THE URBAN DEVELOPMENT CORPORATION OF TRINIDAD AND TOBAGO LIMITED (UDeCOTT)

REQUEST FOR PROPOSALS
HILTON TRINIDAD AND CONFERENCE CENTRE REFURBISHMENT

The Urban Development Corporation of Trinidad and Tobago Limited (UDeCOTT) invites suitably qualified and experienced entities to submit proposals for the following Works on the **Hilton Trinidad and Conference Centre Refurbishment Project;**

a) **Structural Repairs**

b) **Civil Infrastructure**

In accordance with the Public Procurement and Disposal of Public Property Act, 2015 (as amended), suppliers of goods, works and services, interested in conducting business with UDeCOTT must be registered on the OPR Procurement Depository. The relevant guidelines for registration can be found on the OPR website via https://oprtt.prg/procurement-depository/.

The tender process for this project will be conducted via UDeCOTT's E-Tender System. To register or access the E-Tender System go to https://udecott.etenderworld.tt/login.php.

Should you encounter any technical difficulties in accessing or using the system, you are to immediately contact our IT Helpdesk at 225-4004 ext. 206 or etenderhelpdesk@udecott.com, carbon copying the Office of the Chief Procurement Officer at tenders@udecott.com.

The successful contractors shall be chosen using competitive selection processes as set out in the Requests for Proposals (RFP). Proponents are informed that submissions must include ALL the documents as set forth in the RFP. Failure to do so may result in disqualification.

INFORMATION SESSION

Online Information Sessions will be held **via Microsoft Teams** on **Friday August 18, 2023 at 9:00 a.m. (Structural Repairs**) and **11:00 a.m. (Civil Infrastructure)**. This will be followed by **Site Visits** on **Friday August 18, 2023 at 1:00 p.m.** and **2:30 p.m.** respectively. Interested parties are kindly asked to confirm their availability, together with the **names and preferred email addresses** of their representatives who will be in attendance, via email to tenders@udecott.com.

SUBMISSION

Proponents are advised that submissions must include ALL the documents as set forth in the RFP and must be in accordance with the terms therein.

Failure to do so may result in disqualification.

The deadline date for submissions is **September 8, 2023 (AST)**.

Additional information may be requested through email forwarded to the attention of **The Office of the Chief Procurement Officer** at tenders@udecott.com.

UDeCOTT reserves the right to reject any or all proposals for failure to comply with any mandatory requirements stated in the RFP.

THE OFFICE OF THE CHIEF PROCUREMENT OFFICER

FREQUENTLY ASKED QUESTIONS (FAQs)
HILTON TRINIDAD AND CONFERENCE CENTRE REFURBISHMENT

What is the purpose of this Request for Proposal?
The purpose of this Request for Proposal is to identify and contract a suitably qualified and experienced Contractor to undertake the following:

a) **Structural Repairs**
b) **Civil Infrastructure**

I am interested in this project. Can I view the RFP before purchasing to confirm the requirements prior to purchasing?
The RFP will be available for viewing at UDeCOTT's Head Office, First Floor, 38-40 Sackville Street, Port of Spain, 100622, from Wednesday August 10, 2023 (excluding weekends and public holidays), between the hours of 9:00 a.m. to 4:00 p.m. (AST).

What is the Location of the site?
The Project Site is the Hilton Trinidad and Conference Centre, located on Lady Young Road, Port of Spain.

Is it mandatory to attend the site visit and online information session?
Attendance to the site visit and online information session is **not** mandatory. It does however, provide a greater understanding of the requirements of the RFP.

Are there any eligibility requirements for this Procurement Process?
In order to be eligible for evaluation and/or consideration to provide the Works, Proponents must be able to demonstrate the following:

- Incorporation or otherwise registered to do business in Trinidad and Tobago as evidenced by the Certificate of Incorporation or Registration (as applicable);
- Submission of Statutory Clearance/Compliance Certificates, (for companies incorporated/registered in Trinidad and Tobago) valid as at the tender submission deadline, namely;
  - VAT Clearance Certificate
  - BIR Clearance Certificate
  - NIS Certificate of Compliance

Are interest parties required to register with the Office of the Procurement Regulator?
Proponents are advised that in light of the proclamation of the Public Procurement and Disposal of Public Property Act, 2015, all proponent interested in conducting business with UDeCOTT must be registered on the OPR Procurement Depository. The relevant guidelines for registration can be found on the OPR website via https://oprtt.prg/procurement-depository/.

Are Proponents required to purchase the RFP package?
There will be no cost for the RFP package.

Are Proponents required to submit a Bid Bond with their Proposals?
No, a Bid Bond is not required for this RFP.

Proponents are to note that the responses provided as guidance to these Frequently Asked Questions does not relieve the Proponent of its obligation and responsibility to fulfil and comply with all requirements of the Request for Proposals.

URBAN DEVELOPMENT CORPORATION OF TRINIDAD AND TOBAGO

HILTON TRINIDAD, PORT OF SPAIN

Civil Specifications

May 2023

Urban Development Corporation Of Trinidad & Tobago
38-40 Sackville Street
Port of Spain

EMPLOYER

Beston Consulting Limited
308 Gangadeen Street
Pasea Village
Tunapuna

LEAD CONSULTANT / CIVIL & STRUCTURAL ENGINEER

VOLUME II - TECHNICAL SPECIFICATIONS

INDEX

INDEX (Continued)

INDEX (Continued)

Specification Series 800 – NOT USED

Specification Series 900 – Dayworks

SERIES 100:
GENERAL

SERIES 100: GENERAL

SECTION 101: DEFINITIONS AND TERMS

101.1 General Definitions and Terms

101.2 Standard Methods of Sampling and Testing of Soils and Materials

101.3 Standard Methods of Sampling and Testing for Traffic Management Materials

101.1 GENERAL DEFINITIONS AND TERMS

In these specifications, the following terms, words or expressions shall have the meanings hereby assigned to them.

Bituminous Material/ Concrete — A mixture to predetermined proportions of aggregate, filler and bituminous binder material prepared off the road and usually placed by means of a paving machine (alternatively known as asphalt concrete).

Abutment — The portion of the bridge substructure at either end of a bridge which transfers loads from the superstructure to the foundation and provides lateral support for embankment.

Alignment Bearing — A bearing that prevents transverse movement of the superstructure. Normally, one beam on each span has an alignment bearing. However, seismic considerations may warrant provision of more than one alignment bearing.

Asphaltic Surface Course — The top layer of bituminous material intended to directly support vehicles within the roadway. Bituminous material may be placed on top of binder or granular base course or asphaltic base course materials.

Asphaltic Base Course — The bottom layer of bituminous material placed on top of binder or granular base course.

Back Wall — The portion of an abutment behind the bridge seats which extends upward from the top of the bridge seats to the top of the abutment or bottom of the header.

Batter — A deviation from the vertical, commonly found on the back sides of walls and on piles.

Bearing — Usually, a device which supports the end of a girder and distributes superstructure loads to the abutment or pier. Fixed bearings do not provide for longitudinal movement of the superstructure to compensate for expansion and contraction due to temperature changes.

Bent — A row or group of piles in a structure, a row of columns. Piers are also referred to as bents when the piles extend above the ground to the pier cap.

Asphaltic Binder Course — The layer of bituminous material placed on top of base course material and under the surface course to support the surface course, or placed on an existing roadway to remove irregularities before a surface course is laid (see levelling course).

Boring/Borehole — An exploration of subsurface material. Borings are used by the design engineer in determining the types and dimensions of foundations required. Borings/Boreholes are used by construction personnel to determine the type of materials in which piles are to bear, and to determine suitable bearing strata in foundation excavations.

Borrow Area	An area within designated boundaries, approved for the purpose of obtaining borrow material. A borrow pit is the excavated pit in a borrow area
Borrow Excavation, Bridge Foundation (BEBF)	Select compacted material used for foundations.
Borrow Material	Any gravel, sand, soil, or rock obtained from borrow areas, or sources other than cuttings and excavations within the road reserve, and which is used in the construction of the Works. It shall not include crushed stone or sand obtained from commercial sources.
Bridge	A structure erected over a depression, river, watercourse, railway line, road or other obstacle for carrying motor, railway, pedestrian, or other traffic or services and having a length of 6 metres or more, measured between the abutment faces along the centreline of the road, except that road-over-road or road-over-rail structures are always classified as bridges.
Bridge Seat	The horizontal surface on an abutment or pier on which the girders are to be supported.
Camber	A slight parabolic curvature constructed into a girder to: 1. Compensate for deflection in the girder due to the weight of the girder and weight of concrete supported by it. 2. Provide curvature to the superstructure if the roadway profile is on a vertical curve. 3. Provide architectural curvature to the girder.
Cap Beam	A steel, timber or concrete beam capping a bent of piles or columns.
Capping Layer	The lower layer or layers of the pavement which is constructed directly onto a weak or moisture sensitive subgrade prior to the placing of the sub-base (see selected subgrade material).
Carriageway	The surface of the pavement over which traffic normally passes usually delineated by edge markings or constraints such a slipper drains or kerbs.
Centreline of Bearings	A horizontal alignment control line through the centres of the bearings which is used in abutment or pier layout and girder erection.
Chamfer	The inclined flat surface formed by removing a square edge or corner; a beveled edge.
Column	A vertical compression member usual circular or rectangular in cross section. In piers, columns transfer loads from the superstructure to the foundation.
Construction Joint	A joint where adjacent portions of the structure are joined together. This is usually roughly finished and has reinforcement steel extending through it.

Contraction Joint A joint which separates two adjacent portions of the structure and contains a bond break such as a paraffin coating.

Coping A projecting course of concrete. Usually, this is a projection on the outside of bridge sidewalks. It is also found on wingwalls of stub abutments and some pier cap beams.

Culvert A structure, other than a bridge, which provides an opening under the roadway, for drainage or other purposes.

Cutoff Wall A type of concrete header constructed under headwall aprons, culvert invert slabs and culvert wingwall footings to prevent washouts caused by scouring action of the water.

Diaphragm Channel, angle steel or cast-in-place concrete cross bracing between girders.

Dismantling of Bridge When the Contract calls for dismantling of the existing bridge structure, the Contractor shall remove the existing piers and abutments to the elevations indicated on the Drawings. Material removed from the existing bridge structure shall be disposed of as provided in the Specifications or as directed by the Engineer. In general, old concrete shall be disposed of as provided in the Specifications or used for rip-rap or deposited adjacent to the Site in areas approved by the Engineer, but shall not be left in the watercourse. If the old concrete is to be used for rip-rap, protruding reinforcing steel shall be cut off.

Structural steel and timber members which are suitable for re-use shall be match-marked as directed by the Engineer and dismantled at all original field connections unless directed otherwise. Rivets shall be removed by cutting the rivet heads or by burning, provided that care is used not to damage the rivet holes. All portions of the rivets shall be completely removed from the members. Welded connections shall be dismantled by cutting the weld metal out. Nuts, bolts and washers are to be removed from bolted connections ensuring that the connecting hardware and bolt holes are not damaged during the loosening and removal processes.

Structural steel and timber to be stored shall be supported on blocks above the ground so as to be kept clean and dry at all times. The blocks shall be placed close enough together to prevent injury to the members from deflection.

Dowel A reinforcement bar extending through a construction joint connecting two adjacent portions of the structure.

Elevation View A front or side view.

Embankment That portion of the road prism consisting of suitable material which lies above the formation and is bounded by the side slopes, shown on the typical cross-sections on the drawings running downwards and outwards from the outer edge of the shoulder, and on which the capping layer, sub-base, base course and shoulders are to be constructed.

Excess Overburden	Overburden within a borrow area which is not required or is unsuitable for use in construction.
Expansion Joint	A joint which separates two adjacent portions of a structure and contains compressible material to allow for concrete expansion.
Fascia Beams	The outermost girders on any span.
Flange	The projecting portion of a beam or channel. The top or the bottom plate of a steel girder.
Footing	Part of a foundation, normally wider than the supported wall or column, which transmit loads from above to the soil below either by direct contact or through piles.
Formation	The existing ground (after clearing and grubbing and the removal of topsoil), onto which material is placed for the construction of embankments.
Foundation	The part of a structure which is usually placed below the surface of the ground which distributes the load upon the subsoil.
Girder	A horizontal supporting structure member. (Beam, Stringer)
Granular Base Course	The granular layer of material constructed on top of the sub-base, or in the absence thereof, the capping layer. A granular base course may extend outside the roadway.
Header	A concrete wall on the top of an abutment backwall usually found between the end of a deck slab and the roadway approach slab.
Integral Abutment Bridge	A bridge where the superstructure is rigidly connected to its abutments.
Lane	That part of the roadway intended for a single stream of traffic in one direction, which has normally been demarcated as such by road/pavement markings.
Levelling Course	One or more layers of asphalt of varying thicknesses, but with a specified minimum total thickness, which are applied to improve the cross sectional characteristics of a road, such that constructing the final wearing course or resurfacing layer in accordance with the required standards for levels, thickness and cross section will be possible.
Overlay	Additional bituminous pavement layer(s) applied on top of an existing road for strengthening the pavement and/or for improving the riding quality.
Parapet	A concrete railing or barrier located on the bridge deck fascia and the tops of retaining walls.

Pavement Layers	The upper layers of the road comprising of, as appropriate, the capping or selected subgrade layer, sub-base, base course and wearing courses, and the shoulder layers.
Pier	The portion of the bridge substructure which transfers loads from the superstructure to the foundation. Provides intermediate support for multi-span bridges.
Piles	Shafts of concrete, timber, or steel which are used to transfer foundation loads through subsurface materials.
Pitch	The vertical distance covered by one turn of spiral reinforcement in columns.
Plan View	Top view.
Retaining Wall	A wall design to retain embankment and prevent erosion.
Road Reserve	The entire area included by the boundaries of the road as legally stated.
Roadway	The extents of the top layer of the pavement, between the vertical face of edge constraints or, in the absence of any constraint, the back of the shoulder.
Roadway Reconstruction	The excavation of the existing roadway over one half or the whole of the width to a depth below the existing road surface and the reconstruction of the subgrade and the individual pavement layers each in accordance with the appropriate sections of the specification.
Roadway Subgrade	The layer of re-compacted material consisting of existing pavement material pulverised and re-laid on to which is placed the capping layer, sub-base or base course.
Rock	Those geological strata or deposits which require the use of blasting techniques for their removal, but excluding individual masses having volumes of less than $0.2m^3$. The criteria to be used to establish the need for blasting shall be that a Caterpillar 325 excavator or similar in good working condition with a rock bucket cannot excavate such material when encountered 1m below ground level.
Roller Passes	An area will be considered to have received one roller pass when a roller has passed over such an area once. Additional passes made only as a result of nominal overlapping so as to ensure full coverage shall not be taken into account.
Section View	An internal view. In Bridge Plan, sections are usually shown through all parts of the structure.
Services	Cables, pipes or other facilities to provide conduits for electricity, telephone, water, sewage, natural gas, oil, etc.

Selected Subgrade Material	The lower layer or layers of the pavement which is constructed directly onto a non-moisture sensitive subgrade prior to the placing of the aggregate sub-base (see capping material).
Shear Connectors	Usually stud type connectors welded to the top of girders or U type reinforcement protruding from prestressed concrete beams and embedded in the concrete deck slabs.
Side Drain	An open longitudinal drain situated adjacent to and at the bottom of cut or embankment slopes.
Side Slope	The sloping surface to the side of an embankment supporting the road commencing at the shoulder breakpoint or the outside edge of the verge.
Site (The)	The Site shall be the area between the limits of the right of way of the highway and not more than 20m beyond the limits of any works on the project road and any intersecting roads. In addition, the site shall include the extent of any works outside of the right of way to the limits defined on the drawings or to that agreed with the landowner(s). See also special definition contained in Section 104.
Shoring	Prop or support, usually temporary that is used during the repair or original construction and in excavations.
Shoulder	1. When referring to this as a surface: The area between the outside edge of the roadway and the shoulder breakpoint 2. When referring to this as a pavement layer: The upper pavement layer lying between the outside edge of the base course and the shoulder breakpoint.
Soffit	The underside portion of a deck slab overhanging the exterior of fascia girders.
Stiffener	Longitudinal or vertical plates (welded to structural steel beams) to prevent buckling.
Sub-base	The layer of material on top of the subgrade or capping layer and below the granular base course and shoulders.

Substructure	The part of a structure below the superstructure. The part of the structure below: 1. The bottom of the grout pad for the simple and continuous span bearing, or 2. The bottom of the girder or bottom slab soffit, or 3. Construction joints at the top of vertical abutment members or rigid frame piers. Substructures include end walls, wingwalls, barrier and railing attached to the wingwalls, and cantilever barriers and railings.
Superstructure	In a bridge, the superstructure consists of bearings, girders, decks, sidewalks, etc. (all above the substructure). The part of the structure above: 1. The bottom of the grout pad for the simple and continuous span bearing, or 2. The bottom of the girder or bottom slab soffit, or 3. Construction joints at the top of vertical abutment members or rigid frame piers. Superstructures include, but are not limited to, girders, slab, barrier, and railing attached to the superstructure. Superstructures do not include end walls, wingwalls, barrier and railing attached to the wingwalls, and cantilever barriers and railings unless supported by the superstructure.
Top Soil	The top layer of soil that can support vegetation.
Verge	The surface between the shoulder break point and the top of the side drain or side slope.
Wedging	One layer of asphalt of varying thicknesses, but with a specified minimum thickness, which is applied to provide the longitudinal characteristics of a road at the tie in to an existing pavement, such that constructing the final wearing course or resurfacing layer in accordance with the required standards will be possible.
Wingwall	A wall at the end of an abutment or culvert for retaining slopes and preventing erosion.
Viaduct	A bridge made up of multi-spans supported on piers carrying the roadway over streets, highways, railroads and/or streams.

101.2 STANDARD METHODS OF SAMPLING AND TESTING OF SOILS AND MATERIALS

The following lists the methods of testing prescribed by AASHTO relevant to the Contract. The Contractor shall ensure that all materials incorporated into the permanent works conform to the requirements of the specification and that, as required for the materials supplied; the tests listed can be undertaken under the Contract to confirm compliance. All material testing shall be undertaken fully in accordance with the procedures laid down in the prescribed test, taking due account of the material being tested. In the case of tropical soils and aggregates the materials will be tested in their natural condition and as prescribed in the test procedures for tropically weathered soils and rocks.

1. Soils	**AASHTO* Test No.**
Dry preparation of Disturbed Soil and Soil	
Aggregate Samples for Test AASHTO *	T-87
Wet preparation of Disturbed Soil Samples for Test	T-146
Mechanical Analysis of Soils	T-88
Liquid Limit (LL)	T-69
Plastic Limit (PL) and Plasticity Index (P1)	T-90
Shrinkage Factors	T-92
Standard Density	T-99
Modified Density	T-180
Moisture Density Relations of Soil-Cement Mixtures	T-134
Cement Content of Soil-Cement Mixtures	T-144
Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test	T-176
Density of Soil In-Place by the Sand-Cone Method	T-191
Density of Soil and Soil Aggregate In-Place by Nuclear Methods	T-238
California Bearing Ratio (CBR)	T-193
Determination of Organic Matter in Soils	T-194
Determination of Cement Content in Cement Treated Aggregate	T-211
Sampling Hydrated Lime	T-218
Determination of the Strength of Soil-Lime Mixtures	T-220
Correction for Coarse Particles in the Soil Compaction Test	T-224
Determination of Lime Content in Lime Treated Soils	T-232
Moisture Content of Soil and Soil-Aggregate In-Place by Nuclear Methods	T-239
In-Place Density of Soil and Soil Aggregate by Nuclear Methods	T-310
*All are AASHTO Standard Tests unless otherwise noted.	

2. Aggregates	
Sampling Stone, Slag, Gravel, and Stone Block for use as Highway Materials	T-2
Amount of Material Finer than 0.075 mm sieve in Aggregate	T-11
Unit Weight of Aggregate	T-19
Voids in Aggregate For Concrete	T-20

Organic Impurities in Sands for Concrete	T-21
Sieve Analysis of Fine and Coarse Aggregates	T-27
Mechanical Analysis of Extracted Aggregate	T-30
Sieve Analysis or Mineral Filler	T-37
Effect of Organic Impurities in Fine Aggregate on Strength of Mortar	T-71
Specific Gravity and Absorption of Fine Aggregate T-84	
Specific Gravity and Absorption of Coarse Aggregate T-85	
Resistance to Abrasion of Coarse Aggregate by use of the Los Angeles Machine	T-96
Soundness of Aggregates by Use of Sodium Sulphate or Magnesium Sulphate	T-104
Clay Lumps and Friable Particles in Aggregates	T-112
Lightweight Pieces in Aggregate	T-113
Surface Moisture in Fine Aggregate	T-142
Percentage of Particles of less than 1.95 Specific Gravity in Coarse Aggregate	T-150
Scratch Hardness of Coarse Aggregate Particles	T-189
Production of Plastic Fines in Aggregates	T-210
Direct Shear Test of Soils under Consolidated Drained Conditions	T-236
Reducing Field Samples of Aggregate to Testing Size T-248	
Percent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures	T-269

*All are AASHTO Standard Tests unless otherwise noted.

3. Concrete

Compressive Strength of Cylindrical Concrete Specimens	T-22
Making and Curing Concrete Compressive and Flexural Test Specimens in the Field	T-23
Obtaining and Testing Drilled Cores and Sawed Beams of Concrete	T-24
Quality of Water to be Used in Concrete	T-26
Effect of Organic Impurities in Fine Aggregate on Strength of Mortar	T-71
Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)	T-97
Slump of Portland Cement Concrete	T-119
Weight per Cubic Foot, Yield, and Air Content (Gravimetric) of Concrete	T-121
Making and Curing Concrete Compression and Flexure Test Specimens in the Laboratory	T-126
Compressive Strength of Concrete Using Portions of Beams Broken in Flexure	T-140
Sampling Fresh Concrete	T-141
Measuring Length of Drilled Concrete Cores	T-148
Air Content of Freshly Mixed Concrete by the Pressure Method	T-152
Water Retention Efficiency of Liquid Membrane-Forming Compounds and Impermeable Sheet Materials for Curing Concrete	T-155
Air-Entraining Admixtures for Concrete	T-157
Bleeding of Concrete	T-158
Comparing Concrete on the Basis of the Bond Developed with Reinforcing Steel	T-159
Length Change of Cement Mortar and Concrete	T-160

Flexural Strength of Concrete (Using Simple Beam with Centre-Point Loading)	T-177
Cement Content of Hardened Portland Cement Concrete	T-178
Ball Penetration in Fresh Portland Cement Concrete	T-183
Air Content of Freshly Mixed Concrete by the Volumetric Method	T-196
Time of Setting of Concrete Mixtures by Penetration Resistance	T-197
Splitting Tensile Strength of Cylindrical Concrete	T-198
Capping Cylindrical Concrete Specimens	T-231

*All are AASHTO Standard Tests unless otherwise noted.

4. Bituminous Materials

Sampling Bituminous Materials	T-40
Solubility of Bituminous Materials in Organic Solvents	T-44
Loss of Heating of Oil and Asphaltic Compounds	T-47
Flash and Fire Points by Cleveland Open Cup	T-48
Penetration of Bituminous Materials	T-49
Float Test for Bituminous Materials	T-50
Ductility of Bituminous Materials	T-51
Softening Point of Asphalts and Tar in Ethylene Glycol (Ring and Ball Apparatus)	T-53
Water in Petroleum Products and Bituminous Materials by Distillation	T-55
Residue of Specified Penetration	T-56
Testing Emulsified Asphalts	T-59
Saybolt Viscosity	T-72
Distillation of Cut-Back Asphaltic Products	T-78
Flash point with Tag Open Cup Apparatus	T-79
Spot Test of Asphaltic Materials	T-102
Settlement Ratio of Mineral Matter in Bituminous Filler	T-109
Moisture or Volatile Distillates in Bituminous Mixtures	T-110
Inorganic Matter or Ash	T-111
Distillation of Petroleum Products	T-115
Quantitative Extraction of Bitumen from Bituminous Paving and Mixtures	T-164
Effect of Water on Cohesion of Compacted Bituminous Mixtures	T-165
Specific Gravity of Compacted Bituminous Mixtures	T-166
Sampling Bituminous Paving Mixtures	T-168
Recovery of Asphalt from Solution by Abson Method	T-170
Bituminous Mixing Plant Inspection	T-172
Effect of Heat and Air on Asphalt Materials (Thin-Film Oven Test)	T-179
Coating and Stripping of Bitumen-Aggregate Mixtures	T-182
Degree of Particle Coating of Bituminous-Aggregate Mixtures	T-195
Kinematic Viscosity of Asphalts	T-201
Absolute Viscosity of Asphalts	T-202
Maximum Specific Gravity of Bituminous Paving Mixtures	T-209
Density, Specific Gravity or API Gravity of Crude Petroleum by Hydrometer Method	T-227
Specific Gravity of Road Oils, Road Tars, Asphalt Cements, and Soft Tar Pitches	T-228
Specific Gravity of Solid Pitch and Asphalt (Displacement Method)	T-229
Determining Degree of Pavement Compaction of Bituminous	

Aggregate Mixtures	T-230
Effect of Heat and Air on a Moving Film of Asphalt (Roiling-Thin-Film Oven Test)	T-240
Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus	T-245
Concrete Pipe, Sections or Tile	T-280
Resistance of Compacted Bituminous mixture to Moisture Induced Damage	T-283
Hubbard-Field Method ASTM	D-138

*All are AASHTO Standard Tests unless otherwise noted.

5. Portland Cement

Fineness of Portland Cement by the Turbid meter	T-98
Chemical Analysis of Hydraulic Cement	T-105
Compressive Strength of Hydraulic Cement Mortars	T-106
Autoclave Expansion of Portland Cement	T-107
Sampling Hydraulic Cement	T-127
Fineness of Hydraulic Cement by the 0.150mm and 0.075 mm Sieves	T-128
Normal Consistency of Hydraulic Cement	T-129
Time of Setting of Hydraulic Cement by Vicat Needle	T-131
Tensile Strength of Hydraulic Cement Mortars	T-132
Specific Gravity of Hydraulic Cement	T-133
Air Content of Hydraulic Cement Mortar	T-137
Fineness of Portland Cement by Air Permeability Apparatus	T-153
Time of Setting of Hydraulic Cement by Gillmore Needles	T-154
Mechanical Mixing of Hydraulic Cement Pastes and Mortars of Plastic Consistency	T-163
False Set of Portland Cement (Mortar Method)	T-185
False Set of Portland Cement (Paste Method)	T-186
Fineness of Hydraulic Cement by the 0.045 mm (No. 325) Sieve	T-192

*All are AASHTO Standard Tests unless otherwise noted.

6. Sieve Sizes

ASTM Sieve Size or Number	Sieve Opening	
	Millimetres	Inches
4”	100	4.00
3½”	90	3.50
3”	75	3.00
2½”	63	2.50
2”	50	2.00
1¾”	45	1.75
1½”	37.5	1.50
1¼”	31.5	1.25
1”	25.0	1.00
⅞”	22.4	0.875
¾”	19.0	0.750

ASTM Sieve Size or Number	Sieve Opening	
	Millimetres	Inches
⅝”	16.0	0.625
½”	12.5	0.500
7/16”	11.2	0.438
⅜”	9.5	0.375
5/16”	8.0	0.3 12
¼”	6.3	0.250
7/32”	5.6	0.223
No. 4	4.75	0.187
No. 5	4.00	0.157
No. 6	3.35	0.132
No. 7	2.80	0.111
No. 8	2.36	0.0937
No. 10	2.00	0.0787
No. 12	1.70	0.0661
No. 14	1.40	0.0555
No. 16	1.18	0.0469
No. 18	1.00	0.0394
No. 20	0.850	0.0331
No. 25	0.710	0.0280
No. 30	0.600	0.0232
No. 35	0.500	0.0197
No. 40	0.425	0.0165
No. 45	0.355	0.0138
No. 50	0.300	0.0117
No. 60	0.250	0.0098
No. 70	0.212	0.0083
No. 80	0.180	0.0070
No. 100	0.150	0.0059
No. 120	0.125	0.0049
No. 140	0.106	0.0041
No. 170	0.090	0.0035
No. 200	0.075	0.0029
No. 230	0.063	0.0024
No. 270	0.053	0.0021
No. 325	0.045	0.00 17
No. 400	0.038	0.0015

101.2 STANDARD METHODS OF SAMPLING AND TESTING OF TRAFFIC MANAGEMENT WORKS.

The following lists the methods of testing prescribed by British Standard Institute (BS), American Association of State Highway and Transportation Officials (AASHTO) and American Society for Testing and Materials (ASTM) relevant to the Contract. The Contractor shall ensure that all materials incorporated into the works conform to the requirements of the specification and that, as required for the materials supplied; the tests listed can be undertaken under the Contract to confirm compliance. All material testing shall be undertaken fully in accordance with the procedures laid down in the prescribed test, taking due account of the material being tested.

1. Pavement Markings Test No.

a. Thermoplastic

Chromaticity co-ordinates and Luminance factor	BS EN 1871:2000 Annex E
Alkali resistance of the materials	BS EN 1871:2000 Annex D
Softening point	BS EN 1871:2000 Annex F
Heat stability	BS EN 1871:2000 Annex G
Cold Impact resistance	BS EN 1871:2000 Annex H
Indentation value	BS EN 1871:2000 Annex J
Tröger wear	BS EN 1871:2000 Annex K

b. Traffic Paint

Chromaticity co-ordinates and Luminance factor	BS EN 1871:2000 Annex A
Storage Stability	BS EN 1871:2000 Annex B
Bleed resistance	BS EN 1871:2000 Annex C
Alkali Resistance	BS EN 1871:2000 Annex D

c. Preformed Thermoplastic

Road marking materials. Preformed road markings	BS EN 1790:1998

d. Premix Glass Beads

Road marking materials. Premix glass beads	BS EN 1424:1998
Road marking materials. Drop on materials. Glass beads, antiskid aggregates and mixtures of the two	BS EN 1423:2012

e. Road Marking Material Performance

Road marking materials. Road marking performance for road users	BS EN 1436:2007+A1:2008

2. Retro-reflecting Raised Pavement Markers

Road marking materials. Retroreflecting road studsInitial performance requirements	BS EN 1463-1:2009
Road marking materials. Retroreflecting road studsRoad test performance specifications	BS EN 1463-2:2000
Miscellaneous road traffic signs and devices. Requirements and test methods	BS EN 8442:2006

3. Adhesives for Raised Pavement Markers

a. Bituminous Adhesives

	ASTM
Density of Semi-Solid Bituminous Materials (Pycnometer Method)	D-70
Sealants and Fillers, Hot-Applied, for Joints and Cracks in Asphaltic and Portland Cement Concrete Pavements	D-5329
Apparent Viscosity of Petroleum Waxes Compounded with Additives (Hot Melts)	D-2669
Fineness of Hydraulic Cement by the 45-µm (No. 325) Sieve	C-430
Standard Test Method for Recovery of Asphalt From Solution by Abson Method	D-1856
Standard Test Method for Effect of Heat and Air on Asphaltic Materials (Thin-Film Oven Test)	D-1754
Standard Test Method for Water and Sediment in Fuel Oils by the Centrifuge Method (Laboratory Procedure)	D-1796

	AASHTO
Standard Method of Test for Softening Point of Bitumen (Ring-and-Ball Apparatus)	T-53
Standard Method of Test for Flash and Fire Points by Cleveland Open Cup (ASTM D 92-05a)	T-48
Standard Method of Test for Penetration of Bituminous Materials	T-49
Standard Method of Test for Viscosity of Asphalts by Vacuum Capillary Viscometer	T-202

SERIES 100: GENERAL

SECTION 102: GENERAL REQUIREMENTS AND PROVISIONS

102.1 Scope

102.2 Performance Security, Insurances and Maintenance during Defects Notification Period

102.3 Submission by the Contractor

102.4 Relocation and Protection of Services

102.5 Road Intersections and Junctions

102.6 Workmanship and Quality Control

102.7 Setting Out of Works and Protection of Controls

102.8 Notices, Signs and Advertisements

102.9 Measurements and Quantities

102.10 Contract Rates and Payment

102.11 Water for Construction

102.12 Drawings Provided by the Contractor

102.13 Use of Explosives

102.14 Site Progress Meetings

102.15 Legal Provisions

102.16 Sewers, Drainage and River Channels

102.17 Adverse Weather

102.1 SCOPE

This section covers matters, which relate to the Contract as a whole. Definitions, phrases or wording which would otherwise require repetition in other sections of the specifications are also covered by clauses in this section. Matters covered by the General Conditions of Contract are not repeated in this section, except where necessary for providing more detailed information.

102.2 PERFORMANCE SECURITY, INSURANCES AND MAINTENANCE DURING DEFECTS NOTIFICATION PERIOD

Attention is drawn to the obligation of the Contractor under the Conditions of Contract:

i. To provide a Performance Security.

ii. To provide insurance for the Works, Contractor's Equipment, Injury to Persons and Damage to property and the Contractor's Personnel.

iii. To maintain the Works during the Defects Notification Period in accordance with the requirements and provisions of the Conditions of Contract, except where the need for such maintenance is determined by the Engineer to be outside the responsibility of the Contractor.

Separate payment items are included in the Bill of Quantities to compensate the Contractor for his compliance with Items ii and iii listed above. No separate payment shall be made for the provision of Performance Security the cost which shall be included in the rates tendered for in the Bill of Quantities.

102.3 SUBMISSION BY THE CONTRACTOR

In addition to the other submittals required from the Contractor as defined in the Specifications, the Contractor shall make the following submissions to the Engineer not more than 28 days from the date of the Letter of Acceptance for the Contract:

1. Organisation chart with curricula vitae of all the key personnel, including, but not limited to:
   a. Project Manager
   b. Project Engineer(s)
   c. Site Supervisor
   d. Health and Safety Officer (primary and deputy)
   e. Engineering Surveyor
2. A detailed time programme in Microsoft Project format. See Specification Section 109 (Programme and Material Supply).
3. S-curves showing the following information which will be used to monitor progress:

a. Cash flow versus time
b. Baseline schedule progress versus time
   A two-week timescale should be used when preparing the S-curves.

4. Contract specific Health and Safety Plan. See Specification Section 103 (Health and Safety).
5. Contract specific Environmental Management Plan. See Specification Section 104 (General Environmental Requirements).

6. Contract specific Risk Assessment and Mitigation Plan.
7. Detailed Demolition Plan and Method Statement.
8. Detailed Traffic Management Plan. See Specification Section 107 (Accommodation of Traffic).
9. Detailed Storm Water / Flood Control Plan providing, among other things, measures to be implemented to control river/flood water during construction.
10. Contract specific Quality Assurance (QA)/Quality Control (QC) Plan and Inspection and Testing Plan.

102.4 RELOCATION AND PROTECTION OF SERVICES

This Contract may include certain work relating to the protection, moving and reinstating of existing services that may be affected by the construction of the Works.

The Employer will, in the Contract documents, provide information available to him regarding the location of existing utility services, but the Employer does not accept responsibility for the accuracy of this information. The Employer will not be responsible for providing information regarding the location of service connections.

The Contractor shall check and determine on the site the positions of any services shown on the drawings. This shall be done by visual inspections, using detecting apparatus, and by making excavations to expose the position of the service at critical points. This shall also be done where no services are shown on the drawings but where such services can reasonably be believed to be present. The positions of all services so detected shall be marked carefully on site and then drawn in on the drawings. These services will then be defined as "known services". The Contractor shall take all reasonable precautions not to damage the services during the search, when the onus shall rest with him to prove that, in the event of damage being done to such services during the search, that such damage was unavoidable.

The Contractor will be held responsible for any damage caused by him to known services, unless he can prove that he has taken all the above precautions and that the damage has nevertheless been caused because the position of the known service had deviated by more than one metre from the position as may reasonably have been deduced from the investigation made by him.

The Contractor shall take all reasonable precautions to support and protect existing services and service connections during construction and during the relocation of the same. All known services, or other pipes, cables, conduits of any nature whatsoever damaged as a result of the Contractor's operations shall be repaired and reinstated forthwith by the Contractor or by the authority concerned, all at the expense of the Contractor and to the satisfaction of the Engineer.

It shall be clearly understood that, in certain instances, existing services can be relocated only after the Contractor has advanced sufficiently on or has completed certain sections of earthworks or certain structures.

Whenever services are encountered which are in conflict with the permanent Works and which thereby need to be permanently moved or relocated, the Contractor shall advise the Engineer, who will determine the extent of the work, if any, to be undertaken by the Contractor in moving, relocating and reinstating or protecting such services. Any work

required to be undertaken by the Contractor in permanently moving and relocating the services for which no provision has been made in the Contract documents, or for which there are no appropriate tender rates, will be classed as a variation, as provided in the General Conditions of Contract.

The Contractor shall work in close co-operation with private owners or public authorities controlling services affected by the Works. Should the owners of services refuse to co-operate with the Contractor in a reasonable manner in connection with the protection or moving of services belonging to them, the Contractor shall refer the matter to the Engineer.

The Contractor shall, in consultation with the Engineer, clearly indicate in his programme of the Works as to when he proposes to start with and conclude the relocation of each service or when he will require the owner to start with and conclude the moving of each service.

102.5 ROAD INTERSECTIONS AND JUNCTIONS

Except where otherwise specified, no additional payment over and above payment for the various items of work included in this Contract will be made for the construction in a confined space of curves, tapers, bellmouths, traffic islands, farm accesses and other appurtenant Works in connection with the construction and maintenance of road intersections and junctions.

102.6 WORKMANSHIP AND QUALITY CONTROL

The onus rests with the Contractor to produce work which conforms in quality and accuracy of detail to all the requirements of the specifications and drawings, and the Contractor shall, at his own expense and before the commencement of any permanent Works, institute and have approved by the Engineer a quality-control system and provide experienced Engineers,

foremen, surveyors, materials technicians, other technicians and other technical staff, together with all transport, instruments and equipment, to ensure adequate supervision and positive control of the Works at all times. If, during the course of the Works, the Engineer shall consider that work is being undertaken that does not conform to the specifications and drawings he may instruct the Contractor to amend the quality-control system in order to ensure that future work does conform. The increased costs associated with such an instruction will remain at the Contractor’s expense.

In accordance with the quality-control system the Contractor shall conduct tests or have them conducted continually on a regular basis, to check the properties of natural materials and processed natural materials and of products manufactured on the site, such as concrete and bituminous mixes. Although not a requirement for the Contractor to conduct regular tests on any commercially produced products such as cement, bitumen, steel and pipes, the Contractor shall remain fully responsible for any defective material or equipment provided by him. Similarly, the quality of all elements of the Works shall be checked on a regular basis so as to ensure compliance with the specified requirements. The results of all tests, quality checks, etc shall be made available to the Engineer within 24 hours of their completion.

The intensity of control and of tests to be conducted by the Contractor in terms of these obligations is not specified but shall be adequate to ensure that proper control is being exercised.

Where any natural materials or products made from natural materials are supplied to the Works the Contractor shall test and check such materials, products and/or elements for compliance with the specified requirements and shall submit his results to the Engineer for approval. Such submission shall include all his measurements and test results and shall furnish adequate proof of compliance with the specified requirements.

No specific pay items are provided as compensation for the above obligations, including the provision of all samples delivered to the Engineer, the repair of places from which samples were taken, and the provision of the necessary personnel and testing apparatus and facilities, for which compensation shall be included in the tendered rates of the Contractor for the various items of work to which these obligations apply.

The contractor shall submit to the Engineer appropriate Manufacturer's Test Certificates for all commercially produced products to be incorporated into the Works. No payment shall be made for products/materials for which test certificates have not been submitted and approved the Engineer.

102.7 SETTING OUT OF WORK AND PROTECTION OF CONTROLS

The Contractor's attention is drawn to the requirements of the Conditions of Contract, and he shall also comply with all legal provisions in regard to surveying and setting out work.

The Contractor shall check the condition of all reference and level controls and shall satisfy himself that they have not been displaced and are true in regard to position and level. If controls have been destroyed, displaced or damaged before the site is handed over to the Contractor, the Engineer will arrange to have new controls installed. A beacon that has been displaced shall not be used unless its true position and level have been re-established and the new values verified by the Engineer.

Where a beacon is likely to be displaced during construction operations, the Contractor shall establish suitable reference controls at locations where they will not be displaced during construction. No beacon shall be covered over, displaced or destroyed before accurate reference

controls have been established and details of the position and levels of such controls have been submitted to and approved by the Engineer. The Contractor's reference controls shall be of at least the same quality and durability as the existing controls.

The Contractor shall establish for the Works, temporary bench marks adjacent to each bridge, retaining wall and culvert site and at intermediate points so that the distance between adjacent temporary bench marks does not exceed 100m. The temporary bench marks shall be located within 15m of each Site and the line and level of each shall be agreed with the Engineer.

All survey control and setting-out points, bench marks and their coordinates and levels shall be expressed in terms of the National Grid and Datum system

The Contractor shall submit to the Engineer the method of setting-out he proposes to employ. To ensure beyond all doubt that the complex elements of the road, such as traffic interchanges, structures and other important features are located truly and correctly, the Contractor shall check all setting-out by a second method. The Engineer may at any time request the Contractor to submit proof that his setting-out has been satisfactorily checked.

The Contractor shall, as soon as practicable, supply the Engineer with records in an approved form relating to all references, stakes and temporary bench marks and shall keep these records up to date by formal notice to the Engineer. All stakes shall be painted in such distinguishing colours as may be agreed with the Engineer.

All survey reference stakes shall be carefully preserved except where construction requires their removal. Before such removal, the approval of the Engineer shall be obtained and adequate alternative measures taken to allow accurate relocation of reference points and re-establishment of survey stakes if necessary.

All computations, survey notes and other records necessary to accomplish the Works shall be neatly compiled and made available to the Engineer on request. On completion of the Contract, all data shall be submitted to the Engineer and shall become the property of the Employer

In cases where the displacement of or damage to property controls or trigonometric-survey controls is unavoidable, the Contractor shall notify the Engineer in good time so that he may arrange to have such controls suitably referenced and later on reinstated.

The Contractor shall give the Engineer not less than 24 hours notice in writing of his intention to set out or give levels for any part of the work in order that arrangements may be made for the data to be checked.

Following the completion of the site clearance and before the commencement of any earthworks, the site shall be surveyed in conjunction with the Engineer's Representative to establish existing ground levels. These agreed ground levels shall form the basis for calculation of quantities of any subsequent excavation, filling, or the formation of bunds.

For preparation of the formation and all subsequent stages of pavement or other construction, lines and levels shall be set out at intervals not exceeding 10m using stakes, stakes or steel pins. These shall be securely fixed and capable of being used to stretch a taut nylon line across the pavement with which to check the compliance with surface level tolerances. The levelling devices shall be immediately replaced whenever they are disturbed and the same devices shall be used for all stages of the pavement construction. The levels of the devices shall be correct to a tolerance of ±3mm.

The setting-out of work will not be measured and paid for directly, and compensation for the work involved in setting-out will be deemed to be covered by the rates tendered and paid for the various items of work included in this Contract.

If the Contractor removes any beacon unknowingly or conducts any work in the vicinity of such controls which results in their displacement without the Contractor having it suitably referenced then the Engineer shall have these controls re-installed at a cost which

would be borne by the Contractor. Refer to Volume 1, Instructions to Tenderers, Clause 35.0 – Site Stakes.

The Right of Way (ROW) is defined on the drawings and the Contractor shall refrain from conducting any activities pertaining to the contract Works outside of the ROW, without written approval from the Engineer. The Contractor shall give the Engineer advanced notification of his intention to conduct Works outside of the ROW so that permission can either be granted or withheld. Failure to comply with this above specification will result in severe actions to be taken against the Contractor depending on the nature of the breach. Refer to Volume 1, Instructions to Tenderers, Clause 33.0 – Schedule of Existing Conditions and Clause 34.0 – Adjoining Property.

102.8 NOTICES, SIGNS AND ADVERTISEMENTS

The Contractor shall not erect any signs, notices or advertisements on or along the Works or the site of the Works without the written approval of the Engineer.

The Contractor shall at each project location provide, erect and maintain at a prominent location approved by the Engineer at both the start and end of the project limits, Project Sign Boards as defined in the Contract. The text for signs shall be as defined in the Contract and shall include the full name of the Contractor, and a contact name and details for the Contractor's 'Liaison Officer'. The Contractor shall submit for the Engineer's approval the design, text, and lettering proposed for the signs. The Project Sign Boards shall be erected not later than one month after the Contractor has been given access to the site.

No signboards other than those specified above will be permitted on or adjacent to the Works, except that the Contractor may permit each of his subcontractors to display one signboard, and one only, of less than 2 m^2 at the Works office.

The Engineer shall have the right to have any sign, notice or advertisement moved to a better position or to have it removed from the site of the Works if it should in any way prove unsatisfactory, inconvenient or dangerous to the general public.

All advertisements, notices and temporary signs shall be removed by the Contractor upon completion of the Works.

102.9 MEASUREMENTS AND QUANTITIES

(a) Units of Measurements

Generally, all work shall be measured in accordance with the SI System of metric units. If however any materials described in the Contract or ordered by the Engineer are described by dimensions in the Metric or Imperial measure, and the Contractor cannot in accordance with the Contract procure such materials in the measure specified in sufficient time to avoid delay in the performance of his other obligations under the Contract, but can obtain such materials in the other measure to dimensions equivalent to those described in the Contract or ordered by the Engineer, then the Contractor shall forthwith give notice to the Engineer of these facts stating the dimensions to which such materials are procurable in the other measure. The foregoing is subject to the Contractor providing evidence

that he attempted to procure, at the earliest possible time, the item in the specified measurement units and had taken satisfactory alternative steps to procure said item.

As soon as practicable after the receipt of any such notice under the preceding Sub-Clause the Engineer shall give an order to the Contractor pursuant to Clause 13 of the Conditions of Contract, which shall either:

(i) direct the Contractor to supply such materials to the dimensions stated in his said notice to be procurable instead of to the dimensions described in the Contract or originally ordered by the Engineer: or

(ii) direct the Contractor to make some other variation whereby the need to supply such materials to the dimensions described in the Contract or originally ordered by the Engineer will be avoided.

The provisions of this Clause shall apply to variations ordered pursuant to this Clause and Clause 13, as they do to variations ordered pursuant to Clause 13 alone.

The provisions of this Clause shall apply irrespective of whether the materials in question are to be supplied, in accordance with the Contract, directly by the Contractor or indirectly by a nominated Sub-Contractor or nominated supplier.

(b) Schedule of quantities

The quantities set out in the schedule of quantities are estimated quantities and are used for the comparison of tenders and for awarding the Contract. It must be clearly understood that only the actual quantities of work done or materials supplied will be measured for payment, and that the scheduled quantities may be increased or decreased as provided in the General Conditions of Contract.

(c) Measurement of completed work

(i) All distances along the centre line of the road as shown on the drawings are horizontal distances, which will be used in calculating the quantities of fill and pavement layers for purposes of payment. All cross-sections shall be taken in a vertical plane.

(ii) All materials, which are specified to be measured in a vehicle, shall be hauled in vehicles of such type and size that the actual volume may be readily and accurately determined. Unless all vehicles are of uniform capacity, each vehicle shall bear a plainly legible identification mark indicating its specific approved capacity.

(iii) The quantity of bituminous and similar materials to be paid by volume shall be measured at the specified temperature.

(iv) Structures shall be measured to the neat lines shown on the drawings and shall include any changes ordered in writing by the Engineer and, for purposes of payment, the calculated volume of concrete structures no

deduction shall be made for the volume of the reinforcing steel or strands, or for individual minor openings (e.g. weep holes) of less than $0.02m^2$ passing through the thickness of the structure.

102.10 CONTRACT RATES AND PAYMENT

(a) Contract Rates

In computing the final Contract amount, payment shall be based on the actual quantity of authorized work done in accordance with the specifications and drawings. The tendered rates shall apply, subject to the provisions of the General Conditions of Contract, irrespective of whether the actual quantities are more or less than the scheduled quantities.

Where no rate or price has been entered against a pay item in the schedule of quantities by a tenderer, it shall be understood that he does not require any compensation for such work. Where, however, a pay item described in these specifications or in the project specifications does not appear in the schedule of quantities, the Contractor will receive reasonable compensation for such work if required, unless anything to the contrary has been determined elsewhere.

(b) Rates to be inclusive

The Contractor shall accept the payment provided in the Contract and represented by the rates tendered by him in the schedule of quantities, as payment in full for executing and completing the work as specified, for procuring, furnishing, placing and installing all materials, for procuring and providing labour, supervision, constructional plant, tools and equipment, for wastage, transport, loading and off-loading, handling, double handling, maintenance, temporary work, protection of the Works from loss or damage, testing, quality control including process control, overheads, profit, risk and other obligations and for all other incidentals necessary for the completion of the work and maintenance during the period of maintenance.

The Contractor shall note that the cost of all Works and materials for minor construction details at bridges, for example small quantities of caulking compound and joint filler (other than expansion joints), anchor-bar covers, etc, not shown in the schedule of quantities, shall be included in the tendered rates for concrete.

This clause shall apply in full to all pay items except where these requirements may be specifically amended in each case.

(c) The meanings of certain phrases in payment clauses

(i) Procuring and furnishing . . . (material)
Where any of the words “supply”, “procure”, “provide”, “provision of' or “furnish (material)” are used in the description of a pay item, it shall mean the supply and delivery to the point of use of all materials of any kind required for the work covered by the particular pay item, including all tax, purchase costs, claims, damages, royalties and transport costs involved, but excluding overhaul. In the case of borrow materials, stone and sand and the like it shall also include all negotiations with the owners concerned, royalties,

excavating, producing, preparing, processing, testing, hauling and delivering the material to the point of use; the construction, repair, maintenance and making good after completion of all access roads, and all work required in opening, using and finishing off borrow pits unless covered by other pay items in the schedule of quantities.

(ii) Placing material
The phrase "placing material" shall mean the off-loading, spreading, blending, processing, watering, mixing, shaping and compacting (where specified) of the material in the Works, as well as the procuring, furnishing, applying and admixing of water; the breaking-down of oversize material, the removing of oversize material which cannot be broken down, correcting irregular or uneven surfaces or layers, the thickness of which is not to specification, finishing-off to within the specified tolerances, the refilling of test holes and maintaining the completed work. In the case of asphalt courses and bituminous seals, it shall also mean the heating and spraying of binder, the spreading of aggregate or asphalt mixtures, rolling, compacting, finishing-off to within the specified tolerances, and maintaining the completed work.

The phrase "procuring, furnishing and placing" shall mean procuring and furnishing in addition to placing, all as defined herein.

(d) Pay items

The descriptions under the pay items in the various sections of the specifications, indicating the work for which allowance shall be made in the tendered rates for such pay items, are for the guidance of the Contractor and do not necessarily repeat all the details of work and materials required by and described in the specifications.

These descriptions shall be read in conjunction with the relevant specifications and drawings, and the Contractor shall, when tendering, bear in mind that his rates shall be inclusive as specified in subclause (b) above.

102.11 WATER FOR CONSTRUCTION

The Contractor himself shall make arrangements for procuring, transporting, storing, distributing and applying the water needed for construction and other purposes, except where otherwise specified. No direct payment will be made for providing water, the cost of which shall be included in the rates tendered for the various items of work for which water is needed.

Only clean water, free from undesirable concentrations of deleterious salts and other deleterious materials, shall be used. All water sources used shall be subject to the Engineer's approval.

102.12 DRAWINGS PROVIDED BY THE CONTRACTOR

Where the Contractor is required to prepare any drawings for the purpose of this Contract, they shall be prepared and submitted to the Engineer for his adjudication in the form of five hard (paper) copies and a copy contained on a compact disc (CD). The

standard of detailing and quality of print shall be the same as those of the Drawings supplied to the Contractor under the Contract. The drawings shall be compiled in the English language and shall comply in all respects with the requirements of the Employer.

Accepted drawings shall form an integral part of the Contract documents, and any drawing not accepted and signed will not be authorised for construction purposes and/or used for the manufacture of any item. Notwithstanding the approval and/or acceptance and signing of the drawings, the Contractor shall take full responsibility for all details, discrepancies, omissions, errors, etc, in respect of the said drawings as well as for the consequences thereof.
The Contractor shall submit only fully completed drawings in accordance with this Specification and shall not be entitled to claim for delays resulting from the submission of incomplete drawings. The Engineer will require a period of four to eight weeks, depending on circumstances, for reviewing the complete drawing(s).

No direct payment for design, preparation and submission of drawings will be made and all costs shall be included in the rates tendered for the relevant pay items as provided in the schedule of quantities. The cost of reviewing the design/drawings shall be for the Contractor's account.

102.13 USE OF EXPLOSIVES

Generally, the Contractor will be permitted to use explosives for breaking up rock and hard material during excavation, for demolishing existing structures, and for such other purposes for which it may normally be required, subject to the following conditions:

(a) The Engineer will have the right to prohibit the use of explosives in cases where, in his opinion, the risk of injury to persons or damage to property or adjoining structures is too high. Such action by the Engineer shall not entitle the Contractor to any additional payment for having to resort to other less economical methods of construction unless otherwise provided in the project specifications or the schedule of quantities.

(b) The Contractor shall take proper care when excavating cuts not to loosen, where it can be avoided, any material outside the specified cut line, whether by ripping, blasting or by other means, which would endanger the stability of the slopes or which would subsequently cause undue erosion or disintegration of the batters.

(c) Legal provisions in regard to the use of explosives and the requirements of the Inspector of Explosives shall be strictly complied with.

(d) The Contractor shall, at his own cost, make arrangements for supplying, transporting, storing and using explosives.

(e) Before any blasting is undertaken, the Contractor, together with the Engineer, shall examine and measure up any buildings, houses or structures in the vicinity of the proposed blasting and establish and record, together with the owner thereof, the extent of any cracks or damage that may exist before blasting operations are commenced. It shall be the responsibility of the Contractor to make good, at his own expense, any further damage to such houses, buildings or structures which is a result of the blasting operations.

(f) Where there is considerable danger of damage to power or telephone lines or underground or other services or any other property, the Contractor shall suitably adapt his method of blasting and the size of the charges, and shall take adequate protective measures, such as cover blasting, in order to limit the risk of damage as far as possible.

(g) The Engineer shall, twenty-four hours before each blasting operation is carried out, be advised thereof, in writing, unless otherwise agreed on with the Engineer.

102.14 SITE PROGRESS MEETINGS

The Contractor or his authorized representative shall attend regular meetings on the Site with representatives of the Employer and the Engineer, at dates and times to be determined by the Employer. Such meetings will be held for evaluating the progress of the Contract and for discussing matters pertaining to the Contract which any of the parties represented may wish to raise. Such meetings are not intended for discussing matters concerning the normal day-to-day running of the Contract.

102.15 LEGAL PROVISIONS

The Contractor shall keep himself fully conversant with the latest enactments, provisions and regulations of all legislative and statutory bodies, and, in all respects and at all times, shall comply with such enactments, provisions and regulations in regard to executing the Contract.

102.16 SEWERS, DRAINAGE AND RIVER CHANNELS

Drains and sewer connections that are to remain in service and are connected to existing pipelines that are to be abandoned or removed shall remain in service until connected to new or existing pipelines. Where the work intercepts or affects existing drains or sewers, whether shown on the Drawings or not, the Contractor shall arrange to keep such drains or sewers in proper working order at his own expense until new connections are made by others.

The Contractor's attention is directed to the fact that he may be required to make alteration to existing drainage channels. Prior consultation shall be made with the Ministry of Works and Transport – Drainage Division and approval shall be obtained from the Engineer in advance of the start of the operations for the Contractor's proposals for any alterations to drainage systems and temporary drainage structures and the placement of falsework in a drainage or river channel.

Temporary drainage facilities may be required and the Contractor shall in no way interfere with normal adequate drainage systems. It will be the responsibility of the Contractor to provide adequate temporary drainage throughout this Contract until such time as new drainage facilities are completed. All proposed drainage diversions must be submitted to the Engineer for his approval.

102.17 ADVERSE WEATHER

Adverse weather shall be deemed to have occurred if, during any given month, the total monthly rainfall measured at an agreed point(s) within the project or individual sites

making up the project should exceed the five year monthly average rainfall estimated for the area of the project or an individual site. The period for determining the five year monthly average rainfall shall be the five years preceding the year in which the Contractor's claim is being made. The estimation will be made by the Government's Meteorological Department, at the Contractor's cost to justify any claim for an extension of the Time for Completion. Weather will only be considered to be adverse, on a daily basis, if the foregoing has been substantiated and rainfall in excess of the average has been recorded during that day during the same month, and the day was an approved working day under the Contract.

The Contractor is reminded that the impact of the average five year monthly rainfall or such other rainfall as the Contractor may consider appropriate should already have been accommodated in his programme of Works and as such the Engineer may assume an appropriate number of days lost to inclement weather have already been allowed for in the Contractor's time programme. Should the rainfall in any month be below average, the Engineer may consider this benefit in assessing the impact of inclement weather on the Contractor's programme.

The Contractor shall be responsible for the provision of recording stations at each Site and for recording the rainfall in conjunction with the Engineer. In submitting justification for proof of excess rainfall the Contractor shall provide records from the nearest Government recording station to confirm the order of accuracy of the site measurements.

SERIES 100: GENERAL

SECTION 103: HEALTH AND SAFETY

103.1 HEALTH AND SAFETY STANDARDS

The standards and guidelines regarding Health and Safety (H&S) to be adopted by the Contractor shall be in accordance with the following:

i) The Occupational Safety and Health Act 2004 and The Occupational Safety and Health (Amendment) Act 2006.
ii) The Public Health Ordinance, Ch. 12 No. 4.

These requirements shall be supplemented by the guidelines outlined in the U.S. Army Corps of Engineers manual, "General Safety Requirements", E.M. 385-1-1 and NIDCO's Contractor Code of Practice. A copy of NIDCO's Code of Practice is included as an Appendix in Volume III.

A copy of the Occupational Safety and Health Act, Public Health Ordinance and the U.S. Army Corps of Engineers manual shall be held at the Contractor's Site offices and shall be made available for inspection on request to any member of the workforce.

103.2 HEALTH AND SAFETY PLAN AND MONTHLY HEALTH AND SAFETY REPORTS

The Contractor's Method Statements shall include a Health and Safety Plan, which sets out, to the satisfaction of the Engineer, the general and specific measures and procedures which are to be adopted to ensure the health and safety of the workforce and of the general public in the vicinity of the Site, during construction of temporary and permanent Works. The Health and Safety Plan shall also set out the emergency procedures to be adopted in the event of unforeseen events occurring which present a hazard to the workforce or to the general public. All activities shall be undertaken in accordance with the approved Plan. The Contractor is required to submit a bi-weekly Health and Safety Report to the Engineer, which is to document all H&S provisions being implemented during the period, such that he can be fully satisfied that the provisions set out are being adhered to and justifies payment. The format of the Health and Safety Report shall be discussed with and approved by the Engineer prior to the first submission.

The Contractor shall be required to make the following submittals prior to mobilising to the Site, as well as during the execution of the Works where the certificates previously submitted have expired and new certificates obtained:

1. Valid fit for purpose inspection certificates for all construction equipment and power tools from an independent and qualified inspection/testing agency.

2. Valid licences and/or training certificates for equipment operators being used on Site.

103.3 APPOINTMENT OF HEALTH AND SAFETY OFFICER

The task of ensuring that all workforce health and safety matters are properly and fully addressed shall be the responsibility of a senior member of the Contractor's Site staff, designated by the Contractor as the Health and Safety Officer. A deputy shall also be designated by the Contractor to act during temporary absences of the Health and Safety Officer from the Site. No work shall be carried out in the absence of the Health and Safety

Officer from the Site.

The Contractor shall notify the Engineer of the names of the Health and Safety Officer and his deputy, together with the method whereby they can be contacted at any time during normal working hours. This information shall also be prominently displayed in the Contractor's Site offices in a location where it can be seen easily by the workforce. In the event that, in the opinion of the Engineer, the Health and Safety Officer or his deputy is failing to address health and safety issues adequately, the Engineer shall require his immediate replacement.

The assigned responsibilities of the Health and Safety Officer shall cover all aspects of workforce health and safety. They shall include, but not be limited to, instruction of the workforce in the measures and procedures which are to be adopted in relation to health and safety matters, safe working practices and Site monitoring to ensure that such measures and procedures are being adopted and are effective, and the preparation of health and safety action plans to accompany the Contractor's method statements.

The Contractor shall provide documentation showing the qualifications of the designated Health and Safety Officer for the approval of the Engineer. The minimum qualifications of a General Certificate in Occupational Health and Safety (NEBOSH or equivalent) will be required, as well as at least five (5) years' experience in a similar position.

103.4 PROTECTIVE CLOTHING AND SAFETY EQUIPMENT

All members of the workforce and Contractor's supervisory staff shall be issued with protective clothing and other safety equipment (PPE) appropriate to the tasks being undertaken or supervised, as set out in the Health and Safety Standards, at no cost to themselves. It shall be a condition of employment that the appropriate clothing and equipment be worn and/or used as indicated in relation to specific activities set out in the Standards or face instant dismissal. All workers shall be provided with overalls, eye protection, gloves, hard-toe cap safety boots and safety helmets of patterns approved by the Engineer, and these shall be replaced by the Contractor when they become worn-out or damaged.

Fluorescent jackets of a type approved by the Engineer shall be worn by all workers and supervisory staff deployed on or adjacent to public roads, and at such other locations as may be decided by the Engineer.

Safety belts/harnesses and lifelines shall be used when other safe guards such as guardrails, planking and scaffolding cannot be provided. Safety lines shall be independent of any other rigging. The lanyard shall be secured to a structural member with the capability to sustain the forces imposed in the event of a fall. Any fall protection device that is "shock loaded" or otherwise damaged shall be removed from service and destroyed immediately.

Hearing protection is mandatory for decibel levels higher than 85 decibels. For decibel levels higher than 120, full ear muffs are mandatory.

Appropriate respiratory protective equipment shall be required when health hazards exist due to the presence of hazardous substances in the air.

Modification or alteration of any piece of personal protective equipment shall be strictly prohibited. Defective or damaged personal protective equipment shall be immediately replaced or repaired.

103.5 FIRST AID KITS TO BE AVAILABLE

First aid kits, of a type equivalent to that specified in the Health and Safety Standards, or as approved by the Engineer, shall be provided by the Contractor at each worksite and in the Contractor's offices. Any consumable items which have been used shall be replaced without undue delay. The Health and Safety Officer or his Deputy shall be responsible for making weekly checks to ensure that the kits are complete. The location of first aid kits at each workplace shall be made known to all members of the workforce. The kits shall be freely accessible and shall not be kept locked or in locked storage during working hours.

Minimum requirements of the First Aid Kit should be as follows:

No.	Item
10	Antiseptic Towelettes
50	Band-Aid strips
10	4"x4" Sterile Gauze pads
3	4" Compress with ties
3	6" Compress with ties
1	ABD pad
2	3" Roller gauze bandage
4	Triangular bandages
8	Safety pins
1	First aid scissors
1	Splinter forceps (tweezers)
1	1" Hospital tape
2	3" Tensor bandage
1	CPR barrier device w/one-way valve
6	Pr. Disposable gloves
1	First aid pocket guide
1	Waterproof waste bag
5	Campus accident reports
1	Kit inventory list

103.6 STAFF TO BE TRAINED AS FIRST-AIDERS

One person who has been trained in basic first aid/CPR and holds a currently valid first aid certificate issued by an organisation approved by the Engineer, shall be present at each work location and at the Contractor's Site offices or, in cases where a number of separate work locations are close together, at each group of locations, during all construction operations. In the event that one first-aider is to be responsible for a group of locations, the Engineer will determine the number of locations which constitute a group for first aid purposes.
First aid certificates shall be those issued by the St John's Ambulance Brigade or Emergency Medical Planning International, or equivalent as determined by the Engineer. The Engineer shall be provided by the Contractor with a list of names of first-aiders and copies of their certificates. The Contractor's Health and Safety Officer shall ensure that

the workforce at each worksite is made aware of the name of the person responsible for first aid at that worksite, and the means whereby they can be called in the event of an accident occurring.

103.7 REPORTING OF ACCIDENTS AND NEAR MISSES

The Contractor shall provide, within 24 hours of the occurrence of any accident or near miss at or about the Site or in connection with the execution of the accident, a report to the Engineer. The Contractor shall also report such accident to the competent authority whenever such report is required by law.

The Contractor's Health and Safety Officer shall institute procedures for the reporting of minor and major accidents and shall keep a record of such events in an Accident Register of a form acceptable to the Engineer. The Accident Register shall be available at all times during normal working hours for inspection by the Engineer.

103.8 EMERGENCY EVACUATION PLANS

The Contractor's Health and Safety Officer shall draw up plans, to the satisfaction of the Engineer, for the emergency evacuation to hospital of any seriously injured member of the workforce. The plan shall not rely on the provision of transport by EHS but shall make provision for transport using the Contractor's own resources. Each person responsible for first aid shall be advised in writing of the procedure to be adopted to call for emergency evacuation.

The Contractor shall provide such equipment and facilities as are necessary or required, in case of accidents, for first aid service to any, who may be injured in the progress of the Work; and he shall have standard arrangements with local hospitals for the removal and hospital treatment of any employee who may be injured or who may become ill. Details of the equipment, facilities and hospital arrangements shall be submitted to the Engineer for approval.

103.9 CONTRACTOR'S SITE OFFICE

The Contractor shall provide appropriate sanitary/ablution facilities for the use of base-camp personnel, with separate facilities for males and females. The numbers of male and female toilets and male and female wash basins shall be appropriate to the peak numbers of staff of each sex working at the base camp. The toilet facilities shall be provided at all times with adequate supplies of toilet paper.

Wash basins shall be provided at all times with adequate supplies of water, soap and paper towels. The toilets/ablution facilities shall be maintained in a clean and hygienic condition at all times to the satisfaction of the Engineer. The arrangements for toilet/ablution facilities shall be approved by the Engineer, prior to commencement of base camp establishment.

Toilets shall be of the flush WC type and shall be located in a ventilated weatherproof enclosure. An adequate water supply for flushing shall be available at all times. In the event that connection to a municipal sewer is not feasible and, in the opinion of the Engineer, the soil conditions are suitable, all wastewater arising from toilets, ablution and other Site office facilities shall be discharged to a septic tank connected to a soakaway. In

the event that soil conditions are unsuitable for soakaways to be effective, wastewater discharges shall be to a cess pit, which shall be pumped out as and when necessary. Rainwater shall be prevented from entering septic tanks or cesspits.

Enclosed change rooms must be kept in a clean and orderly manner at all times, with separate changing facilities for males and females.

The Contractor's Site office and compound for the project shall have proper fencing, lighting and adequate number of security guards to ensure the safety of all personnel and equipment on the Site.

103.10 CONTRACTOR'S SITE SANITARY FACILITIES

The use of pit latrines as Site toilets is specifically prohibited. Site toilets shall be of the portable chemical type in a ventilated weatherproof housing, and shall be emptied at least twice per week, well before they become full, by a contractor who is duly authorised and licensed to carry out this activity. Separate facilities shall be provided for male and female site workers.

The numbers of toilets at each worksite shall be in a ratio of not less than one toilet for every 10 workers, with the proviso that there shall be at least one toilet reserved for female use, if any female workers are present at the worksite.

The toilets shall have adequate supplies of toilet paper available at all times. Hand washing facilities including soap, and paper towels shall be provided adjacent to each toilet and an adequate supply of water shall be available at all times. Toilet and hand washing facilities shall be maintained in clean, tidy and hygienic condition at all times, to the satisfaction of the Engineer.

103.11 GENERAL SAFE PRACTICES

i. Jewelry and long hair

The wearing of jewelry (neck chains, bracelets or rings) on the job is not permitted. Long hair should be tied back or covered to avoid any injury

ii. Misconduct

Fighting, gambling, horseplay or other misconduct shall not be permitted.

iii. Operation and repair of machinery, equipment and tools

Only authorised experienced personnel shall operate/repair power driven machinery, plant equipment and tools. Vehicle drivers must possess a valid vehicle driving licence for the type of vehicle they are operating.
All machinery guards and other protective devices must be kept in place and must be used while operating the machinery.

Machinery, equipment and tools must not be cleaned while they are in motion.

iv. Hazardous Energy

Whenever the use of equipment utilising hazardous energy, e.g., nuclear density gauges, the Contractor shall ensure that the personnel are trained and qualified in safe handling, operation and storing of such equipment and that all operations are carried out in accordance with the manufacturer's specifications.

103.12 DRUG AND ALCOHOL ABUSE

Drug and alcohol abuse represents a threat to a safe working environment for all employees. The use of drugs and alcohol shall be prohibited on the job Site. Any employee found in possession of drugs or suspected of being under the influence of narcotics, drugs or drunkenness shall be removed from the Site. Drugs for the purpose of this Specification Section include all illegal and/or narcotics restricted by law as to their possession or use, along with synthetic or "designer" drugs that have not been so regulated yet are capable of affecting employee safety or work performance. Drugs also include prescription drugs used in an abusive or intoxicating manner.

The Employer reserves the right to subject Site staff to drug testing if the employee is suspected of being under the influence of drugs.

103.13 SCAFFOLDING

i. Scaffolds or work platforms shall not be altered once they are erected and properly tagged. All scaffolding shall be inspected and approved by a competent person.

ii. All scaffold members shall be visually inspected before each use. Damaged scaffold members shall be removed from service or repaired immediately.

iii. Access ladders shall be provided for each scaffold. Climbing the end frames is prohibited unless their design incorporates an approved ladder.

iv. Adequate mud sills or other rigid footing, capable of supporting the maximum intended load, shall be provided.

v. Scaffolds shall be secured to the building or structure at intervals not to exceed 9m horizontally and 8m vertically.

vi. Scaffolds shall not be overloaded. Materials should be brought up as needed. Excess materials and scrap shall be removed from the scaffold immediately.

vii. Barrels, boxes, kegs and similar unstable objects shall not be used as work platforms or to support scaffolds.

viii. Where persons are required to work under a scaffold, a screen of 18 gauge, ½ inch wire mesh or equivalent protection shall be required between the toe board and the guardrail.

ix. Overhead protection shall be required if employees working on scaffolds are exposed to overhead hazards.

Two-Point Suspended Scaffolds (Swinging Stages)

x. Each employee working from a two-point suspended scaffold must wear a safety belt and be tied off to an independent lifeline. Multi-stage scaffolds require additional safety suspension, lines and fall protection devices. Ropes shall be protected from burning or welding operations.

xi. Suspended scaffolds shall not be less than 508mm nor more than 914mm wide.

xii. Wire ropes used to suspend scaffolds must have a safety factor of six times the maximum intended load.

xiii. When there is a chance of contact with an electrical source, non-conductive insulating material shall be placed over scaffold suspension cables.

103.14 EXCAVATIONS AND TRENCHES

All excavating and trenching operations shall conform to established Statutory Standards.

i. Trenches 1.5m or deeper shall be shored, stepped or sloped back to a safe angle of repose. Any excavation in unstable soil may require shoring or additional sloping.

ii. Materials shall not be placed within 0.6m of the excavation limit. Precautions must be taken to prevent such materials from falling into the excavation.

iii. Each excavation shall be inspected daily and after each rain by a competent person. If evidence of cave-ins or slides is apparent, all work in the excavation must cease until necessary precautions have been taken to safeguard employees.

iv. Where vehicles or equipment operate near excavations or trenches, the sides of the excavation must be shored or braced as necessary to withstand the force exerted by the superimposed load. Also, stop logs or other substantial barricades must be installed at the edges of such excavations.

v. Materials used for sheeting, shoring, or bracing shall be in good condition. Timbers must be sound, free of large or loose knots, and be of adequate dimensions.

vi. Safe access shall be provided into all excavations by means of ladders, stairs, or ramps.

vii. Trenches 1.2m or more in depth must have ladders spaced so that employees' lateral travel does not exceed 7.6m. Such ladders shall extend at least 0.9m above grade level. Ladders shall not be constructed from timber.

viii. Walkways, bridges or ramps with standard guardrails shall be provided where employees or equipment are permitted or required to cross over excavations or trenches.

103.15 CRANES, HOISTS, MOTOR VEHICLES, ELEVATORS AND HEAVY EQUIPMENT

The Contractor shall provide to the Engineer, prior to mobilisation to the Site, valid fit for purpose inspection certificates for all cranes, hoists, lifting slings, lifting shackles, motor vehicles, elevators, crane suspended personnel platforms, and the like, from an independent and qualified inspection/testing agency and/or statutory/regulatory agency. The Contractor shall also provide to the Engineer valid licences and/or training certificates for equipment operators being used on Site.

General

i. All cranes, hoists, motor vehicles, elevators and heavy equipment shall be operated and maintained to conform to established standards.

ii. All cranes, hoists motor vehicles, elevators and heavy equipment shall be inspected prior to use on each shift. Operators of such equipment must keep inspection records required.

iii. Rated load capacity charts, recommended operating speeds, special hazard warnings, and other essential information shall be conspicuously posted in all cranes, hoists and other equipment.

iv. Operators must take signals from only one person. In an emergency, however, a STOP signal can be given by anyone.

v. Only standard hand signals will be acknowledged.

vi. Routine maintenance, fuelling or repairs shall not be performed while the equipment is in use or the power is on.

vii. When handling, recharging, or using jumper cables on batteries, wear safety glasses and a face shield.

viii. Employees are prohibited from riding the hook or load.

ix. **Cranes**

- The swing radius of all cranes shall be barricaded to prevent employees from being struck by the counterweight.
- A fire extinguisher, rated at least 5 BC, shall be located in the cab of each crane.

- Safety latches are required on all crane and spreader cable hooks (with the exception of shake out hooks that are used for their intended purpose).

- Cranes or other equipment shall NOT be operated within 3m of energised electrical transmission or distribution lines. For lines rated over 50kV, the minimum clearance between the lines and any part of the crane load line or load must be 3m plus 10mm for each 1kV over 50kV, or twice the length of the line insulator, but never less than 3m.

- During transit with no load and the boom lowered, the minimum equipment clearance is 1.2m for 50kV or less, 3m for 50kV to 345kV and 4.5m for voltages up to 750kV.

- A designated employee must observe clearance of the equipment and give timely warning for all operations where the operator's vision is obstructed.

- Any overhead line shall be considered energised unless the Employer and utility company representative are present and ensure that it is not.

- Loads shall be guided and prevented from swinging by attaching a tag line to the load.

- Loads shall not be suspended on an unattached crane.

x. **Motor Vehicles and Heavy Equipment**

- For employee safety, seat belts should be used if available in vehicles and equipment.

- Riding in the bed of a truck containing any unsecured materials shall be prohibited.

- Employees shall be prohibited from riding on loads, fenders, running boards, and tailgates. Sit on vehicle manufacturer provided seats.

- Drivers shall not move vehicles until riders comply with all safety procedures.

- Vehicles or equipment shall not be backed up when the view to the rear is obstructed, unless:

  - The vehicle is equipped with an operating backup alarm which is audible above the surrounding noise for a distance of 60m, and when clearance from obstructions to the rear is assured.

  - An observer signals that it is safe to back up.

- Vehicles and equipment shall not be operated if unsafe.

- Unattended vehicles and equipment shall not be left running.

- Key shall be left in vehicles so that they can be moved in an emergency.

xi. **Material Hoists**

1. Erection and operation of material hoists shall conform to established standards.

2. A sign stating "No Riders Allowed" shall be posted on the car frame and at each landing. Workers are prohibited from riding material hoists except for authorised purposes (inspection and maintenance).

xii. **Crane Suspended Personnel Platforms**

1. Crane suspended personnel platforms shall not be used to transport personnel if other feasible means of access exist. The need for such use and the appropriate safe practices shall be reviewed by the Contractor's Health and Safety Department and the Engineer. All cranes used to hoist crane suspended personnel platforms shall be operated and maintained in accordance with ANSI B30.5 (current edition) and manufacturer's specifications.

2. Crane suspended personnel platforms shall be visually inspected, and a trial lift conducted by a competent person prior to each use.

3. Crane suspended personnel platforms shall be rigged with a four-point suspension capable of supporting five times the maximum intended load. An independent safety choker must be secured from the personnel platform to a point above the headache ball or load block.

4. An effective method of signaling personnel platforms must be established prior to use and maintained at all times when lifting the crane suspended personnel platform.

5. Employees in crane suspended personnel platforms shall wear a safety belt which must be secured to the platform itself.

6. Adequate means shall be provided to secure the crane suspended personnel platform at the work level.

7. Overhead protection must be provided when there is a possibility of materials falling from above.

8. Employees must not pass under the crane suspended personnel platform while it is suspended.

9. All employees must comply with the project Crane Suspended Personnel Platform Procedure.

103.16 TRANSPORT SAFETY

The Contractor shall at all times ensure that all safety measures are in place during the transportation of plant, equipment and materials to and from the Site.

i. Arrangements shall be made, when necessary, with the Traffic Branch of the Police Service for traffic control along busy routes so as to help reduce the problems associated with traffic congestion, especially during the morning and afternoon rush hours.

ii. Warning signs must be posted to indicate the high-risk areas where large vehicles will be in operation.

iii. It must be ensured that all trucks and other vehicles accessing the Site adhere to the traffic laws and roads codes.

iv. Materials being transported by vehicles to the Site must be covered whilst en route.

v. The wheels of all delivery and other vehicles must be washed before they leave the Site.

103.17 OUTBREAKS AND EPIDEMICS

The Contractor shall include in their Health and Safety Plan any guidelines and protocols for outbreaks and epidemics from Ministry of Works and Transport Environmental Health and Safety division, the Ministry of Health and any other Government Ministry.

103.18 NON CONFORMANCE

The Engineer is authorised to suspend any activity which in his opinion is deemed to be in violation of any safety clause as laid out in the Occupational Safety and Health Act 2004 and the Occupational Safety and Health (Amendment) Act 2006, or The Public Health Ordinance, Ch. 12 No. 4, or the U.S. Army Corps of Engineers manual, "General Safety Requirements", E.M. 385-1-1, or NIDCO's Contractor Code of Practice and/or is carried out in an unsafe manner or not in accordance with the Specifications outlined herein.

Any consequential delay to execution of the Works arising from being ordered to suspend or halt the activity concerned, or in rectifying the breaches, shall not be considered due cause for a claim by the Contractor.

103.19 MEASUREMENT AND PAYMENT

Pay Item No.	Description	Unit
103.1	**Compliance with the requirements of Section 103: Health and Safety**	**month**

The tendered rate per month shall include full compensation for full and thorough compliance with the requirements and provisions of Section 103 for one month and to the satisfaction of the Engineer.

However, where the Engineer is not satisfied that the Contractor has adhered to the guidelines set in this section he reserves the right to suspend all Works until the breaches have been rectified and until such time payment of this item will be withheld.

Where the Engineer feels that it is not justified in withholding the entire amount and full compliance is not being met, adjustments to the amount that is to be paid will be made at the discretion of the Engineer.

Payment of this item would be for the Contract Time for Completion, which would also be inclusive of any award of time extension to the duration of the Contract.

Upon expiry of the Contract Time for Completion, the Contractor shall be expected to fully comply with all provisions in this section at his own cost.

Where the Engineer finds that the Contractor is not performing up to standards required, payment of this item will be withheld.

SERIES 100: GENERAL

SECTION 104: GENERAL ENVIRONMENTAL REQUIREMENTS

104.1 Definition of the Site

104.2 Acts Prejudicial to the Environment

104.3 Contractor to Appoint Public Liaison Officer

104.4 Haulage of Equipment and Construction Materials

104.5 Naturally-Occurring Construction Materials

104.6 Hot Mix Plant Operation

104.7 Dust, Noise and Other Nuisances

104.8 Land and Water Pollution

104.9 Wastes and Waste Disposal

104.10 Private Land Permit

104.11 Siltation and Erosion Control

104.12 Site Clearance

104.13 Abstraction of Water from Natural Sources

104.14 Protection from Asphalt, Fuels, Lubricants etc.

104.15 Air Emissions / Air Quality

104.16 Environmental Management Plan and Submission of Monthly Reports

104.17 Protection of Historical / Cultural and/or Archaeological Finds

104.18 Fire Precaution

104.19 Non-Conformance

104.1 DEFINITION OF THE SITE

The term "Site" shall, for the purposes of these Environmental Requirements, be deemed to include all places where the Contractor carries out construction-related activities including but not limited to Site base camps, material and equipment storage areas, temporary access areas, areas occupied by temporary Works, and quarries and borrow pits opened by the Contractor to supply materials for use in the Works.

104.2 ACTS PREJUDICIAL TO THE ENVIRONMENT

The Engineer shall have the authority to order an immediate suspension of and/or halt to any activity on the part of the Contractor, which, in his opinion, is causing, or is likely to cause, significant environmental damage. The Contractor shall, without undue delay and at his own expense, carry out remediation in accordance with the instructions of the Engineer.

Any consequential delay to execution of the Works arising from being ordered to suspend or halt the activity concerned, or in carrying out the remediation, shall not be considered due cause for a claim by the Contractor. The Engineer shall require the summary and permanent dismissal from the Site of any member of the Contractor's workforce who, in his opinion, is committing, or has committed, acts prejudicial to the environment or any of its components, either on Site or in vicinity of the Site. Such acts shall include, but not be limited to the unsanctioned felling of trees, the theft of or interference with agricultural crops, the theft of or interference with the property of other persons, offensive or threatening behaviour towards other persons, the trapping or killing of wildlife (other than vermin) and the collection of plants.

104.3 CONTRACTOR TO APPOINT PUBLIC LIAISON OFFICER

The Contractor shall designate one of his senior Site staff as Public Liaison Officer, who shall have responsibility for dealing with complaints from the general public concerning any aspects of the Site activities. The Engineer shall be advised of the name of the person so designated, together with details of how he can be contacted during normal working hours, and his usual work location.

The Public Liaison Officer's contact details shall be displayed on all project signboards. The Public Liaison Officer shall develop effective procedures for recording public complaints and ensuring that these are dealt with appropriately without undue delay. He shall maintain an up-to-date Register of Public Complaints, which is available during normal working hours for inspection by the Engineer. The Register shall be of a form acceptable to the Engineer and shall record such details as the Engineer may require. These shall include, but not be limited to, the name and address of the complainant, the nature of the complaint, the action which has been taken to address the complaint and the name of the person responsible for implementing the action. In the event of no action being considered necessary by the Public Liaison Officer, the Register shall contain a record setting out the reasons for no action being taken. The Public Liaison Officer shall monitor implementation of actions taken in relation to complaints and shall sign the Register accordingly when he is satisfied that the requisite action has been completed.

104.4 HAULAGE OF EQUIPMENT AND CONSTRUCTION MATERIALS

All vehicles used by the Contractor for haulage of equipment and materials on public roads shall be of a type and capacity suitable for the duty they are employed on. They shall be duly licensed, in a roadworthy condition, and shall have a valid inspection certificate and inspection sticker affixed to the vehicle's front windscreen from the Licensing Division of the Ministry of Works and Transport.

All loads shall be properly secured. No load shall be carried that results in an axle loading or MGW (maximum gross weight) that is greater than the limit imposed by law. The tailgates and drop sides of vehicles used to haul loose materials shall be properly secured at all times when travelling on public roads. When loose materials are being transported they shall be covered with a heavy duty load sheet which is adequately fastened down to prevent the emission of dust and load shedding. Loading of loose materials above the level of the truck sides (as provided by the original manufacturer) shall not be permitted. The use of truck side and/or tailgate height extensions to increase carrying capacity shall not be permitted. Haulage vehicles shall be maintained according to the original manufacturer's specifications and manuals. If, in the opinion of the Engineer a haulage vehicle is not in a roadworthy condition, is excessively loaded, or is emitting undue smoke or noise, that vehicle shall immediately be taken out of service and the faults rectified before it shall be permitted to return to Site duty. No claim for additional costs associated with such action by the Engineer shall be entertained.

All drivers shall be duly licensed for the category of vehicle they drive and shall be trained in defensive driving. They shall comply at all times with speed limits on public roads which are imposed by law. The Contractor shall dismiss from the Site any driver who persistently ignores speed limits or drives in a reckless manner. The Engineer shall have the right to require dismissal from the Site and immediate replacement of any driver who, in his opinion persistently engages in speeding or reckless driving. No claim for additional costs associated with such action by the Engineer shall be entertained.

Particular care shall be taken to ensure that concrete mix trucks and fuel tankers are driven in such a manner as will not result in fresh concrete or fuel spilling on public roads. The Contractor shall be responsible, at his own cost, for cleaning up of any such spillage or shedding of other loads without undue delay.

Where vehicles are coming onto public roads, the Contractor shall implement measures, such as washing the wheels of all delivery and other vehicles before they leave the Site, to ensure that debris and mud from the Site are not deposited on the carriageways.

104.5 NATURALLY-OCCURRING CONSTRUCTION MATERIALS

The use of sand or any other material extracted from existing beaches or the beds and/or banks of existing watercourses in any part of the Works shall not be permitted, with the exception of material excavated in accordance with the Drawings, which is approved by the Engineer for use elsewhere in the Works, and which would otherwise be disposed of as waste.

All naturally-occurring construction materials supplied for use in the Works shall be obtained only from quarries and borrow pits which are in possession of such valid licences, permits and authorisations as may be required under the law for their operation. The

Contractor shall provide the Engineer with copies of such licences, and the like, at the time of seeking approval of material sources.

The Contractor's attention is drawn to the provisions of Article 43 of the Minerals Act 2000 which requires an application for a licence under the Act to extract and/or process construction materials to be accompanied by an Environmental Impact Assessment and a Certificate of Environmental Clearance. The Contractor is advised that preparation of the required documents and the official procedures relating to their processing are likely to take at least six months in total. In the event that the Contractor chooses to open new quarries or borrow pits to supply material for use in the Works, he shall note that delays in obtaining the necessary licence shall not be considered a valid reason for a claim for an extension of time to complete the Works.

104.6 HOT MIX PLANT OPERATION

Asphalt and other hot-mix bituminous materials supplied for use in the Works shall be obtained only from plants which are in possession of such valid licences, permits and authorisations as may be required by law for their operation. The Contractor shall provide the Engineer with copies of such licences, and the like, at the time of seeking approval of material sources.

In the event that the Contractor chooses to employ demountable (moveable) plant for the supply of hot-mix bituminous materials, he shall seek the approval of the Engineer of the location or locations where such plant is to be deployed, prior to commencement of installation. The location shall be deemed part of the Site. The Contractor is advised that approval will not normally be given for any installation to be sited within 500m of any dwelling or other occupied buildings. Such plant shall be fitted with noise and dust suppression equipment and shall be operated and maintained in a manner which will minimise emissions of dust and fumes. If, in the opinion of the Engineer, the plant is emitting undue dust or fumes, he shall have the discretion to order immediate shutdown of the plant, until such time as appropriate and effective remedial action has been taken. No valid claim for delay shall arise in such circumstances. The Contractor's attention is drawn to Item 18 (a) of the Schedule which forms part of the Certificate of Environmental Clearance (Designated Activities) Order 2001. This may result in the need for a Certificate of Environmental Clearance to be issued before a new hot-mix plant can legally be operated. The Contractor is advised that preparation of the required documents and the official procedures relating to their processing may take several months in total. In the event that the Contractor chooses to install hot-mix plant at a location not currently used for that purpose in order to supply material for use in the work, he shall note that delays in obtaining the necessary Certificate shall not be considered a valid reason for a claim for an extension of time to complete the Works.

104.7 DUST, NOISE AND OTHER NUISANCES

The Contractor shall conduct all his activities in a manner which minimises nuisance to the general public and to the occupiers of premises adjacent to the Site.

The Contractor's activities shall be conducted in a manner which complies fully with the relevant provisions of the Noise Pollution Control Rules 2001. The Engineer, at his discretion, will undertake to monitor the level of noise as he deems appropriate. In the case of activities taking place in the vicinity of premises which, in the opinion of the Engineer,

are noise sensitive (including but not limited to educational establishments, hospitals and places of worship), or where construction activities take place outside the hours of 7 a.m. and 7 p.m. on the same day, the Engineer shall have the discretion to require appropriate measures to be adopted by the Contractor to reduce noise levels.

The Engineer may authorise, at his discretion, the conducting of construction activities during the period between 10 p.m. to 6 a.m., subject to compliance with the Noise Pollution Control Rules 2001. In the case of pile driving, the Engineer will refuse to authorise such activities between 7 p.m. and 7 a.m., if there are dwelling-houses in close proximity to the Site.

The construction equipment will be maintained in such a condition that, at all times, the level of noise produced while in operation, will be substantially similar to out of factory condition.

The Contractor shall take all appropriate measures to minimise the generation of fugitive dust on the Site to the satisfaction of the Engineer. These shall include, but not be limited to, the regular watering of unsealed pavement layers which are being rehabilitated as part of the Works and of unsealed parts of material haul routes, watering of stockpiles of construction aggregates and soil materials, and the adoption of procedures for Site clearance and demolition which minimise dust generation. The maximum length of time during which road pavement shall remain unsealed following removal of existing surfacing as part of the Works shall be decided by the Engineer. The Engineer shall require such special precautions to be taken as he shall consider appropriate in the circumstances to prevent harmful fugitive dust emissions arising from activities such as cement- or lime-stabilisation of soils. Specific provision shall be made in the Contractor's Method Statements for dust minimisation measures, to the satisfaction of the Engineer.

The Contractor shall keep clean and free of mud, soil and other materials, sections of public roads which have material deposited on them as a result of his activities, to the satisfaction of the Engineer. All Site vehicles and machinery deployed to Site by the Contractor shall not emit undue noise or smoke, and shall be maintained in this state throughout the Contract period. If, in the opinion of the Engineer, any of the Contractor's vehicles or machinery is emitting undue noise or smoke, such shall be removed from the Site immediately or immediate rectification shall be carried out.

All Works shall be executed in a manner which does not unduly impede pedestrian and/or vehicular access by owners and the general public to adjacent houses, other premises and lands. Specific provision shall be made in the Contractor's Method Statements for the maintenance of access, to the satisfaction of the Engineer.

104.8 LAND AND WATER POLLUTION

The Contractor shall take all necessary precautions to prevent pollution of land and water resources arising directly or indirectly from his activities. He shall be responsible for taking immediate remedial action at his own cost to minimise the effects of any spills and leakages of polluting substances, to the satisfaction of the Engineer and in accordance with any instructions given by the Engineer in this respect. The Contractor shall be responsible for the payment of full and fair compensation to any persons or entities that have suffered damage to resources or property following spillages or leakages.

With respect to water resources the Contractor will prevent the contamination of rivers, water courses, lakes, lagoons, wetland areas and riparian zones. The Contractor shall be responsible for the spillage and leakage of pollutant waste including chemical products, fuel lubricant, sewerage water, paints, silts, solid waste, or any other substance so identified by the Engineer, into rivers, water courses, lakes, lagoons, wetland areas, seas and riparian zones. The Contractor shall be responsible for the cost associated with rehabilitation of these areas to the satisfaction of the Engineer.

The waste water to be discharged from the construction facilities must comply with standards for the discharge of effluent (Water Pollution Rules 2019). Waste water must be adequately treated or filtered in order to eliminate material likely to cause pollution on natural water courses and/or endanger wet lands or breeding areas of aquatic birds.

If by accident, the Contractor directly or indirectly dumps, discharges or spills over any fuel or chemical product likely to contaminate any water course or the aquifer, he will immediately advise the jurisdictional authority (ies), and will take immediate action to arrest and eliminate the pollution caused by such material.

Sanitary facilities at the Site offices and at worksites shall be maintained in a clean and hygienic condition at all times, and shall be provided in such numbers and of such types as set out in the Specification.

The washing of vehicles and construction equipment in or adjacent to watercourses is specifically prohibited. All such washing is to be carried out at designated washing areas, approved by the Engineer, which are equipped with efficient oil and grease traps. Where the Contractor fails to ensure that the oil and grease traps are working efficiently, all clean up Works will be carried out immediately to rectify any damages to the surroundings and it will be done at the Contractor's own expense.

Refuelling, routine servicing and non-emergency repair of vehicles and equipment shall only be carried out in designated refuelling/maintenance areas approved by the Engineer, with the exception of refuelling of small mobile equipment such as pumps, compressors, generators and concrete mixers, which may be carried out at deployment locations. Refuelling/maintenance areas shall be provided with an impermeable base and drainage systems which discharge through efficient oil and grease traps. They shall be protected from rain by means of suitable roofing. Facilities shall be provided to contain and clean up spillages and leakages of petroleum products to the satisfaction of the Engineer. Recovered petroleum products may be returned to store or shall be disposed of as special wastes, as provided for in the Contract. Materials used in clean up shall be disposed of as special waste.

Fuel stores shall have an impermeable base which shall be surrounded by an impermeable bund such that the volume of the area contained within the bund is not less than 110% of the maximum capacity of the storage. Storage facilities shall be subject to the approval of the Engineer and Ministry of Energy and Energy Industries. Spillages and leakages shall be dealt with without undue delay in the same manner as those which occur in maintenance/refuelling areas.

In the event of refuelling of minor equipment or emergency repairs to vehicles or plant being carried out at locations other than the designated refuelling/maintenance area, drip trays shall be employed to contain spillage of potentially polluting materials. These shall

be of size and capacity appropriate to the activity being undertaken and shall be of a type approved by the Engineer. Any soil which becomes contaminated with petroleum products shall be carefully and immediately removed and disposed of as special waste.

Storage facilities for potentially polluting materials other than petroleum products shall be of a type approved by the Engineer.

In the demolition of existing bridges and construction of new ones, the Contractor shall ensure that neither rubble nor surplus construction material is dumped onto existing water courses.

Particular care shall be taken when activities are carried out in, or in the vicinity of, watercourses or bodies of standing water, to ensure that pollution does not occur. Special precautions shall be taken as necessary, to the satisfaction of the Engineer, to ensure that materials such as, but not limited to, cement dust, fresh concrete, lime and petroleum products do not pollute the water body.

The construction activities on rivers and water courses will be confined to the areas shown in the final design Drawings, and where the erection of temporary and/or permanent structures have been so designated. Scaffolding or falsework erected for the undertaking of construction Works, will be removed opportunely from rivers or water course beds, upon termination of the construction activities.

The crossing of construction equipment over river and water course beds, during construction activities will not be permitted. If and when needed, temporary structures will be erected to allow such operation activity of construction equipment.

104.9 WASTES AND WASTE DISPOSAL

All wastes arising directly or indirectly in connection with construction activities shall be disposed of only at landfill sites operated by Trinidad and Tobago Solid Waste Management Company Limited (SWMCOL), or at an approved site as defined in the Trinidad and Tobago Litter Act Chapter 30:52, or by recycling at a facility which is duly authorised to conduct recycling activities. Disposal of any type of waste by burning or burial is specifically prohibited. In the event of the Contractor disposing of wastes other than as provided for in this Contract, he shall be required to remove any such wastes, dispose of them at a SWMCOL Site and clean up the disposal area at his own cost and to the satisfaction of the Engineer.

Prior to the commencement of any activities which may result in the generation of wastes, the Contractor shall consult with SWMCOL concerning any special arrangements which they may require in relation to waste disposal at sites under their control, and shall comply fully with any such requirements. The Contractor shall confirm to the Engineer that such consultation has taken place, and shall inform him of any requirements of SWMCOL regarding waste disposal.
All wastes shall be segregated for haulage and disposal purposes. Loads of mixed wastes shall not be delivered to SWMCOL sites. Deliveries of wastes to SWMCOL sites shall be properly recorded by the Contractor. Drivers of waste haulage vehicles shall be provided with record books, available for inspection by the Engineer, which set out the registration number of the vehicle, the driver's name, the date and time of delivery of waste to a SWMCOL Site, and the nature and volume of the waste. The record of each delivery shall

be signed as correct by the driver, and shall be countersigned by the SWMCOL employee at the landfill Site who is responsible for logging and inspecting waste deliveries. Disposal of wastes at the landfill Site shall be carried out in accordance with the instructions of SWMCOL Site staff. Waste concrete shall be broken into lumps which are no greater than 350mm in any dimension. Reinforcing steel shall be bent parallel and close to the concrete surface or cut off flush with the surface, so as to facilitate use in temporary roadways.

Waste oils shall be stored on Site in leak proof containers until taken for disposal at a duly licensed recycling facility approved by the Engineer. Waste steel and other metals shall be disposed of at a duly licensed recycling facility approved by the Engineer. In the event that the material is considered unsuitable for recycling, it shall be disposed of in accordance with the instructions of the Engineer.

Arrangements for the disposal of special wastes including, but not limited to, soil and other materials contaminated by petroleum products, waste paint, resins and other potentially polluting materials and their containers, shall be discussed and agreed with SWMCOL, and shall be to the satisfaction of the Engineer.

Temporary storage of wastes shall not be done in such a manner as causes pollution or public nuisance in any form and shall be for the minimum practicable time. If, in the opinion of the Engineer, temporary storage arrangements are inappropriate in any way, the Contractor shall be required to remove such wastes for disposal forthwith.

104.10 PRIVATE LAND PERMIT

The Contractor shall not dispose of any surplus material in private land, unless authorised by the owner in writing, authenticated before a Notary Public, and with previous authorisation of the Engineer.

The Contractor must obtain permission in writing for the use of any land, which is required temporarily in connection with the associate Works. The treatment and maintenance of such an area shall be in accordance with any related item in the Specifications.

The Engineer shall not agree to the temporary use of lands by the Contractor, which are located in or adjacent to environmentally sensitive areas or have been designated as Environmentally Sensitive Areas by the relevant governmental authority under the Environmentally Sensitive Areas Rules 2001 and subsidiary legislation. The Engineer shall not agree to the temporary use by the Contractor of beach or foreshore areas or riparian areas.

104.11 SILTATION AND EROSION CONTROL

The Contractor shall take temporary control measures to control erosion on haul roads and at borrow pits. These shall include the construction of berms, dykes, dams, sediment basins, fibre mats, netting gravel, mulches, grasses, silt fences and slope drains.

The Contractor shall take all precautionary measures, either transitory or permanent in nature, to control and/or minimise erosion and/or siltation of rivers, permanent water courses, lakes, seas and lagoons. Such measures shall include, but shall not be limited to, the use of berms, siltation basins, geotextile membranes, gabions, slope drains and any other reasonable measure. The erosion and siltation control measures, permanent in nature,

shall be applied to any erodible material exposed to any activity associated with the Works, including sources of material supply and production, storage of raw materials, and disposal areas of surplus materials.

The transitory measures will be co-ordinated with the construction of permanent installation of drainage and other activities contracted, to the extent of practical cost, in order to ensure an effective and continuous permanent installation of drainage will be built wherever required, lining the sections subject to scouring, or at places where change of slope is required. After each heavy rainfall, and daily when intermittent rainfall occurs, the Contractor shall inspect the state of the erosion and siltation control Works, in order to ascertain any deficiency, and take the corrective action as deemed suitable. The Contractor shall take precautions to prevent siltation or obstructions of waterways and drainage channels within the Site. In the event of siltation or erosion of a channel or drain occurring as a result of the Contractor's operation, the Contractor shall clean, desilt and rebuild as necessary and generally maintain the Site in a clear, unobstructed condition to the satisfaction of the Engineer for the duration of the project. The Engineer may direct the Contractor to maintain drains or waterways periodically if in the opinion of the Engineer it is required to ensure surface drainage.

In executing the Works, the Contractor shall take all reasonable steps to minimise siltation and erosion arising as a consequence of his activities. If, in the opinion of the Engineer, the Contractor's activities are causing undue erosion and/or siltation, or inappropriate or ineffective control measures are being adopted, the Contractor shall be required to implement, at his own cost, such additional siltation and erosion control measures and removal and disposal of deposited silt and repair of eroded locations as the Engineer may decide are appropriate in the circumstances.

In-bank or in-waterway excavation undertaken in connection with bridge replacement or bank protection Works shall be carried out behind a coffer dam or silt curtain. Dewatering systems shall incorporate sedimentation basins whose out flow has suspended sediment content which is not, in the opinion of the Engineer, significantly higher than that in the watercourse immediately upstream of the structure. The Contractor's Method Statements for bridge replacement and bank protection Works shall contain full details of the measures to be adopted to minimize siltation, and shall be to the satisfaction of the Engineer.

The excavation of river-mouth sand bars in order to facilitate execution of the Works shall be expressly prohibited.

104.12 SITE CLEARANCE

The Contractor will limit Site clearance to areas specifically needed for construction activity. Such clearance should be scheduled such as to prevent the prolonged exposure of the Site before construction Works.

The Contractor shall preserve large, living trees greater than 10cm DBH (diameter at breast height), trees of commercial, genetic, ecological or landscape value as identified by the Engineer and/or Employer. If large trees must be removed this must be done after approval by the Engineer and the relevant removal permits obtained from the competent authority. Any costs incurred shall be borne by the Contractor.
The use of herbicides and fire in the removal of under-storey vegetation, shrubs and any other vegetation type shall be strictly prohibited.

All cleared vegetation must be disposed of in a manner as approved by the Engineer.

The Contractor shall remove the topsoil and store it at a designated Site, to be approved by the Engineer, for use in the rehabilitation of the area.

The Contractor shall avoid injury to standing trees within the Site. Where injury does occur the necessary remedial measure must be implemented as approved by the Engineer.

The Contractor shall avoid angle termination at the borders of cuts and back-fills.

104.13 ABSTRACTION OF WATER FROM NATURAL SOURCES

The Contractor shall consult with the relevant authorities regarding suitable locations from which water may be abstracted for construction or other purposes from surface or groundwater resources. He shall obtain at his own expense any permits, authorisations and licences which are required by law in relation to the abstraction of water, prior to commencement of abstraction. In the event that abstraction by the Contractor adversely affects the availability of supply to other users, he shall provide an adequate alternative supply at his cost and to the satisfaction of the Engineer.

104.14 PROTECTION FROM ASPHALT, FUELS, LUBRICANTS ETC

Materials that are hazardous to health and the environment, such as asphalt, fuels, lubricants, etc, shall be stored in protected areas. Bunds shall be provided to prevent leakage of fuels and lubricants to surrounding lands or watercourses and storage areas shall be lined with leak proof membranes in sensitive areas. No fuelling or servicing of vehicles will be permitted outside of these bunded areas. The following table shows the recommended dimensions for the construction of a bunded area to prevent spillage from an overhead tank.

No.	Capacity of Tank (gal.)	Capacity of Tank (m^3)	10% Increase (m^3)	Length (m)	Width (m)	Height (m)	Volume (m^3)
1	500	1.9	2.1	4	4	0.75	12
2	1000	3.8	4.2	6	4	0.75	18
3	2000	7.6	8.4	8	4	0.75	24

Table 104.1
Volumes for Bund

A spill containment plan (including provisions for removal and remediation of contaminated soil after the end of construction) shall be prepared and approved by the Engineer prior to the start of work on Site. On-Site remediation of soil will not be permitted without the approval of the Employer and authorisation from the EMA.

Where there is a spill of fuels, oils or lubricants, the EMA should be contacted at once and the following should be put into effect:

a. When the spill occurs on a paved surface, sand is to be applied to absorb the excess fuel and once absorption occurs, it should be disposed of as directed by EMA officials and or the Engineer.

b. If the spill occurs on vegetation, then the Contractor should use an approved material by the EMA and or the Engineer, for absorption. The method should be to remove the layer of topsoil to depth of 150mm and then apply the absorbing material. After letting the absorption occur for a minimum of five hours it should be removed as per specifications of the EMA.

104.15 AIR EMISSIONS / AIR QUALITY

The Contractor shall take all necessary steps, throughout the duration of the project, to minimize the emission of noxious gaseous contaminants to the atmosphere. Vehicles and equipment shall be routinely serviced and fitted with adequate exhaust systems. If any vehicle or equipment (in the Engineer's opinion) emits excessive smoke, it shall (on the Engineer's instruction) be removed from the Site for repair or maintenance.

104.16 ENVIRONMENTAL MANAGEMENT PLAN AND SUBMISSION OF MONTHLY REPORTS

The Contractor is to prepare and present to the Engineer for approval an Environmental Management Plan (EMP) that clearly states the methodology for implementing the mitigation measures during construction activities. This EMP must be submitted within 28 days of award of the Construction Contract.

During the duration of the Contract, it is the duty of the Contractor to produce a monthly report, which will give details of where the Contractor has complied with the provisions of this section, which is to be submitted to the Engineer. This is in order to assess the performance of the Contractor and ensure that all provisions are being adhered to. Based on the valuation done by the Engineer, so shall the Contractor be paid. The format of the Environmental Monthly Report shall be discussed with and approved by the Engineer prior to the first submission.

104.17 PROTECTION OF HISTORICAL / CULTURAL AND/OR ARCHAEOLOGICAL FINDS

In the event that material of potential archaeological significance is unearthed during excavation works, the following measures are to be implemented to reduce disturbance to newly discovered sites:

- Suspend work in the vicinity of the find;
- For new finds, arrange for the inspection of the surface for about 30 m on each side for man-made material after clearance of route but before earth's surface is disturbed. This should be done in conjunction with the History Department of the University of the West Indies, the National Trust or other relevant authority.
- Allow a two-week period for assessment of find and location before the latter is further disturbed.

104.18 FIRE PRECAUTION

The Contractor shall take all reasonable precautions to prevent outbreaks of fire on the Site and in all offices, stores, camps and other places things connected therewith or nearby.

All fire buckets, sands, water and chemical extinguishers and other such appliances, together with sufficient trained personnel and fire warning devices shall be maintained at all times to the satisfaction of the Engineer and Fire Service Authorities.

Special measures for the fire precautions are to be taken with regard to petrol and asphalt stores and the protection of other flammable materials in accordance with Legislation.

104.19 NON-CONFORMANCE

The Engineer is authorised to suspend any activity which in his opinion is deemed to be in violation of any environmental clause as laid out in the Environmental Management Act 2000, Noise Pollution Control Rules 2001, Minerals Act 2000, Certificate of Environmental Clearance (Designated Activities) Order 2001, Trinidad and Tobago Bureau of Standards TTBS547 and TTBS 417, Water Pollution Rules 2019, Environmentally Sensitive Areas Rules 2001, or the Contractor Code of Practice and/or is carried out in a manner not in accordance with the Specifications outlined herein.

Any consequential delay to execution of the Works arising from being ordered to suspend or halt the activity concerned, or in rectifying the breaches, shall not be considered due cause for a claim by the Contractor.

SERIES 100: GENERAL

SECTION 105: OFFICE FACILITIES FOR THE ENGINEER

105.1 Scope of Works

105.2 Construction and Equipment Requirements for Engineer's Office

105.3 Construction and Equipment Requirements for Engineer's Laboratory

105.4 Assistance for the Engineer

105.5 Provision and maintenance of Video Monitoring Cameras

APPENDIX 105

105.1 SCOPE OF WORKS

The Contractor shall provide and maintain land, offices and laboratory facilities for the exclusive use of the Engineer for the duration of the Contract, including the Defects Notification Period after which the offices and equipment and furnishings shall become the property of the Employer. These facilities shall be located adjacent to the project Site in a place to be approved by the Engineer. The Engineer shall have exclusive use of the land, office and all furnishings in the administration of this or any other similar Contract for the duration of the Contract, including the maintenance period.

The Contractor shall obtain the permission in writing of landowners or those who have right-of-use of any land which is required temporarily in connection with execution of the Works. Such permission shall state the name and address of the owner concerned, the location and area of the land, the intended use for the land, the period over which it will be required and the extent to which the Contractor intends to clear the land in connection with the intended use. The location and type of any trees or structures which are not to be cleared/demolished shall be stated. Copies of such permissions shall be provided to the Engineer, whose agreement to use of such parcels of land for the specified purpose and period shall be obtained prior to commencement of any activity on that land by the Contractor. Such lands shall be deemed part of the Site. The Contractor shall be responsible for obtaining, at his own expense, any legal agreements and/or permits and authorisations required by law, in connection with the intended use of such lands.

The Engineer shall not agree to temporary use of lands by the Contractor which, in his opinion, are located in or adjacent to environmentally sensitive areas or have been designated as Environmentally Sensitive Areas by the relevant authority under the Environmentally Sensitive Areas Rules 2001 and subsidiary legislation. The Engineer shall not agree to the temporary use by the Contractor of beach or foreshore areas.

105.2 CONSTRUCTION AND EQUIPMENT REQUIREMENTS FOR ENGINEER'S OFFICE

Office buildings shall be supplied in the numbers and types shown in Appendix 105.

All materials used in the construction of the Employer’s office shall be new and unused and shall provide completely weatherproof and secure office buildings with adequate natural and artificial lighting and all finishes, fixtures, fittings as specified in Appendix 105. The Contractor shall provide and maintain utility services and parking areas as specified and provide security fencing around the office and parking areas.

The furniture and equipment shall be new, of standard manufacture and supplied and installed immediately on completion of the building. All items shall comply with the specifications contained in Appendix 105. All items shall become the property of the Employer at the end of the Defects Notification Period.

The offices, furnishings and equipment and all other requirements of this sub-section shall be provided within three (3) weeks of the Commencement Date.

The Contractor shall insure, provide 24 hour security, repair, clean daily and maintain the Engineer's Offices and their contents for the duration of the Contract.

105.3 CONSTRUCTION AND EQUIPMENT REQUIREMENTS FOR ENGINEER'S LABORATORY

In order to facilitate all the necessary testing of material in accordance with the relevant bill items in the Specifications or as directed by the Engineer, the Contractor shall provide a laboratory as described in Appendix 105 to the satisfaction of the Engineer. Laboratories shall be supplied in the numbers and types specified in Appendix 105. All materials used in the construction of the laboratories shall be new and unused and shall provide completely weatherproof buildings with adequate natural and artificial lighting and all finishes, fixtures, fittings, furniture and equipment as shown and specified in Appendix 105. The Contractor shall provide and maintain utility services and parking areas as specified and provide security fencing around the buildings and parking areas.

The Contractor shall supply, calibrate, maintain and service all testing equipment required in Appendix 105 as specified for the relevant items or as directed by the Engineer. The above items shall remain with the Engineer for the duration of the Contract, including the Defects Notification Period. This equipment shall be for the exclusive use of the Engineer who reserves the right to utilize the same on other similar Contracts for the Employer. All items shall become the property of the Employer at the end of the Defects Notification Period.

The laboratories, furnishings and equipment and all other requirements of this sub-section shall be provided within six (6) weeks of the Commencement Date of the Contract. No element of the permanent Works shall be commenced until two (2) weeks after the full and complete compliance of the Contractor with this sub-section (unless alternative facilities acceptable to the Engineer are made available at the Contractor's cost).

The Contractor shall insure, secure (including the provision of night watchmen), repair, clean daily and maintain the Engineer's Laboratory and its contents for the duration of the Contract.

105.4 PROVISION OF STAFF, EQUIPMENT AND SERVICES FOR THE ENGINEER

In addition to staff, equipment and services provided incidentally to the supply of offices and laboratories, the Contractor shall provide to the Engineer such additional staff, equipment and services as are specified in Appendix 105.

The Engineer may also instruct the Contractor to provide additional staff, equipment and services during the course of the Contract at agreed rates and prices.

105.5 PROVISION AND MAINTENANCE OF VIDEO MONITORING CAMERAS

The Contractor shall provide and maintain video monitoring cameras in a location approved by the Engineer to facilitate monitoring of the Works for the duration of the Contract. The video monitoring cameras shall include the following as a minimum:

- 4MP 25x Network IR PTZ Camera
- Custom Made Pole mount and bracket max. 4m high.
- 1 month Storage
- Installation/set-up viewing & programming up to 5 Users (individual devices)

The Contractor shall supply product specifications to the Engineer for approval prior to purchasing the equipment. All items shall become the property of the Employer at the end of the Contract.

APPENDIX 105: OFFICES FOR ENGINEER'S STAFF

Offices

The following offices and equipment will be supplied new and unused and equipped in accordance with Section 105 of the Specification and as defined below:

- (1) Office Type B – 8.2m x 3.7m moveable. Alternatively, a converted container 12m x 2.5m.
  (2) Office Type C – 5.8m x 3.7m moveable. Alternatively, a converted container 6m x 2.5m.

- Office to have a minimum ceiling height of 2.5m.

- Walls and roofs shall be fully waterproof, and floors damp proof, and all of solid construction. All offices shall be constructed on skids or jacks and shall be designed and constructed to be sufficiently rigid to enable them to be relocated by low loader or other similar means.

- All offices: roofs may be flat or ridged and shall be finished with a minimum layer of asphalt sheeting to give a 5 year min. life. Roofs shall overhang walls by 600mm, walls shall be of 75mm x 50mm timber stud work, with vapour barrier and finished with tongue and groove exterior cladding or similar. All timber to be treated against insect attack and rot. Outside wall surface to be painted with grey coloured gloss paint. An alternative material can be proposed to the Engineer for the external walls provided on that, the material is strong and durable.

- All offices to have lined internal walls and ceilings (sheet plaster board or similar) providing a smooth and regular surface with all joints sealed. Surfaces shall be painted with two or more coats of light coloured emulsion paint to a consistent finish.

- Floors shall be smooth and level without 'trips' or other hazards. They shall be fully covered with 2mm or thicker proprietary sheet flooring material cut to shape and glued in place.

- All windows to have vertical blinds and insect screens internally and burglar bars externally, and 50% minimum of glass area to be openable. Metal louvres will not be permitted in the construction.

- External doors to be solid wood with two security locks per door and with external insect screen.

- All offices to have electricity and piped potable water supplies adequate for the anticipated use.

- Electricity to be connected through fuse box of adequate capacity for intended loads.

- Type B office to have a minimum of eight plug sockets.

- Type C office to have a minimum of six plug sockets.
- Air-conditioning units to be connected to supply through fused switchable outlet. All offices to have electric light fittings providing adequate artificial light levels to all works surfaces in accordance with recognized standards of provision.

- All offices shall have provided flush toilets and hand washing facilities inside.

- 1- 400 gallon Water Tank on elevated stand with external standpipe and connected to internal plumbing system.

- Level and hardened parking spaces to be provided adjacent to each offices as follows:
  - Type B – 6
  - Type C – 4

- Level and hardened access paths to be provided from roadway, parking areas and toilets to office doors.

Equipment for Office

All equipment to be new, of standard manufacture (not prefabricated by Contractor) and to Engineer's approval.

Item	Office Type	
	B	C
5 drawer metal keyhole office desk 1.5m x 0.75m, lockable with laminate edge top	2	1
Metal office side table 1.5m x 0.75m to match above construction	1	1
Padded medium back pneumatic tilting office swivel chairs with adjustable arms	- 2	2
Padded office chairs, steel frame to match above swivel chairs (arms unpadded)	2	2
Steel folding office chairs	2	2
Vertical file cabinet, 675mm deep, 4-drawer, legal size, lockable, non-tiltable	1	1
Twin lock lateral suspension files – legal size (8.5" x 14")	100	100
Conference table 1.8m x 1.2m type, solid frame construction (not folding) with heavy laminate top and steel legs	1	1
Plain paper, Telephone/Fax/Photocopier/Scanner machine HP Officejet Pro 7740 or approved equivalent	1	1
Replacement Original Black and Colour (Cyan, Magenta and Yellow) Ink Cartridges for HP Officejet Pro 7740 or approved equivalent	7	7
A4 Size Plain White Printing Paper, 500 page Ream	5	5
Legal (8.5" x 14") Size Plain White Printing Paper, 500 pages Ream	1	1
A3 Size Plain White Printing Paper, 500 pages Ream	1	1
Air-conditioning unit, fitted, 24,000 BTU	1	0
Air-conditioning unit, fitted, 12,000 BTU	0	1
Automatic kettle (8 cup capacity)	1	1
Electric water chiller and two 5 gal. water bottles (Contractor to replenish as required)	1	1
Paper cone cups, 133mL capacity (Box of 200)	20	20
Frost Free Refrigerator (4.0 cu.ft. or greater)	0	1
Frost Free Refrigerator (8.0 cu.ft. or greater)	1	0
4.5kg ABC dry chemical powder fire extinguisher	1	1
Telephone connection	1	1

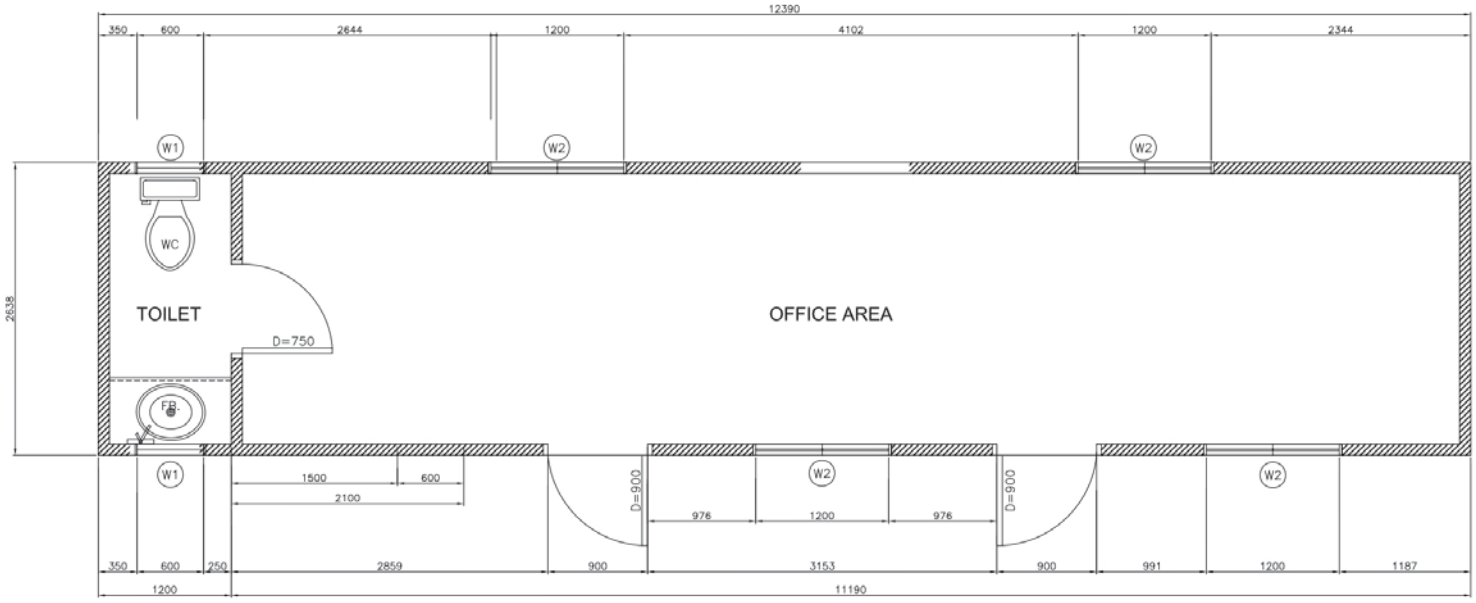
Item	Office Type	
	B	C
Telephone with drop	2	1
Wireless internet connection (Minimum 6MBPS download)	1	1
Wireless router that conforms to the 802.11 ac standard or newer	1	1
Microwave oven 1.0 cu.ft.	1	1
Sanitation by flush toilet	1	1
Wash basin	1	1
Double roll toilet paper dispenser	1	1
Wall mounted liquid soap dispenser, 400mL capacity, pump action	1	1
Wall mounted paper towel roll holder	1	1
HDPE office bin, 4.5gal. capacity	2	2
HDPE trash bin with lid, 45gal. capacity	1	1
Boot scrubber (inclusive of fixing to ground)	1	1
High traffic, weather resistant, exterior grade door mat, 457mm x 762mm	1	1
No. of keys to be provided for every lock	3	3

The Engineer may substitute alternative equipment for any number of the foregoing, whilst retaining the same overall cost to the Contractor. Upon completion of the Contract the site office with the furniture and all material and furnishing becomes the property of the Employer.

SECURE COMPOUND

The office for the Engineer and the laboratory (if required) shall be provided within a secure, fenced, gated and security lit compound with a guard booth. The guard booth shall be manned by adequate security staff at all times. Security lighting is to be provided during all non-daylight periods. The access road, the road within the compound and the parking area are to be adequately paved and drained and are to be maintained in clean condition, pothole and crack free, at all times.

No separate payment will be made for the secure compound. The cost involved is to be included in the price tendered for the provision of the office for the Engineer.



TYPE B SITE OFFICE LAYOUT (ENGINEER / EMPLOYER)

SCALE : 1:20

LEGEND:–

(W1) – 600x600 VENT WINDOWS

(W2) – 1200x1200 WINDOWS

K.S. – KITCHEN SINK

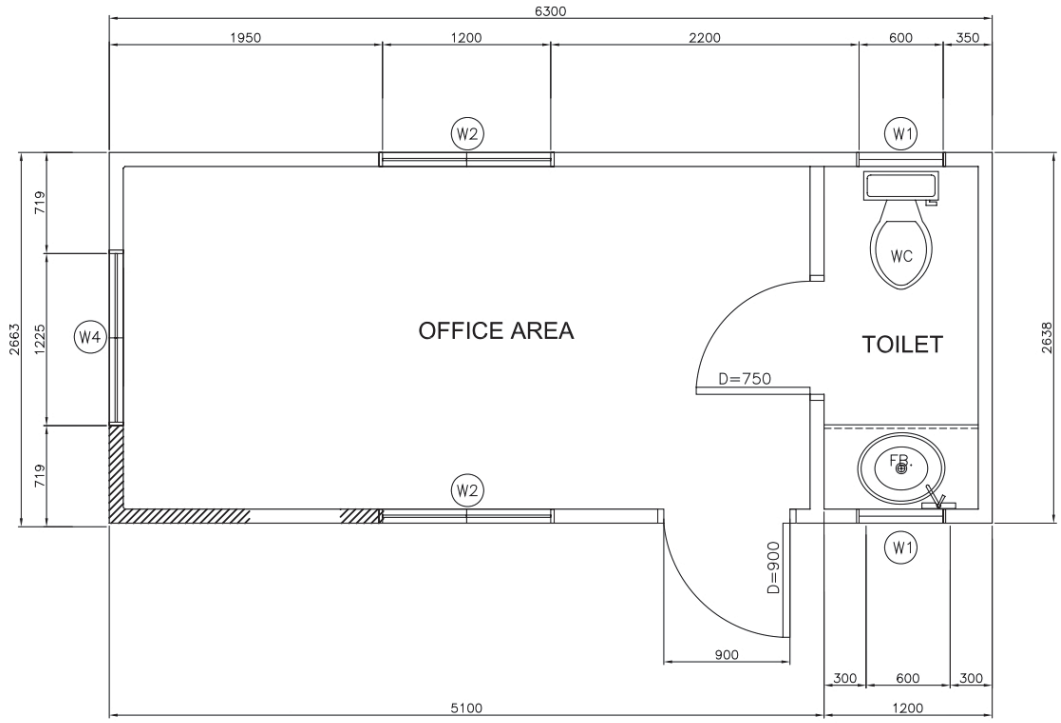
FB. – FACE BASIN

WC. – WATER CLOSET

D= – DOOR SIZE

NOTE:

1. REFER TO SPECIFICATIONS FOR FINISHES & OFFICE FURNISHING
2. A/C LOCATION TO BE CONFIRMED
3. FINAL LOCATION OF DOORS & WINDOWS TO BE DETERMINED BASED ON ORIENTATION OF SITE OFFICE.



TYPE C OFFICE LAYOUT (ENGINEER/EMPLOYER)

SCALE : 1:20

LEGEND:–

- (W1) – 600x600 VENT WINDOWS
- (W2) – 1200x1200 WINDOWS
- (W2) – 600x1200 WINDOWS
- (W4) – 1200x600 WINDOWS

K.S. – KITCHEN SINK
FB. – FACE BASIN
WC. – WATER CLOSET
D= – DOOR SIZE

NOTE:
1. REFER TO SPECIFICATIONS FOR FINISHES & OFFICE FURNISHING
2. A/C LOCATION TO BE CONFIRMED
3. FINAL LOCATION OF DOORS & WINDOWS TO BE DETERMINED BASED ON ORIENTATION OF SITE OFFICE.

SERIES 100: GENERAL

SECTION 106: TRANSPORT AND COMMUNICATION FACILITIES FOR THE ENGINEER

106.1 Description

This Section describes the transport and communication equipment to be supplied and maintained for the use of the Engineer, his staff or staff of the Employer. The facilities will be disbursed by the use of provisional sums.

The specific requirements in respect of transport and/or communication facilities are specified in Appendix A106.

106.2 Hired Vehicles

Appendix A106 might require the Contractor to supply to the Engineer hired vehicles for all or part of the duration of the Contract. The hired vehicles shall be as specified in Appendix A106. The hire of the vehicles as well as their various maintenance costs shall be paid for by means of provisional sum items.

106.3 Purchased Vehicles

The Contractor shall furnish to the Engineer Vehicles of the type(s) specified in Appendix A106 as instructed by the Engineer. The vehicles shall all be capable of being centrally locked and shall be fitted with a remote operable alarm and anti-theft system, all to the approval of the Engineer. The vehicles shall be purchased in the name of the Employer and upon delivery become the property of the Employer.

The Contractor shall, for the duration of the Contract, be responsible for all running costs for the purchased vehicles provide licenses, fully comprehensive insurance, lubricants, fuel, oil, filters, tyres and all other consumables, servicing, repairs and maintenance as required in respect of purchased project vehicles which shall be paid by means of provisional sum items.

106.4 Maintenance of Existing Project Vehicles

The Contractor shall, for the duration of the Contract, provide licenses, fully comprehensive insurance, lubricants, fuel, oil, filters, tyres and all other consumables, servicing, repairs and maintenance as required in respect of existing project vehicles as detailed in Appendix A106 which shall be paid by means of provisional sum items.

106.5 Communication Equipment

Where specified in Appendix A106, the Contractor shall furnish to the Engineer new communication equipment as specified in Appendix A106. The Contractor shall arrange for all licenses, etc necessary for the installation and operation of the communication equipment. Reimbursement will be by means of provisional sums.

106.6 Maintenance of Communication Equipment

The Contractor shall, for the duration of the Contract, provide licenses, insurance and all other services and maintenance as required in respect of purchased or existing project communication equipment as detailed in Appendix A106. Reimbursement will be by means of provisional sums.

106.7 Measurement and Payment

Pay Item No.	Description	Unit
106.1	Provide transport facilities for the Engineer	Prov. Sum
106.2	Maintain transport facilities for the Engineer	Prov. Sum
106.3	Provide communication facilities for the Engineer	Prov. Sum
106.4	Maintain communication facilities for the Engineer	Prov. Sum

SERIES 100: GENERAL

SECTION 107: ACCOMMODATION OF TRAFFIC

107.1 General

107.2 Public Safety, Access and Traffic Flow to be Maintained

107.3 Public Participation

107.4 Construction Considerations

107.5 Carriageway Rehabilitation Work

107.6 Traffic Control Devices

107.7 Flag persons

107.8 Temporary Policemen

107.9 Removal and Salvaging of Existing Signs and Guideposts

107.10 Roadway Maintenance

107.11 Sequential Arrow boards

107.12 Dust Abatement

107.13 Temporary Construction Signing

107.14 Temporary Shoring, Protection and Maintenance of the Roadway

107.1 GENERAL

The Contractor shall make suitable provisions, including the use of detours, to accommodate all vehicular and pedestrian traffic safely and with a minimum of inconvenience through or around the Works.

The Contractor shall prepare a Traffic Accommodation Strategy detailing the measures he proposes for accommodating traffic throughout the project. Specifically, the Traffic Accommodation Strategy shall consist of drawings detailing the configuration of temporary construction signs and other traffic control devices in the work zone(s) and written confirmation of the methods or procedures being used by the Contractor to address specific traffic safety issues or situations at the work zone.

The Contractor shall submit the Traffic Accommodation Strategy to the Engineer 14 days prior to a date as agreed upon by the Engineer. The Engineer will review the Traffic Accommodation Strategy and communicate any concerns to the Contractor within 7 days of the pre-construction meeting. Any issues or concerns regarding the Contractor's proposed Traffic Accommodation Strategy shall be addressed to the mutual satisfaction of the Contractor and the Engineer prior to the commencement of the Work.

Before commencing with any part of the Works, the Contractor shall first submit to the Engineer a plan and schedule for any traffic diversion at least seven (7) days in advance for written approval prior to implementation. This requirement should not be confused with the requirement for the overall Traffic Accommodation Strategy mentioned elsewhere.

107.2 PUBLIC SAFETY, ACCESS AND TRAFFIC FLOW TO BE MAINTAINED

The Contractor shall at all times in all his operations and in using his construction plant take the necessary care to protect the public and to facilitate the flow of traffic. If work has to be done adjacent to traffic, the Contractor shall see to it that his employees are clearly visible to drivers and all Health and Safety requirements are being enforced inclusive of the employees being provided with the approved PPE.

The Contractor shall ensure uninterrupted access to all developments and existing accesses along the project. As far as possible, the Contractor shall carry out construction operations in one continuous operation at road crossings, intersections and entrances for each phase of the work, and control his operations to ensure normal school bus operations and emergency services operations are not interfered with.

The Contractor shall coordinate his traffic accommodation measures with those of other parties at or adjacent to the Work, as required, to accommodate traffic safely and convenience. This shall not relieve the Contractor of his responsibility for the safe accommodation of traffic over the whole of the Work.

The Engineer has the right to require the Contractor to modify his operations if, in the opinion of the Engineer, traffic is being unduly hindered or public safety is being compromised. The Contractor shall promptly make any modifications to the traffic accommodation operations deemed necessary by the Engineer. The Engineer may suspend work in cases where in his opinion, the Contractor fails to adequately provide for

the safety of the public, for re-occurring safety issues or when the Contractor fails to comply with orders issued by the Engineer regarding traffic accommodation operations.

Prior to any prolonged shut down of construction, the Contractor shall ensure that any disturbed roadway surface is restored to a condition suitable for traffic operations approved by the Engineer.

107.3 PUBLIC PARTICIPATION

The Contractor shall take all reasonable steps to ensure that the public is kept informed (e.g. through public advertisement) of all proposed traffic diversions, and that the Public Liaison Officer appointed in terms of the Conditions of Contract is accessible to the public by the advertisement of his contact details on all project signs and notices.

107.4 CONSTRUCTION CONSIDERATIONS

As far as possible during construction operations where half width construction are required, the Contractor shall:

- Employ half-width construction in accordance with the Drawings wherever possible.

- Complete construction of adjacent traffic lanes to the design elevations and cross fall except that differences up to 40mm, or 75mm with a 3:1 fillet, may be left with "Uneven Lane" warning signs.

- Complete the construction of carriageway lane inclusive of buffer zone between staged construction, to the elevation as required by the design, before transfer of traffic to the stage one section. Sign shoulder drop offs in excess of 40mm, or 75mm with a 3:1 fillet, with "Low Shoulder" warning signs.

- Provide minimum lane widths of 3m. Use barricades, traffic cones, or other approved devices to delineate traffic lanes through the construction areas where the edge of pavement or carriageway or intended path has been outlined in accordance with the Drawings.

- Park equipment at least 9m from the travelled way or behind approved traffic barriers. Provide parking areas for employees' personal vehicles in approved areas.

107.5 CARRIAGEWAY REHABILITATION WORKS

107.5.1 Dual Carriageway Rehabilitation

Where Works involve the rehabilitation of dual carriageway the public traffic using the dual carriageway shall be diverted from the section of that particular carriageway length that is under construction to the opposite parallel carriageway which shall operate as the temporary diversion of two-way traffic during construction. The Contractor shall construct temporary median cross over points together with lane channelization as per the requirements of this Specification. The minimum requirements for diversion of traffic from a dual carriageway

system to a two way traffic system on the opposite carriageway as the temporary diversion shall be as follows:-

(a) Traffic warning signs as indicated.
(b) Channelization of traffic to be diverted from two lanes to a single lane.
(c) Barriers and directional signs prior to median cross-over.
(d) Construction of diversion median crossovers.
(e) Two-way traffic lane separation over the length of the diversion on the opposite carriageway.
(f) Barriers and directional signs to the return median cross-over.
(g) Channelization and warning system for opposing traffic to converge from a two lane to single lane system,
(h) All necessary lighting systems for night time operation of diversions.

Subject to the approval of the Engineer, detours may be utilized to carry traffic around the Works.

107.5 2 New Diversion Roads

When traffic is diverted entirely off the right-of-way around a closed section of road bringing it back onto the same road the Contractor shall construct and maintain a diversion road in accordance with the Drawings. It shall be complete with signs at every intersection and in accordance with the Drawings and Specifications subject to the approval of the Engineer.

107.5.3 Existing Diversion Route

When a secondary or local road is used as a detour, the Contractor shall ensure that it is adequate to carry the proposed traffic which may include localized maintenance and upgrading as shown on the drawings or as directed by the Engineer. The Contractor shall provide sufficient and suitable traffic signing, maintain the road and signs to the initial standard during the diversion use and leave it in a satisfactory condition, as directed by the Engineer.

107.5.4 Existing Route Using Half- Width Construction

Where the Works involve the construction operation on part of an existing roadway, the contractor shall, as far as possible, undertake the following:

- Provide the necessary shoring, bracing, slope treatment, and/or other support system to the roadway in accordance with Specifications 203

- Employ half-width construction in accordance with the Drawings wherever possible.

- Complete construction of adjacent traffic lanes to the design elevations and cross fall except that differences up to 40mm - 75mm with a 3:1 fillet, may be left with “Uneven Lane” warning signs.

- Complete the construction of the carriageway lanes inclusive of buffer zone between the staged construction sections, to the elevation as required by the design, before transfer of traffic to the stage one section. Sign shoulder drop offs in excess of 40mm - 75mm with a 3:1 fillet, with "Low Shoulder" warning signs.

- Provide minimum lane widths of 3m. Use barricades, traffic cones, or other approved devices to delineate traffic lanes through the construction areas where the edge of pavement or carriageway or intended path has been outlined in accordance with the Drawings.

- Park equipment at least 9m from the travelled way or behind approved traffic barriers. Provide parking areas for employees' personal vehicles in approved areas.

107.6 TRAFFIC CONTROL DEVICES

The Contractor shall provide, install, maintain and protect traffic control devices such as signs, barriers, fences, lights, in accordance with the plans and specifications necessary to accommodate traffic safely through the work site and to protect the Contractor's personnel. In addition, the Contractor shall provide, install, maintain and protect any additional traffic control devices that the Engineer chooses to provide, The Contractor shall remove or cover all existing traffic control devices when essential for the safe accommodation of traffic, in order to eliminate unnecessary inconvenience to the traffic. He shall provide and use such other methods or equipment as is necessary to accommodate traffic safely through the work site. Upon completion of construction works, traffic control devices purchased for use on the project should be safely removed and transported to an approved location as determined by the Engineer.

107.7 FLAG PERSONS

During all periods of active equipment operations which may affect normal traffic operations, or when construction operations or work zone conditions require the use of flag persons, responsible flag persons shall be continuously maintained for the direction and control of traffic. The Contractor shall ensure that flag persons are instructed in and use proper traffic control procedures appropriate for the prevailing conditions.

Flag persons shall be dressed in clean white uniforms or coveralls, orange hardhats and fluorescent red/orange over vests for maximum visibility, and shall be equipped with the traffic control paddles specified in the Plans. The fluorescent red-orange over vests shall have 50mm wide reflective yellow striping with a minimum total length of 600mm on the front and 1200mm on the back.

During hours of darkness, flag persons shall be additionally equipped with a red signal hand-light of sufficient brightness to be clearly visible to approaching traffic and flagging stations shall be illuminated by overhead lighting. Signs indicating hazardous conditions and signs requiring increased attention shall be marked with flashers.

107.8 TEMPORARY POLICEMEN

The Contractor shall make arrangements for the provision of temporary policemen from the Traffic Management Branch of the Trinidad and Tobago Police Service as are necessary for the traffic direction during the course of construction. The Contractor shall, in conjunction with the Traffic Management Branch, determine the number and distribution of policemen considered necessary to ensure the control of traffic and shall prepare and submit this plan to the Engineer for approval. The Engineer shall be empowered to modify the policemen requirements if the Contractor's proposal is inadequate. The provision of policemen to assist in traffic control shall in no way relieve the Contractor of his obligations under the heading "Traffic Safety and Control". All costs of meeting this provision will be for the Contractor's account.

107.9 REMOVAL AND SALVAGING OF EXISTING SIGNS AND GUIDEPOSTS

All existing signs and guideposts, which must be removed in the execution of the Works, shall be carefully salvaged by the Contractor. Critical signs necessary for the protection of traffic such as stop signs shall be maintained. Maintenance, removal and salvage of signs and guideposts will not be paid for separately but shall be considered incidental to the Work.

107.10 ROADWAY MAINTENANCE

When the Works require disturbance of the surface of any existing roadway which is carrying public traffic, the Contractor shall, at his own expense keep the disturbed areas of the travelled lanes well graded, free of potholes and of sufficient width for the required number of travel lanes.

Prior to any prolonged shut down of construction, the Contractor shall ensure that any disturbed roadway surface is restored to a condition suitable for traffic operations as approved by the Engineer.

The Contractor will not be responsible for maintenance of those areas of any existing roadway which are to be constructed or reconstructed but which have not yet been disturbed by the Contractor's construction or hauling activities.

107.11 SEQUENTIAL ARROW BOARDS

When specified or directed by the Engineer, the Contractor shall use a sequential arrow board for the accommodation of traffic. The Contractor shall supply a sequential arrow board conforming to the following specifications:

(i) Minimum size 0.75m x 1.52m

(ii) 12-volt solid-state circuitry.

(iii) Minimum 25 amber sealed beam, hooded lamps.

(iv) Fully adjustable light intensity on all arrow board lights.

(v) Operating modes which include:

(a) sequential left arrow or chevron
(b) sequential right arrow or chevron
(c) sequential double arrow or chevron
(d) horizon bar
(e) all four lamps in the extreme corners of the panel flashing simultaneously at 35-50 flashes per minute with the flashing lights lit for 50% of the time.

107.12 DUST ABATEMENT

The Contractor shall keep detours and disturbed areas of existing roadways, which carry traffic free of excessive dust. The Contractor shall supply and apply all dust abatement materials at his expense.

If the Contractor fails to promptly undertake dust abatement measures, the Employer shall make other arrangements to have the work done, and deduct the cost of thereof from any money owing to the Contractor.

107.13 TEMPORARY CONSTRUCTION SIGNING

1. General

This Specification covers the installation, maintenance and removal of temporary signing and traffic control devices which are specifically related to construction, repair or emergency situations and which are generally removed when the Work is completed or the situation returns to normal.

2. Typical Drawings

The typical drawings for temporary construction signing are contained in Volume IV Drawings and entitled Proposed Traffic Management Plan – Temporary Works. Final signage details are subject to the approval of the Engineer.

3. Materials

The Contractor shall supply all signing materials including sign posts, weighted stands, brackets and any required mounting hardware and miscellaneous materials required for the erection of temporary construction signs.

All signs, barricades and other traffic control devices shall conform to the requirements for shape, colour and size specific in The Republic of Trinidad and Tobago Signing Manual. The orange portion of all signs, barricades and other traffic control devices shall be fully reflectorised using high brightness, retroreflective, non-metallised, prismatic sheeting material which incorporates durable, transparent, fluorescent, pigment and meets the following requirements.

BRIGHTNESS REQUIREMENTS (90º Rotation Angle)		
Observation Angle	**Entrance Angle**	**Orange**
0.2	-4	200
0.2	+30	92
0.5	-4	80
0.5	+30	50
A minimum Coefficient or Retro reflection (R_A) cd/fc/ft^2 (de. 1 x-1 m^{-2})		

Larger construction signs or oversized signs may be used where conditions require greater visibility in order to be effective. They shall be used in special circumstances where more than average attention value is required from the sign.

4. Equipment

The Contractor shall supply all equipment required to complete the Works.

5. Erection of Signs

Work on the Site shall not commence until all necessary temporary construction signs and all other traffic control devices as proposed in the traffic accommodation strategy are in place.

When signs require frequent moves, portable type signs, mounted on weighted stands, may be used. Portable signs shall be placed on the shoulder of the road such that the face of the sign is fully visible to oncoming traffic and the bottom of the sign is not less than 0.3m above the road surface. The stands shall be securely weighted and erected to ensure against being blown over by prevailing winds or gusts from passing vehicles.

Non-portable signs shall be conspicuously posted, and erected at right angles to the roadway, with the bottom of the sign at a height of 1.0m above the road, and not less than 2.0m or more than 6.0m from the nearest traffic lane.

Traffic signs and devices shall be moved and kept as close to the work area as practical, as construction proceeds. Objects within or immediately adjacent to the roadway which constitutes a hazard to traffic shall be marked with alternating black and orange stripes attached directly to the object or erected immediately in front of it.

The use of signs shall be held to a minimum to prevent confusion.

“STOP” signs shall be installed on all subsidiary roads (local, district, municipal, service or approach) intersecting a primary highway detour route.

6. Maintenance and Removal of Signs

Poorly maintained, defaced, damaged or dirty construction signs shall be replaced, repaired or cleaned without delay. Special care must be taken to ensure that construction materials and dust are not allowed to obscure the face of a sign.

Signs not in effect shall be covered or removed and all construction signs shall be removed after the project is completed.

7. Modifications to Temporary Construction Signing

The Contractor shall be totally responsibility for the supply and proper placement of temporary construction signs. However, in the case of potential danger to the travelling public or other circumstances where the Engineer determines that signing is inadequate, the Engineer will require changes to the Contractor's operations to remedy the situation. These changes may involve the use of different types and/or sizes of signs, modifying the number of locations of signs, and any other modifications or additions required to protect the safety of the travelling public.

8. Daily-Recording of Temporary Construction Signing

Each day as the work area changes, where applicable, the Contractor shall record the location of all temporary construction signs and any other traffic control devices used at the work areas. The Contractor shall record this information on a form suitable to the Engineer and shall submit it to the Engineer on a weekly basis or when requested.

9. Compliance

In cases where the contractor is not in compliance with the specifications and, in the opinion of the Engineer there is imminent danger to the travelling public, the Engineer has the authority to order the immediately suspension of Works. Such orders must be made in writing.

In other cases where the Contractor is not in compliance with the Specifications but, in the opinion of the Engineer the infraction is not causing imminent danger to the travelling public, the Engineer will use the following escalating process to address the situation:

(i) Issue verbal instructions requiring the Contractor to correct the infraction
(ii) Issue a written warning instructing the Contractor to correct the infraction
(iii) Issue a written order instructing the Contractor to suspend Works until the infraction is corrected to the satisfaction of the Engineer.

107.14 TEMPORARY SHORING, PROTECTION AND MAINTENANCE OF THE ROADWAY

The Contractor shall install temporary shoring for excavation, embankment construction and/or filling operations wherever required. The provision of shoring shall be undertaken in accordance with Specification Section 203 (Earthworks for Structures).

The Contractor shall implement the necessary measures to protect and maintain the roadway such that it is free of potholes, cracks and depressions in order to facilitate the continuous flow of traffic in accordance with the requirements of this section of the Specification

SERIES 200:
EARTHWORKS

SERIES 200: EARTHWORKS

SECTION 201: CLEARING, GRUBBING, DISMANTLING AND DEMOLITION

201.1 Description

201.2 General

201.3 Demolition and Clearing Buildings and Structures

201.4 Dismantling of Bridges and Structures

201.5 Clearing Bush

201.6 Grubbing

201.7 Clearing Trees

201.8 Dismantling and Transporting an Existing Bailey Bridge.

201.1 DESCRIPTION

The work to be performed under this Section consists in general of:

- The removal and satisfactory disposal from the Site, in the way of or otherwise affected by the Works as shown in the Drawings or as designated by the Engineer, of grass, trees and other vegetation including grubbing up of roots;

- The demolishing, breaking up, removing and satisfactory disposal of buildings (including all building appurtenances), structures, fences, poles, debris and superficial obstructions on the Site in the way of or otherwise affected by the Works as shown in the drawings or as designated by the Engineer. It shall not include for the demolishing of minor roadside structures such as sign foundations, slipper drains, kerbs (curbs), sidewalks, and the like, box drains up to 1m deep, or 750mm diameter or less pipe culverts and their headwalls which shall all be considered general excavation.

- Salvaging and preservation of designated materials and objects and the backfilling of resultant trenches, holes and pits.

201.2 GENERAL

The Engineer shall establish the right-of-way and construction lines defining the limits of areas to be cleared.

The Employer may withdraw from the Contract any or all of the items, which are designated for demolition in the Drawings and for which items are included in the Bills of Quantities.

All buildings, structures and other things to remain are as marked on the Drawings or as designated by the Engineer. The Contractor shall protect existing features to be retained and repair damage as specified by the Engineer. Any cut or scarred surfaces of trees or shrubs selected for retention shall be neatly cut back to sound wood.

No land monuments, property, markers or official data points shall be removed until an authorized agent has witnessed or otherwise referenced their locations and approved their removal.

The Contractor shall prevent all damage to pipes, conduits, wires, cables or structures above or below ground. Numerous underground services e.g., pipes, cables, ducts etc. exist and may be encountered. The services shown on the Drawings are provided only as a guide to the general location of major services.

The Contractor must consult with the appropriate utility authorities to determine these locations and the extent of all affected services and take the necessary precautions and measures for their care, protection and diversion. The Contractor will be required to bear the cost of such precautions and measures unless specifically stated otherwise on the Drawings.

The Contractor shall give notice in writing to each of the utility authorities owning or controlling any services or appurtenances which may be affected by demolition sufficiently

in advance of demolition to permit ample time for any utility authority to disconnect its services if deemed necessary. This notification must be made prior to the commencement of demolition of the structures.

The Contractor shall at this time furnish the Engineer with signed copies of the aforementioned notices. The Contractor shall co-operate with utility authorities in protecting such services and appurtenances as may be exposed to hazard during the work.

During the work or upon completion of the work, utilities or services shall be protected, capped or sealed in a manner required by the utility authority. The Contractor shall furnish the Engineer with the necessary compliance certificates.

The Contractor shall clear each part of the Site at times and to the extent required or approved by the Engineer. The sequence of demolition of buildings and major structures shall have the approval of the Engineer before the work is commenced. The Contractor shall not proceed with the demolition of a building or structure without the Engineer's written approval.

Demolition shall be carried out in such a manner as to cause as little inconvenience as possible to the owners or the public and the Contractor will be held responsible for any claims which may arise from the disregard of this clause.

All materials arising from demolition and clearance and declared by the Engineer as useful shall be the property of the Employer. They shall be carefully stockpiled (in separate stacks as per each category) at places designated by the Engineer within the Site. Any surplus material thereof, after reuse on the Works, when so ordered by the Engineer, shall be removed from the Site, transported to the place or places approved by the Engineer and stockpiled carefully for which the Contractor will be paid for separately.

All materials arising from demolition and clearance and declared by the Engineer as unsuitable for reuse shall become the property of the Contractor and he shall be responsible for its disposal.

Disposal by burning at Site is prohibited. Rather, materials should be disposed of at approved landfill sites in accordance with environmental requirements. The Contractor shall obtain written permission of the landfill Site owner for the use of the disposal area and bear any cost involved.

The Contractor shall keep the approach roads, the Works and all places occupied by him clear of refuse and rubbish that may accumulate from his operations and shall maintain such places in neat condition. When a local inconvenience is caused by dust, the Contractor shall apply water in such a way to alleviate this condition. The steps taken shall be approved by the Engineer.

No debris or other material required to be disposed of shall be dumped or placed within the limits or any existing projected public street or road nor shall any material be excavated without the written permission of the Engineer.

All surplus materials, earth, sand, rubbish and stone shall be removed from within the limit of the Works as the Works progress except such materials that are retained by order of the

Engineer. During the execution of the Works the Contractor shall keep the Site clean. The Contractor must remove from the Site all stains and defacements caused by his operations.

201.3 DEMOLITION AND CLEARING BUILDINGS AND STRUCTURES

Demolition work shall be carried out without damage to parts of the structure or adjoining property that is to remain. If such damage occurs during the carrying out of demolition, the Contractor shall reinstate and make good such damage at his own expense. All reinstatements shall be executed with materials and workmanship to match in every respect the surrounding work and is to be properly bonded thereto.

The Contractor shall provide all necessary plant, scaffolding, planks, etc. for proper protection and execution of Works.

For the partial demolition of buildings or structures the Contractor shall provide, erect and maintain all necessary shoring to the satisfaction of the Engineer. The construction and efficiency of shoring for the purpose for which it is erected shall be the responsibility of the Contractor. Should any subsidence or any other damage occur due to the inefficiency of the shoring or any other support provided, the damage shall be made good by the Contractor at his own expense.

The Contractor shall notify the relevant utilities well in advance of operations to allow them time to remove their fixtures, fittings or services.

Structures, electrical, telephone, water, sewer or other services that come within the area to be demolished shall be disconnected or diverted so that they may be entirely self-contained within any portion of the premises which is to remain.

Where floors of the partially demolished building are exposed to the outside air, the Contractor shall provide and erect 1m from edge of the floor, temporary frames, and close-boarded screens, with access doors, fastenings, etc.

The Contractor shall make arrangements for the security of the Works and the partially demolished property during these Works. This cost is to be borne by the Contractor.

Underground structures and chambers shall be demolished to the level of excavation or to the depths shown in the drawings and as designated by the Engineer. They shall be properly cleaned out and wherever there are to be abandoned shall be filled with suitable excavated material in layers of not more than 150mm (compacted thickness) and compacted in compliance with Section 203 (Earthworks for Structures) or as directed by the Engineer. All surplus soil and excavated materials unless otherwise ordered by the Engineer, shall be spread over the ground and sectioned neatly to the lines and grades designated by the Engineer.

201.4 DISMANTLING OF BRIDGES AND STRUCTURES

When the Contract calls for dismantling of the existing bridge structure, the Contractor shall remove the existing piers and abutments to the elevations indicated on the Drawings. Material removed from the existing bridge structure shall be disposed of as provided in the Specifications or as directed by the Engineer. In general, old concrete shall be disposed of as provided in the Specifications or used for rip-rap or deposited adjacent to the Site in

areas approved by the Engineer, but shall not be left in the watercourse. If the old concrete is to be used for rip-rap, protruding reinforcing steel shall be cut off.

Structural steel and timber members which are suitable for re-use shall be match-marked as directed by the Engineer and dismantled at all original field connections unless directed otherwise. Rivets shall be removed by cutting the rivet heads or by burning, provided that care is used not to damage the rivet holes. All portions of the rivets shall be completely removed from the members. Welded connections shall be dismantled by cutting the weld metal out. Nuts, bolts and washers are to be removed from bolted connections ensuring that the connecting hardware and bolt holes are not damaged during the loosening and removal processes.

Structural steel and timber members to be stored shall be supported on blocks above the ground so as to be kept clean and dry at all times. The blocks shall be placed close enough together to prevent injury to the members from deflection.

Where the Contract calls for the dismantling of the existing modular bridge, the Contractor shall remove the components of the modular bridge with due care so as not to damage the respective parts of the bridge. The Contractor shall provide a method statement for the removal procedure in compliance to the manufacturer's specifications to the Engineer prior to the commencement of the dismantling process. The dismantled bridge parts are to be transported to the Employer's depot.

Explosives shall not be used for demolition work.

201.5 CLEARING BUSH

Bushes, undergrowth, hedges, tree stumps up to 300mm in girth and small trees, the trunks of which are more than 150mm and up to 300mm in girth, up to 3m above ground level, are classified as bush for purposes of this section. The area of the bush to be cleared shall be as shown in the Drawings or as designated by the Engineer.

The area of bush to be cleared shall be scrupulously uprooted and the material arising thereof shall be the property of the Contractor and disposed of by him, as approved by the Engineer, at his own expense.

201.6 GRUBBING

The work to be performed under grubbing consists of grubbing, cutting and removal of all grass, vegetation, organic sod, top soil, organic earth, roots and other objectionable material from the areas to be excavated, filled, graded, constructed on and other areas designated to be stripped.

Where the Contractor has completed these Works as specified he will be paid in accordance with the rates tendered in the Bill of Quantities but where the Contractor has to return to areas where work has been previously completed, due to his own fault, no additional payment will be made.

The areas for clearing and grubbing shall be as shown on the drawings or as designated by the Engineer. The total depth to be grubbed shall be a minimum of 300mm in areas where the soil conditions permit, and a maximum of 500mm where the conditions require such a depth to be grubbed. Where the Contractor has to excavate beyond 500mm in depth, all

Works shall conform to Section 202 (General Excavation).

All grass, brush and trash shall be removed together with all roots, stumps; organic sod and other waste materials shall be the property of the Contractor and disposed of by him, as approved by the Engineer, at his own expense.

Areas where fill is required for construction, all provisions made in this section shall be adhered to before any fill material can be placed as designated by the Engineer.

All materials such as topsoil, earth, sand and stone obtained in the operation of grubbing shall be carefully and separately stockpiled on Site at places designated by the Engineer. All material deemed reusable shall become property of the Client and it shall be reused wherever possible.

201.7 CLEARING TREES

Where shown in the drawings or designated by the Engineer, all trees shall be uprooted and cut down as near to the ground level as possible. All felled timber designated by the Engineer as useful shall be the property of the Employer. Such timber shall be cut in even 1m increments between 2m to 14m in length and stacked in orderly fashion at places within the Site as indicated by the Engineer. If the Engineer so desires, the surplus useful felled timber shall be transported out of the Site and carefully deposited and stacked in an orderly fashion at places designated by the Engineer, for which the Contractor will be paid for separately. All felled timber and other material designated by the Engineer as not suitable for use shall be the property of the Contractor to be disposed of, as approved by the Engineer, at his own expense.

Stumps and tree roots left after felling the trees shall be grubbed up scrupulously. The material arising thereof shall be the property of the Contractor and shall be removed, as approved by the Engineer, off of the Site at his expense. Holes left by the stumps and roots shall be filled with suitable excavated material and compacted in layers of not more than 150mm (compacted thickness) and compacted in compliance with Section 203.

In forested areas, all Specifications above will be adhered to and the areas where the trees will have to be removed shall be shown on the drawings or designated by the Engineer. Where the Contractor removes trees not marked for removal he will be responsible for the replanting the number of trees removed without authorisation and all material obtained once useful shall become the property of the Employer and will transferred to a location of the Employer's choice, at no cost to the Employer.
The Contractor is to note that prior to commencement of clearing, the Forestry Division of the Ministry of Agriculture, Land and Fisheries will select specific trees for removal by their own means. The Contractor will be required to liaise with the Forestry Division to arrange a joint inspection.

The Contractor shall ensure all required tree felling permits are obtained and relevant personnel are briefed on Health and Safety regulations before felling of trees can occur.

For isolated trees, all specifications above shall be adhered to and they shall be identified on the drawings or be designated by the Engineer.

201.8 DISMANTLING AND TRANSPORTING AN EXISTING MODULAR BRIDGE

Where the existing structure is a modular bridge, the Contractor will be required to dismantle the bridge in accordance with the manufacturer's and MoWT specifications, prepare a detailed inventory listing of all parts and deliver to the Employer's designated depot. The inventory list shall be approved by the Engineer prior to parts and materials leaving the Site. The Contractor shall supply transmittal signed by the MoWT confirming receipt of the parts.

SERIES 200: EARTHWORKS

SECTION 202: GENERAL EXCAVATION

202.1 Description

202.2 Definitions

202.3 Excavation

202.4 Blasting of Rock

202.5 Excavated Materials

202.1 DESCRIPTION

General Excavation shall comprise excavation, grading and formation of side slopes, in all soils including rock and existing roadway material as defined below and depositing in stockpiles for use within the works or disposal, as approved by the Engineer, to approved landfill off Site. It shall also include excavation in river channels.

It shall not include excavation for structures, box culverts and any other excavation that can be classified as structural excavation. It shall include for excavation in river channels and the like, outside of the limits of structures.

It shall not include for excavation for gabion walls, pipe culverts, box drains, and the like which shall be included in the pay items for these work items.

It shall include for benching specified to meet the requirements of Section 205 – Embankment.

The scope shall also include for shaping the river channel to the designed dimensions.

202.2 DEFINITIONS

Definition and classification of Earthworks materials are as follows:

(i) "Top Soil" shall mean the top layer of soil that can support vegetation.

(ii) "Suitable material" shall comprise all that which is acceptable in accordance with the
Contract Specifications for use in the Works.

(iii) "Unsuitable material" shall mean other than suitable material and shall comprise:
- material from swamps, marshes and bogs;
- peat logs, stumps and perishable materials;
- material susceptible of spontaneous combustion;
- clay of liquid limit (LL) exceeding 90 and/or plasticity index (PI) exceeding 65;
- materials having a moisture content greater than the maximum permitted for such materials in the Contract.

(iv) "Rock" shall mean those geological strata or deposits which require the use of blasting techniques for their removal but excluding individual masses having volumes of less than 0.2 cubic metre. The criteria to be used to establish the need for blasting shall be that a Caterpillar 325 excavator or similar in good working condition with a rock bucket cannot excavate such material when encountered one metre below ground level.

(v) "Existing roadway material" includes all materials contained in the roadway. Classification under "Existing roadway material" shall be by decision of the Engineer.

(vi) "River Channel" excavation shall mean the excavation of material from the sides, up to the level of the top of the bank forming the channel, and bottom of channels that

contain a constant flow of water throughout the year.

(vii) The Contractor shall be at liberty to use any method he wishes to use for excavating any class of material, subject to the provisions elsewhere in the Contract, but the method of excavating the material shall not dictate the classification of the excavation. The Engineer shall decide under which one of the classes any excavation shall be classified for the purposes of payment. In the event of disagreement between the Contractor and the Engineer, the Contractor shall undertake the necessary materials testing required to confirm the material designations. The decision of the Engineer as to the classification shall thereafter be final and bidding.

202.3 EXCAVATION

The Contractor shall submit to the Engineer not less than 28 days in advance of the start of excavation, his proposed method of excavation and the type of equipment that would be used for carrying out the excavation and the Contractor shall not commence until the Engineer's approval has been given.

The Contractor shall employ only that plant which is suited to the soils to be handled. He shall not at any time use any plant, which damages or reduces the natural strength of the soil either in its in-situ state or during handling and placing or in its final compacted state.

The Contractor is required to excavate to levels, grades and slopes as described in the Contract and the finished cut surfaces shall be machine dressed and left with even surfaces.

Where any material below formation level in cuttings or below the natural ground level under embankments is required to be excavated, it shall be removed to such depth and over such areas as are described in the Contract or as directed by the Engineer and shall be paid for as unsuitable material.

Excavation operations shall be conducted so that material beyond slope limits is undisturbed.

Naturally occurring unstable subgrade material shall be undercut below normal subgrade elevation when so indicated on the Drawings or as directed by the Engineer. It shall be replaced with approved material in accordance with Section 205 – Embankment at the cost of Employer. If, in the Engineer's opinion, firm subgrade has become unstable because of the Contractor's poor practices, e.g., failure by neglect to keep cut free of water, the Contractor shall, at his own expense, by repair or replacement, provide a subgrade satisfactory to the Engineer.

Construction plant shall not use the surface of the bottom of a cutting or excavation at a level less than 300mm above formation/subgrade level. Any damage arising from such use of the surface shall be made good by the Contractor at his own expense with approved material in accordance with Section 205. Where the excavation base will form the subgrade and is an expansive clay the 300mm layer will be retained in place until such time as the Contractor is ready to place the capping layer. Once the layer is removed the subgrade shall be treated in accordance with Section 204 – Preparation of Subgrade and capping placed over the subgrade within 24 hours.

Excavations areas shall be maintained free of all water at all times during construction. The

Contractor shall arrange for the rapid dispersal of water off the earthworks or completed formation during construction, and for the disposal of water which enters the excavation from any source, and when practicable the water shall be discharged into the permanent outfall for the drainage system. Adequate measures shall be taken to prevent the pollution of existing watercourses.

The Contractor shall provide where necessary temporary watercourses, ditches, drains, pumping or other means of maintaining the earthworks free from water. Such provision shall include carrying out the works in such a manner that their surfaces have at all times a sufficient minimum crossfall and where practicable a sufficient longitudinal gradient to enable them to shed water and prevent ponding. The Contractor shall construct all such ditches so as to avoid eroding adjacent banks. All ditches dug by the Contractor shall be maintained and kept free from debris by him until final acceptance of the Works.

The Contractor shall ensure that excavations in river channels are undertaken so as to minimise disruption to flow and so as to maintain an adequate water way cross section for the flows anticipated in the season of year. All excavated material shall be deposited outside of the river channel and no plant shall remain in the channel overnight or when the Site is unoccupied. No equipment or temporary works will be placed within the existing channel without the Engineer's prior approval and the agreement of the authority responsible for the channel.

Slope adjustments shall be made as shown on the Drawings or as directed by the Engineer to avoid injury to standing trees, to harmonize with landscape features or to arrive at a more stable condition. Gradual transitions shall be made to these adjusted slopes and at intersections between cuts and fills so that a pleasing effect results with no noticeable breaks in grade.

Material outside the planned roadway or ditch slopes (that is unstable and constitutes potential slides in the opinion of the Engineer), material from slides which has come into the roadway or ditches, and material which has slipped out of new or old embankments shall be excavated and removed. The material shall be excavated to designated lines or slopes either by benching or in such a manner as directed by the Engineer.

The Contractor shall be responsible for the location, care and protection of any underground piping, conduit or cables or any other subsurface lines or structures that may be encountered and for any damage caused to same by his operations.

For excavation in river channels, the Contractor shall shape the river bed and the sides of the channel in accordance with the dimensions shown on the Drawings. This work shall include compaction of the river bed and side slopes.

202.4 BLASTING OF ROCK

When the use of explosives is necessary for blasting of rock for the execution of the work, the Contractor shall exercise the utmost care not to endanger life or property, including the Works. The Contractor shall be responsible for all the damage resulting from the storage, handling and use of explosives and shall conform with the appropriate laws and regulations relating to the handling, transportation, storage and use of explosives. The Contractor shall at all times make full arrangement with and inform well in advance and obtain such permission as is required from all government authorities, public bodies and private parties

whatsoever concerned or affected or likely to be concerned or affected by blasting operations

The written consent of the Engineer shall be obtained on each occasion the Contractor wishes to use explosives.

The Contractor shall provide to the Engineer prior to undertaking any blasting operation copies of the blasting licences of his personnel responsible for the blasting together with any other legal authority necessary to undertake blasting. The Contractor shall not use or bring on to the Site any explosives of any kind without the prior consent of the Engineer in writing. Permission to use explosives given in accordance with this Clause shall not absolve the Contractor from any liability in respect of damage to public or private property.

The Contractor shall store explosives in manner in compliance with all laws and ordinances in a licensed store or magazine provided with a separate compartment for detonators, approved by the Engineer.

Explosives shall be handled only by currently licensed shot firers. The Contractor shall ensure that there is no unauthorised issue or improper use of explosives brought on the Site and shall maintain a strict check on quantities issued and consumed. The requirements of the Explosives, Factories, Health and Safety Acts and the requirements of the Local Authority shall be strictly complied with.

Any explosive to be used on the Site shall be removed from the magazine immediately before it is required and any unused explosive shall be returned to the magazine before dark the same day. All explosives shall be guarded by no less than two armed guards from the time it leaves the magazine to the time it is fired or is returned to the magazine.

The Contractor shall notify each property owner and public utility company having structures or facilities in proximity to the Site of the work of his intention to use explosives. Such notice shall be given sufficiently in advance to enable them to take such steps as they deem necessary to protect their property from injury.

When blasting is to be carried out, the Contractor shall determine the danger zone likely to be created and ensure, by the use of heavy blasting mats when necessary to prevent material being projected, that no damage is caused to persons or property on or off Site. When engaged in blasting operations post sufficient warning flagmen to the full satisfactory of the Engineer

Plaster shooting shall not be permitted within 400m of any building or structure.

Where blasting is proposed adjacent to a building or other structure, existing or under construction and being part of or outside the Works, the Contractor shall satisfy the Engineer, by preliminary Site trials, that safe values of vibrational amplitude and particle velocity will not be exceeded. Unless otherwise agreed by the Engineer the vibrational amplitude shall not exceed 50mm/s where blasting is confined to single events and 25mm/s where blasting is frequently repeated. Vibrograph readings shall be recorded throughout the period of blasting or as required by the Engineer.

No loaded holes shall be left unfired at the close of work.

Costs for permits and related costs and expenses necessary to obtaining, delivering, using

and guarding explosives is a subsidiary obligation of the Contractor and no direct payment will be made therefore.

202.5 EXCAVATED MATERIALS

All suitable materials arising from any excavation shall be vested in the Employer until such time as it is defined as surplus to the Employer's requirements. Until such material is so defined the Contractor shall remain responsible for the safe keeping of the material and should such material be lost to the works it shall be replaced by the Contractor at his expense.

All the excavated materials shall be deposited or stockpiled (separately as per each category defined in paragraph 202.2 of this Section) within or adjacent to the Site at places provided by the Contractor and approved by the Engineer.

All materials arising from the excavation and declared by the Engineer as unsuitable for use shall become the property of the Contractor to be removed off the Site and disposed of at approved landfill sites only. The Contractor shall obtain written approval of the Engineer for the use of disposal locations and bear any costs involved in the use of that location.

Surplus suitable material, when so ordered by the Engineer, shall be removed from the Site, transported to a place or places designated by the Engineer and carefully stockpiled. Otherwise, surplus material shall become the property of the Contractor to be removed off the Site and disposed of at approved landfill sites.

SERIES 200: EARTHWORKS

SECTION 203: EARTHWORKS FOR STRUCTURES

203.1 Description

203.2 Utilisation of Excavated Material

203.3 Material for Structural Backfill and Foundation Fill

203.4 Construction Requirements

203.1 DESCRIPTION

Work under this section shall include the earthworks generally required for construction of bridge substructures such as abutments and piers, bridge approach structures, box culverts, retaining walls, silt traps and other works in accordance with the Plans or as directed by the Engineer.

Structural earthwork shall include, in addition to the necessary excavation, backfilling operations to the original ground elevation using the excavated or imported material as directed by the Engineer.

Unsuitable excavated material shall be disposed only in a location approved by the Engineer and in a manner that will not contribute to the pollution of the surrounding area, stream or channel.

This work shall also include the construction of all cribs, cofferdams, dikes, berms or other devices necessary for the work, the protection, dewatering and maintenance of the excavated region.

No distinction shall be drawn between wet and dry excavation, the prices being the same for both.

Clearing and grubbing shall be considered an incidental part of earthworks for structures excavation and shall be inclusive with the various pay items under this Section.

Test certificates from an independent testing agency, approved in advance by the Engineer, shall be submitted prior to the materials being brought to the Site confirming that the proposed materials conform to the requirements of this Specification Section. Test certificates for material source approval shall be dated not more than three (3) months in advance of the date when the materials are to be brought to the Site for incorporation within the Works.

Quality control testing of materials during execution of the Works shall conform to the frequency and specified types of tests as detailed in these Specifications.

203.2 UTILISATION OF EXCAVATED MATERIAL

Excavated material and material recovered from temporary works shall, if suitable, be stockpiled for use as fill or backfill. Material unsuitable for use as backfill or in excess of the required quantity, or rock shall be spoiled or utilised as directed by the Engineer.

203.3 MATERIAL FOR STRUCTURAL BACKFILL AND FOUNDATION FILL

1. Selected Structural Backfill

Selected Structural Backfill shall be a material yielding a minimum California Bearing Ratio (CBR) value of 15% and shall have an angle of internal friction of not less than 33 degrees. The angle of internal friction shall be determined by the direct shear test in accordance with AASHTO T 236.

2. Selected Granular Material for Structural Backfill

Select granular material to structures, including gabions, shall consist of stone, sand, gravel or other acceptable granular material. All of the material for this item shall be well-graded and shall have a uniformity coefficient (C_u) greater than 4.0. All of the material shall pass the 75mm sieve, with not more than 40% by weight passes the 0.425mm sieve and not more than 10% by weight passes the 0.075mm sieve. In addition, the Liquid limit shall be less than 27%; Plasticity Index less than 5%; and the 4 day soaked CBR not less than 20%.

3. Foundation Fill

Material to be used for fill under foundations shall be of at least sub-base quality as defined in Section 302 – Sub-Base.

203.4 CONSTRUCTION REQUIREMENTS

1. Access and Drainage

The Contractor shall effect all necessary sheeting, bracing, cribs, cofferdams, artificial islands and piling platforms etc. in order to carry out the works. These and any temporary drainage works shall be removed on completion of the Permanent Works.

Special care shall be exercised to keep the Site of and all excavation free from water. The Contractor shall arrange for the rapid disposal of water from the earthworks during construction and when practicable, the water shall be discharged into the permanent drainage system. Adequate means to trapping silt shall be provided on temporary drainage systems.

The Contractor shall provide where necessary temporary water courses, ditches, drains, pumping or other means of maintaining the earthworks free from water. Such provisions shall include carrying out the work of forming the cuttings and embankments in such a manner that their surfaces have at all times a sufficient longitudinal gradient and minimum crossfall to enable them to shed water and prevent ponding.

The Contractor shall be responsible for the care and protection of any underground piping, conduit or cable, or any other sub-surface lines or structures that may be encountered, and for any damage caused to same by his operations. The Contractor shall maintain and keep open and free from leaves, sticks and other debris, including silt, all ditches dug by him until final acceptance of the Works.

No additional payment will be made for Temporary Works.

2. Excavation, Shoring and Underpinning

Trenches and pits for structures or structure foundations shall be excavated to the lines, grades and elevations shown on the Drawings. They shall be of sufficient size to permit the placing of structures or structure foundations to the full length and width shown. Boulders, logs, and other objectionable material encountered in

excavation shall be removed. All excavations shall be in compliance with Sections 103 and 104 of the Technical Specifications in addition to the applicable sections of the Occupational Safety and Health Act 2004 and the Occupational Safety and Health (Amendment) Act 2006.

The sides of excavations shall, where necessary, be battered back or be adequately shored by timber or by other means, and all such excavations shall be to sizes sufficient to enable the concrete structures to be laid accurately, and proper refilling and compacting be carried out. Shoring shall be in accordance with relevant standards which may include, *inter alia,* ASTM standards for the use of structural steel or American Welding Standard (AWS) for pipe, plates and other sections or National Design Council (NDS)/American Wood Preservers Association (AWPA) for structural use of timber.

The Contractor shall take all precautions necessary for the safety of adjoining structures. Such measures may include shoring, sheet piling, staggered excavation in short lengths or otherwise as approved by the Engineer.

Shoring is the provision of a support system for open excavation faces to prevent movement of soil, roadway and foundations. The design of the shoring system shall comply with OSHA standards and accepted Engineering Practices to ensure the stability of adjacent structures and road carriageway or other disruptions that have the potential to extend into the failure zone of the excavation. The execution of the shoring system shall comply with the requirements of Sections 103 and 104 of the Technical Specifications.

The Contractor shall provide working drawings, accompanied by engineering calculations where appropriate, of excavation procedures, embankment construction and backfilling operations. These drawings shall show the details of shoring, bracing, slope treatment, and/or other support system proposed for use and shall be accompanied by engineering design calculations and supporting data in sufficient detail to permit an engineering review of the proposed design.

The Contractor shall take into consideration the Site conditions and relevant loads in the design of the shoring, bracing, slope treatment, and/or other support system. Such loads may include, but not be limited to, the following:

- Live load due to adjacent road traffic
- Other live loads
- Dead load
- Active earth pressure due to soil
- Passive earth pressure due to soil
- Active earth pressure due to surcharge loads (for example, construction materials, construction equipment, foundations from adjacent structures, and the like)
- Active earth pressure due to sloped embankment
- Hydrostatic pressure due to groundwater table and/or water infiltration from surface water runoff
- Buoyancy
- River flow pressure

Engineering calculations, drawings and method statements shall be prepared and sealed by a Registered and/or Professional Civil/Structural Engineer. Engineering calculations shall include, but not be limited to, the following:

- List of all assumptions used to design the shoring, bracing, slope treatment, and/or other support system
- Clear indication of input and output data for computerised calculations and programmes
- Sample calculations with values to support computerised output and which match the calculated computer result.
- Simple free body diagram showing all controlling dimensions and applied loads
- Calculated lateral deflections of the shoring, bracing and/or other support system
- Design code references which support design assumptions and calculations
- Proprietary bracing/shoring manufacturer's recommendations which support design assumptions and calculations

Where available, detailed geotechnical information for the Site will be provided by the Employer to assist the Contractor with the preparation of the required engineering calculations, method statements and drawings. The working drawings, calculations and method statements shall be submitted at least twenty-one (21) days in advance of proposed use to allow for their review, revision, if needed and approval without delay to the Works.

The Contractor shall not carry out any excavation and/or backfilling Works unless:

1. The working drawings, calculations and method statements have been approved by the Engineer.

2. The Registered and/or Professional Civil/Structural Engineer responsible for the design of the shoring, bracing, slope treatment, and/or other support system writes a letter to the Engineer certifying that construction of the shoring, bracing, slope treatment, and/or other support system was completed by the Contractor in accordance with the working drawings and meets their approval.

The shoring, bracing, slope treatment, and/or other support system shall not be removed until the new structures have acquired sufficient strength to support their weight and loads superimposed thereon safely. In no case shall the shoring, bracing, slope treatment, and/or other support system be removed until the time and sequence has been approved by the Engineer.

Approval by the Engineer of the design, installation and removal of the shoring, bracing, slope treatment, and/or other support system shall not relieve the Contractor of any responsibility under the Contract for the successful completion of the Works.

The elevation of the bottom of footing, as shown on the Drawings shall be considered as approximately only and the Engineer may order, in writing, such changes in dimensions or elevations of footings as may be deemed necessary to secure a satisfactory foundation. Poor foundation material shall be removed and disposed of as directed by the Engineer. The resulting additional excavation shall be backfilled with Class 9 concrete or with concrete of the same class as the footing or foundation fill, at the Engineer's instruction.

The Contractor shall notify the Engineer after each excavation is completed and no blinding, foundation, bedding material or box culvert shall be placed until the Engineer has approved the depth of excavation and the character of the foundation material. When the footing is located in a stratum of soil material other than rock, excavation to final grade shall not be made until just before the blinding concrete is to be placed.

Excavation in hard rock formations should, where possible, be done without use of blasting techniques. Pneumatic tools of adequate power may be used as deemed necessary and as approved by the Engineer.

All rock or other hard foundation material shall be cleaned of all loose material and cut to a firm surface, either level, stepped or serrated, as shown on the Drawings or directed by the Engineer. All seams and crevices shall be cleaned out and grouted with an approved grout. All loose and disintegrated rock and thin strata shall be removed. When the footing is to rest on material other than rock, excavation to final grade shall not be made until just before the footing is to be placed.

3. Foundation Fill

Foundation fill shall be constructed in layers not exceeding 150mm in thickness after compaction. Each layer shall be moistened or dried to the optimum moisture content for the material and compacted to a density of not less than 95% of Modified Proctor density as determined by AASHTO T 180.

4. Structural Backfill

Excavated areas around structures shall be backfilled with approved material in horizontal layers not exceeding 150mm in thickness after compaction, to the level of the original ground surface. Each layer shall be moistened or dried to the optimum moisture content for the material and then compacted to a density of not less than 95% of Modified Proctor density for soils and gravels, and not less than 100% of Modified Proctor density for cohesionless sands, or the density of the surrounding soil, whichever shall be the lesser, except that, in the road prism, the material shall be compacted to a density of not less than 95% of Modified Proctor density.

In placing backfill or embankment against an abutment, pier or wall, the material shall be placed simultaneously to approximately the same elevation on both sides of the structure. If conditions require placing backfill or embankment appreciably higher on one side than on the other side, the additional material on the higher side shall not be placed until permission shall have been given by the Engineer and preferably not until the concrete or masonry has been in place 14 days or until tests made by the laboratory establishes that the concrete or masonry has attained sufficient strength to withstand any pressure created by the methods used in placing of the materials without damage or strain beyond its safe factor.

Backfill or embankment to the sidewalls of box culverts shall be carried up simultaneously on both sides of the culvert and to associated sidewalls or abutments.

Quality control testing shall be in accordance with Section 205 – Embankment.

SERIES 300:
ROAD WORKS

SERIES 300 ROADWORKS

SECTION 301 OVERALL REQUIREMENTS

301.1 Description

301.2 Construction Requirements

301.3 Quality Control Testing

301.1 DESCRIPTION

This Section describes the overall requirements for the pavement layers, both gravel or granular and bituminous. It gives the required tolerances for horizontal alignment, surface levels and surface regularities of pavement courses and describes methods of rectification where those tolerances are exceeded. It gives overall requirements for use of the surfaces by construction traffic, as well as defining the layer thicknesses required for the road pavements included in the Contract.

Related Sections include the following:

Section 204	-	Preparation of Subgrade
Section 302	-	Sub-Base
Section 303	-	Granular Surface Course
Section 304	-	Granular Base Course
Section 306	-	Bituminous Mixes
Section 307	-	Bituminous Base Course
Section 308	-	Bituminous Binder Course
Section 309	-	Bituminous Surface Course

301.2 CONSTRUCTION REQUIREMENTS

1. Horizontal Alignments

Horizontal alignment shall be determined as shown on the Drawings. The edges of all carriageways as constructed shall be correct within a tolerance of ±13mm horizontally as shall the edges of all bituminous or concrete layers. The tolerances for unbound underlying layers shall be ±25mm.

2. Surface Levels of Pavement Courses

The levels of all pavement courses shall be determined from the true pavement surface which shall be the surface of the surface course, calculated from the carriageway vertical profile and cross-fall as shown on the Drawings. The vertical tolerance of any point on the surface of the formation or pavement courses shall be in the range given in Table 301.1.

Surface	Vertical Tolerance
Subgrade	±25mm
Sub-base	±20mm
Non-Bituminous Road-base	±12mm
Bituminous Layers	±6mm

Table 301.1
Vertical Tolerances of Pavement Courses and Formation

The finished level of the laid surface course shall not deviate vertically at any point from the true pavement surface by more than ± 6mm. However, the combination of permitted tolerances in different pavement levels shall not result in a reduction in

thickness of the wearing course of more than 5mm from that specified for a bituminous road, nor a reduction in the thickness of the whole pavement, above the sub-base, of more than 15mm from the specified thickness.

For checking compliance with Table 301.1, measurements of surface levels will be taken at 10m centres longitudinally and at 2m centres transversely, starting 1m from the edge of the carriageway. In any length of carriageway, compliance with the requirements of Table 301.1 shall be regarded as met when not more than one measurement in ten exceeds the tolerances permitted in Table 301.1, but this one measurement shall not exceed 5mm more than the tolerances for the layer concerned.

3. Surface Regularity

Longitudinal irregularities of the surfaces of constructed surface courses and base and binder courses shall be within the relevant tolerances stated in the Table 301.2. An irregularity is a variation not less than 4mm or 7mm of the profile of the road surface as measured by a rolling straightedge, set at 4mm or 7mm as appropriate.

	Surface Course of Carriageway				**Base and Binder Course of Carriageway, Surface Course of Hard Shoulders**			
Irregularity	4mm		7mm		4mm		7mm	
Traverse Length	300m	75m	300m	75 m	300m	75m	300m	75m
Mainline Roadway	20	9	2	1	40	18	4	2
Other Pavements (Access Roads)	40	18	4	2	40	27	6	3

Table 301.2
Maximum Permitted Number of Surface Irregularities

Compliance with Table 301.2 shall be tested by a rolling straightedge of the type designated by the British Transport Research Laboratory (TRL) or an approved wedge and straightedge device operated parallel to the centre line of the carriageway and 1.2m from the near side edge of each lane of the carriageway. If a rolling straight edge is used, it should be maintained and used as recommended by the TRL.

The traverse length of 300m and its associated numbers or irregularities shall apply wherever the continuous length of completed carriageway is 300m or more, whether or not it is constructed to shorter lengths.

For lengths less than 75m, the laid pavement surface and the surface of the bituminous base and binder courses shall be tested with a 3m straightedge placed parallel and at right angles to the centreline of the road. The laid surface and binder course surfaces and the surface of the bituminous base course shall have no greater depression under the straightedge than 3mm and 6mm, respectively.

4. Rectification

Where any tolerance is exceeded, the Contractor shall determine the full extent of the area that is out of tolerance and shall make good by rectifying the surface of the

pavement course or formation in the manner described below:

(i) Formation Level
If the surface is too high, it shall be re-trimmed and re-compacted in accordance with Section 204. If the surface is too low, the deficiency shall be corrected by the addition of fresh suitable materials of the same classification, laid and compacted to specification.

(ii) Granular Base Course and Sub-Base
Where these consist of unbound material, the top 75mm shall be scarified, reshaped with added material as necessary and re-compacted, all to these specification. The area treated shall normally be not less than 30m long and 2m wide, or such area to be determined by the Engineer as necessary to obtain compliance with the Specification.

The Contractor may at his own expense and only with the approval of the Engineer, make up low areas with the material of the layer immediately above the one being rectified.

(iii) Courses of Bituminous Mixtures
Rectification of surface level errors shall be by replacement of the full layer depth for the full lane, or layer width if less for a minimum length of 15m for the final surface course and 5m for all other courses.

Rectification of surface irregularities in excess of the specification shall be by replacement of the full lane width over either the full 300m or 75m length over which the out of specification irregularities occur, or such lesser length as the Engineer may direct to bring the surface into conformity with the specification.

5. Use of Surfaces by Construction Traffic

Construction traffic using pavements under construction shall be suitable in relation to the thickness of the courses it traverses so that damage is not caused to the subgrade or the materials already constructed.

The wheels or tracks of plant moving over the various pavement courses shall be kept free from deleterious materials.

301.3 QUALITY CONTROL TESTING

(a) General

The materials supplied and works carried out by the Contractor shall conform to the specifications as prescribed in the appropriate Clauses.

For ensuring the requisite quality of construction, the materials and Works shall be subjected to quality control tests by the Contractor, as described hereinafter, detailed in the 'Quality Control Manual' produced by the Contractor (refer to Clause 102.6), or as directed by the Engineer. The testing frequencies included in these Specifications are the desirable minimums.

The Engineer shall have the full authority to carry out additional tests as frequently as he may deem necessary to satisfy himself that the materials and works comply with the appropriate specifications and the Contractor shall allow reasonable time within his works programme for this to be done.

Test procedures for the various quality control tests are indicated in the respective Sections of the Specifications or for certain tests within this Section. Where no specific testing procedure is mentioned, the tests shall be carried out as per the prevalent accepted engineering practice to the directions of the Engineer.

(b) Compaction Control:

Insitu density tests of granular and cement and lime stabilized materials shall be carried out in accordance with AASHTO T-310 or AASHTO T-191 unless otherwise authorised by the Engineer in writing. The intensity of testing shall be such as to give a minimum of 5 tests for a section of work constructed with essentially the same materials and plant with a minimum of one measurement of density for each 250 square metres of compacted area, or 5 for evaluating a day's work. Test locations shall be chosen only through stratified random sampling techniques in accordance with ASTM D 3665. Control shall not be based on the result of any one test but on the mean value of a set of 5 to 10 density determinations. The number of tests in one set of measurements shall be 5 as long as it is felt that sufficient control over uniformity of borrow material and the method of compaction is being exercised. If considerable variations are observed between individual density results, the minimum number of tests in one set of measurements shall be increased to 10. The acceptance of work shall be subject to the condition that the mean dry density equals or exceeds the specified density and the standard deviation for any set of results is below 0.08g/cm^3.

(c) Tests on Sub-Bases and Bases (excluding bitumen bound bases)

The tests, using AASHTO, ASTM and/or BS test procedure numbers, and their frequencies for sub-base and base shall be as given in Table 301.3. The intensity of testing and evaluation of density results for compaction control shall be as given in the preceding paragraph "(b) Compaction Control".

Types of Construction	**Test**		**Frequency**
Granular Sub-Base	(i)	Grain Size Analysis; T88 & T11	One test per 500m^3
	(ii)	Atterberg Limits; T89 & T90 using wet preparation T146	One test per 500m^3
	(iii)	Resistance to Degradation (LAA); T96 Grading A	One test per 1000m^3
	(iv)	Flakiness Index; BS 812	One test per 250m^3
	(v)	Moisture-Density Relationship; T180, Method D no reuse with T224 correction for >19mm	One set per 1000m^3
	(vi)	CBR test on a set of 3 specimens at T180 OMC; T193 without replacement >19mm to determine the CBR at the specified level of	One set per 1000m^3

		compaction	
Types of Construction	**Test**		**Frequency**
Unbound Base Course	(i)	Grain Size Analysis; T88 & T11	One test per 250m^3
	(ii)	Atterberg Limits; T89 & T90 using wet preparation T146	One test per 250m^3
	(iii)	Flakiness Index; BS 812	One test per 250m^3
	(iv)	Resistance to Degradation (LAA); T96 Grading A	One test per 500m^3
	(iv)	Moisture-Density Relationship; T180 Method D, no reuse with T224 correction for >19mm	One set per 500m^3
	(v)	CBR test on a set of 3 specimens at T180 OMC; T193 without replacement >19mm to determine the CBR at the specified level of compaction	One set per 500m^3

Table 301.3
Control Tests and their Frequency for Sub-Bases and Bases
(Excluding Bitumen Bound Bases)

(d) Tests on Bituminous Material Constructions

The tests and their frequencies for the different types of bituminous constructions shall be as given in Table 301.4.

Types of Construction	**Test**		**Frequency**
Tack Coat or Prime Coat	(i)	Quality of binder	As required. QA certificates from manufacturer.
	(ii)	Binder temperature for application	At regular close intervals
	(iii)	Rate of spread of binder; ASTM D2995	Two tests per day
Layers of bituminous mixtures	(i)	Quality of binder	As required. QA certificates from manufacturer.
	(ii)	Resistance to Degradation (LAA); T96 Grading C	One test per 500m^3 of aggregate
	(iii)	Flat and Elongated Particles; ASTM D4791	Two tests per day from sample (v)
	(iv)	Stripping Value	One test at start and as instructed by Engineer.
	(v)	Grading of aggregates in Cold Feed Hoppers and Hot Bins and combined plant mix grading; T27	One set of tests on individual constituents and mixed aggregates for

		& T11.	each 100 tonnes of mix subject to a minimum of two sets per plant per day.
	(vi)	Control of temperature of binder in boiler, aggregate in the dryer and prior to mixing and mix at the time of laying and rolling	At regular close intervals.
Layers of Bituminous Mixtures	(vii)	Marshall design mix properties (ASTM D 1559 & AASHTO T245), set comprising: Compact Marshall Briquettes, Bulk SG, & Voids (set of 8); T245, T166, & T269. Max Theoretical SG (set of 2) from Marshall Briquettes; T209 Marshall Stability and Flow and Immersion Index (2 sets of 3); T245	A set for each 100 tonnes of mix produced, subject to a minimum of two sets per mix type per plant per day.
	(viii)	Binder content and gradation in the mix; T164 & T30.	One test for each 100 tonnes of mix subject to a minimum of two tests per day per plant.
	(ix)	Rate of spread of mixed material	Regular control through checks on the weight of mixed material and layer thickness.
	(x)	Relative compaction of compacted layer from cores. Bulk SG core compared to Marshall SG determined in (vii); T166 & T230.	Minimum of a set of 5 cores per day's production with minimum 1 core per 500m^2 laid.

Table 301.4

Control Tests and their Frequency for Bituminous Construction

SERIES 300: ROADWORKS

SECTION 304: GRANULAR BASE COURSE

304.1 Description

304.2 Materials

304.3 Execution

304.4 Protection and Maintenance

304.1 DESCRIPTION

The work to be performed under this Section shall consist of furnishing, placing and compacting crushed rock, stone or gravel to form a pavement base.

Related Sections include the following:

Section 301 – Overall Requirements
Section 302 – Sub-Base

Test certificates from an independent testing agency, approved in advance by the Engineer, shall be submitted prior to the materials being brought to the Site confirming that the proposed materials conform to the requirements of this Specification Section. Test certificates for material source approval shall be dated not more than three (3) months in advance of the date when the materials are to be brought to the Site for incorporation within the Works.

Quality control testing of materials during execution of the Works shall conform to the frequency and specified types of tests as detailed in these Specifications.

304.2 MATERIALS

The aggregate shall consist of crushed aggregate free from an excess of flat, elongated thinly laminated, soft or integrated pieces and free from fragments coated with dirt or other objectionable matter.

The grading requirements for the aggregate shall conform to either of the following as determined using AASHTO T-27 and AASHTO T-11:

Sieve Designation		**Percent Passing**	
Standard mm	**Alternate No.**	**Grading**	
		A	**B**
50	2''	-	100
37.5	1/1/2''	100	90-100
25	1''	80-100	
19	¾'	70-90	50-85
12.5	½''	55-80	
4.75	No.4	35-60	25-45
2.36	No. 8	25-50	
0.600	No. 30	12-30	10-25
0.075	No. 200	5-10	2-9

Table 304.1
Requirements for Granular Base Course

In addition to conforming to the grading requirements, the material shall not be gap-graded, nor shall the curve of distribution of those particles sized smaller than D60 deviate by more than ±3% on any specified sieve from lying parallel with the grading envelope, where D60 is the sieve size through which 60% by weight of the material passes.
The portion of material retained on a No. 10 (2.00mm) sieve shall be known as coarse

aggregates and that portion passing a No. 10 sieve shall be known as filler.

Unless otherwise approved by the Engineer, coarse aggregate shall have a percentage wear of not more than 40 as determined by AASHTO T-96.

The material passing the 19.0mm sieve shall be capable of giving a soaked California Bearing Ratio (CBR) value of 80 per cent when tested in accordance with AASHTO T-193 and when compacted to 98 per cent of the maximum dry density as determined by AASHTO T-180 (Method D).

For all gradings, that portion passing a No. 40 (425μm) sieve, shall be non-plastic or shall have a liquid limit of not more than 25 and plasticity index of not more than 6 as determined by AASHTO T-89 and AASHTO T-90. The wet preparation method (AASHTO T-146) shall be used for preparing the specimen for the liquid limit and plastic limit tests.

At least 50 per cent by numerical count of all coarse aggregate, particles retained on the 4.75mm (No. 4) sieve, shall have at least one fractured face or shall be naturally angular with sharp edges as determined by ASTM D 5821. If this requirement cannot be met for a specified crushed aggregate type then the Contractor shall, at no additional charge, crush aggregate to the next smaller size or intermediate size as the Engineer may direct in order that the crushed aggregate shall meet the requirement.

The material shall have a Flakiness Index of less than 35 as determined by BS 812: Section 105.1.

Aggregates for preliminary testing (at least 50kg in mass) shall be furnished by the Contractor to the Engineer prior to the start of production. The Contractor shall also provide to the Engineer prior to the start of production, certified test results indicating that the aggregate meets the Specification requirements. Certified test results shall be less than 3 months old as determined from the date of the test report to the date when the aggregate is scheduled to be brought on Site.

Samples of aggregates shall be furnished by the Contractor to the Engineer at the start of production and at intervals during production. The sampling points and intervals will be designated by the Engineer. The samples will be the basis of approval of specific lots of aggregates from the standpoint of the quality requirements of this Specification Section.

Samples of aggregates to check gradation shall be taken by the Engineer at least two per lot. The lot will be consistent with acceptable sampling for density. The samples shall be taken from the in-place, compacted material. Sampling shall be in accordance with AASHTO T-2, and testing shall be in accordance with AASHTO T-27 and AASHTO T-11.

304.3 EXECUTION

Base material shall be placed on sub-base only after the sub-base has been inspected by the Engineer, immediately prior to the proposed start of base laying execution and it is found to be in conformance with the Specification. The sub-base shall be maintained in acceptable condition while base is being placed. Deformations, ruts, etc., caused by haulage vehicles or other plant and equipment shall be restored at Contractor's expense.

The Contractor shall take care to load and haul the material to the Works so that it arrives in an un-segregated condition and stock pile maintained for Engineer to sample & approve material.
The material after approval from the Engineer at designated stock pile shall be mixed water at -2% or + 4% at laboratory determined OMC, hauled in trucks and spread by self-spreading vehicles or towed spreader boxes and no layer shall exceed 150mm compacted thickness**. A motor grader must not be used to spread the material.** The material shall be deposited on the sub-base at a uniform quantity per linear metre, which quantity will provide the required compacted layer thickness without resorting to spotting, picking-up or otherwise shifting the aggregates to whole required width of carriage way. When the required compacted thickness is more than 150mm, the material shall be spread and compacted in two or more layers of approximately equal thickness. Each layer shall be spread and compacted in a similar manner and be approved prior to the placement of a succeeding layer. The surface of each layer shall be maintained in acceptable condition at all times. Deformation ruts, etc., caused by hauling vehicles and other equipment or plant shall be restored at Contractor's expense.

The material shall be brought to the proper moisture content and each layer shall be compacted to 98% of the modified AASHTO density (AASHTO T-180) when tested in accordance with AASHTO T-310 or AASHTO T-191. The Engineer may also direct the Contractor to carry out proof rolling of the aggregate sub-base. Proof rolling shall consist of at least four passes (producing at least two complete coverages) of a pneumatic tyred supercompactor having wheel loads and tyre pressures of 11,500kg and 10.5kg/cm^2 respectively for each tyre. Alternatively, proof rolling can be carried out using a loaded truck with tyre pressures and passes as described previously. During proof rolling, the moisture content of the aggregate sub-base shall be within two percentage points, plus or minus, of the optimum moisture content for a maximum depth of 300mm. If any soft or spongy areas are disclosed by this proof rolling, these areas shall be excavated and backfilled with new aggregate base.

Compaction shall continue until the surface is even and true to the proposed lines and grades within the tolerances defined in Section 301.

Any specific area of base that, after being compacted does not form a satisfactory, solid, stable pavement layer (regardless of test results) shall be removed, replaced and compacted to the Engineer's satisfaction at the Contractor's expense

304.4 PROTECTION AND MAINTENANCE

The Contractor shall protect and maintain the completed pavement layers against damage. Protection includes protection against rain and floodwater and against any undue wear and tear of, or damage to unsealed layers by construction or other traffic.

In addition, payment may be withheld at the sole discretion of the Engineer for any pavement layers on a particular section of the road, until the trimming of the sides of cuts and fills, the construction of side drains, including subsurface drainage where specified through cuttings, the installation of culverts other than low height culverts, etc, have all been completed for that section.

Where paved side drains are specified and the geometric shape of such drains do not permit the completion thereof before the construction of the sub-base or subsequent layers a temporary profile will be permitted for the side drain provided that such profile shall effect

positive drainage of the surface water with no water allowed to pond on and/or against structural layers of the pavement.

Maintenance shall include, inter alia, the immediate repair of any damage or defects that may have occurred.

SERIES 300: ROAD WORKS

SECTION 306: BITUMINOUS MIXES

306.1 DESCRIPTION

This Section consists of specifications and general requirements that are applicable to all types of bituminous mixtures of the plant mix type irrespective of gradation of aggregate, kind and amount of bituminous material used. The work shall consist of one or more courses of bituminous mixture constructed on a prepared foundation in accordance with these Specifications and the specific requirements of the type of bituminous mixture required under the contract, and in close conformity with the lines, grades, thickness, and typical cross sections shown on the Drawings or established by the Engineer.

Related Sections include the following:

Section 307	-	Bituminous Base Course
Section 308	-	Bituminous Binder Course
Section 309	-	Bituminous Surface Course
Section 310	-	Overall Requirements for Asphaltic Concrete
Section 312	-	Bituminous Materials (Binders)
Section 313	-	Bituminous Prime Coat
Section 314	-	Bituminous Tack Coat and Joint Sealer
Section 318	-	Pavement Patching

Test certificates from an independent testing agency, approved in advance by the Engineer, shall be submitted prior to the materials being brought to the Site confirming that the proposed materials conform to the requirements of this Specification Section. Test certificates for material source approval shall be dated not more than three (3) months in advance of the date when the materials are to be brought to the Site for incorporation within the Works.

Quality control testing of materials during execution of the Works shall conform to the frequency and specified types of tests as detailed in these Specifications.

306.2 MATERIALS

Materials shall be in accordance with the requirement of each specific type of bituminous mixture included in the contract.

The bituminous mixture (asphalt) shall be composed of a mixture of sound aggregate, inert and active filler, if required, and bituminous material. The several aggregate fractions, the coarse components of which shall comprise particles whose shapes shall satisfy the criterion for flakiness, shall be sized, uniformly graded and combined in such proportions that the resulting mixture meets the grading requirements of the job-mix formula.

(a) Bituminous Material

Bituminous materials (binders) shall be in accordance with the requirement of each specific type of asphalt included in this Specification and/or shown on the Drawings. Bituminous material shall consist of penetration grade bitumen complying with AASHTO M-20, a blend of penetration grade bitumen and Lake Asphalt or emulsified bitumen.

(b) Aggregates for Bituminous Mixtures

Coarse Aggregate – The portion of the aggregate retained on the 2.36mm sieve shall be known as coarse aggregate. The coarse aggregate shall consist of crushed un-weathered rock or crushed boulders and gravel approved by the Engineer.

Only one type of coarse aggregate shall be used except by written permission from the Engineer.

The crushed aggregates shall be produced by crushing fresh un-weathered rock, which is free from geological defects, such as zones of decomposition, weathering or inclusions of strata of Shales, Phyllite, Mica or other mudstones and shall be free from contamination by overburden, vegetable matter or other objectionable materials.

The material shall not have more than 5% by weight passing the 75μm sieve as determined by AASHTO T-11.

When crushed boulders and gravel are used, not less than 75% by weight of the particles retained on a 4.75mm sieve shall have at least two fractured faces as determined by ASTM D 5821.

Quarry and crusher sites, loading points and trucks shall be kept clean and the Contractor shall provide access roads at his own expense to insure the sites remaining clean.

The aggregate shall have a percentage wear of not more than 30 for surface course mixes and not more than 35 for binder, base and levelling course mixes, as determined by AASHTO T-96.

The aggregate shall have a value of water absorption of not greater than 1.0% when tested in accordance with AASHTO T-85.

The aggregate shall not have more than 10% by weight of flat and elongated particles based upon a 5:1 maximum-to-minimum dimension ratio as determined by ASTM D 4791.

When the aggregate is subjected to five cycles of the soundness test (AASHTO T-104), the weighted loss shall not exceed 12% by weight when sodium sulphate is used or 18% when magnesium sulphate is used.

Bitumen retained on aggregates after subjection to stripping test (AASHTO T182) shall be 95% minimum.

Soft fragments (AASHTO T112) shall be 2% maximum.

Fine Aggregate – The portion of the aggregate passing a 2.36mm sieve shall be known as fine aggregate and shall consist of stone screenings or a combination of stone screenings and natural sand with a maximum percentage of natural sand of 20%. Fine aggregates shall be composed of clean tough, rough surfaced, and angular grains approved by the Engineer, free from lumps or balls of clay or of clay

and sand, or other objectionable material. Stone screenings shall be produced from rock or boulders meeting the above requirements for coarse aggregate.

The material shall not have more than 8% by weight passing the 75μm sieve as determined by AASHTO T-11. Any fine aggregate having a variation in fineness modulus (ASTM C 125) greater than ±0.25 from the fineness modulus of the representative sample may be rejected.

When the aggregate is subjected to five cycles of the soundness test (AASHTO T-104), the weighted loss shall not exceed 10% by weight when sodium sulphate is used or 15% when magnesium sulphate is used.

The fine aggregate shall have a sand equivalent of not less than 40 as determined by ASTM D 2419.

That portion passing a No. 40 (425μm) sieve shall have a plasticity index of not more than 4 as determined by AASHTO T-89 and AASHTO T-90. The wet preparation method (AASHTO T-146) shall be used for preparing the specimen for the liquid limit and plastic limit tests.

Clay lumps and friable particles shall not exceed 1.0%, by weight, when tested in accordance with AASHTO T-112.

The fine aggregate shall not contain more than 20% natural sand by weight of total aggregates.

The fine aggregate shall have a minimum uncompacted void content of 45% when tested in accordance with AASHTO T-304.

Mineral filler – The material finer than 75μm in the coarse and fine aggregates shall be considered as inert mineral filler. That portion passing a No. 40 (425μm) sieve shall have a plasticity index of not more than 4 as determined by AASHTO T-89 and AASHTO T-90. The wet preparation method (AASHTO T-146) shall be used for preparing the specimen for the liquid limit and plastic limit tests. Active filler**,** where required as an adhesion-anti-stripping agent, shall consist of fresh hydrated lime or Portland Cement, approved in writing by the Engineer. Hydrated lime and Portland cement shall not be subject to the plasticity index requirement. Filler shall be free from foreign or other objectionable material. It shall be dry and free from lumps and when tested by laboratory sieves shall meet the following grading requirements:

Sieve Designation		**Percent Passing**
Standard (mm)	**Alternate (No.)**	
0.6	30	100
0.3	50	95 – 100
0.15	100	90-100
0.075	200	65 – 100

Table 306.1: Requirements for Mineral Filler

Combined Aggregate Grading – The combined grading (including mineral filler)

for the 'Job Mix' formula shall be within the grading limits, and as close as practical to median values of the requirements of Table 306.2 while conforming to the requirements of Clause 306.4.6.

Sieve Designation		**Percent Passing (by weight) Type**			
Standard (mm)	**Alternate (" / No.)**	**Base**	**Binder & Levelling**	**Surface & Binder & Levelling**	**Surface & Binder & Levelling**
37.5	1½"	100			
25.4	1"	72 - 92	100		
19.1	¾"	60 - 80	76 – 96	100	
12.6	½"	50 – 70	60 – 80	70 – 90	100
9.5	⅜"	42 – 62	50 - 70	60 – 80	75 - 95
4.75	4	30 – 48	35 -54	44 – 60	50 - 70
2.36	8	20 – 36	25 – 40	30 – 45	35 - 50
1.18	16	14 – 28	16 – 33	22 – 35	26 – 37
0.600	30	10 – 23	12 – 26	15 – 27	18 - 29
0.300	50	7 – 20	7 – 20	10 – 24	13 - 23
0.150	100	5 – 13	5 -15	6 - 15	8 - 16
0.075	200	Determined from Filler/Binder Ratio requirements of 1/1 to 1.5/1			
Layer Thickness; min/max (mm)		65/125	50/100	40/65	25/50

Table 306.2
Aggregate Gradation Limits for 'Job-Mix'/Thickness Requirements for Various Types of Bituminous Mixtures

The gradation of the material retained on the 1.18mm sieve shall be uniform within the limits shown and shall not vary from the low limit on one sieve size to the high limit on the adjacent sieve size, nor from the high limit on sieve size to the low limit on the adjacent sieve size.

When plotted on a 0.45 power gradation chart, the combined aggregate gradation shall not deviate more than 3% upward in the gradation curve from a straight line drawn from the origin of the chart to the point at which the gradation curve crosses the 4.75mm (No. 4) sieve line. Combined aggregate gradations which show this characteristic shall be rejected.

The mineral aggregate when combined in the proportions required by the job mix formula shall have a sand equivalent of not less than 50 as determined by ASTM D 2419.

306.3 REQUIREMENTS

Prior to the start of bituminous work, the Contractor shall submit:

- A job mix formula for each bituminous mixture required.

- A paving plan for approval to shall include the following:
  - The width of laydown of each course.
  - The numbers and full particulars of spreading, compacting and hauling equipment.
  - The proposed rate of laydown.
  - Additional information requested by the Engineer.

306.4 JOB-MIX FORMULA

1. It is the responsibility of the Contractor to prepare bituminous mix designs and to submit the same to the Engineer's for his verification and to obtain his approval in writing before any mixtures are produced for incorporation into the permanent Works. The Contractor shall make due allowance in his programme for obtaining approvals for each pavement course mixture and for mixtures having differing nominal stone sizes. All mix designs shall be prepared explicitly for the project and for each aggregate source and each bitumen supplier. The job-mix formula for each mix design shall be prepared not more than two months before the date when the Contractor proposes to utilise the asphalt on Site.

   In addition to the production and agreement of the initial mix designs described herein the Contractor shall be required to repeat the procedure at intervals consequent upon changes in the source, supplier, or method of production of constituents of the mix or of the mix itself. These will be additional to the regular mix assessment required to be undertaken by the Contractor (Clause 301.3) to ensure conformity of the mixtures with the requirements of the Specification with respect to the 'Job-mix'.

2. The Contractor shall use a qualified professional engineering service and a qualified testing laboratory licensed to practice in the Republic of Trinidad and Tobago, to assess the aggregate materials proposed for use and to carry out the design of the bituminous mixtures.

   The Contractor shall maintain adequate and approved testing facilities, with appropriate staff, at the site of the mixing plant throughout the period of manufacture of bituminous mixtures.

   All costs incurred in preparation and testing associated with the mix designs are the responsibility of the Contractor. Shipping costs for samples sent to the Engineer for verification and approval are the responsibility of the Contractor.

3. Before the preparation of any mix designs are undertaken, representative samples of the various nominal sized aggregates (each a minimum mass of 100kg), along with confirmation of the source of the aggregates, shall be submitted to the Engineer for approval. The submission shall also include the results of laboratory tests undertaken on the individual and combined aggregate components to confirm conformity with the relevant Sections and requirements of the Specification. The submission shall be in a manner approved by the Engineer and also include the value for Voids in Mineral Aggregate (VMA) that was recorded on a representative portion of the combined aggregates to be used in the laboratory trials. Representative samples of the bitumen proposed for use in the mix designs together with a quality assurance certificate from the manufacturer reporting the parameters required in AASHTO M-20 shall also be

submitted for approval.

4. Upon the approval of the Engineer to the proposed aggregates and bitumen, the Contractor shall commence the mix design trials (laboratory trial mixes) for each type and nominal size of asphalt included in the Contract.

   The hot mix asphalt shall be designed using procedures contained in Marshall Method of Mix Design, of the Asphalt Institute's MS-2, Mix Design Manual, 7th Edition. In the mix design process, laboratory mixtures shall be conditioned in accordance with AASHTO R 30. ASTM D 6926 shall be used for preparation of specimens using the manually held and operated hammer for the mix design procedure. ASTM D 6927 shall be used for testing for Marshall Stability and Flow.

   The trial mixes shall be undertaken to derive a 'Job-mix' formula that complies with the requirements in Sub-Section 306.4.6. The Contractor shall supply to the Engineer copies of all worksheets and test results produced during the laboratory trials. From the laboratory trial mixes the Contractor shall propose for each mix a 'Job-mix' formula giving definite single values for:

   a) Per cent passing each sieve
   b) Per cent of asphalt cement
   c) Type of bituminous material (penetration grade or Lake Asphalt blended bitumen)
   d) Asphalt viscosity or penetration grade
   e) Number of blows of hammer compaction per side of molded specimen
   f) Mixing temperature
   g) Compaction temperatures (temperature for start of compaction and temperature below which no further compaction should be done)
   h) Temperature of the mix when discharged from the mixer
   i) Plot of the combined aggregate gradation on the 0.45 power gradation chart
   j) Graphical plots of stability, flow, air voids, voids in the mineral aggregate and unit weights versus asphalt content
   k) Per cent natural sand
   l) Per cent fractured faces
   m) Per cent flat and elongated particles

   The Contractor shall supply the Engineer with a certificate obtained from the original supplier of the bitumen, giving specified test results to confirm the quality of the bitumen.

   Should the job mix formula have the design asphalt cement content on the "wet" or right hand increasing side of the voids in mineral aggregate curve this shall be deemed sufficient cause for the job mix formula to be rejected.

5. The Engineer will agree a job-mix formula with single values for A, B, C, D, E, F and G above for each type of asphalt from the results of laboratory trial mixes and so notify the Contractor in writing. None of the material will be incorporated into the permanent Works until the Engineer's approval has been given. The bituminous mixtures furnished by the Contractor shall conform to the agreed relevant job-mix formula within the following range for tolerances:

Aggregates:

Aggregate passing maximum size sieve	0%
Aggregate passing the 4.75 mm and larger sieves	±7%
Aggregate passing the 2.36 mm through 0.150 mm sieves	±5%
Aggregate passing the No. 0.075 mm sieve	±2%
Bituminous mixture:	
Binder Content (%) Surface Course	±0.3%
Binder Content (%) Base and Binder Course	±0.4%
Temperature leaving the mixer	±10°C
Temperature delivered on the road	±10°C
Temperatures for start and completion of compaction	±5°C

Failure of the asphalt laid in the pavement to conform to any of the tolerances above or any requirements in Table 306.3 is deemed sufficient cause for the asphalt to be rejected, and not approved for payment.

6. Mix Properties

When tested in accordance with AASHTO T-245 (Marshall Method) the bituminous mixes shall conform to the criteria in Table 306.3.

TEST REQUIREMENT	**Base**	**Binder & Levelling**	**Surface**
Number of Compaction Blows (Top and Bottom)	75 (Test on <19mm agg)	75 (Test on <19mm agg)	75
Stability, kN (min.) @ 60°C	8.0	8.0	8.0
Flow (mm)	2 – 3.5	2 – 3.5	2 – 3.5
Voids, Total Mix (percent)	3 - 5	3 - 5	3 - 5
Aggregate Voids Filled (percent)	65 - 75	65 - 75	65 - 75
Binder content in total mix (% by weight)	4.5%-7%	4.5%-7%	4.5%-7%
Marshall Quotient, (min.) (kN/mm)	2	2	2
Immersion Index, (min.) (24 hrs. at 60°C)	75%	85%	85%
Filler - Bitumen ratio	1.5 - 1	1.5 - 1	1.5 - 1
Voids in Mineral Aggregate (VMA)	≥12	≥13	≥14

Table 306.3
Marshall Properties for Various Types of Bituminous Mixtures

306.5 BITUMINOUS MIXTURE PRODUCTION EQUIPMENT

All production plant used by the Contractor for the preparation of bituminous mixtures shall be well maintained, in conformity with the manufacturer's recommendations and recognised international standards, and shall incorporate a quality control and/or quality assurance system all such that they are fully capable of producing mixtures fully in compliance with the Specification. It will be the Contractor's responsibility to ensure compliance with the foregoing.

The Contractor is required to provide the Engineer with free and unhindered access to the production plant and associated building and structures, to allow him to inspect them in accordance with the procedures set out in AASHTO T-172 and to assess for his own purposes the adequacy or not of the plant, etc. and the associated quality systems. Such assessment shall not relieve the Contractor of any of his responsibilities under the Contract, but the Engineer will have the authority to recommend improvements to the plant, systems, etc. and to refuse acceptance of any mixtures produced by the plant until such time as either the recommendations have been put in place to his satisfaction or the Contractor can show by the production and testing of test batches of the mixtures that the plant and the systems can consistently produce mixtures in compliance with the Specification.

In assessing the production plant the Engineer will assess the plant, systems, etc against the following requirements under A below, except that scale requirements shall apply only where weight proportioning is used; and, in addition, for batch mixing plants the special requirements under B and for continuous mixing plants the special requirements under C.

A. Requirements for all Plant

1. Uniformity - Plant shall be so designed, maintained, co-ordinated and operated as to produce a mixture within the job-mix tolerances.

2. Measuring and metering devices – All measuring and metering devices shall be the subject of a quality control/quality assurance system which shall define the time periods for and standard and type of checks to be applied to ensure that the devices record accurately the measurement for which they are intended. Such systems shall be in place and fully operative before any mixtures, whether for test purposes or for incorporation into the permanent works, are produced under the Contract. A record of all test and calibrations, and adjustments made resulting there from, shall be submitted to the Engineer before any mixtures are produced. No mixtures shall be produced until the Engineer has approved the sufficiency of the tests, calibrations and adjustments made. The Contractor shall not be relieved of any of his responsibilities under the Contract as a result of the approval and shall continue to undertake all tests required under the system or directed by the Engineer and supply within one working day full records of the tests and the adjustments made.

3. Plant scales - Scales for any weight box or hopper may be of the beam or springless dial type or electronic and shall be of a standard make and design accurate to within 0.5% of the maximum load that will be required. They shall be regularly checked for accuracy and calibration and records of the checks recorded, as well as the action taken to remedy any deficiencies to assure their continued accuracy; at least every two months. The Contractor shall provide and have at hand sufficient standard calibrated weights for the testing of all scales. Testing shall be done by the Contractor or other authorised body under supervision of the Engineer.

   When scales are of the beam type, there shall be a separate beam for each size of aggregate. There shall be a "tell-tale" dial attached which shall start to function when the load being applied is within 45kg of that desired. Sufficient vertical movements shall be provided for the beams to permit the

"tell-tale" dial to function properly. Each beam shall have a locking device designed and so located that the beam can easily be suspended or thrown into action. The weighing mechanism shall be balanced on knife edges and fulcrums and shall be so constructed that it cannot be easily thrown out of alignment and adjustment.

When springless dial scales are used, the end of the pointer shall be set close to the face of the dial and shall be of a type that will be free from excessive parallax. The scale shall be provided with adjustable pointers for marking the weight of each material to be weighted into the batch. The scales shall be substantially constructed, and those that get out of adjustment easily shall be replaced. All dials shall be so located that they will be in plain view of the operator at all times.

Scales for weighing bituminous material shall conform to the specifications of scales for aggregate except that each beam scale shall be equipped with a tare beam and a full capacity beam. The value of the minimum gradation in any case shall not be greater than 1kg. Dial scales for weighing the bituminous material shall not have a capacity of more than twice the weight of the material to be weighed and shall read to the nearest kilogram. Beam scales shall be equipped with a "tell-tale" device which will start to function when the load being applied is within 5kg of that desired.

4. Equipment for preparation of bituminous material - Tanks for storage of bituminous material shall be equipped for heating the material under effective and positive control, at all times, to a temperature within the range specified. The heating shall be accomplished by steam coils, electricity, or other means such that no flame shall come in contact with the heating tank. The circulating system for the bituminous material shall be of adequate size to insure proper and continuous circulation during the entire operating period.

   Suitable means shall be provided, either by steam jackets or other insulation, for recording and maintaining the specified temperature of the bituminous material in the pipe lines, metres, weigh buckets, spray bars, and other containers or flow lines. The storage tank capacity shall be sufficient for at least one day's run. Upon written approval of the Engineer, bituminous material may be partially heated in the tanks and brought to the specified temperature by means of booster heating equipment between the tanks and the mixer.

5. Feeder for drier - The plant shall be provided with an accurate mechanical means for uniformly feeding the mineral aggregate into the drier so that uniform production and uniform temperature are maintained.

6. Drier - A rotary drier of any satisfactory design for drying and heating the aggregate shall be provided. The drier shall be capable of drying and heating the aggregate to the specified temperature and recording the temperature.

7. Screens - Plant screens, capable of screening all aggregates to the specified sizes and proportions and having normal capacities slightly in excess of the full capacity of the mixer, shall be provided. They shall have an operating efficiency such that the aggregate deposited in any bin shall not contain more than ten percent of oversize and undersize material.

8. Bins - The Plant shall include storage bins of sufficient capacity to supply the mixer when it is operating at full capacity. Bins shall be divided into at least three compartments and shall be arranged to ensure separate and adequate storage of appropriate fractions of the aggregate, not including mineral filler. Each compartment shall be provided with an overflow pipe that shall be of such size and at such location as to prevent any backing up of material into other bins. Bins shall be so constructed that samples can be readily obtained.

9. Bituminous control unit - Satisfactory means, either by weighing or metering, shall be provided to obtain the proper amount of bituminous material in the mix to better than the tolerance specified for the job-mix.

   A metering device for bituminous material shall be a rotating, positive displacement, asphalt-metering pump, with a satisfactory spray nozzle arrangement at the mixer. For use with batching plants, the device shall provide the designated quantity of bituminous material for each batch. For continuous mixing plants, the operating speed of the pump shall be synchronized with the flow of aggregate in the mixer by an automatic locking control, and the device shall be easily and accurately adjustable. Means shall be provided for checking the quantity or rate of flow of bituminous material into the mixer at the anticipated temperatures.

10. Thermometric equipment - An armoured thermometer reading from 40 degrees to 200 degrees Celsius shall be fixed in the bituminous feed line at a suitable location near the discharge valve at the mixer unit.

    The plant shall be further equipped with approved dial-scale, mercury-actuated thermometer, an electric pyrometer, or other approved thermometric instrument so placed at the discharge chute of the drier and in the hot aggregate storage bins as to register automatically or indicate the temperature of the heated aggregates immediately prior to mixing.

    For better regulation of the temperature of the aggregates, replacement of any thermometer by an approved temperature-recording apparatus may be required by the Engineer, and he will require that daily temperature charts are completed and supplied to him whenever mixtures are being produced.

11. Dust collector - The plant shall be equipped with a dust collector and storage silo so constructed as to waste and return measured amounts of inert filler uniformly back into the elevator or mixer in order that the plant mix complies with the filler requirements of the ‘Job-mix’ formula and tolerances.

12. Control of mixing time - The plant shall be equipped with positive means to govern the time of mixing and to maintain it constant unless changed at the direction of the Engineer.

13. Scales for the weighing of trucks transporting asphalt - The Contractor shall furnish platform scales and a weigh house. The scales shall be satisfactory to the Engineer and shall be tested and sealed as often as the Engineer shall deem it necessary to ensure their accuracy. The weigh house shall be constructed in such a manner as to protect the recording device of the scales and to provide space for storage of testing equipment. It shall be weather-proof and not less than 3m by 4m in plan, and shall have one sliding window facing the scale platform, one end window, and a shelf desk at least 1m wide and 2m long. It shall include water and electric facilities.

    A monitoring system of delivery notes shall be operated indicating mass of truck before loading, mass of truck and asphalt after loading and time of dispatch.

14. Safety requirements - Adequate and safe stairways to the mixer platform and guarded ladders to other plant units shall be placed at all points required for accessibility to all plant operations. Accessibility to the top of truck bodies shall be provided by means of a platform or other suitable device to enable the Engineer to obtain sampling and mixture temperature data. To facilitate handling scale calibration equipment, sampling, equipment, etc., a hoist or pulley system shall be provided to raise or lower the equipment from the ground to platform or vice-versa.

    All gears, pulleys, chains, sprockets, and other dangerous moving parts shall be thoroughly guarded and protected. Ample and unobstructed passage shall be maintained at all times in and around the truck loading space. This space shall be kept free from drippings from the mixing platform.

B. Special requirements for batching plants

1. Weigh box or hopper - The equipment shall include a means for accurately weighing each bin size of aggregate in a weigh box or hopper suspended on scales, ample in size to hold a full batch without hand raking or running over. The weigh box or hopper shall be supported on fulcrums and knife-edges so constructed that they will not be easily thrown out of alignment or adjustment. All edges, ends, and sides of weighing hoppers shall be free from contact with any supporting rods or columns or other equipment that will, in any way effect the proper functioning of the hopper. There shall be, also, sufficient clearance between hoppers and supporting devices to prevent accumulations of foreign materials. The discharge gate of the weigh box shall be so hung that the aggregates will not be segregated when dumped into the mixer and shall close tightly when the hopper is empty so that no material is allowed to leak into the batch in the mixer during the process of weighing the next batch.

2. Mixer - The batch mixer shall be an approved twin pugmill type capable of producing a uniform mixture within the job-mix tolerances. It shall be heat-jacketed with steam, hot oil, or other means approved by the Engineer. It

shall be of such design as to permit visual inspection of the mix. The mixer capacity shall not be less than a 1,000kg batch and shall be so constructed as to prevent leakage of contents. If not enclosed, the mixer box shall be equipped with a dust hood to prevent loss of dust by dispersion. The mixer shall have an accurate time lock to control the operation of a complete mixing cycle by locking the weigh box gate after the charging of the mixer until the closing of the mixer gate at the completion of the cycle. It shall lock the bitumen bucket throughout the dry mixing period and shall lock the mixer gate throughout the dry and wet mixing periods. The dry mixing period is defined as the interval of time between opening of the weigh box gate and the start of application of bitumen. The wet mixing period is the interval between the time the bituminous material is spread on the aggregate and the time the mixer gate is opened. The control of the timing shall be flexible and capable of being set at intervals of not more than five seconds throughout cycles up to three minutes. A mechanical batch counter shall be installed as a part of the timing device and shall be so designed as to register only completely mixed batches. Bituminous material shall not be added if the temperature of the aggregate exceeds the temperature of the bitumen by more than 10°C at the typical mixing temperatures defined for the mix.

The mixer shall be equipped with a sufficient number of paddles or blades with proper arrangements to produce a proper and uniformly mixed batch. The clearance of blades from all fixed and moving parts shall not exceed 20mm except in the case of aggregates having a nominal maximum size of over 25mm in which case the clearance shall be so adjusted as to prevent undue breakage of the coarse aggregate during the mixing operation.

C. Special Requirements for continuous mixing plants

1. Gradation control unit - The plant shall include a means for accurately proportioning each size of aggregate either by weighing or by volumetric measurement. Multi screening of crushed aggregates shall not be permitted.

   When gradation control is by volume, the unit shall include a feeder mounted under the compartment bins. Each bin shall have an accurately controlled individual gate to form an orifice for volumetrically measuring the materials drawn from each respective bin compartment. The orifice shall be rectangular of dimensions about 200mm by 230mm, with one dimension adjustable by positive mechanical means provided with a lock. Indicators shall be provided for each gate to show the respective gate opening.

2. Weight calibration of aggregate feed - The plant shall include provision for calibration of the gate openings by means of weight test samples so that each of the materials fed out of the bins through individual orifices may be bypassed satisfactorily to suitable test boxes, each bin material being confined separately. The plant shall be equipped to handle, conveniently, test samples weighing 150kg or more, or combined weight of samples from all bins, and not less than 50kg for any one bin sample an accurate platform scale having a capacity of 150kg or more shall be provided.

3. Synchronization of aggregate and bitumen feed - satisfactory means shall be provided to afford positive inter-locking control between the flow of aggregate from the bins and the flow of bitumen from the metre or other proportioning source. This control shall be accomplished by inter-locking mechanical means or by any positive method satisfactory to the Engineer.

4. Mixer unit for continuous method - The plant shall include a continuous mixer of an approved twin pugmill type, steam-jacketed, capable of producing a uniform mixture within the job-mix tolerances. The paddles shall be of a type adjustable for angular position on the shafts and reversible to retard the flow of the mix. The mixer shall carry a manufacturer's plate giving the net volumetric contents of the mixer at the several heights inscribed on a permanent gauge and charts shall be provided by the manufacturer giving the rate of feed of aggregate per minute at plant operating speed.

   Determination of the mixing time shall be by weight method, using the following formula (the weights shall be determined for the job by the test made by the Engineer).

$$\text{Mixing time in seconds} = \frac{\text{Weight of Pugmill Dead Capacity}}{\text{Weight of Pugmill Output Per Second}}$$

5. Hopper - The mixer shall be equipped with a hopper at the discharge end, of such size and design that no segregation of mix occurs. Any elevator used for loading the mixture into vehicles shall have an equally satisfactory hopper.

306.6 BITUMINOUS MIXTURE PRODUCTION

Preparation of Bituminous Material - The bituminous material shall be heated to the specified temperature in kettles or tanks so designed as to avoid local overheating and provide a continuous supply of the bituminous material to the mixer at a uniform temperature at all times.

Preparation of Aggregates - The aggregates for the mixture shall be dried and heated at the asphalt plant before being placed in the mixer. Flames used for drying and heating shall be adjusted properly to avoid injury to the aggregate and to avoid forming a coating of soot on the aggregate. The aggregates, immediately after heating, shall be screened into three or more fractions and conveyed into separate bins ready for batching and mixing with bituminous material.

Preparation of Mixture - The dried aggregates, prepared as described above, shall be combined in the plant in the amount of each fraction of aggregate required to meet the job-mix formula for the particular mixture. The bituminous material shall be measured or gauged and introduced into the mixer in the amount approved by the Engineer. When a batching plant is used, the combined aggregate shall be thoroughly dry mixed, after which the proper amount of bituminous material shall be distributed over the aggregate. The whole shall be thoroughly mixed for a period calculated in accordance with the mix design but for at least 45 seconds, to produce a homogeneous mixture in which all particles of the aggregate are coated uniformly. The total mixing time shall be agreed by the Engineer and regulated by a quitable locking means. For a continuous mixing plant, the mixing time shall be 45

seconds as determined above and may be regulated by fixing a minimum gauge in the mixer unit and/or by other mixing unit adjustment.

The heated ingredients shall be combined in such a manner as to produce a mixture which, when emptied from the mixer, is at a temperature not be lower than is required to obtain complete coating and uniform distribution of the aggregate particles and to provide a mixture of satisfactory workability.

306.7 TRANSPORTATION OF BITUMINOUS MIXTURES

Trucks - Trucks for hauling bituminous mixtures shall have tight, clean and smooth metal beds that have been sprayed with a minimum amount of soapy water, thinned fuel oil, paraffin oil, or lime solution to prevent the mixture from adhering to the beds. Each load shall be covered with a canvas or other suitable material securely fastened and of such size as to protect the mixture from the weather. Any truck causing excessive segregation of material by its spring suspension or other contributing factors, or that shows oil leaks in detrimental amounts, or that causes undue delays, shall upon direction of the Engineer, be removed from the work until such conditions are corrected.

Transportation and Delivery of Mixture - The mixture shall be transported from the mixing plant to the point of use in vehicles conforming to the above. No loads shall be sent out so late in the day as to prevent completion of the spreading and compaction of the mixture during daylight hours.

306.8 PLACING BITUMINOUS MIXTURES

Spreading and finishing equipment - The equipment for spreading and finishing shall be approved mechanical, self-powered pavers, capable of spreading and finishing the mixture true to the line, grade and crown required.

The pavers shall be equipped with hoppers and distributing screws of the reversing type to place the mixture evenly in front of adjustable screeds. They shall be equipped with quick and efficient steering devices and shall have reverse as well as forward travelling speeds. The pavers shall be so equipped as to allow the placing of layers from 1.5m to 4.0m in width special side attachments may be used to the extent approved by the Engineer.

The pavers shall employ mechanical devices such as equalizing runners, straightedge runners, evener arms, or other compensating devices, to maintain trueness of grade and to confine the edges of the pavement to true lines without the use of stationary side forms. The equipment shall include blending or joint levelling devices for smoothing and adjusting longitudinal joints between lanes. The assembly shall be so adjustable to give the cross-section shape prescribed and shall be so designed and operated as to place the thickness or weight per square metre of material required.

Pavers shall be equipped with activated screeds and devices for heating the screeds to the temperature required for the laying of the mixture without pulling or marring.

The term "screed" includes any cutting, crowding, or other practical action that is effective in producing a finished surface of the evenness and texture specified, without tearing, shoving or gouging.

If, during construction, it is found that the spreading and finishing equipment in operation leaves tracks in the pavement surface or indented areas or other objectionable irregularities that are not satisfactorily corrected by scheduled operations, the use of such equipment shall be discontinued and other satisfactory spreading and finishing equipment shall be provided by the Contractor.

Spreading and Finishing – The mixed material shall as soon as possible after arrival at the site, be supplied continuously to the paver and laid without delay. The rate of delivery of material to the paver shall be so regulated as to enable the paver to be operated wherever practicable

The mixture shall only be laid upon a clean and approved surface free from standing water, and only when weather conditions are suitable and can be reasonably assumed to remain so for the immediate future. At the onset of rain, instructions shall be given by the Contractor to delay or suspend mixing of further supplies. Material already mixed may be laid only with the approval of the Engineer.

Wherever practicable, bituminous materials shall be spread, levelled and tamped by self-propelled pavers conforming to the above and capable of laying to the required width, profile, camber and crossfall. The rate of travel of the paver and its method of operation shall be adjusted to ensure an even and uniform flow of material across the full laying width, freedom from dragging or tearing of the material and minimum segregation

Joints in one layer shall offset that in a layer immediately below by at least 150 mm, all as described in Clause 306.10.

In areas where irregularities or unavoidable obstacles make the use of the mechanical spreading and finishing equipment impracticable, in the determination of Engineer, the mixture shall be spread, raked, and luted by hand.

Hand-laying of any bituminous material will only be permitted in the following circumstances:

(i) In confined spaces where it is impracticable for a paver to operate;
(ii) At the approaches to expansion joints at bridges;
(iii) For laying regulating courses of irregular shape and varying thickness in small areas;
(iv) On footways.

Hand laid work shall conform to all Specification requirements of this Clause except those relating to the manner of operating pavers. The mixture shall be placed on steel dump boards and spread and screeded to leave the thickness or weight of material required.

Immediately after any course is placed and before rolling is started, the surface shall be checked and all defects and irregularities in alignment, grade or texture, corrected by the addition or removal of mixture. However, hand raking of base course, binder and/or wearing course materials that have been laid by a paver and the addition of such material by hand spreading to adjust the level of the paved area will be permitted only in the following circumstances:

(i) At the edges and at longitudinal and transverse joints and at gullies and manholes;
(ii) For laying regulating courses of irregular shape and varying thickness;
(iii) At the approaches to expansion joints at bridges;
(iv) Where otherwise directed by the Engineer.

Small tools - The Contractor shall provide suitable means for keeping all small tools clean and free from accumulations of bituminous material. He shall provide and have ready for, use at all times enough tarpaulins or covers as may be directed by the Engineer for use in any emergency such as rain or unavoidable delays or for the purpose of covering or protecting any material that may have been dumped and not spread.

An adequate supply of hand tools shall be to hand before paving commences. Such tools might include:

Rakes;	Shovels;	Lutes;
Cleaning Equipment;	Small vibrating compactor;	Hand Tampers;
Cans of spray paint ;	3m straight edge;	Thermometers;
Builders lines and line level;	Spirit level;	Saw cutting machine with water dispenser.

306.9 COMPACTION OF BITUMINOUS MIXTURES

Rollers - Rollers shall be in good condition capable of reversing without backlash.

Steel wheel rollers

- Three wheel steel rollers shall weigh not less than 9070kg with a compression on the rear wheels of not less than 60kg/cm of wheel width.
- Three axle steel wheel tandem rollers shall weigh not less than 9070kg.
- Two axle steel wheels tandem rollers shall weigh not less than 9070kg.

Rollers used for initial or breakdown rolling shall be equipped with rolling wheels having a diameter of 1,000mm or more.

Pneumatic tyre rollers – These shall be of the oscillating type having a width of not less than 1.2m and equipped with pneumatic tyres of equal size and diameter, having tracks satisfactory to the Engineer. Wobble-wheel rollers will not be permitted. The tyres shall be so spaced that the gap between adjacent tyres will be covered by the tread of the following tyre, or shall be so spaced that any resulting uncovered gap will not exceed 4cm in width when the tyres are inflated to 6.3kg/cm^2 and the operating weight is 900kg per tyre.

When the pneumatic-tyre roller furnished by the Contractor is so constructed that there is an uncovered resulting gap between tyre tracks as permitted in the preceding paragraph, the complete coverage of the bituminous material with the roller required shall be increased by one complete coverage for each 1cm or fraction thereof, of the maximum uncovered gap between any two tyre tracks.

The tyres shall be inflated to 6.3kg/cm^2, or such lower pressure as designated by the Engineer, and maintained so that the air pressure will not vary more than 0.35kg/cm^2 from the designated pressure. Pneumatic tyre rollers shall be so constructed that the total weight of the roller can be varied to produce an operating weight per tire of not less than 900kg. The total operating weight of the roller shall be varied as directed by the Engineer.

Minimum equipment provision - The Contractor will be required to furnish a minimum of 9070kg three-wheel roller, or tandem roller, one pneumatic tyre roller, and 7260kg 2-axle tandem roller for each asphalt paver.

The required minimum rolling equipment specified above may be reduced to one two-axle, tandem roller, weighing at least 9070kg for each paver under the following conditions, provided it is demonstrated to the satisfaction of the Engineer that one roller can satisfactorily compact the laid material within the constraints of the specification:

- When bituminous mixture is placed at a rate of 50 metric tonnes, or less per hour at any location.
- When bituminous mixture is placed at a rate of 100 metric tonnes, or less, per hour and at the following location and conditions:

    - Placed in miscellaneous areas as determined by the Engineer.
    - When the width to be placed is less than three metres.
    - When the total thickness to be placed is less than thirty millimetres.

- When the total amount of bituminous mixture included in the contract is 1,000 metric tonnes, or less.

When rolling equipment is reduced as provided in this sub-clause, the rolling requirements may be reduced as directed by the Engineer.

At least two rollers shall be used, one of which shall be a three-wheel roller and the other a tandem roller, for every 1600m^2 of bituminous concrete placed per day.

The equipment in operation shall be sufficient to compact the mixture to the required density while it is in a workable condition. The use of equipment, which results in crushing of the aggregate, will not be permitted.

Compaction Procedure

Immediately after the mixture has been spread and struck-off, the surface shall be checked and any inequalities adjusted, and then compacted thoroughly and uniformly by rolling. The layer shall be rolled when the mixture is in proper condition and when the rolling does not, in the opinion of the Engineer, cause undue displacement, cracking, or shoving.

Initial or breakdown rolling shall consist of one complete coverage of the layer performed by a two-axle or three-axle tandem or a three-wheel roller. Such rollers shall conform to the provisions above.

Rolling shall commence at the lower edge and shall progress toward the highest portion. Under no circumstances shall the centre be rolled first. Rolling shall be performed with the drive wheel of the tandem roller forward with respect to the direction of spreading operations, unless otherwise permitted.

The initial or breakdown rolling shall be followed by additional rolling consisting of three complete coverages with a pneumatic-tyred roller as soon as the rollers can be used without excessive distortion of the material. All compaction must be completed before the mat cools to less than 80°C. The final rolling of the uppermost layer shall be performed with a tandem roller.

The surface of the mixture after compaction shall be smooth and true to the established crown and grade within the tolerances specified. Any mixture that becomes loose and

broken, mixed with dirt, or which is defective in any way, shall be removed immediately and replaced. Any area of 0.80m^2 or more, showing an excess or deficiency of bituminous material shall be removed and replaced. All high spots, high joints, depressions, and honeycombs shall be adjusted. Any ridges, indentations or other objectionable marks left in the surface of the asphalt concrete by blading or other equipment shall be eliminated by rolling or other means. The use of any equipment that leaves ridges, indentations, or other objectionable marks in the asphalt concrete shall be discontinued and other acceptable equipment shall be furnished by the Contractor.

To prevent adhesion of the mixture to the roller, the wheel shall be kept properly moistened but excess water will not be permitted.

Along forms, curbs, headers and walls, and at other places not accessible to the roller, the mixture shall be thoroughly compacted with hot hand tampers or with mechanical tampers giving equivalent compression. Each hand tamper shall weigh not less than ten kilograms and shall have a tamping face area of not more than 300cm^2.

306.10 JOINTS

Spreading shall be as nearly continuous as possible and the roller shall pass over the unprotected end of the freshly laid mixture only when authorized by the Engineer. In all such cases, including the formation of joints as hereinafter specified, provisions shall be made for proper bond with the new surface for the full specified depth of the course. A joint in a successive pavement layer shall be offset by 150mm from the parallel joint position in the preceding layer. The position of a longitudinal joint in the surface course shall be at the road centreline, or located at or immediately adjacent to a lane dividing line in wide pavements. Joints in the centre of lanes shall be avoided and will only be allowed with the Engineer's approval. No joint shall be located in the anticipated wheel tracks of vehicles using the finished surface.

No mixture shall be placed against previously rolled bituminous material or an existing pavement material (e.g., pavement widening or patching) unless the edge, either lateral or longitudinal, is vertical or has been cut back to a vertical face. A brush coat of bitumen used for contact surfaces shall be applied to the face just before additional mixture is placed against the prepared joint.

306.11 TRIMMING EDGES

The edges of the pavement shall be straight and true to the required lines. Any excess material shall be cut off square after final rolling and disposed of by the Contractor to a licensed landfill or recycled within the works.

306.12 ADDITIONAL GENERAL REQUIREMENTS

Temperature Requirements of Bitumen - The maximum temperature of the bitumen as delivered to the mixer shall be that at which it has a Saybolt-Furol viscosity of 75 seconds. Bitumen shall not be used while foaming nor shall it be heated above 175°C at any time.

The Engineer will set the job-mix temperature with due consideration of the above factors but in no case shall the specified maximum temperature be exceeded. The temperature of the mixtures in the paver hopper shall at no time be less than 115°C at the time of spreading.

Layer Thickness - The thickness of any layer shall not exceed, after compaction, the thickness given in Clause 306.2 for the particular mixture unless a greater thickness is allowed by the Engineer in writing. When the required thickness of any one course (base, binder, surface) exceeds the allowable thickness for the material, that course shall be placed in equal layers, such that each layer remains within the thickness limits defined.

Surface Preparation and Protection - Immediately before placing successive layers, the underlying course shall be cleaned of loose or deleterious material by sweeping with a power sweeper equipped with blower, supplemented with hand brooms if necessary, or as ordered by the Engineer. A tack coat of undiluted material shall be applied at a rate as specified in Specification Section 314 unless otherwise ordered by the Engineer.

The surfaces of base and binder layers shall be kept clean and uncontaminated for so long as they remain uncovered by a successive layer. The only vehicles permitted access to the layer shall be those engaged in preparation for or required for the placement of the successive layer. The Contractor is reminded of the requirement to cover base and binder course layers within a limited time after laying. Any contaminated surface shall be cleaned to the satisfaction of the Engineer or if impracticable, will the layer will be removed and replaced at the Contractor's expense.

The Contractor shall plan his operations so as to minimise the use of underlying layers of levelling, wedging or initial layers of thick surface courses by traffic and such use will be subject to the Engineers approval.

Regulating or Levelling Existing Pavements - Where the existing carriageways are to be overlaid, material for regulating or levelling shall be of the courses as described in the Contract and shall be subject to specific mix designs to accommodate the range and variations of layer thicknesses required.

306.13 CONFIRMATION OF LAYER THICKNESS, FIELD DENSITIES AND VOIDS IN THE MIX

Field densities and layer thicknesses will be determined using 102mm diameter cores (150mm for basecourse) taken by the Contractor as directed by the Engineer. The thickness of each bituminous layer shall not vary by more than that specified in the Section pertaining to that layer.

Cores 102mm in diameter of the full thickness of the bituminous pavement courses will be taken by the Contractor following final compaction of the surface course. A series of a minimum of 5 cores shall be taken by the Contractor for each day's production with a minimum of one core per 500 square metres of asphalt laid. The test locations shall be determined along and across the laid width using stratified random sample techniques.

Cores will be correctly referenced to the road location and made available for inspection by the Engineer either at the time of initial coring or within 24 hours thereof. The cores taken will be immediately upon removal, be referenced and photographed and stored in a manner to retain their integrity, yet such that they can be readily inspected.

The Contractor shall arrange for tests to be undertaken on all the cores to establish the field densities of the various pavement layers in the cores. Where required the tests will be undertaken in the Engineer's presence or additional cores will be taken for testing at his

laboratory. No additional payment will be made to the Contractor for core taking and refilling and compacting the core holes, nor for the cost of testing.

The pavement mix shall be such that the voids shall be within the limits of the voids obtained in a laboratory. There must be a minimum of 5 specimens representing a day's paving, with the average air voids content of the 5 specimens being between 3% and 5%.

Remedies for Non Compliance.

Notwithstanding the Engineer's right to condemn any work or material not in compliance with the Specification and require its removal and replacement with conforming Works, the Engineer may decide in the interest of expediency to allow such work to be accepted subject to payments to the Employer being made in accordance with sub-paragraphs (a), (b), and (c) below. Until such payments have been received in full by the Employer, the Engineer may still require the removal of the work. In addition, such accepted works will remain the responsibility of the Contractor throughout the Defects Notification Period and should the works exhibit defects during such period these defects will be corrected to the Engineer's satisfaction, at the Contractors expense.

(a) Thickness

(i) The thickness of each bituminous layer, except the levelling course shall not vary by more than that specified in the Section pertaining to that layer.

(ii) Cores of the full thickness of the asphaltic concrete courses will be taken following final compaction of the surface course. A series of a minimum of 5 cores shall be taken by the Contractor as detailed in Clauses 301.3 (d) and 306.13 above or as directed by the Engineer and correctly labelled. Each series shall represent not more than 2500 square metres of pavement.

(iii) The actual total thickness of asphaltic concrete will be determined by the Engineer using the cores and will be compared with the required thickness as prescribed on the Drawings or ordered by the Engineer. If the actual thickness is:

- Greater than the prescribed thickness - the prescribed thickness shall be used to calculate the volume of material laid.
- Between 90% of and the prescribed thickness - the prescribed thickness shall be used to calculate the volume of material laid.
- Between 80% and 90% of the prescribed thickness - 80% of the prescribed thickness shall be used to calculate the volume of material laid.
- For courses, other than surface course, where the thickness is less than 95% of the specified layer thickness, the thickness shall be made up to the total thickness of the combined courses, with material of the next course. However, the additional material will be paid for at the rate for the material of the deficient course.
- If the surface course is less than 80% of the prescribed thickness it shall either be removed and replaced or overlaid with a further 25mm plus the deficient amount to meet the acceptable tolerances of this Clause. All costs associated with providing and accommodation the overlay will be paid for by the Contractor.

(b) Density

The density of the completed asphalt layer shall be measured on cores taken at locations determined as indicated above for thickness.

Where the average density of a set of results does not conform to the density requirement detailed for the type of asphalt layer in the relevant Section of this Specification, a cash payment to the Employer in lieu of replacement may be applied as indicated in the relevant section.

SERIES 300: ROAD WORKS

SECTION 309: BITUMINOUS SURFACE COURSE

309.1 Description

309.2 Materials

309.3 Execution

309.4 Saw Cut Construction Joints

309.1 DESCRIPTION

The work to be performed under this Section consists of furnishing, placing and compacting hot, plant mixed bituminous mixture to form a bituminous surface course as defined on the Drawings.

Related sections are:
Pavement Layers from Gravel or Granular Material:
Section 300 - Overall Requirements

Pavement Layers from Bituminous Material;
Section 306 - Bituminous Mixes
Section 312 - Bituminous Materials
Section 313 - Bituminous Prime Coat
Section 314 - Bituminous Tack Coat and Joint Sealer

Test certificates from an independent testing agency, approved in advance by the Engineer, shall be submitted prior to the materials being brought to the Site confirming that the proposed materials conform to the requirements of this Specification Section. Test certificates for material source approval shall be dated not more than three (3) months in advance of the date when the materials are to be brought to the Site for incorporation within the Works.

Quality control testing of materials during execution of the Works shall conform to the frequency and specified types of tests as detailed in these Specifications.

309.2 MATERIALS

1. Bituminous cement shall be of Penetration Grade 60/70 Bitumen or Trinidad Lake Asphalt Blend as indicated in the Contract and shall conform to the requirements of Section 312.

2. Aggregates shall be obtained by crushing fresh durable rock, boulders or gravel and sand that conforms to the requirements of Section 306.2.

3. The maximum aggregate size for the surface course layer shall be chosen to be consistent with the thickness to be laid as detailed in the table in Section 306.2

309.3 EXECUTION

1. Execution shall proceed in conformance with the requirements of Sections 301 and 306.

2. A prime coat, in accordance with Section 313 (Bituminous Prime Coat) shall be applied to a granular or stabilised surface to receive bituminous surface material. In addition to the prime coat, and where the existing surface is a bituminous tack coat, in accordance with Section 314 (Bituminous Tack Coat) shall be applied. Prior to placing of an asphaltic surface course on existing pavement the surface is to be cleaned of dust, dirt and all deleterious material using a mechanical broom or compressor or any appropriate tool or equipment, to the approval of the Engineer before the tack coat is applied to the surface.

3. The completed thickness of the course or each layer comprising the course shall not vary from the thickness shown on the Drawings or as ordered by the Engineer by more than 5mm. It shall be the Contractor's responsibility to establish the thickness of uncompacted material to be placed in order to obtain the required thickness when compacted to the specified density. Areas of pavement failing to meet the tolerance stated above shall be corrected as directed by the Engineer.

   Attention is directed to Section 306 concerning total pavement thickness.

4. The average degree of compaction as determined by comparing the Bulk SG measured on cores (minimum 5 per day) with the average Bulk SG measured on Marshall Briquettes (minimum 16 per day) shall be not less than 97% of the Marshall Bulk SG when determined in accordance with AASHTO T-166, T-280 and T-245.

5. Where the average density of a set of results does not conform to the density requirement above, and provided there is no other cause for rejection, a cash payment to the Employer in lieu of replacement may be applied (refer Clause 306.13) as indicated below.

Average Density Percent	**Cash Payment in lieu**
97 or higher(Max. 99)	No payment
96 to 96.99	20% of in place mix cost
95 to 95.99	50% of in place mix cost
< 95	Full replacement at Contractor’s expense

309.4 SAW CUT CONSTRUCTION JOINTS

To ensure the best possible construction joints the Contractor shall “tie“ into the existing pavement surfacing at the start and end of the project and at intersecting roadways and streets, and at any other location as determined by the Engineer as follows.

The Contractor shall saw cut into the existing pavement for a trench to a minimum depth of 30mm across the full width of the existing bitumen pavement. The width of the trench between the saw cuts shall be 2m.

The trench shall carry across the entire existing asphalt surface. It shall at be at an angle of 45 degrees to the traffic flow and the angle shall either continue unchanged across the road or of break through 90 degrees at the centreline as directed by the Engineer. The direction of the angle shall be such that water is shed to the road edges.

The existing pavement material shall be carefully removed from the area of the trench. The material shall become the property of the Contractor and be disposed to an approved landfill or recycled into the Works.

Once the excavation is complete and before the application of the bituminous surface course, the entire cut area shall be swept clean and a coating of bituminous tack coat applied to the vertical saw edges and the base of the excavation.

Where the Engineer indicates a saw cut is required at an intersecting roadway, the cut will normally begin 25m from the centreline of the project roadway measured along the intersecting roadway centreline.

Where there is to be a longitudinal joint between the existing pavement and the new asphalt the existing pavement will be saw cut at the approved construction joint.

SERIES 300: ROAD WORKS

SECTION 312: BITUMINOUS MATERIALS

312.1 Description

312.2 Materials

312.3 Execution

312.1 DESCRIPTION

The work to be performed under this Section consists of furnishing bituminous cement. Throughout these Specifications the terms bitumen and asphalt are interchangeable.

Test certificates from an independent testing agency, approved in advance by the Engineer, shall be submitted prior to the materials being brought to the Site confirming that the proposed materials conform to the requirements of this Specification Section. Test certificates for material source approval shall be dated not more than three (3) months in advance of the date when the materials are to be brought to the Site for incorporation within the Works.

Quality control testing of materials during execution of the Works shall conform to the frequency and specified types of tests as detailed in these Specifications.

312.2 MATERIALS

A. This Specification covers quality and characteristics the following bituminous materials:

(i) Penetration Grade Bitumen
(ii) Emulsified Bitumens
(iii) Waterproofing Materials
(iv) Bitumen/Lake Asphalt Blends

B Descriptions and Requirements

(i) Penetration Grade Bitumen

Bituminous cement shall be of the Penetration Grade 60/70 or 80/100 bitumen and shall conform to the requirements of ASTM D946/D946M.

(ii) Emulsified Bitumens

Emulsified bitumens shall conform to the requirements of AASHTO M-140 Cationic emulsified bitumens shall conform to the requirements of AASHTO M-208

(iii) Bitumen/Lake Asphalt Blend

Bitumen Lake Asphalt Blend shall contain at least 25% Lake Asphalt and shall conform to ASTM D5710 and the following requirements:

Requirements	***Min.***	***Max***
Penetration at 77°F (25°C) 100g 5s, mm	60	75
Viscosity at 27°5F (135°C) cst.	275	-
Flashpoint of (Cleveland open cup), °F	450	-
Ductility at 77°F (25°C) 5cm/min, cm	100	-
Solubility in trichloroethylene, %	77	90
Retained penetration after thin-film oven test, %	52	-
*Ductility at 77°F (25°C) 5cm/min, cm after thin film oven test	50	-
Inorganic matter (ash), %	7.5	19.0

Table 3.12
Bitumen / Lake Asphalt Blend Specifications

*If ductility is less than 100cm, the test shall be repeated on the extracted bitumen containing not more than 5 % inorganic matter ash. If ductility at 77°F (25°C) is still less than 100cm, material will be accepted if ductility at 60°F (15.5°C) is 100cm minimum at the pull rate of 5cm/min.

312.3 EXECUTION

Execution shall proceed in conformance with the general requirements of Section 306 and Specifications for the appropriate layers.

SERIES 300: ROAD WORKS

SECTION 313: BITUMINOUS PRIME COAT

313.1 Description

313.2 Materials

313.3 Execution

313.1 DESCRIPTION

The work to be performed under this Section consists of applying bituminous prime coat material to a previously prepared aggregate road bed.

313.2 MATERIALS

Bituminous material to be used shall be a cationic slow setting emulsified asphalt CSS-1 and shall conform to the requirements of Section 312. It shall be placed at a temperature between 25°C and 70°C unless otherwise ordered by the Engineer.

Sand shall be clean coarse sand with the following grading:-

Sieve Size	Percent Passing Sieve
6mm	100
0.3mm	< 15
0.15mm	< 2

313.3 EXECUTION

1. Immediately before applying the bituminous prime coat material, all loose dirt and other objectionable material shall be removed from the surface with a power broom and/or blower as required. If the Engineer so orders, the surface shall be lightly bladed and rolled immediately prior to the application of bituminous material, in which case brooming or blowing may not be required. When so ordered by the Engineer, a light application of water shall be made just before the application of bituminous material.

2. The bituminous material shall be applied undiluted and formulated as a penetrating prime coat by means of an approved pressure distributor at the rate of 0.45L/m^2 to 1.35L/m^2 and at the above noted temperature unless otherwise ordered by the Engineer. The application shall be divided into two applications when necessary to prevent flowing off the surface, and additional bituminous material shall be applied where surface conditions indicate it to be necessary, if the Engineer so directs. When applied in two or more lanes, there shall be a slight overlap of bituminous material along adjoining edges of lane.

3. The surface of structures and trees adjacent to the areas being treated shall be protected in such manner as to prevent their being spattered or marred. No bituminous material shall be discharged into a borrow pit or gutter.

4. The distributor shall be self-powered and shall be equipped with a power unit for the pump and full circulation spray bars adjustable laterally and vertically. The equipment shall also be equipped with a suitable recirculation/agitation system to thoroughly mix the polymerized emulsion and water added for diluting. Distributors shall be equipped with fog nozzles.

5. The use of a wand applicator to place the prime coat shall only be done with the approval of the Engineer.

6. The distributor shall be so designed that bituminous material may be sprayed at readily determined and controlled rates, at even temperatures and uniformly on variable widths of surface up to 4 metres. The allowable variation from the specified application rate shall not exceed 10 per cent.

7. The prime coat application rate shall be verified by test strip(s) and approved by the Engineer prior to production paving in accordance with test method ASTM D 2995 where both the transverse and longitudinal application rates shall be verified.

8. Traffic other than that engaged in the pavement construction will not be permitted on the primed surface until it has cured.

9. The Contractor shall maintain the primed surface for a minimum of two days before covering it with the surfacing or next course. Any areas containing an excess or deficiency of priming material shall be corrected by the addition of blotter material or bitumen as directed by the Engineer. Prior to the application of the surfacing or next course, any surface breaks shall be patched and all excessive blotter material, dirt and other objectionable materials shall be removed by sweeping.

10. To accommodate the Contractor's programme he may propose by way of trials alternative bitumen materials and methodologies to enable the surface to be satisfactorily primed and either opened to traffic or overlain within a shorter period than the requirements of the foregoing paragraph. Sand for protection of the layer shall comply with the requirements of Sub-Section 313.2.

SERIES 300: ROAD WORKS

SECTION 314: BITUMINOUS TACK COAT AND JOINT SEALER

314.1 Description

314.2 Materials

314.3 Execution

314.1 DESCRIPTION

The work to be performed under this Section consists of applying a tack coat and a joint sealer if required, to paved surfaces prior to overlaying with bituminous concrete pavement material.

314.2 MATERIALS

The material to be used as tack coat shall be a cationic rapid setting emulsified asphalt CRS-1 satisfying the requirements of Section 312. It shall be placed at a temperature between 25°C and 70°C unless otherwise ordered by the Engineer.

When a joint sealer is required, it shall be a cationic slow setting emulsified asphalt CSS-1 satisfying ASTM D 2397 and ASTM D 3628 and shall be covered with a sand meeting either of the following gradations:

U.S. Bureau of Standards Sieve Size	**% Passing by Weight**	**% Passing by Weight**
9.5mm	100	
4.75mm (No. 4)	98 - 100	100
2.36mm (No. 8)	75 - 95	90 - 100
1.18mm (No. 16)	50 - 75	55 - 85
600□m (No. 30)	20 - 53	20 - 55
300□m (No. 50)	6 - 25	5 - 35
150□m (No. 100)	1 - 17	1 - 15
75□m (No. 200)	0 - 3	0 - 5

314.3 EXECUTION

1. When directed by the Engineer, immediately before placing the bituminous concrete pavement courses, the existing underlying course shall be cleaned of loose or deleterious materials by sweeping with a power sweeper equipped with a blower, supplemented by hand brooms, if necessary in the opinion of the Engineer.

2. The tack coat shall be applied only when the existing surface is dry.

3. When in the opinion of the Engineer the underlying layer requires treatment, all joints and cracks shall be sealed with bituminous material and a sand covering meeting Clause 314.2. The bituminous material shall be allowed to penetrate the cracks and joints in any old existing surface and any surplus shall be squeezed back and forth over the area to fill cracks, etc., fully, the sealed surface shall be covered with approximately 2.7 kg/m^2 of sand.

4. The distributor shall be self-powered and shall be equipped with a power unit for the pump and full circulation spray bars adjustable laterally and vertically. The equipment shall also be equipped with a suitable recirculation/agitation system to thoroughly mix the polymerized emulsion and water added for diluting. Distributors shall be equipped with fog nozzles.
5. The use of a wand applicator to place the tack coat shall only be done with the approval of the Engineer.

6. The distributor shall be so designed that bituminous material may be sprayed at readily determined and controlled rates, at even temperatures and uniformly on variable widths of surface up to 4 metres. The allowable variation from the specified application rate shall not exceed 10 per cent.

7. The application rate of diluted tack material shall correspond to an application rate of the residual (i.e., without diluting water) as follows:

Surface Type	**Residual Rate (L/m^2)**
New asphalt	0.09 – 0.20
Existing asphalt	0.18 – 0.32
Milled asphalt surface	0.18 – 0.36
Portland Cement Concrete	0.14 – 0.23

Table 314.3-1:
Tack Coat Application Rates

The application rate and the need for dilution shall be determined by test strip(s) and approved by the Engineer prior to production paving.

8. The tack coat application rate shall be verified by test strip(s) and approved by the Engineer prior to production paving in accordance with test method ASTM D 2995 where both the transverse and longitudinal application rates shall be verified.

9. Following the application, the surface shall be allowed to cure without being disturbed for such period of time as may be necessary to permit drying out and setting of the tack coat. This period shall be determined by the Engineer. Tack coat shall be applied only so far in advance of binder or wearing course placement as is necessary to obtain this proper condition of tackiness. The surface shall then be maintained by the Contractor until the next course has been placed. Suitable precautions shall be taken by the Contractor to protect the surface against damage during this interval.

SERIES 300: ROAD WORKS

SECTION 316: BITUMINOUS SLURRY SEAL, CRACK FILLING

316.1 Description

316.2 Materials

316.3 Execution

316.1 DESCRIPTION

The work to be performed under this Section consists of filling cracks in the existing pavement that are equal to or greater than 3mm wide by applying a bituminous emulsion slurry. The mixture will consist of fine aggregate, mineral filter and emulsified bitumen with water added to produce a slurry consistency. The liquid slurry is to be poured directly into the crack or applied over the affected surface area by the use of a squeegee or stiff bristle broom.

316.2 MATERIALS

Bituminous material to be used shall be cationic emulsified bitumen CSS-1or CSS-1h and shall conform to the requirements of Section 312.

Fine aggregate shall consist of clean crushed aggregate or coarse sand or a combination of both such that it shall conform to the following grading requirements:

Sieve Size	Percent Passing Sieve (by weight)	
9.5mm	100	-
4.75mm	98-100	100
2.36mm	75-95	90-100
1.18mm	50-75	55-85
0.6mm	20-53	20-55
0.3mm	6-25	55-35
0.15mm	1-17	21-15
0.075mm	0-3	0-5

Mineral filler shall conform to the requirements of Section 306.

316.3 EXECUTION

When directed by the Engineer existing pavement cracks shall be filled with an in-situ mixture of slow setting asphalt emulsion, fine aggregate, mineral filler and water. They may be mixed in a conventional plaster mixer or in small quantities in a wheelbarrow. The mixture should be prepared in the form of a slurry and applied directly in individual cracks or spread over the surface of the affected area in an average thickness of 1.5mm to 3.0mm.

The mixture should form a creamy-textured slurry, which will easily flow in a wave ahead of the strike-off squeegee. This will allow the slurry to flow down into pits and cracks and fill them before being struck-off with a squeegee.

The following proportions will serve as a guide in making a trial batch of slurry seal:

Aggregate, including mineral filler	50kg
Asphalt emulsion	7.5 – 15kg
Water	5 – 7.5kg or as required.

As soon as the emulsion breaks the material must be covered with fine sand or rock dust to prevent possible tracking of the asphalt onto adjacent surfaces. A neat inconspicuous appearance of filled the cracks is required to meet the Engineer's approval.
Preparation of Cracks:

The surface of each crack should be scrubbed vigorously with a stiff bristle broom. Special tools may be needed to remove dirt and other loose matter from wider cracks. Small cracks should be cleaned thoroughly by compressed air to remove all loose particles prior to filling with bituminous slurry.

SERIES 300: ROAD WORKS

SECTION 318: PAVEMENT PATCHING

318.1 Scope

318.2 Materials

318.3 Execution

318.1 SCOPE

This work shall consist of excavation in existing pavements and the supplying and placing of granular and/or bituminous pavement layers as patches to existing roadways.

Related sections are:

Pavement Layers From Gravel or Granular Material;
Section 300: - Overall Requirements

Pavement Layers From Bituminous Material;
Section 306 - Bituminous Mixes
Section 312 - Bituminous Materials
Section 313 - Bituminous Prime Coat
Section 314 - Bituminous Tack Coat and Joint Sealer

318.2 MATERIALS

The following materials will be supplied and used by the Contractor. These and other materials will be in accordance with these standard specifications.

- Section 309 Bituminous Surface Course.
- Sections 313 and 314, Bituminous Prime Coat and Bituminous Tack Coat and Joint Sealer.
- Sections 302 and 304 Gravel Sub-Base and Granular Base Course materials.

318.3 EXECUTION

Two repair methods may be specified to correct the pavement deficiencies as indicated in the contract. The method of execution of each is described below.

All supply, placing, spreading and compacting of gravel sub-base, granular base course and bituminous courses concrete shall be carried out in accordance with the relevant Sections 302, 304,306, 307, 308 and 309, unless designated by the Engineer to be a small area in which case the Contractor shall obtain the Engineer's approval to his work method with the prior to commencement of the Work.

(a) Replacement Patch

Replacement patching shall be used to correct bituminous pavement layer deficiencies such as potholes, shoving, etc. The construction method shall be as follows:

- Define the perimeter of the pavement deficiency and make a vertical cut through the existing pavement 300mm beyond the perimeter. Remove all failed bituminous pavement material down to the top of an underlying undamaged structural layer and arrange for its inspection by the Engineer. If the underlying layer is a granular base, remove any contaminated and foreign material and recompact any loose material. Vertical cuts through multiple lifts of pavement shall be staggered horizontally by a minimum of 150mm.

- Where in the opinion of the Engineer the granular base should be replaced, he will instruct its replacement with granular base to the Specifications and the cost of the same will be additional to the cost of the patch.
- Prepare the area by applying a tack coat to all asphaltic concrete pavement surfaces and a prime coat to all granular base surfaces.
- Place bituminous mix material in the prepared area and layout with a shovel, or other mechanical means.
- Compact in layers not to exceed the compacted thickness specified for the mixture to the densities specified for that mixture. The compaction of small areas shall continue until all particles are well keyed into place using industry standard asphalt mix vibratory compacting equipment.
- The finished patch shall be consistent with the line, grade, and crossfall of the adjacent pavement and ready to receive an overlay of bituminous surface course.

(b) Full Depth Patch

Full depth patching shall be used to correct base or total bearing capacity failure pavement deficiencies. Where no depth is defined the excavation and construction shall be as follows:

PAVEMENT LAYER	SUBGRADE	
	Cohesive Clay	**Non-Cohesive**
Bituminous Surface Course	50mm	50mm
Granular Base Course	250mm	150mm
Granular Subbase	300mm	200mm
Total Excavation Depth	600mm	400mm

The construction method shall be as follows:

- Define the perimeter of the pavement deficiency and make an initial vertical cut through the existing pavement 300mm beyond the perimeter. Remove all pavements, base and any contaminated and unsuitable material to the depth and/or pavement layer defined in the Contract. or such lesser depth as instructed by the Engineer upon inspection. Shape and compact the base of the excavation to 95% maximum dry density or to the method approved by the Engineer. Where the base of the excavation is an expansive clay material ensure that it is protected and capping material placed over it in accordance with the requirements of Section 205, Embankment. Place and compact capping and granular sub-base in accordance with the relevant sections of the Specification to the compacted thickness as stated. Offset excavation vertical cuts through multiple lifts of pavement by staggering horizontally by a minimum of 150mm.
- Place and compact granular base course material to a compacted thickness as stated in lifts not to exceed 150mm in thickness compacted in accordance with the Specification. Finish top surface to allow for surface course.
- Prepare the area by applying a tack coat to all asphaltic concrete pavement surfaces and a prime coat to granular base course surfaces in accordance with Section 313 Bituminous Prime Coat and Section 314 Bituminous Tack Coat and Joint Sealer.

- Place and compact bituminous surface course in the prepared area in accordance with Section 309, unless it is a designated small area where spreading shall be by other means agreed with the Engineer and compaction of the layer shall continue until all particles are well keyed into place using industry standard asphalt mix vibrator compacting equipment.
- The finished patch shall be consistent with the line, grade, and cross fall of the adjacent pavement and ready to receive an overlay of Bituminous Surface Course in accordance with Section 309.

SERIES 300: PAVEMENT LAYERS OF BITUMINOUS MATERIAL

SECTION 319: COLD MILLING OF ASPHALT PAVEMENT

319.1 Scope

319.2 Execution

319.1 SCOPE

This section refers to those portions of the Work that are unique to the milling and patching for overlay of existing asphalt pavement. This section must be referenced to and interpreted simultaneously with all other sections pertinent to the Works described herein. The work is essentially to assist with the restoration of the carriageway cross-section.

Related sections are:

- Pavement Layers From Gravel or Granular Material;
- Section 300 - Overall Requirements

319.2 EXECUTION

(a) Equipment

The milling machine must be track mounted with a minimum cutting width of 1.37m and be capable of milling 100mm in one pass with automatic longitudinal and crossfall control. No substitute equipment will be permitted.

(b) Milling

The existing pavement shall be milled to a minimum depth of 50mm or as directed by the Engineer. Tapers from existing pavement grade to full depth milling shall not exceed 25mm/m vertically. The widths to be milled will be determined in the field by the Engineer.

Cold milling asphalt shall be performed in a manner, which prevents the tearing and breaking of underlying and adjacent pavement and the contamination of the milled bituminous material with granular, subgrade or deleterious materials. All milled bituminous material shall be loaded directly to trucks from the milling machine and hauled to stockpile or disposed of at licensed landfill sites or in an approved manner.

The travelled roadway shall be kept clean of all loose material during the milling operation, and the newly milled surface shall be swept clean of all loose material prior to reopening for traffic use. The manner of sweeping shall minimise the production of dust.

Milling work shall be restricted to one travelled lane to accommodate traffic. At the end of a milling shift or at the end of each full lane section to be milled the pavement shall be tapered up at a rate of 15:1 longitudinally.

The milled surface shall have a uniform textured appearance, free from longitudinal and transverse irregularities and capable of allowing smooth passage of traffic. The Contractor shall provide and maintain approved signing warning traffic using the milled surface of the degraded surface condition until the milled surface has been surfaced.

(c) Preparation for Patching

Following the completion of the milling process the surface shall be inspected and any indications of weakness in the underlying layers shall be patched in accordance with Section 318 (Pavement Patching) and payment made under that Section.
Should the milled surface becomes pot holed as a result of unnecessary delays between the milling operations and subsequent paving, repairs shall be carried out at once under the direction of the Engineer in accordance with Section 318. No additional payment will be made under Section 318.

(d) Drainage

The Contractor shall make provisions, subject to the approval of the Engineer, to ensure that milled or partially milled sections will adequately drain water runoff in a manner ensuring safety to the travelling public and the roadway. This may require some alternating of the side of the roadway being milled to accommodate unhindered drainage.

SERIES 400:
STRUCTURAL WORKS

SERIES 400: STRUCTURAL WORKS

SECTION 401: PORTLAND CEMENT CONCRETE – GENERAL REQUIREMENTS

401.1 DESCRIPTION

This Section specifies the general requirements for Portland cement concrete, including the selection, sampling and testing of materials to be used, the composition of concrete and the mixing, transporting and testing of concrete.

Portland cement concrete shall be understood to mean an intimate mixture of Portland cement, fine aggregate, coarse aggregate and water, with admixtures as allowed or required, of the qualities herein specified. It shall be proportioned, mixed and transported as herein specified.

Also specified are requirements for the selection, testing, and use of ancillary materials such as curing materials, concrete grouts, epoxy compounds, joint fillers and sealants, water stops and the like.

Test certificates from an independent testing agency, approved in advance by the Engineer, shall be submitted prior to the materials being brought to the Site confirming that the proposed materials conform to the requirements of this Specification Section. Test certificates for material source approval shall be dated not more than three (3) months in advance of the date when the materials are to be brought to the Site for incorporation within the Works.

Quality control testing of materials during execution of the Works shall conform to the frequency and specified types of tests as detailed in these Specifications.

401.2 CLASSES OF CONCRETE

Classes of concrete shall be designated by a numeral indicating the minimum 28-day compressive strength in megapascal as determined by ASTM C39. The classes of concrete included in this section are:

Class 9, Class 15, Class 21, Class 25, Class 30 and Class 35.

These classes of concrete refer to the cylinder strength as specified in the ASTM standards.

Unless otherwise specified in the Drawings or Bill of Quantities, if high early strength concrete is specified, compressive strength shall be 7-day strength.

The following table shows the comparison between the strength of cube and cylinder samples.

Table 1: Compressive strength classes for normal-weight and heavy weight concrete.
(based upon BS EN 206-1:2000 Table 7 and BS 8500 – 1 Table A.20)

Require minimum characteristic cylinder strength (MPa)	**Required minimum characteristic cube strength (MPa)**
8	10
12	15
20	25
25	30

30	37
35	45

Each class of concrete may consist of one or more mixes determined by the maximum size and type of aggregate, intended location and use, cement factory and types of admixtures or special aggregates used. Types shall not be varied within a given structural element.

Each mix within a class will require approval of the design mix prior to use.

401.3 CONSTITUENT MATERIALS FOR CONCRETE AND MORTARS

The materials and ancillary requirements to be used for Portland cement concrete and mortar manufacture are given in the following sub-clauses. General provisions for the selection, sampling and testing, handling and use of these materials are also given.

A. Portland Cement

General

Only one brand or type of cement shall be used in any part of a structure. Cements of the same type but from different mills shall not be mixed in any part of a structure except with the written permission of the Engineer.

The use or presence of calcium chloride is prohibited.

Specifications

Cement may be Portland cement to ASTM C150; air-entraining Portland cement to ASTM C175; Portland-Pozzolan cement to ASTM C340 or C 91 and shall be as specified on the drawings or by the Engineer.

Types Permitted

1. Type I Portland cement may be used in general concrete construction where low heat of hydration is not required and where no sulphate action is anticipated. Type II Portland cement may be used for general concrete construction. Either Type I or II may be used in the contract unless stated differently on the Drawings or elsewhere in the specifications.

   Type III cement may be used in all concrete provided that a retardant admixture is used in concrete for bridge decks and for cement concrete pavement or approach slabs.

2. Type I-P cement will be allowed as an alternate to Type I in all classes of concrete subject to the following conditions:

   Type I-P Portland Pozzolan Cement shall meet the requirements of ASTM C-595 except that the Pozzolan (fly ash) constituent shall not exceed 20% by weight.
   The Pozzolan shall conform to ASTM C 618 Type F, except that the loss on ignition shall not exceed 6%.

Type I-P cement will not be permitted in prestressed concrete members.

The minimum time for removal of forms shall be extended by two days over that required with use of Type 1 and Type II cement.

3. Only Portland cements containing less than 0.6% alkali, calculated as Sodium Oxide (Na_20), (%Na_20 plus 0.658 times K_20, where K_20 is Potassium Oxide), shall be used with any alkali reactive aggregate.

Storage

Cement may be delivered in bags or in bulk. All cement shall be stored in suitable weatherproof buildings that will protect the cement from dampness. These buildings shall be placed in locations approved by the Engineer. Provisions for storage shall be ample and the shipments of cement as received shall be separately stored in such a manner as to provide easy access for the identification and inspection of each shipment. Storage buildings shall have a capacity for the storage of a sufficient quantity of cement to allow sampling at least 12 days before the cement is to be used.

Stored cement shall meet the test requirements at any time after storage when a retest is ordered by the Engineer.

On small jobs, storage in the open may be permitted by written authorization from the Engineer, in which case a raise platform and ample waterproof covering shall be provided by the Contractor to protect the cement from the elements.

The Contractor shall keep accurate records of the deliveries of cement and of its use in the work. Copies of these records shall be supplied to the Engineer in such form as may be required.

Transportation of Loose Cement

When under the provisions of these Specifications, it becomes necessary to transport loose cement, it shall be kept in a weatherproof compartment, separate from other aggregates, otherwise the cement shall be deposited directly from the container, as shipped, into the mixer skip, or dumped directly on the batch of aggregates just previous to the batch being deposited into the mixer skip.

Sampling and Testing

Tests for chemical and physical properties shall be in accordance with test method stipulated by ASTM C 150.

1. Cement may be sampled either at the mill or at the site of the batch plant. The Contractor shall notify the Engineer of dates of delivery so that there will be sufficient time for sampling the cement, either at the mill or upon delivery. If this is not done, or if additional tests are necessary, the Contractor may be required to re-handle the cement in the storehouse for the purpose of obtaining the required samples.

2. Samples removed for testing shall conform to the requirements for cement above. Cement that does not meet the test requirements, has been damaged, is partially set or which is lumpy or caked, shall not be used, and the entire contents of the sack of cement or the container of bulk cement, that contains failed, damaged, partially set or lumps of cement, will be rejected for use.

B. Aggregate for Concrete

General

The Contractor shall furnish aggregates for use in Portland cement concrete in conformance to the requirements specified herein.

1. Aggregate for use in concrete 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 in an amount sufficient to cause excessive expansion of mortar or concrete, except that if such materials are present in injurious amounts, the fine aggregate may be used with a cement containing less than 0.6% alkali as measured by percentage of sodium oxide plus 0.658 times percentage of potassium oxide, or with the addition of a material that has been shown to prevent harmful expansion due to the alkali-aggregate reaction.

2. The nominal size of aggregate used in each mix shall be appropriate for the purpose of the mix and correct placement and compaction. The particular use of concrete mixes having a particular nominal size of aggregate in each element of the works shall be subject to the Engineer's prior approval.

Sampling and Testing

1. Representative samples of aggregates proposed for use in Portland cement concrete shall be selected for laboratory testing as directed by the Engineer. Aggregates may not be used until the samples are approved as a result of the testing, and their use authorized by the Engineer.

2. Sampling and testing shall be in accordance with the following standard methods of the American Society for Testing and Materials. Tests to be performed on a particular sample shall be determined by the Engineer.

		Designation
a.	Unit Weight of Aggregate	C 29
b.	Concrete Aggregates	C 33
c.	Organic impurities in Sands for Concrete	C 40
d.	Surface Moisture in Fine Aggregate	C 70
e.	Measuring Mortar-Making Properties of Fine Aggregate	C 87
f.	Soundness of Aggregates	C 88
g.	Material Finer than No. 200 Sieve in Aggregate	C 117
h.	Lightweight Pieces in Aggregate	C 123
i.	Definitions (Fineness Modulus)	C 125
j.	Specific Gravity and Absorption of Coarse Aggregate	C 127

k.	Specific Gravity and Absorption of Fine Aggregate	C 128
l.	Abrasion of Course Aggregate (Los Angeles)	C 131
m.	Sieve Analysis of Fine and Coarse Aggregates	C 136
n.	Clay Lumps in Natural Aggregates	C 142
o.	Tensile Strength of Hydraulic Cement Mortars	C 190
p.	Scratch Hardness of Coarse Aggregate (Soft Particles)	C 235
q.	Sampling	D 75
r.	Potential Alkali Reactivity (Mortar Bar Method)	C 227
s.	Potential Reactivity (Chemical Method)	C 289
t.	Potential Volume Change (Linear Expansion)	C 342

3. The required tests shall be made on test samples that comply with requirements of the designated test methods and are representative of the grading that will be used in the concrete. The same test sample may be used for sieve analysis and for determination of material finer than the No. 200 sieve. Separated sizes from the sieve analysis may be used in preparation of samples for soundness or abrasion tests. For determination of all other tests and for evaluation of potential alkali reactivity where required, independent test samples shall be used.

4. The fineness modulus of an aggregate is the sum of the percentages of a sample retained on each of a specified series of sieves divided by 100, using the following standard sieve sizes (or an acceptable equivalent):

   No.100, No. 90, No. 30, No. 16, No. 8, No. 4, 3/8", 3/4", 1½" and larger, increasing in the ratio of 2 to 1. Sieving shall be done in accordance with ASTM C 136.

Care and Storage of Concrete Aggregate

1. Aggregates shall be handled in a manner to prevent segregation or lack of uniformity of grading or the intrusion of foreign materials. Coning of stockpiles will not be permitted.

2. Fine and coarse aggregates shall be stored separately so as to prevent the two materials from becoming intermixed. Fine or coarse aggregates of different gradings shall, similarly, be stored separately from one another. A minimum of 50 cubic metres of fine and coarse aggregates, in excess of the requirements of the daily concrete operations, shall be maintained in stockpiles at the batching plants to allow continuity of the works with tested and approved aggregates. Aggregates shall be stored in an approved manner at the allocated area. As aggregates are removed from stockpiles for batching, a blanket of at least 1 metre of each material shall be left on the ground unless the material is stored on a proper platform.

3. Coarse aggregate stockpiles shall be maintained in a continuously wet condition during batching operations, such as to assure uniformity of concrete consistency.

Coarse Aggregates

1. Coarse aggregate shall consist of crushed stone, gravel, or a combination thereof, or subject to the approval of the Engineer, other inert materials with similar characteristics, having hard, strong, durable pieces, free from adherent coating and shall conform to the requirements of this Specification.

   Gravel shall be composed of tough, clean, durable quartz. The loss when the material is subjected to the Los Angeles Abrasion Test (AASHTO T-96) shall be no more than 50%. The dry-rodded weight per cubic metre of gravel, tested according to AASHTO T-19, shall be not less than 1,440 kg.

   Stone shall be composed of clean durable rock. The loss when the stone is subjected to the Los Angeles Abrasion Test (AASHTO T-96) shall not exceed 45%.

   When the aggregate is subjected to five cycles of the soundness test (AASHTO T-104), the weighted loss shall not exceed 12% by weight when sodium sulphate is used or 18% when magnesium sulphate is used.

2. Gradation
   The permissible gradation of coarse aggregates shall comply with the standard sizes of processed aggregate defined in Table 1 of AASHTO M-43 for the relevant size number proposed for the specific mix.

   These gradations represent the extreme limits for the various sizes indicated that will be used in determining the suitability for use of coarse aggregate from all sources of supply. For any grade from any one source, the gradation shall be held reasonably uniform and not subject to the extreme percentages of gradation specified above.

3. Deleterious Substances
   All coarse aggregate shall be washed and shall be free from disintegrated pieces, salt, alkali, vegetable matter and adherent coatings.
   Deleterious substances in the coarse aggregate shall not exceed the following:

Substances	**Percent by Weight**
Clay lumps and friable particles	0.25
Soft Particles	5.0
Chert that will break down in 5 cycles of the soundness test	1.0
Material finer than No. 200 sieve	1.0
Coal and Lignite when surface appearance is of importance	0.5
Coal and Lignite, all other concrete	1.0

Fine Aggregates

Fine aggregate shall consist of sand composed of hard, strong, durable quartz, or

subject to the approval of the Engineer, other inert materials with similar characteristics. Lightweight aggregate shall not be used.

The permissible gradation of fine aggregates is as follows:

Sieve Size	**Percent by Weight Passing**
9.5mm (3/8")	100
4.75mm (No. 4)	95 to 100
2.36mm (No. 8)	80 to 100
1.18mm (No. 16)	50 to 85
0.60mm (No. 30)	25 to 60
0.30mm (No. 50)	l0 to 30
0.15mm (No. 100)	2 to 10

The minimum percentages shown above for material passing the 0.30mm (No. 50) and 0.15 mm (No. 100) sieves may be reduced to 5 and 0, respectively, if the aggregate is to be used in air-entrained concrete containing more than 250kg of cement per cubic metre or in non-air-entrained concrete containing more than 310kg of cement per cubic metre or if an approved mineral admixture is used to supply the deficiency in percentages passing these sieves. Air-entrained concrete is here considered to be concrete containing air-entraining cement or an air-entraining agent and having an air content of more than 3%.

The fine aggregate shall have not more than 45% retained between any two consecutive sieves of those shown above and its fineness modulus shall be not less than 2.3 nor more than 3.1.

For walls and other locations where smooth surfaces are desired, the fine aggregate shall be graded within the limits shown in the above table, except that not less than 15% shall pass the 0.3 mm (No. 30) sieve and not less than 3% shall pass the 0.15mm (No.100) sieve.

To provide uniform grading of fine aggregate, a preliminary sample representative of the material to be furnished shall be submitted at least 10 days prior to actual deliveries. Any shipment made during progress of the work which varies more than 0.20 from the fineness modulus of the preliminary sample shall be rejected or, at the option of the Engineer, may be accepted provided suitable adjustments are made in concrete proportions to compensate for the difference in grading.

When the aggregate is subjected to five cycles of the soundness test (AASHTO T-104), the weighted loss shall not exceed 10% by weight when sodium sulphate is used or 15% when magnesium sulphate is used.

1. Deleterious Substances

   All fine aggregates shall be reasonably free from lumps of clay, soft or flaky particles, salt, alkali, organic matter, topsoil or other extraneous substances. The amount of deleterious substances in the fine aggregate shall not exceed the following limits:

Substances	**Percent by Weight of Total Sample, Maximum**
Clay lumps and friable particles	3.0
Material finer than No. 200 sieve;	
Concrete subject to Abrasion	3.0
All other concrete	5.0
Coal and lignite: where surface appearance of	
Concrete is of importance	0.5
All other concrete	1.0
Cinders and clinkers	0.5

In addition, the sum of the percentages of all material listed above shall not exceed 5%.

Fine aggregate shall be free of injurious amounts of organic impurities when tested in accordance with AASHTO T-21. Except, as herein provided, aggregates subjected to the test for organic impurities and producing a colour darker than the standard shall be rejected. A fine aggregate failing in the test may be used, provided that the discoloration is due principally to the presence of small quantities of coal, lignite, or similar discrete particles.

A fine aggregate failing in the test may be used, provided that, when tested for mortar-making properties, the mortar develops a compressive strength at 7 and 28 days of not less than 95% of that developed by a similar mortar made from another portion of the same sample which has been washed in a 3% solution of sodium hydroxide followed sufficient to produce a colour lighter than standard with the washed material.

Mortar Strength

Fine aggregate shall be of such quality that when made into a mortar and subjected to the mortar strength test prescribed in ASTM Method of Test, C 87, the mortar shall develop a compressive strength not less than that developed by a mortar prepared in the same manner with the same cement and graded standard sand having a fineness modulus of 2.40 ± 0.10. The graded sand shall consist of approximately equal parts by weight of standard Ottawa sand and graded Ottawa sand as defined in ASTM Method of Test, C l90 and C 109, respectively.

Mortar Sands

Mortar sands for masonry shall meet all requirements for fine aggregates above, except that the material shall be uniformly graded from coarse to fine with all passing 2.36mm (No. 8) sieve.

Synthetic Fibre Reinforcement

1. Material: 100 per cent virgin homopolymer polypropylene multifilament fibres, containing no reprocessed olefin materials.
2. Conformance: ASTM C 1116, Type III.

3. Fibre Length: Graded.
4. Alkali Resistance: Alkali proof.
5. Absorption: Nil.
6. Specific Gravity: 0.91.
7. Melt Point: 162°C.

Manufacturer's Certification for Synthetic Fibre Reinforcement

1. Submit manufacturer's certification that synthetic fibre reinforcement complies with specified requirements.
2. Submit evidence of manufacturer's ISO 9001:2000 certification.
3. Submit evidence of satisfactory performance history of synthetic fibre reinforcement.

C. Water for Concrete

Water for use in concrete and for use with cement shall be clean and practically free of oil, acid, alkali, chlorides, organic matter, and other deleterious substances. Water from city water supplies or other sources approved by a public health department as potable may be accepted without being tested. Water from other sources shall be tested in accordance with ASTM C94/C94M and approved before use and shall not contain impurities in excess of the following limits:

Acidity or alkalinity calculated in terms of calcium carbonate	0.05%
Total organic solids	0.05%
Total inorganic solids	0.08%
Total Chlorides as sodium chloride	0.05%

Wash water from mixer washout operations shall not be used as mixing water.

D. Admixtures for Concrete

Admixtures shall not be used in concrete without the approval of the Engineer, who may require that tests be conducted before the admixtures may be used to prove their suitability.

Unless otherwise directed by the Engineer and/or the admixture manufacturer, all admixtures shall be added at the batch plant.

Admixtures, if their use is allowed, shall comply with the following requirements:

(i) Admixtures shall be used only in liquid form and shall be batched in solution in the mixing water by mechanical batcher capable of dispensing the admixture in quantities accurate to within 5% of the required quantity.

(ii) All admixtures shall comply with the requirements of ASTM C494 or AASHTO M194 and shall be of an approved brand and type.

(iii) Air entraining agents shall comply with the requirements of ASTM C260 or AASHTO M154.

(iv) Admixtures shall not contain any chlorides.

Retarding Agents:

In order to permit the retarding of the set and extend the finishing time of concrete, a retarding agent shall be used when specified on the plans or may be used when permission for its use is requested by the Contractor in writing, and such approval is given. The retarding agent shall be a Type B or Type D admixture. The Contractor shall support his request with a manufacturer's certified formulation of the proposed agent and with sufficient evidence that the proposed agent has given satisfactory results on other similar work. Permission to use the agent may be withdrawn at any time when unsatisfactory results are obtained.

When air-entrained concrete is specified, the air-entraining agent and the retarding agent shall be so incorporated that the air content of the concrete shall fall within the percentage range stipulated in the specifications. When air-entrained concrete is not specified, the concrete to which the retarding agent has been added shall have an air content no greater than 3% except as recommended for bridge decks.

No compensation will be made for furnishing and incorporating the agent in the mix. No additional compensation will be made for furnishing, placing, finishing, and curing the concrete involved.

Superplasticizers

Superplasticizers may be utilized for the purpose of water/cement ratio reduction or for increasing workability With the Engineer’s approval. Only superplasticizers of the sulphonated melamine formaldehyde or sulphonated naphthalene formaldehyde condensate types may be utilized.

The required entrained air may be reduced by the Engineer if no loss of durability will result.

401.4 ANCILLARY MATERIALS FOR CONCRETE

The materials and ancillary appurtenances to be used for concrete construction are given in the following sub-clauses. General provisions for the selection, sampling and testing, handling and use of these materials are also given.

A. Curing Materials

The objective of the curing method shall be to restrict the loss of water to no more than 0.55 kg per square metre of surface in 72 hours.

1. Burlap for curing concrete shall consist of two layers weighing 0.30kg/m^2 to 0.55kg/m^2 each or of four layers of 0.18kg/m^2 to 0.21kg/m^2 each. Burlap that has been used as a container for sugar shall not be used. Burlap that is being used for the first time shall be thoroughly washed in order to remove starches used in sizing.

2. Vapour proof sheeting shall be tough, strong, resilient and capable of withstanding normal use without puncturing or tearing. Sheeting material may consist of any of the following and conform to the requirements of ASTM C 171 (AASHTO M l71).

    - Waterproof paper
    - Polyethylene film
    - White burlap-polyethylene sheet

3. Membrane Curing Compound
   Curing compound shall conform to the requirements of ASTM C 309 (AASHTO M 148) Type 1.

   The curing compound shall be delivered to the job in the manufacturer's original container, labelled with the manufacturer's name, plant location and grade designation of compound, lot number and quantity.

B. Joint Filler and Sealant

1. Joint filler shall be a non-extruding material such as bitumen impregnated fibreboard or closed cell flexible polythene sheet. Timber will not be accepted as joint filler material.

2. Joint sealant shall be one or two part polysulphide or elastomeric sealant. Joints to be sealed shall be primed with a compound compatible with the sealant material, as recommended by the sealant manufacturer.

C. Waterstops

1. Waterstops may be extruded PVC or rubber sections placed either centrally in a concrete section or on the outer face of a concrete section.

2. Rubber waterstops shall have a tensile strength of 17 to 20MN/mm^2, a minimum elongation at break of 450% and a hardness (IRHD) of 60 to 70. They shall be capable of accommodating joint movements of up to 50mm.

3. PVC waterstops shall have a tensile strength of 13 to 15MN/mm^2, an elongation at break of around 300% and a Shore Hardness (A) of 80 to 90.They shall be capable of accommodating joint movements of up to 10mm.

D. Concrete Grouting Material

1. Description

   This Clause covers grouting material for use in grouting anchor bolts, dowels and other miscellaneous items in concrete.

   The material shall be a non-metallic, non-shrink grout which, when mixed with water will harden rapidly to produce a permanent anchoring bond. It shall contain no metals or rust or corrosion promoting agents. The colour shall be light grey, matching approximately the colour of hardened concrete.

2. Material

The material, when prepared in accordance with the manufacturer's instructions, shall be of a trowel-able consistency. It shall also have the following properties: The material shall exhibit no shrinkage on setting but may exhibit slight expansion of no more than 0.10%.

The compressive strength of 50mm cubes of this material (ASTM C 109/109M), when cured as shown, shall have the following minimum compressive strengths:

Cure	Strength
24 hour air cure at 24°C	27.5MPa minimum
7 day air cure at 24°C	41.0MPa minimum
7 day air, l0-day water submersion	41.0MPa minimum

The material shall have a minimum initial set of 30 minutes.

Pull-out Strength: a 16mm deformed reinforcement bar grouted 150mm deep in 22mm diameter hole in saturated surface dried concrete shall have a pull-out strength of 44.5kN.

The material shall contain no more than 0.05% chlorides or 5% sulphates.

E. Epoxy Compounds

1. Types of Compounds

Epoxy resin compounds for application to Portland cement concrete, bituminous cement concrete, metals and other type surfaces shall be two-component systems of the applicable of the following types, as designated. Type A - An epoxy resin, for bonding fresh concrete to hardened concrete. Type B - An epoxy resin adhesive, for bonding hardened concrete to hardened concrete. Type C - An epoxy resin adhesive, for bonding traffic markers to hardened concrete and to asphaltic concrete. Type D - A coal-tar, modified epoxy resin for application as a skid-resistant or protective overlay for cement concrete.

2. Approval of Compound

Samples and literature of epoxy compounds proposed for use shall be submitted to the Engineer for approval. No material shall be used in the works prior to the receipt of the Engineer's written acceptance.

3. Mixing and Application

Types A and B epoxy compounds (for bonding fresh concrete to hardened concrete or bonding precast concrete parts) shall be mixed, applied, and cured in accordance with the manufacturer's directions, or as might be directed otherwise by the Engineer.

Epoxy compounds shall be used only under conditions, which are compatible with the material being applied in accordance with the specific directions of the

manufacturer.

4. Performance Tests

- For Epoxy Bonding Compounds

  The performance test upon which the acceptance or epoxy bonding compounds is based is described below. Test Specimens shall be cured at a temperature of 23°C plus or minus 1°C. The epoxy compounds shall be tested for composite cylinder shear (diagonal shear) as specified below.

  The test specimen of concrete shall be prepared in a 75 by 150mm mould. The first portion of the test specimen may be formed by sawing a full size 75 by 150mm cylinder on a 45 degree slope from the vertical giving a maximum height of 108mm to a minimum height of 30mm or through the use of an elliptical insert of the same dimensions. The concrete shall be cast as described in AASHTO T 23; using Class 35 Concrete with Type III cement. The specimen shall be cured in the standard manner, and for at least four days. At the end of this period the half cylinder is to be applied shall be on which the epoxy resin is to be applied shall be prepared for bonding by removal of all loose particles and oil film and then coated with a thick coat of the epoxy compound under test. The portion of the cylinder shall then be replaced in the mould and plastic concrete of the same mix as before added to the mould to form the 75 by 150mm cylinder. Reference test cylinders are prepared with each batch of concrete.

  After the composite test cylinder has cured for a three-day period in a moist cabinet, the compressive strength is determined. This strength is compared to the strength of the weaker of the two concretes from which the test cylinder was made. If the ratio of the compressive strength of the composite cylinder to the compressive strength of the weaker concrete is less than 0.90, the epoxy compound is rejected.

- For Epoxy Mortars

  The epoxy mortar shall be tested in compression, in the following manner:

  Three 50mm cubes shall be made with epoxy mortar, using the same mix and materials as described above.
  After curing for three days, the cubes shall be tested in direct compression. The required minimum average of the results for the three cubes is 35MPa.

- Retesting for non-representative Specimens

  In any of the required tests of the epoxy compounds, in the event that a failure of the specimen occurs in the cement or in the cement mortar, too early to indicate whether the epoxy material itself will meet the specified requirements, then new specimens shall be prepared for retest, as is necessary to complete the test on the epoxy material.

5. Specific Requirements for Type C Compounds

   Type C epoxy compounds (for bonding pavement markers to the pavement) shall be as recommended by the manufacturer of the particular markers used, and for the particular pavement to which they are to be bonded. Mixing and application shall be in accordance with the manufacturer's directions.

6. Specific Requirements for Type D Compounds

   Type D (coal-tar modified epoxy compounds) shall meet the requirements of AASHTO M 200. The manufacturer shall furnish six copies of a certification stating that the material meets this Specification.

7. Limitations of Storage

   Epoxy materials that have been in storage for more than 12 months, will not be accepted for use.

401.5 CONCRETE MIX DESIGNS

A. General Requirements

1. Concrete mixes shall have minimum water content per cubic metre of concrete consistent with required workability, a cement content corresponding to the appropriate water-cement ratio, the specified maximum size of coarse aggregate, and the required percentage of fine aggregate. Minimum and maximum values for key parameters should be as defined in the table below.

2. The design mixes for each class of concrete used shall be as determined by the Contractor to produce the results as specified herein and accepted by the Engineer.
3. For each class of concrete there shall be as many design mixes as there are different combinations or types of ingredients anticipated to cover the requirements of the work.

4. Design mixes will not be approved when the sum of chloride content of component materials indicates that the concrete mix derived from those materials will have a chloride content exceeding 0.24kg/$m^3$of concrete. When the source of any component material for the concrete is changed or when the design mix is altered, a chloride content determination test will be made immediately by the Engineer with new samples provided by the Contractor.

Description	**Class of Concrete**		
	20	**25**	**30**
Ordinary Concrete – Type and Class of Cement	OPC	OPC	OPC
Minimum Cement Content (kg/m^3)	280	300	320
Maximum Water-Cement Ratio	0.5	0.5	0.47
Maximum Aggregate Size (mm)	20	20	20

5. Concrete encasements for underground electrical ducts and cover slabs for direct-buried cables shall have a specified 28-day compressive strength of 14MPa and be coloured red by adding 6 kilograms per cubic metre of concrete unless otherwise noted in the Drawings.

B. Workability

The workability of the concrete shall be suitable for the use for which the concrete mix is intended. The Contractor shall be responsible for nominating the design workability and the range of uses for which the mix is proposed. The workability proposed will be subject to the Engineer's agreement but it will remain the Contractor's responsibility to ensure the concrete can be correctly placed and compacted into its final position in full conformity with the Specification.

For the guidance of Contractors, the following ranges of slump measurements are indicative of the workabilities anticipated to be required. These should not be considered as definitive requirements or to be all encompassing of possible situations.

Location	**Non-Vibrated Compaction**	**Vibrated Compaction**
Concrete pavement, sidewalk, and incidental construction:	75 to l50mm	25 to 90mm
Un-reinforced concrete other than above:	75 to l50mm	25 to 90mm
Reinforced concrete	75 to l50mm	25 to 90mm
Concrete placed by pumping:	75 to l50mm	25 to 75mm
Constricted spaces:	0 to l25mm	N/A

C. Admixtures

The use of admixtures to enhance the properties of any design mix shall only incorporated into a design if defined in the Contract or if the Engineer agrees that the use of such admixtures are beneficial to the overall performance of the Contract and are not a disadvantageous to the permanent works. Mix designs using admixtures shall only be prepared after mix designs for the same strength and nominal aggregate size have been prepared without the use of admixtures.

All admixtures shall be incorporated into the mix fully in compliance with the manufacturer's recommendations. It shall be the Contractor's sole responsibility to prove by testing and trial production and placement that the use of the admixture is acceptable.

D. Strength

The strength of each concrete mix shall be designed based on the required over design factor according to ASTM C94, and assuming a coefficient of variation appropriate for facilities to be used. Tests made on the concrete must meet both the following two criteria for each pour of concrete to be considered acceptable:

1. Not more than 5% of the strength tests shall have values less than specified strength.
2. No strength test shall fall below 90% of the specified strength and the average of any three tests from any pour will be equal to or greater than the specified strength.

E. Submittal of Mix Design and Samples

1. The Contractor shall submit to the Engineer satisfactory details of all mix designs proposed for use in the work. Accompanying such submittal shall be satisfactory and representative samples of all materials to be used for each mix design. Such samples shall include not less than 100kg of each type of aggregate, handled, packaged and delivered as directed by the Engineer.

2. Each sample shall be clearly identified by means of an attached tag as to source, project number and design mix for which it is intended to be used.

3. Upon receipt of the samples and mix data, the Engineer will prepare standard concrete test cylinders. These cylinders will be broken at various ages up to 28 days to determine the potential strength gain characteristics of the concrete. If the results do not satisfy the design and the construction requirements, the Contractor shall revise his mix to the Engineer's satisfaction. No concrete shall be placed in any part of the works until the design mix has been approved by the Engineer.

4. The approval of the Engineer of any design mix will in no way relieve the Contractor of the responsibility for providing concrete having compressive strengths specified herein for all concrete used in the work.

5. Once a design for any class of concrete is accepted, it shall not be varied as to source, quantity, grading of materials, proportioning, or in any other way.

6. Proposed changes in design mixes shall be accomplished by preparing and having approved a new design mix as specified above.

401.6 QUALITY CONTROL

A. The Contractor shall implement a full quality control testing regime to ensure all concrete batched by him conforms to the requirements of the Specification, and such testing will, as a minimum comply with this Section . In addition, the Engineer shall undertake his own compliance testing under this Section, for which the Contractor shall furnish concrete for casting specimens and for the specified sampling and testing all as required by the Engineer. Such testing by the Engineer will be additional to the Contractor’s testing and shall not relieve the Contractor of his obligations to test for compliance with the Specifications.

B. Testing: The Contractor shall supply sufficient concrete to enable the Engineer to perform the following testing for each concrete pour as follows:

1. Slump and air content tests for each 10 cubic metres or fraction thereof, placed.

2. Yield test and unit weight tests for each 150 cubic metres, or fraction thereof, placed or as deemed necessary by the Engineer.
3. A minimum of one set of six standard cylinders made and cured in accordance with ASTM C 3l for compressive strength testing, and sampled as follows:
    a) For structures and foundations
        i. One set of six standard cylinders minimum per 75 cubic metres of concrete
        ii. One set of six standard cylinders minimum for each structure or foundation except if placing a number of items each smaller than 11 cubic metres of concrete
        iii. One set of six standard cylinders minimum per 11 cubic metres of concrete if placing a number of items each smaller than 11 cubic metres of concrete
    b) For paving and slabs on grade, obtain one set of six standard cylinders per 38 cubic metres of concrete.
    c) For underground pipe or electrical encasements, obtain one set of six standard cylinders at the beginning of each day of concreting work.
    d) For all other concrete, obtain samples in accordance with Sub-Section 401.6.B.3(a) above.

    Additional samples shall be obtained if observations of tests for air content, slump, or temperature indicate non-conformance with the Drawings and Specifications.

    Additionally, the Contractor will be expected to provide the results of his tests, in accordance with Sub-Section 401.6.C below, undertaken for the same pour which shall be no less frequent than that specified in Sub-Section 401.6.B.3(a) above.

4. Test cylinders shall be dated and numbered consecutively.

C. Materials shall be sampled according to ASTM C l72 and tested as follows:

1. Air content: ASTM C 173.
2. Weight per cubic metre, yield, air content and cement content: ASTM C l38.
3. Slump: ASTM C143.
4. Compressive strength of cylindrical concrete specimens: ASTM C39.

Target Mean Strength

The characteristic strength of concrete is the 28 days strength below which not more than 5% of the test results may be expected to fall. The concrete mix should be designed to have a mean strength greater than the required characteristic strength by an adequate margin to ensure the above. at least the current margin. The current margin for each particular type of concrete mix shall be determined; it may be taken as having the smaller of the values given by (1) or (2) below.

1) 1.64 times the standard deviation of tests on at least 100 separate batches of concrete of nominally similar proportions of similar materials and produced over a period not exceeding 12 months by the same plant under similar

supervision.

2) 1.64 times the standard deviation of tests on at least 40 separate batches of concrete of nominally similar proportions of similar materials and produced over a period exceeding 5 days but not exceeding 6 months by the same plant under similar supervision.

Where there are insufficient data to satisfy (1) or (2) above, the margin for the initial mix design should be taken as two-thirds of the characteristic strength for concrete. This margin should be used as the current margin only until sufficient data are available to satisfy (1) or (2) above. However, when the required characteristic strength approaches the maximum possible strength of concrete made with a particular aggregate, a smaller margin may be permitted by the Engineer for the initial mix design.

D Testing Plan

Each set of test specimens shall be made from a sample obtained from a representative batch of concrete.

Compliance with the specified characteristic strength may be assumed if:

1) The average strength determined from any group of four consecutive test specimen exceeds the specified characteristic strength by not less than 0.5 times the current margin, and

2) Each individual test result is greater than 85% of the specified characteristic strength.

The current margin should be taken to be two-thirds of the specified characteristic strength for concrete, unless as mentioned above a smaller margin has been established to the satisfaction of the Engineer.

If only one test specimen result fails to meet the second requirement then that result may be considered to represent only the particular batch of concrete from which that specimen was taken provided the average strength of the group satisfies the first requirement.

If more than one specimen in a group fails to meet the second requirement or if the average strength of any group of four consecutive test specimens fails to meet the first requirement then all the concrete in all the batches represented by all such specimens shall be deemed not to comply with the strength requirements. For the purposes of this Sub-Section, the batches of concrete represented by a group of four consecutive test specimens shall include the batches from which samples were taken to make the first and the last specimens in the group of four, together with all the intervening batches.

Synthetic Fibre Reinforcement

Submit manufacturer's sample of synthetic fibre reinforcement and product's technical data sheets to the Engineer.

E Action to be taken in the Event of Non-Compliance with the Testing Plan

When the average strength of four consecutive test specimens fails to meet the first requirement in (E) above, the mix proportions of subsequent batches of concrete should be modified to increase the strength.

The action to be taken in respect of the concrete which is represented by the test specimens which fail to meet either of the requirements (or not by correct statistical proof can be verified to have the required strength) shall be determined by the Engineer. This may range from qualified acceptance in less severe cases, to rejection and removal in the most severe cases.

The Engineer may also require the Contractor at his own expenses to prove statistically the strength, by boring out cores and testing them according to a programme approved by the Engineer. The age of the concrete and degree of hardening at the time of the new testing shall be considered.

Additional tests which will comprise the obtaining and testing of drilled cores of concrete will be conducted in accordance with ASTM C 42M and evaluated in accordance with ACI 318. In such cases, three (3) cores shall be taken at each area where the concrete is considered questionable.

Concrete in an area represented by core tests shall be considered structurally adequate if the average of three cores is equal to at least 85 per cent of the specified minimum compressive strength and if no single core is less than 75 per cent of the specified minimum compressive strength.

If the core tests indicate that the concrete meets the specified strength, results of test cylinders shall be waived. If the core tests fail to meet the requirements of ACI 318, the Contractor shall at his own expense, remove and replace the defective concrete with concrete meeting the Specification requirements.

401.7 MIXING EQUIPMENT

A. Batching Plant

The equipment for batching of concrete materials shall conform to the following requirements except that, with the Engineer's approval, portable batch weighing equipment of a suitable type and capacity may be used where only small quantities of concrete or mortar are to be placed.

The batching equipment shall be substantially constructed on a firm foundation and with sufficient clearance at all points for the weighing hoppers to function properly. All batching plant structures shall be maintained properly level within the accuracy required by the design of the weighing mechanisms. A platform with suitable steps for access shall extend around the weighing hopper for easy means of inspection, adjustment and weighing.

1. The Batching Equipment
   Separate bins or compartments for each size of classification of aggregate and for each type of bulk Portland cement shall be provide. The compartments shall be as follows:

   Compartments shall be of ample size and constructed so that materials will be separated under working conditions. The batching plant be so equipped that when the quantity desired in the weighing hopper is being approached the material may be added slowly in small quantities and shut off with precision. A means of removing any overload of any one of the several materials in the weighing hopper shall be provided.

   Weighing hoppers shall be constructed so as to eliminate accumulations of tare materials. They shall weigh aggregates in separate weight batches with individual scales, or cumulatively in one batcher on one scale. They shall weigh bulk cement on separate scale in a separate weight batcher.

   Where mix water is measured by weight it shall be weighed separately from other ingredients. The hopper discharge mechanism shall be interlocked: against opening until the full batch is in the hopper and the scale balanced; against opening while the hopper is being filled; against closing until the hopper is entirely discharged and the scale back in balance; and against opening if the batch in the hopper is either overweight or underweight by more than 0.5% of the amount specified. The weighing hopper discharge gate shall operate in such a manner as will not affect the scale balance. The discharge chute, boot or other approved device shall be suspended from the encasement and not from the weighing hopper and shall be so constructed that the material will not lodge therein and there will be no loss of material.

   Facilities for obtaining representative samples of aggregate from each of the bins or compartments for test purposes shall be provided.

2. Water batcher and admixture dispensers

   Equipment for batching water and admixtures at the batching plant shall be provided, except in cases where the mixing has been authorized by the Engineer to be performed at the job site in paving mixers or in truck mixers.

   A device capable of measuring mixing water within the specified requirements for each batch shall be fitted and also a mechanism for delivering water to the mixers so that leakage will not occur when the valves are closed.

   The filling and discharge valves for the water batcher shall be interlocked so that the discharge valve cannot be opened before the filling valve is fully closed.

   The plant shall be equipped with measuring devices for admixtures capable of ready adjustment to permit varying quantity of admixture to be batched. The dispenser for admixtures shall be interlocked with the batching and discharging operations so that the batching and discharging to the mixture will be automatic.

If non-interlocked dispensers are permitted, the calibration of the dispensers shall be checked at intervals as required by the Engineer. Results of such calibration be recorded and made it available for the inspection by the Engineer.

3. Moisture content

At the time of batching, all aggregates shall be in a saturated surface-dry condition.

In no event shall the free moisture content of the fine aggregate at the time of batching exceed 8% of its saturated surface-dry weight. The batch-to-batch uniformity of all aggregates shall be such that variations in moisture content within one hour do not exceed 7kg in the batch quantity for one cubic metre of concrete, or that a gradual change does not exceed twice this variation in a period of four (4), hours.

An electrically actuated moisture meter which will indicate on a readily visible scale the percentage of moisture in the fine aggregate as it is batched, within a sensitivity of 0.5% by weight of the fine aggregate shall be installed and maintained in operating condition.

4. Scales

The scales for weighing aggregates and cement may be of either the horizontal beam or springless dial type designed as an integral unit of the batching plant and shall be of rugged construction to withstand hard usage due to working conditions. These scales shall be accurate to within the 0.50%.

If scales are of the dial type, the dial shall be of such size and so arranged that it may be read easily from the operating platform.

If scales are of the multiple beam type, the scales shall be provided with an indicator operated by the main beam, which will give positive visible evidence of over or underweight. The indicator shall be so designed that it will operate during the addition of the last 90 kilograms of any weighing. The over travel of the indicator hand shall be at least one-third of the loading travel. Indicators shall be enclosed against moisture and dust. Poises shall be installed for locking in any position and to prevent unauthorized removal.

Clearance between scale parts and hopper and bin structures shall be such as to avoid displacement of, or friction between, parts due to accumulations, vibrations, or other cause. Pivot mountings shall be designed so that none of the parts will jar loose and so as to insure unchanging spacing of knife edges under all conditions. Scales shall be constructed of non-corrosive materials and so designed that all exposed fulcrums, clevises, and similar working parts may be kept clean readily. Scales shall be maintained in proper operating condition.

Accuracy of Scales:

All scales shall be certified and sealed by the Engineer prior to the delivery of

the material.

Ten 22.5kg weights shall be provided for checking, with a shelf or suitable provision for attaching them to the weighing hopper.

5. Recorders

An accurate recorder for producing a digital printout of the batch number and scale readings corresponding to each of the ingredients of each concrete batch, including zero initial readings shall be fitted. It shall indicate by name or code the individual ingredient corresponding to each weight. It shall also indicate by pressure only, each admixture measured by volume.

On each printout shall be shown: the date and time of batching; an identification number identical to that of the concrete delivery ticket; and codes for the mix design and for the project section.

The printout shall be prepared in duplicate and one copy, with its corresponding concrete delivery ticket, delivered to the Engineer.
Each recorder mechanism shall be housed in a locked, dust-tight cabinet, in a position convenient for observation.

B. Concrete Mixers

1. General requirements

Concrete shall be machine mixed at the site, using mechanically operated batch mixers for mixing concrete, unless authorized by the Engineer and for batches not exceeding one-third cubic metre that may be hand mixed.

Concrete mixers shall be of the revolving drum type or pan type. Truck mixers shall be of the revolving drum type. Pick-up and throw over blades of revolving drum mixers shall be replaced when any part or section is worn 25mm or more below the original dimensions of the manufacturer's design. A copy of the manufacturer's design, showing dimensions and arrangements of blades, shall be available to the Engineer. Batches shall be charged into the mixer so that some water will enter in advance of cement and aggregates. All water shall be in the drum by the end of the first quarter of the specified mixing time.

2. On-site mixers

On-site mixing shall be done using paving or stationary type mixers. Mixers shall be operated at the speeds recommended by the mixer manufacturers, except that revolving drum mixers shall make no less than 14 and more than 18 revolutions per minute.

Paving and stationary mixers shall be operated by an automatic timing device that can be locked by the Engineer. The timing device and discharge mechanism shall be interlocked so that, during normal operation, no part of the batch will be discharged until the specified mixing time has elapsed. The total elapsed time between the intermingling of damp aggregates and the discharging

of the completed mix from the mixer shall not be less than 60 seconds or more than 300 seconds. The minimum allowable mixing time may be increased in order to produce a more homogeneous mixture.

The mixer shall be equipped with adequate water storage and a device for accurately measuring and automatically controlling the amount of water used in each batch. Mechanical means shall be provided for recording the number of revolutions for each batch and automatically preventing the discharge of the mixer until the materials have been mixed the specified minimum time.

3. Truck mixers

Truck mixers shall be of the revolving drum type, watertight, and so constructed that the concrete can be mixed to insure a uniform distribution of materials throughout the mass. All solid materials for the concrete shall be accurately measured in accordance with this Section and charged into the drum at the proportioning plant. Except as provided below, truck mixers shall be equipped with a tank for carrying mixing water. Only the prescribed amount of water shall be placed in the tank unless the tank is equipped with a device by which the quantity of water added can be readily verified. The mixing water may be added directly to the batch only when so approved by the Engineer in writing, in which case a tank shall not be required. Truck mixers may be required to be provided with means by which the mixing time can be readily verified by the Engineer.

The maximum size of batch in truck mixers shall not exceed the maximum rated capacity of the mixer as stated by the manufacturer and stamped on the mixer. Truck mixing shall be continued for not less than 50 revolutions after all ingredients, including water, are in the drum.
Mixing shall begin within 30 minutes after the cement has been added to aggregate.

401.8 MIXING AND DELIVERY

A. General

1. Concrete placed quantities greater than two cubic metres shall be mixed and delivered in accordance with the requirements of ASTM C 94.

2. The entire contents of the mixer shall be removed from the drum before materials for a succeeding batch are placed therein.

3. The materials comprising a batch shall be deposited simultaneously in the mixer. No mixer shall be charged in excess of its rated capacity as stated on the manufacturer's stamp on the mixer.

4. The first batch of concrete materials placed in the mixer shall contain a sufficient excess of cement, sand and water to coat the inside of the drum without reducing the required mortar content of the mix. Upon the cessation of mixing for a considerable period, the mixer shall be thoroughly cleaned.

5. When a truck mixer, or an agitator provided with adequate mixing blades, is used for transportation the mixing time at the stationary machine mixer may be reduced to 30 seconds and the mixing time in the truck mixer or agitator equipped with adequate mixing blades shall be as specified for truck mixing.

Synthetic fibre reinforcement shall be added to concrete mixture strictly in accordance with manufacturer's instructions.

Synthetic fibre reinforcement shall be added into stationary mixer after batching other concrete materials. The consistency of the mix should be neither too stiff nor too fluid, to ensure that the fibres are immediately dispersed and intermixed. This may be achieved, with prior approval of the Engineer, by premixing with half of the mixing water (including any plasticiser), introducing the fibres and mixing, and adding the remainder of the water.

B. Site Mixing

Mixing of batches two cubic metres and more shall continue 60 seconds plus 20 seconds for each cubic metre in excess of two cubic metres. The mixing time may be reduced to a period of not less than 60 seconds if it is demonstrated to the satisfaction of the Engineer that a shorter mixing time results in satisfactory mixing. The mixer shall be operated at the drum speed as stipulated by the manufacturer of the mixer. Evidence of satisfactory mixing shall consist of the variation in slump of samples, taken from the first and last quarters of the discharge, being not more than 20mm from the average of the two slump values.

C. Plant Mixing

Mixing at a central plant shall conform to the requirements for mixing at the site.

D. Hand Mixing

Hand mixing shall not be done unless authorised by the Engineer. When hand mixing is authorised, it shall be done on a watertight platform and in such a manner as to insure a uniform distribution of the materials throughout the mass. Mixing shall be continued until a homogenous mixture of the required consistency is obtained.

E. Time for Hauling and Placing Mixed Concrete

Concrete transported in an agitator, or other similar transportation device shall be discharged at the job. The maximum volume of mixed concrete transported in an agitator shall be in accordance with the specified rating. All concrete shall be placed in its final position in the forms within 60 minutes after the introduction of the mixing water to the cement aggregate, or the cement to the aggregate except that in hot weather or under other conditions contributing to quick stiffening of the concrete, the maximum allowable time may be reduced by the Engineer

The elapsed time before completion of concrete placement may be exceeded if, 24 hours prior to the commencement of the pour the Engineer's approval had been granted to the use of a designed mix incorporating a retarding admixture, and the

maximum extension of the above time agreed and approved.

F. Delivery

Suppliers of concrete shall have sufficient plant and transport capacity to ensure continuous delivery at the rate required. The rate of delivery of concrete during concreting operations shall be such as to provide for the proper handling, placing and finishing of the concrete. The rate shall be such that the interval between batches shall not exceed 20 minutes. The methods of delivering and handling the concrete shall be such as will facilitate placing with the minimum of re-handling and without damage to the structure or the concrete.

Delivery, Storage and Handling of Synthetic Fibre Reinforcement

A. Delivery: Deliver synthetic fibre reinforcement in manufacturer's original, unopened, undamaged containers and packaging, with labels clearly identifying product name, unique identification number, code approvals, and directions for use, manufacturer, and weight of fibres.

B. Storage:

1. Store synthetic fibre reinforcement in clean, dry area indoors in accordance with manufacturer's instructions.
2. Keep packaging sealed until ready for use.

C. Handling: Protect synthetic fibre reinforcement during handling to prevent contamination.

D. Retempering

The concrete shall be mixed only in such quantities as are required for immediate use and any which has developed an initial set shall not be used. Concrete, which has partially hardened, shall not be re-tempered or remixed.

SERIES 400: STRUCTURAL WORKS

SECTION 402: CAST IN PLACE CONCRETE

402.1 DESCRIPTION

The work in this Section shall consist of constructing cast in place concrete bridges, including approach slabs, deck slabs, box culverts, retaining walls, head walls, end walls, paved waterways and other types of Portland cement concrete structures not specifically covered by other sections of these Specifications to the lines and grades established by the Engineer and in accordance with the designs and details shown on the Drawings. The structures may be reinforced or un-reinforced concrete.

This Section specifies the requirements for cast-in-place concrete, including furnishing, placing, curing, protecting, and finishing; designing, furnishing, erecting, and removing form work; constructing expansion and contraction joints and water-stops; and furnishing and placing grout and epoxy mortar.

402.2 MATERIALS

A. Cast in place concrete shall be in accordance with Section 401.

B. Concrete reinforcement shall be in accordance with Section 405.

C Requirements for the following materials are as specified in Section 401.3, Concrete Materials:

a) Portland cement
b) Aggregates for concrete
c) Water for concrete
d) Admixtures for concrete
e) Curing materials for concrete
f) Concrete grouting materials
g) Epoxy compounds
h) Expansion joint filler and sealants
i) Water-stops

402.3 MIXES

A. Cast in place concrete shall be mixed in accordance with Section 401. The class of concrete for any purpose shall be as indicated in the Contract.

B. Grout for surface repair and bond coats:

1. Mortar for repairs shall consist of one part Portland cement to two parts mortar sand plus water to produce a stiff mortar. Mortar for bond coats shall comprise one part Portland cement to one part mortar sand.

2. Blending of white and grey Portland cement to produce coloured mortar to match surrounding concrete shall be determined by trials.

3. Up to one percent by weight of catalytic agents for increasing bond and decreasing water requirements may be used, subject to approval of the Engineer.

C. Epoxy Mortar shall be an approved two-component product with a three-day minimum compressive strength 35MPa. The two-component product shall be mixed and applied in accordance with manufacturer's instructions.

402.4 FORMWORK MATERIALS AND ACCESSORIES:

A. Formwork materials and accessories of permanent and temporary nature shall be supplied as needed. Materials and accessories shall be non-corroding and non-staining under conditions of service and storage. Temporary materials that are to be reused shall be made good to their original condition before reuse. Damaged and corroded materials and materials that by wear or change during earlier uses, may cause change in the colour, shape or texture of the concrete will be discarded.

B. All forms shall be of wood, metal or glass fibre reinforced plastic and shall be built mortar tight and of sufficient rigidity to prevent distortion due to the pressure of the concrete and other loads incidental to the construction operations. Form material shall be of a quality and maintained so as to prevent warping and the opening of joints due to shrinkage of the lumber.

C. Forms for exposed surfaces shall be made of dressed lumber of uniform thickness, or satisfactory plywood with waterproof glue with or without a form liner of an approved type.

D. Metal ties or anchorages within the forms shall be so constructed as to permit their removal to a depth of at least 50mm from the face without injury to the concrete. In case ordinary wire ties are permitted, all wires, upon removal of the forms, shall be cut back at least 6mm from the face of the concrete with chisels or nippers; for green concrete, nippers shall be used. All fittings for metal ties shall be of such design that upon their removal, the cavities that are left will be of the smallest possible size. The cavities shall be filled with cement mortar and the surface left sound smooth even and uniform in colour.

E. Bevel or chamfer strips shall be formed from varnished lumber strips or equally rigid non-staining plastic, 20mm wide on each leg.

F. V-Grooves and drip notch forms shall be formed from varnished lumber strips or equally rigid non-staining plastic, 20mm on each leg.

G. Weepholes shall be formed from 100mm inside diameter Schedule 40 P.V.C. or ABS. pipe, matching the colour of the concrete. Outlet cut-offs shall project 40mm from the wall and shall be in a plane parallel to it.

H. Inserts shall be formed from galvanized cast steel or galvanized welded steel, complete with anchors to concrete and fittings such as bolts, wedges and straps.

I. Release agent for steel forms shall be an approved material that will not colour, stain or otherwise affect the finish of the concrete. A natural non-petroleum base, non-staining, non-retarding, non-dusting low gloss release agent shall be used for wood forms.

402.5 FORMWORK DESIGNS

A. Watertight formwork shall be designed and executed in accordance with ACI 347 Chapter 1 and shall withstand pressures resulting from the placement and vibration of the concrete. It shall be formed from materials that do not stain the concrete, and shall be sufficiently hard and rigid to resist indentation and scratching while maintaining tolerances. The maximum deflection between form supports shall be 1/240 of the span length.

B. Forms shall be designed to provide the indicated finish. The deflection of form facing materials between studs, as well as the deflection of studs and walers, shall be limited to 1/240 of the span length while maintaining the tolerances specified.

C. Forms shall be designed for easy removal without damage to the finished concrete.

D. Panels in the forms shall be arranged in an orderly fashion, with joints between panels, expansion joints and rustication laid out equally spaced, symmetrical with relation to such elements as centreline, corners and major openings.

E. Tie holes shall be placed in rustication or other emphasized joints. Where there are no rustications or joints, ties shall be placed in orderly vertical and horizontal lines, evenly spaced at approximately 600mm centres unless otherwise indicated.

F. Earth shall not be used as a form except in case of solid rock that has been trimmed to the precise profile of the work to be cast.

G. The design, engineering, and construction of the formwork shall be the responsibility of the Contractor.

H. The design, engineering and construction of all shoring to be used in conjunction with formwork shall be the responsibility of the Contractor.

I. The Engineer may at his discretion require the submittal of the design and/or working drawings of formwork or shoring for his review and approval. This review shall not be construed of relieving the Contractor of his responsibility for these designs or their execution.

J. The Contractor is advised that the deck formwork must be adjustable to permit lowering or rising with respect to the top of the precast elements.

402.6 CONSTRUCTION OF FORMS

A. The forms shall be substantial and unyielding and shall be so designed that the finished concrete will conform to the proper dimensions and contours in accordance with the specified tolerances. All forms shall be set and maintained true to the line designated until the concrete is hardened. Forms shall remain in place for periods that shall be determined as hereinafter specified. When forms appear to be unsatisfactory in any way, either before or during the placing of concrete, the Engineer shall order the work stopped until the defects have been corrected.

B. Forms shall be made sufficiently tight to prevent loss of mortar from the concrete. Tape shall not be used on interior face of forms to achieve water tightness, except at concrete faces not exposed to view. Form edges shall be sealed by such means as gasket material or sealant placed in the joints in such a way that neither fin nor groove is made in the face of the cast concrete. If forms must be drilled for tie rods, holes shall be made to fit tie tightly so as not to leak.

C. Unless otherwise specified in the Drawings, bevel or chamfer strips, 20mm wide, shall be placed on all external corners of permanently exposed concrete surfaces. Internal corners of concrete shall not be bevelled unless otherwise indicated.

D. Formwork shall be cambered to compensate for anticipated deflections prior to hardening of the concrete so as to maintain specified dimensional tolerances.

E. Forms shall be securely braced against lateral deflection and settlement. Positive means of adjustment of shores, struts and walers, shall be provided by means of jacks, wedges and adjustable ties, so that deflection and settlement can be adjusted during concrete placement.

F. Where indicated, ties spaced equally vertical and horizontal shall be provided at walls and columns. Tie layout shall be centred both vertically and horizontally.

G. Formwork shall be anchored to shores and other supporting surfaces or members in such a way that upward or lateral movement of any part of the formwork during concrete placement and consolidation is prevented.

H. Runways for moving equipment shall be supported on structural members, shoring or walers.

I. Any warped or bulged lumber must be re-sized before reuse. Forms that are unsatisfactory in any respect shall not be reused.

J. For narrow walls and columns, where the bottom of tail form is inaccessible, the lower form boards shall be left loose so that they may be removed for cleaning out extraneous material immediately before placing the concrete.

K. Circular column forms shall be fabricated of two pieces and clamped watertight without horizontal joints. Horizontal construction joints shall be installed as indicated. Circular columns shall be made using flanged steel forms or fibre forms that leave no impression of spiral winding or joints in the hardened concrete.

L. All side and bottom surfaces of structures that will be exposed shall be formed. Unless otherwise approved by the Engineer, vertical surfaces of subgrade structures and pavements shall be formed at least to a depth of 300mm below grade. The structure below this level may be placed against earth.

402.7 PREPARATION OF FORM SURFACES:

A. Mortar, rust and dirt shall be cleaned from form surfaces before placing concrete.

B. All forms shall be treated with form release agent or saturated with water immediately before placing the concrete. For girder members or other members with exposed faces, the forms shall be treated with an approved oil (formwork oil), to prevent the adherence of concrete. Any material that may adhere to or discolour the concrete shall not be used.

C. Form-release agents shall not be applied if concrete surfaces shall receive special finishes or where the agent may affect applied coverings.

402.8 FALSE-WORK

A. Detailed plans for false-work or centring shall be supplied to the Engineer on request but, in no case, shall the Contractor be relieved of responsibility for results obtained by the use of these plans.

B. For designing false-work and centring, a weight of 2400kg/m^3 shall be assumed for green concrete. All false-work shall be designed and constructed to provide the necessary rigidity and to support the loads in order that the profile of the concrete as cast will be within the dimensional tolerances defined in the Specification. The Engineer may require the Contractor to employ screw jacks or hardwood wedges to take up any settlement in the formwork either before or during the placing of concrete.

False-work that cannot be founded on a satisfactory footing shall be supported on piling, spaced, driven and removed as approved by the Engineer, or supported on substructure piled footings as approved by the Engineer.

False-work shall be set to give the finished structure the camber specified or indicated on the Drawings.

402.9 REMOVAL OF FORMS AND FALSE-WORK

A. Form and false-work removal shall be in accordance with ACI 301.

B. Methods of form removal likely to cause over stressing of the concrete shall not be used. In general, the forms shall be removed from the bottom upwards. The Engineer may direct the delay of removal of forms and their supports at his discretion. 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. See following sub-section also.

C. Forms and shoring used to support the weight of concrete in beams, slabs and other structural members shall be kept in place until the concrete has reached the minimum strength or time period specified for removal of forms and shoring.

D. When shores and formwork framing are arranged so that non-load bearing form facing panels may be removed without loosening or disturbing the shores or

framing, the form facing may be removed at an earlier age as will not damage the structure.

E. When concrete surfaces are to be repaired or further finished, forms shall be removed as soon as the concrete has hardened sufficiently to resist damage resulting from the removal operations.

F. Top forms on sloping surfaces of concrete shall be removed as soon as the concrete has attained sufficient stiffness to prevent sagging. Repairs shall be performed at once, followed immediately by curing.

G. Wood forms for wall openings shall be removed as soon as possible without damaging concrete.

402.10 REMOVAL STRENGTH

A. Formwork shall remain in place until the concrete has attained the minimum percentage of indicated design compressive cylinder strength or for the period of time specified in the following table:

Structural Member or Condition	Normal Strength Concrete	High Strength Concrete	Minimum Compressive Strength for Form Removal (% of required design strength)
Cantilevers	12 days	7 days	90%
Over 6m between supports	14 days	7 days	90%
Centring under girders	14 days	7 days	80%
Stairways	14 days	7 days	80%
Deck slabs, and bottom of caps	14 days	7 days	80%
Free standing walls, columns and piers	7 days	5 days	70%
Walls, piers, columns, sides of beams, footings, slabs on grade and vertical surfaces.	24-48 hours	12-24 hours	70%
Curb front face forms	6-24 hours	6 hours	70%

402.11 CONSTRUCTION JOINTS

A. Construction joints shall be located as indicated on the Drawings. Joints shall be located so as not to impair the strength and appearance of the Work. Where a location for a construction joint must be selected, it shall be located, where possible, at a rusticated joint line in the concrete. Location of construction joints not shown on the Drawings shall be approved by the Engineer.

B. Prior to placing fresh concrete against a construction joint all laitance shall be removed, aggregate exposed as required and all reinforcing steel and other surfaces

cleaned of materials foreign to the concrete. Surfaces of horizontal construction joints, where expansion joint filler or bond breaking compound is to be placed, shall be cleaned of dirt, sawdust and all other loose material and debris. Surfaces against which new concrete is to be placed shall be painted with 1:1 sand: cement slurry or a concrete adhesive to the satisfaction of the Engineer immediately before placing the new concrete.

C. When it is necessary to make a construction joint because of an emergency, additional reinforcing steel shall be placed across the joint at the Contractor's expense.

D. When new concrete is shown to be joined to existing concrete by means of steel dowels mortared in holes drilled in the existing concrete, the holes shall be drilled to the required depth, blown out with an air compressor, wetted and filled with epoxy mortar, after which the dowel shall be inserted and left undisturbed until the mortar is hardened.

E. The Engineer may require an epoxy-bonding compound be applied at construction joints to ensure structural integrity. The compound shall be accurately proportioned, mixed in a clean dry container, and applied in accordance with the manufacturer's instructions. A container that can be disposed of after each batch is mixed shall be used. The cost of epoxy bonding compound and application, as required, shall be incidental to price of concrete.

F. See Section 402.20, Bonding

402.12 EXPANSION, CONTRACTION AND ISOLATION JOINTS

A. No reinforcement or other fixed metal items shall be run continuous through expansion and contraction joints, unless indicated.

B. Open joints shall be constructed at the locations indicated, by means of a wood strip, metal plate, or other approved material to be subsequently removed.

C. Contraction joints to be cut with a saw shall be cut as soon as the concrete is hard enough to prevent surface ravelling and aggregate dislodging, and within 12 hours after concrete placement.
   a) Contraction joints shall be cut in accordance with the saw manufacturer's written recommendations.
   b) Sawing sequence shall be based on pour time and size of slab.

D. Contraction joints in slab toppings shall be located directly above and in line with the control joints in the underlying concrete slab.

E. Isolation joints shall be placed where the pavement adjoins vertical surfaces (e.g., walls, columns, catchpits, manholes, and equipment foundations). Isolation joints shall be located in accordance with the Drawings.

402.13 WATER-STOPS

A. The configuration and location of water-stops in construction joints and expansion joints shall be as indicated on the Drawings or ordered by the Engineer.

Water-stops shall be provided in the maximum lengths practicable, with thermal or solvent joints at all cuts, breaks and corners.

402.14 INSERTS AND OTHER EMBEDDED ITEMS

A. Sleeves, inserts, anchors, weep-holes and other embedded items needed for adjoining work or for its support shall be placed before placing concrete.

B. Anchor bolts, anchors, inserts, sleeves, drains, kerb and seat angles, nosing, and other embedded items shall be installed before placing concrete. Welding of these items to the reinforcing bars shall not be permitted.

C. Ample notice shall be given to trades whose work is related to the concrete or a supported by it so that they have the opportunity to introduce or furnish or locate embedded items before the concrete is placed.

D. Joint material, water-stops and embedded items shall be supported against displacement during concrete casting.

E. Embedded aluminium items shall not be permitted.

F. Anchor bolt threads shall be protected from damage and kept free of concrete.

G. Anchor bolt sleeves shall be capped or plugged to keep out water, concrete, and debris.

H. Unless otherwise specified in the Specifications, embedments shall be installed in accordance with the tolerances shown in Table 402.14.1. The term “bolt group” used in Table 402.14.1 is defined as the set of anchor bolts for a single fabricated steel shipping piece, or a single piece of equipment.

Measurement	Tolerance
Anchor bolt projection	+6mm, –0 mm
Centre of bolt group	±6mm
Centre-to-centre of any two anchor bolts within a bolt group	±3mm
Centre-to-centre between bolt groups	±6mm
Anchor bolt plumbness	4mm in 1000mm
Plate insert horizontal and vertical location	±6mm horizontal ±1mm vertical

Table 402.14.1:
Tolerances for Embedments

402.15 PREPARATION BEFORE PLACING CONCRETE

A. Hardened concrete and foreign material shall be removed from surfaces of conveying equipment.

B. Forms shall be cleaned of water, dirt, debris, hardened concrete film and lumps, bar and wire fragments, and all other deleterious matter before concrete is placed.

C. Cleaning holes shall be sealed and made fully flush with interior surfaces of forms. Cleaning holes shall be located so as not to be visible upon completion, where possible.

D. Moisture barriers shall be placed, where indicated, over granular fill and bare earth before placing concrete, except at footings. Joints shall have 150mm laps.

E. Debris and deleterious matter shall be removed from the subgrade which shall then be made smooth, compacted and wetted before placing concrete.

F. Concrete shall not be placed until the forms and the cleanliness thereof; reinforcement, moisture barriers and embedded items have been inspected and approved by Engineer.

G. Materials and equipment for protection and curing of concrete shall be operational at the placement site before placement begins.

402.16 CONVEYING

A. Concrete shall be moved from the mixer to the place of final deposit as rapidly as practicable by methods that will prevent segregation, undue drying due to temperature rise, or loss of ingredients, and in a manner that will maintain the required quality of concrete.

B. Conveying equipment, of size and design to maintain a continuous flow of concrete at the delivery end may be used if acceptable to the Engineer. The Engineer may order discontinuance of their use if an inferior quality of concrete is produced by the use of such conveyors, and institute a satisfactory method of handling the concrete. Conveying equipment with aluminium parts, such as chutes, hoppers, or scrapers that could come in contact with the concrete during conveying shall not be used.

C. Belt conveyors that are horizontal or at a slope that causes neither segregation nor loss may be used. Baffle boards or other arrangement at the discharge end shall be used to prevent segregation. Long runs shall be discharged into a hopper without segregation. Concrete shall not adhere to the return belt.

D. Steel or steel-lined chutes that have a slope not exceeding one vertical to two horizontal and not less than one vertical to three horizontal may be used. Chutes more than 6m long, and chutes not satisfying slope requirements, may be used if the chutes discharge into a hopper designed to prevent segregation, before distribution.

E. Concrete shall be placed in forms using troughs, chutes or pipes with the end held not more than a one metre above the surface of the bare form or the concrete.

Troughs, chutes or pipes shall have steel hopper tops with sides sloping at least 45 degrees.

F. Bottom-drip buckets to place concrete shall be used wherever possible. Buckets shall permit gradual release and shall have sides sloping at least 45 degrees near discharge.

402.17 PLACING CONCRETE

A. Concrete shall be deposited into the forms as nearly as possible to its final position, to eliminate segregation of aggregates. Vibrators shall not be used for extensive moving of the mass of fresh concrete.

B. Layers of concrete shall not taper nor be wedge shaped but shall be built with squared ends and level tops. Concrete shall be deposited continuously or in layers of such thickness that no concrete will be deposited on concrete that has hardened sufficiently to cause the formation of seams or planes of weakness within the section. If a section cannot be placed continuously, construction joints shall be located at points as indicated or as approved by Engineer. Concrete shall be deposited at such a rate that concrete being integrated with fresh concrete is plastic. Vibrators shall be used to blend the plastic concrete layers.

C. Struts, stays and braces, serving temporarily to hold the forms in correct shape and alignment pending the placing of concrete at their locations, shall be removed when the concrete placing has reached an elevation rendering their service unnecessary. These temporary members shall be entirely removed from the forms and not buried in the concrete.

D. Concrete shall not be deposited in supported elements until concrete previously placed in columns or walls is no longer plastic and initial shrinkage has occurred.

E. Concrete that does not reach its final position in the forms within the time stipulated under Specification Section 401 shall be rejected.

F. Concrete shall be placed so as to avoid segregation of the materials and the displacement of the reinforcement.

G. Concrete shall be placed in horizontal layers not more than 300mm. thick except as hereinafter provided. When less than a complete layer is placed in one operation, it shall be terminated at a vertical bulkhead. Each layer shall be placed and compacted before the preceding batch has taken initial set to prevent injury to the green concrete and avoid surfaces of separation between the batches. Each layer shall be compacted so as to avoid the formation of a construction joint with a preceding layer, which has not taken initial set.

All chutes, troughs and pipes shall be kept clean and free from coatings of hardened concrete by thoroughly flushing with water after each run. Water used for flushing shall be discharged clear of the structure.

When placing operations would involve dropping the concrete more than 1m, it shall be deposited through sheet metal or other approved pipes. As far as practicable, the

pipes shall be kept full of concrete during placing and their lower ends shall be kept buried in the newly placed concrete. After initial set of the concrete, the forms shall not be jarred and no strain shall be placed on the ends of reinforcement bars, which project.

H. Slabs shall be placed in alternating strips.

I. The interval between concrete deliveries shall be such that no more than 20 minutes interruption elapse during placement of a single foundation or slab, unless approved by the Engineer.

J. Discharge of the concrete shall be completed within 45 minutes after the introduction of the mixing water to the cement and aggregates or the introduction of the cement to the aggregates. This time may be extended up to 90 minutes with approval of the Engineer.

K. When the placing of concrete is temporarily discontinued, the concrete, after becoming firm enough to retain its form shall be cleaned of laitance and other objectionable material to a sufficient depth to expose sound concrete. To avoid visible joints as far as possible upon exposed faces, the top surface of the concrete adjacent to the forms shall be smoothed with a trowel. Where a "feather edge" might be produced at a construction joint, as in the sloped top surface of a wingwall, an inset form shall be used to produce a blocked out portion in the preceding layer that shall produce an edge thickness of not less than 150mm in the succeeding layer. Work shall not be discontinued within 450mm of the top of any face, unless provision has been made for a coping less than 450mm thick, in which case, if permitted by the Engineer, the construction joint may be made at the under side of the coping.

L. Immediately following the discontinuance of placing concrete, all accumulations of mortar splashed upon reinforcement steel and the surfaces shall be removed. Dried mortar chips and dust shall not be puddled into the inset concrete. If the accumulations are not removed prior to the concrete becoming set, care shall be exercised not to injure or break the concrete-steel bond at and near the surface of the concrete, while cleaning the reinforcement steel.

M. Concrete delivery tickets shall be maintained as a record for ready-mixed concrete. Copies of all concrete delivery tickets shall be delivered to the Engineer at the end of each concrete pour.

402.18 CONSOLIDATION

A. Concrete shall be consolidated until voids are filled and free mortar appears on the surface. With the exception of concrete placed under water, concrete shall be consolidated by means of internal vibrators unless special authorization is given by the Engineer or as provided herein.

B. Vibrators shall have a minimum frequency of 5,000 vibrations per minute and massive heads with sufficient amplitude to effectively consolidate concrete. The intensity of vibration shall be such as to visibly affect a mass of concrete of 25mm slump over a radius of at least 450mm.

C. A sufficient number of vibrators shall be used so to consolidate the concrete within 15 minutes after depositing in forms. At least one spare vibrator shall be available at the site of each structure during concrete placement. Vibrators shall not be held against the forms or against the reinforcing steel.

D. The location, manner, and the duration of vibration shall be such as to secure maximum consolidation of the concrete without causing segregation of mortar and coarse aggregate and without causing water or cement paste to flush to the surface. Particular care in this regard shall be exercised during placement of concrete mixes with high slumps. The thickness of the layers shall not be greater than can be satisfactorily consolidated by vibrators. Vibrators shall vertically penetrate into the previous layer at regular intervals.

E. Vibrators must not be kept in one area long enough to create a cavity. They shall be plunged into concrete rapidly so as not to spatter forms or create depressions in the lift and removed slowly.

F. Vibrators shall be manipulated so as to thoroughly work the concrete around the reinforcement, embedded fixtures and into the corners and angles of the forms. They shall not be used for the extensive moving of the mass of fresh concrete.

G. Vibrators shall be applied at points uniformly spaced and not farther apart than twice the radius over which the vibration is visibly effective.

H. Vibration shall be supplemented by such spading as is necessary to ensure smooth surfaces and dense concrete along form surfaces and in corners and locations impossible to reach with the vibrators.

402.19 PROTECTION

A. Arrangements for cooling and shading concrete in advance of placement, adequate to maintain the required temperature and moisture conditions without injury due to concentration of heat, shall be made.

B. Concrete shall have a maximum placing temperature that will not cause difficulty from loss of slump, flash set, or cold joints.

C. The temperature of concrete as placed shall not exceed 35°C, except the temperature of concrete placed in walls and slabs one metre or greater in thickness shall not exceed 32°C. When the temperature of reinforcement is greater than 50°C, it shall be sprayed with water and any free water removed from the forms all immediately prior to placing the concrete.

D. Protection during inclement weather:

Concrete pouring shall be stopped when the quantity of rain falling on the surface is sufficient to wash the cement paste from the concrete surface.

402.20 BONDING

A. Longitudinal keys at least 40mm deep or inclined dowels at least 300mm long shall be provided at all joints in walls and slabs footing, unless otherwise indicated. Other construction joints may be made without keys, except where keys are indicated. Where keys are indicated, they shall be formed to dimensions indicated.

See Section 401.11 Construction Joints.

B. When indicated or permitted, surface bond shall be attained by use of an approved chemical retarder that delays but does not prevent setting of the surface mortar. Retarded mortar shall be removed within 24 hours after placing to produce a clean, exposed coarse aggregate bonding surface.

C. After placement has been completed to the construction joint and before placing fresh concrete, clean reinforcing steel and the surfaces of horizontal and vertical construction joints of surface laitance, curing compound and other materials foreign to the concrete, and expose clean coarse aggregate of at least 10 mm in size. Hardened concrete surfaces shall be cleaned by abrasive blast methods to expose coarse aggregate, after the curing period or immediately before placing concrete at the joint. Surfaces of concrete, that have been in place not more than eight hours may be cleaned with air and water jets if surface laitance is removed and clean coarse aggregate is exposed. Surfaces of horizontal construction joints, where expansion joint filler or bond breaking compound is to be placed, shall be cleaned of dirt, sawdust, and other loose materials. Surfaces on which concrete is to be placed shall be moistened immediately before placing concrete.

D. When new concrete is shown to be joined to existing concrete by means of steel dowels mortared in holes drilled in the existing concrete, the holes shall be drilled at least 300mm, blown out with an air compressor, wetted and filled with epoxy mortar after which the dowel shall be inserted and left undisturbed until the epoxy mortar is hardened.

402.21 FINISHING CONCRETE SURFACES

A General

1. Finishing of concrete surfaces shall generally be in accordance with the following clauses. Finishes indicated on the Drawings, if different, shall have precedence. Surface finishes shall be classified as follows:

    - Class 1 Ordinary surface finish
    - Class 2 Rubbed finish
    - Class 3 Tooled finish
    - Class 4 Floated surface finish

2. All concrete shall be given Class 1, Ordinary Surface Finish, and in addition, if further finishing is required, such other type of finish as is specified. If not otherwise indicated, the following surfaces shall be given at Class 2 Rubbed Finish: the exposed surfaces of piers, abutments, wing walls and retaining walls;

the outside faces of girders, T-beams, slabs, columns, brackets, curbs, headwalls, railings, arch rings, spandrel walls and parapets; but not on unexposed portions of the tops and bottoms of deck slabs, bottoms of beams and girders, sides of interior beams and girders, backwalls above bridge seat or the underside of copings. The surface finish on piers and abutments shall include all exposed surfaces below bridge seat to 300mm below the finish slope lines on the outside face and shall be finished on top and for a depth of 300mm below the top of the back sides.

3. Where Class 3, Tooled Finish is applicable, the Contractor shall provide a small sample panel, and shall provide several groups of bush hammered finishes, in order to permit the Engineer to select the particular finish to be incorporated in the work.

4. Tops of sidewalks shall be given a Class 4 Floated Finish. Bridge concrete approach and deck slabs shall be given a Class 4 Floated Finish.

B Class 1, Ordinary Surface Finish

1. Immediately following the removal of forms, all fins and irregular projections shall be removed from all surfaces except from those that are not to be waterproofed. On all surfaces, the cavities produced by form ties and all other holes, honeycomb spots, broken corners or edges and other defects shall be thoroughly cleaned and, after having been kept saturated with water for a period of not less than three hours, shall be carefully pointed and trued with a mortar of cement and fine aggregate mixed in the proportions used in the grade of the concrete being finished. Mortar used in pointing shall be not more than one hour old. The mortar patches shall be cured as specified under Specification Section 402.22.

2. All construction and expansion joints in the completed works shall be left carefully tooled and free of all mortar and concrete. Joint filler shall be cut back not less than 25mm from the exposed face for its full length and the depth filled with caulking compound approved by the Engineer to a smooth and sightly appearance.

3. The resulting surfaces shall be true and uniform. All repaired surfaces, the appearance of which is not satisfactory to the Engineer, shall be "rubbed" as specified under Specification Section 402.21.3.

C Class 2 Rubbed Finish

1. After removal of forms, the rubbing of concrete shall be started as soon as its condition will permit. Immediately before starting this work the concrete shall be kept thoroughly saturated with water for a minimum period of three hours. Sufficient time shall have elapsed before the wetting down to allow the mortar used in the pointing of rod holes and defects to thoroughly set. Surfaces to be finished shall be rubbed with a medium coarse Carborundum stone, using a small amount of mortar on its face. The mortar shall be composed of cement and fine sand mixed in proportions used in the concrete being finished. Rubbing shall be continued until all form marks,

projections and irregularities have been removed, all voids filled and a uniform surface is attained. The paste produced by this rubbing shall be left in place at this time.

2. After all concrete above the surface being treated has been cast; the final finish shall be obtained by rubbing with a fine carborundum stone and water. This rubbing shall be continued until the entire surface is of a smooth texture and uniform appearance and colour.

3. After the final rubbing is completed and the surface has dried, it shall be rubbed with burlap to remove loose powder and shall be left free from all unsound patches, paste, powder and objectionable marks.

D Class 3, Tooled Finish

Finish of this character for panels and other like work may be secured by the use of a bush hammer, pick, Crandall, or other approved tool. Air tools shall be employed unless another method is approved by the Engineer. No tooling shall be done until the concrete has set for at least 14 days and as much longer as may be necessary to prevent the aggregate particles from being picked out of the surface. The finished surface shall show a grouping of broken aggregate particles in a material of mortar, each aggregate particle being in slight relief.

E Class 4, Floated Surface Finish

1. Striking Off

After the concrete is compacted as specified under Clause 402.18, the surface shall be carefully rodded and struck off with a strike board to conform to the cross section and grade shown on the Drawings. Proper allowance shall be made for camber, if required. The strike board may be operated longitudinally or transversely and shall be moved forward with a combined longitudinal and transverse motion, the manipulation being such that neither end is raised from the side forms during the process. A slight excess of concrete shall be kept in front of the cutting edge at all times.

2. Floating

After striking off and consolidating as specified above, the surface shall be made uniform by a longitudinal or transverse floating, or both. Longitudinal floating will be required except in places where this method is not feasible.

3. Longitudinal Floating

The longitudinal float, operated from foot bridges, shall be worked with a sawing motion while held in a floating position parallel to the road centreline and passing gradually from one side of the pavement to the other. The float shall then be moved forward one half of its length and the above operation repeated. Care shall be taken to preserve the crown and cross-section of the pavement.

4. Straight Edging

After the longitudinal floating has been completed and the excess water removed, but while the concrete is still plastic, the slab surface shall be tested for trueness with a straightedge. For this purpose, the Contractor shall furnish and use an accurate 3m straightedge swung from handles 1m longer than one half the width of the slab.

The straightedge shall be held in successive positions parallel to the surface centreline and in contact with the surface and the whole area gone over from one side of the concrete to the other as necessary. Advancement along the deck shall be in successive stages of not more than one half the length of the straightedge. Any depressions found shall be immediately filled with freshly mixed concrete, struck off, consolidated and refinished. High areas shall be cut down and refinished. The straightedge testing and refloating shall continue until the entire surface is found to be free from observable departures from the straightedge and the surface has the required grade and the contour until there are no deviations of more than 3mm under the 3m straightedge.

5 Final Finishing

When the concrete has hardened sufficiently, the surface shall be given a broom finish. The broom shall be of an approved type. The strokes shall be square across the surface, from edge to edge with adjacent strokes slightly overlapped and shall be made by drawing the concrete, but so as to produce regular broom without tearing the concrete, but so as to produce regular corrugations not over 3mm in depth. The surface as thus finished shall be free from porous spots, irregularities, depressions and small pockets or rough spots such as may be caused by accidental disturbance during the final brooming of particles of coarse aggregate embedded near the surface. Any areas intended for pedestrian traffic shall be given a wood float finish. In no case shall a smooth steel trowel finish be allowed.

F Daylight Finishing

Unless approved lighting facilities are provided by the Contractor, the placing of deck concrete shall commence at such time that will permit finishing during daylight hours.

402.22 CONCRETE CURING AND PROTECTION

A. Beginning immediately after placement, concrete shall be protected from premature drying, temperatures above 38°C and mechanical injury. **A method statement defining the materials and methods of curing and protection shall be submitted to the Engineer for approval 7 working days in advance of each proposed pour.** Concrete shall be cured and protected in accordance with the provisions of ACI 301-05, Section 5.3.6. The pour may not commence until such approval is granted.

B. For surfaces on which forms are kept continuously in place without loosening, for a period of five days or more, no further curing will be required. All other surfaces will be cured as described below.

C. Concrete shall be kept continuously under cure until the accumulated time is at least five days for bottom slabs and footings and seven days for all other concrete.

D. The Contractor shall have adequate equipment and material on hand before placement of concrete beams to ensure that satisfactory curing is assured. Water if required for curing shall be as specified for concrete.

E One of the following methods shall be used as approved by the Engineer.

1. Ponding: the surface shall be kept submerged at all times for the required curing period. Water must not be allowed to flow to erode the surface. Water shall be kept clean and free of dirt and debris.

2. Continuous fogging: this shall be accomplished by fogging with a nozzle that so atomizes the water flow that a mist and not a spray is formed. Water must not be allowed to erode the surface. The concrete shall be fogged regularly, without allowing any part of the surface to dry.

3. Wet burlap and vapour barrier curing: this shall consist of covering the concrete surface with wet burlap as soon as the concrete has set sufficient to support the burlap without marking. Once burlap has been placed it shall be thoroughly wetted down and covered with vapour proof sheeting. Both the burlap and vapour proof sheeting shall be furnished in pieces large enough to extend at least 450mm beyond the edge of the concrete. Sheets for vapour barrier shall be lapped a minimum of 150mm. Sheets shall be adequately weighed to prevent displacement by billowing. The Contractor shall be responsible for the condition of the vapour proof sheeting at all times during the curing period and any damaged pieces shall be patched immediately to the satisfaction of the Engineer. Materials used for this curing method shall be as approved by the Engineer.

4. Membrane curing compound: curing compound shall be mixed and applied in accordance with the manufacturer's recommendations, except that the rate of application shall be at least $1L/m^2$ of exposed surface to be cured. The membrane curing compound shall be continuous, flexible and without defects. It shall retain the required moisture in the concrete. However, liquid membrane curing compounds shall not be used on surfaces that shall receive bonded treatments, tiles, paint or other adhered finishes, epoxy toppings, or additional concrete.

F If in the opinion of the Engineer, unsatisfactory results will be or are being achieved by methods 1, 2 or 3 above, the Engineer may instruct the use of a membrane-curing compound, the cost of which shall be borne solely by the Contractor.

G Protection from Injury:

1. During the curing period, the concrete shall be protected from damaging mechanical disturbances, such as load stresses, impact, and heavy vibration. Concrete surfaces shall be protected from damage by construction equipment, materials and methods, by curing methods, rain, or running water. Construction activities that result in ground induced vibrations, such as from pile driving operations and/or road construction compaction equipment, shall not be carried out within a distance of 10m from the concrete element being cured, and shall not be carried out until the concrete has cured for a minimum period of seven (7) days, or unless otherwise approved by the Engineer.

2. Self-supporting structures shall not be loaded in such a way as to over stress the concrete.

3. Drilled metal shielded bolts only shall be used for fastenings. Explosive or other power driven fasteners must not be used in concrete.

402.23 DEFECTIVE CONCRETE WORK

A. The Contractor shall provide advance warning of any formwork stripping to the Engineer's Representative in sufficient time as to allow inspection of the finished concrete prior to remedial work being carried out. No remedial works shall be carried out without the approval of the Engineer's Representative.

B. Porous areas open or porous construction joints and honeycombed concrete will be considered to indicate that the requirements for mixing, placing and handling have not been complied with and will be sufficient for rejection of the members of the structure thus affected.

C. Defective work exposed upon removal of forms shall be entirely removed or repaired within 48 hours after forms have been removed.

D Repaired areas will not be accepted if:

1. The structural requirements have been impaired by reducing the net section of compression members;

2. The bond between the steel and concrete has been reduced; and

3. The area is not finished to conform in every respect to the texture, contour, and colour of the surrounding concrete.

E. If the above requirements are not satisfied, the Engineer may require that the members or unit involved be entirely removed and satisfactorily replaced at no additional expense.

402.24 REPAIR OF SURFACE IMPERFECTIONS:

A. As soon as possible after stripping forms, holes left by form ties and other temporary inserts, shall be thoroughly cleaned and filled and corrective work carried out.

B. Surfaces generally shall be of uniform appearance with regard to colour and texture and shall have a smooth finish.

C. Small surface holes caused by air bubbles, normal joint form marks, minor chips and spalls may be tolerated in limited areas, but no major or unsightly imperfections, honeycombs or structural defects will be permitted without carrying out remedial work, if and as approved by the Engineer, to remove such imperfections.

D. In general, pin holes and holes smaller than 10mm in diameter and not more than 10mm deep may be left unfilled if their distribution is random, if they do not form unsightly clusters and if they are not rusty or discoloured.

E. Imperfect texture, laitance, fins and roughness shall be removed by rubbing affected areas with concrete blocks or carborundum stones until smooth and uniform.

Holes 10 to 20mm in their greatest dimension, that are not more than 20mm deep, shall be cleaned of loose and staining material and filled with grout formulated to match the colour of the concrete when dry. Deeper holes shall be repaired only after the Engineer is satisfied that they do not affect structural integrity.

If other defects do not cause rejection, holes, honeycombed areas, spalls, and discoloured areas of oily or bond-breaking substances shall be cleaned out. The surface of each defect shall be roughened or keyed and the bottom and sides coated with a non-staining acrylic or epoxy-bonding agent. Spalled, loose, porous material shall be cut back until coarse aggregate will break under chipping rather than fall out. A bonding agent shall be applied and the defect filled with non-shrinking grout or epoxy-Portland cement intrusion grout that has been formulated to match the colour of the concrete when dry. The grout shall be tamped and struck off flush with the surrounding concrete without smearing. The grout shall be confined until cured, keeping it damp when exposed to sun or other rapid drying.

Efflorescence

If on completion of the work, there is a marked efflorescence at any point on the surface, it shall be removed as directed by washing with 10% solution of Muriatic Acid and thoroughly rinsed off with water from a hose when the acid has ceased foaming.

402.25 ADDITIONAL PROVISIONS

A Deck and approach Slabs

1. General

The Contractor shall place the deck concrete on precast beam spans in one continuous operation for the full length of the span or between pour lines as shown on the Drawings. When the deck width exceeds 15m, one longitudinal joint near the centre of the slab may be permitted, subject to the Engineer's approval regarding location and details. Pours shall be made in the sequence indicated on the Drawings and no transverse joints shall be permitted at alternate locations.

Deck surfaces shall be finished using a mechanical deck finisher of the "Bidwell", "Gomalo", or "Borges" type or equivalent acceptable to the Engineer. However, the final finish shall be Class 4 Floated Surface Finish. The Contractor shall furnish a work bridge having a span at least equivalent to that of the deck finisher. It shall be of rigid construction, easily moved and free of excessive wobble and springing when in use.

Concrete shall be placed on a uniform heading parallel to the substructure.

2. Construction Method and Equipment

Immediately upon award of the Contract, the Contractor shall submit, to the Engineer for approval a complete description of the method and equipment proposed for the handling, placing and finishing of the concrete.

It shall include the equipment for mixing, transporting, distributing and vibrating the concrete, the concrete deck finisher and guide rails and complete details for the support of such equipment and the location of same for inspection purposes.

All equipment shall be subject to inspection by the Engineer and only approved equipment will be accepted for use.

Regardless of previous approval, equipment may be rejected during operation if it is unsatisfactory. Mixers having an accumulation of hard concrete or mortar or having any part of section of a blade worn 25mm or more below the original height of the manufacturer's design will not be approved for use.

At the same time the Contractor shall submit a list of all personnel who will be working on the placing and finishing of concrete, with a brief resume of their experience.

Any approval given by the Engineer will not relieve the Contractor of the responsibility of a satisfactory performance for his method and equipment.

3. Initial Set

The initial set of all concrete in place in a section shall take place at about the same time and after the deck surface has been machined finished. This condition shall be obtained by the use of a set-retarding agent ("Plastiment" or approved equal).

4. Handling and Placing Concrete

Concrete shall be delivered and distributed at a uniform and adequate rate ahead of the deck finisher such that not less than 7.5 cubic metres of concrete shall be placed per hour for the full width of the deck. The concrete shall be vibrated by mechanical vibrators in accordance with Clause 402.18. Standby plant and equipment must be available in case of breakdown.

Concrete shall be placed so as to avoid segregation of materials and the displacement of reinforcement. Special care shall be taken to distribute the concrete to each part of forms by depositing concrete directly as near the final position as possible. Concrete shall not be moved by means of vibrators. Concrete shall not be dropped a distance of more than 600mm.

5. Finishing Machine Guide Rails

   The Contractor shall furnish and install finishing machine guide rails to suit the transverse profile of the deck as shown on the drawings and the longitudinal profile, with due allowance for dead load deflection and creep. Guide rails shall be adequately supported outside the curb line of the bridge and shall be completely in place and firmly secured prior to the placing of concrete in each span.

6. Deck Finish at Curbs

   Cement grout that builds up in areas adjacent to curbs that cannot be machine finished shall be removed. Concrete shall be hand screeded and floated to conform to the machine-finished deck.

7. Surface Defects and Tolerances in Bridge Deck and Approach Slabs

   The finished surface of the slab shall conform to the longitudinal and transverse profiles as indicated on the drawing or ordered by the Engineer.

   The surface shall be free from open texturing, plucked aggregate and local projections.

   Except across the crown, the surface shall be such that when tested with a 3m long straight edge placed anywhere in any direction, on the surface there shall not be a gap greater than 9.5mm. The surface shall be checked as described above immediately after screeding.

   The surface shall again be checked at the end of the curing period in the same manner and to the same tolerance.

   Areas that do not meet the required surface accuracy shall be clearly marked out and the Contractor shall build them up or grind them down at his own expense as required by the Engineer.

   If the surface is damaged in any way by construction operations, or if the deck shows sign of distress or scaling prior to the final acceptance of the deck, it shall be cut out and replaced by the Contractor at his own expense.

B Box Culverts

1. In general, the base slab or footings of box culverts shall be placed and allowed to set before the remainder of the culvert is constructed. In this case suitable provision shall be made for bonding the sidewalls to the culvert base, preferably

by means of raised longitudinal keys so constructed as to prevent as far as possible, the percolation of water through the construction joint.

2. Before concrete is placed in the sidewalls, the culvert footings shall be thoroughly cleaned of all shavings, stocks, sawdust, or other extraneous material and the surface carefully chipped and roughened in accordance with the method of bonding construction joints as specified herein.

3. In the construction of box culverts 1.2m or less in height, the sidewalls and top slab may be constructed as a monolith. When this method of construction is used, any necessary construction joints shall be vertical and at right angles to the axis of the culvert.

4. In the construction of box culverts more than l.2m in height, the concrete in the walls shall be placed and allowed to set before the top slabs are placed. In this case, appropriate keys shall be left in the sidewalls for anchoring the cover slab.

C Concrete Placed in Footings or below Ground Level

1. Where concrete can be placed in dry excavation, cribs, cofferdams and forms may be omitted, subject to compliance with the following limitations and conditions. This procedure may be used only in locations not exposed to view from the travelled roadway.

   The elevations and dimensions shown in the drawings for the extent of the footing shall be obtained as a minimum subject to the following requirements for increased cover to reinforcement. Reinforcement will be placed in its correct position according to the drawings and the cover to any reinforcement from any unsupported excavated face shall be increased by 25mm from the minimum cover stated in the Contract. Such increase shall be achieved by extension of the minimum concrete dimensions shown on the drawings or elsewhere in the Contract and all additional costs associated with the increased structures dimensions shall met by the Contractor.
   The sides of the excavations shall be trimmed to a regular shape and as near vertical as can be obtained and the material remain stable. All loose material shall be removed from the base of the excavation and from the faces so as to prevent falls of material and should any material fall into the excavation during placement it shall be immediately removed along with any contaminated concrete.

   The entire excavation shall be filled with concrete to the required elevation of the top of the footing. The volume of concrete to be paid for will be determined from the neat line dimensions shown on the Drawings.

402.26 CONCRETE TOLERANCES

A. Form work, concrete placement and workmanship shall be such that the following concrete tolerances are achieved.

B. Tolerance classes:

Class A: this requires a 4mm maximum deviation along a 3m straightedge placed anywhere on the surface.

Class B: this requires an 8mm maximum deviation along a 3m straightedge placed anywhere on the surface.

C. Locations:
A Class A tolerance is required on the top surfaces of slabs, and sidewalks.
A Class B tolerance is required on all other surfaces.

D The maximum allowable deviations from dimensions, elevations, slopes and positions shall be as follows unless otherwise indicated, except that no tolerance shall be allowed to be combined with another tolerance at any location such that the overall design of the structure, either structurally or visibly, is impaired

1. Footings:
   Width, depth and length: plus 90mm; minus 15mm.
   Misplacement or eccentricity: 30mm.
   Top elevation: plus or minus 10mm.

2. Top elevation of slabs not otherwise specified: plus or minus 8mm at each point.
   If a slope is indicated: plus or minus 4mm in 3m.

3. Top elevation of columns, walls and piers: as necessary to join other surfaces and not more than plus or minus 8mm.

4. Plumb of columns, piers, walls and joints not exposed to view in finished structure: 8mm in 3 m not exceeding 25mm total.

5. Plumb of columns, piers, walls, vertical joints and grooves and other prominent vertical lines exposed to view in finished structure: 8mm. in 6m not exceeding 20mm total.

6. Level and grade of exposed lintels, sills, parapets, horizontal grooves and other conspicuous lines: plus or minus 8mm in 6m, not exceeding plus or minus 20mm in entire length.

7. Cross sectional dimension of columns, beams and slabs: plus or minus 10mm except increase thickness of slabs on grade as necessary to achieve indicated top elevation and slope.

8. Thickness of walls: plus 20mm, minus 10mm.

9. Location of sleeves, size and location of slab openings and wall openings: plus or minus 20mm.

10. Location of sleeves, size and location of slab openings and wall openings: plus or minus 20mm.

11. Misplacement of Work Points with respect to theoretical grid position: 5mm.

12. Dimensional Tolerances of Girder Bearing Areas and Anchor Bolts over which the girders will be erected shall be constructed with dimensional tolerances as specified below:

    Elevation of top of bearing area: plus 0mm, minus 15mm level.
    Axes of bearing area over contiguous structure: plus or minus 20mm longitudinally and transversely from theoretical locations.
    Clear distance between faces of girder supports: plus or minus 40mm throughout the transverse width of support.

    Anchor bolt location: 30mm longitudinally, 20mm transversely. Tolerances specified are with respect to absolute theoretical locations and not the actual axes of bearing area.

402.27 SAMPLING AND TESTING

A. Sampling and Testing shall be in accordance with the requirements for Section 401 Portland Cement Concrete except that the followings specific requirements shall take precedence.

B. Core tests: Core samples of in-place concrete will be made when cylinder crushing strengths are such that there is reasonable doubt that the specified concrete strengths have been attained in the structure. Additional tests which will comprise the obtaining and testing of drilled cores of concrete will be conducted in accordance with ASTM C 42M and evaluated in accordance with ACI 318. In such cases, three (3) cores shall be taken at each area where the concrete is considered questionable.

   Concrete in an area represented by core tests shall be considered structurally adequate if the average of three cores is equal to at least 85 per cent of the specified minimum compressive strength and if no single core is less than 75 per cent of the specified minimum compressive strength.
   If the core tests indicate that the concrete meets the specified strength, results of test cylinders shall be waived. If the core tests fail to meet the requirements of ACI 318, the Contractor shall at his own expense, remove and replace the defective concrete with concrete meeting the Specification requirements.

C. Workmanship: Concrete work that does not conform to the specified requirements, including strength, colour, tolerances and finishes, shall be corrected or replaced at the Contractor's expense.

402.28 SUBMITTALS

Submittals shall conform to requirements of the Engineer.

A. The names and descriptions of the following products, items and accessories:

1. Tie rods and cones.
2. Circular column forms.
3. Flatform material.
4. Release agent.
5. Vibrator frequency and head weight.

6. Concrete materials per Section 401.

B. At least 24 hours (non-working days excluded) before placing any concrete the Contractor shall submit to the Engineer the following:

1. The exact location and portion of structure to be placed.
2. The date, time, volume and class of concrete is to be placed.
3. Method of conveying and placing of the concrete.

No concrete shall be placed until such time as all inspections and approvals have been completed by the Engineer.

Within 24 hours of the completion of the pour the Contractor shall submit to the Engineer signed certification confirming or amending as appropriate items 1, 2, and 3 above as they applied to the pour, and the submittal shall additionally include the commencement and completion times of the pour.

SERIES 400: STRUCTURAL WORKS

SECTION 405: REINFORCING STEEL

405.1 Description

405.2 Materials

405.3 Construction requirements

405.1 DESCRIPTION

The work to be performed under this Section consists of furnishing and placing reinforcing bars of the grade, type and size designated, in accordance with these Specifications, and in conformity with the locations shown on the Drawings.

Test certificates from an independent testing agency, approved in advance by the Engineer, shall be submitted prior to the materials being brought to the Site confirming that the proposed materials conform to the requirements of this Specification Section. Test certificates for material source approval shall be dated not more than three (3) months in advance of the date when the materials are to be brought to the Site for incorporation within the Works.

Quality control testing of materials during execution of the Works shall conform to the frequency and specified types of tests as detailed in these Specifications.

405.2 MATERIALS

Bar reinforcement in sizes up to and including 32mm shall conform to the requirements of ASTM A615/A615M Grade 60 from billet steel grades, except that the use of cold twisted bars is forbidden. Additionally, only metric sized bars shall be used in the Works.

Welded wire fabric (mesh) shall conform to ASTM A185/A185M.

If purchased in small lots from a warehouse, reinforcement may be accepted at the discretion of the Engineer upon certification that it meets the requirements of the Specifications listed above and subject to the applicable bending test.

Bar reinforcement for concrete structures, except that 6mm, which may be round, shall be deformed bars.

Tying wire for fixing of steel reinforcement shall consist of 1.6mm or 1.25mm black annealed wire.

405.3 CONSTRUCTION REQUIREMENTS

1. General

The Contractor shall prepare, thoroughly check, and submit to the Engineer for approval, working drawings, bar lists, and bar bending diagrams as may be required for the detailing and placement of reinforcing steel to all reinforced concrete structures.

Reinforcement placing drawings and bar bending schedules shall be prepared in accordance with ACI SP-66. Drawings and schedules shall show number, grade size, length, weight, mark, location, and bending diagrams for reinforcing bars.

Weights of steel shall be shown for each structure. Working drawings shall be 600mm x 900mm in size. Bar lists may be on smaller size sheets.

Four prints of each shall be submitted to the Engineer for his approval. Approval of

these Drawings by the Engineer shall not relieve the Contractor of any of his responsibilities under the terms of the Contract.

Fabrication tolerances shall comply with the requirements of ACI 117.

2. Bending

Bars shall be cold bent to the shapes shown on the Drawings and all bends shall be made accurately around pins of the following sizes:

- Bars 25mm and under: minimum pin size of 6 times the bar diameter
- Bars larger than 25mm: minimum pin size of 8 times the bar diameter
- Ties: pin size over 2 times, but not greater than 4 times the bar diameter.

The extension of free ends on hooks shall be 4 times the bar diameter, but not less than 60mm. Bends for stirrups and ties shall have radii on the inside of the bar of not less than one bar diameter.

3. Fixing

Reinforcement shall be placed accurately in the positions shown on the Drawings and held securely during the placing and compacting of concrete. The placing and fastening of reinforcement in each section of the work shall be approved by the Engineer before any concrete is deposited in the section.

All reinforcement shall be free from dirt, oil, paint, grease, mill scale, and loose or thick rust before being placed. Where the Engineer finds that the steel is rusting severely, he shall order the removal and replacement of the steel.

Main reinforcing bars carrying determinate stresses shall be spliced only where shown on the Drawings unless approval is obtained from the Engineer in writing before the reinforcing steel is ordered. Other reinforcing bars shall have a minimum length of 6m unless otherwise specified in the Drawings or limited by the physical dimensions of the section being reinforced. Splices shall be staggered as far as possible. Welding of reinforcing steel or mechanical splices shall not be permitted. Unless otherwise called for on the Drawings, a minimum lap length of 40 times the diameter of the bars shall be maintained.

Bars shall be tied at all intersections except where spacing is less than 300mm in each direction, when alternate intersections shall be tied. On site welding of reinforcing steel shall not be permitted. Where required to prevent the movement of the free ends of bars or to provide additional restraint at bends in bars additional reinforcing bars shall be included by the Contractor at his expense.

The minimum cover to bars from all forms and the relative position of all bars shall be maintained by stays, precast concrete/mortar blocks (of strength greater than the concrete in which they are to be placed), ties, hangers or other approved supports. Chairs for supporting deck reinforcement steel shall be either of galvanized steel, approved plastic material, or precast concrete blocks acceptable to the Engineer. The maximum spacing of the chairs shall be 1.20m.

The location of the top reinforcement steel (with respect to deck surface) shall be checked by running a full deck width template along the longitudinal screeds. No

main steel shall touch the template nor be more than 6mm distant from it.

SERIES 400: STRUCTURAL WORKS

SECTION 409: CONCRETE BLOCKWORK

409.1 Description

409.2 Materials

409.3 Nominal Block Dimensions

409.4 Strength Tests

409.5 Execution

409.1 DESCRIPTION

This work shall consist of the construction of blockwork in accordance with these Specification and as directed by the Engineer.

Test certificates from an independent testing agency, approved in advance by the Engineer, shall be submitted prior to the materials being brought to the Site confirming that the proposed materials conform to the requirements of this Specification Section. Test certificates for material source approval shall be dated not more than three (3) months in advance of the date when the materials are to be brought to the Site for incorporation within the Works.

Quality control testing of materials during execution of the Works shall conform to the frequency and specified types of tests as detailed in these Specifications.

409.2 MATERIALS

1. Precast Concrete Blocks

   Blocks shall conform to B.S. 6073: Part 1: 1981. Where plaster finish is required on blockwork, rough textured type blocks shall be supplied. Where "fair faced" finished is required all blocks shall be smooth textured with clean unbroken edges. All blocks to be incorporated in the works shall be delivered to the Site in a dry and fully cured state.

2. Sand for Mortar

   Sand shall be clean naturally occurring plastering sand free from salts, organic matter, clay, loam, dirt or other deleterious matter and shall conform to BS 1200. All sand shall be stored and kept free from contamination by any other material. Samples of sand shall be supplied to the Engineer for testing and approval at any time during the performance of the Works.

3. Water

   Water for use in concrete and for use with cement shall be clean and practically free of oil, acid, alkali, chlorides, organic matter, and other deleterious substances. Water from city water supplies or other sources approved by a public health department as potable may be accepted without being tested.

4. Plasticizer

   Where necessary a plasticizing agent conforming to BS 4887 may be added to the mortar in sufficient quantity to gain the required workability. The plasticizer shall be approved by the Engineer and applied in accordance with the manufacturer's instructions.

5. Mortar

Cement mortar shall consist of one part by volume of Portland cement and two parts by volume of natural sand. The components shall be thoroughly mixed in the dry state, and then water added to achieve the desired workability. Cement mortar shall be mixed in small quantities as and when required, and any mortar that has begun to set or that has been mixed for a period in excess of one hour shall be rejected.

Mortar made on Site shall be mixed by machine, unless otherwise approved by the Engineer, which shall be cleaned before use to avoid contamination and shall be cleaned out before changing mixes, and at the end of every working period. All materials shall be measured accurately by volume or weight, and not shovels. Powdered plasticizer, if used, shall be dissolved in part of the mixing water before use.

6. Concrete Filling

Where vertical reinforcement is specified the reinforced cores shall be filled with Class 21 concrete for the full height of the wall. The workability of the concrete shall be such that the mix will flow into and fill all the cavities in the cores without separation or segregation. The slump of the concrete to be used in filling shall be between 75mm and 100mm and it shall be placed as soon as possible and not more than 1.5 hours after water is first added. Admixtures may be used subject to prior approval by the Engineer. The concrete fill shall develop a minimum compressive strength of $21N/mm^2$.

Concrete fill shall not be placed to a height of more than 1m at one time and there shall be a minimum interval of 60 minutes between pours. No concrete fill shall be placed until such time as the masonry has sufficiently hardened to prevent "blow outs".

7. Reinforcement

Concrete blockwork shall generally have horizontal fabric reinforcement such as "Brickforce" or other equal and approved product laid in the joints after every third course in addition to any vertical bar reinforcement shown on the Drawings or requested by the Engineer.

Vertical reinforcement shall be held in position at the top and bottom and at intervals not exceeding 200 diameters. Vertical reinforcing steel shall have a minimum clearance of 6mm from the masonry and not less than one bar diameter between bars. Fabric reinforcement shall be completely embedded in mortar and lapped to a minimum of 150mm at splices and shall contain at least one cross wire of each piece of reinforcement in the lapped length.

409.3 NOMINAL BLOCK DIMENSIONS

Free standing blockwalls used as free draining diaphragms behind bridge abutments and wing walls shall have the following nominal dimensions:

Nominal width	Nominal length	Nominal height
150mm	400mm	200mm
200mm	400mm	200mm

Minimum face shell thickness and web thickness shall be as follows:

Nominal width	Nominal length	Nominal height
150mm	25mm	25mm
200mm	30mm	25mm

Measurements shall be the average of 5 units taken at the thinnest point.

409.4 STRENGTH TESTS

Hollow concrete blocks shall be made from Portland cement and suitable aggregate by an approved reputable manufacturer. All units shall be sound and free from cracks or other defects that would impair the strength or performance of the construction. Load bearing blocks shall have an average crushing strength of not less than $7N/mm^2$ measured over the gross area. Concrete blocks shall be tested in accordance with BS 6073: Part 2: 1981 or ASTM C140. The Contractor shall allow for testing 5 random units prior to commencement of the job. The units to be tested shall be selected at random by the Engineer or his duly authorized representative.

409.5 EXECUTION

Concrete blockwork shall be accurately set out to the dimensions shown on the Drawings or as directed by the Engineer. All surfaces on which blockwork is to be built shall be cleaned and levelled. Blocks shall be laid on a 10mm mortar bed to give a good continuous face-shell mortar bedding. All joints shall be filled with mortar at every course. Vertical joints shall be staggered, and blocks shall be set with the cells vertical. The lines of all courses and bonds shall be properly maintained.

At the time of laying, all blocks are to be free from excessive dust and dirt and shall be free from cracks and chips. Where cutting is necessary it should be carried out by the use of a broad, heavy chisel and a heavy chipping hammer. The blocks to be cut should be scored along the cutting line, after which heavier blows are struck until the unit splits.

Unless otherwise specified on the Drawings, the joints of all external visible facings and fair faced blockwork internally shall be flush pointed as the work proceeds.

Work in hot weather: When blockwork is to be constructed in hot dry conditions, individual units shall be wetted with a light spray just prior to setting in the mortar bed.

During construction all walls shall be adequately restrained and laterally supported by temporary supports able to resist forces as may be imposed by the wind and other loadings, until such time that the wall has been completed, achieved its full strength and is permanently restrained.

Backfilling of the structure shall only be carried out after the masonry block joints and concrete block core infill have moist cured for 7 days.

SERIES 400: STRUCTURAL WORKS

SECTION 410: DOWEL BARS

410.1 Description

410.2 Materials

410.3 Execution

410.1 Description

This Section covers the provision of dowel bars.

410.2 Materials

All Dowel Bars shall be Grade 60 steel conforming to the requirements of ASTM A615 for billet steel grades. Bearings shall be supplied with dowel holes to match the size of the dowels indicated on the Drawings.

410.3 Execution

All bars are to be placed accurately in position fixed into the abutment as shown on the Drawings.

Dowel Bars are to be thoroughly cleaned of all dirt, rust, oil, etc. and coated with a long pot life epoxy adhesive, Eucopoxy LPL MV, or approved equivalent, as per manufacturer's specification upon positioning and before pouring of concrete.

Two layers of bond breaking tape are to be provided only to that portion of the epoxy coated dowel bar protruding out of the abutment.

Epoxy coating shall meet the requirements of ASTM C883 and ASTM C884.

SERIES 500:
DRAINAGE WORKS

SERIES 500: DRAINAGE WORKS

SECTION 501: PIPE CULVERT

501.1 Description

501.2 Materials

501.3 Construction Requirements

501.1 DESCRIPTION

The work to be performed under this Section consists of supplying and installing pipe culverts of the types, classes, sizes and dimensions required, furnished and installed at such locations as are designated on the Drawings or by the Engineer in accordance with these Specifications and in conformity with the lines and grades given.

501.2 MATERIALS

1. **Reinforced Concrete Pipe** - Pipes shall be manufactured and conform fully to the requirements of AASHTO M 170 for Class IV, Wall C, pipes. The Contractor shall submit to the Engineer for approval, certificates from manufacturers showing their products comply with the stated standards.

2. **Corrugated High Density Polyethylene (HDPE) Pipe** – HDPE pipes shall be non-perforated dual wall pipe with smooth interior wall and corrugated exterior wall manufactured in accordance with the requirements of AASHTO M 294 Type S. The Contractor shall submit to the Engineer for approval, certificates from manufacturers showing their products comply with the stated standards.

3. **Concrete** - Encasement concrete shall conform to the requirements of Sections 401 and 402.

4. **Reinforcing Steel** - Reinforcing steel and steel fabric reinforcement shall conform to the requirements of Section 405.

5. **Rubber Gaskets** - Rubber gaskets for reinforced concrete pipe shall conform to the requirements of AASHTO M 198. Rubber gaskets for HDPE pipes shall be factory installed and shall conform to the requirements of ASTM F477.

6. **Joint Sealer** – For reinforced concrete pipe, this shall be made out of mortar and all materials and the respective ratios shall conform to the requirements of Sections 401, 402 and this Section. For HDPE pipes, joints shall be designed to meet the requirements of ASTM D3312 and ASTM F2487.

501.3 CONSTRUCTION REQUIREMENTS

1. **Excavation and Backfill** - Excavation and backfilling shall be performed in accordance with the requirements of Section 203, except that the costs of this work shall be included in the unit prices tendered per linear metre of pipe. The trench width shall be constrained to the width shown on the Drawings for a depth from 300mm above the top of the pipe to the base of the excavation. Any excess excavation shall be backfilled with concrete to the Engineer's instructions at the Contractor's expense.

2. **Pipe Bedding** - shall be Class B as ASCE Manual No. 37 unless defined in the Contract. Before bedding material is placed in the trench the base and the sides of the trench shall be trimmed to provide a regular shape in conformity with the drawings and all loose or soft material removed from the trench floor. Bedding material shall be placed and compacted in the trench to the level of the underside of the pipe barrel. Where the bed and surround is full concrete encasement the pipes

shall be first laid on temporary supports so as to support the pipe in its correct position until encasement.

3. **Laying of Pipe** – Reinforced concrete pipe laying shall begin at the downstream end with the bell or groove ends facing upstream. When the pipes are laid, the barrel of each pipe shall be in contact with the bedding material throughout its full length, inclusive of the bell.

When elliptical pipe with circular reinforcement or circular pipe with elliptical reinforcement is used, the pipe shall be laid in such a position that the manufacturer's marks designating the "top" or "bottom" of the pipe shall not be more than five degrees from a vertical plane through the longitudinal axis of the pipe.

HDPE pipe shall be installed in accordance with the pipe manufacturer's recommendations.

In the event of rain and the trench being filled with water, all works will cease until the period of rainfall has subsided and works will resume with the first task being to remove the water and all fallen material from the trench.

Where pipes have already been laid and water begins to engulf the trench, the mouth of the pipe shall be sealed temporally to ensure no unwanted material flows into the pipe causing disruptions to the expected flow.

4. **Joint Seal** - Joints shall be made with:

a) Portland cement mortar;
b) Portland cement grout; or
c) Rubber gaskets.

as described below, or by a combination of these types unless one type or combination is specified in the Special Conditions of Contract.

5. **Joints**

a) Mortar Joints – Reinforced Concrete Pipe

Mortar mixes shall be one part Portland cement and two parts sand. The quantity of water in the mix shall be sufficient to produce a stiff, workable mortar. Excess water in the mix shall be grounds for rejection. Pipe ends shall be thoroughly cleaned and wetted with water before the joint is made. The two pipes sections shall then be joined tightly with their inner surfaces flush and even. The joints shall be entirely filled and packed with mortar, and sufficient additional mortar shall be used to form a bead around the outside of the joint.

b) Grouted Joints – Reinforced Concrete Pipe

Grout shall consist of Portland cement mixed to a workable consistency with not more than 19 litres of water per sack of cement. The grout shall be

poured or pumped into the joint space and retained by moulds or runners around the pipe.

c) Rubber Gasket Joints

Rubber gaskets shall be fitted snugly in the annular space between the bevelled surfaces of the tongue and groove ends of connecting reinforced concrete pipe section to form a flexible watertight seal.

Joints in HDPE pipes shall be sealed by a factory-installed rubber gasket that conforms to the requirements of ASTM F477.

6. Joint Finishing – Reinforced Concrete Pipe

After joints of the above types are made, the inside face of the pipes and the annular recess between the ends of the pipes shall be cleaned. The recess shall then be filled with mortar and finished smooth and even with the inside surface of the pipes. For pipes 750mm. or less in diameter, joints shall be finished on the outside surface using grout or mortar. For pipes of greater diameter than 750mm, joints shall not be finished until all fill over the pipe has been completed.

7. Pipe Surround and Backfilling

In the case of granular bedding and surround the material shall be thoroughly tamped in under the flanks of the culverts to provide uniform bedding, all to the Engineer's satisfaction.

Surrounding alongside and backfilling over all culverts shall be placed at optimum moisture content and compacted in layers not exceeding 150mm after compaction, to a density of at least the density required for the material in adjoining layers of fill, subgrade and subbase. The density of backfilling in excavations made in natural ground shall be at least 95% of the Modified Proctor density.

Backfilling shall be carried out simultaneously and equally on both sides of a culvert to prevent unequal lateral forces from occurring.

Where shown on the drawings or ordered by the Engineer, pipes shall be fully encased in concrete according to class and dimensions as shown on the drawings or as ordered by the Engineer. Supports shall be provided close to the pipe ends to support the pipes during the placing of concrete. The concrete shall be so placed as to fill all spaces below the pipe completely. Poker vibrators shall be used to ensure the proper filling of all spaces below and around the pipes with concrete. Concrete casing shall be cast in one continuous operation until completed.

SERIES 500: DRAINAGE WORKS

SECTION 503: DRAINAGE APPLIANCE REHABILITATION

503.1 SCOPE

Drainage appliance rehabilitation will be done as shown on the Drawings or as directed by the Engineer to ensure that roadway surfaces are safe and well drained, and that surface run-off is channelled to watercourses, and to prevent any erosion of roadway side slopes and surfaces. The Work excludes new construction of manholes or catchpits, and grade adjustment.

503.2 MATERIALS

Materials to be supplied and used are as follows:

a) Culvert pipe, concrete inverts, catch basin boxes and grates, manhole boxes and covers and cast iron frames for catch basins and manholes will be required to match existing materials as replacement to those materials damaged or worn.
b) Clean granular aggregates will be used for backfill. Bituminous material will be required to complete repairs enclosing collection devices and aiding channelisation for run-off and materials shall be in accordance with the relevant 300 series Sections.
c) Concrete shall be Class 21 unless otherwise directed and shall conform to Specifications 401 and 402.
d) Reinforcement shall conform to the detailed Drawings and Specification 405.

503.3 EXECUTION

(a) Preliminary

The Contractor shall make a joint inspection of all drainage appliances including, without limitation, culverts, concrete inverts, catch basin boxes and frames, sumps manhole boxes and frames, grates, manhole covers, and related hardware to be rehabilitated or maintained to permit unobstructed passage of water from the Roadway surface and across or along the Right-of-Way. Any worn, blocked or silted-up, bent, broken, missing or damaged appliances will be noted for cleaning, repair or replacement. Where the inlet or outlet of a culvert is damaged, cracked or unravelled, repairs will be noted for replacing of the damaged section. The kerb and slope invert sections, which have become disconnected or damaged, will be noted for repair or replacement. All damaged asphalt kerbs will be noted for patching using an appropriate asphalt mix in accordance with the relevant 300 series sections.

(b) Methods

Methods of clearing debris will vary according to the severity of the problem and will include, but not be limited to:

- removing debris culverts, debris catchment areas and catch basins by hand or by specialized machinery;
- flushing the appliance with a high pressure hose to remove any build up of debris; and
- cleaning out catch basins and manholes using a vacuum catch basin cleaner or flushing with a high pressure hose.

SERIES 500: DRAINAGE WORKS

SECTION 505: CONCRETE CURB, SLIPPER, AND SWALE DRAINS

505.1 Description

505.2 Materials

505.3 Construction Requirements

505.1 DESCRIPTION

The terms 'curb' and 'kerb' shall be considered to be directly interchangeable when referred to in the Contract.

This work shall consist of the construction or repair of concrete curbs, curb and slippers, slipper and swale drains and similar features in accordance with these Specifications and in conformity with the locations, lines, grades and dimensions shown on the plans or as ordered by the Engineer.

505.2 MATERIALS

1. Concrete used shall be Class 30 or as specified on the drawings and shall conform to Sections 401 and 402.

2. Preformed expansion joint filler shall conform to Section 412.

3. Joint sealant shall be as designated in Specification Section 412.

4. Reinforcing steel and welded wire fabric shall conform to Section 405.

5. Synthetic fibre reinforcement as indicated on the detail Drawings shall conform to the requirements of Section 401.

6. Aggregate sub-base shall conform to Section 302.

505.3 CONSTRUCTION REQUIREMENTS

1. Excavate to the base of the underside of the proposed concrete curb, slipper etc. All soft and unsuitable material shall be removed and replaced with suitable material. If the base of the excavation is pavement quality materials of subbase or better compact the base of the excavation with 6 passes of a vibrating plate compactor having a mass per square metre of base plate of >1200kg, or an equivalent. If the base of the excavation is natural materials the excavation shall be continued for a further 150mm. The additional excavation will be backfilled with subbase material in 2 x 75mm layers with each layer being compacted by 6 passes of the plate compactor specified above.

2. Forms shall conform to the requirements of Section 402. Metal forms shall be of an approved section. Forms shall be placed so as to ensure a positive gradient of the slipper or swale to outfall(s). In flat areas the Engineer may instruct that the crossfall of the slipper or swale to be varied along its length to ensure that backfalls do not occur.

3. Concrete Placing - Mixing, placing, finish and curing of cement concrete shall conform to the requirements of Section 402 for cast-in-place concrete or as modified by the requirements given below. Reinforcement shall be securely fixed in place to conform to the drawings.

The concrete shall be brought up to the depth required in the forms in layers of 100mm each. It shall be rodded or spaded and tamped until fully compacted and mortar entirely covers the top and formed surfaces and no air voids remain.

The top of the concrete shall be finished to a smooth and even surface and the edges rounded to the radii shown on the plans. When the concrete is given the final finishing, the surface of the slipper or swale shall be tested with a 3.0m straightedge and any irregularities of more than 3mm in any 3m length shall be corrected. The completed construction shall be correct to the line and level shown on the drawings to within ±5mm. Upon curing the surface of slippers or swales shall be tested by the application of water from a bowser or similar, to confirm to the Engineer's satisfaction that a continuous gradient is maintained to the outfall(s). Should water pond in the slipper the Engineer may instruct remedial action, including the breaking out of the construction and its replacement at the Contractor's expense.

4. Joints - The works shall be constructed in uniform sections 3m in length, except where shorter sections are necessary for closures; but no section shall be less than 1.2m long. The sections shall be separated by sheet metal templates set perpendicular to the face and top of the curb or slipper. Templates shall be set carefully and held firmly during the placing of the concrete and shall be allowed to remain in place until the concrete has set sufficiently to hold its shape.

Expansion joints shall be formed at intervals of 6m using preformed 6mm thick filler and joint sealant conforming to the requirements of Specification Section 401. When the Works are placed next to a concrete sidewalk, expansion joints shall be located opposite expansion joints in the sidewalk. The forms shall not be removed until 24 hours after the concrete has been poured.

Contraction joints 6mm wide and 25mm deep shall be constructed at intervals of 3m. Contraction joints shall be filled with joint sealant conforming to the provisions of Section 412.

Minor defects only shall be repaired with mortar containing one part of Portland cement and two parts of fine aggregate. Plastering shall not be permitted on the faces and all rejected portions shall be removed and replaced at the Contractor's expenses. The exposed surfaces shall be finished while the concrete is still green, by wetting a soft brick or a wood block and rubbing the faces until they are smooth. The surfaces shall be wet thoroughly, either dipping the brick or block in water, or by throwing water on the surfaces with a brush. After the concrete has been rubbed smooth, using water, it shall be again rubbed with a thin grout containing one part of Portland cement and one part of fine aggregate. Rubbing with grout shall continue until a uniform colour is produced.

When completed, the concrete shall be cured for a minimum period of three days in accordance with Section 401. The concrete shall be suitably protected from the weather until thoroughly hardened. After the concrete has set sufficiently, the excavated spaces at the back of the construction shall be refilled to the required elevation with suitable materials which shall be tamped in layers of not more than 150mm until consolidated. At the front face or to each face of swales the excavated space shall be filled with a Class 9 concrete mix to 50mm from the new or existing

road level and the top 50mm filled with bituminous surface course or as directed by the Engineer.

Roadway pavement base and bituminous courses shall not be placed against any construction until it has gained sufficient strength to resist damage and also until curbs are properly supported by backfill or other means.

SERIES 500: DRAINAGE WORKS

SECTION 506: DRAINAGE CHANNELS

506.1 Description

506.2 Materials

506.3 Execution

506.1 DESCRIPTION

This work shall consist of constructing and repair of drainage channels, manholes / inspection chambers, catchpits, and concrete box drains in accordance with these Specifications and in accordance with the lines, grades, dimensions and design shown on the Drawings.

506.2 MATERIALS

1. Concrete shall be Class 30 or other class as specified and conform to Section 401 and be placed in accordance with Section 402. The nominal aggregate size shall be 10mm for core filling to blocks.

2. Reinforcing steel and welded wire fabric shall conform to Specification Section 405.

3. Load bearing hollow concrete blocks shall have a minimum thickness of 120mm and shall conform to Specification Section 409, with a minimum compressive strength for the average gross area of $21N/mm^2$. They shall be locally made by a reputable firm and all units shall be sound and free from cracks or other defects.

4. Excavation and backfill shall conform to Section 203.

506.3 EXECUTION

1. Excavation - soft base material, that in the opinion of the Engineer could cause adverse results, shall be removed and replaced with compacted suitable backfill material to the Engineer's satisfaction.

   Care shall also be exercised when cutting sides and bottoms of lined drains to prevent over cutting. Any over cut, that in the opinion of the Engineer might lead to scour under or alongside lined drains, will be backfilled with Class 9 concrete at the expense of the Contractor.

   Trenches should be excavated to the exact requirements as no extra payment shall be made for form work required because of excessive excavation. The Contractor shall make every effort to keep the trench free from water and excavation of the trench shall only be done portions where the works can be completed in the shortest possible time without leaving the trench susceptible to collapse or erosion.

2. Unlined Drains - For unlined earthen channels, the channel shall be excavated and sloped to the design lines and dimensions as shown on the Drawings. Side slopes of channels shall be sloped as shown on the Drawings and trimmed to present a smooth finish.

3. Blocks - Blocks shall be well bedded with all joints flushed up solidly with mortar of typical width 12mm. Vertical bonding joints shall be aligned approximately in the middle of the blocks of the course above or below. Mortar for blocks shall conform to the requirements of Section 409.2(5). Blocks shall be filled with concrete which shall be well rodded and tamped to completely fill all voids. Blocks shall be damp when laid and shall be cured wet as described in Section 401 for concrete for a minimum 48 hours.

4. Precast Concrete Inverts and Drains - These shall be constructed to design lines and dimensions as shown on the Drawings and as required by the Engineer. Precast units shall be bedded on and surrounded with concrete as shown on the Drawings and any voids between the excavation and the sides of the units completely filled with Class 9 concrete.

5. In situ Concrete Lining - These shall be constructed to design lines and dimensions as shown on the Drawings and as required by the Engineer.

6. Junctions with Other Drains - Junctions with other drains or intersecting pipes or drainage shall be made as shown on the Drawings with Class 30 concrete to the required section.

   No extra payment shall be made for the joints or connections.

7. Reinforced Concrete Drains - These cast insitu reinforced concrete box drains shall be constructed to design lines and dimensions as shown on the Drawings and as required by the Engineer. The requirements of Clause 506.3.1 shall still apply and any overcut shall be filled with Class 9 concrete.

8. Covered Box Drains - These shall be constructed to design lines and dimensions as shown on the Drawings and as required by the Engineer. The requirements of Clause 506.3.1 shall still apply and any overcut shall be filled with Class 9 concrete.

9. Catchpits - These shall be constructed to design lines and dimensions as shown on the Drawings and as required by the Engineer. The requirements of Clause 506.3.1 shall still apply and any overcut shall be filled with Class 9 concrete.

10. Manholes and Inspection Chambers - These shall be constructed to design lines and dimensions as shown on the Drawings and as required by the Engineer. The requirements of Clause 506.3.1 shall still apply and any overcut shall be filled with Class 9 concrete.

SERIES 600:
TRAFFIC MANAGEMENT WORKS

SERIES 600: TRAFFIC MANAGAEMENT WORKS

SECTION 604: PAVEMENT MARKINGS

604.1 Description

604.2 Materials

604.3 Construction Requirements

604.4 Quality Control

604.5 Non-Conforming Pavement Markings

604.6 Maintenance

604.1 DESCRIPTION

The work to be performed under this Section shall consist of the preparation of the road surface and the application of pavement marking material in accordance with these Specifications. Designs will be as shown on the Drawings and/ or as directed by the Engineer.

604.2 MATERIALS

1) Definitions

This Specification covers quality and characteristics of the following pavement markings and their material composition:

a) Thermoplastic Pavement Marking:

A compound extruded or mechanically sprayed on the pavement in a molten state that cools to the pavement temperature. When combined with glass spheres it produces a reflectorized pavement marking of specified thickness and width capable of resisting deformation by traffic. The material composition shall consist of:

(i) Pigment
(ii) Binder Resin
(iii) Glass Beads and
(iv) Fillers

The thermoplastic material shall be available in white or yellow as required.

b) Traffic Paint Pavement Marking:

Traffic Paint Pavement Marking is a liquid product containing solids suspended in organic solvent or in water. It can be supplied in single or multi-component systems. When applied by brush, roller, spray or any other appropriate method it produces cohesive film by the process of solvent evaporation and/or by a chemical process suitable for use as a reflecting pavement marking on Portland cement or bituminous pavements consisting of:
(i) Pigment
(ii) Binder and
(iii) Glass Beads

c) Glass Bead

A transparent spherical glass particle used to provide night visibility for road markings by retro-reflecting the incident headlight beams of a vehicle towards the driver.

d) Preformed Pavement Marking

A factory produced road marking material, in a sheet or roll form, capable of being applied to the substrate with adhesive, pressure, heat or a combination of them.

2) Characteristics of Pavement Marking Material

a) Thermoplastic Pavement marking materials shall meet the requirements of the British Standards Institute BS EN 1871:2000 and the colour and performance shall comply with BS EN 1436: 2007+A1:2008 or its latest revision.

b) Paint Pavement marking shall be white reflectorized road marking paint similar to 3-M Green-stripe and conform to EN 1871:2000 and BS EN 1436: 2007+A1:2008and shall be subject to approval by the Engineer.

c) Premix glass beads shall comply with BS EN 1424:1998 and Drop on glass beads shall comply with BS EN 1423:2012.

d) Preformed Thermoplastic road markings shall comply with BS EN 1790:1998.

e) All Road Marking designs shall be in accordance with the Road Marking detail Drawings and/ or as specified by the Engineer.

3) Thermoplastic Material

Thermoplastic Pavement Marking shall meet the following criteria:

a) The binder resin shall be a synthetic hydrocarbon or maleic modified glycerol ester resin.

b) The material when heated to application temperature shall not exude fumes which are toxic, or injurious to persons or property.

c) The thermoplastic material shall contain not less than 0.54kg/L of beads. The pigment and vehicle shall be so prepared and blended that the resulting material shall be uniform in composition and of the required consistency. The material shall not bleed on asphalt surfaces.

d) The material shall have a no-pick up maximum drying time of one hour at 24°C and 50 to 60 percent relative humidity. Glass beads shall have a minimum of 70% true spheres essentially free of sharp angular particles and particles showing milkiness and shall be free of colour.

e) The beads shall meet the grading requirements as shown in Table 604.1:

Passing Sieve Size	Retained On Sieve Size	% Passing by Weight
No. 16	No. 16	0 - 5
No. 16	No. 20	0 - 12
No. 20	No. 30	5 - 35
No. 30	No. 50	35 - 65
No. 50	No. 100	0 - 15
No. 100		0 – 10

Table 604.1
Grading Requirements for Glass Beads

f) Beads shall be moisture-proof and show no tendency toward decomposition, including surface etching, when exposed to atmospheric conditions, moisture, dilute acids, alkalis, local soils, paint film constituents, petroleum from vehicles, and shall be manufactured from glass of composition designed to be highly resistant to traffic wear.

g) The material shall not scorch, discolour, or deteriorate if kept at manufacturer's recommended application temperature or at a minimum of 190°C, for up to 4 hours.

4) Traffic Paint Material

Traffic Paint Pavement Marking shall meet the following criteria:

a) Shall be homogeneous, well ground to a uniform and smooth consistency and shall not skin or settle badly, nor cake, liver, thicken, curdle or gel in the container. The pigments shall remain in suspension to a reasonable degree satisfactory to the Engineer.

b) The paint shall be free of skins, dirt and other foreign matter.

604.3 CONSTRUCTION REQUIREMENTS

1) Overview

a) General

The application of pavement markings shall conform to the widths and spaces as shown on the Drawings and as directed by the Engineer. Striping shall not be applied to any surface until such surface has been inspected and approved by the Engineer. The lines shall be straight with clear - cut edges.

Pavement markings shall be placed only upon surfaces which are dry and free from all dirt and foreign matter. No separate payment will be made for cleaning and preparation of surface to be marked. Pavement marking

shall be applied only to surfaces that are free of moisture both external and internal. Sufficient time shall be allowed after rain and dew to permit the surface to become thoroughly dry. The Contractor may expedite drying by the use of compressed air.

Unless specified otherwise, new markings shall be placed at the same location as the previous markings. If the existing markings are obviously incorrect, clarification should be obtained from the Engineer before proceeding.

Pavement striping that is not straight and uniform and of good appearance or that has been applied over dirt or moisture, or that has dripped or been spilled on the pavement shall be removed by the Contractor at his own expense to the satisfaction of the Engineer.

Before commencing road marking the Contractor shall set out all markings with paint spots or other appropriate methods to ensure start, finish, and orientation is defined. These spots shall be at a spacing of 10m or less.

If the Engineer directs road marking on new or unmarked surfaces, setting out shall be marked using appropriate methods, e.g. chalk lines and/or string lines. The alignment method shall be used in a way which does not detrimentally affect the thermoplastic lines appearance or adhesion to the road surface.

Where pavement remarking does not require setting out it shall be superimposed on the existing marking within the tolerances specified below, Subsection 604.3. (3) Dimensional Tolerances. If the existing markings are obviously incorrect, clarification shall be obtained from the Engineer before proceeding.

b) Traffic Paint Pavement Marking

i) Paint shall be applied at not less than $17m^2/L$ but not more than $25m^2/L$.

ii) The Contractor will be liable for all damage resulting from spattering paint on passing vehicles. The Contractor shall protect all painting from traffic or other damage until fully set.

iii) Where raised pavement markers are supplementing paint lines the paint may be omitted for a length of 150mm before and after the marker.

c) Thermoplastic Pavement Marking

i) All new thermoplastic markings where deemed necessary shall be applied to painted pilot markings having a thickness of less than 150 microns, unless otherwise directed by the Engineer.

ii) Thermoplastic markings shall not be applied over existing paint or thermoplastic pavement markings unless the existing markings are worn to a degree satisfactory as determined by the Engineer. The Engineer shall approve all areas where the removal of existing pavement markings is deemed necessary prior the application of new thermoplastic pavement markings, and shall be done in accordance with Section 605, Removal of Existing Pavement Markings.

iii) Where raised pavement markers are supplementing thermoplastic lines the thermoplastic may be omitted for a length of 300mm before and after the raised pavement marker.

2) Protection of Pavement Markings

i) During striping, markings shall be protected with warning and directional signs. Warning signs shall be installed prior to the beginning of each operation and signs shall be placed in accordance with Traffic Management Plans approved by the Engineer.

ii) Freshly completed markings shall be protected by cones, drums or other markers approved by the Engineer until the pavement marking is dry, and the beads securely held.

iii) Any markings on adjoining pavement caused by mishap, or transfer of wet marking material by tyres of passing vehicles shall be removed and the Contractor shall be held fully responsible for their removal. Removal methods shall be in compliance with Sub-Section 604.5, Non-Conforming Markings and Section 605, Removal of Existing Pavement Markings.

iv) Pavement markings shall be protected during the time required for drying as per manufacturer's recommendations and prior to inspection as required by the Engineer.

3) Dimensional Tolerances

a) Application Dimensional Tolerance

The maximum permitted dimensional tolerances in the overall width of the lines shall be from setting centre of roadway to edge of lane width as approved by the Engineer:

i) *Traffic Paint line width*:
   (1) All line widths + 10 % to - 5 %
ii) *Thermoplastic line width*:
   (1) All line widths + 10 % to - 5 %

b) Setting Out Location Tolerance:

For new marking in the specified location, tolerances for setting out shall be measured from centre of roadway to edge of lane width as

approved by the Engineer:

i) Transverse location ± 20mm

ii) Longitudinal location ± 50mm

iii) All lines shall appear by eye to be straight or where designed as a curve, the smooth curve.

iv) When markings already exist, within 15mm of the average centreline of the existing marking.

v) For new markings when spotting out is provided by the Engineer, within 15mm of the pilot line.

Any deviation beyond these permitted tolerances shall be corrected at the Contractor's expense.

4) Preparation of Road Surface

a) General:

All extraneous or loose material shall be removed from areas where the material is to be applied, immediately prior to road marking.

The surface shall be free of oil and moisture immediately prior to new pavement marking material being applied. Existing painted markings shall be free from flaking.

All surface areas to be painted, inclusive of roadway edges shall be thoroughly cleaned prior to painting. This shall be inclusive of uprooting of vegetation, grass, bushes, removal of road film and foreign matter and disposed in an approved location.

The pavement surface may be cleaned by means of hand brooms, rotary brooms, air blasts, scrapers or other approved methods that leave the pavement clean and undamaged.

All new Portland cement pavement surfaces shall be mechanically wire brushed or abrasive cleaned to remove all laitance and curing compound before being striped.

b) Traffic Paint Pavement Markings

The Contractor shall prepare the surface to ensure that there is a satisfactory bond between the paint and the pavement as approved by the Engineer. The Contractor at his expense shall replace all markings where failure has occurred due to poor adhesion to the road surface.

c) Thermoplastic Pavement Marking

When remarking over painted markings greater than 0.15mm thick, a site inspection with the Engineer is required to determine any additional preparation of the surface necessary to ensure adequate adhesion. Additional preparation may include measures such as mechanical abrasion and surface etching.

5) Application of Materials

a) Traffic Paint Material

i) The paint shall be thoroughly mixed before being poured into the paint container of the applicator. Where that container is of more than 20 litre capacity the paint shall be continuously agitated while the applicator is in operation, unless the paint manufacturer can provide evidence of no settlement for paint stored for a minimum three month period. The containers must be clearly marked with the date of paint filling.

ii) All markings up to 200mm wide shall be applied in one pass of the applicator. Wider markings shall be applied with the minimum number of passes possible using spray widths of up to 200mm.

iii) All markings shall have a uniform spread of paint, a clearly defined edge, and be free from light spot, paint spots, paint skins, stains and other deleterious matter.

iv) Throughout the process of marking edge lines, transverse lines and symbols, the road marking paint applicator shall travel wholly on the asphalt pavement surface and not on the shoulders, kerbs, or partly on each.

v) For all marking of reflectorized double continuous centre line, the road marking applicator shall travel in the traffic lane to which the no restrictive line applies; unless the applicator can demonstrate that a dual gun application system provides acceptably retro-reflectivity results for both lines in the direction viewed by the oncoming traffic.

b) Thermoplastic Material

i) To avoid discolouration and embrittlement due to overheating, the material shall be added to a pre-heating tank in pieces or lots, each weighing not more than 4kg. Powder material may be fed from 25kg bags in accordance with the manufacturer's recommendations.

ii) Sufficient pre-heating tanks shall be available such that continuous application is achieved without unnecessary delays.

iii) The material shall be maintained within the manufacturer's recommended temperature range in the pre-heating tanks and applicator storage/heating tank, throughout its transfer to the point of application, and at the point of application to the road surface.

iv) Thermoplastic material shall not be heated in excess of the manufacturer's recommended maximum temperature. The Contractor shall ensure that the compound does not break down, deteriorate, scorch or discolour if held for six (6) hours at the plastic temperature of 218°C; or if reheated up to four (4) times in succession.

v) Thermoplastic material shall be used within six hours of achieving application temperature. At the end of this period or if overheated above the manufacturer's maximum specified application temperature occurs, the material shall be discarded.

vi) All markings up to 300mm wide shall be applied in one pass of the applicator. Wider markings shall be applied with the minimum number of passes possible using widths of up to 300mm. Multiple passes shall be joined at the edge (flush), not overlapped.

vii) All markings shall have a uniform spread of thermoplastic, a clearly defined edge, no signs of pulsing, and be free from blisters, streaks and other defects and/or deleterious matter.

viii) Marking edge lines, transverse lines and symbols the road marking applicator shall travel wholly on the pavement and not on the shoulder, kerbs or partly on each.

ix) Where adjacent runs are required for markings wider than 200mm, as with for example arrows, alphabetic characters, intercepts and joins of lines, the multiple passes shall be butted not overlapped unless the overlapped material is less than specified in Section 604.6(b)(i).

x) For continuous markings an approximate 100mm drainage gap is to be provided every 10m to 15m, or less if required, to allow water to drain from the high side of the markings.

c) Bead Application

Where remarking of reflectorized work is required, the application of paint and beads shall be as required for the initial application.

d) Pre-formed Application

The pre-formed application shall be in accordance with the manufacturer's requirements for surface preparation and application.

e) Reflectorized Lines

Reflectorized lines shall have drop-on glass beads dispensed with the pressurized glass bead dispenser so as to ensure the beads achieve optimum embedment.

The beads shall be applied in such a way that their optimum retro-reflective characteristics are obtained when traffic is travelling towards them and there is coverage of beads on the total painted area.

f) Drop-On Beads Applied to Paint

For reflectorized markings the beads shall be applied uniformly at the minimum rate of 275g/$m^{2.}$

g) Drop-On Beads Applied to Thermoplastic

i) For reflectorized markings the beads shall be embedded uniformly at such a minimum rate of 700g/m^2 to achieve the retro-reflection required in BS EN 1436: 2007+A1:2008.

ii) The glass sphere top-coating shall be applied with a pressure-type gun specifically designed for applying glass spheres that will be embedded at least one-half of the sphere's diameter into the thermoplastic immediately after the material has been applied to the pavement.

6) Finished Product

a) Traffic Paint

i) The finished dry film thickness shall be 150 microns or greater.

ii) When brushed or rolled on a smooth, horizontal surface, the paint shall dry hard and elastic without running, streaking, sagging or spotting.

iii) Target paint usage rates shall be calculated for the purpose of comparison with actual paint usage. This information shall be available to the Engineer on request.

b) Thermoplastic

i) The finished cold film thickness of thermoplastic material shall fall within the range shown in Table 604.2 below:

Description	Requirements
New markings	2.0 – 2.5mm maximum
Remarking over existing thermoplastic (TBD**)	4.0mm maximum
Joins and overlaps on lines	4.0mm maximum
Joins and overlaps on letters and symbols	4.0mm maximum

TBD** – To be determined and approved by the Engineer

Table 604.2
Finished Cold Film Thickness for Thermoplastic Material

ii) The markings shall not smear or spread under normal traffic conditions at temperatures below 49°C.

iii) The Thermoplastic stripe shall give a uniform cross section, with pigment evenly dispersed throughout the material and has a uniform material density and character throughout its thickness.

iv) The marking shall maintain its original dimension and placement and has ductility properties that permit normal movement with the road surface without chipping or cracking.

v) Target paint usage rates shall be calculated for the purpose of comparison with actual paint usage. This information shall be available to the Engineer on request.

c) Skid Resistance

i) The skid resistance of the marking after one (1) hour of application and thereafter shall as given in Table 604.3:

Description	Requirements
Lines less than 0.9mm thick without surface glass beads	30 *BPN or greater
Lines less than 0.9mm thick with surface glass beads	45 *BPN or greater
Lines greater than 0.9mm thick with or without surface glass beads	Greater than 50 BPN but less than 65 *BPN

**BPN – British Pendulum Number*

Table 604.3
Skid Resistance of Marking One (1) Hour after Application

604.4 QUALITY CONTROL

a) Materials Records

The Contractor shall maintain a daily record as part of the quality records showing materials used, location and details of work completed. Details to be recorded include:

i) Time and date the applicator's paint storage tank(s) are filled;

ii) Volume, batch number and type of paint, including thinners, in tank prior to refilling;

iii) Volume of paint added;

iv) Time and date thermoplastic marking material is deposited in the pre-heating tank;

v) Mass (in kilograms) of thermoplastic material added

vi) Total time at which the material has been maintained at the manufacture's recommended application temperature

vii) Details of any primer that may be used

viii) Paint manufacturer's name, paint designation (class and type), volume of paint used for pavement marking including percentage thinners if added, and whether recorded volume is before or after thinning;

ix) Thermoplastic material grade, manufacturer's name, batch number, resinous primers (if used), date of manufacture and mass of thermoplastic material used for pavement marking;

x) Beads – manufacturer's name and bead designation;

xi) Location, date and time where material is placed;

xii) Details of work, by line thickness, width and length. Miscellaneous short markings may be grouped as such provided the location is identified;

xiii) Surface preparation methods for thermoplastic;

xiv) Temperatures as in Clause 604.3.5.b.iii. – Application of Thermoplastic material

xv) Ambient weather conditions

This record shall be submitted in support of Contractor's claims for payment and shall be available for checking by the Engineer at all times.

b) Materials Warranty

i) The Engineer shall be furnished with a certificate of analysis and manufacturer's guarantee for each brand of paint submitted for acceptance under these Specifications, prior to the use of the material.

ii) The certificate of analysis and manufacturer's guarantee shall show the paint trade name, including a duplicate of the label if the paint is ready-mixed, and an analysis showing the percentage of each of the chemical elements and the compounds in the pigment and vehicle. The guarantee shall assert that all paint furnished conforms to the analysis shown on the certificate filed and to the statement of percentages of ingredients shown on the labels, which are required to be on each container. The guarantee shall be sworn to by an individual person having authority to bind the manufacturer into an agreement.

c) Testing

i) General

The Contractor shall co-operate fully in whatever testing of application rates may be required by the Engineer, including evidence in the Quality Assurance records to support application rates and methodology. If any test is found to have paint application less than the lower limits specified in this Specification the Contractor shall be responsible for developing and performing a suitable remedy agreed to and approved by the Engineer prior to execution.

ii) Thermoplastics

(1) Thermoplastics when required to be tested shall meet the following standards as shown in Table 604.4.

Property	Test Method	Class
Chromaticity co-ordinates and Luminance factor	BS EN 1871:2000 Annex E	LF4
Alkali resistance of the materials	BS EN 1871:2000 Annex D	-
Softening point	BS EN 1871:2000 Annex F	SP2
Heat stability	BS EN 1871:2000 Annex G	Less than 0.05
Cold Impact resistance	BS EN 1871:2000 Annex H	-
Indentation value	BS EN 1871:2000 Annex J	-
Tröger wear	BS EN 1871:2000 Annex K	-

Table 604.4
Standards for Testing White Thermoplastics

(2) Thermoplastics when required to be tested shall meet the following standards as shown in Table 604.5.

Property	Test Method	Class
Chromaticity co-ordinates and Luminance factor	BS EN 1871:2000 Annex E	LF2
Alkali resistance of the materials	BS EN 1871:2000 Annex D	-
Softening point	BS EN 1871:2000 Annex F	SP2
Heat stability	BS EN 1871:2000 Annex G	Less than 0.05
Cold Impact resistance	BS EN 1871:2000 Annex H	-
Indentation value	BS EN 1871:2000 Annex J	-
Tröger wear	BS EN 1871:2000 Annex K	-

Table 604.5
Standards for Testing Yellow Thermoplastics

(3) Premix Glass Spheres shall conform to BS EN 1424:1998
(4) Drop-On Glass Spheres shall meet the requirements of BS EN 1423:2012

iii) Traffic Paint

(1) White Traffic Paint when required to be tested shall meet the standards in Table 604.6.

Property	Test Method	Class
Chromaticity co-ordinates and Luminance factor	BS EN 1871:2000 Annex A	LF6
Storage Stability	BS EN 1871:2000 Annex B	
Bleed resistance	BS EN 1871:2000 Annex C	BR1
Alkali Resistance	BS EN 1871:2000 Annex D	

Table 604.6
Standards for Testing White Traffic Paint

2) Yellow Traffic Paint when required to be tested shall meet the standards in Table 604.7.

Property	Test Method	Class
Chromaticity co-ordinates and Luminance factor	BS EN 1871:2000 Annex A	LF6
Storage Stability	BS EN 1871:2000 Annex B	
Bleed resistance	BS EN 1871:2000 Annex C	BR1
Alkali Resistance	BS EN 1871:2000 Annex D	

Table 604.7
Standards for Testing Yellow Traffic Paint

604.5 NON-CONFORMING PAVEMENT MARKINGS

1) General

In the instance that the Engineer identifies non-conforming markings the Contractor shall be responsible for correcting such markings that do not comply with the standards stipulated in Clause 604.2.

i) Any paint on the pavement surface as a result of the Contractor's operations outside of the specified markings and tolerances shall be removed before any payment is made.
ii) On no account will the non-conforming markings be covered by paint, thermoplastic materials, bitumen or other material, be accepted.
iii) Any paint removal method used by the Contractor must be approved by the Engineer before any paint removal is carried out.
iv) There shall be no evidence of paint remaining after the process of paint removal has been completed.
v) Records of non-conformance and remedial action shall be maintained by the Contractor and submitted to the Engineer for sign-off.

2) Defects

Defects exhibited during the Defects Notification Period shall include, but not be limited to, the following:

i) Road markings which exhibit signs of spalling, flaking, or any other form of deterioration (other than fair wear and tear) resulting in the road marking not complying with the specified requirements for width and thickness.
ii) Road markings which show signs of excessive wear within the maintenance period of one (1) year.
iii) Road markings exhibiting lack of adhesion to the road surface.

3) Remedial Markings

a) Thermoplastic:

i) When carrying out remedial work to substandard markings, any single thermoplastic application shall not be less than 1.5mm thick.
ii) Any length of marking in which the thermoplastic film thickness is greater than the upper limit may not require remedial action provided:

iii) The difference in thermoplastic film thickness between any two zones on a plate does not exceed 0.5mm; and

iv) Any error in flatness across the width of marking is not of a concave nature.

ii) All remedial markings shall be carried out in accordance with Clause 604.3.1 (c)

iii) Where remarking of reflectorized work is required, the application of thermoplastic material and beads shall be as required in Clause 604.3.6 and Clause 604.3.5 (g).

604.6 MAINTENANCE OF THERMOPLASTIC MATERIAL

a) Maintenance Period

The maintenance period shall be one year commencing:

i) For Contracts of three months or less the maintenance period shall commence at the completion of all road markings;

ii) For Contracts longer than three months duration the Contractor may apply at intervals of three (3) months, to have the maintenance period commence for any completed section of marking.

b) Maintenance Requirements

Defective road markings once identified by the Engineer shall be the responsibility of the Contractor to ensure that such areas are remarked in accordance with this Specification at his expense. This shall include, where necessary, removal of the defective markings, preparation of road surface, and remarking.

The maintenance period for any section of road markings repaired under this clause, shall be as specified in Clause 604.6.a.

In the instance where the Contractor can provide technical data that confirms that the deterioration of the road markings is as a result of the breakdown of the road, restoration if required shall be a variation under the Contract.

SERIES 900:
DAYWORKS

901 DAYWORK

A. SCOPE

This section shall apply to the execution of additional or substituted work on a daywork basis as instructed by the Engineer, if in his opinion, it is necessary or desirable.

The daywork shall be carried out only on the written instructions of the Engineer and the Contractor shall then be paid for such work under the stipulations and at the rates set out hereunder. These rates shall only apply when the Engineer is of the opinion that the rates in the Bill of Quantities are inapplicable.

If any rate or rates are not entered against Daywork items it will be assumed that the cost of using this item or items is included elsewhere in the Contract. No payment will be made for the use of the described item or items or any alternative items offered against the unpriced item or items.

B. LABOUR

The payment for labour shall be for the actual hours worked at the rate set out in the Bill of Quantities and shall include allowances and employees benefits. In establishing the rate, the Contractor shall incorporate the cost for all allowances, employees' benefits, profits, overhead charges, supervision, subsistence, temporary scaffolding, staging, checking, lights, insurance, transportation, small tools and other operational and incidental items. The rate inserted in the Tender shall not be subject to any further increase on any grounds or cause whatsoever for the duration of the Contract.

C. MATERIALS

The payment for materials delivered on the Site shall be the net cost of materials including transportation costs to the Site as listed out in the Bill of Quantities.

Payment for materials not listed shall be the net cost of materials (less discounts) paid by the Contractor plus the actual transportation cost incurred by him. The Contractor shall furnish to the Engineer such receipts or vouchers as evidence to prove the amounts so paid and before ordering materials, the Contractor shall submit to the Engineer quotations for the same and obtain his approval. The Contractor's rate shall include the cost of overheads, supervision, handling, profit, insurance and other incidental items. The rate inserted in the Tender shall not be subject to any further increase on any grounds or cause whatsoever for the duration of the Contract.

D. PLANT AND EQUIPMENT

Payment for Plant and Equipment shall be at the rates set out in the Bill of Quantities. Payment will be made for actual "operating time" only. "Standing time" and "break-down periods" will not be paid for. Rates shall include for wages of all drivers, operators, attendants etc., all fuel, oil and consumable items, maintenance, transportation, etc. The Contractor's rate shall include the cost of overheads, supervision, profits and other incidental items. The rate inserted in the Tender shall not be subject to any further increase on any grounds or cause whatsoever for the duration of the Contract.

E. RECORDS

In respect of all work executed on a daywork basis, the Contractor shall during the continuance of such work deliver each day to the Engineer an exact list in duplicate of the names, occupation and time of all workmen employed on such work and a statement also in duplicate showing the description and quantity of all materials and plant used thereon and therefore. One copy of each list and statement will, if correct, be signed by the Engineer and returned to the Contractor.

At the end of each month, the Contractor shall deliver to the Engineer a priced statement of the labour, material and plant (except as aforesaid) used and the Contractor shall not be entitled to any payment unless such list and statements have been fully and punctually rendered. Provided always that, if the Engineer shall consider that for any reason the sending of such list and statements by the Contractor in accordance with the foregoing provision was impracticable, he shall nevertheless be entitled to authorise payment for such work either as Daywork (on being satisfied as to the time employed and materials and plant used on such work) or at such value therefore as he shall consider fair and reasonable.

URBAN DEVELOPMENT CORPORATION OF TRINIDAD AND TOBAGO

HILTON TRINIDAD, PORT OF SPAIN

Technical Specifications

May 2023

Urban Development Corporation Of Trinidad & Tobago
38-40 Sackville Street
Port of Spain

EMPLOYER

Beston Consulting Limited
308 Gangadeen Street
Pasea Village
Tunapuna

LEAD CONSULTANT / CIVIL & STRUCTURAL ENGINEER

TABLE OF CONTENTS

SPECIFICATION SERIES 03 00 00
CONCRETE

SERIES 03 00 00: CONCRETE

SECTION 03 10 00: CONCRETE FORMING AND ACCESSORIES

CONTENTS

SERIES 03 00 00: CONCRETE

SECTION 03 10 00: CONCRETE FORMING AND ACCESSORIES

1. Description

The work in this Section shall consist of constructing cast in place concrete deck slabs, foundations, columns, column encasements, beams, concrete tiers, retaining walls, paved waterways and other types of Portland cement concrete structures not specifically covered by other sections of these Specifications to the lines and grades established by the Engineer and in accordance with the designs and details shown on the Drawings. The structures may be reinforced or unreinforced concrete.

This Section specifies the requirements for cast-in-place concrete, including furnishing, placing, curing, protecting, and finishing; designing, furnishing, erecting, and removing form work; constructing expansion and contraction joints and waterstops; and furnishing and placing grout and epoxy mortar.

2. Materials

a. Cast-in-place concrete shall be in accordance with Section 03 30 00, Cast-in-Place Concrete.
b. Concrete reinforcement shall be in accordance with Section 03 20 00, Concrete Reinforcing.
c. Requirements for the following materials are as specified in Section 03 30 00, Cast-in-Place Concrete:

   A. Portland cement
   B. Aggregates for concrete
   C. Water for concrete
   D. Admixtures for concrete
   E. Curing materials for concrete
   F. Concrete grouting materials
   G. Epoxy compounds
   H. Expansion joint filler and sealants
   I. Waterstops

SERIES 03 00 00: CONCRETE

SECTION 03 10 00: CONCRETE FORMING AND ACCESSORIES

3. Mixes

a. Cast in place concrete shall be mixed in accordance with Section 03 30 00, Portland Cement Concrete – General Requirements. The class of concrete for any purpose shall be as indicated in the Contract.

b. Grout for surface repair and bond coats:
   1. Mortar for repairs shall consist of one part Portland cement to two parts mortar sand plus water to produce a stiff mortar. Mortar for bond coats shall comprise one part Portland cement to one part mortar sand.
   2. Blending of white and grey Portland cement to produce coloured mortar to match surrounding concrete shall be determined by trials.
   3. Up to one percent by weight of catalytic agents for increasing bond and decreasing water requirements may be used, subject to approval of the Engineer.

c. Epoxy Mortar shall be an approved two-component product with a three-day minimum compressive strength 35 megapascals. The two-component product shall be mixed and applied in accordance with manufacturer's instructions.

4. Formwork Materials and Accessories

a. Formwork materials and accessories of permanent and temporary nature shall be supplied as needed. Materials and accessories shall be non-corroding and non-staining under conditions of service and storage. Temporary materials that are to be reused shall be made good to their original condition before reuse. Damaged and corroded materials and materials that by wear or change during earlier uses, may cause change in the colour, shape or texture of the concrete will be discarded.

b. All forms shall be of wood, metal or glass fiber reinforced plastic shall be built mortar tight and of sufficient rigidity to prevent distortion due to the pressure of the concrete and other loads incidental to the construction operations. Form material shall be of a quality and maintained so as to prevent warping and the opening of joints due to shrinkage of the lumber.

c. Forms for exposed surfaces shall be made of dressed lumber of uniform thickness, or satisfactory plywood with waterproof glue with or without a form liner of an approved type.

d. Metal ties or anchorages within the forms shall be so constructed as to permit their removal to a depth of at least 50 mm from the face without injury to the concrete. In case ordinary wire ties are

permitted, all wires, upon removal of the forms, shall be cut back at least 6 mm from the face of the concrete with chisels or nippers; for green concrete, nippers shall be used. All fittings for metal ties shall be of such design that upon their removal, the cavities that are left will be of the smallest possible size. The cavities shall be filled with cement mortar and the surface left sound smooth even and uniform in colour.

e. V-Grooves and drip notch forms shall be formed from varnished lumber strips or equally rigid non-staining plastic, 20 mm on each leg.
f. Inserts shall be formed from galvanized cast steel or galvanized welded steel, complete with anchors to concrete and fittings such as bolts, wedges and straps.
g. Release agent for steel forms shall be an approved material that will not colour, stain or otherwise affect the finish of the concrete. A natural non-petroleum base, non-staining, non-retarding, non-dusting low gloss release agent shall be used for wood forms.

5. Formwork Designs

a. Watertight formwork shall be designed and executed in accordance with ACI 347 Chapter 1 and shall withstand pressures resulting from the placement and vibration of the concrete. It shall be formed from materials that do not stain the concrete, and shall be sufficiently hard and rigid to resist indentation and scratching while maintaining tolerances. The maximum deflection between form supports shall be 1/240 of the span length.
b. Forms shall be designed to provide the indicated finish. The deflection of form facing materials between studs, as well as the deflection of studs and walers, shall be limited to 1/240 of the span length while maintaining the tolerances specified.
c. Forms shall be designed for easy removal without damage to the finished concrete.
d. Panels in the forms shall be arranged in an orderly fashion, with joints between panels, expansion joints and rustication laid out equally spaced, symmetrical with relation to such elements as centerline, corners and major openings.
e. Tie holes shall be placed in emphasized joints. Where there joints, ties shall be placed in orderly vertical and horizontal lines, evenly spaced at approximately 600 mm centres unless otherwise indicated.
f. Earth shall not be used as a form except in case of solid rock that has been trimmed to the precise profile of the work to be cast.

g. The design, engineering, and construction of the formwork shall be the responsibility of the Contractor.
h. The design, engineering and construction of all shoring to be used in conjunction with formwork shall be the responsibility of the Contractor.
i. The Engineer may at his discretion require the submittal of the design and/or working drawings of formwork or shoring for his review and approval. This review shall not be construed of relieving the Contractor of his responsibility for these designs or their execution.
j. The Contractor is advised that the deck formwork must be adjustable to permit lowering or raising with respect to the top of the precast elements.

6. Construction of Forms

a. The forms shall be substantial and unyielding and shall be so designed that the finished concrete will conform to the proper dimensions and contours in accordance with the specified tolerances. All forms shall be set and maintained true to the line designated until the concrete is hardened. Forms shall remain in place for periods that shall be determined as hereinafter specified. When forms appear to be unsatisfactory in any way, either before or during the placing of concrete, the Engineer shall order the work stopped until the defects have been corrected.
b. Forms shall be made sufficiently tight to prevent loss of mortar from the concrete. Tape shall not be used on interior face of forms to achieve water tightness, except at concrete faces not exposed to view. Form edges shall be sealed by such means as gasket material or sealant placed in the joints in such a way that neither fin nor groove is made in the face of the cast concrete. If forms must be drilled for tie rods, holes shall be made to fit tie tightly so as not to leak.
c. Formwork shall be cambered to compensate for anticipated deflections prior to hardening of the concrete so as to maintain specified dimensional tolerances.
d. Forms shall be securely braced against lateral deflection and settlement. Positive means of adjustment of shores, struts and walers, shall be provided by means of jacks, wedges and adjustable ties, so that deflection and settlement can be adjusted during concrete placement.
e. Where indicated, ties spaced equally vertical and horizontal shall be provided at walls and columns. Tie layout shall be centered both vertically and horizontally.
f. Formwork shall be anchored to shores and other supporting surfaces or members in such a way that upward or lateral movement of any part of the formwork during concrete placement and consolidation is prevented.

g. Runways for moving equipment shall be supported on structural members, shoring or whalers.
h. Any warped or bulged lumber must be re-sized before reuse. Forms that are unsatisfactory in any respect shall not be reused.
i. For narrow walls and columns, where the bottom of tail form is inaccessible, the lower form boards shall be left loose so that they may be removed for cleaning out extraneous material immediately before placing the concrete.
j. Circular column forms shall be fabricated of two pieces and clamped watertight without horizontal joints. Horizontal construction joints shall be installed as indicated. Circular columns shall be made using flanged steel forms or fiber forms that leave no impression of spiral winding or joints in the hardened concrete.

7. Preparation of Form Surfaces

a. Mortar, rust and dirt shall be cleaned from form surfaces before placing concrete.
b. All forms shall be treated with form release agent or saturated with water immediately before placing the concrete. For girder members or other members with exposed faces, the forms shall be treated with an approved oil to prevent the adherence of concrete. Any material that may adhere to or discolour the concrete shall not be used.

8. Falsework

a. Detailed plans for falsework or centring shall be supplied to the Engineer on request but, in no case, shall the Contractor be relieved of responsibility for results obtained by the use of these plans.
b. For designing falsework and centring, a weight of 2400 kg/cu. m shall be assumed for green concrete. All falsework shall be designed and constructed to provide the necessary rigidity and to support the loads in order that the profile of the concrete as cast will be within the dimensional tolerances defined in the Specification. The Engineer may require the Contractor to employ screw jacks or hardwood wedges to take up any settlement in the formwork either before or during the placing of concrete. Falsework that cannot be founded on a satisfactory footing shall be supported on piling, spaced, driven and removed as approved by the Engineer, or supported on substructure piled footings as approved by the Engineer. Falsework shall be set to give the finished structure the camber specified or indicated on the Drawings.

SERIES 03 00 00: CONCRETE

SECTION 03 10 00: CONCRETE FORMING AND ACCESSORIES

9. Removal of Forms and Falsework

a. Methods of form removal likely to cause over stressing of the concrete shall not be used. In general, the forms shall be removed from the bottom upwards. The Engineer may direct the delay of removal of forms and their supports at his discretion. 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. See following sub-section also.

b. Forms and shoring used to support the weight of concrete in beams, slabs and other structural members shall be kept in place until the concrete has reached the minimum strength or time period specified for removal of forms and shoring.

c. When shores and formwork framing are arranged so that non-load bearing form facing panels may be removed without loosening or disturbing the shores or framing, the form facing may be removed at an earlier age as will not damage the structure.

d. When concrete surfaces are to be repaired or further finished, forms shall be removed as soon as the concrete has hardened sufficiently to resist damage resulting from the removal operations.

e. Top forms on sloping surfaces of concrete shall be removed as soon as the concrete has attained sufficient stiffness to prevent sagging. Repairs shall be performed at once, followed immediately by curing.

f. Wood forms for wall openings shall be removed as soon as possible without damaging concrete.

10. Removal Strength:

a. Formwork shall remain in place until the concrete has attained the minimum percentage of indicated design compressive strength or for the period of time specified in the following table:

SERIES 03 00 00: CONCRETE

SECTION 03 10 00: CONCRETE FORMING AND ACCESSORIES

Structural Member or Condition	Normal Strength Concrete	High Strength Concrete	Minimum Compressive Strength for Form Removal (% of required design strength)
Cantilevers	12 days	7 days	90%
Over 20 feet (6meters) between supports	12 days	7 days	90%
Centring under girders	10 days	5 days	80%
Stairways	10 days	5 days	80%
Slabs	5 days	3 days	0%
Free standing walls, columns and piers	5 days	3 days	70%
Walls, piers, columns, sides of beams, footings, slabs on grade and vertical surfaces.	24-48 hours	12-24 hours	70%
Curb front face forms	6-24 hours	6 hours	70%

11. Construction Joints

a. Construction joints shall be located as indicated on the Drawings. Joints shall be located so as not to impair the strength and appearance of the Work. Where a location for a construction joint must be selected, it shall be located, where possible, at a rusticated joint line in the concrete. Location of construction joints not shown on the Drawings shall be approved by the Engineer.

b. Prior to placing fresh concrete against a construction joint all laitance shall be removed, aggregate exposed as required and all reinforcing steel and other surfaces cleaned of materials foreign to the concrete. Surfaces of horizontal construction joints, where expansion joint filler or bond breaking compound is to be placed, shall be cleaned of dirt, sawdust and all other loose material and debris. Surfaces against which new concrete is to be placed shall be painted with a 1:1 sand: cement slurry to the satisfaction of the Engineer immediately before placing the new concrete.

c. When it is necessary to make a construction joint because of an emergency, additional reinforcing steel shall be placed across the joint at the contractor's expense.

d. When new concrete is shown to be joined to existing concrete by means of steel dowels mortared in holes drilled in the existing concrete, the holes shall be drilled to the required depth,

blown out, wetted and filled with epoxy mortar, after which the dowel shall be inserted and left undisturbed until the mortar is hardened.

e. The Engineer may require an epoxy-bonding compound be applied at construction joints to insure structural integrity. The compound shall be accurately proportioned, mixed in a clean dry container, and applied in accordance with the manufacturer's instructions. A container that can be disposed of after each batch is mixed shall be used. The cost of epoxy bonding compound and application, as required, shall be incidental to price of concrete.

12. Expansion and Contraction Joints

a. No reinforcement or other fixed metal items shall be run continuous through expansion and contraction joints, unless indicated.
b. Open joints shall be constructed at the locations indicated, by means of a wood strip, metal plate, or other approved material to be subsequently removed.

13. Waterstops

a. The configuration and location of waterstops in construction joints and expansion joints shall be as indicated on the Drawings or ordered by the Engineer.
b. Waterstops shall be provided in the maximum lengths practicable, with thermal or solvent joints at all cuts, breaks and corners.

14. Inserts and Other Embedded Items:

a. Sleeves, inserts, anchors, weepholes and other embedded items needed for adjoining work or for its support shall be placed before placing concrete.
b. Ample notice shall be given to trades whose work is related to the concrete or a supported by it so that they have the opportunity to introduce or furnish or locate embedded items before the concrete is placed.
c. Joint material, waterstops and embedded items shall be supported against displacement during concrete casting.

SERIES 03 00 00: CONCRETE

SECTION 03 10 00: CONCRETE FORMING AND ACCESSORIES

15. Preparation Before Placing Concrete

a. Hardened concrete and foreign material shall be removed from surfaces of conveying equipment.
b. Forms shall be cleaned of water, dirt, debris, hardened concrete film and lumps, bar and wire fragments, and all other deleterious matter before concrete is placed.
c. Cleaning holes shall be sealed and made fully flush with interior surfaces of forms. Cleaning holes shall be located so as not to be visible upon completion, where possible.
d. Moisture barriers shall be placed, where indicated, over granular fill and bare earth before placing concrete, except at footings. Moisture barriers joints shall have 150 mm laps.
e. Debris and deleterious matter shall be removed from the subgrade which shall then be made smooth, compacted and wetted before placing concrete.
f. Concrete shall not be placed until the forms and the cleanliness thereof, reinforcement, moisture barriers and embedded items have been inspected and approved by the Engineer.

16. Conveying

a. Concrete shall be moved from the mixer to the place of final deposit as rapidly as practicable by methods that will prevent segregation, undue drying due to temperature rise, or loss of ingredients, and in a manner that will maintain the required quality of concrete.
b. Conveying equipment, of size and design to maintain a continuous flow of concrete at the delivery end may be used if acceptable to the Engineer. The Engineer may order discontinuance of their use if an inferior quality of concrete is produced by the use of such conveyors, and institute a satisfactory method of handling the concrete. Conveying equipment with aluminum parts, such as chutes, hoppers, or scrapers that could come in contact with the concrete during conveying shall not be used.
c. Belt conveyors that are horizontal or at a slope that causes neither segregation nor loss may be used. Baffle boards or other arrangement at the discharge end shall be used to prevent segregation. Long runs shall be discharged into a hopper without segregation. Concrete shall not adhere to the return belt.
d. Steel or steel-lined chutes that have a slope not exceeding one vertical to two horizontal and not less than one vertical to three horizontal may be used. Chutes more than 6 metres long, and chutes not satisfying slope requirements, may be used if the chutes discharge into a hopper designed to prevent segregation, before distribution.

e. Concrete shall be placed in forms using troughs, chutes or pipes with the end held not more than a one metre above the surface of the bare form or the concrete. Troughs, chutes or pipes shall have steel hopper tops with sides sloping at least 45 degrees.

f. Bottom-drip buckets to place concrete shall be used wherever possible. Buckets shall permit gradual release and shall have sides sloping at least 45 degrees near discharge.

17. Placing Concrete

a. Concrete shall be deposited into the forms as nearly as possible to its final position, to eliminate segregation of aggregates. Vibrators shall not be used for extensive moving of the mass of fresh concrete.

b. Layers of concrete shall not taper nor be wedge shaped but shall be built with squared ends and level tops. Concrete shall be deposited continuously or in layers of such thickness that no concrete will be deposited on concrete that has hardened sufficiently to cause the formation of seams or planes of weakness within the section. If a section cannot be placed continuously, construction joints shall be located at points as indicated or as approved by Engineer. Concrete shall be deposited at such a rate that concrete being integrated with fresh concrete is plastic. Vibrators shall be used to blend the plastic concrete layers.

c. Struts, stays and braces, serving temporarily to hold the forms in correct shape and alignment pending the placing of concrete at their locations, shall be removed when the concrete placing has reached an elevation rendering their service unnecessary. These temporary members shall be entirely removed from the forms and not buried in the concrete.

d. Concrete shall not be deposited in supported elements until concrete previously placed in columns or walls is no longer plastic and initial shrinkage has occurred.

e. Concrete that does not reach its final position in the forms within the time stipulated under Specification Section 500 shall be rejected.

f. Concrete shall be placed so as to avoid segregation of the materials and the displacement of the reinforcement.

g. Concrete shall be placed in horizontal layers not more than 300 mm. thick except as hereinafter provided. When less than a complete layer is placed in one operation, it shall be terminated at a vertical bulkhead. Each layer shall be placed and compacted before the preceding batch has taken initial set to prevent injury to the green concrete and avoid surfaces of separation between the batches. Each layer shall be compacted so as to avoid the formation of a construction joint

with a preceding layer, which has not taken initial set. All chutes, troughs and pipes shall be kept clean and free from coatings of hardened concrete by thoroughly flushing with water after each run. Water used for flushing shall be discharged clear of the structure. When placing operations would involve dropping the concrete more than 1 metre, it shall be deposited through sheet metal or other approved pipes. As far as practicable, the pipes shall be kept full of concrete during placing and their lower ends shall be kept buried in the newly placed concrete. After initial set of the concrete, the forms shall not be jarred and no strain shall be placed on the ends of reinforcement bars, which project.

h. When the placing of concrete is temporarily discontinued, the concrete, after becoming firm enough to retain its form shall be cleaned of laitance and other objectionable material to a sufficient depth to expose sound concrete. To avoid visible joints as far as possible upon exposed faces, the top surface of the concrete adjacent to the forms shall be smoothed with a trowel. Where a "feather edge" might be produced at a construction joint an inset form shall be used to produce a blocked out portion in the preceding layer that shall produce an edge thickness of not less than 150 mm in the succeeding layer. Work shall not be discontinued within 450 mm of the top of any face, unless provision has been made for a coping less than 450 mm thick, in which case, if permitted by the Engineer, the construction joint may be made at the underside of the coping.

i. Immediately following the discontinuance of placing concrete, all accumulations of mortar splashed upon reinforcement steel and the surfaces shall be removed. Dried mortar chips and dust shall not be puddled into the inset concrete. If the accumulations are not removed prior to the concrete becoming set, care shall be exercised not to injure or break the concrete-steel bond at and near the surface of the concrete, while cleaning the reinforcement steel.

18. Consolidation:

a. Concrete shall be consolidated until voids are filled and free mortar appears on the surface. With the exception of concrete placed under water, concrete shall be consolidated by means of internal vibrators unless special authorization is given by the Engineer or as provided herein.

b. Vibrators shall have a minimum frequency of 5,000 vibrations per minute and massive heads with sufficient amplitude to effectively consolidate concrete. The intensity of vibration shall be such as to visibly affect a mass of concrete of 25 mm slump over a radius of at least 450 mm.

c. A sufficient number of vibrators shall be used so to consolidate the concrete within 15 minutes after depositing in forms. At least one spare vibrator shall be available at the site of each structure during concrete placement. Vibrators shall not be held against the forms or against the reinforcing steel.

d. The location, manner, and the duration of vibration shall be such as to secure maximum consolidation of the concrete without causing segregation of mortar and coarse aggregate and without causing water or cement paste to flush to the surface. Particular care in this regard shall be exercised during placement of concrete mixes with high slumps. The thickness of the layers shall not be greater than can be satisfactorily consolidated by vibrators. Vibrators shall vertically penetrate into the previous layer at regular intervals.

e. Vibrators must not be kept in one area long enough to create a cavity. They shall be plunged into concrete rapidly so as not to spatter forms or create depressions in the lift and removed slowly.

f. Vibrators shall be manipulated so as to thoroughly work the concrete around the reinforcement, embedded fixtures and into the corners and angles of the forms. They shall not be used for the extensive moving of the mass of fresh concrete.

g. Vibrators shall be applied at points uniformly spaced and not farther apart than twice the radius over which the vibration is visibly effective.

h. Vibration shall be supplemented by such spading as is necessary to insure smooth surfaces and dense concrete along form surfaces and in corners and locations impossible to reach with the vibrators.

19. Protection

a. Arrangements for cooling and shading concrete in advance of placement, adequate to maintain the required temperature and moisture conditions without injury due to concentration of heat, shall be made.

b. Concrete shall have a maximum placing temperature that will not cause difficulty from loss of slump, flash set, or cold joints.

c. The temperature of concrete as placed shall not exceed 35°C, except the temperature of concrete placed in walls and slabs one metre or greater in thickness shall not exceed 32°C. When the temperature of reinforcement is greater than 50°C, it shall be sprayed with water and any free water removed from the forms all immediately prior to placing the concrete.

d. Protection during inclement weather:
Concrete pouring shall be stopped when the quantity of rain falling on the surface is sufficient to wash the cement paste from the concrete surface.

20. Bonding

a. Longitudinal keys at least 40 mm deep or inclined dowels at least 300 mm long shall be provided at all joints in walls and slabs footing, unless otherwise indicated. Other construction joints may be made without keys, except where keys are indicated. Where keys are indicated, they shall be formed to dimensions indicated. See Section 501.11 Construction Joints.

b. When indicated or permitted, surface bond shall be attained by use of an approved chemical retarder that delays but does not prevent setting of the surface mortar. Retarded mortar shall be removed within 24 hours after placing to produce a clean, exposed coarse aggregate bonding surface.

c. After placement has been completed to the construction joint and before placing fresh concrete, clean reinforcing steel and the surfaces of horizontal and vertical construction joints of surface laitance, curing compound and other materials foreign to the concrete, and expose clean coarse aggregate of at least 10 mm in size. Hardened concrete surfaces shall be cleaned by abrasive blast methods to expose coarse aggregate, after the curing period or immediately before placing concrete at the joint. Surfaces of concrete, that have been in place not more than eight hours may be cleaned with air and water jets if surface laitance is removed and clean coarse aggregate is exposed. Surfaces of horizontal construction joints, where expansion joint filler or bond breaking compound is to be placed, shall be cleaned of dirt, sawdust, and other loose materials. Surfaces on which concrete is to be placed shall be moistened immediately before placing concrete.

d. When new concrete is shown to be joined to existing concrete by means of steel dowels mortared in holes drilled in the existing concrete, the holes shall be drilled at least 300 mm, blown out, wetted and filled with epoxy mortar after which the dowel shall be inserted and left undisturbed until the epoxy mortar is hardened.

SERIES 03 00 00: CONCRETE

SECTION 03 10 00: CONCRETE FORMING AND ACCESSORIES

21. Finishing Concrete Surfaces

a. General

1. Finishing of concrete surfaces shall generally be in accordance with the following clauses. Finishes indicated on the Drawings, if different, shall have precedence. Surface finishes shall be classified as follows:
   - Class 1 - Ordinary surface finish
   - Class 2 - Rubbed finish
   - Class 3 - Tooled finish
   - Class 4 - Floated surface finish
2. All concrete shall be given Class 1, Ordinary Surface Finish, and in addition, if further finishing is required, such other type of finish as is specified. If not otherwise indicated, the following surfaces shall be given at Class 2 Rubbed Finish: the exposed surfaces of columns, beams and retaining walls; the outside faces of girders, slabs, curbs, and parapets; but not on unexposed portions of the tops and bottoms of deck slabs, bottoms of beams and girders, sides of interior beams and girders.
3. Where Class 3, Tooled Finish is applicable, the Contractor shall provide a small sample panel, and shall provide several groups of bush hammered finishes, in order to permit the Engineer to select the particular finish to be incorporated in the work.
4. Tops of sidewalks shall be given a Class 4 Floated Finish. Bridge concrete approach and deck slabs where no other finish is shown shall be given a Class 4 Floated Finish.

b. Class 1, Ordinary Surface Finish

1. Immediately following the removal of forms, all fins and irregular projections shall be removed from all surfaces except from those that are not to be waterproofed. On all surfaces, the cavities produced by form ties and all other holes, honeycomb spots, broken corners or edges and other defects shall be thoroughly cleaned and, after having been kept saturated with water for a period of not less than three hours, shall be carefully pointed and trued with a mortar of cement and fine aggregate mixed in the proportions used in the grade of the concrete being finished. Mortar used in pointing shall be not more than one hour old. The mortar patches shall be cured as specified under Specification Section 501.15.
2. All construction and expansion joints in the completed works shall be left carefully tooled and free of all mortar and concrete. Joint filler shall be cut back not less than 25 mm from the

exposed face for its full length and the depth filled with caulking compound approved by the Engineer to a smooth and sightly appearance.

3. The resulting surfaces shall be true and uniform. All repaired surfaces, the appearance of which is not satisfactory to the Engineer, shall be "rubbed" as specified under Specification Section 501.21.3.

c. Class 2 Rubbed Finish

1. After removal of forms, the rubbing of concrete shall be started as soon as its condition will permit. Immediately before starting this work the concrete shall be kept thoroughly saturated with water for a minimum period of three hours. Sufficient time shall have elapsed before the wetting down to allow the mortar used in the pointing of rod holes and defects to thoroughly set. Surfaces to be finished shall be rubbed with a medium coarse Carborundum stone, using a small amount of mortar on its face. The mortar shall be composed of cement and fine sand mixed in proportions used in the concrete being finished. Rubbing shall be continued until all form marks, projections and irregularities have been removed, all voids filled and a uniform surface is attained. The paste produced by this rubbing shall be left in place at this time.
2. After all concrete above the surface being treated has been cast, the final finish shall be obtained by rubbing with a fine carborundum stone and water. This rubbing shall be continued until the entire surface is of a smooth texture and uniform appearance and colour.
3. After the final rubbing is completed and the surface has dried, it shall be rubbed with burlap to remove loose powder and shall be left free from all unsound patches, paste, powder and objectionable marks.

d. Class 3, Tooled Finish

1. Finish of this character for panels and other like work may be secured by the use of a bush hammer, pick, Crandall, or other approved tool. Air tools shall be employed unless another method is approved by the Engineer. No tooling shall be done until the concrete has set for at least 14 days and as much longer as may be necessary to prevent the aggregate particles from being picked out of the surface. The finished surface shall show a grouping of broken aggregate particles in a material of mortar, each aggregate particle being in slight relief.

SERIES 03 00 00: CONCRETE

SECTION 03 10 00: CONCRETE FORMING AND ACCESSORIES

e. Class 4, Floated Surface Finish

1. Striking Off

   After the concrete is compacted as specified under Clause 501.18, the surface shall be carefully rodded and struck off with a strike board to conform to the cross section and grade shown on the Drawings. Proper allowance shall be made for camber, if required. The strike board may be operated longitudinally or transversely and shall be moved forward with a combined longitudinal and transverse motion, the manipulation being such that neither end is raised from the side forms during the process. A slight excess of concrete shall be kept in front of the cutting edge at all times.

2. Floating

   After striking off and consolidating as specified above, the surface shall be made uniform by a longitudinal or transverse floating, or both. Longitudinal floating will be required except in places where this method is not feasible.

3. Longitudinal Floating

   The longitudinal float, operated from foot bridges, shall be worked with a sawing motion while held in a floating position parallel to the road centerline and passing gradually from one side of the pavement to the other. The float shall then be moved forward one half of its length and the above operation repeated. Care shall be taken to preserve the crown and cross-section of the pavement.

4. Straight edging

   After the longitudinal floating has been completed and the excess water removed, but while the concrete is still plastic, the slab surface shall be tested for trueness with a straightedge. For this purpose the contractor shall furnish and use an accurate 3 metre straightedge swung from handles 1 metre longer than one half the width of the slab. The straightedge shall be held in successive positions parallel to the surface centerline and in contact with the surface and the whole area gone over from one side of the concrete to the other as necessary. Advancement along the deck shall be in successive stages of not more than one half the length of the straightedge. Any depressions found shall be immediately filled with freshly mixed concrete, struck off, consolidated and refinished. High areas shall be cut down and refinished. The straightedge testing and refloating shall continue until the entire surface is found to be free from observable departures from the straightedge and the surface has the required grade and the contour until there are no deviations of more than 3 mm under the 3 metre straightedge.

5. Final Finishing

When the concrete has hardened sufficiently, the surface shall be given a broom finish. The broom shall be of an approved type. The strokes shall be square across the surface, from edge to edge with adjacent strokes slightly overlapped and shall be made by drawing the concrete, but so as to produce regular broom without tearing the concrete, but so as to produce regular corrugations not over 3 mm in depth. The surface as thus finished shall be free from porous spots, irregularities, depressions and small pockets or rough spots such as may be caused by accidental disturbance during the final brooming of particles of coarse aggregate embedded near the surface. Any areas intended for pedestrian traffic shall be given a wood float finish. In no case shall a smooth steel trowel finish be allowed.

f. Daylight Finishing

Unless approved lighting facilities are provided by the contractor, the placing of deck concrete shall commence at such time that will permit finishing during daylight hours.

22. Concrete Curing and Protection

a. Beginning immediately after placement, concrete shall be protected from premature drying, temperatures above 38 degrees C and mechanical injury. A method statement defining the materials and methods of curing and protection shall be submitted to the Engineer for approval 7 working days in advance of each proposed pour. The pour may not commence until such approval is granted.

b. For surfaces on which forms are kept continuously in place without loosening, for a period of five days or more, no further curing will be required. All other surfaces will be cured as described below.

c. Concrete shall be kept continuously under cure until the accumulated time is at least five days for bottom slabs and footings and seven days for all other concrete.

d. The Contractor shall have adequate equipment and material on hand before placement of concrete beams to ensure that satisfactory curing is assured. Water if required for curing shall be as specified for concrete.

e. One of the following methods shall be used as approved by the Engineer:

SERIES 03 00 00: CONCRETE

SECTION 03 10 00: CONCRETE FORMING AND ACCESSORIES

1. Ponding: the surface shall be kept submerged at all times for the required curing period. Water must not be allowed to flow to erode the surface. Water shall be kept clean and free of dirt and debris.
2. Continuous fogging: this shall be accomplished by fogging with a nozzle that so atomizes the water flow that a mist and not a spray is formed. Water must not be allowed to erode the surface. The concrete shall be fogged regularly, without allowing any part of the surface to dry.
3. Wet burlap and vapour barrier curing: this shall consist of covering the concrete surface with wet burlap as soon as the concrete has set sufficient to support the burlap without marking. Once burlap has been placed it shall be thoroughly wetted down and covered with vapour proof sheeting. Both the burlap and vapour proof sheeting shall be furnished in pieces large enough to extend at least 450 mm beyond the edge of the concrete. Sheets for vapour barrier shall be lapped a minimum of 150 mm. Sheets shall be adequately weighed to prevent displacement by billowing. The contractor shall be responsible for the condition of the vapour proof sheeting at all times during the curing period and any damaged pieces shall be patched immediately to the satisfaction of the Engineer. Materials used for this curing method shall be as approved by the Engineer.
4. Membrane curing compound: curing compound shall be mixed and applied in accordance with the manufacturer's recommendations, except that the rate of application shall be at least one litre per square metres of exposed surface to be cured. The membrane curing compound shall be continuous, flexible and without defects. It shall retain the required moisture in the concrete.

f. If in the opinion of the Engineer, unsatisfactory results will be or are being achieved by methods 1, 2 or 3 above, the Engineer may instruct the use of a membrane-curing compound, the cost of which shall be borne solely by the Contractor.

g. Protection from Injury:

1. During the curing period, the concrete shall be protected from damaging mechanical disturbances, such as load stresses, impact, and heavy vibration. Concrete surfaces shall be protected from damage by construction equipment, materials and methods, by curing methods, rain, or running water.

2. Self-supporting structures shall not be loaded in such a way as to over stress the concrete.
3. Drilled metal shielded bolts only shall be used for fastenings. Explosive or other power driven fasteners must not be used in concrete.

23. Defective Concrete work:

a. The Contractor shall provide advance warning of any formwork stripping to the Engineer's Representative in sufficient time as to allow inspection of the finished concrete prior to remedial work being carried out. No remedial works shall be carried out without the approval of the Engineer's Representative.
b. Porous areas, open or porous construction joints and honeycombed concrete will be considered to indicate that the requirements for mixing, placing and handling have not been complied with and will be sufficient for rejection of the members of the structure thus affected.
c. Defective work exposed upon removal of forms shall be entirely removed or repaired within 48 hours after forms have been removed.
d. Repaired areas will not be accepted if:
    1. The structural requirements have been impaired by reducing the net section of compression members;
    2. The bond between the steel and concrete has been reduced; and
    3. The area is not finished to conform in every respect to the texture, contour, and colour of the surrounding concrete.
e. If the above requirements are not satisfied, the Engineer may require that the members or unit involved be entirely removed and satisfactorily replaced at no additional expense.

24. Repair of Surface Imperfections:

a. As soon as possible after stripping forms, holes left by form ties and other temporary inserts, shall be thoroughly cleaned and filled and corrective work carried out.
b. Surfaces generally shall be of uniform appearance with regard to colour and texture and shall have a smooth finish.
c. Small surface holes caused by air bubbles, normal joint form marks, minor chips and spalls may be tolerated in limited areas, but no major or unsightly imperfections, honeycombs or structural defects will be permitted without carrying out remedial work, if and as approved by the Engineer, to remove such imperfections.

d. In general, pin holes and holes smaller than 10 mm in diameter and not more than 10 mm deep may be left unfilled if their distribution is random, if they do not form unsightly clusters and if they are not rusty or discoloured.

e. Imperfect texture, laitance, fins and roughness shall be removed by rubbing affected areas with concrete blocks or carborundum stones until smooth and uniform. Holes 10 to 20 mm in their greatest dimension, that are not more than 20 mm deep, shall be cleaned of loose and staining material and filled with grout formulated to match the colour of the concrete when dry. Deeper holes shall be repaired only after the Engineer is satisfied that they do not affect structural integrity.

If other defects do not cause rejection, holes, honeycombed areas, spalls, and discoloured areas of oily, or bond-breaking substances shall be cleaned out. The surface of each defect shall be roughened or keyed and the bottom and sides coated with a non-staining acrylic or epoxy-bonding agent. Spalled, loose, porous material shall be cut back until coarse aggregate will break under chipping rather than fall out. A bonding agent shall be applied and the defect filled with non-shrinking grout or epoxy-Portland cement intrusion grout that has been formulated to match the colour of the concrete when dry. The grout shall be tamped and struck off flush with the surrounding concrete without smearing. The grout shall be confined until cured, keeping it damp when exposed to sun or other rapid drying.

Efflorescence

If on completion of the work, there is a marked efflorescence at any point on the surface, it shall be removed as directed by washing with 10% solution of Muriatic Acid and thoroughly rinsed off with water from a hose when the acid has ceased foaming.

25. Additional Provisions

a. Uncovered Slabs

1. General

The Contractor shall place the deck/suspended concrete in one continuous operation for the full length of the span. Joints may be permitted, subject to the Engineer's approval regarding location and details. Pours shall be made in the sequence indicated on the

SERIES 03 00 00: CONCRETE

SECTION 03 10 00: CONCRETE FORMING AND ACCESSORIES

Drawings and no transverse joints shall be permitted at alternate locations. Deck surfaces shall be finished to Class 4 Floated Surface Finish.

2. Construction Method and Equipment

Immediately upon award of the contract, the Contractor shall submit, to the Engineer for approval a complete description of the method and equipment proposed for the handling, placing and finishing of the concrete.

All equipment shall be subject to inspection by the Engineer and only approved equipment will be accepted for use.

Regardless of previous approval, equipment may be rejected during operation if it is unsatisfactory. Mixers having an accumulation of hard concrete or mortar or having any part of section of a blade worn 25 mm or more below the original height of the manufacturer's design will not be approved for use.

At the same time the Contractor shall submit a list of all personnel who will be working on the placing and finishing of concrete, with a brief resume of their experience.

Any approval given by the Engineer will not relieve the Contractor of the responsibility of a satisfactory performance for his method and equipment.

3. Initial Set

The initial set of all concrete in place in a section shall take place at about the same time and after the deck surface has been machined finished. This condition shall be obtained by the use of a set-retarding agent ("Plastiment" or approved equal).

4. Handling and Placing Concrete

Concrete shall be delivered and distributed at a uniform and adequate rate ahead of the deck finisher such that not less than 7.5 cubic metres of concrete shall be placed per hour. The concrete shall be vibrated by mechanical vibrators in accordance with Clause 501.13. Standby plant and equipment must be available in case of breakdown.

SERIES 03 00 00: CONCRETE

SECTION 03 10 00: CONCRETE FORMING AND ACCESSORIES

Concrete shall be placed so as to avoid segregation of materials and the displacement of reinforcement. Special care shall be taken to distribute the concrete to each part of forms by depositing concrete directly as near the final position as possible. Concrete shall not be moved by means of vibrators. Concrete shall not be dropped a distance of more than 600 mm.

5. Surface Defects and Tolerances in Slabs

The finished surface of the slab shall conform to the longitudinal and transverse profiles as indicated on the drawing or ordered by the Engineer.

The surface shall be free from open texturing, plucked aggregate and local projections.

The surface shall be such that when tested with a 3 metre long straight edge placed anywhere in any direction, on the surface there shall not be a gap greater than 9.5 mm. The surface shall be checked as described above immediately after screeding.

The surface shall again be checked at the end of the curing period in the same manner and to the same tolerance.

Areas that do not meet the required surface accuracy shall be clearly marked out and the Contractor shall build them up or grind them down at his own expense as required by the Engineer.

If the surface is damaged in any way by construction operations, or if the deck shows sign of distress or scaling prior to the final acceptance of the deck, it shall be cut out and replaced by the Contractor at his own expense.

b. Concrete Placed in Footings or below Ground Level

1. Where concrete can be placed in dry excavation, cribs, cofferdams and forms may be omitted, subject to compliance with the following limitations and conditions. This procedure may be used only in locations not exposed to view from the travelled roadway.

SERIES 03 00 00: CONCRETE

SECTION 03 10 00: CONCRETE FORMING AND ACCESSORIES

The elevations and dimensions shown in the drawings for the extent of the footing shall be obtained as a minimum subject to the following requirements for increased cover to reinforcement. Reinforcement will be placed in its correct position according to the drawings and the cover to any reinforcement from any unsupported excavated face shall be increased by 25mm from the minimum cover stated in the Contract. Such increase shall be achieved by extension of the minimum concrete dimensions shown on the drawings or elsewhere in the Contract and all additional costs associated with the increased structures dimensions shall met by the Contractor.

The sides of the excavations shall be trimmed to a regular shape and as near vertical as can be obtained and the material remain stable. All loose material shall be removed from the base of the excavation and from the faces so as to prevent falls of material and should any material fall into the excavation during placement it shall be immediately removed along with any contaminated concrete.

The entire excavation shall be filled with concrete to the required elevation of the top of the footing. The volume of concrete to be paid for will be determined from the neat line dimensions shown on the plans.

26. Concrete Tolerances

a. Form work, concrete placement and workmanship shall be such that the following concrete tolerances are achieved.
b. Tolerance classes:
   - Class A: this requires a 4 mm maximum deviation along a 3 metres straightedge placed anywhere on the surface.
   - Class B: this requires a 6 mm maximum deviation along a 3 metres straightedge placed anywhere on the surface.
c. Locations:
   - A Class A tolerance is required on the top surfaces of slabs, and sidewalks.
   - A Class B tolerance is required on all other surfaces.

SERIES 03 00 00: CONCRETE

SECTION 03 10 00: CONCRETE FORMING AND ACCESSORIES

d. The maximum allowable deviations from dimensions, elevations, slopes and positions shall be as follows unless otherwise indicated, except that no tolerance shall be allowed to be combined with another tolerance at any location such that the overall design of the structure, either structurally or visibly, is impaired.

1. Footings:
   - Width, depth and length: plus 90 mm; minus 15 mm.
   - Misplacement or eccentricity: 15 mm.
   - Top elevation: plus or minus 10 mm.
2. Top elevation of slabs not otherwise specified: plus or minus 4 mm at each point. If a slope is indicated: plus or minus 4 mm in 3 metres.
3. Top elevation of columns, walls and piers: as necessary to join other surfaces and not more than plus or minus 4 mm.
4. Plumb of columns, piers, walls and joints not exposed to view in finished structure: 6 mm in 3 metres not exceeding 15 mm total.
5. Level and grade of exposed lintels, sills, parapets, horizontal grooves and other conspicuous lines: plus or minus 4 mm in 6 metres, not exceeding plus or minus 10 mm in entire length.
6. Cross sectional dimension of columns, beams and slabs: plus or minus 6 mm except increase thickness of slabs on grade as necessary to achieve indicated top elevation and slope.
7. Thickness of walls: plus 10 mm, minus 6 mm.
8. Location of sleeves, size and location of slab openings and wall openings: plus or minus 10 mm.
9. Misplacement of Work Points with respect to theoretical grid position: 5 mm.
10. Dimensional Tolerances of Girder Bearing Areas and Anchor Bolts shall be constructed with dimensional tolerances as specified below:
    - Elevation of top of bearing area: plus 0, minus 15 mm level.
    - Axes of bearing area over contiguous structure: plus or minus 10mm longitudinally and transversely from theoretical locations.
    - Clear distance between faces of girder supports: plus or minus 20mm throughout the transverse width of support.

SERIES 03 00 00: CONCRETE

SECTION 03 10 00: CONCRETE FORMING AND ACCESSORIES

- Anchor bolt location: 30mm longitudinally, 20mm transversely. Tolerances specified are with respect to absolute theoretical locations and not the actual axes of bearing area.

27. Sampling and Testing

a. Sampling and Testing shall be in accordance with the requirements for Section 500 Portland Cement Concrete except that the followings specific requirements shall take precedence.

b. Core tests: Core samples of in-place concrete will be made when cylinder crushing strengths are such that there is reasonable doubt that the specified concrete strengths have been attained in the structure. Tests will be conducted to determine strength and other characteristics of the in-place concrete in accordance with ASTM C42, by load testing or analysis as specified in ACI 318, or other tests as required. The cost of core tests taken to determine the specified concrete strength in lieu of acceptable cylinders will be borne by the Contractor.

c. Workmanship: Concrete work that does not conform to the specified requirements, including strength, colour, tolerances and finishes, shall be corrected or replaced at the contractor's expense.

28. Submittals

Submittals shall conform to requirements of the Engineer.

a. The names and descriptions of the following products, items and accessories:
   1. Tie rods and cones.
   2. Circular column forms.
   3. Flatform material.
   4. Release agent.
   5. Vibrator frequency and head weight.
   6. Concrete materials per Section 03 30 00.

b. At least 24 hours (non-working days excluded) before placing any concrete the contractor shall submit to the Engineer the following:
   1. The exact location and portion of structure to be placed.
   2. The date, time, volume and class of concrete is to be placed.
   3. Method of conveying and placing of the concrete.

SERIES 03 00 00: CONCRETE

SECTION 03 10 00: CONCRETE FORMING AND ACCESSORIES

No concrete shall be placed until such time as all inspections and approvals have been completed by the Engineer.

Within 24 hours of the completion of the pour the Contractor shall submit to the Engineer signed certification confirming or amending as appropriate items 1, 2, and 3 above as they applied to the pour, and the submittal shall additionally include the commencement and completion times of the pour.

- END OF SECTION -

SERIES 03 00 00: CONCRETE
SECTION 03 20 00: CONCRETE REINFORCING

CONTENTS

1. Description

The work to be performed under this Section consists of furnishing and placing reinforcing bars of the grade, type and size designated, in accordance with these Specifications, and in conformity with the locations shown on the Drawings.

2. Materials

Bar reinforcement in sizes up to and including 32 mm. shall conform to the requirements of ASTM 615 Grade 60 from billet steel grades, except that the use of cold twisted bars is forbidden. Additionally, only metric sized bars shall be used in the Works. Welded steel fabric (mesh) shall conform to the relevant AASHTO specification.

If purchased in small lots from a warehouse, reinforcement may be accepted at the discretion of the Engineer upon certification that it meets the requirements of the Specifications listed above and subject to the applicable bending test.

Bar reinforcement for concrete structures, except that 6 mm, which may be round, shall be deformed bars.

Tying wire for fixing of steel reinforcement shall consist of 1.6mm or 1.25mm annealed wire.

3. Construction Requirements

1. General

   The Contractor shall prepare, thoroughly check, and submit to the Engineer for approval, bar lists, and bar bending diagrams as may be required for the detailing and placement of reinforcing steel to all reinforced concrete structures. Weights of steel shall be shown for each structure.

SERIES 03 00 00: CONCRETE

SECTION 03 20 00: CONCRETE REINFORCING

Four copies of each shall be submitted to the Engineer for his approval. Approval of these Drawings by the Engineer shall not relieve the Contractor of any of his responsibilities under the terms of the Contract.

2. Bending

Bars shall be cold bent to the shapes shown on the Drawings and all bends shall be made accurately around pins of the following sizes:

- Bars 25 mm and under: minimum pin size of 6 times the bar diameter
- Bars larger than 25 mm: minimum pin size of 8 times the bar diameter
- Ties: pin size over 2 times, but not greater than 4 times the bar diameter.

The extension of free ends on hooks shall be 4 times the bar diameter, but not less than 60 mm. Bends for stirrups and ties shall have radii on the inside of the bar of not less than one bar diameter.

3. Fixing

Reinforcement shall be placed accurately in the positions shown on the Drawings and held securely during the placing and compacting of concrete. The placing and fastening of reinforcement in each section of the work shall be approved by the Engineer before any concrete is deposited in the section.

All reinforcement shall be free from dirt, oil, paint, grease, mill scale, and loose or thick rust before being placed.

Main reinforcing bars carrying determinate stresses shall be spliced only where shown on the Drawings unless approval is obtained from the Engineer in writing before the reinforcing steel is ordered. Other reinforcing bars shall have a minimum length of 6 metres unless otherwise specified in the Drawings or limited by the physical dimensions of the section being reinforced. Splices shall be staggered as far as possible. Welding of reinforcing steel shall not be permitted. Unless otherwise called for on the Drawings, a minimum lap length of 40 times the diameter of the bars shall be maintained.

Bars shall be tied at all intersections except where spacing is less than 300 mm in each direction,

SERIES 03 00 00: CONCRETE

SECTION 03 20 00: CONCRETE REINFORCING

when alternate intersections shall be tied. On site welding of reinforcing steel shall not be permitted. Where required to prevent the movement of the free ends of bars or to provide additional restraint at bends in bars additional reinforcing bars shall be included by the Contractor at his expense.

The minimum cover to bars from all forms and the relative position of all bars shall be maintained by stays, precast concrete/mortar blocks (of strength greater than the concrete in which they are to be placed), ties, hangers or other approved supports. Chairs for supporting deck reinforcement steel shall be either of galvanized steel, approved plastic material, or precast concrete blocks acceptable to the Engineer. The maximum spacing of the chairs shall be 1.20 metres.

The location of the top reinforcement steel (with respect to deck surface) shall be checked by running a full deck width template along the longitudinal screeds. No main steel shall touch the template nor be more than 6 mm distant from it.

- END OF SECTION -

SERIES 03 00 00: CONCRETE

SECTION 03 30 00: CAST-IN-PLACE CONCRETE

CONTENTS

1. Description

This Section specifies the general requirements for Portland cement concrete, including the selection, sampling and testing of materials to be used, the composition of concrete and the mixing, transporting and testing of concrete.

Portland cement concrete shall be understood to mean an intimate mixture of Portland cement, fine aggregate, coarse aggregate and water, with admixtures as allowed or required, of the qualities herein specified. It shall be proportioned, mixed and transported as herein specified.

Also specified are requirements for the selection, testing, and use of ancillary materials such as curing materials, concrete grouts, epoxy compounds, joint fillers and sealants, water stops and the like.

2. Classes of Concrete:

Classes of concrete shall be designated by a numeral indicating the minimum 28-day compressive strength in mega pascal as determined by ASTM C39. The classes of concrete included in this section are:
Class 9, Class 12, Class 20, Class 25, Class 30 and Class 35.

SERIES 03 00 00: CONCRETE

SECTION 03 30 00: CAST-IN-PLACE CONCRETE

Each class of concrete may consist of one or more mixes determined by the maximum size and type of aggregate, intended location and use, cement factor and types of admixtures or special aggregates used. Types shall not be varied within a given structural element.

Each mix within a class will require approval of the design mix prior to use.

3. Constituent Materials for Concrete and Mortars

The materials and ancillary requirements to be used for Portland cement concrete and mortar manufacture are given in the following sub-clauses. General provisions for the selection, sampling and testing, handling and use of these materials are also given.

a. Portland Cement

General

Only one brand or type of cement shall be used in any part of a structure. Cements of the same type but from different mills shall not be mixed in any part of a structure except with the written permission of the Engineer. The use or presence of calcium chloride is prohibited.

Specifications

Cement may be Portland cement to ASTM C. 150; air-entraining Portland cement to ASTM C. 175; Portland-Pozzolin cement to ASTM C. 340 or C 91 and shall be as specified on the drawings or by the Engineer.

Types Permitted

1. Type I Portland cement may be used in general concrete construction where low heat of hydration is not required and where no sulphate action is anticipated.

   Type II Portland cement may be used for general concrete construction. Either Type I or II may be used in the contract unless stated differently on the Drawings or elsewhere in the specifications.

   Type III cement may be used in all concrete provided that a retardant admixture is used in concrete for bridge decks and for cement concrete pavement or approach slabs.

SERIES 03 00 00: CONCRETE

SECTION 03 30 00: CAST-IN-PLACE CONCRETE

2. Type I-P cement will be allowed as an alternate to Type I in all classes of concrete subject to the following conditions:
    - Type I-P Portland Pozzolin Cement shall meet the requirements of ASTM C-595 except that the Pozzolin (fly ash) constituent shall not exceed 20% by weight.
    - The Pozzolin shall conform to ASTM C 618 Type F, except that the loss on ignition shall not exceed 6%.
    - Type I-P cement will not be permitted in prestressed concrete members.
    - The minimum time for removal of forms shall be extended by two days over that required with use of Type 1 and Type II cement.

3. Only Portland cements containing less than 0.6% alkali, calculated as Na 2 0 (% Na 2 0 plus 0.658 K 2 0), shall be used with any alkali reactive aggregate.

Storage

Cement may be delivered in bags or in bulk. All cement shall be stored in suitable weatherproof buildings that will protect the cement from dampness. These buildings shall be placed in locations approved by the Engineer. Provisions for storage shall be ample and the shipments of cement as received shall be separately stored in such a manner as to provide easy access for the identification and inspection of each shipment. Storage buildings shall have a capacity for the storage of a sufficient quantity of cement to allow sampling at least 12 days before the cement is to be used.

Stored cement shall meet the test requirements at any time after storage when a retest is ordered by the Engineer.

On small jobs storage in the open may be permitted by written authorization from the Engineer, in which case a raise platform and ample waterproof covering shall be provided.

The Contractor shall keep accurate records of the deliveries of cement and of its use in the work. Copies of these records shall be supplied to the Engineer in such form as may be required.

SERIES 03 00 00: CONCRETE

SECTION 03 30 00: CAST-IN-PLACE CONCRETE

Transportation of Loose Cement

When under the provisions of these Specifications, it becomes necessary to transport loose cement, it shall be kept in a weatherproof compartment, separate from other aggregates, otherwise the cement shall be deposited directly from the container, as shipped, into the mixer skip, or dumped directly on the batch of aggregates just previous to the batch being deposited into the mixer skip.

Sampling and Testing

Tests for chemical and physical properties shall be in accordance with test method stipulated by ASTM C 150.

1. Cement may be sampled either at the mill or at the site of the batch plant. The contractor shall notify the Engineer of dates of delivery so that there will be sufficient time for sampling the cement,
2. Either at the mill or upon delivery. If this is not done, or if additional tests are necessary, the contractor may be required to re-handle the cement in the storehouse for the purpose of obtaining the required samples.
3. Samples removed for testing shall conform to the requirements for cement above. Cement that does not meet the test requirements, has been damaged, is partially, set or which is lumpy or caked, shall not be used, and the entire contents of the sack of cement or the container of bulk cement, that contains failed, damaged, partially set or lumps of cement, will be rejected for use.

b. Aggregate for Concrete

General

1. The contractor shall furnish aggregates for use in Portland cement concrete in conformance to the requirements specified herein.
2. Aggregate for use in concrete 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 in an amount sufficient to cause excessive expansion of mortar or concrete, except that if such materials are present in injurious amounts, the fine aggregate may be used with a cement containing less than 0.6% alkali as measured by percentage of sodium oxide plus 0.658 times percentage of potassium

oxide, or with the addition of a material that has been shown to prevent harmful expansion due to the alkali-aggregate reaction.

3. The nominal size of aggregate used in each mix shall be appropriate for the purpose of the mix and correct placement and compaction. The particular use of concrete mixes having a particular nominal size of aggregate in each element of the works shall be subject to the Engineer's prior approval.

Sampling and Testing

1. Representative samples of aggregates proposed for use in Portland cement concrete shall be selected for laboratory testing as directed by the Engineer. Aggregates may not be used until the samples are approved as a result of the testing, and their use authorized by the Engineer.

2. Sampling and testing shall be in accordance with the following standard methods of the American Society for Testing and Materials. Tests to be performed on a particular sample shall be determined by the Engineer.

		Designation
a.	Unit Weight of Aggregate	C 29
b.	Concrete Aggregates	C 33
c.	Organic impurities in Sands for Concrete	C 40
d.	Surface Moisture in Fine Aggregate	C 70
e.	Measuring Mortar-Making Properties of Fine Aggregate	C 87
f.	Soundness of Aggregates	C 88
g.	Material Finer than No. 200 Sieve in Aggregate	C 117
h.	Lightweight Pieces in Aggregate	C 123
i.	Definitions (Fineness Modulus)	C 125
j.	Specific Gravity and Absorption of Coarse Aggregate	C 127
k.	Specific Gravity and Absorption of Fine Aggregate	C 128
l.	Abrasion of Course, Aggregate (Los Angeles)	C 131
m.	Sieve Analysis of Fine and Coarse Aggregates	C 136
n.	Clay Lumps in Natural Aggregates	C 142
o.	Tensile Strength of Hydraulic Cement Mortars	C 190
p.	Scratch Hardness of Coarse Aggregate (Soft Particles)	C 235
q.	Sampling	D 75
r.	Potential Alkali Reactivity (Mortar Bar Method)	C 227
s.	Potential Reactivity (Chemical Method)	C 289
t.	Potential Volume Change (Linear Expansion)	C 342

SERIES 03 00 00: CONCRETE

SECTION 03 30 00: CAST-IN-PLACE CONCRETE

3. The required tests shall be made on test samples that comply with requirements of the designated test methods and are representative of the grading that will be used in the concrete. The same test sample may be used for sieve analysis and for determination of material finer than the No. 200 sieve. Separated sizes from the sieve analysis may be used in preparation of samples for soundness or abrasion tests. For determination of all other tests and for evaluation of potential alkali reactivity where required, independent test samples shall be used.

4. The fineness modulus of an aggregate is the sum of the percentages of a sample retained on each of a specified series of sieves divided by 100, using the following standard sieve sizes (or an acceptable equivalent):

   No.100, No. 90, No. 30, No. 16, No. 8, No. 4, 3/8", 3/4", 1½" and larger, increasing in the ratio of 2 to 1. Sieving shall be done in accordance with ASTM Method C 136.

5. Soundness

   Except as provided in paragraphs 2 and 3, aggregates subjected to five cycles of the soundness test shall show a loss, weighted in accordance with the grading of a sample complying with the limitations set forth herein, not greater than the following percentages:

Aggregate	**Sodium Sulphate**	Magnesium Sulphate
Fine	10%	15%
Coarse	12%	18%

   Aggregate failing to meet the requirements of paragraph 1 may be accepted, provided that concrete of comparable properties, made from similar aggregate from the same source has given satisfactory service when exposed to weathering similar to that to be encountered.

SERIES 03 00 00: CONCRETE

SECTION 03 30 00: CAST-IN-PLACE CONCRETE

Care and Storage of Concrete Aggregate

1. Aggregates shall be handled in a manner to prevent segregation or lack of uniformity of grading or the intrusion of foreign materials. Coning of stockpiles will not be permitted.
2. Fine and coarse aggregates shall be stored separately so as to prevent the two materials from becoming intermixed. Fine or coarse aggregates of different grading shall, similarly, be stored separately from one another. A minimum of 50 cubic metres of fine and coarse aggregates, in excess of the requirements of the daily concrete operations, shall be maintained in stockpiles at the batching plants to allow continuity of the works with tested and approved aggregates. Aggregates shall be stored in an approved manner at the allocated area. As aggregates are removed from stockpiles for batching, a blanket of at least 1 metre of each material shall be left on the ground unless the material is stored on a proper platform.
3. Coarse aggregate stockpiles shall be maintained in a continuously wet condition during batching operations, such as to assure uniformity of concrete consistency.

Coarse Aggregates

1. Coarse aggregate shall consist of crushed stone, gravel, or a combination thereof, or subject to the approval of the Engineer, other inert materials with similar characteristics, having hard, strong, durable pieces, free from adherent coating and shall conform to the requirements of this Specification.

Gravel shall be composed of tough, clean, durable quartz. The loss when the material is subjected to the Los Angeles Abrasion Test (ASTM C 131) shall be no more than 50%. The dry-rodded weight per cubic metre of gravel, tested according to ASTM C-29, shall be not less than 1,440 kg.

Stone shall be composed of clean durable rock. The loss when the stone is subjected to the Los Angeles Abrasion Test ASTM C 131) shall not exceed 45%.

SERIES 03 00 00: CONCRETE

SECTION 03 30 00: CAST-IN-PLACE CONCRETE

2. Gradation

The permissible gradation of coarse aggregates shall comply with the standard sizes of processed aggregate defined in Table 1 of AASHTO M43 for the relevant size number proposed for the specific mix.

The above gradations represent the extreme limits for the various sizes indicated that will be used in determining the suitability for use of coarse aggregate from all sources of supply. For any grade from any one source, the gradation shall be held reasonably uniform and not subject to the extreme percentages of gradation specified above.

3. Deleterious Substances

All coarse aggregate shall be washed and shall be free from disintegrated pieces, salt, alkali, vegetable matter and adherent coatings.

Deleterious substances in the coarse aggregate shall not exceed the following:

Substances	**Percent by Weight**
Clay lumps and friable particles	0.25
Soft Particles	5.0
Chert that will break down in 5 cycles of the soundness test	1.0
Material finer than No. 200 sieve	1.0
Coal and Lignite when surface appearance is of importance	0.5
Coal and Lignite, all other concrete	1.0

Fine Aggregates

Fine aggregate shall consist of sand composed of hard, strong, durable quartz, or subject to the approval of the Engineer, other inert materials with similar characteristics. Lightweight aggregate shall not be used.

SERIES 03 00 00: CONCRETE

SECTION 03 30 00: CAST-IN-PLACE CONCRETE

The permissible gradation of fine aggregates is as follows:

Sieve Size	**Percent by Weight Passing**
9.5mm (3/8")	100
4.75mm (No. 4)	95 to 100
2.36mm (No. 8)	80 to 100
1.18mm (No. 16)	50 to 85
0.60mm (No. 30)	25 to 60
0.30mm (No. 50)	l0 to 30
0.15mm (No. 100)	2 to 10

The minimum percentages shown above for material passing the 0.30 mm (No. 50) and 0.15 mm (No. 100) sieves may be reduced to 5 and 0, respectively, if the aggregate is to be used in air-entrained concrete containing more than 250 kg of cement per cubic metre or in non-air-entrained concrete containing more than 310 kg of cement per cubic metre or if an approved mineral admixture is used to supply the deficiency in percentages passing these sieves. Air-entrained concrete is here considered to be concrete containing air-entraining cement or an air-entraining agent and having an air content of more than 3%.

The fine aggregate shall have not more than 45% retained between any two consecutive sieves of those shown above and its fineness modulus shall be not less than 2.3 nor more than 3.1.

For walls and other locations where smooth surfaces are desired, the fine aggregate shall be graded within the limits shown in the above table, except that not less than 15% shall pass the 0.30 mm (No. 30) sieve and not less than 3% shall pass the 0.15 mm (No. 100) sieve.

To provide uniform grading of fine aggregate, a preliminary sample representative of the material to be furnished shall be submitted at least 10 days prior to actual

deliveries. Any shipment made during progress of the work which varies more than 0.20 from the fineness modulus of the preliminary sample shall be rejected or, at the option of the Engineer, may be accepted provided suitable adjustments are made in concrete proportions to compensate for the difference in grading.

1. Deleterious Substances

All fine aggregates shall be reasonably free from lumps of clay, soft or flaky particles, salt, alkali, organic matter, topsoil or other extraneous substances. The amount of deleterious substances in the fine aggregate shall not exceed the following limits:

Substances	**Percent by Weight of Total Sample, Maximum**
Clay lumps and friable particles	3.0
Material finer than No. 200 sieve; Concrete subject to Abrasion	3.0
All other concrete	5.0
Coal and lignite: where surface appearance of Concrete importance	0.5
All other concrete	1.0
Cinders and clinkers	0.5

In addition, the sum of the percentages of all material listed above shall not exceed 5%. Organic Impurities

Fine aggregate shall be free of injurious amounts of organic impurities. Except, as herein provided, aggregates subjected to the test for organic impurities and producing a colour darker than the standard shall be rejected.

A fine aggregate failing in the test may be used, provided that the discoloration is due principally to the presence of small quantities of coal, lignite, or similar discrete particles.

A fine aggregate failing in the test may be used, provided that, when tested for mortar-making properties, the mortar develops a compressive strength at 7 and 28 days of not less than 95% of that developed by a similar mortar made from

another portion of the same sample which has been washed in a 3% solution of sodium hydroxide followed sufficient to produce a colour lighter than standard with the washed material.

Mortar Strength

Fine aggregate shall be of such quality that when made into a mortar and subjected to the mortar strength test prescribed in ASTM Method of Test, C 87, the mortar shall develop a compressive strength not less than that developed by a mortar prepared in the same manner with the same cement and graded standard sand having a fineness modulus of 2.40 ± 0.10. The graded sand shall consist of approximately equal parts by weight of standard Ottawa sand and graded Ottawa sand as defined in ASTM Method of Test, C l90 and C 109, respectively.

Mortar Sands

Mortar sands for masonry shall meet all requirements for fine aggregates above, except that the material shall be uniformly graded from coarse to fine with all passing 2.36 mm (No. 8) sieve.

c. Water for Concrete

Water for use in concrete and for use with cement shall be clean and practically free of oil, acid, alkali, chlorides, organic matter, and other deleterious substances. Water from city water supplies or other sources approved by a public health department as potable may be accepted without being tested. Water from other sources shall be tested and approved before use and shall not contain impurities in excess of the following limits:

- Acidity or alkalinity calculated in terms of calcium carbonate 0.05%
- Total organic solids 0.05%
- Total inorganic solids 0.08%
- Total Chlorides as sodium chloride 0.05%

d. Admixtures for Concrete

Admixtures shall not be used in concrete without the approval of the Engineer, who may require that tests be conducted before the admixtures may be used to prove their suitability.

SERIES 03 00 00: CONCRETE

SECTION 03 30 00: CAST-IN-PLACE CONCRETE

Admixtures, if their use is allowed, shall comply with the following requirements:

i. Admixtures shall be used only in liquid form and shall be batched in solution in the mixing water by mechanical batcher capable of dispensing the admixture in quantities accurate to within 5% of the required quantity.
ii. All admixtures shall comply with the requirements of ASTM C494 or AASHTO M194 and shall be of an approved brand and type.
iii. Air entraining agents shall comply with the requirements of ASTM C260 or AASHTO M154.
iv. Admixtures shall not contain any chlorides.

Retarding Agents:

In order to permit the retarding of the set and extend the finishing time of concrete, a retarding agent shall be used when specified on the plans or may be used when permission for its use is requested by the Contractor in writing, and such approval is given. The retarding agent shall be a Type B or Type D admixture. The Contractor shall support his request with a manufacturer's certified formulation of the proposed agent and with sufficient evidence that the proposed agent has given satisfactory results on other similar work. Permission to use the agent may be withdrawn at any time when unsatisfactory results are obtained.

When air-entrained concrete is specified, the air-entraining agent and the retarding agent shall be so incorporated that the air content of the concrete shall fall within the percentage range stipulated in the specifications. When air-entrained concrete is not specified, the concrete to which the retarding agent has been added shall have an air content no greater than 3% except as recommended for bridge decks.

No compensation will be made for furnishing and incorporating the agent in the mix. No additional compensation will be made for furnishing, placing, finishing, and curing the concrete involved.

Super plasticizers

Super plasticizers may be utilized for the purpose of water/cement ratio reduction or for increasing workability With the Engineer’s approval. Only super plasticizers of the sulphonated melamine formaldehyde or sulphonated naphthalene formaldehyde condensate types may be utilized.

SERIES 03 00 00: CONCRETE

SECTION 03 30 00: CAST-IN-PLACE CONCRETE

The required entrained air may be reduced by the Engineer if no loss of durability will result.

4. Ancillary Materials for Concrete

The materials and ancillary appurtenances to be used for concrete construction are given in the following sub-clauses. General provisions for the selection, sampling and testing, handling and use of these materials are also given.

a. Curing Materials

The objective of the curing method shall be to restrict the loss of water to no more than 0.55 kg per square metre of surface in 72 hours.

1. Burlap for curing concrete shall consist of two layers weighing 0.30 to 0.55 kilograms each per square metre or of four layers of 0.18 to 0.21 kilograms each. Burlap that has been used as a container for sugar shall not be used. Burlap that is being used for the first time shall be thoroughly washed in order to remove starches used in sizing.
2. Vapour proof sheeting shall be tough, strong, resilient and capable of withstanding normal use without puncturing or tearing. Sheeting material may consist of any of the following and conform to the requirements of ASTM C 171 (AASHTO M l7I).
   - Waterproof paper
   - Polyethylene film
   - White burlap-polyethylene sheet
3. Membrane Curing Compound

   Curing compound shall conform to the requirements of ASTM C 309 (AASHTO M 148) Type 1. The curing compound shall be delivered to the job in the manufacturer's original container, labelled with the manufacturer's name, plant location, grade designation of compound, lot number and quantity.

b. Joint Filler and Sealant

1. Joint filler shall be a non-extruding material such as bitumen impregnated fiberboard or closed cell flexible polythene sheet. Timber will not be accepted as joint filler material.
2. Joint sealant shall be one or two part polysulphide or elastomeric sealant. Joints to be sealed shall be primed with a compound compatible with the sealant material, as recommended by the sealant manufacturer.

SERIES 03 00 00: CONCRETE

SECTION 03 30 00: CAST-IN-PLACE CONCRETE

c. Waterstops

1. Waterstops may be extruded PVC or rubber sections placed either centrally in a concrete section or on the outer face of a concrete section.
2. Rubber waterstops shall have a tensile strength of 17 to 20 Mn/sq.mm, a minimum elongation at break of 450% and a hardness (IRHD) of 60 to 70. They shall be capable of accommodating joint movements of up to 50 mm.
3. PVC waterstops shall have a tensile strength of 13 to 15 Mn/sq.mm, an elongation at break of around 300% and a Shore Hardness (A) of 80 to 90.They shall be capable of accommodating joint movements of up to 10 mm.

d. Concrete Grouting Material

1. Description

This Clause covers grouting material for use in grouting anchor bolts, dowels and other miscellaneous items in concrete. The material shall be a non-metallic, non-shrink grout which, when mixed with water will harden rapidly to produce a permanent anchoring bond. It shall contain no metals or rust or corrosion promoting agents. The colour shall be light grey, matching approximately the colour of hardened concrete.

2. Material

The material, when prepared in accordance with the manufacturer's instructions, shall be of a trowelable consistency. It shall also have the following properties:

- The material shall exhibit no shrinkage on setting but may exhibit slight expansion of no more than 0.10%.
- The compressive strength of 50 mm cubes of this material, when cured as shown, shall have the following minimum compressive strengths:

Cure	**Strength**
24 hour air cure at 24 ° C	27.5 MPa minimum
7 day air cure at 24 ° C	41.0 MPa minimum
7 day air, l0-day water submersion	41.0 MPa minimum

- The material shall have a minimum initial set of 30 minutes.
- Pull-out Strength: a 16 mm deformed reinforcement bar grouted 150 mm deep in 22 mm diameter hole in saturated surface dried concrete shall have a pull-out strength of 44.5 kilonewtons.

SERIES 03 00 00: CONCRETE

SECTION 03 30 00: CAST-IN-PLACE CONCRETE

- The material shall contain not more than 0.05% chlorides or 5% sulphates.

e. Epoxy Compounds

1. Types of Compounds

Epoxy resin compounds for application to Portland cement concrete, bituminous cement concrete, metals and other type surfaces shall be two-component systems of the applicable of the following types, as designated.

- Type A - An epoxy resin, for bonding fresh concrete to hardened concrete.
- Type B - An epoxy resin adhesive, for bonding hardened concrete to hardened concrete.
- Type C - An epoxy resin adhesive, for bonding traffic markers to hardened concrete and to asphaltic concrete.
- Type D - A coal-tar, modified epoxy resin for application as a skid-resistant or protective overlay for cement concrete.

2. Approval of Compound

Samples and literature of epoxy compounds proposed for use shall be submitted to the Engineer for approval. No material shall be used in the works prior to the receipt of the Engineer's written acceptance.

3. Mixing and Application

Types A and B epoxy compounds (for bonding fresh concrete to hardened concrete or bonding precast concrete parts) shall be mixed, applied, and cured in accordance with the manufacturer’s directions, or as might be directed otherwise by the Engineer.

Epoxy compounds shall be used only under conditions, which are compatible with the material being applied in accordance with the specific directions of the manufacturer.

4. Performance Tests

- **For Epoxy Bonding Compounds**

  The performance test upon which the acceptance or epoxy bonding compounds is based is described below. Test Specimens shall be cured at a temperature of 23°C plus or minus 1°C. The epoxy compounds shall be tested for composite cylinder shear (diagonal shear) as specified below.

SERIES 03 00 00: CONCRETE

SECTION 03 30 00: CAST-IN-PLACE CONCRETE

The test specimen of concrete shall be prepared in a 75 by 150 mm mould. The first portion of the test specimen may be formed by sawing a full size 75 by 150 mm cylinder on a 45 degree slope from the vertical giving a maximum height of 108 mm to a minimum height of 30 mm or through the use of an elliptical insert of the same dimensions. The concrete shall be cast as described in AASHTO T 23; using Class 34 Concrete with Type III cement.

The specimen shall be cured in the standard manner, and for at least four days. At the end of this period the half cylinder is to be applied shall be on which the epoxy resin is to be applied shall be prepared for bonding by removal of all loose particles and oil film and then coated with a thick coat of the epoxy compound under test. The portion of the cylinder shall then be replaced in the mould and plastic concrete of the same mix as before added to the mould to form the 75 by 150 mm cylinder. Reference test cylinders are prepared with each batch of concrete.

After the composite test cylinder has cured for a three-day period in a moist cabinet, the compressive strength is determined. This strength is compared to the strength of the weaker of the two concretes from which the test cylinder was made. If the ratio of the compressive strength of the composite cylinder to the compressive strength of the weaker concrete is less than 0.90, the epoxy compound is rejected.

- **For Epoxy Mortars**
  The epoxy mortar shall be tested in compression, in the following manner:
  Three 50 mm cubes shall be made with epoxy mortar, using the same mix and materials as described above.
  After curing for three days, the cubes shall be tested in direct compression. The required minimum average of the results for the three cubes is 34 MPa.

- **Retesting for non-representative Specimens**
  In any of the required tests of the epoxy compounds, in the event that a failure of the specimen occurs in the cement or in the cement mortar, too early to indicate whether

the epoxy material itself will meet the specified requirements, then new specimens shall be prepared for retest, as is necessary to complete the test on the epoxy material.

5. Specific Requirements for Type C Compounds
   Type C epoxy compounds (for bonding pavement markers to the pavement) shall be as recommended by the manufacturer of the particular markers used, and for the particular pavement to which they are to be bonded. Mixing and application shall be in accordance with the manufacturer's directions.

6. Specific Requirements for Type D Compounds
   Type D (coal-tar modified epoxy compounds) shall meet the requirements of AASHTO M 200. The manufacturer shall furnish six copies of a certification stating that the material meets this specification.

7. Limitations of Storage
   Epoxy materials that have been in storage for more than 12 months, will not be accepted for use.

5. Concrete Mix Design

a. General requirements

1. Concrete mixes shall have minimum water content per cubic metre of concrete consistent with required workability, a cement content corresponding to the appropriate water-cement ratio, the specified maximum size of coarse aggregate, and the required percentage of fine aggregate. Minimum and maximum values for key parameters should be as defined in the table below.
2. The design mixes for each class of concrete used shall be as determined by the Contractor to produce the results as specified herein and accepted by the Engineer.
3. For each class of concrete there shall be as many design mixes as there are different combinations or types of ingredients anticipated to cover the requirements of the work.
4. Design mixes will not be approved when the sum of chloride content of component materials indicates that the concrete mix derived from those materials will have a chloride content exceeding 0.24 kilograms per cubic metre of concrete. When the source of any component material for the concrete is changed or when the design mix is altered, a chloride content

determination test will be made immediately by the Engineer with new samples provided by the Contractor.

Description	Mix Preference Grade			
	20	25	30	35
Ordinary Concrete Type & Class of Cement	OPC	OPC	OPC	OPC
Min. Cement Content (kg/cu.m)	280	300	320	320
Max. free water/cement ratio	0.5	0.5	0.47	0.45
Max. Agrregate size	20	20	20	20

b. Workability

The workability of the concrete shall be suitable for the use for which the concrete mix is intended. The Contractor shall be responsible for nominating the design workability and the range of uses for which the mix is proposed. The workability proposed will be subject to the Engineer's agreement but it will remain the Contractor's responsibility to ensure the concrete can be correctly placed and compacted into its final position in full conformity with the specification.

For the guidance of Contractors the following ranges of slump measurements are indicative of the work abilities anticipated to be required. These should not be considered as definitive requirements or to be all encompassing of possible situations.

LOCATION	**Non-vibrated Compaction**	**Vibrated Compaction**
Concrete pavement, sidewalk, and incidental construction:	75 to l50 mm	25 to 90 mm
Un-reinforced concrete other than above:	75 to l50 mm	25 to 90 mm
Reinforced concrete	75 to l50 mm	25 to 90 mm
Concrete placed by pumping:	75 to l50 mm	25 to 75 mm

SERIES 03 00 00: CONCRETE

SECTION 03 30 00: CAST-IN-PLACE CONCRETE

Constricted spaces:	0 to l25 mm	N/A

c. Admixtures

The use of admixtures to enhance the properties of any design mix shall only incorporated into a design if defined in the Contract or if the Engineer agrees that the use of such admixtures are beneficial to the overall performance of the Contract and are not a disadvantageous to the permanent works. Mix designs using admixtures shall only be prepared after mix designs for the same strength and nominal aggregate size have been prepared without the use of admixtures.

All admixtures shall be incorporated into the mix fully in compliance with the manufacturer's recommendations. It shall be the Contractor's sole responsibility to prove by testing and trial production and placement that the use of the admixture.

d. Strength

The strength of each concrete mix shall be designed based on the required over design factor according to ASTM C94, and assuming a coefficient of variation appropriate for facilities to be used. Tests made on the concrete must meet both the following two criteria for each pour of concrete to be considered acceptable:

1. Not more than 5% of the strength tests shall have values less than specified strength.
2. No strength test shall fall below 90% of the specified strength and the average of any three tests from any pour will be equal to or greater than the specified strength.

e. Submittal of Mix Design and Samples

1. The contractor shall submit to the Engineer satisfactory details of all mix designs proposed for use in the work. Accompanying such submittal shall be satisfactory and representative samples of all materials to be used for each mix design. Such samples shall include not less than 25 kilograms of each type of aggregate, handled, packaged and delivered as directed by the Engineer.
2. Each sample shall be clearly identified by means of an attached tag as to source, project number and design mix for which it is intended to be used.
3. Upon receipt of the samples and mix data, the Engineer will prepare standard concrete test cylinders. These cylinders will be broken at various ages up to 28 days to determine the

potential strength gain characteristics of the concrete. If the results do not satisfy the design and the construction requirements, the contractor shall revise his mix to the Engineer's satisfaction. No concrete shall be placed in any part of the works until the design mix has been approved by the Engineer.

4. The approval of the Engineer of any design mix will in no way relieve the contractor of the responsibility for providing concrete having compressive strengths specified herein for all concrete used in the work.
5. Once a design for any class of concrete is accepted, it shall not be varied as to source, quantity, grading of materials, proportioning, or in any other way.
6. Proposed changes in design mixes shall be accomplished by preparing and having approved a new design mix as specified above.

6. Quality Control

a. The Contractor shall implement a full quality control testing regime to ensure all concrete batched by him conforms to the requirements of the specification, and such testing will, as a minimum comply with the this section . In addition, the Engineer shall undertake his own compliance testing under this section, for which the Contractor shall furnish concrete for casting specimens and for the specified sampling and testing all as required by the Engineer. Such testing by the Engineer will be additional to the Contractor’s testing and shall not relieve the Contractor of his obligations to test for compliance with the Specifications.

b. Testing: The Contractor shall supply sufficient concrete to enable the Engineer to perform the following testing for each concrete pour as follows:
   1. Slump and air content tests for each 10 cubic metres or fraction thereof, placed.
   2. Yield test and unit weight tests for each 150 cubic metres, or fraction thereof, placed or as deemed necessary by the Engineer.
   3. A minimum of one set of six standard cylinders made and cured in accordance with ASTM C3l for each 75 cubic metres, or fraction thereof, of concrete placed, for compressive strength testing. Additionally the Contractor will be expected to provide the results of his tests, in accordance with C below, undertaken for the same pour which shall be no less frequent than the foregoing.

SERIES 03 00 00: CONCRETE

SECTION 03 30 00: CAST-IN-PLACE CONCRETE

c. Materials shall be sampled according to ASTM CI72 and tested as follows:
   1. Air content: ASTM C173.
   2. Weight per cubic metre, yield, air content and cement content: ASTM CI38.
   3. Slump: ASTM C143.
   4. Compressive strength of cylindrical concrete specimens: ASTM C39.

d. Target Mean Strength

The characteristic strength of concrete is the 28 days strength below which not more than 5% of the test results may be expected to fall. The concrete mix should be designed to have a mean strength greater than the required characteristic strength by at least the current margin. The current margin for each particular type of concrete mix shall be determined; it may be taken as having the smaller of the values given by (1) or (2) below.

1. Times the standard deviation of tests on at least 100 separate batches of concrete of nominally similar proportions of similar materials and produced over a period not exceeding 12 months by the same plant under similar supervision.

2. 1.64 times the standard deviation of tests on at least 40 separate batches of concrete of nominally similar proportions of similar materials and produced over a period exceeding 5 days but not exceeding 6 months by the same plant under similar supervision.

Where there are insufficient data to satisfy (1) or (2) above, the margin for the initial mix design should be taken as two-thirds of the characteristic strength for concrete. This margin should be used as the current margin only until sufficient data are available to satisfy (1) or (2) above. However, when the required characteristic strength approaches the maximum possible strength of concrete made with a particular aggregate, a smaller margin may be permitted by the Engineer for the initial mix design.

e. Testing Plan

Each set of test specimens shall be made from a sample obtained from a representative batch of concrete.

Compliance with the specified characteristic strength may be assumed if:

SERIES 03 00 00: CONCRETE

SECTION 03 30 00: CAST-IN-PLACE CONCRETE

1. The average strength determined from any group of four consecutive test specimen exceeds the specified characteristic strength by not less than 0.5 times the current margin, and
2. Each individual test result is greater than 85% of the specified characteristic strength.

The current margin should be taken to be two-thirds of the specified characteristic strength for concrete, unless as mentioned above a smaller margin has been established to the satisfaction of the Engineer.

If only one test specimen result fails to meet the second requirement then that result may be considered to represent only the particular batch of concrete from which that specimen was taken provided the average strength of the group satisfies the first requirement.

If more than one specimen in a group fails to meet the second requirement or if the average strength of any group of four consecutive test specimens fails to meet the first requirement then all the concrete in all the batches represented by all such specimens shall be deemed not to comply with the strength requirements. For the purposes of this sub-Section, the batches of concrete represented by a group of four consecutive test specimens shall include the batches from which samples were taken to make the first and the last specimens in the group of four, together with all the intervening batches.

f. Action to be Taken in the Event of Non-Compliance with the Testing Plan

When the average strength of four consecutive test specimens fails to meet the first requirement in (F), above, the mix proportions of subsequent batches of concrete should be modified to increase the strength.

The action to be taken in respect of the concrete which is represented by the test specimens which fail to meet either of the requirements (or not by correct statistical proof can be verified to have the required strength) shall be determined by the Engineer. This may range from qualified acceptance in less severe cases, to rejection and removal in the most severe cases.

The Engineer may also require the Contractor at his own expenses to prove statistically the strength, by boring out cores and testing them according to a programme approved by the Engineer. The age of the concrete and degree of hardening at the time of the new testing shall be considered.

SERIES 03 00 00: CONCRETE

SECTION 03 30 00: CAST-IN-PLACE CONCRETE

7. Mixing Equipment

a. Batching Plant

The equipment for batching of concrete materials shall conform to the following requirements except that, with the Engineer's approval, portable batch weighing equipment of a suitable type and capacity may be used where only small quantities of concrete or mortar are to be placed.

The batching equipment shall be substantially constructed on a firm foundation and with sufficient clearance at all points for the weighing hoppers to function properly. All batching plant structures shall be maintained properly level within the accuracy required by the design of the weighing mechanisms. A platform with suitable steps for access shall extend around the weighing hopper for easy means of inspection, adjustment and weighing.

1. <u>The Batching Equipment</u>

Separate bins or compartments for each size of classification of aggregate and for each type of bulk Portland cement shall be provide.

The compartments shall be as follows:

- Compartments shall be of ample size, and constructed so that materials will be separated under working conditions. The batching plant be so equipped that when the quantity desired in the weighing hopper is being approached the material may be added slowly in small quantities and shut off with precision. A means of removing any overload of any one of the several materials in the weighing hopper shall be provided.
- Weighing hoppers shall be constructed so as to eliminate accumulations of tare materials. They shall weigh aggregates in separate weight batches with individual scales, or cumulatively in one batcher on one scale. They shall weigh bulk cement on separate scale in a separate weight batcher. Where mix water is measured by weight it shall be weighed separately from other ingredients.
- The hopper discharge mechanism shall be interlocked: against opening until the full batch is in the hopper and the scale balanced; against opening while the hopper is being filled; against closing until the hopper is entirely discharged and the scale back in balance; and against opening if the batch in the hopper is either overweight or underweight by more than 0.5% of the amount specified. The weighing hopper discharge gate shall operate in such a manner as will not affect the scale balance. The discharge chute, boot or other approved device shall be suspended from the

encasement and not from the weighing hopper and shall be so constructed that the material will not lodge therein and there will be no loss of material.

- Facilities for obtaining representative samples of aggregate from each of the bins or compartments for test purposes shall be provided.

2. Water batcher and admixture dispensers

Equipment for batching water and admixtures at the batching plant shall be provided, except in cases where the mixing has been authorized by the Engineer to be performed at the job site in paving mixers or in truck mixers.

A device capable of measuring mixing water within the specified requirements for each batch shall be fitted and also a mechanism for delivering water to the mixers so that leakage will not occur when the valves are closed.

The filling and discharge valves for the water batcher shall be interlocked so that the discharge valve cannot be opened before the filling valve is fully closed.

The plant shall be equipped with measuring devices for admixtures capable of ready adjustment to permit varying quantity of admixture to be batched. The dispenser for admixtures shall be interlocked with the batching and discharging operations so that the batching and discharging to the mixture will be automatic.

If non-interlocked dispensers are permitted, the calibration of the dispensers shall be checked at intervals as required by the Engineer. Results of such calibration be recorded and made it available for the inspection by the Engineer.

3. Moisture content

At the time of batching, all aggregates shall be in a saturated surface-dry condition.

In no event shall the free moisture content of the fine aggregate at the time of batching exceed 8% of its saturated surface-dry weight. The batch-to-batch uniformity of all aggregates shall be such that variations in moisture content within one hour do not exceed

7 kg. in the batch quantity for one cubic metre of concrete, or that a gradual change does not exceed twice this variation in a period of four hours.

An electrically actuated moisture metre which will indicate on a readily visible scale the percentage of moisture in the fine aggregate as it is batched, within a sensitivity of 0.5% by weight of the fine aggregate shall be installed and maintained in operating condition.

4. Scales

The scales for weighing aggregates and cement may be of either the horizontal beam or spring less dial type designed as an integral unit of the batching plant, and shall be of rugged construction to withstand hard usage due to working conditions. These scales shall be accurate to within the 0.50%.

If scales are of the dial type, the dial shall be of such size and so arranged that it may be read easily from the operating platform.

If scales are of the multiple beam type, the scales shall be provided with an indicator operated by the main beam, which will give positive visible evidence of over or underweight. The indicator shall be so designed that it will operate during the addition of the last 90 kilograms of any weighing. The over travel of the indicator hand shall be at least one-third of the loading travel. Indicators shall be enclosed against moisture and dust. Poises shall be installed for locking in any position and to prevent unauthorized removal.

Clearance between scale parts and hopper and bin structures shall be such as to avoid displacement of, or friction between, parts due to accumulations, vibrations, or other cause. Pivot mountings shall be designed so that none of the parts will jar loose and so as to insure unchanging spacing of knife edges under all conditions. Scales shall be constructed of non-corrosive materials and so designed that all exposed fulcrums, clevises, and similar working parts may be kept clean readily. scales shall be maintained in proper operating condition.

Accuracy of Scales:

All scales shall be certified and sealed by the Engineer prior to the delivery of the material.

Ten 22.5 kgs. weights shall be provided for checking, with a shelf or suitable provision for attaching them to the weighing hopper.

5. Recorders

An accurate recorder for producing a digital printout of the batch number and scale readings corresponding to each of the ingredients of each concrete batch, including zero initial readings shall be fitted. It shall indicate by name or code the individual ingredient corresponding to each weight. It shall also indicate by pressure only, each admixture measured by volume.

On each printout shall be shown: the date and time of batching; an identification number identical to that of the concrete delivery ticket; and codes for the mix design and for the project section.

The printout shall be prepared in duplicate and one copy, with its corresponding concrete delivery ticket, delivered to the Engineer.

Each recorder mechanism shall be housed in a locked, dust-tight cabinet, in a position convenient for observation.

b. Concrete Mixers

1. General requirements

Concrete shall be machine mixed at the site, using mechanically operated batch mixers for mixing concrete, unless authorized by the Engineer and for batches not exceeding one-third cubic metre that may be hand mixed.

Concrete mixers shall be of the revolving drum type or pan type. Truck mixers shall be of the revolving drum type. Pick-up and throw over blades of revolving drum mixers shall be replaced when any part or section is worn 25 mm or more below the original dimensions of the manufacturer's design. A copy of the manufacturer's design, showing dimensions and arrangements of blades, shall be available to the Engineer. Batches shall be charged into the mixer so that some water will enter in advance of cement and aggregates. All water shall be in the drum by the end of the first quarter of the specified mixing time.

SERIES 03 00 00: CONCRETE

SECTION 03 30 00: CAST-IN-PLACE CONCRETE

2. On-site mixers

   On-site mixing shall be done using paving or stationary type mixers. Mixers shall be operated at the speeds recommended by the mixer manufacturers, except that revolving drum mixers shall make not less than 14 nor more than 18 revolutions per minute.

   Paving and stationary mixers shall be operated by an automatic timing device that can be locked by the Engineer. The timing device and discharge mechanism shall be interlocked so that, during normal operation, no part of the batch will be discharged until the specified mixing time has elapsed. The total elapsed time between the intermingling of damp aggregates and the discharging of the completed mix from the mixer shall not be less than 60 seconds or more than 300 seconds. The minimum allowable mixing time may be increased in order to produce a more homogeneous mixture.

   The mixer shall be equipped with adequate water storage and a device for accurately measuring and automatically controlling the amount of water used in each batch. Mechanical means shall be provided for recording the number of revolutions for each batch and automatically preventing the discharge of the mixer until the materials have been mixed the specified minimum time.

3. Truck mixers

   Truck mixers shall be of the revolving drum type, watertight, and so constructed that the concrete can be mixed to insure a uniform distribution of materials throughout the mass. All solid materials for the concrete shall be accurately measured in accordance with this Section and charged into the drum at the proportioning plant. Except as provided below, truck mixers shall be equipped with a tank for carrying mixing water. Only the prescribed amount of water shall be placed in the tank unless the tank is equipped with a device by which the quantity of water added can be readily verified. The mixing water may be added directly to the batch only when so approved by the Engineer in writing, in which case a tank shall not be required. Truck mixers may be required to be provided with means by which the mixing time can be readily verified by the Engineer.

   The maximum size of batch in truck mixers shall not exceed the maximum rated capacity of the mixer as stated by the manufacturer and stamped on the mixer. Truck mixing shall

be continued for not less than 50 revolutions after all ingredients, including water, are in the drum. Mixing shall begin within 30 minutes after the cement has been added to aggregate.

8. Mixing and Delivery

1. General
   1. Concrete placed quantities greater than two cubic metres shall be mixed and delivered in accordance with the requirements of ASTM C94.
   2. The entire contents of the mixer shall be removed from the drum before materials for a succeeding batch are placed therein.
   3. The materials comprising a batch shall be deposited simultaneously in the mixer. No mixer shall be charged in excess of its rated capacity as stated on the manufacturer's stamp on the mixer.
   4. The first batch of concrete materials placed in the mixer shall contain a sufficient excess of cement, sand and water to coat the inside of the drum without reducing the required mortar content of the mix. Upon the cessation of mixing for a considerable period, the mixer shall be thoroughly cleaned.
   5. When a truck mixer, or an agitator provided with adequate mixing blades, is used for transportation the mixing time at the stationary machine mixer may be reduced to 30 seconds and the mixing time in the truck mixer or agitator equipped with adequate mixing blades shall be as specified for truck mixing.

2. Site Mixing
   Mixing of batches two cubic metres and more shall continue 60 seconds plus 20 seconds for each cubic metre in excess of two cubic metres. The mixing time may be reduced to a period of not less than 60 seconds if it is demonstrated to the satisfaction of the Engineer that a shorter mixing time results in satisfactory mixing. The mixer shall be operated at the drum speed as stipulated by the manufacturer of the mixer. Evidence of satisfactory mixing shall consist of the variation in slump of samples, taken from the first and last quarters of the discharge, being not more than 20 mm from the average of the two slump values.

3. Plant Mixing
   Mixing at a central plant shall conform to the requirements for mixing at the site.

SERIES 03 00 00: CONCRETE

SECTION 03 30 00: CAST-IN-PLACE CONCRETE

4. Hand Mixing
When hand mixing is authorized it shall be done on a watertight platform and in such a manner as to insure a uniform distribution of the materials throughout the mass. Mixing shall be continued until a homogenous mixture of the required consistency is obtained.

5. Time for Hauling and Placing Mixed Concrete
Concrete transported in an agitator, or other similar transportation device shall be discharged at the job. The maximum volume of mixed concrete transported in an agitator shall be in accordance with the specified rating. All concrete shall be placed in its final position in the forms within 60 minutes after the introduction of the mixing water to the cement aggregate, or the cement to the aggregate except that in hot weather or under other conditions contributing to quick stiffening of the concrete, the maximum allowable time may be reduced by the Engineer.

The elapsed time before completion of concrete placement may be exceed if, 24 hours prior to the commencement of the pour the Engineer's approval had been granted to the use of a designed mix incorporating a retarding admixture, and the maximum extension of the above time agreed and approved.

6. Delivery
Suppliers of concrete shall have sufficient plant and transport capacity to insure continuous delivery at the rate required. The rate of delivery of concrete during concreting operations shall be such as to provide for the proper handling, placing and finishing of the concrete. The rate shall be such that the interval between batches shall not exceed 20 minutes. The methods of delivering and handling the concrete shall be such as will facilitate placing with the minimum of re-handling and without damage to the structure or the concrete.

7. Re-tempering
The concrete shall be mixed only in such quantities as are required for immediate use and any which has developed an initial set shall not be used. Concrete, which has partially hardened, shall not be re-tempered or remixed.

- END OF SECTION -

SPECIFICATION SERIES 04 00 00
MASONRY

SERIES 04 00 00: MASONRY

SECTION 04 22 00: CONCRETE UNIT MASONRY

CONTENTS

1. Description

This work shall consist of the construction of blockwork in accordance with these Specification and as directed by the Engineer.

2. Materials

1. Precast Concrete Blocks
   Blocks shall conform ASTM C90 for loadbearing masonry units. Where plaster finish is required on blockwork, rough textured type blocks shall be supplied. Where "fair faced" finished is required all blocks shall be smooth textured with clean unbroken edges. All blocks to be incorporated in the works shall be delivered to the Site in a dry and fully cured state.
2. Sand for Mortar
   Sand shall be clean naturally occurring plastering sand free from salts, organic matter, clay, loam, dirt or other deleterious matter. All sand shall be stored and kept free from contamination by any other material. Samples of sand shall be supplied to the Engineer for testing and approval at any time during the performance of the Works.
3. Water
   Water for mixing mortar shall be clean and free from impurities.
4. Plasticizer
   Where necessary a plasticizing agent may be added to the mortar in sufficient quantity to gain the required workability. The plasticizer shall be approved by the Engineer and applied in accordance with the manufacturer's instructions.

SERIES 04 00 00: MASONRY

SECTION 04 22 00: CONCRETE UNIT MASONRY

5. Mortar

   Cement mortar shall consist of one part by volume of Portland cement and two parts by volume of natural sand. The components shall be thoroughly mixed in the dry state, and then water added to achieve the desired workability. Cement mortar shall be mixed in small quantities as and when required, and any mortar that has begun to set or that has been mixed for a period in excess of one hour shall be rejected.

6. Concrete Filling

   Where vertical reinforcement is specified the reinforced cores shall be filled with Class 20 concrete for the full height of the wall. The workability of the concrete shall be such that the mix will flow into and fill all the cavities in the cores without separation or segregation. The Slump of the concrete to be used in filling shall be between 75 mm and 100 mm and it shall be placed as soon as possible and not more than one and one-half (1.5) hours after water is first added. Admixtures may be used subject to prior approval by the Engineer. The concrete fill shall develop a minimum compressive strength of 20 N/mm^2.

   Concrete fill shall not be placed to a height of more than one (1) metre at one time and there shall be a minimum interval of sixty (60) minutes between pours. No concrete fill shall be placed until such time as the masonry has sufficiently hardened to prevent "blow outs".

7. Reinforcement

   Concrete blockwork shall generally have horizontal fabric reinforcement such as "Brickforce" or other equal and approved product laid in the joints after every third course in addition to any vertical bar reinforcement shown on the Drawings or requested by the Engineer.

   Vertical reinforcement shall be held in position at the top and bottom and at intervals not exceeding 200 diameters. Vertical reinforcing steel shall have a minimum clearance of 6 mm from the masonry and not less than one bar diameter between bars. Fabric reinforcement shall be completely embedded in mortar and lapped to a minimum of 150 mm at splices and shall contain at least one cross wire of each piece of reinforcement in the lapped length.

SERIES 04 00 00: MASONRY

SECTION 04 22 00: CONCRETE UNIT MASONRY

3. Nominal Block Dimensions

Free standing block walls used as free draining diaphragms behind bridge abutments and wing walls shall have the following nominal dimensions:

Nominal width	Nominal length	Nominal height
150 mm	400 mm	200 mm
200 mm	400 mm	200 mm

Minimum face shell thickness and web thickness shall be as follows:

Nominal width	Nominal length	Nominal height
150 mm	25 mm	25 mm
200 mm	30 mm	25 mm

Measurements shall be the average of 5 units taken at the thinnest point.

4. Strength Tests

Hollow concrete blocks shall be made from Portland cement and suitable aggregate by an approved reputable manufacturer. All units shall be sound and free from cracks or other defects that would impair the strength or performance of the construction. Load bearing blocks shall have an average crushing strength of not less than 12 N/mm^2 measured over the gross area. The Contractor shall allow for testing 5 random units prior to commencement of the job. The units to be tested shall be selected at random by the Engineer or his duly authorized representative.

5. Execution

Concrete blockwork shall be accurately set out to the dimensions shown on the Drawings or as directed by the Engineer. All surfaces on which blockwork is to be built shall be cleaned and levelled. Blocks shall be laid on a 10 mm mortar bed to give a good continuous face-shell mortar bedding. All joints shall be filled with mortar at every course. The lines of all courses and bonds shall be properly maintained.

SERIES 04 00 00: MASONRY

SECTION 04 22 00: CONCRETE UNIT MASONRY

At the time of laying, all blocks are to be free from excessive dust and dirt and shall be free from cracks and chips. Where cutting is necessary it should be carried out by the use of a broad, heavy chisel and a heavy chipping hammer.

The blocks to be cut should be scored along the cutting line, after which heavier blows are struck until the unit splits.

Work in hot weather: When blockwork is to be constructed in hot dry conditions, individual units shall be wetted with a light spray just prior to setting in the mortar bed.

- END OF SECTION -

SPECIFICATION SERIES 05 00 00
METALS

SERIES 05 00 00: METALS

SECTION 05 05 13: SHOP APPLIED COATINGS FOR METAL

CONTENTS

1. Description

The work covered in this Section shall consist of the protection of steelwork against corrosion as directed by the Engineer or as shown on the Drawings. The work includes, but is not limited to, the preparation of surfaces to be treated and the painting of the prepared surfaces.

1. This Specification defines the requirements for the purchase and application of protective coating systems.
2. All paints shall be obtained only from suppliers approved by the Engineer. Unless otherwise agreed by the Engineer all paints forming part of any one painting system shall be obtained from the same source. Paint shall be supplied in sealed containers of not more than 4.5 litre capacity and shall be used in strict rotation. Unless otherwise agreed by the Engineer, samples of paint not less than 2.5 litre capacity shall be submitted for testing to the engineer or his nominated testing authority equivalent approved standard.

2. Blast Cleaning

A. Concrete Encased Steelwork

Steel to be cleaned to power tool cleaning standard SSPC-SP3.

B. Low Exposure Environment

Steel to be cleaned to power tool cleaning standard SSPC-SP3.

C. High Exposure Environment

Steel to be sandblasted to SSPC-SP10 standard

SERIES 05 00 00: METALS

SECTION 05 05 13: SHOP APPLIED COATINGS FOR METAL (cont'd)

3. Materials

A. Soluble Salt Remover

Soluble salt remover to be Chlor*rid or approved equal. The soluble salt remover shall meet the following.

- Material to organic and non-hazardous
- Material to be non-flammable
- pH shall be 3.3 +or- 0.2

B. Painting Metal Surfaces

Concrete Encased Steelwork

- The coating to be used shall be one coat of a two part clear solvent less Epoxy sealer with a theoretical coverage at 38 microns thick of 1060 square feet per gallon.

Low Exposure Environment Referred to as

- The coating to be used shall be 100-200 microns of a two part semigloss Epoxy with a theoretical coverage at 25 microns thick of 1300 square feet per gallon.
- Abrasion Resistance using ASTM D4060 to be 102mg using 1kg load/1000 cycles with a CS-17wheel.
- Impact Resistance to ASTM D2794- Direct 24 in-lb, Reverse 6 in-lb
- Moisture/Vapour Transmission to ASTM F1249 4gm/sq.m/day
- Adhesion ASTM D4541 1200psi.

High Exposure Environment Referred to as

The prime coat shall be a 65 micron coat of heavy-duty two component inorganic –zinc silicate with a coverage at 25 microns of 990 square feet per gallon.

- The prime coat shall comply with the SSPC-Paint 20 standard.
- The prime coat is to be coated with a two part epoxy The coating to be used shall be 100-200 microns of a two part semigloss Epoxy with a theoretical coverage at 25 microns thick of 1300 square feet per gallon.
- Abrasion Resistance using ASTM D4060 to be 102mg using 1kg load/1000 cycles with a CS-17wheel.
- Impact Resistance to ASTM D2794- Direct 24 in-lb, Reverse 6 in-lb

SERIES 05 00 00: METALS

SECTION 05 05 13: SHOP APPLIED COATINGS FOR METAL (cont'd)

- Moisture/Vapour Transmission to ASTM F1249 4gm/sq.m/day
- Adhesion ASTM D4541 1200psi.

4. Construction Requirements

Preparation of Surfaces to Receive Paint

1. Before paint is applied to any metal surface, the appropriate surface preparation as described in the Contract shall be carried out in accordance with the following:

   a. Blast Cleaning

   Blast cleaning shall be carried out in accordance with SSPC-SP10 to the quality of surface finish as described as a near white blast cleaning. Surface shall be protected within 4 hours of having been blast cleaned. A sample blast cleaned steel panel measuring not less than 150mm x 150mm x 6mm adequately protected by sealed cleaned polyethylene wrapping shall be submitted to the Engineer for approval before any work is put in hand.

   The approved sample shall then be retained by the Engineer's inspectors for comparison with the prepared steelwork.

   b. Mechanical Cleaning

   Mechanical cleaning shall be carried out in accordance with SSPC-SP3 by power driven tools such as carborundum grinding discs, chipping hammers and needle guns, followed by steel-wire brushing and dusting to remove all loosened material. Excessive burnishing of the metal through prolonged application of rotary wire brushes shall be avoided. Surfaces shall be protected within 4 hours of having been mechanically cleaned.

   c. Soluble Salt Removal

   Soluble Salt removal shall be by pressure washing at a minimum of 2,000 p.s.i. using One gallon of Chlor*Rid or equal for each 100 gallons of potable water. The pressure washer device is to be equipped with a 0 to 15degree nozzle, which shall

SERIES 05 00 00: METALS

SECTION 05 05 13: SHOP APPLIED COATINGS FOR METAL (cont'd)

be held 4" to 10" from the surface. Soluble chloride tests are to be performed in the manner prescribed by the manufacturer every 500 square feet to ascertain cleanliness to meet the required level.

d. Welds and Areas Affected by Welding

Welds and surfaces, which have been affected by welding, shall be prepared for painting by the same process as for the adjoining metal.

e. Metal Coatings

1. Sprayed metal coatings, which are subsequently to be painted, shall have a nominal thickness of 100 micrometer unless otherwise specified.
2. Sampling and testing shall be carried out in accordance with BS 729, BS 4921 or BS 2569: Part 1, whichever is appropriate.
3. Where a metal coating is required only on part of an assembled section, it shall be applied before the rest of the section receives its first priming coat.

f. Treatment of Surfaces

- Chemical Pollution
  1. A protective coating shall not be applied to surfaces bearing atmospheric corrosion products or other chemicals, which may be harmful to the coating or succeeding coatings. These contaminants which include any remaining after surface preparation, as specified in Sub-Clause 1, and any produced by welding shall be cleaned off to an extent agreed by the Engineer to be compatible with the specified protective system.

- Welded Joints
  1. Unless otherwise described in the Contract, welds and surfaces, which have been affected by welding, shall receive the protective system, which is applied to the parent surfaces.

- Treatment Adjacent to Joints
  1. Metal spray shall be kept at least 15 mm clear of areas to be welded and these areas shall be masked off during spraying.

SERIES 05 00 00: METALS

SECTION 05 05 13: SHOP APPLIED COATINGS FOR METAL (cont'd)

2. Where paints other than blast primers are to be applied to the parent surfaces before the making of a joint, they shall be stepped back at 30 mm intervals commencing at 80 mm from welded joints and at 10 mm from the perimeter of all other joints.

- Surface Preparation and Painting of Completed Joints

1. Within 14 days of the joints having been made and passed by the Engineer, the parent and joint material, exposed parts of bolts, nuts and washers, weld and weld affected areas shall be prepared and painted.

- Other Treatment at Joints

1. All bolted joints shall be sealed against the ingress of water. Before painting commences and subject to the approval of the Engineer, gaps at joints shall be plugged with an approved filler. The perimeter of all joints shall be sealed with subsequent coats of paints.

- Storage of Paint

1. Paint shall be stored in sealed containers in a lock-up store where it is not exposed to extreme temperatures. The temperature of the store shall not exceed 35^{o}C. Any special storage conditions recommended by the manufacturer shall be observed.
2. Paint which has not been used within the 'shelf life' period specified on the containers or within 12 months of the date of manufacture, whichever is the lesser, shall be replaced.
3. Paint from painters' kettles shall be returned to store at the end of each working period, where it shall be kept in a sealed container. Before it is re-issued for use, it shall be thoroughly mixed and no fresh paint or thinners shall be added.

- Application of Paint

1. All paint shall be supplied from the store to the painters ready for application and the addition of thinners or of any other material shall be thereafter prohibited. Any instructions given by the paint manufacturer shall be strictly followed.

SERIES 05 00 00: METALS

SECTION 05 05 13: SHOP APPLIED COATINGS FOR METAL (cont'd)

2. All painting shall be carried out by skilled painters under competent supervision.
3. Paint shall be applied to dry surfaces, which have been prepared and cleaned in accordance with Sub-Clause 1.
4. No part of the steelwork shall be painted until the surface has been approved by the Engineer, and after approval the painting is to be carried out immediately.
5. Paints shall not be applied under the following conditions:
   i. When the relative humidity rises above 90 percent;
   ii. During rain or mist;
   iii. When condensation has occurred or is likely to occur on the steel.
6. Two pack paints of the epoxy resin type shall be applied as required by the paint manufacturer.
7. Each coat of paint shall be applied by a method approved by the Engineer to produce a continuous film of paint, of uniform and even thickness. As soon as the first priming coat has dried, an extra stripe coat of paint shall be applied by brush, to edges, corners, crevices, bolt heads, rivet heads and welds, using paint of a similar composition to the priming coat, but in a contrasting shade. Successive coats shall have different shades for identification and each coat shall be thoroughly dry before the application of a further coat.
8. The total dry paint film thickness of the paint system on bare steel surfaces and on metal coated surfaces shall not be less than 125 micrometer, except where otherwise specified in the Contract. The dry paint film thickness shall be measured by an Elcometer or other instruments approved by the Engineer.
9. In order to obtain the dry film thickness specified the Contractor shall ensure that the coverage rate given by the paint manufacturer will enable this thickness to be attained.
10. Wet film thickness gauges may be used for checking but shall not be permitted as a means of predicting the dry film thickness.
11. Unless otherwise agreed by the Engineer, the paint system with the exception of one final finishing coat shall be applied under cover in controlled conditions at the fabricator's works. One final finishing coat shall be applied

SERIES 05 00 00: METALS

SECTION 05 05 13: SHOP APPLIED COATINGS FOR METAL (cont'd)

at Site.

12. No paint shall be used after the expiration of the 'pot life' stipulated by the manufacturer and paints of limited 'pot life' shall not be mixed with fresh paint or have thinners added to them.
13. All tools, brushes, solvents and plant used, shall be such as to ensure the best possible result and shall be maintained in good condition both in use and in storage.
14. All paints shall be thoroughly mixed before use and shall be kept stirred to ensure uniformity of composition and application.
15. Unless otherwise described in the Contract, a coat of paint in a system shall be applied by one of the following methods:
    i. Brush;
    ii. Roller supplement by brush were necessary;
    iii. Air pressure spraying;
    iv. Airless spraying.
16. Solvent used for the removal of oil grease and dirt shall be non-injurious to both metal and paint and any excess shall be cleaned off immediately after use.
17. The thickness of coats of paint shall be checked at frequent intervals and whenever ordered by the Engineer. Where the meter shows that the paint film is less than that specified above, one or more additional coats shall be applied, as ordered by the Engineer at the Contractor's expense. Special attention shall be given to corners, sharp edges and similar parts, to maintain the thickness of the paint film. Care shall be taken to ensure that each coat is uniform in thickness and not so thick as to cause defects in the dried surface.
18. Each coat of paint of a specified paint system shall be generally free from surface defects, particularly cratering, pin-holing, rivelling, sagging, bettiness, dry spray and cissing. The finished system shall have an even and uniform appearance.

SERIES 05 00 00: METALS

SECTION 05 05 13: SHOP APPLIED COATINGS FOR METAL (cont'd)

- Storage of Painted Steelwork

1. Painted fabricated steelwork which is to be stored prior to erection shall be kept clear of the ground and shall be laid out or staked in an orderly manner that will ensure that no pools of water or dirt can accumulate on the surfaces. Suitable packing shall be laid between the layers of stacked materials. Where cover is provided it shall be ventilated.
2. Prime painted steelwork which is to be stored outdoors or transported prior to fabrication of erection shall not be exposed before being over coated for periods longer than the following:

- Outdoors

Red line primers (1 coat)	8 weeks
Metallic lead primers (2 coats)	16 weeks
Calcium plumbate primers	4 weeks
Zinc Chromate primers	2 weeks
Zinc chromate/Red oxide primers	2 weeks
Zinc-rich primers 1/2-1 mil thick	4 weeks

No steelwork shall be loaded for transport until the paint system has been passed by the Engineer as being sufficiently dry for handling.

- Repairs to Damaged Surfaces

1. Areas of paint which have been damaged during handling, storing loading and off-loading transportation, erection and construction, shall be cleaned to bare metal or metal coating, where this has been applied and the edges of the undamaged paint levelled with sand paper.
2. Where a metal coating has been damaged, the affected area shall be rubbed down to remove excessive roughness, cleaned, and an additional coat of approved zinc-rich primer applied to a minimum thickness of 100 micrometer.
3. The fill specified painting system shall then be re-applied and the new paint shall overlap the existing paint by at least 50mm all-round the affected area.

- END OF SECTION -

SERIES 05 00 00: METALS

SECTION 05 10 00: STRUCTURAL METAL FRAMING

CONTENTS

1. Materials

a. Materials conforming to any of the standard specifications listed below are approved for use under this specification.

American Society for Testing and Materials (ASTM):

A36/A36M-01..... Standard Specification for Carbon Structural Steel
A53/A53M-01..... Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless
A123/A123M-02..... Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
A242/A242M-01..... Standard Specification for High-Strength Low-Alloy Structural Steel
A307-00..... Standard Specification for Carbon Steel Bolts and Studs, 60,000 psi Tensile Strength
A325-02..... Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
A490-02..... Standard Specification for Heat-Treated Steel Structural Bolts 150 ksi Minimum Tensile Strength
A500-01..... Standard Specification for Cold Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
A501-01..... Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing

SERIES 05 00 00: METALS

SECTION 05 10 00: STRUCTURAL METAL FRAMING (cont'd)

A572/A572M-01..... Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel
A992/A992M-02..... Standard Specification for Structural Steel Shapes

b. material surface preparations and treatments to be used in the corrosion protection of the structural steelwork shall comply with the requirements of Section 506 of these Specifications.

c. Welding electrodes for manual metal-arc welding or grades of steel shall comply with the requirements of AWS A5.1and A5.5. Electrode wires and fluxes for submerged arc welding shall comply with A5.17and A5.23.

2. Fabrication Drawings

Two copies of all detailed fabrication drawings prepared by or on behalf of the Contractor shall be submitted to the Engineer for his approval, but this approval shall in no way relieve the Contractor of his responsibilities for the work.

3. Inspection and Marking

The Contractor shall notify the Engineer when materials are ready for inspection at the mills and/or fabricated material at the fabricator's shop. After checking or testing at the fabricator's shop, all members and fittings shall, for the purpose of identification during erection, have a distinguishing number and letter (corresponding to the distinguishing number and letter on the approved drawings) painted and where possible stamped on in two positions.

4. Welding and Flame Cutting Procedure Trails

1. When directed by the Engineer and before fabrication is commenced, welding and flame cutting procedure trials shall be carried out using representative samples of materials to be used in the work.

2. The samples of materials shall be selected and marked by the Engineer when the materials for the work are inspected at the mills.

SERIES 05 00 00: METALS

SECTION 05 10 00: STRUCTURAL METAL FRAMING (cont'd)

3. Trials on materials 20 mm thick shall be taken to include all materials up to but not exceeding 20 mm thick. Trials on material 38 mm thick shall be taken to include material over 20 mm and up to but not exceeding 38 mm thick. Material over 38 mm thick shall be tested for every thickness increment of 6 mm.

4. The welding and flame cutting trials shall demonstrate to the satisfaction of the Engineer the procedures to be adopted in the fabrication of the work, which shall include:
   i. Welding in accordance with AWS D1.1. Welds shall be made only by welders and welding operators who have been previously qualified by tests as prescribed in AWS D1.1 to perform type of work required.
   ii. The heat control techniques required to ensure that the flame cut surfaces of steel are free from cracks, local hardness and any other defects, which would be detrimental to the finished work.

5. The trials shall include specimen weld details representative of the actual construction, which shall be welded in a manner simulating the most unfavourable conditions liable to occur in the particular fabrication. Where primers are to be applied to the work prior to fabrication, they shall be applied to sample material before the procedure trials are made.

6. The following groups of tests shall be carried out.
   i. <u>Butt Welds</u>
   - Transverse tensile test;
   - Transverse and longitudinal bend tests;
   - Separate tests shall be performed in each case with the root of the weld in tension and compression;
   - Charpy V-notch impact tests ;
   - Macro examination test.

   ii. Fillet Welds
   - Fillet weld fracture test;
   - Macro examination test.

SERIES 05 00 00: METALS

SECTION 05 10 00: STRUCTURAL METAL FRAMING (cont'd)

5. Welding Plant

The welding plant shall be capable of maintaining at the weld, the voltage and current specified by the manufacturer of the electrodes. The Contractor shall supply instruments for verifying voltages and current as and when required by the Engineer.

6. Welding

1. The temperature of steels shall not be less than 100 deg.C when welding is commenced.

2. Electrodes and fluxes shall be used in accordance with the manufacturer's instructions. The use of welding processes other than those covered by AWS D1.1 shall be subject to the approval of the Engineer.

3. The general welding programme for shop and site welds including particulars of the preparation of fusion faces, the method of pre-heating where required, the methods of making the weld and the types of electrodes shall be submitted to the Engineer for his approval before the work is put in hand. No departure from the agreed welding programme or from the details described in the Contract shall be made without the agreement of the Engineer. Electrodes and fluxes shall be so chosen that the properties of the deposited metal are not inferior to those of the parent metal.

4. The procedures for welding and flame cutting established by the procedure trials under Clause 505.4 shall be strictly followed.

5. Unless otherwise described in the Contract, all butt welds shall be complete penetration welds made between prepared fusion faces.

6. In fabrication of built-up assemblies, all butt welds in each component part shall be completed whenever possible before the final assembly.

7. The position of welds required for temporary attachments shall be agreed by the Engineer before the work commences.

SERIES 05 00 00: METALS

SECTION 05 10 00: STRUCTURAL METAL FRAMING (cont'd)

8. Where automatic or semi-automatic processes are used, back gouging of the deposited weld will not be required where the Engineer is satisfied that the root run is free from imperfection.

9. Where butt welds are to be ground flush, there shall be no loss of parent metal. the final grinding shall be in the direction described in the Contract.

10. All shop welding, unless otherwise approved, shall be done in the down-hand or horizontal-vertical position. Vertical welding shall be done upwards.

11. All parts to be welded shall be accurately prepared so that on assembly, they fit closely together. After assembly and before the general welding is commenced, the parts are to be securely welded together with tack welds in the line of the welded seams. The tack welds shall be strong enough to prevent relative movement of the parts but small enough to be covered by the general welding.

12. In butt joints, the root edges or root faces shall not be out of alignment by more than 0.125 times the thickness of the thinner material, for material up to 12 mm thick or by more than 2 mm for thicker material.

13. Requirements for "run-on plates" and "run-off plates" shall be as follows:
    i. One pair of run-on plates and one pair of run-off plates, all prepared to the same thickness and profile as the parent metal shall be attached by clamps to the start and finish respectively on all butt welds. Unless otherwise required by the Engineer, approximately 1 in 5 pairs of run-off plates for butt welds in tension flanges and 1 in 10 pairs for other butt welds shall be production test plates. The combined size of each pair of production test plates shall be either 230 mm by 330 mm or 380 mm wide by 200 mm long in accordance with Table 1 below. Examination and Testing of Welds, the length being measured in the rolling direction of the metal and at right angles to the weld;
    ii. Butt welds shall run the full length of the joint and extend at full weld profile for a minimum distance of 25 mm into the run-off plates and for minimum distances of 200 mm, 280 mm and 355 mm respectively into the 230 mm by 200 mm, 300 mm by 200 mm and 380 mm by 200 mm run-off production test plates;

SERIES 05 00 00: METALS

SECTION 05 10 00: STRUCTURAL METAL FRAMING (cont'd)

iii. On completion of the welds, the run-off production test plates shall not be removed until they have been marked in a manner agreed by the Engineer to identify them with the joints to which they are attached;

iv. When removing the run-on and run-off plates by flame cutting, the cuts shall not be nearer than 6 mm to the sides of the parent metal and the remaining metal shall be removed by grinding or other method agreed by the Engineer.

Table 1: Examination and Testing of Welds

Material	Combined size (per pair) of production test plates (mm)		
	Plates up to 3mm thick	Plates from 3mm to 75mm thick	Plates over 75mmthick
Steel of Grades 36 and 50B	225 x 200	300 x 200	Sizes to be agreed with the Engineer

v. Specimens for the following tests to be carried out in accordance with Clause 505.9 shall be selected from the run-off production test plates by the engineer;

- Transverse tensile test(s) (the number of test pieces shall be sufficient to cover the full thickness of plate);
- Transverse bend test;
- Three Charpy V-notch tests.

7. Examination and Testing of Welds

1. The Engineer may require the Contractor to prepare and test specimens from time to time. The Contractor shall provide means for making radiographic examination of welds in the shop and such portions of welds as the Engineer may direct shall be so examined. The Contractor shall provide suitable facilities to the Engineer for viewing the originals of all radiographs as soon as possible after they have been made. The Engineer will arrange for making radiographic and/or ultrasonic examinations of welds at Site and such portions of the welds as the Engineer may direct shall be so examined.

SERIES 05 00 00: METALS

SECTION 05 10 00: STRUCTURAL METAL FRAMING (cont'd)

Any welds that in the opinion of the Engineer are shown to have serious defects shall be cut out and renewed to the Engineer's satisfaction at the Contractor's expense.

2. The Engineer will inspect welding at the Site before and during welding and at his discretion each run of welding shall be left bare such inspection before the next run is deposited.

8. Camber

Camber applied to steel girders shall be of smooth curvature and shall be in accordance with the instructions of the Engineer or as described in the Contract.

9. Bolts ASTM A325 A490

1. Bolts shall comply with ASTM A325 and A490.
   The bolt shall be tightened by a part-torque part-turn method. The part-torque tightening for bedding down shall be carried out by a calibrated tightening device such as a torque controlled manual wrench or power operated wrench. The bedding torque to be applied to the bolts shall be given in Table 2.

2. After bedding down of the joints, each nut and the protruding threads of the bolt shall be permanently marked to record their relative positions. The nuts shall then be tightened to the approval of the Engineer by a part-turn of the nut method.

Table 2: Preliminary Tightening of Nuts

Nominal Diameter of bolts mm	Bedding Torque + 10% KNm
16	1.75
19	2.55
22	3.65
25	5.11
29	8.03
32	11.31

SERIES 05 00 00: METALS

SECTION 05 10 00: STRUCTURAL METAL FRAMING (cont'd)

10. Fabrication Tolerances

Fabrication tolerances shall be in accordance with Section 6 of the Code of Standard Practice for Steel Buildings by AISC March 2005 edition.

11. Erection of Steelwork

1. At least one month before the steelwork erection commences, the Contractor shall prepare and submit to the Engineer for approval, detailed particulars of the method and procedure he proposes to adopt for the erection of the steelwork together with such calculations relating to strength and deflection of the structure as the Engineer may require.

   If the erection scheme proposed necessitates the attachment of temporary steelwork, the Contractor shall submit for the approval of the Engineer, his proposals for making good the permanent steelwork after removing the temporary steelwork. Approval of fastenings welded to the permanent work will not normally be given.

2. Erection procedures shall be in accordance with Section 7 of the Code of Standard Practice for Steel Buildings by AISC March 2005 edition.

3.

- END OF SECTION -

SERIES 05 00 00: METALS

SECTION 05 31 13: STEEL FLOOR DECKING

CONTENTS

1. SUMMARY

A. Related Documents:
   1. Drawings and general provisions of the Subcontract apply to this Section.
   2. Review these documents for coordination with additional requirements and information that apply to work under this Section.

B. Section Includes:
   1. Steel floor deck and accessories.
   2. Cold formed steel edge strips and closure strips.
   3. Steel angle reinforcement for small openings.
   4. Shear connector studs for composite beam construction.

C. Related Sections:
   1. Division 05 Section "Structural Steel Framing".

SERIES 05 00 00: METALS

SECTION 05 31 13: STEEL FLOOR DECKING (cont'd)

2. REFERENCES

A. General:
   1. The following documents form part of the Specifications to the extent stated. Where differences exist between codes and standards, the one affording the greatest protection shall apply.
   2. Unless otherwise noted, the referenced standard edition is the current one at the time of commencement of the Work.

B. AISI - Specification for the Design of Cold-Formed Steel Structural Members.

C. ASTM International:
   1. ASTM A36 / A36M Standard Specification for Carbon Structural Steel
   2. ASTM A653 / A653M Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

D. AWS D1.1 - Structural Welding Code.

E. Steel Deck Institute (SDI) - Design Manual for Composite Decks, Form Decks, Roof Decks.

F. Underwriters' Laboratories (UL) - Fire Resistance Directory.

G. Steel Structures Painting Council (SSPC) – Systems and Specifications.

2. SUBMITTALS

A. Shop Drawings shall indicate decking plan, deck profile dimensions, supports, projections, openings, and reinforcement, finishes, pertinent details, and accessories.

B. Certificates are required which indicate the decking meets or exceeds specified requirements.

C. Submit documentation that welders employed on the Work meet AWS qualifications.

SERIES 05 00 00: METALS

SECTION 05 31 13: STEEL FLOOR DECKING (cont'd)

3. DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site and store on wood sleepers with slope for positive drainage cut plastic wrappings to encourage ventilation.

PART 2 - PRODUCTS

1. MATERIALS

A. Sheet steel shall conform to ASTM A653, SS Grade 33, minimum 38,000 psi yield, and galvanized with a G60.

B. Angles: ASTM A36 steel.

C. Welding materials shall conform to AWS D1.1.

D. Accessories: Same material and finish as deck and not lighter than 20 gauge.

1. Provide edge closures of minimum to suit thickness of concrete and closure configuration.
2. Z-closures at beams parallel to flutes shall be 16 gauge minimum.

E. Shear Connector Studs: AWS D1.1, Type B headed studs; 3/4 inch diameter unless otherwise noted, as welded length as noted on Drawings.

F. Galvanizing Repair Paint: SSPC Paint 20 with dry film containing a minimum of 94 percent zinc dust by weight.

PART 3 - EXECUTION

1. EXAMINATION

A. Verify existing conditions prior to starting work.

2. INSTALLATION

A. Erect metal decking in accordance with SDI Design Manual for Composite Decks.

SERIES 05 00 00: METALS

SECTION 05 31 13: STEEL FLOOR DECKING (cont'd)

B. Layout:
   1. Place and adjust units in final position prior to permanent fastening.
   2. Install in straight, continuous rows with ribs at right angles to supporting members.
   3. Align ribs to be straight within 1/4 inch (6 mm) in overall length of decking.
   4. Locate end joints over supporting members and ensure not less than 2 inches (50 mm) bearing of each panel on support. Butt end joints of floor deck tight at center line of structural support. Lap end joints of roof deck not less than 2 inches (50 mm) , unless otherwise noted.
   5. Provide decking continuous over openings that are not surrounded by perimeter safety cables. Do not cut openings in steel deck until the opening is required.

C. Fastening Deck Units:
   1. Perform welding in accordance with AWS D1.3.
   2. Secure to supporting members with arc spot (puddle) welds with a minimum effective fusion area of 1/2 inch (12 mm) diameter. Take special care to secure solid welds where deck is warped or sloped.
      a. [Shear connector studs welded through deck replace deck puddle welds on a one-for-one basis, wherever there is one inch minimum clearance from stud centerline to edge of deck.]

   3. Connect side laps as shown or noted on Drawings.
      a. Top Seam Weld: Clinch first to get contact of lips and make 1-1/2 inch (12 mm) long weld which engages top of inner leg.
      b. Button Punch: Interlock units with 3/16 (4.7 mm) button protruding noticeably.
   4. Touch-up paint welds except where in contact with concrete.

D. Shear Connector Studs: Automatically end weld in accordance with AWS D1.1 and Manufacturer's recommendations in such a manner as to provide complete fusion between the end of the stud and steel member. There shall be no porosity or evidence of lack of fusion between the end of the stud and the steel member.
   1. Single studs welded to beams framing perpendicular to deck flutes shall be placed as close as practical to center of deck flute. Place adjacent studs on opposite sides of center-rib.]

SERIES 05 00 00: METALS

SECTION 05 31 13: STEEL FLOOR DECKING (cont'd)

E. Reinforcement of Openings:
   1. Reinforce openings, except single openings spaced more than 24 inches (610 mm) on center and cutting no webs.
   2. Use reinforcement details shown on Drawings.
   3. At deck to receive concrete fill, do not cut deck until concrete has achieved 3000 psi (20.7 MPa) compressive strength, unless opening is surrounded with steel spanning to structural frame.

F. Install sheet-steel strip closures and angle closures to close openings between walls, columns, and openings. Closures shall be of sufficient strength to remain in place without distortion.

G. Install foam strip closures above walls and partitions perpendicular to deck flutes.

H. Install sheet steel strip closures at floor edge upturned to thickness of slab to contain wet concrete. Provide closures of sufficient strength to remain in place without distortion.

I. Install sheet steel closures and angle flashings to close openings between deck and walls, columns, and openings.

J. Immediately after welding deck in place and removing slag, touch-up welds, burned areas and damaged surface coating with prime paint.

3. FIELD QUALITY CONTROL

A. Inspection and testing will be performed under provisions of Division 1.

B. Testing Laboratory will:
   1. Inspect and test deck welding as required by CBC Section 1701.5, Item 5, in accordance with AWS D1.3. Review materials and qualification of welders and procedures prior to start of work, periodically inspect welding in progress, and perform final visual inspection of welds.
   2. Inspect and test welding of shear connector studs as required by Engineer in accordance with AWS D1.1.

SERIES 05 00 00: METALS

SECTION 05 31 23: STEEL ROOF DECKING

CONTENTS

1. Aluzinc Sheeting and Siding

A. Sheeting for roofing shall be 0.5mm thick ALUZINC to ASTM A792 -83 in standard corrugated sheets manufactured by Caribbean Steel Mill Ltd or Geddes Grant Industries Ltd or Similar and Approved by the Engineer. The sheets shall be in maximum length where possible to avoid end laps or to achieve the dimensions shown on the drawings.

B. Main roof sheets shall have a natural unpainted finish. Sheets to be used as vertical siding shall be pre-painted with a baked on finish of a colour to be approved by the Engineer. All sheets shall be clean in appearance with no surface contamination or defects and free from twist or buckle.

C. The corrugated profile sheets are 42” (1064mm) wide to give an approximate cover width of 36” (968mm) with double side laps. Lay sheets in continuous lengths if possible with two corrugation side laps and 12” (300mm) end laps where necessary.

D. Fix sheets with 3” (75mm) long self-drilling, self-tapping screws with sealing washers fixed through every crown at each purlin support.

E. All end laps where necessary shall be securely sealed with an approved elastomeric strip sealant.

F. Ensure that roof fixings are not over-tightened so that they cause twists or depressions in the sheets.

G. Exercise extreme care in trafficking the sheets during the erection so as to avoid any damage to them.

H. All ridgings, barge boards and flashings to the roofs are to be made up of materials of similar type and colour to the roof sheets.

- END OF SECTION