bill of Quantities, which are furnished, accepted and verified by the Engineer. These quantities are deemed the minimum numbers of each device necessary for the handling of construction traffic and shall be the minimum furnished. Should the character or magnitude of the Contractor's operations result in the need for additional devices, the Engineer may order such additional devices.

The legends of all Temporary Signs shall be as required by the Traffic Control Plan (TCP), modified based on the proposed character and magnitude of the Contractor's operations. Such modifications shall be submitted to the Engineer for approval prior to ordering the signs. Temporary Signs will be measured by the square meter of sign face for the quantity actually installed and accepted which shall include all required signs, sign posts, installation, maintenance, replacement, relocation, and removal as necessary for the duration of the project.

Channelizing Devices on Flexible Supports, (Type), Barricades, Type I or II, Vertical Panels, Plastic Traffic Drums, Traffic Cones and Tubular Markers, Temporary Delineators, Chevrons, Warning Lights Type A, B or C, Flashing Warning Arrow Panels Type A, B or C, Hazard Identification Beacons, Temporary Traffic Signals, Variable Message Signs, Truck Mounted Attenuators and Portable Impact Attenuators will be measured by the unit for the quantities actually installed and accepted which shall include all required devices, supports, installation, maintenance, replacement, relocation and removal as necessary for the duration of the project.

Temporary Guardrail and Portable Crashworthy Safety Barrier, Type ___ will be measured by the linear meter along the face of the rail or barrier for the quantities actually installed and accepted, which shall include all required devices, supports, connections, installation, maintenance, replacement, and removal as necessary for the duration of the project.

Temporary Pavement Markings will be measured by the linear meter of line placed and accepted of the type(s) specified in the Traffic Control Plan (TCP), including installation, maintenance, replacement, and removal as necessary for the duration of the project. Gaps will not be measured. Pavement markings removal will be measured by the linear meter of line removed. Gaps will not be measured.

Temporary Traffic Signal will be measured by the unit for each signal installation required by the Traffic Control Plan (TCP) including the installation, maintenance, replacement and removal as necessary for the duration of the project. The installation will include all supports, brackets, controllers, signal heads along with providing the necessary power to operate the signal.

Temporary Pavement Markings, Symbols and Letters will be measured by the square meter or by the unit. Temporary retroreflective raised pavement markers will be measured by the unit. Temporary Speed Bumps and Type B Rumble Strips will be measured by the square meter which will also include the removal of these devices after their function has been completed.

Flaggers will be measured by the hour for the actual number of hours flagging was performed satisfactorily as ordered by the Engineer.

Pilot Car (including operators) will be measured by the hour for the actual number of hours each vehicle was in operation as ordered by the Engineer.

Moving crashworthy safety barriers will be measured by the linear meter along the face of the barrier as reinstalled at designated locations that are more than three (3) meters from the point of initial installation.

The removal and resetting of portable impact attenuators will be measured by the unit and include all work to reset the attenuator in place even including new foundations, bases and parts lost, damaged or just needed to complete the new installation. The repair of each portable impact attenuator damaged by public traffic through no fault or negligence of the contractor shall be measured at fifty (50) percent of the original bid item if such repair is directed by the Engineer.

Items of Work required for the construction of detours including pavement structure layers shown on the plans will be inspected, tested, measured and accepted as separate lots in accordance with the applicable sections of Part 2, "Earthwork," Part 3, "Aggregate Subbase and Base Courses," and Part 4, "Bituminous Construction" in these General Specifications. Traffic control devices used on several detours shall only be measured for payment the first time they are delivered to the project.

All traffic control management, supervision, labor, equipment, and materials required explicitly or implicitly to implement the Traffic Control Plan (TCP), including these General Specifications and the Special Specifications, not measured individually will be measured on a lump sum basis under the Traffic Control Management item.

Detour Bridge when included in the Bill of Quantities, will include all materials, equipment, construction, labor, maintenance, and incidental items required by the plans and Special Specifications. The square meter measurement for this Work will be all inclusive for the Detour Bridge specified, constructed, maintained, and removed upon completion of the permanent bridge, all to the satisfaction of the Engineer.

Detour Aggregate Subbase, Detour Aggregate Base and Detour Bituminous Concrete will be measured by the cubic meter, as placed and compacted to the required density, within the lines, grades and thickness shown on the plans, specified or directed by the engineer. No measurement will be made for overdepth on areas of pavement placed outside authorized limits. Separate measurement for prime and tack coats will not be made as they are considered subsidiary to the detour bituminous concrete.

9.02.7 PAYMENT.

9.02.7.1 General. The amount of completed and accepted Work measured as provided above will be paid for at the contract unit prices specified in the Bill of Quantities for the various traffic control devices and detour construction, which prices shall be full compensation for furnishing, installing, maintaining, relocating, replacing and removing as necessary, and other items necessary for the proper completion of the Work as specified in Subsection 1.07.2, "Scope of Payment" in these General Specifications. Unless otherwise stated in the Special Specifications, all temporary traffic control devices shall become the property of the contractor upon the completion of the work.

9.02.7.2 Payment Schedule. All traffic control devices, unless otherwise approved by the Engineer, shall be delivered to the project site prior to payment of the first monthly certificate.

1. Traffic control management lump sum will be paid as follows:

(1) Fifty percent (50%) of the lump sum will be paid after all the traffic control devices are installed on the project.

(2) Payment on the remaining fifty percent (50%) of the lump sum will be prorated based on the total work completed.

2. Partial payments for all other traffic control devices, including detour aggregate subbase, aggregate base and bituminous concrete, except those measured by the hours, will be paid as follows:

(1) Fifty percent (50%) of the bid price will be paid when the item is installed on the project.

(2) The remaining fifty percent (50%) of the bid price will be paid upon release of the item from the project by the Engineer.

Detour Bridge, when included in the Bill of Quantities, will be paid by the square meter. Seventy-five percent (75%) of the square meter price will be paid upon completion of the Detour Bridge to the satisfaction of the Engineer. The remaining twenty-five percent (25%) of the square meter price will be paid upon removal of the bridge and restoration of the site to the satisfaction of the Engineer.

Chevrons will be paid for, based upon its support, with fixed support chevrons being paid under Pay Item No. 90222 and flexible support chevrons being paid under Pay Item No. 9022704.

9.02.7.3 Deductions for Noncompliance. The following deductions from the Contractor's payments will be made by the Engineer whenever deficiencies are uncorrected. Deductions will continue until deficiencies are eliminated.

Isolated deficiencies in traffic control procedures occur when the Contractor fails to maintain specific signs, replace missing, damaged or destroyed traffic control devices, maintain detours properly, promptly remove pavement markings, or use safety vests. Deduction per calendar day beginning the day after written notice is provided to the Contractor to correct the isolated deficiencies: two thousand Saudi Riyals (SR 2000) for a maximum of ten (10) days. If the isolated deficiencies have not been corrected by the end of the ten (10) day period the Engineer shall issue a "Stop Work" order which will not be rescinded until the deficiencies have been corrected. All deductions shall continue to be assessed until the corrections are made.

Chronic deficiencies occur when the Contractor accumulates isolated deficiencies along a single detour within the project or has repeated isolated deficiencies throughout the project. Deduction per calendar day beginning the day after written notice is provided to the Contractor: Five thousand Saudi Riyals (SR 5000) for a maximum of ten (10) days. If the chronic deficiencies have not been corrected by the end of the ten (10) day period the Engineer shall issue a "Stop Work" order which will not be rescinded until

the corrections have been made. All deductions will continue to be assessed until the corrections are made.

A serious accident or life-threatening condition, such as failure to taper or place a portable impact attenuator at a barrier terminal, or placing unconnected pieces or sections of portable New Jersey or similar concrete barrier, is one within the Contractor's control which the Contractor fails to recognize and correct immediately. Deduction per day beginning on the day written notice is provided to the Contractor: ten thousand Saudi Riyals (SR 10,000) for a maximum of four (4) days. If the serious accident or life threatening condition has not been corrected by the end of the four (4) day period the Engineer shall issue a "Stop Work" order which will not be rescinded until the corrections have been made. All deductions will continue to be assessed until the corrections are made.

Deductions will not be made to the contract items for traffic control but will be applied against the total amount earned for the Work accomplished to date.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
90201	Traffic Control Management	Lump Sum
90202	Flashing Warning Arrow Panel	Unit
9020201	Flashing Warning Arrow Panel, Type A	Unit
9020202	Flashing Warning Arrow Panel, Type B	Unit
9020203	Flashing Warning Arrow Panel, Type C	Unit
90203	Barricade	Unit
9020301	Barricade, Type 1	Unit
9020302	Barricade, Type II	Unit
90204	Traffic Cone and Tubular Markers	Unit
90205	Temporary Sign	Square Meter
90206	Plastic Traffic drum	Unit
90207	Flagger	Hour
90208	Pilot Car	Hour
90209	Portable Crashworthy Safety Barrier	Linear Meter
9020901	Portable Crashworthy Safety Barrier, Concrete	Linear Meter
9020902	Portable Crashworthy Safety Barrier, Triton	Linear Meter
9020903	Portable Crashworthy Safety Barrier, (Type),	Linear Meter

90210	Moving Crashworthy Safety Barrier	Linear Meter
90211	Remove and Reset Portable Impact Attenuator	Unit
90212	Temporary Guardrail	Linear Meter
90213	Truck Mounted Attenuator	Unit
90214	Portable Impact Attenuator	Unit
9021401	Portable Impact Attenuator, G.R.E.A.T.	Unit
9021402	Portable Impact Attenuator, ET-2000	Unit
9021403	Portable Impact Attenuator, Sand barrels	Unit
9021404	Portable Impact Attenuator, (type)	Unit
90215	Temporary Pavement Markings	Linear Meter
90216	Temporary Pavement Markings, Symbols and Letters	Square Meter
90217	Temporary Pavement Markings, Symbols and Letters	Unit
90218	Temporary Raised Pavement Markers	Unit
90219	Temporary Rumble Strips, Type B	Square Meter
90220	Temporary Speed Bumps	Square Meter
90221	Vertical Panel	Unit
90222	Chevron	Unit
90223	Warning Light, Type A, B or C	Unit
90224	Hazard Identification Beacon	Unit
90225	Temporary Variable Message Sign	Unit
90226	Temporary Traffic Signal	Unit
90227	Channelizing Device on Flexible Support	Unit
9022701	Channelizing Device on Flexible Support, Opposing Traffic Lane Divider	Unit
9022702	Channelizing Device on Flexible Support, Construction Object Panel	Unit
9022703	Channelizing Device on Flexible Support, Vertical Panel	Unit
9022704	Channelizing Device on Flexible Support, Chevron Alignment	Unit
9022705	Channelizing Device on Flexible Support, Tubular Channelizer	Unit
90228	Detour Bridge	Square Meter

90229	Aggregate Subbase for Detours	Cubic Meter
90230	Aggregate Base for Detours	Cubic Meter
90231	Bituminous Concrete for Detours	Cubic Meter

SECTION 9.03 - TRAFFIC MARKINGS

9.03.1 DESCRIPTION. This Work shall consist of furnishing and applying retroreflectorized white and yellow traffic paint lines; thermoplastic retroreflectorized white and yellow traffic paint lines; epoxy thermoplastic retroreflectorized white and yellow traffic paint lines; retroreflectorized painted, thermoplastic retroreflectorized painted and preformed traffic control markings; and retroreflective and ceramic raised pavement markers in accordance with these specifications, at the locations shown on the plans or as directed by the Engineer. The paint and marker application equipment shall be shielded with a Truck Mounted Attenuator (TMA) or shadow vehicle equipped with a TMA.

ITEMS IN BILL OF QUANTITIES
White Traffic Lines
Yellow Traffic Lines
Traffic Control Markings
Retroreflective Raised Pavement Markers
Ceramic Raised Pavement Markers

9.03.2 MATERIALS.

9.03.2.1 Retroreflectorized Traffic Lines. Retroreflectorized paint shall consist of a ready-mixture of binder, white or yellow pigment, and filler specifically compounded for application and adhesion to finished paved areas. The paint shall be retroreflectorized by adding retroreflective glass spheres before the paint film dries or sets, using drop-on or pressurized methods. Retroreflectorized white and yellow lines shall be produced from paint conforming to the requirements of AASHTO M 248, Type F.

The surface application glass spheres shall conform to the requirements of AASHTO M 247, Type I.

9.03.2.2 Retroreflectorized Thermoplastic Traffic Lines. Retroreflectorized thermoplastic lines shall consist of a mixture of binder, white or yellow pigment, glass spheres, filler, and other materials in granular form such as light colored silica sand or quartz specifically compounded for traffic paint that is to be applied to the pavement in a molten state by mechanical means with surface application of glass beads. Upon cooling to normal pavement temperature, this material shall produce an adherent retroreflectorized paint line of specified thickness capable of resisting deformation by traffic. The minimum softening point of the material shall exceed ninety-two degrees Celsius (92° C).

White and yellow thermoplastic paint shall conform to the requirements of AASHTO M 249 except that the titanium dioxide content shall be ten percent (10%) maximum as listed in Table 9.03-1.

TABLE 9.03-1 COMPOSITION

COMPONENT	WHITE	YELLOW
Binder	18.0 min	18.0 min
Glass beads	30-40	30-40
Titanium dioxide	10.0 min	-----
Calcium carbonate & inert fillers	42.0 max	See Note
Yellow pigments	-----	See Note

NOTE: Amount of yellow pigment, calcium carbonate and inert fillers shall be at the option of the manufacturer, providing all other requirements of this specification are met.

Surface application glass spheres shall conform to the requirements of AASHTO M 247, Type I, except the gradation shall conform to the following:

Standard Sieve Size	Percent Passing by Weight
1.70 mm (No. 12)	100
0.600 mm (No. 30)	85-100
0.425 mm (No. 40)	45-100
0.300 mm (No. 50)	10-45
0.180 mm (No. 80)	0-20
0.150 mm (No. 100)	0-5

Pre-mix glass spheres shall conform to the following requirements:

1. *Crushing Resistance.* The chemical composition when tested in accordance with the soda lime glass test - BS 6088 - 1981 shall yield a minimum one and five-tenths (1.5) Refractive Index.

2. *Roundness.* A minimum of seventy-five percent (75%) shall be true spheres when tested in accordance with ASTM D 1155. Not less than seventy percent (70%) of the spheres of each sieve size shall be free from imperfections of all types, including film, scratches, pits, clusters and opaqueness.

3. *Index of Refraction.* The spheres mixed into the material shall have a minimum index of refraction of not less than one and fifty hundredths (1.50) when tested by the liquid immersion method at twenty-five degrees Celsius (25° C), and the spheres automatically applied to the surface of the stripe shall have a minimum index of refraction of not less than one and five tenths (1.5) when tested by the liquid immersion method at twenty-five degrees Celsius (25° C).

4. *Gradation.* When tested in accordance with ASTM D 1214, the beads used in the thermoplastic material compounding shall conform to the following gradation:

Standard Sieve Size	Percent Passing by Weight
1.70 mm (No. 12)	100
0.180 mm (No. 80)	0-5

5. Chemical Resistance. The glass spheres shall withstand immersion in water and acids without undergoing noticeable corrosion or etching, and shall not be darkened or otherwise noticeably decomposed by sulfides. The tests for chemical resistance shall consist of one (1) hour immersion in water and in corrosive agents followed by microscopic examination. A three (3) to five (5) gram sample shall be placed in each of three (3) glass beakers or porcelain dishes and one (1) covered with distilled water, one (1) with a three (3) N solution of sulfuric acid and the last with a solution of fifty percent (50%) sodium sulfide, forty-eight percent (48%) distilled water, and two percent (2%) Aerosol 1B or similar wetting agent. At the end of the one (1) hour immersion, no darkening, hazing or other evidence of instability shall be noticeable when examined microscopically.

6. Silica Content. The silica content ($Si\ O_2$) of the spheres shall be sixty percent (60%) plus or minus five percent (5%) when tested in accordance with U.S. Federal Test Method 141a.

9.03.2.3 Retroreflectorized Epoxy Thermoplastic Traffic Lines (ETP Lines).

9.03.2.3.1 General. ETP lines shall consist of a formulation of two (2) epoxy resins: one solid, one liquid in a sixty (60) to forty (40) ratio by weight; calcium carbonate and inert fillers, glass beads, and either titanium dioxide pigment for the white formulation or silica encapsulated lead chromate pigment for the yellow formulation.

9.03.2.3.2 Epoxy Resins. The liquid and solid resins shall be condensation products of bisphenol A and epichlorohydrin having the properties listed in Table 9.03-2.

TABLE 9.03-2

	Liquid Epoxy Resin		Solid Epoxy Resin	
	Average	Difference*	Average	Difference*
Viscosity, cps 48 degrees C, 20 RPM	680-810	10	-	-
232 degrees C, 10 RPM	-	-	1300-2600	75
Epoxide Equiv. Wt.(gm./equiv.)	180-196	10	1600-2300	50

*Between two replicates.

9.03.2.3.3 Titanium Dioxide. The titanium dioxide shall conform to ASTM D 476, Type II. The oil absorption shall be between thirteen (13) and thirty (30) grams oil per one hundred (100) grams pigment, with a maximum deviation between replicate samples of one (1.0).

9.03.2.3.4 Calcium Carbonate. The calcium carbonate shall conform to ASTM D 1199, Type GC, Grade I, with a dry brightness no less than ninety-one percent (91%). The oil absorption shall be between nine (9) and twenty-one (21) grams oil per one hundred (100) grams pigment, with a maximum deviation between replicate samples of one (1.0).

9.03.2.3.5 Lead Chromate. The lead chromate shall be refractory type, silica encapsulated, and with no additive surface treatment. When tested in accordance with ASTM D 1208 for determining the pH using two and five tenths (2.5) grams of pigment in fifty (50) millimeters water and ASTM D 153 for determining the specific gravity of the pigment and ASTM D 444 for determining the lead chromate shall have the properties listed in Table 9.03-3.

TABLE 9.03 - 3

	Minimum	Maximum	Maximum Deviation Between Replicates
pH in 5 degrees water-slurry	7.0	9.0	0.2
Specific gravity	3.8	4.5	0.01
Lead, percent by weight	44	50	0.5
Chromate (CrO_4), percent by weight	17	27	0.6
Chromium (CR), percent by weight	7.6	12.1	0.5

9.03.2.3.6 Glass Beads. The glass beads shall conform to ASTM D 2205, Type I, except that the gradation when tested in accordance with ASTM D 1214 shall be as follows:

Standard Sieve Size	Percent Passing by Weight
0.85 mm (No. 20)	100
0.60 mm (No. 30)	79-100
0.30 mm (No. 50)	15-60
0.18 mm (No. 80)	0-15

9.03.2.4 Retroreflectorized Traffic Control Markings, Retroreflectorized Thermoplastic Traffic Control Markings and Retroreflectorized Epoxy Thermoplastic Traffic Control Markings. Materials shall conform to the requirements for Retroreflectorized Traffic Lines and Retroflectorized Thermoplastic Traffic Lines and Retroreflectorized Epoxy Thermoplastic Traffic Lines, respectively, as cited above.

9.03.2.5 Retroreflective Raised Pavement Markers.

9.03.2.5.1 General. All Retroreflective Raised Pavement Markers used in the Kingdom shall be prequalified products, approved by the Ministry based on these General Specifications and successful trial usage under extreme conditions. They shall be applied in accordance with the M.O.C. Road Services Department standard marking details for Raised Pavement Markers (RPM).

Color indications of Retroreflective Raised Pavement Markers shall be as shown on the plans or ordered by the Engineer.

Colormetric characteristics will be accepted based on comparison with MOC standards. If there are doubts as to acceptability, characteristics will be tested by the Ministry and approved based on standard required trichromatic coordinates tested in accordance with ASTM E 308.

9.03.2.5.2 Type A Markers (Large Cateye Road Studs). Type A markers shall consist of a mountable aluminum alloy (LM6 or LM24) casting approximately one hundred fifty (150) millimeters by one hundred fifty (150) millimeters and twenty three (23) millimeters high. The stud anchor shall be aluminum, approximately six (6) centimeters long and two and five tenths (2.5) centimeters in diameter. The stud shall be deformed or slotted to resist pullout and rotational displacement. The Type A markers shall withstand a tensile stress of between two hundred seventy five and two hundred eighty five (275-285) N/mm^2 with a Brinell Hardness of between fifty five and sixty (55-60).

Each marker shall have one (1) or two (2) retroreflecting faces as ordered. Each retroreflecting surface shall have four (4) fifteen (15) millimeter diameter discs of seven (7) bi-convex lenses or one stimsonite prismatic face totalling twenty one (21) square centimeters in area. Each retroreflecting surface shall meet the minimum reflectance requirements of Table 9.03-4.

TABLE 9.03-4
Retroreflectance Requirements for
Types A and B Retroreflective
Raised Pavement Markers

Minimum Coefficient of (Retroreflected) Luminous Intensity (R_I)
Candelas per footcandle (Millicandelas per lux)

Observation Angle ° (rad)	Entrance Angle ° (rad)	White [(a)]	Amber	Red
0.2 (0.003)	0 (0)	3.0 (279)	1.8 (167)	0.75 (70)
0.2 (0.003)	20 (0.35)	1.2 (112)	0.72 (67)	0.30 (28)

[(a)]Crystal, clear, or colorless are acceptable color designations.

Notes: [1]Observation angle shall mean the angle at the retroreflector between the observer's line of sight and the axis of the incident light beam. [2]Entrance angle shall mean the angle at the retroreflector between the direction of light incident on it and the direction of the retroreflector axis.

9.03.2.5.3 Type B Markers (Small Cateye Road Studs). Type B markers shall consist of an impact-resistant, smooth, pressure-molded mountable aluminum alloy casting approximately one hundred fifteen (115) millimeters by one hundred fifteen (115) millimeters and twenty three (23) millimeters high. The slope of the retroreflecting face shall be thirty (30) degrees. The stud anchor shall be aluminum, a minimum of six (6) centimeters long and three two and five tenths (2.5) centimeters in diameter. The stud shall be deformed or slotted to resist pullout and rotational displacement. The Type B markers shall withstand a tensile stress of between two hundred seventy five and two hundred eighty five (275-285) N/mm^2 with a Brinell hardness of between fifty five and sixty (55-60).

Each marker shall have one (1) or two (2) retroreflecting faces as ordered. Each reflecting face shall have three (3) 15 millimeter diameter discs of seven (7) bi-convex lenses or one stimsonite prismatic face totaling twenty one (21) square centimeters in area. Each retroreflecting face shall meet the minimum retroreflectance requirements of Table 9.03-4.

9.03.2.5.4 Type C Markers (Plain Prismatic Retroreflectors). Type C markers shall consist of a methyl methacrylate or suitably compounded acrylonitrile butadiene styrene (ABS) shell filled with a mixture of an inert thermosetting compound and filler material approximately ten (10) centimeters by ten (10) centimeters. The exterior surface of the shell shall be smooth and contain one (1) or two (2) methyl methacrylate prismatic retroreflector faces as required. The retroreflective lens shall not contain any voids or air space and the back of the lens shall be metalized. The shell shall be fabricated in a manner that will provide a mechanical interlock between the thermosetting compound and the shell. The thermosetting compound shall bond directly to the backside of the metalized lens surface. The base of the marker shall not deviate from a flat surface by more than two (2) millimeters, shall be rough textured, and free from gloss or substances which may reduce its bond to the adhesive.

The retroreflective markers shall withstand a load of one thousand (1000) kilograms. Such test load shall be applied at the center of the marker by a two and five tenths (2.5) centimeter diameter solid cylinder while the marker is supported on a seven and five tenths (7.5) centimeter inside diameter hollow cylinder.

Type C markers shall meet the minimum retroreflectance requirements of Table 9.03-5.

TABLE 9.03-5 RETROREFLECTANCE REQUIREMENTS FOR TYPE C Retroreflective RAISED PAVEMENT MARKERS				
		Minimum Coefficient of Luminous Intensity (R_I) Milli Candelas per Lux)		
Observation Angle[1]	Entrance Angle[2]	Red	Clear or White	Amber
0.22^G	0^G	280	70	170
0.22^G	22^G	110	28	67

Notes: [1]Observation angle shall mean the angle at the retroreflector between the observer's line of sight and the axis of the incident light beam. [2]Entrance angle shall mean the angle at the retroreflector between the direction of light incident on it and the direction of the retroreflector axis.

9.03.2.6 Ceramic Raised Pavement Markers.

9.03.2.6.1 General. Ceramic raised pavement markers shall consist of a heat-fired, vitreous, ceramic base, and a heat-fired, opaque, glazed surface to produce the properties required in these specifications. The markers shall be produced from any suitable combination of intimately mixed clays, shales, talcs, flints, feldspars, or other inorganic material which will meet the properties herein required. The markers shall be thoroughly and evenly marked and free from defects which effect appearance or serviceability.

The bottoms of the ceramic markers shall be free from gloss or glaze and shall have a number of integrally formed protrusions (comparable to a fine grained sandpaper) projecting from the surface in a uniform pattern of parallel rows. The tips of the protrusions shall not deviate more than one and three tenths (1.3) millimeters from a flat surface. Each protrusion shall have a face parallel to the bottom of the marker. To facilitate forming and mold release, the sides of each protrusion may be tapered. This taper shall not exceed seventeen (17) grads from perpendicular to the marker bottom.

9.03.2.6.2 Finish. The top surface of the marker shall be convex and the radius of curvature shall be between nine (9) and fifteen (15) centimeters except that the radius of the centimeter nearest the edge may be less. Any change in curvature shall be gradual. The top and sides shall be smooth and free of mold marks, pits, indentations, air bubbles, or other objectionable marks or discolorations.

9.03.2.6.3 Physical Requirements.

- Glaze Thickness	0.18 mm minimum
- Height (Total)	19 +/- 2 mm
- Height (Lip)	4.0 to 8 mm
- Hardness	(Moh) 6 minimum
- Diameter	101 +/- 2 mm
- Directional retroreflectance (white markers only)	
Glazed surface	75 minimum
Body of marker	65 minimum
- Yellowness index (white markers only)	
Glazed surface	7 maximum
Body of marker	12 maximum
- Color (yellow markers only)	
Purity	76% to 96%
Dominant wave length	0.579 to 0.585 mm
Total luminous retroreflectance (Y value X 100)	41 minimum
- Autoclave resistance (ASTM C 424)	Glaze shall not spall, craze, or peel
- Strength	680 Kilograms minimum
- Water absorption (ASTM C-373)	2.0% maximum

9.03.2.7 Adhesive. The retroreflective and ceramic raised pavement markers shall be secured by a bituminous compound for use in high temperature climates. The bituminous compound shall be selected and used in accordance with the manufacturer's recommendations.

Only bituminous adhesive, consisting of an asphaltic material with a homogeneously mixed mineral filler, shall be used on new bituminous wearing surfaces. The adhesive shall be suitable for application when the road surface and marker temperatures are in the range of four to seventy degrees Celsius (4° to 70° C). The adhesive properties shall not deteriorate when heated to and applied at temperatures up to two hundred twenty degrees Celsius (220° C), using either air or oil jacketed melters. The material shall not contain rubber polymers, since the necessary application temperatures may cause decomposition. Adhesive asphalt and filler properties shall be the manufacturer's standard for the intended purpose and environment and subject to the Engineer's approval. On stiffer (seasoned) pavements, epoxy adhesives may be used if so recommended by the marker manufacturer and approved by the Engineer. Two (2) component epoxy resin adhesive, conforming to AASHTO M237, Class I shall be applicable.

In either case bituminous or epoxy adhesive, only materials recommended by the marker manufacturer shall be used.

9.03.3 EQUIPMENT.

9.03.3.1 General. The applicating equipment to be used on roadway installations shall consist of either truck-mounted units, motorized ride-on equipment, or manually pushed equipment, depending on the type of lines or markings required. The truck-mounted or motorized ride-on units for centerlines, lane lines, and edgelines shall consist of a mobile self-contained unit carrying its own material capable of operating at a minimum speed of eight (8) kilometers per hour while applying paint. The hand applicator equipment shall be sufficiently maneuverable to install centerlines, lane lines, edge lines, gore striping, turn lines, crosswalks, stop bars, arrows, and legends.

Spray equipment shall be capable of satisfactorily applying the paint under pressure with a uniformity of feed through nozzles spraying directly upon the pavement. Each paint tank shall be equipped with satisfactory cut-off valves which apply broken or skip lines automatically. Each nozzle shall have a mechanical bead dispenser that will operate simultaneously with the spray nozzle and distribute the beads in a uniform pattern at the rate specified. Each nozzle also be equipped with suitable line guides consisting of metallic shrouds or air blasts. The machine shall provide a method for cleaning the surface of dust just prior to paint placement. The applicating equipment shall be mobile and maneuverable to the extent that straight lines can be followed and normal curves can be made in a true arc. The equipment operator shall be located in such a position as to enable full visibility of the striping apparatus.

9.03.3.2 Retroreflectorized Traffic Lines and Markings Application Equipment. The spray machine shall have an attachment that will permit accurate regulation of the rate of application and a tachometer or other approved device to insure uniform paint application at the designated rate.

It shall be adjustable for applying one (1) or two (2) adjacent lines simultaneously along the centerline as may be required. The operation of the unit shall be such that paint will not be spattered or blown on another stripe. The unit shall be so designed that the paint will be properly agitated while in operation.

9.03.3.3 Retroreflectorized Thermoplastic Traffic Lines and Markings Application Equipment. The application equipment shall be especially designed for placing the plastic material in a hot molten state on the pavement, utilizing either an extrusion or spray method. Equipment shall have the capability of providing continuous mixing and agitation of the material while maintaining the material at the proper placement temperature in a continuous stripe of uniform thickness and width. The use of direct flame heat will not be allowed in any heating operation.

A glass sphere top dressing shall be applied to the completed thermoplastic stripe by an automatic glass sphere dispenser attached to the stripping machine in such a manner that the spheres are applied to the molten thermoplastic material immediately after it has been applied. The sphere dispenser shall utilize pressure type spray guns which will embed the spheres into the stripe surface to at least one-half (1/2) the sphere diameter. The sphere dispenser shall be equipped with an automatic cut-off synchronized with the cut-off of the thermoplastic material.

Hand equipment shall be permitted only for markings, including arrows, crosswalks, stop bars, symbols, and legends, and have sufficient capacity to hold seven hundred (700) kilograms of molten material and be as maneuverable as required.

9.03.3.4 Retroreflectorized Epoxy Thermoplastic Traffic Lines and Markings Application Equipment.

9.03.3.4.1 General. The equipment shall be constructed to provide continuous mixing, agitation, and indirect oil jacketed heating of the material. The equipment shall be designed to apply ETP marking material and retroreflective glass spheres in continuous and skip line patterns.

9.03.3.4.2 Pressure Tank. The equipment shall be equipped with a pressure tank, mixer(s), and heating equipment of such capacity to maintain the ETP at a minimum temperature of two hundred twenty-five degrees Celsius (225° C). The heating equipment shall surround the pressure tank and consist of a direct thermostatically controlled heat transfer system medium. Heating by direct flame shall not be allowed.

9.03.3.4.3 Spray System. The equipment shall be equipped with a low pressure spray system. Atomizing air may be used provided it is heated to a minimum of one hundred seventy-five degrees (175° C). All spray lines and appurtenances leading from the heated pressure tank to the spray nozzle shall be fully insulated or suitably heated so as to allow heated ETP material to leave the spray gun at a minimum temperature of two hundred twenty-five degrees Celsius (225° C).

9.03.3.5 Retroreflective and Ceramic Raised Pavement Marker Application Equipment. If epoxy or bituminous adhesive is to be hand-mixed, all containers and stripping devices shall be clean before mixing is begun. Epoxy or bituminous adhesive automatic mixing equipment shall be maintained in a sound mechanical condition, and the mixing head shall be cleaned whenever the steady progress of the Work is halted for any extended period of time. The allowable delays shall be consistent with the pot life of the epoxy or bituminous adhesive system being used. Automatic mixing devices shall be equipped in such a manner that the separate components are delivered to the mixing head at the specified ratio by volume. The lines feeding the mixing head shall be equipped with suitable valves that will allow samples to be taken for checking the ratio of each component. The machine shall be capable of metering the amount of adhesive required to affix each marker to the pavement.

9.03.4 CONSTRUCTION.

9.03.4.1 General. The portion of the highway surface to which the lines, markings, or markers are to be attached shall be dry and free of dirt, existing paint lines, curing compound, grease, oil, moisture, loose or unsound layers, and any other material which would adversely affect the bond. The areas shall be thoroughly clean, using whatever equipment is necessary to clean the pavement thoroughly without damaging the surface, taking particular care to remove all vegetation, loose soil, and other foreign substances from areas where edge stripping is to be applied. Where necessary, the surface shall be wet with a water jet and scrubbed to dislodge all foreign material. After washing, the surface shall be allowed to dry thoroughly and any film of dried mud apparent after surface drying shall be removed before application of paint. Lines, markings, or markers shall be applied as closely as practicable after the surface has been cleaned and dried and the Engineer has given the approval to proceed. Costs for cleaning the surface and removing existing paint lines shall be included in the contract unit prices of the traffic lines, markings, and markers pay items.

The Engineer will not give his permission to proceed when (1) there is any moisture on the pavement surface or the air is misty, (2) the surface temperature of the pavement is below ten degrees Celsius (10 degrees C), (3) wind or other conditions cause a film of dust to be deposited on the surface after cleaning and before installation, or (4) other conditions exist that, in the opinion of the Engineer, would displace, damage, or affect the bonding of the material to the pavement surface. Any installation placed in violation of the above conditions, or damaged due to water or rain within fifteen (15) minutes after application, shall be removed and replaced without additional compensation.

For temporary striping, the weather conditions noted above may be waived at the Engineer's discretion to expedite installation and assure the safety of traffic handling.

Prior to striping two-way roadways, the Contractor shall conduct a detailed survey of the roadway to identify the limits of no-passing zones in accordance with the requirements of the M.U.T.C.D. Such zones shall be clearly marked for the striping crew. A report of the survey shall be submitted to the Engineer for approval at least two (2) weeks prior to scheduled striping. No centerline striping shall proceed until the Engineer approves the no-passing zones or modifies them as applicable.

All lines, markings, and markers shall be placed in accordance with the requirements of these General Specifications, the detailed plans, the Special Specifications and the M.O.C. Standard Markings Manual (TS-03).

The centerline lines of the width shown on the plans shall be of six (6) meter length, with a twelve (12) meter space between line segments, or as otherwise noted on the plans or directed by the Engineer. No-passing lines shall be solid white of the width shown on the plans, located as directed by the Engineer. Intersection markings, special pavement markings, and obstruction hazard zone markings shall be as shown on the plans and/or as directed by the Engineer. Edge lines, markings and markers shall not be applied prior to completion of shoulders. The Contractor shall mark the control points necessary for the placing of the new lines, markings, and markers based on surveyed controls or other controls approved by the Engineer. On irregular sections of roadway, the location of edge striping shall be adjusted so as to fall continuously and uniformly on the pavement.

9.03.4.2 Application. All traffic line and marker application equipment shall be shielded with a Truck Mounted Attenuator (TMA) or a shadow vehicle equipped with a TMA. The Contractor shall demonstrate the capability of his equipment and operators to produce acceptable lines and markings through the successful completion of a preapplication test. The preapplication test shall be performed on roadway surfaces other than those to receive the application to be paid for under the Bill of Quantities Item(s). It shall include verification of the placement of lines and markings of acceptable width, thickness and workmanship.

9.03.4.2.1 Retroreflectorized Traffic Lines and Markings. When the roadway is open to traffic, painting shall be done only during daylight hours, and all painted areas shall be dry enough, before sunset, to permit crossing by traffic without tracking. All protective devices shall be removed no later than sunset to allow free movement of traffic at night.

Traffic paint shall be thoroughly mixed in the shipping container before placing in the machine tank. The paint machine tanks, connections, and spray nozzles shall be thoroughly cleaned with thinner before starting each day's Work.

The minimum wet film thickness for all painted areas shall be four tenths (0.4) millimeter (unbeaded).

The rate of application for ten (10) centimeter width paint lines shall be approved by the Engineer subject to the following minimums:

Solid Traffic Paint Lines:

Rate of Application
- forty (40) liters per kilometer minimum (smooth surface)
- fifty (50) liters per kilometer minimum (rough surface)

Skip Traffic Paint Lines - six (6) meter line - twelve (12) meter gap

Rate of Application - fourteen and five tenths (14.5) liters per kilometer minimum

Minimum rates shall be modified proportionately for varying widths and lengths of stripes.

The measured application rate shall not vary from the approved rate by more than five percent (5%) in any kilometer. At any point where a check indicates a variation in excess of five percent (5%), the Work shall be stopped and the equipment adjusted or replaced. Identifiable areas of deficiency shall be corrected.

Immediately following the application of the paint, a uniform application of glass beads shall be applied at a rate of six tenths (0.6) to seven tenths (0.7) kilogram per liter of paint.

9.03.4.2.2 Retroreflectorized Thermoplastic Traffic Lines and Markings. **If required by the Engineer, in addition to or in lieu of the pavement cleaning requirements contained in Paragraph 9.02.4.1 "General" in these General Specifications , the surface of new and existing asphalt concrete pavement shall be washed with detergent solution followed by a water rinse to remove any clay coating or accumulation of grease. On new and existing Portland cement concrete, the surface shall be abrasive blast cleaned to remove laitance, curing seal, or other foreign material.**

The Contractor shall apply a binder-sealer material prior to the actual thermoplastic installation on Portland Cement Concrete Pavement (PCCP). The binder-sealer material shall form, when applied with conventional mobile paint spraying equipment, a continuous film over the pavement surface which will dry rapidly and adhere to the pavement surface. The binder-sealer shall be dry before the thermoplastic materials are applied. The binder-sealer shall be a product currently used and recommended by the thermoplastic material manufacturer.

To insure optimum adhesion, the thermoplastic material shall be installed in a molten state when the pavement and air temperatures are above ten degrees Celsius (10°C.) at temperatures between two hundred and two hundred twenty degrees Celsius (200-220°C). Thermoplastic material shall not be applied to a new bituminous concrete pavement before it has been exposed to at least fourteen (14) days of use.

The computed (measured volume of material applied divided by the measured area of application) thickness in any section of sprayed thermoplastic lines shall be not less than two (2) millimeters. The computed overall average thickness of extruded thermoplastic lines shall be not less than three and five tenths (3.5) millimeters. The computed overall average thickness of the sprayed thermoplastic markings shall be not less than three (3) millimeters.

The completed stripes shall have the specified cross section, shall be continuous and uniform in shape, and shall have clean and sharp dimensions. The width of paint line specified shall be applied to the completed thermoplastic paint by an automatic glass sphere dispenser attached to the striping machine in such a manner that the spheres are applied to the molten thermoplastic material immediately after it has been placed. The sphere dispenser shall utilize pressure type spray guns which will embed the spheres into the stripe surface to at least one-half (1/2) the diameter at the rate not less than six-tenths (0.6) kilogram per square meter. The sphere dispenser shall be equipped with an automatic cut-off synchronized with the cut-off of the thermoplastic material.

9.03.4.2.3 Retroreflectorized Epoxy Thermoplastic Traffic Lines. The above requirements for the retroreflectorized spray thermoplastic traffic lines and markings shall apply to ETP, except that ETP shall be heated and sprayed at material temperatures between two hundred twenty-five and two hundred thirty-five degrees Celsius (225-235° C.) at the spray nozzle. ETP lines shall be applied at a thickness of forty-five hundredths (0.45) millimeter with a tolerance of plus or minus five hundredths (0.05) millimeter.

No binder-sealer material is required prior to epoxy thermoplastic application on clean bituminous concrete pavement surfaces.

9.03.4.2.4 Retroreflective and Ceramic Raised Pavement Markers. In lieu of the pavement cleaning requirements contained in Paragraph 9.03.4.1, "General" in these General Specifications, the pavement surface to which retroreflective and ceramic raised pavement markers are to be placed shall be thoroughly blast cleaned to remove all materials which could adversely affect the bond of the adhesive. For road stud markers, the hole for the stud shall be drilled slightly wider and deeper than the stud. All debris from the hole shall be removed and any damage to the pavement surface around the hole shall be repaired before installation of the marker. The stud hole shall be completely filled with adhesive. The adhesive shall be placed uniformly on the cleaned pavement surface or on the bottom of the marker in a quantity sufficient to result in complete coverage of the area of contact of the marker and the pavement, with no voids present and with a slight excess after the marker has been pressed in place. The marker shall be placed in position and pressure applied until firm contact is made with the pavement. Excess adhesive around the edge of the marker, excessive adhesive on the pavement, and adhesive on the exposed surfaces of the marker shall be immediately removed. Kerosene or other approved solvent shall be used to remove excess adhesive such that the pavement is not damaged. The marker shall be protected against impact until the adhesive has hardened.

Mixing of adhesive shall be performed in limited quantities such that the markers shall be aligned and pressed in place within five (5) minutes after mixing the adhesive components. Any mixed batch of adhesion which becomes so viscous that the adhesive is not readily extruded from under the marker on application of slight pressure shall not be used.

All markers shall be placed to the lines shown on the plans or established by the Engineer. The Contractor shall mark the location where each marker is to be placed and the marks shall be approved by the Engineer prior to beginning mixing operations. Retroreflective raised pavement markers shall be placed in such a manner that the axis of the marker is parallel to the roadway centerline.

No pavement markers shall be placed over longitudinal or transverse joints of the pavement surface.

9.03.4.3 Protection of Traffic Lines, Markings and Markers. Immediately following the application of the paint lines and markings in areas under public traffic, traffic cones or other approved devices shall be placed alongside or over the line at intervals not exceeding fifteen (15) meters, to remain in place until the line has dried to such an extent that it will not be damaged by the tires of vehicles. Traffic shall be prevented from crossing a wet traffic paint line and the Contractor shall use a sufficient number of flaggers, barricades, or other protection for the wet line, particularly at crossings, to prevent traffic from crossing the wet line. Sections of traffic paint line which have been marred by traffic crossing them before they have cured shall be repaired by the Contractor and the pavement cleaned outside the line without additional compensation.

Raised markers shall be protected from all traffic for at least three (3) hours after placement, when the average ambient temperature is thirteen degrees Celsius (13° C) or above; at least twenty-four (24) hours when said temperature is between four degrees Celsius and thirteen degrees Celsius (4 to 13° C); and at least forty-eight (48) hours when said temperature is four degrees Celsius (4° C) or below. The Engineer will determine when the adhesive has set sufficiently to bear traffic. Regardless of the type of adhesive used, markers shall not be placed under any of the following conditions:

1. The pavement or air temperature is zero degrees Celsius (0° C) or below;
2. The relative humidity of the air is greater than eighty percent (80%);
3. The pavement is not surface dry;
4. Before a new bituminous concrete pavement has been exposed to at least fourteen (14) days of use.

Temporary barricades of the design shown in the plans, or as otherwise designated, together with the signs shown for use therewith, shall be placed as shown with reference to the pavement edges at the beginning and end of the section which the Contractor proposes to work in one operation. As soon as Work is complete in one section, the temporary barricades and cones shall be moved ahead to the next section. No barricades or cones shall be left overnight. The equipment shall be so operated that it will be unnecessary for public traffic to cross the newly placed material behind the equipment in order to safely pass the equipment.

All protective and warning traffic control devices shall be in accordance with the Ministry's Manual on Uniform Traffic Control Devices (M.U.T.C.D.).

9.03.4.4 Surface Tolerances and Appearance. A tolerance of twelve (12) millimeters over, or three (3) millimeters under, the specified line width shall be allowed, provided the variation is gradual and does not detract from the general appearance of the line. Segments of broken line may vary up to thirty (30) centimeters from the specified length. Segments shall be square at each end and without mist or distortion. Deviations form the control line of up to twenty-five (25) millimeters on tangents and fifty (50) millimeters on curves will be applied, provided the deviation does not increase or decrease at a rate of more than fifteen (15) millimeters in ten (10) meters. Lines that do not meet these tolerances shall be removed and replaced without additional compensation.

In all instances, when it is necessary to remove paint, it shall be done by means satisfactory to the Engineer, which will not damage the underlying surface of the pavement. When necessary to correct a deviation which exceeds the permissible tolerance in alignment, that portion of the stripe so affected shall be removed plus an additional five (5) meters in each direction, and a new stripe then painted in accordance with these specifications.

9.03.5 SAMPLING AND TESTING.

All materials shall be shipped to the job site in undamaged, sealed original packaging, clearly identifying each material as to name, color, manufacturer, batch number, and date of manufacture. All materials shall be accompanied by certified test results verifying compliance with all physical and chemical requirements of these specifications. Retroreflective raised pavement markers shall be tested for retroreflectance at the minimum rate of one (1) retroreflector tested per five hundred (500) shipped.

All paint products and other materials designated by the Engineer shall be sampled for testing. Sampling shall be performed by the Contractor in the presence of the Engineer. Materials shall be sampled in their original containers, except that bulk shipments may be sampled and resealed as approved by the Engineer. All samples shall be packaged for shipment as approved by the Engineer. Samples shall be transported to the Ministry's Central Laboratory, or an approved independent laboratory as designated by the Engineer. No materials shall be used until approved by the Ministry.

The Contractor shall be responsible for the cost of all testing including those tests designated by the Engineer to be performed at an independent laboratory.

9.03.6 METHOD OF MEASUREMENT.

Traffic Lines and Traffic Control Markings shall be measured by the square meter based on the dimensions shown on the plans or ordered by the Engineer for all areas of each type authorized, completed and accepted by the Engineer.

Retroreflective and Ceramic Raised Pavement Markers shall be measured by the unit based on the number required by the plans or ordered by the Engineer for each type of markers of each authorized, completed and accepted by the Engineer.

9.03.7 PAYMENT.

The amount of authorized, completed, and accepted Work, as measured above, will be paid at the contract unit prices in the Bill of Quantities, which price shall include all required materials, equipment, tools, labor, and all other items necessary for the proper completion of the Work as specified in Subsection 1.07.2, "Scope of Payment" in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
90301	Reflectorized Traffic Lines	Square Meter
9030101	Reflectorized White Traffic Lines	Square Meter
9030102	Reflectorized Yellow Traffic Lines	Square Meter
90302	Reflectorized Traffic Control Markings	Square Meter
90303	Retroreflectorized Thermoplastic Traffic Lines	Square Meter
9030301	Retroreflectorized Thermoplastic White Traffic Lines	Square Meter
9030302	Retroreflectorized Thermoplastic Yellow Traffic Lines	Square Meter
90304	Retroreflectorized Thermoplastic Traffic Control Markings	Square Meter
90305	Retroreflectorized Epoxy Thermoplastic Traffic Lines	Square Meter
9030501	Retroreflectorized Epoxy Thermoplastic White Traffic Lines	Square Meter
9030502	Retroreflectorized Epoxy Thermoplastic Yellow Traffic Lines	Square Meter
90306	Retroreflectorized Epoxy Thermoplastic Traffic Control Markings	Square Meter
90307	Retroreflective Raised Pavement Markers	Unit
9030701	Retroreflective Raised Pavement Markers, Type A	Unit
9030702	Retroreflective Raised Pavement Markers, Type B	Unit
9030703	Retroreflective Raised Pavement Markers, Type C	Unit
90308	Ceramic Raised Pavement Markers	Unit

SECTION 9.04 - RUMBLE STRIPS AND SPEED BUMPS

9.04.1 DESCRIPTION AND APPLICATION. This Work shall consist of the construction of Speed Bumps, Rumble Strips, and Scored Shoulder Rumble Strips at locations shown on the plans, in accordance with the specifications and in conformity with the lines and grades shown on the plans or established by the Engineer. Speed Bumps shall be used only on roadways with a posted speed of sixty-five (65) kilometers per hour. Rumble strips may be used on either low speed or high speed roadways.

ITEMS IN BILL OF QUANTITIES
Speed Bumps
Rumble Strips
Scored Shoulder Rumble Strips
Milled Shoulder Rumble Strips

9.04.2 MATERIALS.

9.04.2.1 Tack Coat. Bituminous material for tack coat shall be rapid-curing grades RC-70 or as directed by the Engineer, and shall conform to the requirements specified in Section 4.01, "Bituminous Materials" in these General Specifications.

9.04.2.2 Bituminous Mixture. The bituminous mixture for speed bumps shall conform to the requirements specified in Section 4.05, "Bituminous Concrete Pavement" for Bituminous Concrete Wearing Course, Class "C" complete or an equivalent mixture as may be approved by the Engineer.

9.04.2.3 Concrete. Portland cement concrete for the Type A Rumble Strip shall conform to Subsection 5.03.9, "Concrete for Minor Structures" in these General Specifications.

9.04.2.4 Reinforcing Steel. The steel mesh for the Type A Rumble Strip shall be the size shown on the plans and conform to the requirements specified in Section 5.02, "Reinforcing Steel" in these General Specifications.

9.04.2.5 Ceramic Raised Pavement Markers. The ceramic raised pavement markers for the Type B Rumble Strips shall be the size shown on the plans. The markers shall conform to the requirements of Paragraph 9.03.2.6, "Ceramic Raised Pavement Markers" in these General Specifications.

9.04.2.6 Adhesive. The adhesive used to secure ceramic raised pavement markers shall be bituminous compound for use in high temperatures and conforming to the requirements of the manufacturer.

9.04.2.7 Retroreflective Traffic Paint. The white traffic paint used to distinguish the Speed Bumps shall conform to the requirements of Section 9.03, "Traffic Markings" in these General Specifications for Retroreflectorized Traffic Control Markings.

9.04.3 CONSTRUCTION REQUIREMENTS.

9.04.3.1 Speed Bumps.

9.04.3.1.1 Surface Preparation. Immediately prior to the application of the tack coat, the bituminous surface shall be cleaned free of all dirt, dust, and other foreign substances which, in the opinion of the Engineer, would prevent proper bonding of the tack coat. Two five hundred (500) +/- fifty (50) millimeters trenches shall be cut transversely across the roadway with a motor grinder to wedge the speed bump into the existing pavement and the beginning end of each speed bump as detailed in Drawing Number TCD-2 in the M.O.C. "Highway Design Manual, Volume 4."

9.04.3.1.2 Application of Tack Coat. Immediately after the surface has been cleaned and approved by the Engineer, the tack coat shall be applied to the area to receive speed bumps. The bituminous material shall be applied by means of an approved pressure distributor, or when approved by the Engineer, by means of approved hand-spraying equipment which achieves a uniform mist type coverage without blotches or streaks. The rate of application shall be approximately two tenths (0.2) to three tenths (0.3) liter per square meter unless otherwise ordered by the Engineer.

9.04.3.1.3 Placing Bituminous Mixture. When the tack coat has set and has been approved by the Engineer, the Contractor shall place a speed bump form conforming to the cross section in Standard Drawing TCD-2 in position. The hot bituminous mixture shall be placed in the forms by approved hand methods and consolidated by approved hand methods and struck flush with the top of the form.

9.04.3.1.4 Compaction of Bituminous Mixture. After the bituminous mixture has been placed in the form and consolidated, the form shall be carefully lifted and removed from the roadway and rolling operations shall be immediately started. Rolling shall be performed with an approved pneumatic roller traveling parallel to the roadway centerline initially and finally perpendicularly to centerline until the speed bump is compacted to uniform cross section. The height of the speed bumps above the pavement surface shall not exceed one hundred (100) millimeters.

9.04.3.2 Type A Rumble Strips.

9.04.3.2.1 Preparation. Type A (Concrete) Rumble Strips shall be installed after the paving has been completed in accordance with the details in M.O.C. Standard Drawing Number TCD-2. Locations of installation shall be staked as shown on the plans or ordered by the Engineer. The pavement structure shall be removed by saw cutting to a minimum depth of two hundred (200) millimeters for a distance along the centerline of one and eight-tenths (1.8) meters. Underlying subgrade or base course material shall be compacted to Type 100 compaction and moistened immediately prior to concrete installation.

9.04.3.2.2 Concrete Rumble Strips. (Type A Concrete) rumble strips shall be placed, vibrated, and screeded in accordance with the requirements of Section 5.08, "Concrete Pavement" in these General Specifications. Machine placing and finishing will not be required; however, portable screeds shall extend the full one and eight-tenths (1.8) meter width of the installation (parallel to roadway centerline). The installation shall be checked with a full width (parallel to centerline) straightedge before texturing.

9.04.3.2.3 Texturing. Immediately after initial texturing performed in accordance with Paragraph 5.08.4.4, "Placing and Finishing" in these General Specifications. The rumble texture shall be achieved using a template which will produce the size, shape, and pattern of scalloped depressions shown in the M.O.C. Standard Drawing TCD-2. Depression molds may be vibrated or otherwise forced into the surface of the fresh concrete. The template shall form uniform depressions twenty (20) to thirty (30) millimeters deep and seventy-five (75) millimeters between peaks. Molds shall be designed to be withdrawn without damaging the edges of the depression. As texturing progresses, the Contractor shall periodically check the top surface of the concrete with a straightedge to be sure the template is not displacing the mass of concrete.

The Contractor may propose alternate procedures/equipment for achieving the required depressions. Such alternate procedures/equipment will be approved only after having been demonstrated as achieving the desired results.

9.04.3.2.4 Edging. Either before or immediately after the depressions are formed, the edges of the installation shall be finished in accordance with Paragraph 5.08.4.4, "Placing and Finishing" in these General Specifications.

9.04.3.2.5 Curing. Immediately after concreting operations are completed, the installation shall be cured in accordance with Subparagraph 5.08.4.4.7, "Curing" in these General Specifications. If curing compound is used, additional care shall be taken that all vertical surfaces of depressions are adequately coated.

9.04.3.3 Type B Rumble Strips. Type B Rumble Strips are constructed by placing Ceramic Raised Pavement Markers on existing bituminous concrete pavement. Raised ceramic pavement markers for Type B Rumble Strips shall be installed in the geometric pattern shown in the Standard Drawing TCD-2 in the M.O.C. Highway Design Manual, Volume 4, with Paragraph 9.03.2.6, "Ceramic Raised Pavement Markers" in these General Specifications.

9.04.3.4 Type C Scored Shoulder Rumble Strips, (Indented), and Type D Scored Shoulder rumble Strips (Milled).

Description: Scored rumble strips consist of a narrow, continuous rumble strip pattern located on the shoulder just outside of the edge line, and are useful in alerting drivers who are drifting off the roadway due to inattention or being sleepy. There are two types, indented and milled.

<u>Indented Type:</u> This type shall be constructed by rolling patterned indentations into new bituminous concrete highway shoulders using a specially modified roller with steel bars welded to the drum, as shown in the contract drawings.

<u>Milled Type:</u> This type shall be constructed by milling patterned indentations into new or existing bituminous concrete shoulders using small milling machines.

9.04.3.4.1 Equipment. Equipment used for installing indented shoulder rumble strips may be either a vibratory self-propelled steel wheeled roller or a combination vibratory self-propelled steel wheel-rubber tired roller. Only rubber tires that have smooth or "slick" tread design shall be used.

The roller shall be equipped with a water system to moisten the drums and tires sufficiently to prevent picking up bituminous material and shall weigh a minimum or six (6) tons.

9.04.3.4.2 Roller Modification Options. The Contractor has the option of utilizing the following roller modifications, provided that the specified depth and pattern of indented shoulder rumble strip are obtained.

1. Semicircular Pipe Segments Roller Modification Option 1. Semicircular pipe segments of approximately twenty-five (25) millimeters (one-half of fifty (50) millimeter diameter pipe) reinforced with properly sized reinforcing steel bars to prevent flattening, shall be continuously welded to the drum at twenty (20) to twenty-two (22) centimeter intervals, with the rounded side away from the drum.

2. Steel Rods Roller Modification Option 2. Steel rods approximately twenty-five (25) millimeters in diameter shall be continuously welded to the drum on twenty (20) to twenty-two (22) centimeter intervals. The weld shall fill in the area between the roller drum and the outside edge of the rod.

The steel rod or pipe segments shall be of such length as to result in at least six-tenths (0.6) meter of full depth indented shoulder rumble strip as specified in the contract.

Steel rod or pipe segment ends, beyond the six-tenths (0.6) meter full section, may be tapered out to a maximum of one hundred fifty (150) millimeters to prevent pavement tearing.

The properly modified drum may be added to a conventional roller, mounted so that it can be hydraulically forced down onto the bituminous shoulder as needed.

Alternate proposals will be considered for approval if it can be demonstrated to the satisfaction of the Engineer that the specified depth and pattern of indented shoulder rumble strip can be obtained.

9.04.3.4.3 Alignment Control. Each roller shall be equipped with a guide that extends in front of the roller and is clearly visible to the operator in order that proper

alignment of the completed indented shoulder rumble strip is obtained. Other suitable guidance which provides consistent alignment acceptable to the Engineer may be proposed.

9.04.3.4.4 General Requirements. The indented shoulder rumble strips shall be clearly incised grooves of the dimensions and pattern shown in the contract.

The rumble strip indentations shall only be placed where called for in the contract. This may require positioning by using planking or other methods, unless a separate hydraulically operated drum is used.

Extreme care shall be used to avoid placing indentations at other locations. Should this occur, the Contractor shall remove or obliterate the indented rumble strip and restore the pavement to the satisfaction of the Engineer.

9.04.3.4.5 Placement Requirements. Indented shoulder rumble strips shall be formed in one (1) pass of the roller.

Indented shoulder rumble strips shall be formed only when the bituminous shoulder material is at the proper temperature to ensure that tearing does not occur and to ensure that the depth and pattern of the indentations are being provided as specified.

Milled Type: This type shall be constructed by milling (cutting) a continuous pattern of depressions into new or existing paved highway shoulders, using special milling equipment.

***1. Equipment.* The equipment shall consist of a rotary type cutting head with a maximum outside diameter of sixty (60) cm and will be a minimum of forty (40) cm long. The cutting head shall have the cutting tips arranged in such a pattern as to provide a relatively smooth cut (approximately 0.15 cm between peaks and valleys). The cutting head(s) shall be on its own independent suspension from that of the power unit to allow the tool to self align with the slope of the shoulder and/or any irregularities in the shoulder surface. The cutting tool shall be equipped with suitable guidance so as to provide consistent alignment of each cut in relation to the roadway, and to provide uniformity and consistency throughout the project.**

***2. Placement.* The milled rumble strips shall be placed so as to have the finished dimensions of eighteen (18) cm (+/- 1.3 cm) wide in the direction of travel and shall be a minimum of forty (40) cm long measured perpendicular to the direction of travel. The depressions shall have a concave circular shape with a minimum one and three tenths (1.3) cm depth at center (maximum allowable depth one and six tenths (1.6) cm). The rumble strips shall be placed in relation to the roadway according to the patterns shown in the contract drawings.**

Pavement material resulting from the operations will become the property of the contractor to use at his option on the project or removed and disposed of in a manner approved by the Engineer.

The milled rumble strips shall only be placed where called for in the contract. Should they be placed at incorrect locations, the contractor shall remove them and restore the pavement to the satisfaction of the Engineer.

At the end of each working day, all equipment shall be removed to a location where it does not present a hazard to traffic, the pavement shall be cleaned by sweeping or flushing and the work area reopened to traffic.

9.04.4 METHOD OF MEASUREMENT.

9.04.4.1 Speed Bumps, Type A Rumble Strips and Type B Rumble Strips. Speed Bumps, Type A Rumble Strips, and Type B Rumble Strips shall be measured by the square meter for all Work authorized, completed and accepted by the Engineer based on the horizontal dimensions of the installations as shown in Volume 4 of the M.O.C. HIGHWAY DESIGN MANUAL or modified on the plans or ordered by the Engineer.

There shall be no measurement for pavement excavation required to construct Type A Rumble Strips nor will such quantities be deducted from previously paid quantities of pavement structure items. There shall be no separate measurement of the ceramic raised pavement markers included in Type B Rumble Strips.

9.04.4.2 Type C Scored Shoulder Rumble Strips. Type C Indented Scored Shoulder Rumble Strips will be measured longitudinally, parallel to the traveled way, for each side of the roadway where strips are placed. The rumble strip measurement shall begin at the transverse center of the first score and proceed along the centerline of the rumble strip pattern to the center of the final score in the pattern.

Breaks in the rumble strip pattern for exits, principal intersections and other interruptions in normal shoulder width will not be included in the measurement for payment.

9.04.4.3 Type D Scored Shoulder Rumble Strips. Type D Milled Scored Shoulder Rumble Strips will be measured longitudinally, parallel to the traveled way, for each side of the roadway where the stripe are milled. Breaks in the rumble strip pattern will not be included in the measurement for payment.

9.04.5 PAYMENT.

Rumble Strip and Speed Bump Items of Work, measured as provided above, will be paid for at the contract unit price(s) as specified in the Bill of Quantities, which price(s) shall be full compensation for furnishing all materials, construction and for all labor, equipment, tools, supplies and all other items necessary for the proper completion of Work as specified in Subsection 1.07.2, "Scope of Payment" in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
90401	Speed Bumps	Square Meter
90402	Rumble Strips	Square Meter
9040201	Rumble Strips, Type A	Square Meter
9040202	Rumble Strips, Type B	Square Meter
9040203	Scored Shoulder Rumble Strips, Type C - Indented	Linear Meter
9040204	Scored Shoulder Rumble Strips, Type D - Milled	Linear Meter

SECTION 9.05 - HIGHWAY SIGNING

9.05.1 DESCRIPTION. This Work shall consist of furnishing and installing highway signs, delineators, object markers, kilometer posts and support assemblies as shown on the plans and in accordance with the specification or as directed by the Engineer. All sign faces and lettering shall be in accordance with the Ministry Standards for Road Safety Features, the Manual on Uniform Traffic Control Devices (M.U.T.C.D.), as shown on the plans or as directed by the Engineer. Unless otherwise shown in the plans or noted in the Special Specifications, all signs shall be lettered in both Arabic and English. This shall also include construction of concrete foundations for sign supports, gantries and cantilevers and the fabrication, erection and finishing of steel gantry and cantilever sign structures. The Work shall also include the construction, erection and relocation of all temporary signing works required prior to construction, during construction and prior to opening.

ITEMS IN BILL OF QUANTITIES

Highway Signs, Ground-Mounted
Highway Signs, Overhead
Sign Support - (Breakaway)
Sign Support - Overhead
Kilometer Post
Delineators
Reflectors
Object Markers

All overhead signs shall be either internally illuminated or retroreflectorized through the use of high intensity retroreflective sheeting as per the M.O.C. M.U.T.C.D.

9.05.2 MATERIALS. Materials shall conform to the following requirements:

9.05.2.1 Concrete. Concrete for reinforced concrete footings shall conform to Class B as specified in Paragraph 5.01.1 "Description" in these General Specifications. Concrete to support single posts of small signs shall conform to Subsection 5.03.9, "Concrete for Minor Structures" in these General Specifications.

9.05.2.2 Reinforcing Steel. Reinforcing steel shall conform to the requirements of Section 5.02, "Reinforcing Steel" in these General Specifications.

9.05.2.3 Sign Supports. Posts, gantries and cantilever sign supports shall conform to the requirements of the M.O.C. "Standards for Road Safety Features" and M.O.C. Circular No. 747 dated 2/4/1410 Hegira, unless otherwise shown on the plans.

9.05.2.4 Steel Channels. Steel channels shall conform to the requirements of Section 5.05, "Steel Structures and Miscellaneous Metal Work" in these General Specifications.

9.05.2.5 Standard Industrial Sign Supports. Standard industrial steel sign supports shall be fabricated from billet or rail steel conforming to Schedule 40 ASTM

A-120. Pipe posts shall be hot dipped galvanized according to ASTM A 123 after yielding holes are drilled or punched with an absolute minimum outside diameter of seventy-three (73) millimeters ASTM-A-120. Steel pipe and I.P.E. sign supports shall have a slip base breakaway support in accordance with the M.O.C. Sign Erection Standards Manual (TS-02). Signs requiring two (2) or three (3) posts shall use I.P.E. posts in accordance with the M.O.C. Road Services Department "DIMENSIONING OF SIGN POSTS AND FOOTINGS FOR DIRECTIONAL SIGNS."

9.05.2.6 Object Marker and Delineator Posts. The Contractor shall fabricate object marker and delineator posts from steel, aluminum or G.I. pipe of seventy-five (75) millimeters as specified M.O.C. TCD-03. Delineator posts may also be fabricated from plastic.

9.05.2.6.1 Steel Posts. Furnish flanged U-channel steel posts weighing approximately three kilograms per meter (3 kg/m) that conform to ASTM A 36. Galvanize the posts according to ASTM A 123.

9.05.2.6.2 Aluminum Posts. Furnish standard shaped three (3) millimeter thick aluminum posts conforming to ASTM B 221, Alloy 6061-T6.

9.05.2.6.3 Plastic Posts. Furnish flexible delineator posts made with high impact resistant polymer reflective material with a minimum area of seven (7) centimeters wide.

9.05.2.7 Galvanizing. All steel supports, bolts, nuts and washers shall be zinc coated in accordance with ASTM A 123. All bolts, nuts and washers shall be galvanized in accordance with ASTM A 153.

9.05.2.8 Sign Panel Materials. Signboard construction shall conform to the requirements of M.O.C. Standard Details as shown on the plans or as otherwise approved by the Engineer and shall meet the following requirements:

9.05.2.8.1 Aluminum Alloy Panels, Sheets and Miscellaneous Hardware. Aluminum alloy panels, sheets and miscellaneous hardware shall conform to ASTM B 209 or B 211 as appropriate, using alloy 6061-T6 or 5052-h38. All aluminum alloys shall have a minimum tensile strength of two thousand five hundred (2,500) kilograms per square centimeter and a minimum yield strength of two thousand (2,000) kilograms per square centimeter.

9.05.2.8.2 Extruded Aluminum Panels. Extruded Aluminum Panels shall be fabricated from aluminum Alloy 6063-T6 conforming to the requirements of ASTM B221 Panels and shall have a minimum thickness of two millimeters for sizes up to 762 X 762 millimeters. Larger panels shall have a minimum thickness of three millimeters.

Sheets for plain sign plates shall have a minimum thickness of three (3) millimeters unless otherwise specified.

9.05.2.8.3 Steel Sheet Panels. Steel sheet panels shall conform to the requirements of ASTM A 525, minimum two (2) millimeters thickness, unless otherwise noted on the plans.

9.05.2.8.4 Stainless Steel Bolts, Washers and Self-Locking Nuts. These items shall conform to ASTM A 276, Chromium Nickel Grade with a minimum yield of two thousand (2,000) kilograms per square centimeter.

9.05.2.8.5 Vulcanized Fiber Washers. Fiber washers shall conform to ASTM D 710, Gray, Commercial Grade, when shown on the plans.

9.05.2.8.6 Hard Rubber Washers. Hard rubber washers, when shown on the plans, shall be as approved by the Engineer.

9.05.2.8.7 Nylon and Neoprene Fittings. Nylon and/or neoprene washers, spacers, sleeves, etc. when specified on the plans, shall be as approved by the Engineer.

9.05.2.8.8 Porcelain Enamel Coatings. Porcelain enamel coatings for sign faces shall be a minimum of four hundredths (0.04) millimeter in thickness. The coating shall be applied by automatic spray equipment conforming to Porcelain Enamel Institute specifications. The coating shall have a gloss reading of fifty (50) to seventy (70) units at an angle of fifty (50) grads when measured in accordance with ASTM C 346.

Colors shall be in accordance with the M.U.T.C.D. Color samples representative of all signs to be furnished shall be submitted to the Engineer for approval prior to ordering.

Adherence of the coating shall be verified in accordance with the accelerated spall test as specified by the Porcelain Enamel Institute.

The coating shall have a weight loss of less than one-half (½) milligrams per square centimeter in boiling six percent (6%) citric acid when tested in accordance with ASTM C 283.

All exposed surfaces of the coating shall be free of blemishes that may impair the serviceability or detract from the appearance of the sign.

9.05.2.8.9 Letters, Numerals, Arrows, Symbols, Etc. Letters, numerals, arrows, symbols, border and other features of the sign face shall conform to the requirements of the M.U.T.C.D.

Spacing of mounting holes for screws, bolts, or rivets shall be determined by character size and shape but in no case shall the spacing be more than twenty (20) centimeters on center. Each character shall be secured to the sign with non-twist, corrosion resistant screws, bolts, or rivets.

Retroreflective letters, numerals, symbols, etc., cut from retroreflective sheeting, shall be of the color and coefficient of retroreflectivity specified on the plans and applied to the sign face in accordance with instructions of manufacturer of retroreflective sheeting.

Porcelain enamel letters, numerals, borders, etc., shall consist of individual embossed aluminum frames into which reflex retroreflectors are installed so as to be an integral part of the character or otherwise securely affixed to prevent displacement in handling or service. Mounting hole and fasteners requirement shall be as described above.

9.05.2.8.10 Aluminum Sign Sections.

1. General. Aluminum sign sections shall be fabricated in accordance with the plans, from standard widths of aluminum sheets, panels or other hardware and materials as required.

Each section shall be provided with a perimeter frame. The extruded horizontal top and bottom frame members shall have an integral retainer track for affixing mounting bolts to provide for blind fastening of sign panel to post support. The extruded vertical side frame members shall be a channel. An additional slot shall be milled in the top and bottom frame for later field insertion of post clip posts. The perimeter frame shall be assembled by means of self-tapping hex head stainless steel screws. A sealant shall be used at the corner to prevent moisture penetration.

If the horizontal finished dimension of the sign exceeds eight (8) meters and vertical panels are used, the vertical extruded frame members shall have an integral retainer track for mounting bolts. The horizontal frame members shall be extruded channels.

2. Honeycomb Sections. The front sheet of each sign shall be fabricated in one piece from minimum one and sixth tenths (1.6) millimeter aluminum alloy conforming to Subparagraph 9.05.2.8.1, "Aluminum Alloy Sheets and Miscellaneous Hardware" in these General Specifications. The surface shall be treated with amorphous chromate conversion coating conforming to the requirements of ASTM B 449, Class 2.

Core material shall be phenolic impregnated cellulose honeycomb. Core material shall be resistant to fungus. The back sheet of each panel shall be fabricated in one piece from minimum one (1) millimeter aluminum alloy conforming to Subparagraph 9.05.2.8.1, "Aluminum Alloy Sheets and Miscellaneous Hardware" in these General Specifications. The surface shall be treated with an amorphous chromate conversion coating conforming to the requirements of ASTM B 449, Class 2.

The laminating adhesive shall be of the thermoplastic neoprene rubber base solvent type exhibiting a resilient oil and water resistant bond. The solids content shall be suitable for automatic spray application or roller coat application and yield a dry weight of adhesive of fifty (50) grams per square meter minimum. A uniform film of adhesive shall be applied to each surface and force dried at a temperature of eighty-two degrees Celsius (82° C.) minimum. The final bond to be made while the glue line temperature is a minimum of eighty-two degrees Celsius (82° C.) using sufficient pressure to insure intimate mating of the surfaces. Minor amounts of adhesive overspray on perimeter of back sheet or channel shall not be cause for rejection.

The tensile strength of the honeycomb laminate construction shall have a minimum of one and one-half (1½) kilograms per square centimeter when tested in accordance with ASTM C 297 and ASTM C 481, Cycle A.

Weep holes three (3) millimeters in diameter shall be drilled in the perimeter frame at the bottom of each panel. Holes shall be spaced approximately ten (10) millimeters in from either end and in the center of each panel.

3. Panel Sections. Extruded aluminum sign panels that require splicing shall be spliced by rivets, bolts or other fasteners as shown on the plans or approved by the Engineer. All splices shall be capable of developing the full strength of the section. Rivets or other fasteners shall be flush with the face side. The aluminum panels shall be fastened to frames, stiffeners, wind beams, or joint backing strips as shown on the plans or approved by the Engineer. All fabrication of sign panels, including cutting and drilling or punching of holes, except mounting holes for cutout letters, numbers, symbols, etc., shall be completed prior to degreasing and application of coating or retroreflective sheeting.

Seams of all multiple section signs shall be milled to a tolerance of plus or minus eight tenths (0.8) millimeter from a straight plane so that when two adjoining panels are assembled, no gap over one and one-half (1½) millimeters shall be visible between panels. All sharp edges that would present a hazard in handling shall be smoothed. Panels may be milled up to six (6) millimeters on each side in order to achieve edge uniformity.

All adhesively bonded panels shall have exterior faces of such flatness that, when measured at twenty-five degrees Celsius (25° C), the maximum slope of the surface at any point measured from the nominal plane of the surface shall not exceed one and five tenths (1.5%) percent.

At each corner on the face of each panel, one three (3) millimeter self-plugging rivet shall be used to fasten the sheet to the perimeter panel. Rivets appearing on the face side shall be a color similarly required for the face of the panel.

On multiple panel signs, the closure extrusions between panels shall be provided by the manufacturer. Extrusions shall be set in from edge of panels for clearance of rivets and frame.

9.05.2.9 Retroreflective Sheeting. Retroreflective sheeting shall consist of a white or colored sheeting having a smooth outer surface and that essentially has the property of a retroreflector over its entire surface. There are six (6) types and five (5) classes of retroreflective sheeting.

1. **Classification - Retroreflective sheeting shall be classified as follows:**

Type I **- A medium-intensity retroreflective sheeting referred to as "engineering grade" and typically enclosed lens glass-bead sheeting.**

Type II **- A medium-intensity retroreflective sheeting sometimes referred to as "super engineering grade" and typically enclosed lens glass-bead sheeting.**

Type III **- A high-intensity retroreflective sheeting that is typically encapsulated glass-bead retroreflective material.**

Type IV **- A high-intensity retroreflective sheeting. This sheeting is typically an unmetallized microprismatic retroreflective element material.**

Type V **- A super-high-intensity retroreflective sheeting. This sheeting is typically a metallized microprismatic retroreflective element material.**

Type VI **- An elastomeric high-intensity retroreflective sheeting without adhesive. This sheeting is typically a vinyl microprismatic retroreflective material.**

2. **Backing Classes - The backing required for retroreflective sheeting Types I through V shall be classified as follows:**

Class I **- The adhesive backing shall be pressure-sensitive, require no heat, solvent, or other preparation for adhesion to smooth, clean surfaces.**

Class II **- The adhesive backing shall have an adhesive that shall be activated by applying heat and pressure to the material. The temperature necessary to form a durable permanent bond shall be a minimum of sixty-six degrees Celsius (66° C).**

The Class II material shall be respositionable under normal shop conditions and at substrate temperatures up to thirty-eight degrees Celsius (38° C) and without damage to the material. The Class II material may be perforated to facilitate removal of air in heat-vacuum laminators, but the perforation must be of a size and frequency such that they do not cause objectionable blemishes when the sheeting is printed.

Class III **- The adhesive backing shall have a positionable low-tack pressure-sensitive adhesive that requires no heat, solvent, or other preparation for adhesion to smooth, clean surfaces. It shall be repositionable up to a temperature of thirty-eight degrees Celsius (38° C) without damage to the material.**

Class IV **- The adhesive backing shall have a low-temperature pressure-sensitive adhesive that permits sheeting applications at temperatures down to minus seven degrees Celsius (-7° C) without the aid of heat, solvent, or other preparation for adhesion to smooth, dry, clean surfaces.**

Class V - This shall be a nonadhesive backing made of material commercially used for self-supporting products such as traffic cone collars, temporary roll-up warning signs, and post bands.

3. Performance Requirements - This is a summary of the minimum performance requirements for each type of retroreflective sheeting.

Type I - Minimum Coefficient of Retroreflection - Table 9.05-1; Artificial Weathering - 1000 h; Retroreflectance or daytime lightness - Table 9.05-2.

Type II - Minimum Coefficient of Retroreflection - Table 9.05-3; Artificial Weathering - 2200 h; Reflectance or daytime lightness - Table 9.05-2; Other requirements: When the color orange is specified the artificial weathering will be 500 hours.

Type III - Minimum Coefficient of Retroreflection - Table 9.05-4; Artificial Weathering - 2200 h; Reflectance or daytime lightness - Table 9.05-2; Other Requirements: When the color orange is specified the artificial weathering will be 500 hours.

Type IV - Minimum Coefficient of Retroreflection - Table 9.05-5; Artificial Weathering - 2200 h; Reflectance or daytime lightness - Table 9.05-6. Other Requirements: When the color orange is specified the artificial weathering will be 500 hours.

Type V - Minimum Coefficient of Retroreflection - Table 9.05-7; Artificial Weathering-2200h; Reflectance or daytime lightness - Table 9.05-8.

Type VI - Minimum Coefficient of Retroreflection-Table 9.05-9; Artificial Weathering-250 h; Reflectance or daytime lightness-Table 9.05-2.

4. Coefficient of Retroreflection - The coefficient of retroreflection shall meet or exceed the minimum requirements of Tables 9.05-1, 3, 4, 5, 7 and 9 when tested in accordance with ASTM E810 Test Method.

5. Daytime Color - The color of the sheeting shall conform to requirements of Table 9.05-10 and one of the following Tables 9.05-2, 6, or 8 when tested in accordance with Test Method ASTM E97, Method E308, Practice E805, and Practice E 991. Daytime and nighttime color shall have substantially the same hue.

6. Artificial Weathering - The retroreflective sheeting shall be weather resistant and show no appreciable cracking, scaling, pitting, blistering, edge lifting, or curling, or more than eight-tenths (0.8) millimeter shrinkage or expansion when four (4) panels are exposed the number of hours specified in Table 9.05-11 in accordance with ASTM Practice G 123, Type E or FH, with humidifier Off, washing the panels with a five percent (5%) HCl solution for forty-five (45) seconds, rinsing thoroughly with clean water, blotting with a soft cloth, brushing to equilibrium at standard temperature and testing for coefficient of retroreflection. The four (4) panel readings will be averaged.

7. Specular Gloss. The retroreflective sheeting shall have a ninety-four and four tenths (94.4) grad specular gloss of not less than forty (40) when tested in accordance with ASTM D 523.

8. Color Processing. Retroreflective sheeting shall permit cutting and color processing with compatible transparent and opaque process inks in accordance with manufacturer's recommendation at temperatures of fifteen degrees Celsius (15° C.) to forty degrees Celsius (40° C) and relative humidity of twenty (20) to eighty (80) percent. The sheeting shall be heat resistant and permit force curing without staining of applied or unapplied sheeting at temperatures as recommended by the manufacturer. Color process for High Intensity Retroreflective Sheeting shall be restricted to sheeting with heat activated adhesive backing unless otherwise recommended by the manufacturer.

9. Shrinkage. A twenty-three (23) centimeter square retroreflective sheeting sample with liner shall be conditioned a minimum of one (1) hour at twenty-two degrees Celsius (22° C.) and fifty (50) percent relative humidity. The liner shall be removed and the sample placed on a flat surface with the adhesive side up. Ten (10) minutes after liner is removed and again after twenty-four (24) hours, the specimen shall be measured to determine the amount of dimensional change. The retroreflective sheeting shall not shrink in any dimension more than eight tenths (0.8) millimeter in ten (10) minutes nor more than three (3) millimeters in twenty-four (24) hours.

10. Application Requirements. Retroreflective sheeting shall be "Medium Intensity" (Type I), Medium-High-Intensity (type II), or High-Intensity (Type III) unless a higher intensity is specified in these General Specifications or the Special Specifications. All retroreflective sheeting shall satisfy the tests contained in ASTM D4956 for the Type specified. The Contractor shall supply a Certificate of Eligibility stating that the retroreflective material has been specifically modified for use in Saudi Arabia.

TABLE 9.05-1
TYPE I SHEETING
Minimum Coefficient of Retroreflection (RA)
(Candelas per lux per square meter)
Medium Intensity

Observation Angle	Entrance Angle	White	Red	Orange	Brown	Yellow	Green	Blue
0.20°	-4.0°	70	14.0	25.0	2.0	50	9.0	4.0
0.20°	+30°	30	6.0	7.0	1.0	22	3.5	1.7
0.55°	-4.0°	30	7.5	13.5	1.0	25	4.5	2.0
0.55°	+33°	15	3.0	4.0	0.5	13	2.2	0.8

TABLE 9.05-2
SHEETING TYPES I, II, III AND IV
LUMINANCE FACTOR (Y%) (DAYTIME)

Color	Minimum	Maximum
White	27	...
Yellow	15	45
Orange	14	30
Green	3.0	9.0
Red	2.5	12
Blue	1.0	10
Brown	4.0	9.0

TABLE 9.05-3
TYPE II SHEETING
Minimum Coefficient of Retroreflection (RA)
Candelas per Lux Square Meter
Medium-High Intensity

Observation Angle	Entrance Angle	White	Yellow	Orange	Green	Red	Blue	Brown
0.2°	-4°	140	100	60	30	30	10	5.0
0.2°	+30°	60	36	22	10	12	4.0	2.0
0.5°	-4°	50	33	20	9.0	10	3.0	2.0
0.5°	+30°	28	20	12	6.0	6.0	2.0	1.0

TABLE 9.05-4
TYPE III SHEETING
Minimum Coefficient of Retroreflection (RA)
(Candelas per lux per square meter)
High Intensity

Observation Angle	Entrance Angle	White	Red	Orange	Yellow	Green	Blue
0.2°	-4°	250	45	100	170	45	20.0
0.2°	+30°	150	25	60	100	25	11.0
0.5°	-4°	95	15	30	62	15	7.5
0.5°	+30°	65	10	25	45	10	5.0

TABLE 9.05-5
TYPE IV SHEETING
Minimum Coefficient of Retroreflection (RA)
(Candelas per lux per square meter)
High Intensity

Observation Angle	Entrance Angle	White	Yellow	Orange	Green	Red	Blue	Brown
0.2°	-4°	250	170	100	35	35	20	7.0
0.2°	+30°	80	54	34	9	9	5.0	2.0
0.5°	-4°	135	100	64	17	17	10	4.0
0.5°	+30°	55	37	22	6.5	6.5	3.5	1.4

TABLE 9.05-6
SHEETING TYPE IV
LUMINANCE FACTOR (Y%) DAYTIME

Color	Minimum	Maximum
White	50	...
Yellow	30	45
Orange	15	30
Green	6.0	15
Red	6.0	15
Blue	3.0	8.0
Brown	1.0	6.0

TABLE 9.05-7
TYPE V SHEETING
Minimum Coefficient of Retroreflection (RA)
(Candelas per lux per square meter)
Super-High-Intensity

Observation Angle	Entrance Angle	White	Yellow	Orange	Green	Red	Blue
0.2°	-4°	700	470	280	120	120	56
0.2°	+30°	400	270	160	72	72	32
0.5°	-4°	160	110	64	28	28	13
0.5°	+30°	75	51	30	13	13	6.0

TABLE 9.05-8
SHEETING TYPE V
Luminance Factor (Y%) Daytime
Typically Metallized Microprismatic Delineator Material

Color	Minimum	Maximum
White	15	...
Yellow	12	30
Orange	7.0	25
Green	2.5	11
Red	2.5	11
Blue	1.0	10
Brown	1.0	9.0

TABLE 9.05-9
TYPE VI SHEETING
Minimum Coefficient of Retroreflection (RA)
(Candelas per lux per square meter)
Elastomeric-High-Intensity

Observation Angle	Entrance Angle	White	Yellow	Orange	Green	Red	Blue
0.2°	-4°	250	170	70	30	35	20
0.2°	+30°	95	64	26	11	13	7.6
0.5°	-4°	200	136	56	24	28	18
0.5°	+30°	60	40	17	7.2	8.4	4.8

TABLE 9.05-10
Color Specifications for
Retroreflective Sheeting (Daytime)
Chromaticity Coordinates*

	1		2		3		4	
Color	X	Y	X	Y	X	Y	X	Y
White	.303	.287	.368	.353	.340	.380	.274	.316
Red	.613	.297	.708	.292	.636	.364	.558	.352
Brown	.445	.353	.604	.396	.556	.443	.445	.386
Yellow	.498	.412	.567	.442	.479	.520	.438	.472
Green	.030	.380	.168	.346	.286	.428	.201	.776
Blue	.144	.030	.244	.202	.190	.247	.066	.208

*The four pairs of chromaticity coordinates determine the acceptable color in terms of the CIE 1931 Standard Colorimetric System measured with Standard Illuminate source C.

TABLE 9.05-11
Artificial Weathering Photometric Requirements

Type	Hours	Minimum Coefficient of Retroreflection (R_A)
I	1000	50% of Table 9.05-1
II	2200[A]	65% of Table 9.05-3
III	2200[A]	80% of Table 9.05-4
IV	2200[A]	80% of Table 9.05-5
V	2200	80% of Table 9.05-7
VI	250	0% of Table 9.05-9

[A]When the color orange is specified the artificial weathering will be 500 h.

9.05.2.10 Delineators and Retroreflectors. Delineator posts shall be steel, aluminum or plastic as specified in Paragraph 9.05.2.6 "Object Markers and Delineator

Posts" in these General Specifications of the dimensions and weights shown on the plans or in the M.U.T.C.D.

Sheets for delineator panels shall conform to the requirements as specified above in Paragraph 9.05.2.8 "Sign Panel Materials" in these General Specifications.

Retroreflective sheeting material shall be High-Intensity conforming to the requirements of M.U.T.C.D. Section 3.04. When microprismatic retroreflectors are specified, they shall conform to the requirements of Type V Super-High-Intensity Retroreflective Sheeting and the standard drawings, as specified in Paragraph 9.05.2.9 "Retroreflective Sheeting" in these General Specifications.

Epoxy Resin Adhesive for bonding retroreflectors to hardened Portland cement concrete shall conform to AASHTO M 237.

9.05.2.11 Object Markers. Materials for object markers, including sign posts, sign face material, retroreflective sheeting, and retroreflectors as detailed in the Ministry of Communications M.U.T.C.D., shall conform to the requirements as specified above in Subsection 9.05.2, "Materials" in these General Specifications.

9.05.3 CONSTRUCTION REQUIREMENTS.

9.05.3.1 Signs.

9.05.3.1.1 Design. All signs shall be of the type, color, design, and size indicated on the plans. All signs shall conform to the Manual on Uniform Traffic Control Devices (M.U.T.C.D.) and M.O.C. Standard Designs.

For nomenclature purposes, the following designations shall be as defined unless modified in the Special Specifications.

Type A Signs - Retroreflective sheeting on plain aluminum sheets.

Type B Signs - Retroreflective sheeting on extruded aluminum panel sections.

Type C Signs - Porcelain enamel coating on honeycomb aluminum sections.

9.05.3.1.2 Shop Drawings. The Contractor shall submit to the Engineer for approval, three (3) copies of drawings for all special sign faces and all sign faces bearing messages, showing the design and/or arrangement and spacing of both the Arabic and English sign messages. Official town names and their Arabic and English spelling shall be as provided by the Engineer. Size and style of lettering shall be as shown on the plans and in accordance with the M.U.T.C.D.

9.05.3.2 Storage and Shipment of Signs. Signs delivered for use on a project shall be stored off ground and under cover in a manner approved by the Engineer. Any sign damaged, discolored or defaced during transportation, storage or erection shall be

rejected. Shipment to the job site shall be accomplished with each sign separated by heavy paper or cloth and the bundle bound with chord to prevent movement.

9.05.3.3 Placement and Orientation. The Engineer will establish and mark the longitudinal location of each sign.

The sign shall be laterally positioned from the shoulder edge or curb as shown on the plans or directed by the Engineer.

The Contractor shall stake the location of the sign supports.

The Contractor shall be responsible for the proper elevation, off-set, level, and orientation of all signs he erects. He shall exercise due care in the preservation of stakes for his and the Engineer's use. If any stakes are lost, damaged, displaced, or removed the Contractor shall have them reset at his expense.

Unless otherwise shown on the plans, all signs shall be erected so that the edge and face of the sign are truly vertical and the face is at an angle of ninety-three degrees (93°) grads to the centerline; that is, facing slightly toward the centerline of the lane which the sign serves. Where lanes divide or are on sharp curves, the Contractor shall orient sign faces as indicated on the plans or as directed by the Engineer so that they will be most effective both day and night and so as to avoid specular reflection and glare. All sign supports shall be plumbed.

9.05.3.4 Footings for Posts. Footings shall be excavated to the minimum dimensions shown in the Ministry of Communications Circular No. 747 dated 2/4/1410 Hegira. Footings shall be installed and backfilled flush with the finished ground surface. Class B concrete shall be placed against the undisturbed excavated faces, except that the top fifteen (15) centimeters of each footing shall be formed. Forming of the entire footing will not be permitted unless approved by the Engineer. Concrete shall be thoroughly vibrated. Tops of footings shall be finished with a wood float and all exposed edges shall be rounded with an edger. Backfill shall be compacted to ninety percent (90%) of the maximum dry density determined in accordance with AASHTO T 180. Care shall be taken to prevent damage to the finished concrete. Backfill shall be brought up level with the finished ground line. The top of the foundation shall not extend more than seventy-five (75) millimeters above the terrain.

9.05.3.5 Sign Posts.

9.05.3.5.1 General. The number and lengths of posts shown in the plans for small signs are for bidding purposes only. When progress of the Work permits, the Engineer will authorize the location of each sign, with the station and offset distance from the edge of pavement. The Contractor shall be responsible for determination of post lengths to provide the vertical clearance shown on the plans. Field cutting of posts shall be performed by sawing of the bottom (to be embedded) end.

Sign supports shall be fabricated as detailed in the Ministry of Communications Circular No. 747 dated 2/4/1410 Hegira unless modified by the plans. When galvanizing is specified, assemblies shall be hot-dip galvanized after fabrication. All welds shall be mechanically cleaned before galvanizing. Galvanized materials on which the galvanizing has been damaged in transporting, handling or erection will be rejected or may, with the approval of the Engineer, be repaired in the field by the zinc alloy stick method. Required field welds and adjacent areas on which the galvanizing has been damaged shall be galvanized by this same method. The zinc alloy stick shall be cast zinc, tin, and lead in combination with fluxing ingredients. The compound shall be completely liquid at a temperature not lower than two-hundred forty degrees Celsius (240° C). The area to be regalvanized shall be thoroughly cleaned, including the removal of slag on welds. The surface shall be heated with an oxyacetylene torch to approximately three hundred fifteen degrees Celsius (315° C) and the alloy stick rubbed over the surface to fix a deposit. While the alloy is still liquid, a clean wire brush shall be used to smooth the deposit evenly over the entire area being galvanized. If a heavy deposit or build-up is required to match the original coating, more alloy shall be added immediately to the initial bond deposit and spread with a paddle or brush until the required thickness is obtained. Edges of drilled holes shall be coated with commercially available zinc-rich paint. Shop drawings will not be required for pipe posts greater than fifty (50) millimeters in outside diameter showing the details of the breakaway feature.

The Contractor shall furnish to the Engineer, fabricator's certifications in triplicate certifying that the material supplied conforms to all of the requirements specified.

9.05.3.5.2 Painting. All exposed steel surfaces, except galvanized surfaces, shall receive one (1) shop coat of Paint No. 1 and two (2) field coats consisting of Paint No. 5 followed by Paint No. 4.

9.05.3.6 Fastening Signs to Sign Posts. Signs shall be fastened to sign supports in accordance with the requirements of the plans, the recommendations of the sign manufacturer, and to the satisfaction of the Engineer. Fasteners shall be vandal-anti-thief resistant to the extent practical.

All bolt heads, screw heads, and washers used to install sign on support shall be such that they do not protrude out from the surface of the sign. The heads of the bolts or screws shall be as nearly as practical the same as the color of the background or message area at the point where the hardware is exposed. To the extent practical, fastener systems shall be designed so as not to require the drilling of the sign face.

When steel signs are mounted with aluminum hardware or where aluminum signs are mounted with steel hardware or on steel posts, approved asphalt, nylon, or neoprene insulation shall be installed at all points where dissimilar metals might come in contact.

9.05.3.7 Delineators and Retroreflectors. Delineator posts shall be erected at locations shown on the plans and set at elevations such that the delineator retroreflectors will be at the indicated height above the ground surfaces. Posts shall be set plumb and to the established lines and grades. The method of driving shall not substantially alter the cross-sectional dimensions of the posts or damage the post.

Posts which are damaged by driving shall be removed and replaced at the Contractor's expense. Predrilling of post holes may be necessary to avoid damage to the posts.

Sheet metal panels shall be attached to posts as shown on the plans and retroreflectors or retroreflective sheeting installed as specified.

9.05.3.8 Object Markers. Object markers shall be installed at the locations shown on the plans or designated by the Engineer in accordance with the above requirements.

9.05.4 REPLACEMENT SIGNS. The Contractor shall furnish additional signs to be used for maintenance purposes of the number and type as shown in the plans or specified in the Special Specifications. The Contractor shall deliver these signs to the Road District designated by the Ministry. The cost of transporting replacement signs shall be considered subsidiary to other items in the Bill of Quantities.

9.05.5 METHOD OF MEASUREMENT. Ground-mounted and overhead highway signs shall be measured by the face area to the nearest one-hundredth (1/100) square meter for each highway sign and to the nearest one-tenth (1/10) square meter for the total of each type of sign, as specified in the Bill of Quantities. The area of each sign shall be that of the smallest rectangular, circular, triangular, trapezoidal, or other standard Ministry sign shape that will encompass the sign panel. No measurement shall be made of stiffeners, e.g., those needed to support smaller signs onto larger ones, as these are considered subsidiary to the pay items(s) of signs appearing in the Bill of Quantities.

Sign support, breakaway post, of the type specified in the Bill of Quantities, shall be measured by the kilogram for I-beam or by the number of units for tubular as installed and accepted, which shall include the sign post, hinged as required, brackets, coupling bolts, breakaway couplings, nuts, etc., all as specified for the proper erection and anchoring of the post onto the anchor plate; or the threaded reducer when a threaded collar detail is applicable.

Overhead sign supports shall be measured by the metric ton as specified in the Bill of Quantities, complete in place as determined from the Engineer's computed weights and as specified in the specifications under Subsection 5.05.8 "Method of Measurement;" in these General Specifications except that all steel items in connection with walkways on overhead signs, including rails, brackets and fasteners onto the tubular support, gratings and all incidentals thereof, shall be measured by the metric ton, complete in place, as determined by weighing in the presence of the Engineer on an approved, accurate set of scales.

Sign support work shall include all structural excavation and backfill, foundation concrete, reinforcement, structural steelwork, including sign support brackets fittings and fixings and all incidentals associated with these items. See Standard Drawings SS-1A, and SS-1C in the M.O.C. Highway Design Manual, Volume 4. Minor modifications approved by the Engineer to expedite fabrication, will not result in changes to the measure of quantities. There shall be no separate measurement of excavation, backfill,

concrete, reinforcing steel, or any other material or Work incidental to installation of sign supports.

Delineators and Object Markers shall be measured by the unit for all work including the posts and delineators or object markers of each type authorized, completed, and accepted by the Engineer. Retroreflectors shall be measured by the unit of work authorized, completed, and acceptably installed directly to guardrails, barriers and fences when no posts are required.

Retroreflectors shall be measured by the number of units of the various types placed and accepted, irrespective of color. This work shall include the furnishing of all materials; surface preparation; application of the adhesive and/or fastening of the reflective strips or reflectors onto existing elements; curing and cleaning.

Kilometer posts shall be measured by the number of units of each type of single - or double-face assemblies installed and accepted, which shall include the sign plate(s) regardless of size, the post and the post base, including all excavation and backfilling, concrete, reinforcement, anchor bolts, plates, threaded reducer and all incidentals in connection with these items.

All Temporary Signing shall be measured as described in the Bill of Quantities under individual specific items contained in Section 9.02, "Traffic Control Through Work Zones" in these General Specifications.

9.05.6 PAYMENT. Items of Work, measured as provided above, will be paid for at the contract unit price(s) for each as specified in the Bill of Quantities, which price(s) shall be full compensation for furnishing all materials, erection, and for all labor, equipment, tools, supplies, and all other items necessary for the proper completion of the Work as specified in Subsection 1.07.2, "Scope of Payment" in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING:

ITEM NO	PAY ITEM	PAY UNIT
90501	Highway Signs, Ground-mounted	Square Meter
9050101	Highway Signs, Ground-Mounted - Sheet Aluminum	Square Meter
9050102	Highway Signs, Ground-Mounted - Aluminum Planking or Internally Double Skin Aluminum Sheet	Square Meter
90502	Highway Signs, Overhead	Square Meter
9050201	Highway Signs, Overhead - Sheet Aluminum	Square Meter
9050202	Highway Signs, Overhead - Aluminum Planking or Internally Double Skin Aluminum Sheet	Square Meter
90503	Sign Support, (Breakaway) I.P.E.	Kilogram

9050301	Sign Support, (Breakaway) Single Post I.P.E.	Kilogram
9050302	Sign Support, (Breakaway) Double Post I.P.E.	Kilogram
9050303	Sign Support, (Breakaway) Triple Post I.P.E.	Kilogram
90504	Sign Support, (Breakaway) Tubular	Unit
90505	Sign Support-Overhead	Ton
9050501	Sign Support-Gantry	Ton
9050502	Sign Support-Cantilever	Ton
90506	Delineators	Unit
90507	Kilometer Post	Uint
9050701	Kilometer Post, Single-face	Unit
9050702	Kilometer Post, Double-face	Unit
90508	Retroreflectors	Unit
90509	Object Markers	Unit
9050901	Object Markers, Type 1 or 3	Unit
9050902	Object Markers, Type 2	Unit

KINGDOM OF SAUDI ARABIA

MINISTRY OF COMMUNICATIONS

ADDENDUM

TO THE NOVEMBER 1998

GENERAL SPECIFICATIONS

FOR

ROAD AND BRIDGE CONSTRUCTION

PARTS ONE, TWO, THREE AND FOUR

FEBRUARY 2000 **DHU AL-QADHA 1420**

PREAMBLE

ADDENDUM TO THE MOC NOVEMBER 1998 GENERAL SPECIFICATIONS FOR ROAD AND BRIDGE CONSTRUCTION- PARTS ONE, TWO, THREE AND FOUR

- This book is an addendum to the MOC November 1998 General Specifications. It contains special directions, provision, modifications or/and requirements pertaining to matters not covered or detailed in the General Specifications.
- When there is discordance between the stipulations of the Special Specifications of the Project and this addendum, the content of the Special Specifications of the particular project shall govern.

ADDENDEM TO THE MOC NOVEMBER 1998 GENERAL SPECIFICATION
PARTS ONE, TWO, THREE AND FOUR

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ADDENDUM TO THE MOC NOVEMBER 1998 GENERALSPECIFICATIONS

PART ONE

GENERAL

SECTION 1.09 SUPERVISION STAFF FACILITIES

1.09.5 Project Laboratory

1.09.5.5 Testing Equipment, Test and Specifications

Add the following:

Contractor shall furnish the following Superpave Quality Control Test equipment as part of the Project Laboratory.

Asphalt Content Ignition Furnace
Nuclear Density Gauge (Thin Layer)
Programmable Rotational Viscometer

1.09.5.5.1 Equipment Specifications for Superpave Asphalt Content Ignition Furnace

1.09.5.5.1.1 General

The Asphalt Content Ignition Furnace shall rapidly determine asphalt content without the use of solvents and allowing the determination of the aggregate gradation. It shall also include an accurate weighing system to continuously measure the weight loss of the bituminous mixture during combustion and automatically display the percent asphalt content.

1.09.5.5.1.2 Asphalt Content Ignition Furnace Specifications

Performance

Sample size 3500 grams
Scale readout resolution : ± 0 Grams
Precision at 6% AC for 1250 grams: ± 0.06%
Test Time: 30 to 45 minutes

Electrical

Power source: 08/240 VAC, 50/60 Hz
Peak power consumption: 6400/8500 watt
Amps: 31/36
Heat up time: 25 to 550 °C in 25 min
Furnace operating temperature: 25 to 800°C
After burner temperature: above 900°C
Plug: NEMA 6-50 P

Software

Data Storage: Up to 300 test results/correction factors
Positive or negative aggregate correction factor
Programmable weight loss limit for measurement
Interface: RS-232 for data transfer to computer or printer
Baud Rate: 600 to 9600 Baud
Automatic startup and shut down timer

Mechanical

	Width	Depth	Height
Outside Dimensions	61 cm (24 in.)	81 cm (32 in.)	92.25 cm (37.5 in)
Chamber Dimensions	30.5 cm (12 in.)	45.7 cm (18 in.)	30.5 cm (12 in.)

Weight: 94.12 kg (208 lbs)

1.09.5.5.1.3 Standard Accessory Equipment

- One set of 3 sample trays
- Printer
- One pair of high temperature insulated gloves
- One face shield
- One sample heat protection cage
- One sample cool down tray
- Data collection and storage console
- One sample carrying fixture
- 10 ft. (4" diameter) metal exhaust pipe

1.09.5.5.2 Equipment Specifications for a Nuclear Testing Gauge (Thin Layer)

1.09.5.5.2.1 General

The Nuclear Testing Gauge shall provide fast and efficient measurement of the in place density of aggregates and asphalt pavements including thin layer asphalt overlays in accordance with ASTM Test Methods D2922, D3017 and D2950.

1.09.5.5.2.2 Detailed Equipment Specifications

Detailed equipment specifications can be obtained from the MOC materials and Research Department.

1.09.5.5.3 Equipment Specifications for Programmable Rotational Viscometer

1.09.5.5.3.1 Background

A rotational viscometer is used to determine the apparent viscosity of asphalts at various elevated temperatures other than those used for viscosity measurements in ASTM D4402. The specimen test temperature must be closely controlled and monitored and can be achieved through the use of a thermosel device.

1.09.5.5.3.4 General Requirements

The rotational viscometer must function as a stand-alone device and also have the capability of being controlled and operated remotely through the use of a computer. The rotational viscometer shall be able to perform the testing as required in AASHTO TP48 and include the following functions and capabilities:

1. A built-in microprocessor for test data storage and analysis.
2. Built-in user friendly programming
3. Test data display to include – spindle number, RPM, specimen temperature, viscosity, shear rate, and sear stress.
4. Included computer interface and software (IBM PC compatible).
5. Test specimen temperature control and monitoring system.

1.09.5.5.3.3 Software and Other Programmable Rotation Viscometer Specifications

Operating software to control rotational viscometer and thermosel, collect and store test data, perform data analysis from any IBM or compatible computer via RS232 serial port.

Provide a clear and simple, operating and instruction manual for software, viscometer, and temperature controller equipment.

SUBSET EQUIPMENT QUANTITIES WHICH TOGETHER COMPRISE ONE COMPLETE PROGRAMMABLE ROTATIONAL VISCOMETER SYSTEM

Description of Subsets	Quantities
Rotational Viscometer, Programmable	Each
Base with Power Supply	Each
Laboratory Stand	Each
Signal Output Cable	Each
Carrying Case	Each
Programmable Temperature Controller (Thermosel)	Each
Sample Chamber	Each
Operating Software	Each
Spindles – (Required do determine viscosity from 20 mPaS to 500,000 mPaS)	Sets

1.09.5.5.3.4 Detailed Programmable Rotational Viscometer Equipment Specifications

Detailed equipment specifications can be obtained from the MOC Materials and Research Department.

ADDENDUM TO THE MOC NOVEMBER 1998 GENERAL SPECIFICATIONS

PART TWO

EARTHWORK

Section 2.06 UNTREATED SUBGRADE

2.06.2 Materials

Replace requirement 1 with the following:

1. Material classified by MRDTM 210 as A-1-a(0), A-1-b(0) A-2-4(0) having no rock fragments larger than one third (1/3) the layer thickness after compaction.

ADDENDUM TO THE NOVEMBER 1998 MOC GENERAL SPECIFICATIONS

PART 4

BITUMINOUS CONSTRUCTION

SECTION 4.01 BITUMINOUS MATERIALS

4.01.1 Description

Add the following:

6. Performance Graded (PG) bituminous materials

4.01.2 Grades

Add the following

4.01.2.6 Performance Graded (PG) Bituminous Materials

Performance graded Bituminous materials shall conform to AASHTO Performance Graded (PG) Binder Specification MP1 (provisional specification) for PG 76-10, as a minimum. It should be noted, however, that bituminous material conforming to requirements for PG 82-10 is highly desirable and should be used wherever it is available, especially on Roads with heavy traffic.

The Contractor shall submit a certificate of analysis showing conformance with either PG 76-10 or PG 82-10 binder specification MP1 as stated below.

ORIGINAL BINDER

Test	PG 76-10	PG 82-10
Flash point temp, T48	230°C minimum	230°C minimum
Viscosity, ASTM D4402: Maximum, 3 Pa•s 2 Test Temperature of,	135° C	135° C
Dynamic Shear, TP5; G*/sin δ, Minimum, 1.00 kPa Test Temp @ 10 rad/s	76°C	82°C

ROLLING THIN FILM OVEN (T240) or THIN FILM OVEN (T179) RESIDUE

	PG 76-10	PG 82-10
Mass loss, Maximum	1%	1%
Dynamic Shear, TP5; G*/sin δ, Minimum, 2.20 kPa Test Temp @ 10 rad/s	76 °C	82 °C

PRESSURE AGING VESSEL RESIDUE

	PG 76-10	PG 82-10
PAV Aging Temperature	110 °C	110 °C
Dynamic Shear, TP5 G*/sin δ, Minimum, 5000 kPa Test Temp @ 10 rad/s	37°C	40° C
Physical Hardening	Report	
Creep Stiffness, TP1 Stiffness, Maximum, 300.0 MPa @ 60 seconds m-value, Minimum, 0.300 @ 60 seconds Test Temp	0°C	0°C
Direct Tension, TP3 Failure Strain, Minimum, 1.0% (loading rate of 1.0 mm/min) Test Temp	0°C	0°C

G* -- Shear modulus; δ -- phase angle; G*sin δ (for fatigue); G*/sin δ (for rutting) ; m—rate of change in the creep stiffness.

The Contractor is only required to perform viscosity Quality Control Testing on the Performance Graded Binder. The Ministry of Communication Materials and Research Department Materials laboratory is equipped with the remaining equipment for the complete Performance Graded Binder Quality Assurance testing.

SECTION 4.02 BITUMINOUS PRIME COAT, TACK COAT AND FOG SEAL

4.02.8 Measurement

This Subsection is amended to provide that bituminous tack coat shall not be measured for payment.

4.02.9 Payment

Replace the first sentence with the following:

Bituminous tack coat will not be paid for directly as it is subsidiary to the Pay Item for the surface being tacked.

Section 4.05 Bituminous concrete pavement

4.05.1 Description

Add the following:

Bituminous overlay Work shall consist of the construction of one course of hot-mixed, hot-laid bituminous mixture conforming to the requirements of this section, spread and compacted on an approved surface, in compliance with the lines, grades and cross sections indicated on the plans or as directed. The exact limits of construction and the widths and thicknesses of bituminous overlay will be confirmed by the Engineer, and will be based on the job conditions prevailing at the time the Work is performed.

For the purpose of this section, when the term "bituminous wearing course" or "surface course" is used, it shall mean "bituminous wearing course and/or bituminous leveling course and/or bituminous overlay", as applicable.

4.05.2 Materials

4.05.2.1 Bituminous Materials

Replace with the following:

Bituminous Material for bituminous concrete pavements including bituminous concrete friction course, hot mixed, recycled bituminous concrete, bituminous stone matrix asphalt (SMA) and porous bituminous concrete (PBC) shall be performance graded (PG) asphalt cement meeting the requirements of Paragraph 4.01.2.6 – "Performance Graded (PG) Bituminous Materials" in this Addendum to the General Specifications.

4.05.2.2 Aggregate

Add the following immediately below Table 4.05-2:

Improvement of the resistance to loss of Marshall Stability of the bituminous mixture, by increasing the asphalt content, shall not be attempted; instead, this shall be accomplished by improving the quality of aggregate and in particular the portion passing a 4.75 mm (AASHTO No. 4) sieve.

4.05.2.4 Chemical Admixtures a nd Asphalt Modifiers

Replace the third paragraph with the following:

The contractor shall add an approved polymer material to all bituminous concrete mixtures in accordance with the following criteria:

4.05.6 Construction Requirements

4.05.6.5 Preparation of Surface

Add the following :

4. **When an overlay is to be built, and as soon as practicable after receiving the site, the Contractor shall submit to the Engineer cored samples of the**

existing bituminous pavement. The samples shall be cored at the locations specified by the Engineer. Samples shall be obtained in sets of two (2), cut from the same location on the existing bituminous pavement. Two (2) sets of samples per traffic lane-kilometer to be overlaid, or fraction thereof, shall be obtained and all test holes shall be filled and compacted by the Contractor at his own expense.

The Contractor shall perform all tests that may be required to assist the Engineer in his evaluation of the properties of the existing pavement and the verification of the thickness of the bituminous wearing course to be constructed. Should the resulting total thickness of the bituminous layers, including the layer to be constructed, exceed two hundred and fifty (250) millimeters, the matter shall be referred to the Maintenance Department of the Ministry. A detailed report containing the findings of the foregoing investigation, the specific problems encountered, and the proposed solutions accompanied by cost estimates shall be submitted to the said Department by the Engineer. Within fifteen (15) days from receipt of the Engineer's proposal, the Ministry shall advise the Engineer of its decision, that shall be final and binding to the Contractor under the provisions of the Contract.

The Contractor shall perform all sampling and testing at his own expense and in the presence of the Engineer.

Sections of existing, old failed base may, if so directed, be replaced by aggregate base course material, in accordance with General Specifications Section 3.03 - Aggregate Bases. This work shall be paid at the unit rate bid per cubic meter for "Aggregate Base Course" as specified in the Bill of Quantities.

Catch basin grates, drop inlet grates, manhole covers, etc., that must be adjusted to match the new surface grade, shall be paid at the Contract unit price bid per each item for such adjustment, as specified in the Bill of Quantities.

7. **When the bituminous wearing course is to be placed on Portland cement concrete bridge decks or Portland cement concrete pavement, the surface shall be prepared and primed as specified in Section 4.02 - Bituminous Prime Coat, Tack Coat and Fog Seal.**

4.05.10 Method of Measurement

Replace the last paragraph with the following:

Antistripping agents, mineral fillers, fibers and chemical admixture/asphalt modifiers other than polymers used by the contractor to meet the job mix formula (JMF) requirements will be considered subsidiary to the Bituminous Concrete Pay Items in the General Specifications and in this Addendum to the General Specifications and will not be measured separately unless specifically stated in the special specifications and listed in the Bill of Quantities. Polymer chemical admixture/asphalt modifiers shall be measured separately by the kilogram.

4.05.11 Payment

Replace the third paragraph with the following:

Antistripping agents, mineral fillers, fibers and chemical admixture/asphalt modifiers other than polymers will not be paid for separately as they are subsidiary to the Bituminous Concrete Pay Items in the General Specifications and in this Addendum to the General Specifications unless specifically specified in the Special Specifications and listed Bill of Quantities. Polymer chemical admixture/Asphalt modifiers will be paid for

separately when measures in accordance with subsection 4.05.10 Method of Measurement in this Addendum to the General Specifications. Under Pay Item No. 4050802 chemical admixture/asphalt modifier, polymer.

SECTION 4.06 - HOT-MIX RECYCLED BITUMINOUS CONCRETE

4.06.2 Materials

Replace Paragraph 4.06.2.1 -- Bituminous Material with the following:

4.06.2.1 Bituminous Material

Bituminous Material for hot-mix recycled bituminous concrete shall be performance graded (PG) asphalt cement meeting the requirements of Paragraph 4.01.2.6 "Performance Graded (PG) Bituminous Materials" in this Addendum to the General Specifications.

4.06.4 Equipment

Add the following:

Equipment shall be dependent upon the recycling method to be used as specified below. The basic equipment for each method shall be accompanied by the required number of dump trucks, liquid asphalt tanker and distributor, steel-wheel and pneumatic-tired rollers, power broom, air compressor with blower, traffic control devices, and all necessary hand tools.

4.06.4.1 First Method - Hot Recycling in Central Mixing Plant

4.06.4.1.1 Milling Machine and Crusher

The milling machine shall be as specified in General Specifications Subsection 4.11.2 – "Equipment". When entire layers are being removed as approved by the Engineer, the reclaimed materials shall be reduced to the required sizes in a central crushing plant, suitable for the intended purpose. Unless otherwise directed by the Engineer, none of the fines shall be removed from the reclaimed materials and the crusher shall not produce an increase in fine size materials or new fractured faces.

4.06.4.1.2 Central Mixing Plant

1. Batch Plant Type. The batch plant shall prepare the mixture with heat transfer and may employ one of the methods described herein.

The first method shall utilize a long belt conveyor with brake motor and a feeder bin for reclaimed materials. A chute shall be attached to the batching tower to direct the reclaimed material from the incline conveyor into the weigh hopper. The control system on the plant shall be modified with additional presets so that the feeder bin and incline are handled like a fifth aggregate. When adding reclaimed materials, the fifth preset shall automatically turn on the incline conveyor and the recycle bin and run the material into the weigh hopper until the desired weight is reached.

The second method shall utilize a feeder bin for reclaimed material that continuously feeds a separate bucket elevator that dumps the material in a special hopper attached to the tower. This hopper shall be equipped with a gate to release the materials on demand into the weigh hopper as needed for each batch.

2. Drum Mix Plant Type. This type of plant shall be specifically designed to produce a recycled bituminous mix. Its cold feeder system shall consist of at least five cold bins capable of accurate control of the materials supplied. The feeder system shall be automatic, linked to the main control system of the plant. Heating of the reclaimed materials shall be done in the drum in such a manner as to prevent any deterioration of the bituminous binder. The plant shall be provided with a mix storage system with a capacity of not less than forty (40) tons.

4.06.4.2 Second Method - In-Situ Hot Recycling of Bituminous Pavement Surface Course

4.06.4.2.1 Heater/Scarifier/Repaver

Equipment shall be as specified in Subsection 4.12.4 – "Equipment" in the General Specifications.

4.06.4.2.2 Mobile Recycling and Blending Unit

This unit shall be fully independent, capable of treating the surface layer in place and furnished with an additional heater. The unit shall be complete with an integral system for adding the bitumen modifier in a uniform and controlled manner. The mobile blending unit shall be equipped with a coordinated system for adding and mixing with the old materials to be recycled, new aggregate, bitumen, asphalt modifier or new bituminous mixture at the required quantities. The unit shall be capable of disposing any surplus materials prior to the mixing process.

4.06.4.3 Third Method - In-Site Hot Recycling of Bituminous Pavement Layers

4.06.4.3.1 Milling Machine

The milling machine shall be as specified in Subparagraph 4.06.4.1.1 "Milling Machine and Crusher" in this Addendum to the General Specifications.

4.06.4.3.2 Mobile Pickup/Recycling and Blending Unit

The unit shall be capable of picking the reclaimed materials and the new aggregate, heating the mixture, adding asphalt modifier and/or asphalt cement separately and mixing. Materials shall be heated in a drum-type plant in such a manner as to prevent damage to the bituminous binder in the reclaimed materials. The unit shall be capable of cleaning the surface and applying asphalt emulsion thereon after picking up the materials for heating and prior to spreading.

4.06.6 Construction Requirements

Add the following:

Th e exact locations of the areas to be recycled along with the respective thicknesses thereof shall be determined and delineated by the Engineer immediately prior to the start of the Work. The process shall involve controlled removal of the existing pavement layer and the addition and mixing in place or at a central plant of any required new aggregate, new asphalt and asphalt modifiers. The resultant hot mixture shall be spread, compacted and, when directed or shown on the plans, sealed with a surface treatment or an overlay. When such a treatment or an overlay is required, it shall be carried out and paid for separately as specified in other sections of the specifications.

4.06.6.1 First Method - Hot Recycling in Central Mixing Plant

4.06.6.1.1 Bituminous Pavement Layers Removal and Storage

The existing bituminous pavement layer shall be removed in such a manner as to prevent or minimize the mixing of the asphalt-bound materials with untreated base course or subgrade materials. Removal shall be by milling or controlled excavation. Should untreated base course or subgrade materials be removed, they shall be stored separately as directed. Work to remain in place that has been damaged by the Contractor during the removal operations, as determined by the Engineer, shall be repaired by the Contractor at his own expense and prior to the placement of the recycled layer. Deficient parts of base course or subgrade that are to be restored, as shown on the plans or directed by the Engineer prior to start of the removal operations, shall be repaired and paid for separately as specified in the pertinent sections of the General Specifications and this Addendum to the General Specifications.

4.06.6.1.2 Size Reduction and Preparation

Reclaimed bituminous pavement materials shall be reduced to a size smaller than 37.5 mm (1-1/2 inch) as specified in Subparagraph 4.06.2.6.1.1 above. Size reduction shall be by milling or by excavation and subsequent crushing using the equipment and procedures specified in Subparagraph 4.06.4.1.1 above. Reclaimed aggregate, after being reduced to the required size and prior to their use in the recycled mixture, shall be segregated into at least two lots; one for fine aggregate with at least eighty percent (80%), by weight, passing a 4.75 mm (No. 4) sieve; and another for coarse aggregate with less than forty percent (40%), by weight, passing a 4.75 mm (No. 4) sieve.

4.06.6.1.3 Adding New Materials, Heating and Mixing

1. When a batch-type plant is used, the new aggregate shall be proportioned in the cold feed bins and super heated in the dryer. From there they shall be conveyed to the hot storage bins. The reclaimed materials, without heating or drying, shall be conveyed to the weigh hopper and join the super heated new aggregate. Heating of the recycled mixture shall take place in the pugmill by heat transfer between new and reclaimed materials.

2. When the drum-type plant is used, the new aggregate shall enter at the burner end, and shall be dried and super heated. The reclaimed materials, without heating or drying, shall enter the drum near its center through openings in the shell, at a point far enough from the burner, and join the new aggregate. Heating and mixing of the recycled mixture shall then take place in the lower end of the drum.

The mixing plant to be used shall be equipped with a facility to allow addition of new asphalt cement, recycling agent, and mineral filler to be added separately, if needed. The mixing process shall produce full coverage to the aggregate. The Engineer may increase the mixing time as necessary to obtain a homogeneous mixture and good aggregate cover. The water content in the mixture immediately upon its spreading shall not exceed one and one-half percent (1.5%), by weight.

4.06.6.1.4 Prime Coat and Tack Coat

Placing prime coat and tack coat, as shown or as directed, shall be in accordance with Subsection 4.02.5 – “Construction” in the General Specifications.

4.06.6.2 Second Method - In-Situ Hot Recycling of Bituminous Pavement Surface Course

Refer to General Specifications Subsection 4.12.7 – “Construction.”

4.06.6.3 Third Method - In-Situ Hot Recycling of Bituminous Pavement Layers

4.06.6.3.1 Size Reduction

Bituminous pavement layers shall be removed by milling to produce a uniform gradation as close as possible to that specified in General Specifications Paragraph 4.06.2.6 . “RAP”

4.06.6.3.2 Adding New Materials, Heating and Mixing

Reclaimed materials shall be picked up, and mixed with new aggregate, new asphalt cement and recycling agents in a drum-type plant as detailed in Subparagraph 4.06.6.1.3 above. The heating temperature and the overall mixing time shall be suitable for drying, heating, mixing, and covering the aggregate in a manner acceptable to the Engineer. The heating temperature shall be kept within the limits of one hundred-fifty (150) and one hundred-sixty (160) degrees Celsius. The water content in the mixture immediately upon its spreading shall not exceed one and one-half percent (1.5%), by weight.

4.06.9 Method of Measurement

Replace the fourth paragraph with the following:

Antistripping agents, mineral fillers, fibers and chemical admixture/Asphalt modifiers other than polymers used by the contractor to meet the Job Mix Formula (JMF) requirements will be considered subsidiary to the construction of the hot-mix recycled bituminous concrete pavement and will not be measured separately unless specifically stated in the Special Specifications and listed in the Bill of Quantities. Polymer chemical admixture/Asphalt modifiers shall be measured separately by the kilogram.

4.06.10 Payment

Replace the paragraph with the following:

Antistripping agents, minerals fillers, fibers and chemical admixture/asphalt modifiers other than polymers used by the contractor to meet the Job Mix Formula requirement shall be considered subsidiary to the construction of hot-mix recycled bituminous concrete and shall not be paid for separately unless specifically stated in the Special Specifications and listed in the Bill of Quantities. Polymer chemical admixture/asphalt modifiers will be paid for in accordance with subsection 4.05.11 “Payment” in this Addendum to the General Specificatons.

Section 4.07 Bituminous Concrete Friction Course

4.07.2 Materials

Replace Paragraph 4.07.2.1 -- Bituminous Material with the following:

4.07.2.1 Bituminous Material

Bituminous Material for bituminous concrete friction course shall be performance graded (PG) asphalt cement meeting the requirements of paragraph 4.01.2.6 “Performance Graded (PG) Bituminous Materials” in this Addendum to the General Specifications.

4.07.9 Measurement

Replace the last paragraph with the following:

Antistripping agents, mineral fillers, fibers and chemical admixtures/asphalt modifiers other than polymers will be considered subsidiary to the construction of the bituminous concrete friction course and will not be measured separately unless specifically stated in the Special Specification and listed in the Bill Quantities. Polymer chemical admixture/asphalt modifiers shall be measured separately by the kilogram.

4.07.10 Payment

Replace the fourth paragraph with the following:

Asphalt cement modified asphalt cement, antistripping agents, mineral fillers, fibers and chemical additive/asphalt modifiers other than polymers will not paid for separately as they are considered subsidiary to the construction of the bituminous concrete friction course in the General Specifications and this Addendum to the General Specification. Polymer chemical admixture/asphalt modifiers will be paid for separately in accordance with Subsection 4.05.11 “Payment” in this Addendum to the General Specifications.

<u>Section 4.09 - cold-mix recycled bituminous base</u>

4.09.1 Description

Add the following:

This Work shall also consist of constructing and repairing a cold-mix bituminous base course using existing stockpiled milled material, in accordance with these Specifications and as directed by the Engineer.

SUPPLEMENTAL PAY ITEMS

Cold Reuse of Stockpiled Milled Material
Repair of Asphalt Layers Constructed from Milled Materials

4.09.2 Materials

4.09.2.4 Liquid and Emulsified Bituminous Materials

Add the following:

Cutback asphalt shall be medium-curing grade MC-30, MC-70 or MC-250; emulsified asphalt shall be medium- or slow-setting, depending on the aggregate gradation directed and the weather conditions.

4.09.9 Method of Measurement

Add the following:

Cold reuse of stockpiled milled material shall be measured by the cubic meter of completed and accepted base course, in place.

Repair of Asphalt Layers constructed from milled materials shall be measured by the square meter of the accepted repair work.

4.09.10 Payment

Add the following:

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING SUPPLEMENTAL PAY ITEMS WHEN THEY ARE INCLUDED IN THE CONTRACT BILL OF QUANTITIES:

ITEM No.	PAY ITEM	PAY UNIT
40951	Cold Reuse of Stockpiled Milled Materials	Cubic Meter
40952	Repair of Asphalt Layers Constructed from Milled Materials	Square Meter

SECTION 4.16 BITUMINOUS STONE MATRIX ASPHALT (SMA)

4.16.1 Description

This work shall consist of placing Bituminous Stone Matrix Asphalt (SMA) as shown on the plans, and in accordance with these specifications, the General Specifications and as directed by the Engineer. The SMA may be produced in batch or drum mix plant.

The SMA is a gap graded hot mix asphalt mixture consisting of crushed coarse and fine aggregates, mineral filler, asphalt cement, and stabilizing agent. The stabilizing agent typically consists of fibers and / or polymers.

Supplemental Pay Items

Bituminous Stone matrix Asphalt (SMA)

4.16.2 Materials

The materials shall conform to the following requirements:

Bituminous Material

Bituminous material shall be Performance Graded (PG) asphalt cement conforming to the requirements in Paragraph 4.01.2.6 “Performance Graded Bituminous Materials” in this Addendum to the General Specifications

4.16.2.2 Aggregate. Aggregate shall conform to the following criteria:

4.16.2.2.1 Coarse Aggregate

Coarse aggregate for SMA shall meet the requirements in the General Specifications with the following additions or changes:

Sand Equivalent (AASHTO T96)	60% min
L.A. Abrasion Loss (AASHTO T96)	30% max
Sodium Sulphate Soundness Loss (T104)	12% max
Coarse and Fine Durability (T210)	40 min
Polish Value	0.4 min
Friction (at the completion of construction)	40 min
Two or more crushed faces	100%
Flat and Elongated 3 to 1 (ASTM D 4791)	20%
5 to 1	5%

4.16.2.2.2 Fine Aggregate

Fine aggregate shall meet the following requirements:

SODIUM SULPHAT SOUNDNESS LOSS (T104)	12% MAX
Crushed aggregate	100%
Plasticity (T109)	0%

4.16.3 Mineral Filler

Mineral Filler shall be rock dust, crushed lime stone, portland cement or other suitable filler material and shall meet the requirements of AASHTO M17. Additionally, plasticity index (T90) of mineral filler shall not exceed 4%. Filler shall be kept as dry as possible, but in not case the moisture shall exceed 10%.

4.16.4 Fiber

The cellulose fibers which meet the following requirements shall be uniformly dispersed in the SMA mixture. Fiber content shall be between 0.3-0.4% of the total mix (lower limit for cellulose, higher for mineral fibers). [local fine aggregate is not acceptable as a fiber].

Property	Requirement
Sieve Analysis	
Method A – Alpine Sieve [1] Analysis	
Fiber Length	6 mm (0.25 in) Maximum
Passing 0.150 mm (No. 100 sieve)	70 ± 10 %
Method B – Mesh Screen [2] Analysis	
Fiber Length	6 mm (0.25 in) Maximum
Passing 0.850 – mm (No. 20) sieve 0.425 – mm (No. 40) sieve 0.106 – mm (No. 140) sieve	85 ± 10 % 65 ± 10 % 30 ± 10 %
Ash Content [3]	18 ± 5 non-volatile
PH[4]	7.5 ± 1.0
Oil Absorption[5]	5.0 ± 1.0 (times fiber mass)
Moisture Content[6]	Less than 5 % (by mass)

(1) Method A – Alpine Sieve Analysis. This test is performed using and Alpine Air Jet Sieve (Type 200 LS). A representative five gram sample of fiber is sieved for 14 minutes at a controlled vacuum of 5 kPa (11 psi) of water. The portion remaining on the screen is weighed.

(2) Method B – Mesh Screen Analysis. This test is performed using standard 0.850, 0.425, 0.250, 0.180, 0.150, and 0.106 mm sieves, nylon brushes, and a shaker. A representative 10 gram sample of fiber is sieved, using a shaker and two nylon brushes on each screen. The amount retained on each sieve is weighed and the percentage passing calculated. Repeatability of this method is suspect and needs to be verified.

(3) Ash Content – A representative 2 – 3 gram sample of fiber is placed in a tarred crucible and heated between 595 and 650 C (1100 and 1200F) for not less than two hours. The crucible and ash are cooked in a desiccator and weighed.

(4) Ph Test – Five grams of fiber is added to 100 ml of distilled water, stirred and let sit for 30 minutes. The Ph is determined with a probe calibrated with a Ph 7.0 buffer.

(5) Oil Absorption Test – Five grams of fiber is accurately weighed and suspended in an excess of mineral spirits for not less than 5 minutes to ensure total saturation. It is then placed in a screen mesh strainer (approximately 0,5 mm^2 opening size) and shaken on a wrist action shaker for 10 minutes (approximately 32 mm (1 ¼ in) motion at 240 shakes per minutes). The shaken mass is then transferred without touching to a tarred container and weighed. Results are reported as to the amount (number of times its own weight) the fibers are able to absorb.

(6) Moisture Content – Ten grams of fiber is weighed and placed in a 121 C (250 F) forced air oven for two hours. The sample is then re-weighed immediately upon removal form the oven.

4.16.4.1 Introduction of Fibers for batch plants

Fibers may be introduced manually or mechanically.

1) **Manual Introduction.** Pre-weighed packaged fibers may be added directly to the pugmill during dry mixing time.

2) **Automated introduction.** Using a fiber machine, loose fibers may be added directly to the pugmill during dry mixing time.

When fibers are used in batch plant, dry mixing time is increased by 5 – 7 seconds and wet mixing times increased by at least 5 seconds for thorough mixing.

4.16.4.2 Introduction of Fibers for drum plants

Fibers may be introduced to the drum only using mechanical methods.

1) **Introduction of loose fibers** Loose fibers may be added using a fiber machine.
2) **Introduction of pallet fibers** Fibers in pellet form may be introduce using the RAP conveyor.

4.16.5 The Mix Gradation

SMA gradation shall be based on the maximum nominal size (one size above the sieve that retains at least 10% of the material by weight.

15.6 mm SMA shall meet the following gradation:

Sieve Size	**Percentage of sieve passing**	**Authorized limits**
15.6 mm	100	-
12.5 mm	90 –99	± 5%
9.5 mm	70-85	± 5%
4.75 mm	30 – 50	± 4%
2.36 mm	20 – 30	± 4%
0.075 mm	8 – 11	± 2%

19.0 mm SMA shall meet the following gradation:

Sieve Size	**Percentage of sieve passing**	**Authorized limits**
19 mm	100	± 5%
12.5 mm	82 – 88	± 5%
9.5 mm	55	± 4%
4.75 mm	22 – 30	
2.36 mm	14 – 20	± 4%
0.075 mm	9 – 11	± 2%

4.16.5.1 Marshall Mix Design criteria. SMA mixture shall conform to the following criteria:

Test	**Requirement**
Stability	635 kg
Voids in mineral aggregate, VMA	17% minimum (18% desirable)
Air Voids in the mix	3 % minimum (4% recommended for warmer climates)
Voids in coarse aggregate mix, VCA	Less than VCA of the coarse aggregate (T19)
Draindown @ production temperature	0.30% maximum
TSR (D4867)	80% min
Compaction blows	50 both sides

4.16.5.2 Asphalt Cement: Asphalt cement content during the design phase shall be a minimum of 6% and no greater than a maximum of 7%.

4.16.5.3 Determination of Mixing and Compacting Temperatures

The mix design mixing and compacting temperatures shall be according to AASHTO T-245 Subsections 3.3.1 and 3.3.2 or according to the recommendations of the polymer manufacturer in the case of using polymer modified binders.

4.16.5.4 Antistripping Additives

Antistripping additives will be added as needed to meet Marshal Mix Design Quality Requirements in General Specifications Section 4.05 Bituminous Concrete Pavement.

4.16.6 Construction

4.16.6.1 Demonstration

Before proceeding with the actual work, the contractor shall demonstrate to the Engineer that a satisfactory mix can be produced, placed, and compacted to determine the compactive effort needed. A minimum of 100 tons shall be placed at a site that simulates the actual project conditions.

4.16.6.2 Hauling Units

A liquid detergent shall be placed on the truck beds and any extra liquid shall be drained before loading with the mix.

The mix shall not be stored at the plant for more than 30 minutes.

4.16.6.3 Mix Temperature at the site

The compaction temperature is established during the design. However, it should be noted that mix will not compact after its temperature drops below 115°C - 127°C for polymer modified mixes). Therefore, the initial temperature of the mix at the job site should not be less than 140°C. The haul time between the mixing plant and job site should preferably be kept to not more than one hour.

4.16.6.4 Pavement Thickness

Pavement layer thickness be as specified in the contract documents. It should be noted that SMA is generally not placed thicker than 40 mm.

4.16.6.5 Weather

Placement of SMA shall be permitted only when the ambient and pavement temperature are at least 10°C.

4.16.6.6 Tack Coat

If SMA is placed on an existing pavement a tack coat of a slow setting emulsion shall be applied. The application rate for the tack coat shall be between 0.14 and 0.21 l/m².

4.16.6.7 Compaction

Rolling shall be performed using a minimum of three steel-wheeled static rollers, each weighing 12 tons. The rolling shall commence immediately after placement and all rollers will remain within 150 meters of the paver.

The rollers shall be equipped with a watering or soapy watering system that prevents material from sticking to the roller wheels. Roller speed shall be between 1.6 and 4.8 kph. Mix shall be compacted to 94% of the theoretical maximum density. Rolling shall be completed before mat is cooled below 110°C.

No vibrator roller in the vibratory mode or rubber tire roller will be allowed.

4.16.7 Quality Assurance Procedures

The Quality Assurance procedures in Subsection 4.05.8 – "Quality Assurance Procedures" in the General Specifications shall be applied to the acceptance of Bituminous Concrete Stone Matrix Asphalt (SMA).

4.16.8 Method of Measurement

Bituminous Stone Matrix Asphalt (SMA) shall be measured by the cubic meter of mix acceptably placed and evaluated in accordance with the General Specifications and this Addendum to the General Specifications.

4.16.9 Payment

The amount of Bituminous Stone Matrix Asphalt (SMA) actually incorporated in to the work, and measured as provided above, will be paid for at the contract unit prices in the Bill of Quantities.

Prices and payment made under this section shall cover and be full compensation for furnishing labor, equipment, materials, tools and incidentals necessary to complete all the work involved as specified in Subsection 1.07.2 "Scope of Payment" in the General Specifications except for polymer chemical admixture/asphalt modifiers which shall be paid for separately in accordance with Paragraph 4.05.11 "Payment" in this Addendum to the General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING SUPPLEMENTAL PAY ITEMS WHEN THEY ARE INCLUDED IN THE CONTRACT BILL OF QUANTITIES.

ITEM NO.	PAY ITEM	PAY UNIT
41651	Bituminous Stone Matrix Asphalt (SMA)	Cubic Meter

Section 4.17 MICRO-SURFACING

4.17.1 Description

This work includes providing micro-surfacing systems in accordance with this Addendum to the General Specifications and the plan dimensions.

SUPPLEMENTAL PAY ITEMS

Micro-Surfacing Layer
Micro-Surfacing Rut-Fill

4.17.2 Materials Requirements

The contractor shall furnish an asphalt emulsion, polymer modifier one hundred (100) percent crushed mineral aggregate meeting the Type III Slurry Seal Aggregate requirements in General Specifications Paragraph 4.10.2.2. Mineral filler, water and other additives are optional. A signed and dated certification that the materials meet or exceed the following criteria shall be submitted by the contractor as part of his mix design submission.

AGGREGATE

AASHTO T 176 (ASTM D 2419)	Sand Equivalent	60 min.
AASHTO T 104 (ASTM C 88)	Soundness	15% max. for sodium sulphate 25% max. for magnesium sulphate
AASHTO T 96 (ASTM C 131)	Abrasion	30% max.
ASPHALT EMULSION		
AASHTO T 59 (ASTM D 244)	Viscosity	20 min. 100% max.
AASHTO T 59 (ASTM D 244)	Sieve Analysis	0.1% max.
AASHTO T 59 (ASTM D 244)	Asphalt Residual Content	62% min.
ASPHALT RESIDUE		
ASTM D 2171	Absolute Viscosity	8000 poises, min.
AASHTO T 53	Softening Point	57°C, min.
AASHTO T 49 (ASTM D 2397)	Penetration	55 min and 90 max.
ASTM D 113	Ductility	70 min

MIXTURE

The following mixture properties are recommended by the International Slurry Seal Association (ISSA). Document any deviation for the recommended mixture criteria and provide such documentation to the Ministry.

ISSA TB-139	Wet Cohesion @	
	30 minutes	12 kg-cm, min.
	60 minutes	20 kg-cm, min.
ISSA TB-109 *	Asphalt Content,	
	Loaded Wheel Test	540 g/m^2,max
ISSA TB-100 *	Asphalt Content, Wet Track Abrasion Loss	
	1-hour soak	540 g/m^2, max.
	6-day soak	810 g/m^2, max
ISSA TB-147 A,B	Lat. Displace.	5% max.
	Vert. Displace	10% max.
ISSA TB-144	Compatibility	11 grade points, min

* Tests ISSA TB-109 and TB-100 are used to determine optimum asphalt content. In lieu of these test, the Ministry may require the use of a modified Marshall Stability Test (ISSA TB-140) or Hveem Cohesionmeter Test (ASTM D 1560) to determine optimum asphalt content.

4.17.3 Construction Requirements

4.17.3.1 Acceptance Criteria

Thickness The Contractor shall lace surface treatment to a <u>minimum</u> application rate of eleven (11) kg/m^2.

Finished Surface The Contractor shall finish any twenty-five (25) m^2 of surface to a uniform texture to have:

1. **No more than four (4) tear marks greater than thirteen (1) mm wide and or hundred (100) mm long**.
2. No tear marks grater than twenty-five (25) mm wide and seventy five (75) mm long
3. No transverse ripples or longitudinal streaks of five (5) mm or more in depth, as measured with a 3-meter straight edge.

Surface Friction The Contractor shall provide a uniform surface with a skid number measured by ASTM E 274 at sixty-five (65) km/h, of at least forty (40).

Joints Longitudinal and transverse joints shall appear neat and uniform without buildup, uncovered areas, or unsightly appearance.

Longitudinal joints shall be placed on lane lines with less than fifty (50) mm overlap on adjacent passes and no more than six (6) mm difference in elevation between the adjacent passes as measured with a 3-meter straight edge.

Transverse joints shall be restricted to five (5) per six thousand (6000) m of lane. Construct transverse joints with no more than three (3) mm difference in elevation across the joint as measured with a 3-meter straight edge.

Edges Edges shall appear neat and uniform along the roadway lane, shoulder, and curb lines. Edges along curbs shall have no tolerance. Edges shall have no more than fifty (50) mm horizontal variance in any thirty (30) m, along the roadway lane and shoulder.

Opening to Traffic Layers shall be open to traffic no sooner than one (1) hour after placement. Filled ruts shall not be open to traffic for two (2) hours after placement.

Cross Section Cross section with a 3-meter straight edge. Filled ruts shall have no depressions. Ruts shall not be more than three (3) mm per twenty five (25) mm.

If existing ruts are greater than six (6) mm, the ruts shall be filled by separate application of micro-surfacing prior to the surface application. Ruts of six (6) mm or less may be filled during the surface application.

Bleeding and Flushing Limit high severity bleeding and flushing in any one hundred (100) m^2 area to no more than two (2) percent by the end of the warranty period. No bleeding at joints is allowed.

4.17.3.2 Execution Requirements

The Contractor will supply all material and labor to perform installation and repair work at no additional cost to the agency and shall provide a certification that the materials and mixture meet or exceed the requirements of Section 4.17.2 “Materials Requirements” in this Addendum to the General Specifications.

Work shall include repairs, permanent replacement, traffic control, and tests in accordance with the requirements in the General and Special Maintenance Specifications. Traffic control for work operations shall be in accordance with section 9.02 – “Traffic Control Through Work Zones” in the General Specifications and these Special Specifications. Areas shall be repaired within thirty working days of notification by the agency, that do not meet the acceptance criteria.

Temporary repairs shall be performed when the climatic conditions temporarily prohibit permanent repairs. Temporary repairs shall be replaced with permanent repairs as soon as weather allows.

The Contractor shall replace any 400 m lane segment that has repairs or defects exceeding five (5) percent of the area.

4.17.4 Method of Measurement

The layer application of micro-surfacing shall be measured by the square meter for the area upon which the micro-surfacing was actually placed. Tack coat and water used to cover the surface to be sealed shall not be measured separately as they are considered subsidiary to the micro-surfacing item.

The filing of ruts with micro-surfacing shall be measured by the kilogram of the aggregate/ modified asphalt emulsion mixture used to fill the ruts by separate application of micro-surfacing prior to the surface application.

4.17.5 Payment

The layer application of micro-surfacing completed as specified and measured shall be paid for at the contract unit price per square meter. Separate applications of micro-surfacing for rut filling as specified and measured shall be paid for by the kilogram for aggregate modified asphalt emulsion mixture. Mineral fillers, chemical admixtures and asphalt modifiers used to meet the mix design requirements shall be considered subsidiary and shall not be paid for separately unless stated in the Special Specifications and listed in the Bill of Quantities.

Prices and payment made under this section shall cover and be full compensation for furnishing labor, equipment, materials, tools and incidentals necessary to complete all the work involved as specified in Subsection 1.07.2 “Scope of Payment” in these General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING SUPPLEMENTAL ITEMS WHEN THEY ARE LISTED IN THE CONTRACT BILL OF QUANTITITES.

ITEM No.	PAY ITEM	PAY UNIT
41751	Micro-surfacing Layer	Square-Meter
41752	Micro-surfacing, Rut fill	Kilogram

SECTION 4.18 POROUS BITUMINOUS CONCRETE

4.18.1 Description

This work shall consist of placing Porous Bituminous Concrete (PBC) as shown on the plans, and in accordance with these specifications, the General Specifications and as directed by the Engineer. The PBC may be produced in batch or drum mix plant.

The PBC is an open graded hot mix asphalt mixture consisting of crushed coarse and fine aggregates, mineral filler, and asphalt cement. A stabilizing agent will also be needed and typically consists of fibers and / or polymers.

Supplemental Pay Items
Porous Bituminous Concrete (PBC)

4.18.2 Materials

The materials shall conform to the following requirements:

4.18.2.1 Bituminous Material

Bituminous material shall be a Performance Graded (PG) asphalt cement and shall be in conformance with the requirements in Paragraph 4.01.2.6 "Performance Graded (PG) Bituminous Materials" of this Addendum to the General Specifications.

Required bituminous gradation will be noted in the contract documents.

4.18.2.2 Aggregate. Aggregate shall conform to the following criteria:

4.18.2.2.1 Coarse Aggregate

Coarse aggregate for PBC shall meet the requirements in the General Specifications with the following additions or changes:

L.A. Abrasion Loss (AASHTO T96)	30% max
Sodium Sulphate Soundness Loss (T104)	12% max
Coarse and Fine Durability (T210)	40 min
One or more crushed faces (ASTM D5821)	100%
Two or more crushed faces	90%
Flat and Elongated (ASTM D 4791)	
3 to 1	20%
5 to 1	5%
Flakiness	25% maximum
Sand Equivalent (T176)	50 minimum
Absorption (T85)	2% max
Polish Value (ASTM D3319)	0.40 minimum

Note: Only polish resistant aggregate will be used for PBC. Polish value and testing method requirement will be as noted above unless stated otherwise.

Note: Ministry may require a minimum surface friction number of at least 40 [ASTM E274 at 65 km/h] at the completion of construction. If required it will be noted in the contract documents.

4.18.2.2.2 Fine Aggregate

Fine aggregate shall meet the following requirements:

Sodium Sulphate Soundness Loss (T104)	12% max
Crushed aggregate	100%
Plasticity (T109)	0%

4.18.3 Mineral Filler

Mineral Filler shall be rock dust, crushed lime stone, portland cement or other suitable filler material and shall meet the requirements of AASHTO M17. Additionally, plasticity index (T90) of mineral filler shall not exceed 4%. Filler shall be kept as dry as possible, but in no case the moisture content in filler shall exceed 10%.

4.18.3.1 Introduction of Mineral Filler

Either a mineral filler silo with a mechanical delivery system or cold feed bins may be used for introduction of filler. If a silo system is used the filler is blown into the weigh hopper or pugmill of a batch plant or into the drum of a drum mix plant. The delivery system must be able to handle filler loads including metering of the proper amount of filler.

If a conveyor system is used the extra care will be needed to control the filler amount and dusty conditions during windy days.

4.18.4 Fiber

Unless otherwise noted, the PBC shall incorporate a stabilizer (cellulose fibers) to prevent/reduce the draindown. The draindown shall not exceed 0.3% of the mass (test method attached). Fiber content shall be between 0.2-0.3% of the total mix (plant tolerance will be ±0.1). Limits closed to 0.3 are preferred, however, the <u>use and amount</u> of fibers should be based on combination of the design mix evaluation, draindown test results, hauling distance, and the demonstration strip evaluation. [local fine aggregate is not acceptable as a fiber].

Fibers shall be uniformly dispersed in the PBC mixture, and meet the following requirements.

Property	**Requirement**
Sieve Analysis	
Method A – Alpine Sieve [1] Analysis	
Fiber Length	6 mm Maximum
Passing 0.150 mm (No. 100 sieve)	70 ± 10 %
Method B – Mesh Screen [2] Analysis	
Fiber Length	6 mm Maximum
Passing 0.850 mm (No. 20) sieve 0.425 mm (No. 40) sieve 0.106 mm (No. 140) sieve	85 ± 10 % 65 ± 10 % 30 ± 10 %
Ash Content [3]	18 ± 5 non-volatile
PH[4]	7.5 ± 1.0
Oil Absorption[5]	5.0 ± 1.0 (times fiber mass)
Moisture Content[6]	Less than 5 % (by mass)

(1) Method A – Alpine Sieve Analysis. This test is performed using and Alpine Air Jet Sieve (Type 200 LS). A representative five gram sample of fiber is sieved for 14 minutes at a controlled vacuum of 5 kPa (11 psi) of water. The portion remaining on the screen is weighed.

(2) Method B – Mesh Screen Analysis. This test is performed using standard 0.850, 0.425, 0.250, 0.180, 0.150, and 0.106 mm sieves, nylon brushes, and a shaker. A representative 10 gram sample of fiber is sieved, using a shaker and two nylon brushes on each screen. The amount retained on each sieve is weighed and the percentage passing calculated. Repeatability of this method is suspect and needs to be verified.

(3) Ash Content – A representative 2 – 3 gram sample of fiber is placed in a tarred crucible and heated between 595 and 650 C (1100 and 1200F) for not less than two hours. The crucible and ash are cooked in a desiccator and weighed.

(4) Ph Test – Five grams of fiber is added to 100 ml of distilled water, stirred and let sit for 30 minutes. The Ph is determined with a probe calibrated with a Ph 7.0 buffer.

(5) Oil Absorption Test – Five grams of fiber is accurately weighed and suspended in an excess of mineral spirits for not less than 5 minutes to ensure total saturation. It is then placed in a screen mesh strainer (approximately 0,5 mm^2 opening size) and shaken on a wrist action shaker for 10 minutes (approximately 32 mm (1 ¼ in) motion at 240 shakes per minutes). The shaken mass is then transferred without touching to a tarred container and weighed. Results are reported as to the amount (number of times its own weight) the fibers are able to absorb.

(6) Moisture Content – Ten grams of fiber is weighed and placed in a 121 C (250 F) forced air oven for two hours. The sample is then re-weighed immediately upon removal form the oven.

4.18.4.1 Introduction of Fibers. A separate system for feeding fibers shall be used to: 1) proportion the required amount into the mixture, and 2) achieve a uniform distribution.

Introduction of Fibers for batch plant: Fibers may be introduced manually or mechanically. The automated supply system shall include low level and no–flow indicators, and a printout of status of feed rate in kg/min. The filler supply line shall include a section of transparent pipe for visually observing consistency of feed.

1) **Manual Introduction.** Pre-weighed packaged fibers may be added directly to the pugmill. These should be added during dry mixing time so that a uniform dispersion could be achieved prior to injection of asphalt cement into the mixture.

2) **Automated introduction.** Using a fiber machine, loose fibers may be added directly to the pugmill or weigh hopper during dry mixing time.

When fibers are used in batch plant, dry mixing time is increased by 3 – 4 seconds and wet mixing times increased by at least 5 - 10 seconds for thorough mixing.

Introduction of Fibers for drum plants. Fibers may be introduced to the drum by only using mechanical methods. These shall be added to the drum in a manner that prevents the fibers from becoming entangled in the exhaust system.

1) **Introduction of loose fibers -** Loose fibers may be added using a fiber machine.

2) **Introduction of pellet fibers -** Fibers in pellet form may be introduced using the RAP conveyor

4.18.5 The Mix Gradation

PBC gradation shall be based on the required thickness for the surfacing course. The maximum nominal size (one size above the sieve that retains at least 10% of the material by weight) of the gradation shall be 16.0 mm.

For 40 mm thick course, PBC shall meet the following gradation:

Sieve Size	Percentage of sieve passing	Authorized limits
15.6 mm	100	
12.5 mm	85– 100	-5%
9.5 mm	50 – 80	± 5%
4.75 mm	20– 30	± 4%
2.36 mm	12– 15	± 2%
0.075 mm	2 – 4	± 1%

For 50 mm thick course, the PBC shall have the following gradation:

Sieve Size	Percentage of sieve passing	Authorized limits
15.6 mm	95-100	-5%
12.5 mm	75–90	± 5%
9.5 mm	45-65	± 5%
4.75 mm	20– 30	± 4%
2.36 mm	10 – 15	± 2%
0.075 mm	3 – 4	± 1%

4.18.5.1 PBC mix design criteria. The Marshall method is used to compact PBC mixtures in the laboratory, and to prepare samples for further analysis. In the PBC design the determination of specific gravity and void content is more important than stability and flow values. Major requirements are noted below. **Note:** Additional mixture design requirements and details shall be provided by the Ministry.

Test	Requirement
Stability Flow Value, 0.25 mm	NA (635 kg desirable) N/A (8-16 desirable)
Air Voids in the mix (compacted sample, 50 blows Marshall, per side)	18-22% [20% minimum is desirable]
Voids in coarse aggregate mix, VCA	Less than VCA of the coarse aggregate (T19)
Draindown @ mixing temperature (test method is attached)	0.30% maximum
TSR (D4867)	80% min

Note: Ministry may require a permeability test during design and at the end of construction to determine drainage rate for PBC. Details on Permeability Test and minimum permeability requirement will be provided by the Ministry.

4.18.5.2 Asphalt cement content

AC content for PBC shall be determined during the design. Initial binder content can be estimated using an aggregate surface capacity test procedures (as noted for friction course). This initial AC content is then optimized to provide thick asphalt coating (usual binder film thickness 20-40 micron) within the air void limits without resulting in drain down. Note: Optimum AC content will normally be in the range of 5-6.5%.

4.18.5.3 Mixing and Compaction Temperatures

These temperatures shall be determined in accordance with AASHTO T 245, sections 3.3.1,2, or that recommended by the producer when polymer-modified binders are used. [Mixing temperature is generally in the range that will correspond to asphalt cement viscosities of 700-900 centistokes] Mixes with polymer modification and fibers can generally be produced at about 140-160C. If fibers are used mixing time is extended by about 15-25 seconds as noted earlier]

4.18.5.4 Anti stripping Additives

If needed anti stripping additives will be added in accordance with General Specifications.

4.18.6 Construction

4.18.6.1 Demonstration

Before proceeding with the actual work, the contractor shall demonstrate to the Engineer that a satisfactory mix can be produced, placed, and compacted to determine the compactive effort needed. A minimum of 150 meters shall be placed at a site that simulates the actual project conditions.

4.18.6.2 Hauling Units.

To prevent mix sticking on the truck beds, a suitable release agent (such as dry soap powder or a liquid detergent) shall be placed on the truck beds. Any extra liquid shall be drained before loading with the mix.

The mix shall not be stored at the plant for more than 30 minutes.

4.18.6.3 Mix Temperature at the site.

The compaction temperature is established during the design. However, it should be noted that mix will not compact after its temperature drops below 115°C for conventional PBC and 125°C for polymer modified PBC. Therefore, the initial temperature of the mix at the job site should not be less than 135°C. The haul time between the mixing plant and job site should be kept to not more than one hour to prevent mix cooling and draindown.

Each load should be covered with a full tarp to prevent loss of temperature.

4.18.6.4 Pavement Thickness.

Pavement layer thickness be as specified in the contract documents. It should be noted that PBC is generally placed at thicknesses of 40-50 mm.

4.18.6.5 Weather

Placement of PBC shall be permitted only when the ambient and pavement temperature are at least 15°C.

4.18.6.6 Tack Coat.

The surface on which PBC is placed should be impervious and sloped about 2% towards the edge of the road. A strong, durable bond of the PBC to the pavement surface is essential. A heavier tack coat or a SAMI-like seal coat is preferred.

A tack coat of a slow setting emulsion (diluted with 50% water) shall be applied at a rate of 0.35 and 0.50 l/m² to seal the underlying surface. Note: Application rate may have to be adjusted based on the field conditions. [if a SAMI is used the application rate will be in the range of 0.8-1.5 l/m²; and cover aggregate will be 6 to 9.5 mm size]

4.18.6.7 Compaction.

Rolling shall be performed using a minimum of three steel-wheeled static rollers, each weighing 12 tons. The rolling shall commence immediately after placement and all rollers will remain within 152 meters of the paver.

The rollers shall be equipped with a watering or soapy watering system that prevents material from sticking to the roller wheels. Roller speed shall be between 1.6 and 4.8 kph. All rolling shall be completed before mat is cooled below 115°C.

No vibrator roller in the vibratory mode or rubber tire roller will be allowed.

4.18.7 Quality Assurance Procedures

The Quality Assurance procedures in Subsection 4.05.8 – “Quality Assurance Procedures” in the General Specifications shall be applied to the acceptance of PBC.

4.18.7.1 Paving Profile (ride quality)

The finished surface of the PBC pavement when placed as a wearing course shall conform to Ministry ride quality standards contained in Subsection 4.05.8 – “Quality Assurance Procedures” in the General Specifications.

4.18.8 Method of Measurement

PBC shall be measured by the cubic meter of mix acceptably placed and evaluated in accordance with the General Specifications, this Addendum and certified by the Engineer.

4.18.9 Payment

The amount of PBC actually incorporated in to the work, and measure as provided above, will be paid for at the contract unit prices in the Bill of Quantities.

Prices and payment made under this section shall cover and be full compensation for furnishing labor, equipment, materials, tools and incidentals necessary to complete all the work involved as specified in Subsection 1.07.2 “Scope of Payment” in the General Specifications, except for polymer chemical admixture/asphalt modifier which shall be paid for separately in accordance with Paragraph 4.05.11 “Payment” in this Addendum to the General Specifications.

PAYMENT WILL BE MADE UNDER ONE OR MORE OF THE FOLLOWING SUPPLEMENTAL PAY ITEMS WHEN THEY ARE INCLUDED IN THE CONTRACT BILL OF QUANTITIES.

Item No.	Pay Item	Pay Unit
41851	Porous Bituminous Concrete (PBC)	Cubic Meter