

LAO PEOPLE'S DEMOCRATIC REPUBLIC
Peace Independence Democracy Unity Prosperity

Ministry of Public Works and Transport

DEPARTMENT OF ROADS



**STANDARD
TECHNICAL
SPECIFICATIONS**

FINAL

January 2019

PREFACE

These Ministry of Public Works and Transport Standard Technical Specifications were updated during 2017-18 by the Ministry of Public Works and Transport and its Department of Roads in cooperation with the ADB financed Road Sector Governance and Maintenance Project, in order to provide common Standard Technical Specifications for all road construction- and maintenance contracts in Lao PDR.

The first MPWT Standard Technical Specifications were developed 1996. But already some years earlier, the different ADB road construction projects started to prepare project specific technical specifications, the first one being ADB-5 in 1993. In each new ADB project the technical specifications were gradually improved by adding new sections and revising specifications, based on experiences gained from the earlier ADB projects, and from 1996 and onwards also using material from the 1996 published MPWT Standard Technical Specifications. The most recent ADB project specific technical specifications, which existed when preparing these Standard Technical Specifications were the ADB-12 technical specifications from 2013. The ADB-12 technical specifications were used as the basis on which these MPWT Standard Technical Specifications have been built on.

During the work with preparing these technical specifications, extensive consultations were conducted with the Department of Road and its Technical Division. A final draft of the updated technical specifications was presented in a workshop at MPWT on 31/01/2018 chaired by the Vice Minister and with attendance from all 18 provinces, donor community and other stakeholders. Comments were received from provinces, the MPWT - State Enterprise for Survey-Design and Material Testing and others, and all comments were addressed and are incorporated in these specifications.

The main objectives of these updated MPWT Standard Technical Specifications are:

- The use of the same standard specifications in all road construction- maintenance contracts in Lao PDR, irrespective of the stakeholders in the contracts;
- Ensuring durable and safe roads, applying prerequisite environmental and social safeguards;
- Providing efficiency in economy;
- Corresponding to best international and to good practises applied in the neighbouring countries, in ASEAN and in the region in similar climatic conditions;
- Improved specifications for road components where weaknesses in the past have been recognised, e.g. specifications for traffic markings and traffic signs;
- Provide specifications that incorporate recent developments in the road construction industry, e.g. Superpave and solar powered street lighting;
- Conforming with the MPWT-DOR Road Design Manual.

These comprehensively updated MPWT Standard Technical Specifications consist of six main parts, each of them consisting of several Sections as shown below:

SERIES 100 GENERAL PROVISIONS:	9 Sections
SERIES 200 EARTHWORKS:	9 Sections
SERIES 300 PAVEMENT:	13 Sections
SERIES 400 DRAINAGE:	6 Sections

SERIES 500 STRUCTURES:	15 Sections
SERIES 600 MISCELLANEOUS:	18 Sections

In some cases, depending on the contract-specific conditions, some modifications or additions to these MPWT Standard Technical Specifications could be required. In those cases these modified or additional specifications shall be incorporated in separate Particular Technical Specifications.

In case the users of these MPWT Standard Technical Specifications find that some specifications are missing from this document, it is recommended to use the latest AASHTO or ASTM specifications, until these parts are incorporated into the future versions of MPWT Standard Technical Specifications.

In today's world things are developing rapidly, and this is also happening in the road construction/ maintenance industry. Sometime in the future there will be a need to update these MPWT Standard Technical Specifications, taking into consideration the new improved technology, materials etc. These MPWT Standard Technical Specifications can then be modified only when approved by MPWT-DOR.

CONTENTS

SERIES 100

GENERAL PROVISIONS

SECTION 101	Preamble to General Provisions
SECTION 102	General Obligations
SECTION 103	Contractor's Establishments
SECTION 104	Facilities for the Engineer
SECTION 105	Testing and Control
SECTION 106	Permanent Buildings
SECTION 107	General Environmental and Social Impact Requirements
SECTION 108	Removal and Disposal of Pavements, Bridges, Culverts, Other Structures and Road Furniture
SECTION 109	Clearance of Unexploded Ordnance

SERIES 200

EARTHWORKS

SECTION 201	Clearing and Grubbing/ Tree Removal
SECTION 202	Demolition Work
SECTION 203	Roadway Excavation
SECTION 204	Construction of Embankments
SECTION 205	Compaction of Earthworks
SECTION 206	Disposal of Surplus Materials
SECTION 207	Structural Excavation
SECTION 208	Structural Backfill (Free Draining)
SECTION 209	Reconditioning of Existing Pavement

SERIES 300

PAVEMENT

SECTION 301	Aggregate Sub-base
SECTION 302	Crushed Aggregate Base Course
SECTION 303	Prime Coat
SECTION 304	Surface Dressing
SECTION 305	Bituminous Pavement Courses (Asphaltic Concrete)
SECTION 306	Tack Coat
SECTION 308	Cement Stabilised Base and Sub-Base
SECTION 309	Lime Stabilised Base and Sub-Base
SECTION 310	Cold Mixed Asphalt
SECTION 311	Slurry Seal
SECTION 312	Gravel Wearing Course
SECTION 313	Sand Layer under Concrete Pavement
SECTION 314	Rigid Pavements / Concrete Pavements

SERIES 400

DRAINAGE

SECTION 401	Box Culverts
SECTION 402	Pipe Culverts
SECTION 403	Sub-Surface Drains
SECTION 404	Ditch, Apron Protection, Inlet and Outlet Structures
SECTION 405	Minor Drainage Structures
SECTION 406	Bridge Drainage

SERIES 500

STRUCTURES

SECTION 501	General Requirements
SECTION 503	Precast Concrete Piles
SECTION 504	Bored Piles
SECTION 505	Falsework and Formwork
SECTION 506	Steel Reinforcement
SECTION 507	Structural Concrete
SECTION 508	Prestressing of Concrete
SECTION 509	Bearings
SECTION 510	Bridge Railings
SECTION 513	Expansion Joint System
SECTION 514	Bridge Load Testing
SECTION 520	Steel structures
SECTION 521	Painting
SECTION 522	Structural Timber
SECTION 523	Conduits, Fittings and Boxes

SERIES 600

MISCELLANEOUS

SECTION 601	Box Gabions / Gabion Mattresses / Geotextile Sheetings
SECTION 602	Slope Protection and Masonry Structures
SECTION 603	Guardrails
SECTION 604	Traffic Markings
SECTION 605	Traffic Signs
SECTION 606	Kilometre and Edge Marker (Guide) Posts
SECTION 607	Concrete Kerbs (Barrier and Mountable) and Gutter
SECTION 608	Foundation Investigations
SECTION 609	Sodding
SECTION 610	Bio-Engineering: Planting and Sowing
SECTION 611	Street Lighting
SECTION 612	Solar Powered Street Lighting
SECTION 613	Road Traffic Signals
SECTION 614	Permanent Timber Barricades
SECTION 615	Fencing
SECTION 616	Landscaping and Beautification Works
SECTION 617	Traffic Calming Devices
SECTION 618	Daywork

MEASUREMENT AND PAY ITEMS (BoQ)

ABBREVIATIONS

ADT	Average Daily Traffic
ASA	Asset Standards Authority
CBR	California Bearing Ratio
Cc	Compression Index
CEMAP	Contractor Environmental Management Action Plan
CIV	The Characteristic Impact Value
CP	Code of Practice
CVN	Charpy V-notch
Cv	Coefficient of Consolidation
DBST	Double Bituminous Surface Treatment
DCP	Dynamic Cone Penetration
DMD	Daily Marshall Density
EMP	Environment Management Plan
ESAL	Equivalent Single Axle Loads
FEP	Fluorinated Ethylene Propylene
HMA	Hot Mix Asphalt
IEE	Initial Environmental Examination
EIA	Environmental Impact Assessment
ITP	Inspection and Test Plan
JMF	Job Mix Formula
JSM	Job Standard Mix
LED	Light Emitting Diode
LJMF	Laboratory Job mix Formula
LL	Liquid Limit
MDD	Maximum Dry density
MONRE	Ministry of Natural and Environment
MPWT	Ministry of Public Works and Transport
MSDS	Manufacturer's Material Safety Data Sheet
mv	Volume Compressibility
NBCA	National Biodiversity Conservation Area
NS	National Standard
PC	Personal Computer
PI	Plasticity Index
PTFE	Polytetrafluorethylene
PVC	Perforated Polyvinyl Chloride
RAP	Recycled Asphalt Pavement
RP	Relocation Plan
RQD	Rock Quality Designation
SBST	Single Bituminous Surface Treatment
SOP	Standard Operation Procedures
SPT	Standard Penetration Test
TC	Tungsten-Carbide

TSR	Tensile Strength Ratio
USCS	Unified Soil Classification System
UXO	Unexploded Ordnance
Va	Air Voids
VFA	Voids Filled with Asphalt
VIM	Voids in Mix
VMA	Voids in Mineral Aggregate
VTC	Voluntary Testing and Counselling
WMA	Warm Mix Asphalt

STANDARDS REQUIRED

SECTION 101 - Preamble to General Provisions

AASHTO	Standard Specifications for Transportation Materials and Methods of Sampling and Testing”, Parts I and II
AASHTO	Standard Specifications for Highway Bridges
ASTM	Annual Book of Standards”, Volumes 01.04 and 04.01 to 04.09 inclusive
AASHTO T 180 D	Moisture-Density Relations of Soils Using a 4.5 kg Rammer and a 457 mm Drop
ASTM D1250	Correction of bitumen volumes

SECTION 102 - General Obligations

WHO	pH value of water Statutory regulations of the Lao PDR - Handling of explosives
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SECTION 103 - Contractor’s Establishments

No Standards referred to

SECTION 104 - Facilities for the Engineer

No Standards referred to

SECTION 05 - Testing and Control

AASHTO M 145	Classification of embankment and Sub-grade
AASHTO T 100	Specific Gravity of Soils
AASHTO T 102	Spot Tests of Asphaltic Materials
AASHTO T 104	Soundness of Aggregate by Use of Sodium Sulphate or Magnesium sulphate
AASHTO T 106	Compressive Strength of Hydraulic Cement Mortar (Using 2 inch or 50 mm Cube Specimens)
AASHTO T 11	Materials Finer Than 0.075 mm (No. 200) Sieve in Mineral Aggregates by Washing
AASHTO T 110	Moisture of Volatile Distillates in Bituminous Paving Mixtures
AASHTO T 112	Clay Lumps and Friable Particles in Aggregate
AASHTO T 119	Slump of Portland Cement Concrete
AASHTO T 121	Weight per Cubic Foot, Yield and Air Content (Gravimetric) of Concrete
AASHTO T 126	Making and Curing Concrete Test Specimens in the Laboratory
AASHTO T 127	Sampling and Amount of Testing of Hydraulic Cement
AASHTO T 128	Fineness of Hydraulic Cement by different Sieve sizes
AASHTO T 129	Normal Consistency of Hydraulic Cement
AASHTO T 131	Time of Setting of Hydraulic Cement by Vicat Needle
AASHTO T 141	Sampling Fresh Concrete

AASHTO T 146	Wet Preparation of Disturbed Soil Samples for Test
AASHTO T 148	Taking cores for testing compressive strength of concrete
AASHTO T 153	Fineness of Portland Cement by Air Permeability Apparatus
AASHTO T 164	Quantitative Extraction of Bitumen from Bituminous Paving Mixture
AASHTO T 165	Effect of Water on Cohesion of Compacted Bituminous Mixtures
AASHTO T 166	Bulk Specific gravity of Compacted Bituminous Mixtures
AASHTO T 168	Sampling Bituminous Paving Mixtures
AASHTO T 170	Recovery of Asphalt from Solution by Abson Method
AASHTO T 176	Plastic Fines in Graded Aggregates and Soils by Use of Sand Equivalent Test
AASHTO T 179	Effect of Heat and Air on Asphalt Materials (Thin-Film Oven Test)
AASHTO T 180	Moisture-Density Relations of Soils Using a 4.5 kg Rammer and a 457 mm Drop
AASHTO T 182	Coating and Stripping of Bitumen-Aggregate Mixtures
AASHTO T 19	Unit Weight and Voids in Aggregate
AASHTO T 191	Field Density by sand Replacement
AASHTO T 193	California Bearing Ratio
AASHTO T 195	Determining Degree of Particle Coating of Bituminous-Aggregate
AASHTO T 2	Sampling Aggregates
AASHTO T 201	Kinematic Viscosity of Asphalts
AASHTO T 202	Viscosity of Asphalts by Vacuum Capillary Viscometer
AASHTO T 204	Density of Soil In-Place by the Drive Cylinder Method
AASHTO T 205	Field Density by Balloon Densometer
AASHTO T 208	Unconfined Compressive Strength of Cohesive Soil
AASHTO T 209	Maximum Specific Gravity of Bituminous Paving Mixtures
AASHTO T 21	Organic impurities in Fine Aggregates
AASHTO T 22	Compressive Strength of Cylindrical Concrete Specimens
AASHTO T 224	Correction for Coarse Particles in the Soil Compaction Test
AASHTO T 228	Specific Gravity of Semi-Solid Bituminous Materials
AASHTO T 23	Making and Curing Concrete Test Specimens in the Field
AASHTO T 230	Determining Degree of Pavement Compaction of Bituminous Aggregate Mixture
AASHTO T 231	Capping Cylindrical Concrete Specimens
AASHTO T 24	Taking cores for testing compressive strength of concrete
AASHTO T 245	Resistance to Plastic Flow of Bituminous Paving Mixture Using Marshall Apparatus
AASHTO T 26	Quality of Water to be used in Concrete
AASHTO T 265	Laboratory Determination of Moisture Content of Soils
AASHTO T 27	Sieve Analysis of Fine and Coarse Aggregates
AASHTO T 37	Sieve Analysis of Mineral Filler for Road and Paving Materials
AASHTO T 40	Sampling of Bituminous Materials
AASHTO T 44	Solubility of Bituminous Materials
AASHTO T 47	Loss on Heating of Oil and Asphaltic Compounds
AASHTO T 48	Flash and Fire Points by Cleveland Open Cup
AASHTO T 49	Penetration of Bituminous Materials
AASHTO T 51	Ductility of Bituminous Materials
AASHTO T 53	Softening Point of Asphalts and Tar in Ethylene Glycol (Ring-and-Ball)
AASHTO T 55	Water in Petroleum Products and Bituminous Materials by Distillation
AASHTO T 59	Testing Emulsified Asphalt
AASHTO T 71	Effect of Organic Impurities in Fine Aggregate on Strength of Mortar
AASHTO T 72	Saybolt Viscosity

AASHTO T 78	Distillation of Cut-Back Asphaltic Products
AASHTO T 79	Flash Point with Tag Open Cup Apparatus
AASHTO T 84	Specific Gravity and Absorption of Fine Aggregate
AASHTO T 85	Specific Gravity and Absorption of Coarse Aggregate
AASHTO T 87	Dry Preparation of Disturbed Soil and Soil Aggregate Samples for Test
AASHTO T 88	Particle Size Analysis of Soils
AASHTO T 89	Determining the Liquid Limit of Soils
AASHTO T 90	Plastic Limit and Plasticity Index of Soils
AASHTO T 92	Determining the Shrinkage Factors of Soils
AASHTO T 96	Resistance to Abrasion by Use of the Los Angeles Machine
AASHTO T 97	Flexural Strength of Concrete
AASHTO T 99	Moisture-Density Relations of Soils Using a 2.5 kg Rammer and a 305 mm Drop
AASHTO T106	Compression strength of mortars
AASHTO T148	Measuring Length of Drilled Concrete Cores
ASTM D689	Standard Test Method for Internal Tearing Resistance of Paper Nuclear Density Meter
ASTM D882	Standard Test Methods for Tensile Properties of Thin Plastic Sheeting
ASTM C150	Portland Cement
ASTM C295	Petrographic examination (if required)
ASTM C566	Moisture Content of Aggregate
ASTM D2049	Relative Density of Cohesion-less Soils
ASTM D2727	Coating and stripping (with adhesion agent)
ASTM D5874	Characteristic Impact Value (CIV) Test
BS 812 Part III	Determination of the Polished Stone Value
BS 812/7.3	Determination of Flakiness Index
BS 812/7.4	Determination of Elongation Index
CRD C 79	Testing the Pumpability of Grout, US Corps of Engineer's Method
CRD C 79	Testing the Pumpability of Grout, US Corps of Engineer's Method
No Standard specified	pH testing of Soil Aggregates and Water Samples

SECTION 106 - Permanent Buildings

AASHTO M 150	Clinker and limestone, Type II
AASHTO M 85	Cement type for mortar, Type I
AASHTO T 22	Compressive strength
AASHTO T 23	Making and curing specimens in the field
ASTM C141	Hydrated lime
ASTM C35	Sand in Plastering
ASTM C25	Quick-lime

SECTION 107 - General Environmental and Social Impact Requirements

	Ministry of Public Works and Transport (MPWT), and Ministry of Natural Resources and Environment (MONRE) environmental-, social impact- and resettlement guidelines, Decree No.122/PM, 2010 PM Decree No. 192/PM on the Compensation and Resettlement (2005)
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SECTION 108 - Removal and Disposal of Pavements, Bridges, Culverts, Other Structures and Road Furniture

No Standards referred to

SECTION 109 - Clearance of Unexploded Ordnance

	Lao PDR National UXO/Mine Action Standards (issued by the National Regulatory Authority)
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SECTION 201 - Clearing and Grubbing/ Tree Removal

No Standards referred to

SECTION 202 - Demolition Work

No Standards referred to

SECTION 203 - Roadway Excavation

AASHTO T 99 Method D	Moisture-Density Relations of Soils Using a 2.5 kg Rammer and a 305 mm Drop National Forestry Law
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SECTION 204 - Construction of Embankments

AASHTO T 27	Sieve Analysis of Fine and Coarse Aggregates
AASHTO T 193	CBR (4 days soaked)
AASHTO T 89	Liquid limit
AASHTO T 90	Plasticity index
AASHTO T 180	Moisture-Density Relationship (4.54 kg rammer)

SECTION 205 - Compaction of Earthworks

AASHTO T 180	Moisture-Density Relationship (4.54 kg rammer)
AASHTO T 180 Method D	Compaction
AASHTO T 191	In-situ Density, Sand-Cone Replacement
AASHTO T 193	CBR Test
AASHTO T 205	In-place Density, Rubber-Balloon
AASHTO T 265	Moisture Content
AASHTO T 99	Moisture-Density Relationship (2.5 kg rammer)

SECTION 206 - Disposal of Surplus Materials

No Standards referred to

SECTION 207 - Structural Excavation

No Standards referred to

SECTION 208 - Structural Backfill (Free Draining)

AASHTO T 27	Sieve Analysis of Fine and Coarse Aggregates
AASHTO T 99 Method D	Compaction

SECTION 209 - Reconditioning of Existing Pavement

AASHTO T 193	CBR (4 days soaked)
AASHTO T 88	Particle Size Distribution
AASHTO T 89	Liquid Limit
AASHTO T 90	Plasticity Index
TRL Method	Dynamic Cone Penetrometer

SECTION 301 - Aggregate Sub-base

No Standard specified	Wet/Dry Strength Variation
No Standard specified	Plasticity Modulus
AASHTO 27	Sieves for grading
AASHTO No. 4	Sieve No. 4 for grading
AASHTO T 180	Optimum moisture content
AASHTO T 180 Method D	Compaction
AASHTO T 191	In field density measurement
AASHTO T 193	CBR (4 day soaked), @ 95% of MDD
AASHTO T 224	Correction for oversize particles
AASHTO T 89	Liquid Limit
AASHTO T 90	Plasticity Index
AASHTO T 92	Linear shrinkage
AASHTO T 96	Los Angeles abrasion
ASTM D5874	Characteristic Impact Value

SECTION 302 - Crushed Aggregate Base Course

No Standard specified	Plasticity Product (PI x percentage passing 0.425 mm sieve)
AASHTO T 104	Soundness loss
AASHTO T 176	Fines Values
AASHTO T 180	Dry Density, Optimum moisture content
AASHTO T 180 Method D	Compaction (Maximum dry density)
AASHTO T 191	Density
AASHTO T 193	CBR
AASHTO T 224	Correction for oversize particles
AASHTO T 27	Sieve Analysis of Fine and Coarse Aggregates

AASHTO T 89	Liquid Limit
AASHTO T 90	Plasticity Index
AASHTO T 96	Los Angeles Abrasion
ASTM D5874	Characteristic Impact Value
BS 812	Flakiness index & Elongation index

SECTION 303 - Prime Coat

AASHTO M 208	Cationic Slow Setting Emulsified Asphalt
AASHTO M 43	Blotting material aggregate, size 10
AASHTO M 82	Medium curing cutback asphalt
ASTM D5874	Characteristic Impact Value

SECTION 304 - Surface Dressing

AASHTO M 140-82	Bituminous materials
AASHTO M 20-70	Bituminous materials
AASHTO M 208-81	Bituminous materials
AASHTO M 81-75	Bituminous materials
AASHTO T 182	Retained asphalt film - Coating and Stripping of Bitumen-Aggregate Mixtures
AASHTO T 19	Loose density
AASHTO T 27	Sieve Analysis of Fine and Coarse Aggregates
AASHTO T 85	Bulk specific gravity

SECTION 305 - Bituminous Pavement Courses (Asphaltic Concrete)

AASHTO M 156	Mixing plants
AASHTO M 17	Particles of limestone or cement; Mineral Filler
AASHTO M 226	Asphalt binder
AASHTO M 240	Hydraulic Cement
AASHTO M 295	Fly Ash
AASHTO M 303	Lime
AASHTO M 320	Asphalt binder
AASHTO M 85	Hydraulic Cement
AASHTO R 35	Superpave Concrete Mix Design Requirements
AASHTO T 104	Soundness Loss, Sodium Sulphate & Magnesium Sulphate
AASHTO T 11	Grading
AASHTO T 168	Grading
AASHTO T 176	Sand Equivalent
AASHTO T 179	Laboratory Job-Mix Formula (LJMF) for AC
AASHTO T 182	Loss on Heating (5 hr. at 163 °C), %
AASHTO T 21-81	Organic impurities
AASHTO T 27	Grading
AASHTO T 283	Tensile Strength Ratio
AASHTO T 304, Method A	Fine Aggregate Angularity
AASHTO T 308	Asphalt Binder in Recycled Asphalt Pavement (RAP)
AASHTO T 312	Gyratory Compaction
AASHTO T 44	Solubility tricolour ethylene, %
AASHTO T 48	Flash Point, Cleveland Open Cup, °C

AASHTO T 49	Penetration of Bituminous Material
AASHTO T 51	Ductility of residue at 25 °C, (50 mm/min), cm
AASHTO T 53	Softening Point, Ring & Ball apparatus
AASHTO T 84	Coarse and Fine G _{sb}
AASHTO T 85	Coarse and Fine G _{sb}
AASHTO T 88	Gradation analysis
AASHTO T 90	Plasticity
AASHTO T 96	Los Angeles Abrasion Loss
ASTM C128/127	Water Absorption
ASTM D113	Ductility of residue at 25 °C, (50 mm/min), cm
ASTM D1664	Affinity of additive
ASTM D2170	Kinematic Viscosity (Centistokes) at 135 °C
ASTM D2402	Solubility tricolour ethylene, %
ASTM D2419	Sand Equivalent
ASTM D2872	Thin film over test 3.2 mm, 163°C, 5 hr. loss on heating, %
ASTM D3042	Mass of Insoluble Residue
ASTM D36	Softening Point, Ring & Ball apparatus
ASTM D4791	Flat and Elongated Particles
ASTM D5	Penetration at 25 °C (100 g, 5 sec)
ASTM D5821	Fractured Faces
ASTM D6927	Standard Test Method for Marshall Stability and Flow of Asphalt Mixtures
ASTM D92	Flash Point, Cleveland Open Cup. °C
ASTM No. 4	Sieve No. 4 for grading
ASTM Sieve	Grading
BS 1377: Part 2: Test 5	Plasticity Index
BS 812 Part 105.1	Flakiness Index & Elongation Index
BS 812 Part 117	Acid Soluble Chlorides
BS 812 Part 118	Acid Soluble Sulphates
BS 812 Part 3	Aggregate; -Crushing Value, - Impact Value, -Polished Stone Value
BS Sieve	Grading
No Standard specified	Paraffin content, %
No Standard specified	Paraffin content, %

SECTION 306 - Tack Coat

AASHTO M 140	Emulsified asphalt SS1
AASHTO M 43	Blotting material, size 10

SECTION 308 - Cement Stabilised Base and Sub-Base

AASHTO T 180	Compaction, Optimum moisture content
AASHTO T 180 Modified	Compaction
AASHTO T 191	Density
AASHTO T 26	Testing water quality (pH, etc.)

SECTION 309 - Lime Stabilised Base and Sub-Base

AASHTO T 180	Compaction, Optimum Moisture Content
AASHTO T 26	Testing water quality (pH, etc.)
BS 1924, Test 15	Lime content

SECTION 310 - Cold Mixed Asphalt

AASHTO M 147-6S	Crushed aggregate
AASHTO M 17	Filler material
AASHTO M 208	Bitumen emulsion [Cationic emulsion (CSS)]
AASHTO M 29	Fine Aggregate material requirements
AASHTO M 80	Coarse aggregate
AASHTO T 176	Sand Equivalent
AASHTO T 182	Coating
AASHTO T 96	Abrasion loss
ASTM D1073	Fine Aggregate material requirements
ASTM D6927	Standard Test Method for Marshall Stability and Flow of Asphalt Mixtures
BS 812	Flakiness Index & Elongation Index
No Standard specified	Strength Index by Ontario Vacuum Immersion Marshall Test
No Standard specified	Strength Index by U.S. Army Corps of Engineers - Asphalt Institute Immersion Marshall Test

SECTION 311 - Slurry Seal

AASHTO T 49	Penetration of Bituminous Materials
AASHTO T 51	Ductility of Bituminous Materials
AASHTO T 59	Viscosity, Sieve Test, Particle Charge, Distillation Test, Penetration
AASHTO T 72	Viscosity, Saybolt-Furol, 25°C (77°F), sec
ASTM D3910	Standard Practices for Design, Testing and Construction of Slurry Seal - The Asphalt Institute Manual Series No. 19; by C.K.E. Determination Method (Centrifuge Kerosene Equivalent Test)

SECTION 312 - Gravel Wearing Course

AASHTO T 180	Moisture-Density Relations of Soils
AASHTO T 180, Method D	Compaction
AASHTO T 191	Density of Soil In-Place by the Sand-Cone Method
AASHTO T 193	CBR (4 days soaked)
AASHTO T 224	Correction for oversize particles
AASHTO T 27	Sieve Analysis of Fine and Coarse Aggregates
AASHTO T 89	Liquid limit
AASHTO T 90	Plasticity index

SECTION 313 - Sand Layer under Concrete Pavement

AASHTO T 180	Moisture-Density Relations of Soils
AASHTO T 27	Sieve Analysis of Fine and Coarse Aggregates

SECTION 314 - Rigid Pavements / Concrete Pavements

AASHTO M 148	Liquid curing membrane, Type 2
AASHTO M 153	Joint Filter material
AASHTO M 171	White Opaque Polyethylene Film for curing
AASHTO M 213	Joint Filter material
AASHTO M 33	Bituminous joint filter material
AASHTO M 55	Steel Wire Mesh
AASHTO M 74	Subgrade paper
ASTM D6690, Type II	Joint Sealant

SECTION 401 - Box Culverts

No Standards referred to

SECTION 402 - Pipe Culverts

AASHTO M 170	Tolerances in dimensions
AASHTO M 170	Precast Pipes material, Class IV
AASHTO M 45	Sand
AASHTO M 85	Cement
AASHTO T 22	Compressive strength
AASHTO T 280	Precast Pipes material testing

SECTION 403 - Sub-Surface Drains

AASHTO M 278	Pipe material
AASHTO T 27	Sieve Analysis of Fine and Coarse Aggregates

SECTION 404 - Ditch, Apron Protection, Inlet and Outlet Structures

AASHTO T 180	Moisture-Density Relations of Soils Using a 4.5 kg Rammer and a 457 mm Drop
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SECTION 405 - Minor Drainage Structures

AASHTO M 105	Iron castings for frames, covers and gratings for manholes and inlets, Class 30
ASTM A207	Specification for Rolled Wrought Iron Shapes and Bars

SECTION 406 - Bridge Drainage

AASHTO M 111	Galvanised gratings
AASHTO M 183	Steel for Inserts
ASTM A36	Steel for Inserts

SECTION 501 - General Requirements

No Standards referred to

SECTION 503 - Precast Concrete Piles

ASTM D1143	Static load test
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SECTION 504 - Bored Piles

AASHTO M 270	Steel casings material, Grade 36
ASTM D4945	High Strain Dynamic Load Testing
ASTM D5882	Pile Integrity Testing

SECTION 505 - Falsework and Formwork

AASHTO	"Standard Specifications for Highway Bridges"
AASHTO	"Guide Design Specifications for Bridge Temporary Works"

SECTION 506 - Steel Reinforcement

AASHTO	"Division I, Article 8.32" - Splicing
AASHTO M 31	Reinforcing bars material, Grade 40/ 60
AASHTO M 32	Cold drawn steel wire material
AASHTO M 54	Steel bar mats material
AASHTO M 55	Welded steel wire mesh material
AWS D1.4	"Structural Welding Code, Reinforcing Steel, AWS D1.4 of the American Welding Society" - Welding procedures mesh material

SECTION 507 - Structural Concrete

AASHTO M 148	Properties of "Curing membrane", Type 2
AASHTO M 171	Properties of "Waterproof paper and plastic sheeting"
AASHTO M 194	Properties of Admixtures and Additives
AASHTO M 205	Properties of "Single use cylinder moulds"
AASHTO M 6	Fine Aggregate properties, Fineness Modulus
AASHTO M 80	Coarse Aggregate properties
AASHTO M 85	Cement properties
AASHTO T 104	Sodium sulphate soundness
AASHTO T 106	Comparative water tests (unsoundness), Standard mortar test
AASHTO T 112	Content of clay lumps and friable particles
AASHTO T 119	Slump test
AASHTO T 131	Time of Setting of Hydraulic Cement by Vicat Needle; Cement compressive strength
AASHTO T 197	Initial set
AASHTO T 21	Calourimetric method for organic matter (content of sulphide and sulphate)
AASHTO T 22	Curing and testing
AASHTO T 23	Section 9.3 and 9.4 - Curing and protection
AASHTO T 24	Taking and Testing Core samples

AASHTO T 255	Measuring quantity of free water contained in fine and coarse aggregates
AASHTO T 26	Chemical water analysis; pH value
AASHTO T 27	Sieve Analysis of Fine and Coarse Aggregates
AASHTO T 96	Resistance to Abrasion of Small Size Coarse Aggregate by Use of the Los Angeles Machine
AASHTO	Load Factor Design methods, using Load Group IB
ASTM C150	Cement properties, Type I
ASTM D512	Chloride ion concentration
ASTM D516	Sulphate ion concentration
BS 812	Flakiness index & Elongation index "Recommended Practice for Hot Weather Concreting" (American Concrete Institute 305-R77)

SECTION 508 - Prestressing of Concrete

AASHTO M 203	Properties of Steel Strand - nominal weight and nominal cross sectional area
AASHTO M 722	Pre-stressing Steel Bar
AASHTO M 85	Properties of Grout, Type I
Method CRD C79	"US Corps of Engineers Method CRD C79" - Pumpability of Grout

SECTION 509 - Elastomeric Bearings

AASHTO	"AASHTO Standard Specifications for Highway Bridges, Division II - Tables 18.2.3.1A and B" - Properties of Elastomer Compound
AASHTO	Bridge Welding Code
AASHTO M 107	Bronze Bearing and Expansion Plates
AASHTO M 108	Rolled Copper-Alloy Bearing and Expansion Plates
AASHTO M 270	Metal Plates
AASHTO M 270M	Metal Plates
AASHTO M 235	Adhesive Material
AASHTO M 235M	Adhesive Material
ASTM A307	Anchor bolts
ASTM A709	Metal Plates
ASTM A709M	Metal Plates
ASTM B22	Bronze Bearing and Expansion Plates
ASTM B100	Rolled Copper-Alloy Bearing and Expansion Plates
ASTM B103	Porous Bronze Layer
ASTM B103M	Porous Bronze Layer
ASTM B29	Sheet Lead Used as Bedding
ASTM C881	Adhesive Material
ASTM C881M	Adhesive Material
ASTM C920, Type II	Caulking Material Used as Bedding
ASTM D2256	Tensile Strength and Elongation
ASTM D4014	Annex A - Shear stiffness tests
ASTM D429	Method B - Peel strength of Steel Laminated Bearings
ASTM D4894	Melting Point of PTFE Resin
ASTM D4895	Melting Point of PTFE Resin
ASTM D5977	Melting Point of PTFE Resin
ASTM D638	Tensile Strength and Elongation

ASTM D792	Specific Gravity of Filled PTFE Sheet
AWS D1.5	Bridge Welding Code
AWS D1.5M	Bridge Welding Code

SECTION 510 - Bridge Railings

AASHTO M 111	Properties of Galvanised Steel Pipes
ASTM A500	Properties of Steel Pipe Rails

SECTION 513 - Expansion Joint System

AASHTO M 153	Properties of non-extruding and non-bituminous resilient Filler
AASHTO M 213	Properties of non-extruding and resilient bituminous Filler
AASHTO M 251	Properties of Elastomer parts
AASHTO M 33	Properties of preformed bituminous Filler

SECTION 514 - Bridge Load Testing

No Standards referred to

SECTION 520 - Steel structures

AASHTO	AASHTO LRFD Bridge Design Specifications, 4th edition 2007" - Details of connections for highway bridges
AASHTO	Quality Control program for Working Drawings, listing methods and personnel
AASHTO	Load and Resistance Factor Design methods - Load carrying capacity of a structure
AASHTO	Bearing design
AASHTO D1.5	- Properties of high strength steel Stud connectors for use in structural steel joints; - Welder Qualification and Inspection of Welding; - Non-destructive Testing
AASHTO M 270	- Properties of Steel material, Grade 345'
AISC	- "Manual of Steel Construction" published by the AISC - Radius of bend
ANSI D1.5	- Properties of high strength steel Stud connectors for use in structural steel joints; - Welder Qualification and Inspection of Welding; - Non-destructive Testing
ANSI, Part 6	Quality Control program for Working Drawings, listing methods and personnel
ANSI B1.1	- Unified Coarse Thread Series - External Threads, with Class 2A tolerances; - Internal Threads, with Class 2B tolerances
ANSI B1.13M	- External Threads, with Grade 6G tolerances; - Internal Threads, with Grade 6H tolerances
ASTM	Properties of Steel materials
ASTM A106	Properties of high strength steel pipe (Hydrostatic testing will not apply) for use in structural steel joints, Grade B
ASTM A108	Properties of high strength steel Stud connectors for use in structural

	steel joints
ASTM A139	Properties of high strength steel pipe (Hydrostatic testing will not apply) for use in structural steel joints, Grade B
ASTM A27	Properties of high strength Carbon Steel Castings for use in structural steel joints; Grade 65-35, [450-240], Class 1
ASTM A307	<ul style="list-style-type: none"> - Properties of steel Bolts and Studs for general applications - Properties of steel Headed Anchor Bolts for general applications, Grade B, including S1, supplementary requirements
ASTM A325	Properties of high strength steel Bolts for use in structural steel joints, Type 1
ASTM A345	Punching or sub punching of structural steel
ASTM A36	Properties of high strength steel Pin Nuts for use in structural steel joints
ASTM A36M	Properties of high strength steel Pin Nuts for use in structural steel joints
ASTM A449	<ul style="list-style-type: none"> - Properties of steel High-strength Bolts and Studs for general applications, Type 1; - Properties of steel High-strength Threaded Rods for general applications, Type 1
ASTM A47	Properties of high strength steel Malleable Iron Castings for use in structural steel joints, Grade 32510
ASTM A47M	Properties of high strength steel Bolts for use in structural steel joints, Grade 22010
ASTM A48	Properties of high strength steel Gray Iron Castings for use in structural steel joints, Class 30B
ASTM A500	Properties of high strength steel Carbon steel structural tubing for use in structural steel joints, Grade B
ASTM A501	Properties of high strength steel Carbon steel structural tubing for use in structural steel joints
ASTM A53	<ul style="list-style-type: none"> - Properties of high strength steel pipe (Hydrostatic testing will not apply) for use in structural steel joints, Type E, Grade B - Properties of high strength steel pipe (Hydrostatic testing will not apply) for use in structural steel joints, Type S, Grade B
ASTM A563	<ul style="list-style-type: none"> - Properties of steel Nuts for general applications; - Properties of high strength steel Nuts for use in structural steel joints; - Internal Threads; - Properties of Dry Lubricant which is used when tightening Nuts; Supplementary Requirement S2
ASTM A563M	Internal Threads
ASTM A572	Properties of "High strength low alloy columbium vanadium steel", Grade 50 (345)
ASTM A572M	Properties of "High strength low alloy columbium vanadium steel", Grade 50 (345)
ASTM A588	Properties of "High strength low alloy structural steel"
ASTM A588M	Properties of "High strength low alloy structural steel"
ASTM A668	<ul style="list-style-type: none"> - Properties of high strength steel "Carbon steel for forgings, pins and rollers" for use in structural steel joints, Class D; - Properties of high strength steel "Alloy steel for forgings" for use in structural steel joints, Class G
ASTM A668M	<ul style="list-style-type: none"> - Properties of high strength steel "Carbon steel for forgings, pins and rollers" for use in structural steel joints, Class D; - Properties of high strength steel "Alloy steel for forgings" for use in structural steel joints, Class G
ASTM A673	Sampling procedures for Steel material

ASTM A709	<ul style="list-style-type: none"> - Properties of Structural Steel materials; - Properties of Structural Steel materials, 50 [345]; - Properties of Structural Steel materials, 50W [345W]; - Properties of "High strength low alloy columbium vanadium steel", Grade 50 (345); - Properties of "High strength low alloy structural steel", Grade 50W (345 W)
ASTM A709M	<ul style="list-style-type: none"> - Properties of Structural Steel materials; - Properties of Structural Steel materials, 50 [345]; - Properties of Structural Steel materials, 50W [345W]; - Properties of "High strength low alloy columbium vanadium steel", Grade 50 (345); - Properties of "High strength low alloy structural steel", Grade 50W, (345 W)
ASTM E23	Determination of Charpy V notch impact values
ASTM F1852	Properties of high strength steel Tension Control Bolts for use in structural steel joints, Type 1
ASTM F436	Properties of high strength steel Hardened Washers for use in structural steel joints; Type 1, Circular, including S1 supplementary requirements
ASTM F844	Properties of steel Washers for general applications
ASTM F959	Properties of high strength steel Direct Tension Indicators for use in structural steel joints; Type 325, Zinc coated
ASTM, which are relevant	Tests on fastener components and fastener assemblies
AWS D1.5	<ul style="list-style-type: none"> - Quality Control program for Working Drawings, listing methods and personnel; - Properties of high strength steel Stud connectors for use in structural steel joints; - Welder Qualification and Inspection of Welding; - Non-destructive Testing
RCSC	"Specification for Structural Joints Using ASTM A 325 or A 490 Bolts" (RCSC Specification) approved by the Research Council on Structural Connections of the Engineering Foundation - Bolted Connections
RCSC	Section 9(b), "Arbitration Inspection," of the RCSC Specification - Minimum Tension
TT S 230	Federal Specification TT S 230, Type II - Properties of Coating of Non Sag Polysulfide or Polyurethane Caulking, Type II
	"Arbitration of Disputes, Inspection Torque Method Short Bolts," section of the "Structural Bolting Handbook," published by the Steel Structures Technology Centre, Incorporated - Job Inspecting Torque for Short Bolts

SECTION 521 – Painting

ASTM	"American Society for Testing and Materials" Standards
SSPC	"Steel Structures Painting Council" Standards
SSPC-PA2	"Steel Structures Painting Council SSPC-PA2" - Measurement of Dry Film Thickness
SSPC-SP10	"Steel Structures Painting Council (SSPC), Surface Preparation Specification No. 10, SSPC-SP10 - Near-White Blast Cleaning" - Steel Surface Sand Blasting
TT-P-19	U.S. Federal Specification - Properties of Acrylic Emulsion Paint

SECTION 522 - Structural Timber

AITC	Timber Construction Manual - Subsection 7.3.1 - Boring of Holes for Lag Screws
AITC 111	AITC 111, Recommended Practice for Protection of Structural Glued Laminated Timber During Transit, Storage, and Erection
ASTM A153	Galvanization of Wrought Iron and Medium Steel
AWPA	AWPA published Consumer Information Sheet - Handling of Treated Timber
AWPA M4	"Standard for the Care of Preservative-Treated Wood Products" - Treatment of Cuts and Abrasions

SECTION 523 - Conduits, Fittings and Boxes

ASTM A239-40	Preece Copper Sulphate Test for Galvanised Coating
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SECTION 601 - Box Gabions / Gabion Mattresses / Geotextile Sheetings

AASHTO M 288	- Properties of Threads Used in Joining Geotextiles, Class A; - Properties of Threads Used in Joining Geotextiles, Class B"
AASHTO T 85	Absorption Test
AASHTO T 96	Abrasion Loss
ASTM A392	Tensile Strength of Wire
ASTM A90	Zinc Coating of Wire

SECTION 602 - Slope Protection and Masonry Structures

AASHTO T 85	Specific Gravity and Absorption of Coarse Aggregate
AASHTO T 96	Resistance to Abrasion by Use of the Los Angeles Machine
AASHTO T 99	Moisture-Density Relations (Compaction)

SECTION 603 - Guardrails

AASHTO M 111	Galvanisation of Posts and Plates
AASHTO M 180	Properties of Beams; Class A, Type 1
AASHTO M 183	Properties of Structural Steel
AASHTO M 232	Galvanisation of Hardware

SECTION 604 - Traffic Markings

AASHTO M 247	Requirements on Glass Beads
AASHTO T 250-05 (2014)	Standard Method of Test for Thermoplastic Traffic Line Material
ASTM D1155	Shape of Glass Beads
ASTM D1213	Crushing Resistance of Glass Spheres
ASTM D1214 ,	Grading Requirements of Glass Beads
ASTM D6628	Day-Time and Night-Time Colours
ASTM D7585	Sampling Protocol for Retro-Reflectivity
ASTM D771	- Properties (No Pick-up [minutes]) of Paint; - Testing of Paint samples"

ASTM E1710	Retro-Reflectivity
ASTM E28	Softening Point
BS 873	Properties of Road Studs (Reflecting and Non-Reflecting)
Federal Spec TT-P-85B	Brightness of Glass Beads
Federal Spec TT-P-85D	Federal specification TT-P-85D, dated June 26, 1969 - Testing of Paint samples
Federal Standard 141	Federal Test Method Standard No. 141 Paint, Varnish, Lacquer and Related Materials, Method of Inspection, Sampling and Testing - Testing of Paint samples
Federal Standard 141	Properties (Consistency) of Paint, Method 1281
Federal Standard 141	- Properties (Non-volatile Vehicle) of Paint, Method 4051 - Properties (Total Dry Solids) of Paint, Method 4051
Federal Standard 141	Properties (Unit Weight) of Paint, Method 4184
Federal Standard 141	C.I.E. Chromaticity Colour Coordinates, Method 4525
Federal Standard 141	- Federal Test Method Standard No. 141, Method 6121 - Directional Reflectance of White Paint; - Federal Test Method Standard No. 141, Method 6121 - Directional Reflectance of Yellow Paint"
T 04/2516	Department Standard Test Method 204/2516 - Gradation of Glass Beads

SECTION 605 - Traffic Signs

AASHTO	Properties of Steel Posts
AASHTO M 232	Galvanisation of Steel Bolts, Nuts and Washers
ASTM	Properties of Steel Posts
ASTM A123	Zinc Coating (Galvanising) on Steel parts
ASTM A153	Zinc Coating (Galvanising) on Steel parts
ASTM A245	Properties of Steel Plate, Sheet or Strip, Grade B
ASTM A48	Properties of Cast Iron, Class 30
ASTM B108	Properties of Cast Aluminium Alloy, Alloy SG 70A, Condition T6
ASTM B209	Properties of Aluminium Alloy - Flat Sheets and Plates
ASTM B210	Properties of Aluminium Alloy Posts - Drawn Seamless Tubes
ASTM B221	Properties of Aluminium Alloy Posts - Extruded Bars, Rods and Shapes
ASTM B221	Properties of Aluminium Alloy - Extruded Panels
ASTM B235	Properties of Aluminium Alloy Posts - Extruded Tubes
ASTM B241	Properties of Aluminium Alloy Posts - Pipes
ASTM B26	Properties of Cast Aluminium Alloy, Alloy SG 70A, Condition T6
ASTM B308	Properties of Aluminium Alloy Posts - Structural Shapes, Rolled or Extruded
ASTM D4956	Reflective Sheeting
ASTM M111	Torsional Rigidity and Strength of Steel Posts
BSI	Properties of Steel Posts

SECTION 606 - Kilometre and Edge Marker (Guide) Posts

No Standards referred to

SECTION 607 - Concrete Kerbs (Barrier and Mountable) and Gutter

No Standards referred to

SECTION 608 - Foundation Investigations

AASHTO	- Preparation of Test Specimens procedure; - Rock Sample properties
AASHTO T 208	Unconfined Compression Tests procedures
ASTM D1194	Plate Load Test procedure on Investigations for Bridges and Culverts
BS 1377	- Laboratory Test procedure; - Modus operandi for ""Standard Penetration Test"" - Test 19"
BS 5390: 1981	Dynamic Cone Probing procedure on Investigations for Bridges and Culverts
BS 5930: 1981	Trial Pits on Investigations for Bridges and Culverts
BSI	- Preparation of Test Specimens procedure; - Rock Sample properties"
USCS	Unified Soils Classification System (USCS) - Logging of Soils
	Logging of Rocks - "Geological Society Engineering Group Working Party report on the logging of rock cores for engineering purposes, 1969-1970"

SECTION 609 - Sodding

No Standards referred to

SECTION 610 - Bio-Engineering: Planting and Sowing

No Standards referred to

SECTION 611 - Street Lighting

AASHTO	Equipment and Parts properties
ANSI	Equipment and Parts properties
ASTM	Equipment and Parts properties
ASTM A525	Galvanization of Poles and Ferrous Materials
BS 1788, 1964	Mounting of Lantern on Adjustable Support
BS 449	Columns Properties
BS 892:1967	Definitions of Street Lighting - British Standard 892:1967 "Glossary of Highway Engineering Terms"
BSI	- Design of Installation - British Standard Code of practice CP 1004 of 1963 ""Street lighting"" published by the British Standards Institution 2, Park Lane, London, W.1; - Equipment and Parts properties"
CP 1004	Definitions of Street Lighting - British Standard Code of Practice CP 1004 "Street Lighting", 1967
IEE	Pulleys for Electrical Cables - bending properties; British Institution of Electrical Engineers, 14th Edition
IET	Equipment and Parts properties
NIST	Equipment and Parts properties
	Design of Installation - "American Standard Practice for Roadway Lighting" (D 12.1 1963), published by the Illuminating Engineering Society, 345, East 47th Street, New York

SECTION 612 - Solar Powered Street Lighting

IEC	Applicable parts to be applied - International Electro-technical Commission (IEC)
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SECTION 613 - Road Traffic Signals

ANSI	Reflector properties - Clause 8.02 of the Institute of Traffic Engineers Technical Report No. 1 "Adjustable Face Vehicle Traffic Control Signal Head Standard" as approved by the American National Standards Institute (ANSI)
BS	Colour and Transmittance properties of Lenses

SECTION 614 - Permanent Timber Barricades

AASHTO M 122 73	Treatment of Timber Posts
ASTM A153	Galvanization

SECTION 615 – Fencing

No Standards referred to

SECTION 616 - Landscaping and Beautification Works

No Standards referred to

SECTION 617 – Traffic Calming Devices

AASHTO	Guide to the Development of Bicycle Facilities
AASHTO T 250	Low Temperature Stress Resistance
ASTM C531	Coefficient of thermal expansion
ASTM C642	Density
ASTM D2240	Hardness and Indentation Resistance
ASTM D2370	Tensile strength and Elongation
ASTM D256, Method A	Impact Resistance
ASTM D36	Softening Point
ASTM D395	Compression deformation
ASTM D4060	Abrasion
ASTM D412	Tensile strength
ASTM D570	Water Absorption
ASTM D573	Weathering
ASTM D746	Brittleness
ASTM D92	Flash Point

SECTION 618 – Daywork

No Standards referred to

Standards referred to in the MPWT Standard Technical Specifications

AASHTO	American Association of State Highway and Transportation Officials
ACI	American Concrete Institute
AISC	American Institute of Steel Construction
AITC	American Institute of Timber Construction
ANSI	American National Standards Institute
ASTM	American Society for Testing and Materials
AWPA	American Wood Protection Association
AWS	American Welding Society
BS	British Standards
BSI	British Standards Institute
CIE	Commission Internationale de l'Éclairage (French title), (International Commission on Illumination)
CRSI	Concrete Reinforcing Steel Institute
IEC	International Electro-technical Commission
IEE	Institution of Electrical Engineers
IESNA	Illuminating Engineering Society of North America
IET	Institution of Engineering and Technology
MOT	Ministry of Transport, Vietnam
NEC	National Electrical Code
NIST	National Institute of Standards and Technology
RCSC	Research Council on Structural Connections
SSPC	Steel Structures Painting Council
USCS	Unified Soils Classification System
WHO	World Health Organisation

SERIES 100
GENERAL PROVISIONS

SECTION 101

PREAMBLE TO GENERAL PROVISIONS

101.01 GENERAL

101.01.1 Applicability of Specifications

(1) These Standard Specifications are intended for use on all contracts implemented by the Ministry of Public Works and Transport (MPWT), and may therefore contain Sections, Clauses and/or Sub-clauses which are not relevant to the particular Works being undertaken under the specific Contract for which these Standard Specifications form part of the Contract documents

(2) The Works to be constructed are shown on the Drawings and itemised in the Bill of Quantities, and only those Sections, Clauses and/or Sub-clauses of relevance to the Works shall be utilised.

101.01.2 Headings

(1) These Specifications are divided into parts for convenience only and shall be read as one unit, but consisting of the Section, Clause, Sub-clauses and paragraph headings.

101.01.3 Engineer and Engineer's Representative

(1) Without prejudice to the provisions of the Conditions of Contract, in these Specifications the term "Engineer" shall be deemed to import "Engineer's Representative" and vice-versa where the context requires.

101.01.4 Descriptions

(1) The descriptions appearing in any part of the Specifications shall apply equally to other parts where appropriate and shall be read as though repeated therein.

(2) Unless stated to the contrary, the description of any thickness of material means the thickness after compaction in accordance with the Specifications requirements.

101.01.5 Omissions or Inapplicability

(1) The apparent silence of the Specifications or Drawings as to any detail, or the apparent omission from them of a detailed description concerning any point, shall be regarded as meaning that good civil engineering practice is to be used.

(2) Any sections in these Specifications which relate to materials or workmanship not required by the Contract shall be deemed to be non-applicable.

101.01.6 References on Drawings

(1) All Drawings included in the Contract Documents relate to that particular Contract only, notwithstanding any reference on the Drawings to other contracts.

101.02 DEFINITIONS

Whenever the following terms are used in the documents forming the Contract, the intent and meaning shall be as follows:

Aggregate - An inert material such as crushed rock, gravel, sand or the like.

Asphalt - A general term for certain mixtures of asphaltic cement and mineral matter.

Asphaltic cement - Bitumen, a mixture of lake asphalt and bitumen, or lake asphalt and flux oils or pitch or bitumen, having cementing qualities suitable for the manufacture of asphalt pavements.

Asphaltic concrete - A material used to construct a wearing course. It consists of a mixture of aggregate and asphaltic cement. The proportions and grading of the coarse aggregate may be varied to produce different types of mix with differing properties.

Cut-back asphalt - A liquid petroleum product produced by fluxing an asphaltic base with suitable petroleum distillates, used in treatment of road surfaces.

Emulsified asphalt - In which a petroleum product, in finely divided droplets, is dispersed in water by means of an emulsifying agent to form a stable mixture.

Natural asphalt - A bituminous deposit formed in oil-bearing strata by the disappearance of the volatiles.

Sand asphalt - A surfacing material consisting of a hot-mixed, hot-laid, plant mixture of natural sand and, in some cases, mineral filler and crushed fine aggregate, bound with penetration graded asphaltic cement. It is not suitable for heavily trafficked roads.

Emulsion slurry seal - A surfacing material, used by itself in one or two layers, or on top of a single surface dressing. It consists of fine aggregate, mineral filler and emulsified asphalt.

Fog spray - A light application of emulsified or cut-back asphalt, on top of a surface dressing. Its purpose is to improve the water proofness of the surfacing and to assist in holding the chippings.

Base - One or more layers of material constituting the main structural element of the pavement.

Bitumen - A viscous liquid, or a solid, consisting essentially of hydrocarbons and their derivatives, which is soluble in carbon disulphide. It is substantially non-volatile, and softens gradually when heated. It is black or brown in colour, and possesses waterproofing and adhesive properties. It is obtained by refinery processes from petroleum, and is also found as a natural deposit or as a component of naturally occurring asphalt, in which it is associated with mineral matter.

Borrow area - A site from which natural material, other than solid stone, is removed for construction of the works. (The term borrow pit is also used).

Bridge - A structure, including supports, erected over a depression or an obstruction, such as water, a road or railway, with a track or passageway for carrying traffic or other moving loads and having an opening measurement along the line of survey stationing of more than 5 m between the front walls of abutments.

Length - The length of a bridge is the overall length measured along the line of survey stationing back to back of back walls of abutments, or with no abutments, end to end of the bridge deck.

Substructure - The piers and abutments which support the superstructure.

Superstructure - That part of the structure which is supported by the piers and abutments.

Carriageway - That part of the road or highway constructed for use by vehicular traffic, excluding the shoulders.

Cement-stabilised material - Consists of a mixture of natural gravels or coarse clayey sand with approximately 4-8 per cent of ordinary Portland cement such that a rigid material is produced. Acceptance criteria includes unconfined compressive strength.

Commencing surface - In relation to an item in the Bill of Quantities, the surface of the ground before any work covered by the item has been carried out.

Culvert - Any structure not classified as a bridge in the form of pipes or an enclosed channel with an opening of less than 5 m if a single span for conveying water under the roadway.

Excavated surface - In relation to an item in the Bill of Quantities, the surface to which excavation included in the work covered by the item is to be carried out.

Final surface - The surface indicated on the Drawings to which excavation is to be carried out.

Formation - The surface of the ground in its final shape, upon which the pavement structure, consisting of sub-base, base and surfacing is constructed.

Graded crushed stone - A base or sub-base material, conforming to a specified grading, strength, shape and soundness criteria having been crushed in a crusher.

Gravel - A non-cohesive granular material resulting from the natural disintegration of rocks and consisting of irregular, rounded or angular particles. It may contain crushed particles.

Gravel wearing course - Top surfacing course made from gravel and applied to a road formation where no pavement or bituminous surfacing are to be placed. The term "gravel" includes one or a combination of the following materials: lateritic gravel, quartzitic gravel, calcareous gravel, some forms of partly decomposed rock, soft stone, clayey sands and crushed rock.

Landslide - A landslide is the movement of rock, debris or earth down a slope. They result from the failure of the materials which make up the hill slope and are driven by the force of gravity. Landslides can be triggered by natural causes or by human activity. They range from a single boulder in a rock fall to tens of millions of cubic metres of material in a debris flow. They can also vary in their extent, with some occurring very locally and impacting a very small area, while others affect much larger areas.

Lean concrete - A high quality, well graded gravel and Portland cement mixture, mixed in a stationary plant and laid by a paver. It is used as a high quality base.

Limits of construction - An area with established boundaries, identified within the right-of-way or construction easements, where the construction is permitted.

Lot - A section of work or quantity of material which is essentially uniform in nature, with respect to materials, location, method of construction and time of construction. Refer to Section 105 for detailed information.

Materials - Any things or substances (but not Contractor's Equipment) required for the execution and completion of, and the remedying of defects in, the Works. Materials may form (or be intended to form) part of the Permanent or Temporary Works, or may be consumables such as fuel and explosives.

Maximum dry density - The oven-dry density at optimum moisture content as determined by AASHTO Test 180, Method D, often abbreviated to MDD, with "90 MDD" or "MDD (90)", for example, meaning 90 per cent of the maximum dry density.

Original surface - The surface of the ground before any work has been carried out.

Pavement - The part of the road structure above the sub-grade usually comprising sub-base, base and surfacing layers.

Prime coat - An application of low viscosity asphalt binder to an absorbent surface, usually the top of the base. Its purposes are to waterproof the surface being sprayed and to help bind it to the overlying bituminous course.

Quarry - An open surface working from which stone is removed by drilling and blasting, for construction of the works.

Right-of-way - A general term denoting land, property, or interest therein, usually in a strip, acquired for or devoted to a road.

Rockfill - Rock material of such particle size that the material can only be placed in layers of compacted thickness exceeding 300 mm.

Shoulder - The portion of the road pavement contiguous with the carriageway for accommodation of stopped vehicles and for emergency use.

Sidewalk (Footway) - That portion of a road reserved exclusively for pedestrians.

Slope - The inclination of a plane surface to the horizontal, expressed as one vertical linear unit to the number of horizontal linear units.

Sub-base - One or more layers of material situated between the base and the sub-grade.

Sub-grade - The upper part or parts of the soil, natural or constructed immediately below sub-base, which supports the loads transmitted by the overlying pavement.

Selected sub-grade - A layer of selected fill material, the top of which is at formation level, placed where the natural in-situ or fill material is considered to be unsuitable for the direct support of the pavement.

Sub-grade level - The surface of the sub-grade in its final shape after the completion of the earthworks.

Surfacing - A wearing course placed on top of the base.

Surface dressing - A wearing course consisting of a layer of single-sized aggregate lightly rolled into a film of bitumen, road tar, or the like.

Tack coat - A light application of bituminous binder to a bituminous or concrete surface to provide a bond between this surface and the overlying bituminous course.

Variation instruction (Variation Order) - An instruction to vary the Works issued by the Engineer under the provisions of the Conditions of Contract.

Work - The furnishing of all labour (including the supervision thereof), materials, Contractor's Equipment and all other things, whether of a temporary or permanent nature, required in and for the execution of and remedying of defects in the Works, the furnishing of which is specified in or is reasonably to be inferred from the Contract.

Working day - Every calendar day except Sundays and official holidays in the Lao PDR.

Working drawings (Construction drawings) - Stress sheets, shop drawings, erection plans, framework plans, cofferdam plans, bar bending schedules for reinforcing steel, or any other supplementary plans or similar data, which the Contractor is required by the Contract to furnish and to submit to the Engineer.

101.03 ABBREVIATIONS

101.03.1 Institutions and Standards

(1) The following abbreviations have been used to denote various institutions and bodies, and/or the documents, standards and codes published by various institutions and bodies:

AASHTO:	American Association of State Highway and Transportation Officials
ASTM:	American Society for Testing and Materials
BS:	British Standard

101.03.2 Units of Measurement

(1) The following abbreviations have been used for units of measurement:

millimetre	mm
metre	m
kilometre	km
square millimetre	mm ²
square metre	m ²
hectare	ha
cubic metre	m ³
kilogram	kg
tonne	t
litre	l
Mega Pascal	MPa
number	no.
hour	hr
week	wk
month	mon
kilometre per hour	km/hr

101.04 QUALITY SYSTEM**101.04 .1 General**

(1) The Contractor shall plan, develop, implement, and maintain a Quality System following the principles to be found in an international Standard for Quality Systems appropriate to civil engineering construction. All aspects of the system are subject to the Engineer's approval.

(2) The Quality System shall be sufficient to enable the Contractor to manage the work so that regulatory and contractual requirements are satisfied and the quality of all activities is controlled, and to provide evidence of that quality for the Engineer's information and audit. The Engineer shall nevertheless inspect and test the Works independently as a check on the Contractor's Quality System.

(3) The Quality System shall address safety and traffic management.

(4) The Quality System documents provided by the Contractor shall be prepared in accordance with the following requirements or as otherwise reasonably modified by the Engineer.

101.04 .2 Quality Manual

(1) The Quality Manual shall include:

- Policy statement
- Overall Quality Plan, detailing system administration procedures and the responsibility of individuals, and demonstrating the full coverage of the Construction Method Statements, Inspection Test Plans, and other quality records, and the interface between them, and specifying audit scope and procedures.
- Index of standards and codes referred to in the Contract
- Index of Construction Method Statements
- Index of Inspection and Test Plans and sample forms
- Index of equipment used in construction, inspection, or testing requiring certification or calibration
- Index of other quality records and sample forms
- Index of files of detailed quality records
- Index of Non-conformance Reports and sample forms
- Record of Audits
- Record of amendments

(2) The Manual shall be submitted to the Engineer for his approval within 42 days of the Letter of Acceptance and shall be updated throughout the Contract as required. Preliminary works may be commenced before the Quality Manual is approved by seeking specific approvals for the proposed activities.

101.04.3 Standards and Codes

(1) The Contractor shall keep on site, copies of all relevant Codes of Practice, Test Methods and Standards referred to in the Specifications.

101.04.4 Construction Method Statements

(1) The Contractor shall be responsible for preparing comprehensive construction Method Statements for the manufacture, construction, or installation of all parts of the Works for the Engineer's approval.

(2) Method statements may be in A4 or A3 formats and shall be of two types:

- Technical Method Statements for technical operations (such as would be typical of operations throughout the Works)
- Section Method Statements for the coordination of activities on a particular section of the Works.

(3) Technical Method Statements shall describe the materials, type of plant, labour requirements, prerequisite conditions, details and order of activities for each technical operation, safety measures and any other relevant aspect. They shall reference associated ITP's (refer Sub-clause 101.04.5 herein). The purpose of Technical Method Statements is to aid the correct technical execution of the Works. Technical Method Statements shall be approved by the Engineer before any work relevant to the method statement is commenced.

(4) Section Method Statements shall describe the coordination of activities on sections of Works. They shall reference relevant Technical Method Statements and give further information specific to the particular section, such as a list of all activities and their interfaces; the setting out; source of materials; particular plant to be used; staff, labour, and sub-contractors (if any) to be employed; the sequencing and duration of activities; traffic management, environmental and social impact mitigation measures; access to bridges; terrain, geotechnical, and drainage features; and any special features of the section which will affect the execution of the work. The purpose of Section Method Statements is to aid the planning and integration of the Works.

(5) A section shall be a length of road, generally at least 5 km long, comprising Works which can conveniently be programmed and coordinated together. Shorter lengths may be appropriate if variable conditions or specific problems prevail.

(6) Within 21 days of the issue of the Commencement Date, the Engineer and the Contractor shall agree on the number and scope of all Technical Method Statements and shall conduct a joint inspection of the Works to agree a preliminary list of sections of works for which Section Method Statements are required. The Contractor shall then submit a final list of all method statements to the Engineer for his approval 7 days after the joint inspection. The Engineer shall approve or reject the final list within 7 days of its receipt.

(7) Any aspect of a proposed method statement which does not conform with a requirement of the Contract shall be brought to the attention of the Engineer. The method statement shall be prepared in sufficient detail to allow the Contractor's and Engineer's field staff to clearly understand the documents. Acceptance by the Engineer of method statements does not relieve the Contractor of his obligation to comply fully with the Contract.

(8) Three copies of any Technical or Section Method Statement with relevant drawings, sketches and schedules attached as necessary shall be submitted to the Engineer for approval 21 days prior to the commencement of any concerned work. The Engineer shall approve or reject any Method Statement within 14 days of its receipt. Construction on any section of the Works shall not commence until the relevant Technical and Section Method Statements have been approved by the Engineer.

(9) Once a Method Statement has been approved by the Engineer four copies shall be issued to the Engineer. The Contractor shall also be responsible for issuing copies to his supervision staff to ensure that they fully familiar with work methods to be used to complete the works in accordance with the Contract.

(10) Preliminary works within a section may be commenced after the relevant Technical Method Statement(s) have been approved but before a Section Method Statement is approved by gaining approval from the Engineer for the proposed activities.

101.04.5 Inspection and Test Plans

(1) Inspection and Test Plans (ITPs) shall be prepared for each operation to set out the inspection and tests which shall be performed, the criteria for acceptance, and the individual responsible for each inspection or test. ITPs shall note as a hold point any stage or activity which requires the Engineer's approval or presence.

(2) Proforma ITPs shall be issued in time for the Engineer's review/approval and at least 14 days before the relevant operation is first undertaken. The Engineer will respond within 7 days. Operations shall not commence until the ITP is agreed by the Engineer.

(3) The ITPs shall clearly state the times within which each activity will be completed. All test reports shall be made available to the Engineer immediately they are produced. Failure to produce satisfactory test reports within the specified time may be considered to demonstrate that the work to which the test report relates is unsatisfactory, and the Engineer may order remedial works to be undertaken forthwith.

101.04.6 Other Quality Records

(1) Other records shall be kept covering the quality of any other relevant aspects of the work, including but not limited to:

- safety plans including instructions for dealing with emergencies to personnel and in respect of construction activities (e.g. fuel spills) and in regard to natural occurrences (e.g. landslips blocking the roadway, washout of sections of road, etc.).
- certificates and calibration records for defined plant and equipment.

Construction activities shall not commence until the safety plans have been approved by the Engineer and acceptable relevant certificates and calibration records provided to the Engineer.

101.04.7 Identification and Traceability

(1) Unless otherwise specified, the Contractor shall base acceptance of work on testing of the works in lots, as defined in Clause 104.02 of the Specifications. All lots of work shall be clearly identified by a unique numbering system in accordance with Clause 104.02 of the Specifications.

(2) Traceability is required for special materials as follows:

- (i) All structural bearings. The trace shall start at the place of manufacture and finish at the location of the bearings in the Works.
- (ii) All admixtures and proprietary materials. The manufacturer's batch number shall be recorded on the relevant ITP for the incorporation of the admixture or proprietary material in the Works.

101.04.8 Detailed Quality Records

(1) Detailed quality records comprising every single completed ITP and other records shall be maintained by the Contractor and shall be filed in logical order and stored and maintained such that they are readily retrievable in facilities that provide a suitable environment to minimise deterioration or damage, and to prevent loss. They shall be retained until the end of the project when they shall be delivered to the Engineer.

(2) The Contractor shall make the conformance records available to the Engineer at all reasonable times, and provide copies within 24 hours of receipt of the test results.

101.04.9 Non-conformance

(1) The Contractor shall promptly notify the Engineer of any product and/or service non-conformances. Notification shall be submitted as Nonconformance Reports and shall indicate the proposed method of rectification. The Contractor shall prepare standard forms for use as Nonconformance Reports.

(2) No work which is the subject of a Nonconformance Report shall be covered up without having been inspected by the Engineer or his representative.

(3) The Contractor shall review and analyse the cause of detected nonconformance and develop a corrective action to prevent recurrence. Such corrective action shall be subject to the approval of the Engineer.

101.04.10 Sub-Contractors Quality Systems

(1) The Contractor shall be fully responsible for integrating all Sub-Contractor's quality systems into its own Quality System or alternatively for arranging for the Sub-Contractor to work within a quality system developed and provided by the Contractor.

(2) The Contractor shall be the single point of responsibility for the production, implementation and auditing of the quality system required under the Contract.

101.05 STANDARDS AND CODES

101.05.1 Compliance with Standards and Codes

(1) All materials and workmanship shall comply in all respects with the relevant requirements of the cited standards and codes (latest editions).

(2) In the absence of any definite provisions of the Specifications on any particular issue reference shall be made to the latest Codes of AASHTO, ASTM, BS, or other national standards in this order of precedence. Where standards are not available, the construction and completion of the Works and relevant tests shall conform to sound engineering practice and, in case of any dispute arising out of the interpretation of the above, the decision of the Engineer shall be final and binding on the Contractor.

101.05.2 Originals of Standards and Codes

(1) The Contractor shall, within 56 days of the Commencement Date, provide the Engineer with 2 originals of the latest editions of the following books, and all other in these specifications cited standards and codes:

- | | |
|---------|--|
| AASHTO: | "Standard Specifications for Transportation Materials and Methods of Sampling and Testing", Parts I and II |
| AASHTO: | "Standard Specifications for Highway Bridges" |
| ASTM: | "Annual Book of Standards", Volumes 01.04 and 04.01 to 04.09 inclusive. |

101.05.3 Equivalence of Standards and Codes

(1) Where cited standards or codes are national in character, or relate to a particular country or region, other authoritative standards or codes which ensure an equal or higher quality than those specified will be accepted, subject to the Engineer's prior review and written approval.

(2) The differences between the cited standards or codes and any other alternative standards or codes proposed by the Contractor shall be fully described in writing by the Contractor and submitted to the Engineer at least 42 days prior to the date when the Contractor desires the Engineer's approval.

(3) If, in the opinion of the Engineer, the proposed change in standard or code does not ensure equal or higher quality, the Contractor shall comply with the cited standards or codes.

101.06 MATERIALS

101.06.1 Quality Requirements

(1) Unless otherwise specified elsewhere in the Contract Documents, all manufactured materials which will become part of the Permanent Works shall be new.

(2) When the quality requirements for any materials are not stated in the Specifications, the materials shall conform with such quality requirements as the Engineer may reasonably direct.

(3) The Contractor shall make every effort to procure materials with the quality requirements stated in the Specifications, but when, because of priorities or other causes, such materials are not available, substitute materials may be used with the permission of the Engineer. No substitute materials shall be ordered or used without the prior written consent of the Engineer, who may, if he thinks it desirable or necessary, instruct an appropriate variation.

(4) The Contractor shall submit to the Engineer, at the time of placing, copies of all orders (including drawings and other pertinent information) for all materials intended for incorporation in the Permanent Works, or shall submit other documentary evidence if such orders are placed orally.

101.06.2 Handling and Storage

(1) All materials shall be handled in such manner as to preserve their quality and fitness for the Works. Aggregates shall be transported from the storage site to the job site in tight vehicles so constructed as to prevent loss or segregation of materials after loading and/or measuring. There shall be no significant difference in the quantities and qualities of materials intended for incorporation in the Works as loaded, and the quantities and qualities as actually received at the place of operations.

(2) The Contractor's is required to coordinate his transport operations with the work being performed or to be performed on other Contracts, with work of sub-contractors, utility companies and others as may be required. In the case of interference between the operations of different Contractors the Engineer shall have sole power to direct each Contractor and to determine the sequence of work necessary to expedite the completion of the works and in all cases his decision shall be accepted as final and no cause for claim.

(3) If required, the Engineer may impose weight restrictions for the protection of any existing road or structure within the vicinity of the project. The Contractor shall be responsible for any damage to roads or structures resulting from his construction operations.

(4) If, in the opinion of the Engineer, the Contractor's hauling operations are causing damage to a public road or structure, or in the event of any flooding that halts the Contractors hauling operations, the Engineer may direct the Contractor to use an alternative route, and the Contractor shall have no right of any claim for additional compensation as a result of the Engineer's instruction.

(5) Materials shall be stored in such a manner as to ensure the preservation of their quality and fitness for the Works, and so as to facilitate their inspection.

(6) Materials may only be stored within the right-of-way with the prior written consent of the Engineer, which consent shall not be unreasonably withheld. Stockpiling of aggregate material within the right-of-way shall be confined to such authorised areas as may be approved by the Engineer.

(7) Prior to stockpiling, all stockpile sites shall be cleared and levelled. All stockpile sites shall be abandoned immediately upon completion of their utilisation and the original surface shall be restored as nearly as practicable in the opinion of the Engineer to its original condition.

(8) Any material not meeting the requirements of the Specifications will be rejected and shall be removed immediately from the Contract unless defects are corrected and approved by the Engineer.

(9) Special requirements may be imposed for the handling and storage of materials in specified areas or sections of the site, particularly where the Contract traverses or is adjacent to National Biodiversity Conservation Areas or other similar protected areas. Such requirements will be itemised in the Particular Specifications.

101.06.3 Sampling and Testing

(1) The cost of all materials taken as samples, and the cost of all sampling and testing of materials, Plant and workmanship clearly intended by or provided for in the Contract shall be borne by the Contractor.

(2) All samples shall be taken by the Contractor in the presence of an authorised representative of the Engineer or as otherwise permitted by the Engineer.

(3) All tests shall be carried out by the Contractor in the presence of an authorised representative of the Engineer in a laboratory on the Site, unless otherwise specified or permitted. Three copies of all test results shall be furnished to the Engineer.

101.06.4 Imported Materials

(1) All shipments of imported materials shall be accompanied by a manufacturer's certificate of guarantee and a test report from an approved independent laboratory when delivered to the Site. The independent laboratory shall be approved by the Engineer before any materials are submitted for tests.

(2) All such materials shall be subjected to additional testing when required by the Engineer.

(3) All costs in connection with certificates of guarantee and test reports or further tests shall be borne by the Contractor.

101.06.5 Locating Natural Materials

(1) The Contractor shall be responsible for locating and producing materials meeting the Specifications, and shall bear all costs associated with locating and exploring for natural material sources.

101.07 WORKMANSHIP

(1) All workmanship shall be commensurate with good international civil engineering practice. All work performed shall be in close conformity with the lines, grades, cross sections, dimensions and tolerances shown on the Drawings or indicated in the Specifications.

(2) The Contractor shall at all times employ sufficient staff and labour to bring the Works to completion in the manner and time required by the Contract.

(3) All labourers shall have sufficient skill and experience to perform properly the work assigned to them. Skilled labourers shall have sufficient skill and experience in the operation of the equipment required for them to perform their work.

(4) If the Contractor fails to provide suitable and sufficient staff or labour, the Engineer shall be entitled to suspend the Works at his discretion.

101.08 CONTRACTOR'S EQUIPMENT

101.08.1 General

- (1) All Contractor's Equipment used on the Works shall be of sufficient size and capacity and in such mechanical condition as to meet the requirements of the Contract and to produce work of satisfactory quality in a timely manner.
- (2) All wheeled or tracked Contractor's Equipment shall be clearly marked with a service number.
- (3) Contractor's Equipment shall be used and operated in such a way that no injury to the roadway, adjacent property, or other roads will result from its use.
- (4) The Contractor shall be solely responsible for selecting the methods and equipment which will produce work in conformity with the requirements of the Contract.
- (5) The Contractor shall be free to use any methods or equipment which he demonstrates to the satisfaction of the Engineer will accomplish work in conformity with the requirements of the Contract.
- (6) If, after the use of the methods or equipment selected by the Contractor, the Engineer determines that the work produced does not meet the requirements of the Contract, the Contractor shall discontinue the use of such methods or equipment.

101.08.2 Specified Contractor's Equipment

- (1) When the Specifications require that work be performed by certain equipment, such equipment shall be used unless permitted otherwise by the Engineer.
- (2) If the Contractor desires to use equipment other than that specified, he may request the Engineer to instruct a variation. Such request shall be in writing and shall include a full description of the alternative equipment proposed and an explanation of the reasons for desiring to make the change.
- (3) The instruction to vary equipment, if given, shall in no way relieve the Contractor of any of his duties or obligations under the Contract.

101.08.3 Equipment Moving Over Earthworks or Pavement

- (1) Equipment used on sub-grade or pavement work shall be suitable in relation to the material, condition and thickness of the courses it traverses so that no damage is caused to the traversed or underlying courses.
- (2) Equipment moving over fill or embankment shall be deployed uniformly over the full width.
- (3) The wheels or tracks of equipment moving over the various pavement courses shall be kept free from deleterious materials.

101.09 SETTING-OUT

101.09.1 Further Requirements

- (1) In addition to the provisions of the Conditions of Contract, the Contractor shall establish survey bench marks along the full length of the Site to enable convenient checking of alignment and levels by staff of the Contractor and Engineer. The distance between such bench marks shall be of the order of 200 metres, with additional bench marks provided at or adjacent to all major structures (bridges, box culverts, etc.)
- (2) Checks shall be made on these bench marks once every month and adjustments, if any, shall be made as agreed with the Engineer and recorded.
- (3) Where benchmarks have been disturbed and are not longer stable, new benchmarks shall be established by the Contractor.

- (4) An up-to-date record of all benchmarks including approved adjustments, if any, shall be maintained by the Contractor and a copy supplied to the Engineer for his record.

101.09.2 Setting Out of the Works

- (1) The lines and levels of formation, side slopes, drainage systems, carriageway and shoulders shall be carefully set out and frequently checked, care being taken to ensure that correct gradients and cross sections are obtained everywhere.
- (2) In order to facilitate the setting out of the Works, the centreline of the carriageway must be accurately established by the Contractor and approved by the Engineer. It must then be accurately referenced.
- (3) The extents of the proposed earthworks and clearing and grubbing shall be established by the Contractor based on the Drawings. These extents shall be clearly marked, unless agreed otherwise by the Engineer, by fixing stout wooden pegs (at least 100 mm dia. and 500 mm long) at 30 metres intervals or closer if so necessitated by site conditions. The pegs shall be fixed at about 0.5 m beyond the actual limit of the fills and shall be painted in a distinctive colour. A schedule of reference dimensions shall be prepared and supplied by the Contractor to the Engineer. The pegs shall be maintained until the Works reach finished formation level and are accepted by the Engineer.
- (4) On reaching formation level stage of construction the centre line shall again be set out by the Contractor and when approved by the Engineer shall be accurately referenced in a manner satisfactory to the Engineer to marked pegs set at outer limits of the formation.
- (5) No reference peg or marker shall be moved or withdrawn without the approval of the Engineer and no earthworks or structural work shall commence until the centre line has been referenced and approved.
- (6) The Contractor shall be solely responsible for safeguarding all survey monuments, bench marks, reference pegs, etc. The Engineer will provide the Contractor with the data necessary for the setting out of the centreline. All dimensions and levels shown on the Drawings or mentioned in documents forming part of or issued under the Contract shall be verified by the Contractor on the Site and he shall immediately inform the Engineer of any discrepancies therein.
- (7) After completion of setting out and clearing and grubbing the Contractor shall take ground cross-sections at 25 metre intervals or such other intervals on irregular ground or in the section of sharp curvatures as are necessary to define quantities to an acceptable degree of accuracy.
- (8) The Engineer's decision on the necessary cross-section intervals shall be final.

101.09.3 Cross-Sections

- (1) The Contractor shall enter the cross-section details into the highway design program and will provide plotted cross-sections to an approved scale. Three copies of cross-sections shall be submitted to the Engineer for his approval. These cross-sections will form the basis for measurement of the earthworks. The Contractor shall programme for a period of 21 days (or as stated in the Particular Specifications) between his submission to the Engineer and the confirmation or amendment by the Engineer of the design centreline levels and details of the cross-section to be adopted and subsequent preparation of the working drawings by the Contractor.
- (2) The Contractor shall employ an adequate number of experienced and qualified surveyors to undertake the survey work in conformance with the Contractor's programme of work.
- (3) Each surveyor shall be equipped with modern survey equipment and instruments to the approval of the Engineer and shall be supported by an adequate number of competent chainmen.

101.10 PROGRAMME TO BE SUBMITTED

(1) The Programme submitted by the Contractor in accordance with the Conditions of Contract shall be in the form of a print out using Microsoft Project or equivalent approved software. Each bridge and culvert shall be shown as a separate task. Road works shall be programmed into separate tasks reflecting both the various operations and a series of sections along the road. (Refer to Sub-clause 101.04.4 paragraph (5) herein). Each task shall be fully resourced with plant and labour.

(2) The Programme shall include any sub-programme required for UXO activities in accordance with the Particular Conditions of Contract. The Contractor should obtain specialist advice and allow appropriate times for clearance by others of unexploded ordnance, including the following activities:

- Mobilisation
- Reconnaissance survey
- Multi stage survey
- Deep search survey
- Disposal

(3) Following approval of the Programme by the Engineer the Contractor shall submit an **electronic copy** to the Engineer after having established the Programme as a baseline.

(4) At the end of each month the Contractor shall submit a print out of the Programme showing the work completed in the month and the work proposed for the coming three months together with the baseline covering this period.

(5) At the end of each week the Contractor shall submit a Programme of the work he proposes to carry out in the coming week.

101.11 MEASUREMENT OF QUANTITIES

101.11.1 General

(1) All quantities measured under the Contract shall be measured by the metric system. Angles shall be measured by degrees, minutes, and seconds.

(2) The method of measurement and computations to be used in determination of quantities of material furnished and of work performed under the Contract shall be those methods generally recognised as conforming to good engineering practice.

(3) All measurements, including those for payment certificates, shall be made by the Contractor in the presence of the Engineer, unless the Engineer permits otherwise.

(4) The originals of the measurement notes, signed by the Contractor, shall be submitted to, and will be retained by, the Engineer.

(5) Quantities shall be computed by the Contractor and will be checked by the Engineer. Copies of the quantity computations shall be submitted to, and will be retained by, the Engineer.

(6) No measurements or computations will be made of any lengths, areas or volumes exceeding those shown on the Drawings or directed by the Engineer.

(7) If the Contractor fails or refuses to measure items of work and compute quantities for payment certificates, the Engineer may, at his discretion, estimate the quantities or issue no payment certificate for those items.

101.11.2 Area Computations

(1) Unless otherwise specified, longitudinal measurements for area computations shall be made horizontally, and no deductions will be made for fixtures (manholes, etc.) having an area of 1 m² or less.

- (2) Unless otherwise specified transverse measurements for area computations shall be the neat dimensions shown on the Drawings or ordered in writing by the Engineer.

101.11.3 Structures

- (1) Structures shall be measured according to the net lines shown on the Drawings or as modified by the Engineer to fit field conditions.
- (2) All structures which are measured by the linear metre shall be measured parallel to the base or foundation upon which such structures are placed, unless otherwise shown on the Drawings.
- (3) When a complete structure or structural unit (in effect, "lump sum" work) is specified as the unit of measurement, the unit shall be construed to include all necessary fittings and accessories for a completely functional unit whether or not such fittings and accessories are explicitly shown on the Drawings or detailed elsewhere in the Contract Documents.

101.11.4 Earthwork Computations

- (1) Measurements for the various classes of excavation shall be limited to the lines shown on the Drawings, and will be indicated on approved cross sections.
- (2) To calculate volumes of earthwork, the average end area method or other acceptable methods defined by the Engineer shall be used.
- (3) Within 56 days of the date of completion of any section of setting-out work, the Contractor shall submit to the Engineer print outs of the original and the theoretical final earthwork cross sections, together with the area and volumetric earthwork computations from the measurement software provided under the Contract.
- (4) In the event of any variations from the Drawings, the Contractor shall give the Engineer one copy of his setting-out notes and computations. The Contractor shall take cross sections at the intervals shown on the Drawings, and at other locations as may be directed by the Engineer. At the Contractor's option he may also take cross sections intermediate to these locations. The Engineer will indicate the proposed lines of the work or his revision thereof and return it to the Contractor. The Contractor shall re-submit for approval any cross sections the Engineer may revise.

101.11.5 Bituminous Materials

- (1) Bituminous materials shall be included in the items for surface treatment and measurement will be by the litre. Volumes will be measured at 15°C or will be corrected to 15°C using ASTM D 1250 for asphalts.

101.11.6 Standard Manufactured Items

- (1) When standard manufactured items are specified such as fence, wire, plates, rolled shapes, pipes, etc., and these items are identified by gauge, unit weight, section dimensions, etc., such identification shall be considered to be nominal weights or dimensions for measurement purpose.
- (2) Unless more stringently controlled by tolerances in cited standards and codes, manufacturing tolerances established by the industries involved will be accepted.

101.12 SCOPE OF PAY ITEMS

101.12.1 General

- (1) The Contractor shall receive and accept the compensation provided for by the Contract as full payment for furnishing all labour (including the supervision thereof), materials, Contractor's Equipment and all other things manifestly and contingently necessary, whether of a temporary or permanent nature, for the execution of, and remedying of defects in, the Works.

(2) The unit rate or price quoted for any item in the Bill of Quantities shall be considered full compensation for all work essential to that item. The term “lump sum”, when used as an unit of payment, shall mean full compensation for the work described in the Contract.

(3) No work shall be included, or measured and paid for, under more than one item.

(4) When the accepted quantities of work vary from the Bill of Quantities, no allowance will be made, except as provided in the Conditions of Contract, for any increased cost, loss of expected reimbursement, or loss of anticipated profits suffered or claimed by the Contractor resulting either directly from such alterations or indirectly from unbalanced allocation among the items in the Bill of Quantities of overhead costs and profit and subsequent loss of expected reimbursements therefor or from any other cause.

101.13 GUARANTEES AND INSURANCES

101.13.1 General

(1) This Section relates to the provisions of the Conditions of Contract (including Particular Conditions of Contract) stipulating which guarantees and insurances for the execution of the Works shall be provided by the Contractor, as required by the Employer.

101.13.2 Performance Bond/Guarantees

(1) The provision of Performance Security shall be regulated by the Conditions of Contract (including Particular Conditions of Contract) of the Contract Documents.

101.13.3 Insurance of the Works

(1) The provision of Insurance of Works shall be regulated by the Conditions of Contract (including Particular Conditions of Contract) of the Contract Documents..

101.13.4 Insurance of Contractor's Equipment

(1) The provision of Insurance of Contractor's Equipment shall be regulated by the Conditions of Contract (including Particular Conditions of Contract) of the Contract Documents..

101.13.5 Third Party Insurance

(1) The provision of Third Party Insurance shall be regulated by the Conditions of Contract (including Particular Conditions of Contract) of the Contract Documents..

101.14 MEASUREMENT

(1) Measurements will be as follow:

Item No.	Description	Unit
101-1	Performance Security	Lump Sum
101-2	Bank Guarantee for Advance Payment	Lump Sum
101-3	Insurance of the Works	Lump Sum
101-4	Insurance of Contractor's Equipment	Lump Sum
101-5	Third Party Insurance	Lump Sum

101.15 PAYMENT

- (1) Payment will be made at the rates entered in the Bill of Quantities.
- (2) For Items 101-1 through 101-5, payment will be made upon the Contractor producing evidence that he has fulfilled the relevant contractual obligations.
- (3) Other than stated specifically elsewhere in the Specifications, no other payment will be made
Other than stated specifically elsewhere in the Specifications, and no other payment will be made to the Contractor for fulfilling his contractual obligations, be they stated or implied.

SECTION 102

GENERAL OBLIGATIONS

102.01 EXISTING FACILITIES

102.01.1 Maintenance of Existing Roads

(1) The Contractor shall maintain the existing roads within the Contract limits open to traffic and in an acceptable condition for the season of the year, from the time he commences the Works. All routine repair work and emergency repair work shall promptly be carried out by the Contractor. In the rainy season this shall include towing of traffic at soft stretches of road as required and as directed by the Engineer.

102.01.2 Maintenance of Existing Bridges and Culverts

(1) The Contractor shall maintain all existing bridges and culverts open to traffic and in a safe condition from the time he commences the Works. Immediately on commencing the Works the Contractor shall carry out refurbishment of any bridge which, in the opinion of the Engineer, is still capable of safely carrying traffic. Refurbishment shall comprise only replacement of missing or damaged deck planks, provision of missing bolts/nuts/washers, the smoothing of approaches to minimise impact loading on the bridges, speed restriction and load capacity restriction signs (data for both to be provided by the Engineer) and minor repairs as directed by the Engineer. All the above shall be at the expense of the Contractor.

(2) Where the Engineer considers that (more extensive) rehabilitation works are required he shall direct what works are required and the Contractor shall promptly undertake the same, with rates to be agreed in accordance with the Contract.

(3) All routine repair work, emergency repair work and strengthening necessary for any reason whatsoever to existing, refurbished or rehabilitated bridges shall promptly be carried out by the Contractor at his own cost.

(4) At bridges and culverts which are to be replaced by facilities on the same alignment, unless otherwise agreed with the Engineer the Contractor shall construct and open a temporary safe, all-weather diversion bridge or culvert of adequate load capacity, to the satisfaction of the Engineer, before the existing facility is closed. The temporary facility shall be adequately maintained by the Contractor until the new facility is open to traffic.

(5) At bridges/culverts which are to be replaced by new bridges/culverts on a new alignment, the existing bridges/culverts shall not be removed until the new facilities have been opened to traffic. Until superseded they shall be properly maintained and adequately strengthened as directed by the Engineer.

102.01.3 Existing Services and Appurtenances

(1) The Contractor shall satisfy himself as to the exact position of all utility services and structures affected by, or affecting, the Works, and shall take all appropriate measures for the support and protection of such services and structures during the execution of the Works. The Contractor shall notify the Engineer 56 days in advance of the programmed start of work in an area where existing services interfere with the Works.

(2) The position of all services so located shall be marked on site and drawn on the plans. The Contractor shall take all appropriate measures for the support and protection of such services during the execution of the Works.

(3) Any damage done to the services shall be promptly repaired, in consultation with the authorities concerned and the Engineer, by the Contractor or by the authorities, as the need be, at the cost of the Contractor. If an essential public utility service is interrupted, repair work shall be continuous until the service is restored.

(4) In the event that the Contractor discovers a previously undisclosed service during the course of construction operations he shall take immediate steps to protect the installation and shall inform the Engineer of the discovery. The Engineer shall either arrange for the appropriate authorities to relocate or otherwise reinstate the service or shall instruct the Contractor to carry out the work.

(5) If found to be necessary or desirable, the Employer will arrange the removal, relocation, or diversion of utility services within the right-of-way in timely correspondence with the Contractor's work programme.

(6) Wherever utility services which must be diverted can be permanently diverted without temporary diversion at an interim stage of the Works, the Contractor shall programme his work accordingly. Should the Contractor prefer a temporary diversion to facilitate his programme, he shall bear all costs in respect of such temporary diversion.

(7) Where the Works cannot be executed without temporary diversions of utility services, such temporary diversions will be arranged by the Employer at no cost to the Contractor.

(8) No excavation in the vicinity of utility services shall be commenced until the authority concerned has been notified by the Contractor, and their representative has been requested to be present during the digging of trial pits or trenches. The Contractor shall submit copies of such notifications and requests to the Engineer.

(9) If found to be necessary or desirable, buildings (including their foundations) within the limits of construction will be demolished or relocated by the Employer in timely correspondence with the Contractor's work programme.

102.02 COMMENCEMENT OF TEMPORARY WORKS

102.02.1 Engineer's Consent

(1) The Contractor shall not start the construction of any Temporary Works of any kind on the Site without the prior written consent of the Engineer, which consent shall be promptly given and shall not unreasonably be withheld.

(2) The Contractor shall provide the Engineer with such details and drawings (whether prescribed in the Specifications or not) as the Engineer may reasonably require to give such consent.

102.02.2 Engineer's Approval

(1) For those parts of the Temporary Works for which it is stipulated in the Contract that the Contractor must obtain the Engineer's prior approval of his proposals, such approval shall be sought at least 42 days before the date on which the Contractor wishes to start the work.

(2) The Engineer's approval, when given, shall be deemed to be consent to commence construction of the corresponding parts of the Temporary Works.

102.02.3 Local Authorities and Others

(1) The Contractor shall obtain all necessary consents or approvals from local authorities and other concerned persons or parties before commencing any Temporary Works. The Employer will assist the Contractor in obtaining the same. The Contractor shall supply the Engineer with copies of all consents and approvals.

(2) The Engineer's consent for the Contractor to commence any Temporary Works shall at all times be subject to the Contractor obtaining or having obtained all necessary consent or approvals from local authorities and other concerned persons or parties.

(3) The GOL shall make available free of charge to the Contractor all land on which work is planned as detailed in the Contract. Such land shall include the road reserve, road deviations (If the diversion road is outside the road corridor), but shall exclude any land required by the Contractor for his own camps, offices, houses, other temporary works or any other purpose. The Contractor shall be responsible for the payment of royalties and compensation for borrow pits, access roads to borrow pits, for crops, structures and any other costs in respect of land temporarily acquired, including the Contractor's spoil areas outside of the road reserve and work areas outside of the road reserve for camps, offices, temporary works, detour roads, etc. The Contractor should allow in his rates for making such compensation payments for land temporarily acquired as no separate payment will be made.

102.03 MAINTENANCE OF TRAFFIC

102.03.1 General

(1) Throughout the construction of the Works the Contractor shall maintain traffic at all times without undue disruption, over the entire road length covered under the Contract.

(2) The Contractor shall submit to the Engineer, before he commences the Works, a detailed proposal of sequence and method of construction, provision for traffic maintenance, traffic control measures, construction and maintenance of detours and temporary diversions, etc., both for the general public and for his own construction traffic covering the whole of the Contract Period. The Contractor shall be deemed to have satisfied himself as to the nature and location of Works, general and local conditions pertaining to high water levels, volume of current traffic, flow patterns and all other factors which could influence his proposals.

(3) The Contractor shall be permitted to proceed with the actual works only after issuance of approval by the Engineer to his maintenance of traffic proposals.

(4) Diversion/detours roads shall be constructed in advance of any interference with the existing roads and shall be maintained to provide adequately for the traffic flows. Before opening any diversion/detour road to traffic, the Contractor shall obtain the approval of the Engineer that the temporary diversion/detour meets the requirements of the Contract.

(5) In villages and especially near schools where space allows, where it is possible and it is instructed by the Engineer, a graded corridor within the Right-of-Way along the road side-drain suitable for the movement of pedestrians, cyclists, motorcyclists Tok-Toks (hand-tractors) shall be prepared. Provision for this work is included in the Payment for the Maintenance of Traffic.

(6) The Contractor shall at all times adhere strictly to the provisions of the Conditions of Contract regarding the passing of traffic.

(7) Maintenance of Traffic shall be deemed to be a part of the construction activities of the relevant items of the works, and no separate payment will be made.

102.03.2 Maintenance of Traffic Arrangements

(1) The choice of arrangements of traffic maintenance during construction shall be appropriate for the improvement measures specified and the volumes of traffic involved. The length of road for which construction works are to be taken up shall be selected carefully considering probable traffic patterns on the approach and departure ends of detours/diversion. Depending on his capability to handle the volume of work, the Contractor may take up construction works simultaneously over several stretches within the total length of road under the Contract, subject to the approval of the Engineer. Such stretches shall be spaced apart to minimise congestion and disruption to traffic flows.

(2) Considering the duration of work, intensity of traffic, improvement measures specified for a particular stretch and the availability of space, any of the types of traffic maintenance facilities given in Sub-clauses 102.03.3 and 102.03.4 shall be applicable.

102.03.3 Diversions

- (1) Three types of diversions may be implemented:

Type A: Passage of traffic along a part of the existing road under improvement.

Type B: Passage of traffic through a newly constructed temporary diversion.

Type C: Passage of traffic along the existing road along stretches to be replaced by a realignment.

(2) **Type 'A' Diversion**

When the magnitude of the lateral shift from the centreline of the existing road to the centreline of the new alignment is not significant, the Type A Diversion shall in general be adopted provided that adequate width is available. The Contractor shall repair the potholes and ruts and other defects etc., completely re-grade the existing surface, where necessary using a regulating layer of gravel, and shall compact the road by vibratory roller. A minimum width of 3.5 m shall be provided. Necessary barricades and traffic signs, to the approval of Engineer, shall be installed on both sides of the diversion for the guidance of road users, day and night. Since the traffic is to deviate from its normal course, proper channelisation of traffic at entry and exit to the diversion shall be provided, clearly marked with the aid of painted cones or similar suitable devices as may be approved by the Engineer.

Adequate numbers of flagmen shall be provided at each end to guide traffic onto the diversion. In order to minimise the risk of traffic accidents during the night, warning lights shall be provided along the barricades at a maximum distance 50 metre centres for the entire length of the diversion.

(3) **Type 'B' Diversion**

Type 'B' Diversion shall be applicable mainly in cases of reconstruction or rehabilitation of cross-drainage structures and the construction of new bridges. A Type 'B' Diversion comprises localised new construction of a temporary diversion road constructed with suitable locally available materials to the approval of Engineer. The required width of the carriageway for diversion shall be 3.5 m having a camber of 4%. The embankment shall be constructed with locally available approved material with side slope 1:2. The embankment shall be prepared by compacting the earth fill in layers not exceeding 200 mm and the surface of the pavement shall be made of 75 mm thick crushed rock or gravel material, well compacted. Necessary provisions shall be made for bridging the gap of any waterway by means of an adequate number of pipe culverts, a Bailey bridge or other suitable device to ensure safe and uninterrupted movement of traffic. The pipe culverts, Bailey bridges etc., as used for Type 'B' diversions shall remain the property of the Contractor. This type of diversion is intended for short term (approximately 6 months maximum) use only.

(4) **Type 'C' Diversion**

When the proposed routing deviates from the existing alignment mainly due to lateral shifting at a bridge location or similar, thus forming a completely new alignment a Type 'C' Diversion shall be applicable. The existing stretch of road shall be utilised for traffic and shall be maintained by way of repairing potholes, ruts and corrugation etc., and if necessary by application of compacted regulating layer of gravel/lateritic materials to the satisfaction of Engineer.

The provisions as described in preceding paragraphs are merely indicative and shall be considered only as a guide to the Contractor to undertake the work. Construction and maintenance of Type A, B and C diversions shall be deemed to be a part of construction activities of the relevant items of permanent work, and no separate payment will be made.

102.03.4 Detour Roads

- (1) These roads are to be utilised, as directed or approved by the Engineer, to provide for the maintenance of traffic along completely new alignments whilst the existing alignment is upgraded. They are intended for long term use (6 months or more) and shall be designed by the Contractor on an alignment, as approved by the Engineer, to minimise environmental intrusion and disruption to existing vegetation. They will be constructed to the same standards as permanent work and shall be surfaced with 200 mm of sub-base material unless otherwise specified or directed by the Engineer.
- (2) Adequate facilities for cross-drainage shall be incorporated into the design.
- (3) The width of the detour shall be as given in the Particular Specifications.
- (4) Detour roads shall only be utilised if so detailed in the Contract Documents or if so directed by the Engineer.
- (5) The provisions as described in preceding paragraphs are merely indicative and shall be considered only as a guide to the Contractor to undertake the work. Construction and maintenance of detour roads shall be deemed to be a part of constructional activities of the relevant items of permanent work, and no separate payment will be made.

102.03.5 Temporary Access Roads

- (1) The Contractor shall design, construct and maintain all for his own use temporary access roads to, in and around the Site and designated quarrying or disposal areas as are required for the performance of the Works.
- (2) If the Contractor uses any existing roads for temporary access and/or his constructional traffic, he shall maintain the said roads to the satisfaction of the Engineer and restore them to at least their original condition upon completion of the Works.
- (3) If the Contractor choose to improve the said roads (which improvement shall be at his own cost), on completion of their use he shall:
 - a) leave them in their improved condition, or
 - b) restore them to their original condition, or
 - c) amend them to such intermediate condition as directed by the Engineer.

102.03.6 Maintenance of Diversions/Detours

- (1) All diversions/detours shall be maintained by the Contractor in safe and trafficable condition throughout their period of use. The maintenance shall include periodic re-grading, cutting, removing and replacing any deteriorated section, repairing pot holes, cracks, wash-outs, depressions and pavement defects by approved materials all to the satisfaction of the Engineer.
- (2) Temporary pavements shall be kept free of dust by frequent application of water, as necessary.
- (3) Contractor shall keep a constant watch on water levels for the stretches where temporary diversions/detours are constructed and if required shall raise the level of the diversion/detour in order to maintain a minimum free board of 30 cm at all times.
- (4) The Contractor shall take adequate measures to keep the diversion roads free of any inconvenience to traffic and to protect the roads against erosion and inundation by sudden rise of water level.

102.03.7 Removal of Diversions/Detours

- (1) Unless otherwise directed by the Engineer, whenever diversions/detours are no longer required the Contractor shall remove the material forming them and as far as is practical re-instate the land to its original condition and to the approval of the Engineer.

(2) Where economically feasible, all materials used in construction of diversion/detours for traffic maintenance shall be re-utilised in diversions/detours for other stretches of the Works.

102.03.8 Access to Property and Intersecting Roads

(1) The Contractor shall not close or obstruct any road, nor break any fencing, nor obstruct any drain, water courses or irrigation facility. If any such blockage should occur the Contractor shall immediately remove the same and he shall repair all breakages.

(2) The Contractor shall undertake the construction works in such a way as to cause the minimum inconvenience to the abutting property owners/areas. All accesses to private entrances and buildings within and adjacent to the limit of the Works shall be maintained and kept in a safe and trafficable condition at all times.

(3) For compensation for temporary impacts (diversion roads, temporary construction, etc), the contractor is required to provide compensation at replacement costs or otherwise to pay rent not less than the damages incurred as well as to restore affected land to pre-existing conditions within one month of completing use of affected land as indicated in the Relocation Plan (RP).

102.03.9 Signs and Barriers

(1) Suitable regulatory and warning signs, barriers, barricades, etc., as approved by the Engineer, shall be installed for the guidance of road users. Signs shall be of reflective type. Necessary warning lights shall be mounted on the barriers/barricades at night and kept lit from sunset to sunrise. On each approach at least two signs shall be erected, one close to the point where the diversion of the carriageway begins and the other approximately 100 metres in advance. In addition, signs showing restricted speed limit shall be located at appropriate places.

(2) The materials and design of barriers shall be of approved type. Timber or steel tube or concrete may be used in construction of the barriers. Dimensions and colour of all installations shall require the approval of the Engineer. Where work is in progress a line of barriers shall be provided between the work area and the carriageway open to traffic.

102.03.10 Plant and Equipment

(1) At night, all plant, equipment or similar obstructions shall be removed as far from the roadway to be used by traffic as is practical. All plant and equipment near to the pavement shall be lit at night by two amber lamps suspended vertically from the point of nearest to a traffic lane and one amber lamp at each end of the obstruction.

102.03.11 Maintenance of Traffic Control Devices

(1) The Contractor shall maintain all traffic control devices in good order at all times and in correct position throughout day and night. They shall be clearly visible and legible at all times. Beyond working hours the Contractor shall keep one duty officer and a gang of labour with transport ready at all times for repairs, replacement of traffic control devices etc. as required to ensure the safety of the travelling public. The Contractor shall provide only experienced and skilled personnel in traffic control actions.

102.04 TEMPORARY UTILITIES

102.04.1 Electric Power

(1) The Contractor shall at his own cost make his own arrangements for the supply and distribution of all power required for the Works.

(2) The Contractor's electrical installations shall comply with normal practice and accepted standards in the region as determined/approved by the Engineer.

(3) The Contractor shall submit complete details and drawings of his proposed generation and distribution system for approval by the Engineer.

(4) On completion of the Works the Contractor shall remove all generation and distribution systems installed by him, except those supplying buildings which are to become the property of the Employer, unless agreed otherwise with the Engineer.

102.04.2 Telecommunications

(1) The Contractor shall make his own arrangements with the appropriate authorities and bear the cost of any telecommunication services he requires.

(2) The Contractor may use hand-held two-way radios between points on the Site. The Contractor shall obtain the approval of the appropriate authorities as to the power, frequency and other characteristics of such radios.

(3) If the works location has stable signal for mobile phone communication this shall be a sufficient arrangement for telecommunications, provided this is approved by the Engineer.

102.04.3 Water Supply

(1) The Contractor shall at his own cost make his own arrangements for the supply and distribution of all water required for construction and domestic purposes during the performance of the Works.

(2) Water for domestic use shall meet the requirements of the World Health Organisation for potable water, and the pH value shall lie in the range 7.5 to 8.5.

(3) The Contractor shall submit complete details and drawings of his proposed distribution system for approval by the Engineer.

(4) On completion of the Works the Contractor shall remove all water distribution systems installed by him, except those supplying buildings which are to become the property of the Employer, unless agreed otherwise with the Engineer.

102.04.4 Sewage Disposal

(1) The Contractor shall construct, operate and maintain until completion of the Works septic tank systems or other approved systems for the collection and disposal of sewage from all houses, offices, camps and other buildings constructed by him, and from the Engineer's mobile facilities.

(2) The location, capacity and design of the systems shall be subject to the Engineer's approval.

(3) The Contractor shall provide temporary facilities for the collection of sewage at each area where his personnel are working.

(4) On completion of the Works the Contractor shall remove all sewage systems installed by him, except those servicing buildings which are to become the property of the Employer, unless agreed otherwise with the Engineer.

102.04.5 Refuse Disposal

(1) The Contractor shall collect and dispose of all garbage from houses, offices, camps and other buildings occupied by him and the Engineer and from each area where his or the Engineer's employees are working, until completion of the Contract. The refuse disposal shall be done in an environmentally friendly manner, following the environmental- and other related legislation of Lao PDR.

102.04.6 First-Aid Facilities

(1) The Contractor shall engage and employ on the Site during the execution of the Works one competent and qualified first-aid attendant with at least 5 years experience in first-aid and hygiene. Such attendant shall be subject to the approval of the Engineer.

(2) The Contractor shall provide the first-aid attendant with a stock of medicines and medical equipment of a scope, quantity and standard deemed adequate by the appropriate medical authorities, and shall keep such stock and equipment replenished and in good order.

(3) The Contractor shall provide and maintain an adequate number of well-stocked first-aid kits at suitable locations on the Site, in the Engineer's vehicles, and in the vehicles of his own supervisory staff.

(4) The Contractor shall obtain and follow the advice of the appropriate medical authorities on all such matters as water supply, sanitation, refuse and sewage disposal and industrial health and hygiene.

102.04.7 Fire Protection

(1) The Contractor shall take all appropriate measures for the prevention of, and protection against, fire on the Site during the performance of the Works.

(2) The Contractor shall provide and maintain an adequate number of hand fire-extinguishers at suitable locations on the Site, in the Engineer's vehicles, and in the vehicles of his own supervisory staff (the fire-extinguishers for the vehicles shall be heat proof).

102.05 SAFETY PRECAUTIONS

102.05.1 General

(1) The Contractor shall comply with all applicable laws and codes governing safety, health and sanitation, and shall provide all safeguards, safety devices and protective equipment (helmets, safety boots, gloves, safety jackets, hearing protection, protective glasses, etc.) and take any other action reasonably necessary, in the opinion of the Engineer, to protect the life and health of his employees and the safety of the public.

(2) The Contractor shall motivate his employees to undergo "Voluntary Testing and Counselling (VTC)" with a recognised health facility prior to their arrival on Site to check for HIV/AIDS, sexually transmitted diseases and malaria. If tested positive, the VTC facility will inform employees about all aspects of the diseases including spread and treatment. The Contractor's first aid attendant will follow up and provide assistance and advice on a regular basis.

(3) The Contractor shall draw up a safety plan covering the action to be taken on the discovery of unexploded ordnance and shall ensure that all of his employees and those of any sub-contractors are aware of what action they must take in such circumstances. This shall be subject to constant review and amendment in the light of discoveries made and experience gained. The Engineer shall be consulted at all stages.

102.05.2 Accident Prevention Officer

(1) The Contractor shall have constantly on the Site, during the execution of the Works, an approved Accident Prevention (Safety) Officer who shall be qualified in safety, and be familiar with the type of work being performed. The duties of this Officer shall include initiation of measures for the protection of health and the prevention of accidents and who shall see, by personal inspection, that all safety rules and regulations are enforced.

102.05.3 Warning Signs

(1) The Contractor shall provide, erect and maintain all appropriate signs necessary about the Works for the safety and convenience of the public, his employees and the employees of any sub-contractors.

(2) These shall include, but not be limited to, warning and danger signs at temporary diversions and bridges, speed restriction signs, safety and control signs and directional and standard road signs.

(3) The wording on all signs shall be in Lao and English and any other language in common use by the Contractor's employees. The signs shall also show graphic warning symbols, using international symbols so far as practicable.

(4) The size, colour, lettering and location of all signs and the method used to make them visible at night shall be according to MPWT manuals and to the satisfaction of the Engineer. Locations of all signs shall be indicated in standard drawings agreed with the Engineer.

102.05.4 Accident Reports

(1) The Contractor shall promptly report to the Engineer all accidents involving death or serious injury to staff or workmen, and shall furnish monthly reports of all accidents to staff or workmen involving loss of time, giving such detailed information as the Engineer may require.

102.05.5 Explosives

(1) All explosives and detonators shall be manufactured by an approved source within Lao PDR.

(2) The location and design of powder magazines, methods of transporting explosives, use of explosives and, in general, the precautions taken to prevent accidents shall be in accordance with all statutory regulations of the Lao PDR and the Contractor shall take such other additional precautions as the Engineer may direct to ensure conformity with normal international practice.

(3) All powder magazines, vehicles transporting explosives, and packing materials containing explosives shall be clearly marked "Danger! Explosives!" in Lao and English. Powder magazines shall be located at least 300 m from any road, building or camping area. In no case shall the Contractor store explosives at locations or in magazines which have not been approved by the Engineer.

(4) When carrying out blasting operations, the Contractor shall use the standard blasting warning code (for which prior approval shall have been obtained from the Engineer), take all precautions for the protection of persons, the Works and all property, and shall be solely responsible for any injury caused to, or the death of, any person, and for any damage done to the Works or to property by blasting.

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

102.06 ENVIRONMENTAL AND SOCIAL CONTROL

102.06.1 General

(1) The Contractor shall take all reasonable measures required by the Engineer to prevent harm to, and to minimise the impact of his operations on, the environment and socio-economic conditions along the road, and shall ensure that his employees do likewise.

(2) The Contractor shall ensure that the contact between his employees and the local population is kept at a minimum.

(3) The Contractor shall make his employees aware that the hunting, trapping or dealing in wildlife will not be tolerated and shall take all possible steps to ensure that his employees and those of his sub-contractors do not engage in these activities. Any employee found to be engaged in these activities will be instantly dismissed from the Contract. Possession of firearms or animal traps shall be prohibited and shall be regarded as proof that the employee is engaged in these illegal activities.

102.06.2 Dust Control

- (1) The Contractor shall take all reasonable measures , including watering, if necessary in the opinion of the Engineer, to minimise dust nuisance resulting from his operations, including the use by the public of temporary diversions. In addition control of dust on the existing road within the bounds of the Site, where the Contractor has not yet started construction of the Works, shall be undertaken.
- (2) The Contractor shall use tarpaulins, covers and the like on his haulage vehicles to minimise dust nuisance and to protect materials being hauled from contamination.
- (3) Stockpiles of fine material likely to cause dust nuisance shall be covered or watered as appropriate.

102.06.3 Water Control

- (1) The Contractor shall design, construct and maintain levees, diversion channels, flumes, conduits, drains and all other protective works which are necessary to prevent surface and sub-soil water (possibly being contaminated) from entering the various parts of the Works.
- (2) All diverted and pumped water shall be discharged at locations on the surface from which it cannot re-enter the Works and in a manner which does not cause erosion, pollution or nuisance to landowners, other contractors engaged by the Employer, or other persons within or adjacent to the Site.
- (3) The Contractor shall take all measures necessary to prevent the discharge into rivers, streams or existing irrigation or drainage systems of any water containing pollutants or visible suspended matter. Pre-treatment of high volumes of wastewater shall be applied before release.
- (4) The Contractor shall not interfere with the natural flow of rivers, streams, or existing irrigation or drainage systems for any purpose without the prior consent of the Engineer.
- (5) During the construction of the drainage works, the Contractor shall provide adjacent landowners with temporary channels for irrigation and drainage purposes.

102.06.4 Erosion Control

- (1) The Contractor shall take all precautions to prevent the erosion of soil from any lands used or occupied by him, and from the bed or banks or any river, stream, irrigation or drainage system.
- (2) The Contractor shall take all precautions to prevent the deposition of excavated or eroded material that may result from execution of the Works in any river, stream, irrigation or drainage system.

102.06.5 Weed Control

- (1) All plant and equipment being imported into the Contract location shall be certified steam cleaned and sprayed with a weed killer that will sterilise any weed seeds. Copies of the certificates shall be submitted to the Engineer. In particular, care shall be taken to avoid the importation into the Site of borrow or other materials (particularly river sand) impregnated with the seeds of mimosa pigra or mimosa invisa which are noxious weeds known to exist in areas of Lao, especially along the banks of the Mekong and some of its tributaries.
- (2) The Contractor shall provide certification by a recognised authority acceptable to the Engineer that all sources of soil and sand used in the Works are free from such seeds.

102.07 CONTRACT SIGNBOARDS

- (1) The Contractor shall, within 90 days of the Commencement Date, provide and erect 2 metal Contract signboards, bearing legends in Lao and English and logos, all as directed by the Engineer.

(2) The dimensions of the signboards shall be 4m x 3m minimum, and they shall be erected at such positions on the Site as directed by the Engineer. The Contractor shall keep the signboards in good condition, at his own cost, throughout Contract period.

(3) At the end of the Defects Liability Period, the Contractor shall remove the signboards from the Site and dispose thereof.

102.08 AS-BUILT DRAWINGS

(1) Subject always to the provisions of the Conditions of Contract, the Contractor shall, from time to time during the progress of the Works as the various parts of the Works are substantially completed, prepare computer generated drawings and tables showing the levels, lines, positions and dimensions of the Works as finally constructed. Cross-sections shall use the software measurement package supplied to the Engineer by the Contractor.

(2) The drawings and tables shall include plans, profiles and cross sections, and all structural work including masonry and erosion protection (but not other incidentals).

(3) Print outs of the drawings and tables shall be submitted to the Engineer from time to time for approval, and following approval the Contractor shall submit one hard copy on approved stable reproducible film at A1 size and two copies on compact disc thereof, to become the property of the Employer. The hard copy shall have original signatures of the Contractor and the Engineer on every sheet.

(4) The Contractor shall be entitled to receive free-of-charge from the Employer copies on disc of the computer generated original drawings and tables describing the Works as designed, for amendment as appropriate to as -built drawings.

(3) Furnishing 'As Built Drawings' as specified here shall be deemed to be a part of construction activities of the relevant items of permanent works, and no separate payment will be made.

102.09 PROGRESS PHOTOGRAPHS

(1) The Contractor shall during each month take at least 30 colour photographs of all significant stages/facets of Works as directed/approved by the Engineer. He shall supply at the end of each month one set of prints of the photographs taken, and the Engineer will select upto 20 photographs to form a record of the progress during the month. The Contractor shall then supply two standard postcard size colour prints of each of the photographs selected by the Engineer. The Contractor shall also supply the digital data of all photographs taken will good resolution. This data and the prints will serve as a permanent record of documentation for the Works.

(2) The Contractor shall mount each set of photographs in an approved album of good quality.

(3) Furnishing progress photographs as specified here shall be deemed to be a part of construction activities of the relevant items of the works, and no separate payment will be made.

102.10 FINAL CLEAN UP

(1) Upon completion of the Work and before acceptance and final payment will be made the, Contractor shall clean the roadway and adjacent property defaced or occupied by him in connection with the Work of all rubbish, weeds, brush, excess materials, falsework, temporary structures and equipment. All parts of all types of the Work shall be left in a neat and presentable condition and as approved by the Engineer.

(2) The above requirement shall apply to all campsites, quarries and workshops, whether temporary or permanent and all temporary buildings and the foundations of the same shall be removed and the ground reinstated to an acceptable condition.

(3) Borrow pits shall be reinstated in accordance with the requirements of sub-clause 107.04 of these Specifications.

102.11 MEASUREMENT

(1) Measurement will be as follows:

Item No.	Description	Unit
102-1	Maintenance of Roads, Bridges and Culverts	Month
102-2	Contract Sign Board	Number

(2) Measurement for the Maintenance of Roads, Bridges and Culverts item will be from the Commencement Date until the date that the Taking Over Certificate is issued.

(3) All other requirements and obligations under this Section 102 for maintenance of traffic, Diversions Types A, B and C, Detours, temporary access roads, maintaining access to properties, signs and barriers, barricades etc. traffic control devices, final clean up etc., will not be measured but will be considered as incidental to the other Items of the Bill of Quantities.

102.11 PAYMENT

(1) Payment will be made at the rates entered in the Bill of Quantities.

(2) Payment for the Maintenance of Roads, Bridges and Culverts item will include the maintenance of all existing roads, bridges and culverts, the refurbishment of existing bridges capable of safely carrying traffic and minor repairs thereto and subsequent routine and emergency repair work and strengthening.

(3) Where the Contractor does not, in the opinion of the Engineer, fulfil his obligations for maintenance of traffic, the Engineer may deduct from the pay items in this Section such amounts he considers appropriate until such time that, in the opinion of the Engineer, the Contractor fulfils his obligations.

(4) Payment for the Contract Sign Board item will include the provision and erection of the boards, maintenance in good condition throughout the Contract period and subsequent removal and disposal.

SECTION 103

CONTRACTOR'S ESTABLISHMENTS

103.01 GENERAL

- (1) The Contractor shall establish and maintain a main camp and an adequate number of field camps accommodating all offices, housing, workshops, yards, stores and stockpiles as may be necessary for the efficient performance and quality control of the Works.
- (2) The Contractor shall be responsible for the location of the main camp unless designated locations/limits are shown on the Drawings or stated elsewhere in the Contract, subject always to the Conditions of Contract.
- (3) The general layout of the establishments shall be subject to the prior approval of the Engineer, as shall the Contractor's arrangements for guarding and fencing.
- (4) The establishments shall be kept in a tidy condition with the operation and maintenance procedures subject to the approval of the Engineer.
- (5) The specifications as described in this Section are only suggestive and shall be considered only as a guide to the Contractor's Establishments. Specifications for individual contracts are provided in the Particular Specifications of the respective Contract.

103.02 OFFICES AND HOUSING

- (1) The Contractor shall construct a suitable office and housing for his employees in his main camp.
- (2) The Contractor shall arrange such field offices and housing for his own use as are appropriate for the performance of the Works.
- (3) At the option of the Contractor, the buildings may be of a temporary or permanent nature. Permanent buildings shall comply with the requirements of Section 106 of the Specifications. The construction materials and standards for temporary buildings shall be subject to the approval of the Engineer.
- (4) Housing for labour shall in general be of a standard commensurate with normal practice in the Lao PDR, and with any applicable Lao regulations.
- (5) Housing for labour shall be divided into compounds of not more than 150 persons each. Each compound shall have a building containing stores, kitchen, and a dining and lounge area. Housing may be of bamboo on poles with galvanised corrugated steel sheeting as roofing, and with 2 persons per room of 10 m². One ablution block comprising 5 toilets, 5 urinals, 5 showers, 10 washstands and a laundry area shall be provided for every 50 persons, or such other number of persons as the Engineer may agree to.
- (6) All houses shall be safely wired, have proper lighting and a reasonable number of socket outlets, and shall be adequately furnished with beds, mattresses, pillows, wardrobes, tables and chairs.
- (7) In the interests of preserving the forests the Contractor is prohibited from using green timber cut from the forest for any aspect of the construction of his facilities or those for the Engineer. This includes props etc. needed to cast lintels and the like. Further the Contractor shall not use wood burning stoves for cooking or heating.
- (8) The Contractor shall realise that local markets will not be able to supply bulk food supplies for his labour force without causing severe shortages for the local population. Bulk food supplies shall only be purchased from towns approved by the Engineer.

103.03 OTHER ESTABLISHMENTS

103.03.1 Workshops and Yards

(1) Workshops shall be suitably equipped for carrying out major repairs, overhauls or modification to all Contractor's Equipment and Plant used in or on the Works.

(2) Plant yards shall be kept clean in a workmanlike condition and reasonably free from unnecessary obstructions.

(3) Measures, as approved by the Engineer, shall be taken by the Contractor to minimise the occurrence of accidental spillages of oil, petrol, diesel or other such substances and under no circumstance shall the Contractor allow such spillages to pollute any river, stream or other water course, irrigation system, well or water supply facility. Where deemed necessary by the Engineer, the Contractor shall construct sumps or cut-off-drains to capture spillages. Disposal of oil spillages and surplus or waste materials arising from the workshops and yards, and other such facilities shall be at locations and by methods approved by the Engineer. Burning of surplus and/or waste materials will not be permitted.

103.03.2 Stores and Stockpiles

(1) Stores, stockpiles and other storage areas shall be of such size and construction as to provide adequate storage and protection for stocks of materials, fuel, spare parts and the like in quantities ensuring uninterrupted progress of the Works.

103.03.3 Borrow Pits / Quarries

(1) If the Project has a Materials Report indicating locations of potential Borrow Pits / Quarry sites, this report will be made available for inspection by the Contractor. The Engineer gives no guarantee that the materials at these Borrow Pits / Quarries are suitable in terms of either quality or quantity for use in the Works, and the Contractor shall make his own enquiries to ascertain the quality and quantity of materials available.

(2) The Contractor may open Borrow Pits / Quarries at other locations subject to the approval of the Engineer. In seeking approval for these or in using the Borrow Pits / Quarries shown in the Materials Report the Contractor shall obtain the approval requirements of the Ministry of Natural Resource and Environment (MONRE) and submit an environmental management plan clearly defining the works area, environmental constraints, rehabilitation requirements and any necessary compensation provisions.

(3) Topsoil from the Borrow Pit / Quarry area shall be retained and protected in stockpiles no higher than 2 m and shall be used to rehabilitate the land at the end of the Works. Any other overburden shall also be retained for re-use in reinstatement of the area. Materials lost due to inappropriate storage or inadequate protection shall be replaced with equal volumes of similar materials approved by the Engineer, all at the expense of the Contractor.

103.04 RIGHT OF OWNERSHIP

103.04.1 Main Camp

(1) Unless otherwise specified elsewhere in the Contract Documents, on completion of the Contract (or earlier if so approved by the Engineer), the main workshop and all permanent and non-mobile buildings in the Contractor's main camp and all fixtures and fittings therein (including the loose furniture, tools and equipment) shall become the property of the Employer.

(2) Before handing-over such buildings to the Employer, the Contractor shall clean, repair and repaint them, and generally restore them to as near their original condition as is reasonable in the opinion of the Engineer, fair wear and tear excepted.

(3) All non-permanent buildings shall be removed, and unless otherwise required or approved by the Engineer their sites restored as nearly as practicable to their original condition.

103.04.2 Field Camps

(1) All field camps, field offices and field housing shall remain the property of the Contractor at all times. They shall be removed from their sites when they are no longer required for the execution of the Works. Removal shall be not later than the end of the Defects Liability Period for the pertinent part or section of the Works or when so directed by the Engineer, and the sites restored as nearly as practicable to their original condition.

103.05 MEASUREMENT

(1) Measurement will be as follows:

Item No.	Description	Unit
103-1	Provision of Contractor's Establishments	Lump Sum
103-2	Maintenance of Contractor's Establishments	Month

103.06 PAYMENT

(1) Payment will be made at the rates entered in the Bill of Quantities, which rates shall include all work specified within this Section 103.

(2) Ninety percent (90%) of the lump sum for the Provision of the Contractor's Establishments item will be certified in six equal instalments in Interim Payment Certificates Nos. 1 - 6, subject always to the satisfaction of the Engineer that the proportion of the accumulated amounts certified are not greater than the proportion of the value of the accumulated work carried out in which case the Engineer may reduce payment accordingly, and increase subsequent payments accordingly.

(3) The remaining ten percent (10%) of the lump sum will be certified when the Contractor's Establishments have been cleared and tidied, and handed over to the Employer in their original condition, fair wear and tear excepted, to the satisfaction of the Engineer.

(4) Payment for Item 103-2 shall include for all routine maintenance and repairs, running costs, utilities, fuel and all other items and incidentals to maintain the Establishments in satisfactory condition and operational state acceptable to the Engineer.

(5) Where in the opinion of the Engineer, the conditions and/or operational state of any of the Establishments is unacceptable, the Engineer may reduce the monthly payment by such amount(s) as the Engineer considers appropriate taking into consideration all factors pertaining to the condition and state of the Establishments and the period of non-acceptability.

SECTION 104

FACILITIES FOR THE ENGINEER

104.01 GENERAL

(1) The specifications as described in this Section are only suggestive and shall be considered only as a guide to the “Facilities for the Engineer”. Specifications for individual contracts are provided in the Particular Specifications of the respective Contract.

104.01.1 Scope

(1) The Contractor shall provide and properly maintain, until completion of the Contract (or earlier if otherwise agreed), offices, housing, accommodation and other facilities for the sole use of the Engineer and his staff and the Employer’s Representative and his staff.

(2) These facilities shall be located, together with the Main Laboratory (Section 105 of the Specifications), within a Site Office Complex bounded by a brick boundary wall with gates and sign boards in accordance with the requirements specified herein.

(3) The land necessary for this purpose shall be provided by the Employer free of charge to the Contractor.

(4) The Complex shall incorporate infrastructure facilities such as access roads to each building, car parking areas, electrification, water supply, sewerage and its disposal, telephone etc.

(5) The boundary wall shall be made of good quality bricks. The wall shall be one and half (1.5) metres high with 175 mm thick brick work with brick pillars (175 mm x 175 mm) spaced at intervals of 1.75 metres. The wall shall be plastered with 1:4 cement : sand mortar on both sides and be painted with cement based paint of approved quality and colour.

(6) The main access road within the Complex, which shall lead to the Main Office Facility and the Main Laboratory, shall be a 5.5 metre wide pavement construction over a well compacted sub-grade. The pavement shall be made of 150 mm granular sub-base and 100 mm graded aggregate base course properly rolled and compacted with necessary application of water. The top surface shall be single coat surface dressing with proper camber. The whole Complex shall have adequate storm drainage facilities.

(7) Each accommodation building and the mess hall shall be provided with a secondary access road not less than 3.0 m wide leading from the main access road, and parking areas, all surfaced with a minimum of 150 mm gravel, and having adequate drainage.

(8) The areas around all buildings shall be appropriately landscaped with grass and plants, and a covered and paved sitting area of 50 m², with outdoor seating and tables, provided near the mess hall.

(9) A level area suitable for outdoor recreational activities shall be provided within the compound.

(10) Each housing unit shall be provided with an adjacent covered carport to accommodate 1 vehicle.

(11) Proper electrification of the complex with overhead lighting installations along with maintenance thereof shall be provided by the Contractor.

(12) The Complex shall be well protected and the entrance of the Complex shall be provided with strong and secure iron gates of collapsible/sliding type with proper arrangement for locking and guarding.

(13) The Contractor shall provide and install one metal sign board of the appropriate size. The sign board shall be inscribed with the name of the Contract specifying the road length, the name of the Consultant (Engineer), the name of the Employer (MPWT) and any other data as required by the Engineer. The languages of legends shall be in Lao and English with sizes of letters as approved. The Board shall be fixed on two vertical supports made of structural steel pipes or mild steel angles, with adequate bracing, fitted into foundations of Grade 15 concrete. The complete sign board unit shall be erected in a visible and by the Engineer approved location.

(14) All buildings within the Complex, unless otherwise specified in the Bill of Quantities shall be of a permanent nature, and shall be constructed to the general standard indicated by, and the appropriate requirements of, Section 106 of the Specifications.

(15) Where so designated in the Bill of Quantities the buildings within the Complex shall be constructed as follows:

Semi-permanent - Facilities shall be constructed from timber with insulated and lined painted weather board cladding with a timber floor raised approximately one metre off the ground. The facilities shall conform to the entire requirement set out herein and in Section 106 of the Specifications.

Prefabricated Module - Facilities shall be constructed from standard prefabricated transportable modules. The modules shall be of proven design and of robust construction to allow them to be lifted by crane and transported by truck to a new location at least 10 times without any deterioration in their condition. The modules shall be grouped together on concrete plinths and arranged in such a manner as to reflect, as far as is practical, the layouts specified. The facilities provided shall conform to all the requirement set out herein and in Section 106 of the Specifications. Preliminary A3 layout drawings shall be submitted with this alternative.

(16) A proposed layout for the Complex and preliminary floor plans of the buildings (including the Main Laboratory) shall be provided to the Engineer by the Contractor within 21 days of the Commencement Date. Detailed drawings, showing complete structural and architectural details of buildings (including the Main Laboratory), details of all services, and a detailed layout of all associated facilities, shall be submitted for the Engineer's approval within 28 days of the Engineer's approval of the layout and preliminary floor plans.

104.01.2 Utilities and Supplies

(1) The Contractor shall, until so notified by the Engineer upon the substantial completion of the Engineer's work, supply electricity, water and sanitary facilities for the Engineer's facilities. All utilities shall operate 24 hours per day. The Contractor shall be fully responsible for the maintenance and operation, including labour and materials, of the utility systems. The Contractor shall supply bottled drinking water for consumption by the Engineer and his staff and the Employer's Representative and his staff in the offices, mess and housing.

(2) The Contractor shall at his own cost provide the Engineer throughout the duration of the Contract with all stationery and other materials and supplies as can reasonably be expected to be required for the running of the Engineer's offices.

(3) The Contractor shall at his own cost provide the Engineer with such printed forms as the Engineer may require for the administration, supervision and control of the Works. The style, lay-out, quality and quantity of forms shall be as the Engineer may determine.

104.01.3 Cleaning and Messing

(1) The Contractor shall, until so notified by the Engineer upon the substantial completion of the Engineer's work, supply labour to clean and maintain the office, mess halls and houses, and provide cooks and kitchen hands for the messes.

104.02 MAIN OFFICE AND FACILITIES

104.02.1 General Requirements

(1) The main office for the Engineer shall comprise offices, a kitchen, a store room, at least 2 No. toilets and a reception area. The number of offices of each type will be as listed in the Particular Specifications. No office shall have a length more than twice its' width.

(2) The types of office shall be:

Type A	Minimum floor area	14 m ²	
Type B	Minimum floor area	12 m ²	
Type C	Minimum floor area	12 m ²	
Type D	Minimum floor area	10 m ²	
Type E	Minimum floor area	10 m ²	
Type F	Minimum floor area	18 m ²	(secretary/copy/computer)
Type G	Minimum floor area	24 m ²	(conference room)

(3) Other facilities shall be:

Kitchen	Minimum floor area	8 m ²
Store	Minimum floor area	8 m ²
Reception area	Minimum floor area	8 m ²
Toilet	Minimum floor area	4 m ²

104.02.2 Furniture and Fittings

(1) The new furniture and fittings to be provided per office type shall be as listed in below table.

Table 104.1 - Furniture and Fittings for Engineer's Office

	Office Type	A	B	C	D	E	F	G	Reception Area
1.	Twin pedestal desk with locking drawers	1	1	1					
2.	Single pedestal desk with locking drawers				1	1	1		
3.	Executive swivel chair on rollers with arms, cloth upholstery	1							
4.	Swivel chair on rollers with arms, cloth upholstery		1	1	1	1	1		
5.	Easy chair, cloth upholstery	2							3
6.	Straight chair with padded cloth upholstery seat		2	2	1	1			
7.	Occasional table	1							1
8.	Computer desk (adjustable)	1	1	1	1		2		
9.	Drafting table with formica top, T square and stool (cloth upholstery)						1		
10.	Layout Table (1.5m x 0.9m)	1	1	1	1	1			
11.	Conference Table (3m x 1m)							1	
12.	Conference Chair (cloth upholstery)							8	
13.	Typists chair (cloth upholstery)						2		
14.	Steel Cupboard (lockable)	1	1	1			1		
15.	4 drawer filing cabinet (lockable)	1	1	1			2		
16.	2 drawer filing cabinet (lockable)				1	1			
17.	Bookshelf	1	1	1			1	1	
18.	Portable Heater	1	1	1	1	1	1	1	1
19.	Whiteboard plus markers/eraser (1.2m x 0.8m min.)	1	1	1				1	
20.	Notice (pin) board (1.5m x 1.0m min)	1	1	1	1	1	1	2	1

(2) Curtains, table-lamps, waste-paper baskets, coat hangers, shelves, racks in the store and all other miscellaneous items which can reasonably be expected shall also be provided by the Contractor.

(3) The kitchen shall be equipped with a chilled/hot water dispenser, a refrigerator of adequate capacity for the size/number of occupants of the main office, an electric kettle, cups, saucers, plates, glasses, cutlery etc. in adequate numbers, a double sink unit with water heater, cupboards/storage areas, a work surface and other fixtures and fittings normally associated with such facilities.

(4) The toilet shall have a "Western" toilet, matching hand basin, mirror, extractor fan and other fixtures and fittings normally associated with such facilities.

(5) All offices, open areas and the kitchen shall be air-conditioned.

(6) One fire extinguisher shall be provided by the Contractor for each 50 m² or part thereof of main office floor area and one additional extinguisher for the kitchen.

(7) The Contractor shall provide such beverages (tea, coffee, soft drinks, biscuits) as are usual for such office facilities.

104.02.3 Equipment

(1) The equipment to be provided for the Engineer's Main Office shall be as specified in the Particular Specifications.

104.02.4 Site Layout

(1) The Engineer's main office shall be located in the Engineer's main camp.

(2) The office shall be provided with an access road not less than 4.0 m wide, with a parking area surfaced with a minimum of 150 mm gravel, having adequate drainage, and with a covered carport to accommodate all the Engineer's/Employer Representative's vehicles. Within the compound the Contractor shall supply a concrete paved vehicle washing bay adequately drained.

104.03 MOBILE OFFICES AND FACILITIES

104.03.1 Scope

(1) The Contractor shall provide, furnish, equip and maintain, until the completion of the Works, mobile office units suitable for use by the Engineer's field staff as combined office and housing facilities.

104.03.2 Description

(1) A mobile unit shall consist of two sub-units, each sub-unit having a gross floor area of not less than 10 m². The unit shall be founded such that the floor level is approximately 500 mm above ground level.

(2) The office sub-unit shall be furnished with 2 desks, 4 chairs, a lockable 4 drawer filing cabinet, and cupboards and fittings as appropriate.

(3) The housing sub-unit shall be furnished with 2 bunks complete with mattresses, table, chairs and cupboards as appropriate, hand basin with running water, portable stove, portable refrigerator, kettle and necessary cutlery and crockery.

(4) The mobile unit shall have appropriate lighting, air-conditioning and heating, and an adequate and constant electricity supply. Toilet, shower and sewage and refuse disposal facilities shall be provided at each site.

(5) All arrangements shall be to the approval of the Engineer and the Contractor shall allow for moving the unit upto 3 times to alternative sites during the execution of the Works. Such moves shall be carried out in an efficient manner to cause the minimum of inconvenience to the Engineer's staff.

104.04 FIELD EQUIPMENT

104.04.1 Weather Recording Equipment

(1) The Contractor shall provide and maintain until the completion of the Works and as necessary replace the following instruments and their necessary appurtenances for use by the Engineer:

Rain gauge	1
Anemometer	1
Barometer	1
Maximum-minimum thermometer	1

(2) The instruments shall be installed adjacent to the main laboratory or as otherwise directed by the Engineer.

104.04.2 Survey and Inspection Equipment

(1) The Contractor shall provide and maintain until the completion of the Works for the exclusive use of the Engineer all such surveying instruments, equipment and labourers as the Engineer may deem to be necessary for carrying out his duties in connection with the Contract.

(2) Suitable alternative instruments and/or equipment shall be made available by the Contractor when the supplied instruments and/or equipment are under repair or maintenance or cannot be used for any reason.

(3) The labourers shall be selected for their intelligence and knowledge of the English language and, so far as possible, the same men shall be provided throughout the period of the Contract.

(4) The instruments to be provided shall include, but not necessarily be limited to those listed in the Particular Specifications.

104.05 ACCOMMODATION FOR THE ENGINEER'S STAFF

104.05.1 Scope

(1) The accommodation for the Engineer's staff shall consist of housing units, single person quarters and a mess hall located in a separate fenced-in enclosure within the Site Office Complex.

(2) Housing units shall be of one and two bedrooms, with lounge, dining room, kitchen, toilet and bathroom, and covered paved outside sitting area with insect screens. External doors shall be sited in verandas minimum width 2 m forming part of the outside sitting area. The minimum internal floor area of each housing unit shall be as follows:-

Type A - 1 Bedroom House Unit - 70 m ²
Type B - 2 Bedroom House Unit - 90 m ²

(3) The floor area of the single person quarters shall be not less than 220 m² comprising 10 double bedrooms, dining room, a kitchen, toilets, laundry room and bathrooms.

(4) The floor area of the mess hall shall be not less than 150 m². The mess hall shall comprise a dining area, a sitting area with lounge seating, a kitchen, larder, storeroom, laundry, toilet, bathroom, and facility for the accommodation of two mess staff.

104.05.2 Furniture, Fittings and Equipment

(1) The furniture and fittings to be provided in each of the housing units and single person quarters shall be new and shall include as shown in below table.

Table 104.2 - Furniture and Fittings for Housing Units and Single Person Quarters

	Item	2-Bedroom House	1-Bedroom House	Single Quarters
1.	Electrical boiler (150 l) capacity connected to kitchen and bathroom	1	1	2
2.	Electrical cooking stove, 4 plate with integral oven	1	1	1
3.	Electric refrigerator 180 litre,	1	1	1
4.	Freezer 150 litre	1	1	1
5.	Combination safe	1	1	
6.	Washing machine	1	1	1
7.	Iron and ironing board	1	1	1
8.	Electric fan (free standing)	1	1	
9.	Portable heaters	3	2	1 per room
10.	Electric Insect Trap	1	1	1
11.	Exhaust fans	2	2	1
12.	Air conditioners, 2.5 kW	3	2	1 per room
13.	Beds with mattresses	3	2	2 per room
14.	Dressing table with mirror and stool	2	1	1 per room
15.	Chests of drawers (4 drawers)	3	2	1 per room
16.	Wardrobes, built-in or movable	2	1	1 per room
17.	Bedroom chairs		3	2
18.	Bedroom rugs	2	1	1 per room
19.	Bedside lamps	4	2	1 per room
20.	Bedside tables	4	2	1 per room
21.	Bath / shower combination	1	1	2
22.	Bathroom stool	1	1	2
23.	Pedestal toilet and matching hand-basin	1	1	2
24.	Dining table	1	1	4
25.	Dining chairs	6	6	16
26.	Lounge chairs	3	2	2 per room
27.	Settee (3 seater)	1	1	
28.	Coffee table	1	1	1 per room
29.	Side tables	3	2	
30.	Sideboard	1	1	
31.	Book cases	3	2	1 per room
32.	Writing desk	1	1	
33.	Standard lamps	1	1	1
34.	Kitchen table	1	1	1
35.	Kitchen chairs	2	2	2
36.	Built-in kitchen cupboards & work top	2	2	2
37.	4 No plastic outside chairs plus table	1	1	2
38.	TV (42") with satellite dish, card DVR	1	1	
39.	Internet connectivity (Wifi or LAN)	1	1	1

(1) Curtains, towels, blankets, sheets, duvets, linen, cutlery, crockery, pots, pans, kitchen utensils and all such other items as can reasonably be expected to be required by the Engineer's staff and their families shall be supplied by the Contractor.

(2) The mess hall shall be provided with all new furniture, equipment, utensils and fittings as can reasonably be expected, in the opinion of the Engineer, to be required by the occupants and users. Such furniture and equipment shall include as shown in the below table.

Table 104.3 - Furniture, Equipment, Utensils and Fittings for Mess Hall

	Item	Nos
1.	Electric boiler (150 l)	1
2.	Electric stove, 4 plate with integral oven	1
3.	Electric refrigerator (350 l)	2
4.	Electric freezer (200l)	1
5.	Kitchen exhaust fan and hood	1
6.	Exhaust fan	3
7.	Air-conditioner (2.5 kW)	6
8.	Portable Heaters	4
9.	Kitchen sink (large double unit)	1
10.	Washing machine	1
11.	Laundry trough	1
12.	Electric iron and ironing board	1
13.	Kitchen cupboard fitted units	2
14.	Kitchen table	1
15.	Kitchen bench	2
16.	Kitchen chair	4
17.	Electric insect trap	2
18.	Dining table (modular to seat 4)	5
19.	Dining chair	20
20.	Ceiling fan	2
21.	Free standing fan	3
22.	Coffee/Tea making facilities	1
23.	Chilled water dispenser	1
24.	Bookshelf	2
25.	Sofa	3
26.	Lounge chairs	6
27.	Coffee table	2
28.	42"-inch colour TV, with antenna and	1
29.	Digital adjustable satellite antenna	1
30.	Digital Video recorder/player	1
31.	Bath / shower combination	1
32.	Bathroom stool	1
33.	Pedestal toilet and matching hand-basin	2
34.	Bed with mattress	2
35.	Bed side table	2
36.	Dressing table and stool	2
37.	Wardrobe	2
38.	Chest of drawers (3 drawers)	2
39.	Bedroom chair	2
40.	4 No plastic outside chairs plus table	5
41.	Internet connectivity (Wifi or LAN)	1

(3) Curtains, sheets blankets, duvets, floor mats, chair cushions, towels, table cloths, cooking utensils, crockery, cutlery, cleaning and washing and all other necessary miscellaneous mess items are to be supplied by the Contractor, as required by the Engineer.

104.06 ENGINEER'S TRANSPORT

104.06.1 Vehicles

(1) The Contractor shall provide the following vehicles for the exclusive use of the Engineer and his staff:

Type A - 4 Wheel drive double cab pickup 3.5 litre diesel engine, with "Carry Boy" cover to tray, winch, protective bars "bull bars" (front and rear) and fog lights.

Type B - 4 Wheel drive double cab pickup 2.8 litre diesel engine, with "Carry Boy" cover to tray and winch, protective bars "bull bars" (front and rear) and fog lights.

Type C - 4 Wheel drive double cab pickup 2.8 litre diesel engine, with canvas cover to tray and winch, protective bars "bull bars" (front and rear) and fog lights.

(2) Vehicles shall be provided at such times as will be instructed or approved by the Engineer.

(3) The vehicles shall comply with all relevant Lao national and local laws, statutes and regulations.

(4) The vehicles shall be equipped with seat-belts, fire-extinguishers (shall be certified heat proof), air-conditioners, radio-CD player and USB, 1 or 2 No spare tyres per vehicle (the required No of spare tyres to be decided at the discretion of the Engineer, depending on the remoteness and travel distances involved in the works), jack, tools for wheel changes and minor repairs, first-aid kits (which shall be replenished as necessary during the Contract) and antennae to suit radio communications requirements as specified under Sub-clause 104.07.1 herein.

(5) The Contractor shall register/re-register, insure comprehensively, provide fuel and running costs, service, repair, clean and maintain the vehicles throughout the period they are used for the supervision of the Contract.

(6) The Contractor shall immediately furnish the Engineer with copies of the initial and re-registration receipts and of the insurance policy and receipts for payment of the insurance.

(7) The contractor shall be responsible for keeping stocks of such spare parts for the Engineer's vehicles as are necessary for the minimisation of times taken to maintain and repair the vehicles.

(8) Suitable approved alternative transport shall be made available by the Contractor during periods when vehicles are under repair or maintenance or cannot be used for any reason.

(9) The Contractor shall provide each vehicle with a competent, qualified and well experienced driver who has a working knowledge of English and is approved by the Engineer.

(10) Drivers shall not be replaced by the Contractor (unless so requested by the Engineer) without the prior written approval of the Engineer.

104.06.2 Motor-Cycles

(1) The Contractor shall provide new motor-cycles for the exclusive use of the Engineer's staff, and shall insure comprehensively, provide fuel and running costs, service, repair and maintain the same. One safety helmet shall be provided with each motor-cycle plus one spare helmet for each two cycles.

(2) The motor-cycles shall be 125 cc, as approved by the Engineer, with wet weather tyres.

(3) Suitable alternative transport shall be made available during periods when motor-cycles are under repair or maintenance or cannot be used for any reason.

(4) Motor-cycles shall be provided at such times as may be instructed or approved by the Engineer.

104.07 OTHER SERVICES FOR THE ENGINEER

104.07.1 Radio Communications

- (1) The Contractor shall provide a two-way radio communication service, or equivalent, on the Site for the sole use of the Engineer's staff.
- (2) The communication service shall be such that constant contact between the Engineer's main office, mobile accommodation, main laboratory and mobile laboratory, and the Engineer's vehicles, can be maintained at all times under normal conditions.
- (3) The main office and mobile laboratory shall be equipped with base stations and each vehicle shall be equipped with a car radio. Repeaters, antennae, and all necessary equipment shall be provided.
- (4) The Contractor shall install, service, repair and maintain the communication service and radio equipment until completion of the Contract unless otherwise agreed.
- (5) The Employer will arrange frequencies but the costs of all fees and licences required shall be paid by the Contractor.

104.07.2 Walkie Talkies

- (1) The Contractor shall provide in each vehicle and 6 Nos. hand held Transceivers, or equivalent, walkie talkie sets with suitable antennae for use by the Engineer's staff. The range and frequency shall be such as to allow communication to the Engineer's main office, mobile office and vehicles, within the Contract limits.

104.07.3 Telephone Service

- (1) If cabled telephone services are available in the vicinity of the Engineer's main office and housing, or become available during the period of the Contract, the Contractor shall provide one telephone line to the main office and the main laboratory, and one separate line to the mess hall. A switchboard and handsets in each office shall then be installed.
- (2) If cabled telephone services are not available in the vicinity, the Contractor shall provide and maintain one satellite telephone line to the Engineer's main office. The satellite telephone shall be able to transmit and receive faxes and e-mail. Other suitable communication such as mobile phones may be considered.

104.07.4 Security Services

- (1) Notwithstanding the provisions of Sub-Clause 2.6 of the Conditions of Contract, the Contractor shall provide security services acceptable to the Engineer for the compound, offices, vehicles and housing used by the Engineer and his staff.

104.08 PERIODS FOR PROCUREMENT AND RIGHT OF OWNERSHIP

104.08.1 Periods for Procurement

- (1) Mobile offices, single quarters and mess halls shall be completed, fully equipped, and ready for occupation by the Engineer within 30 days of the Commencement Date, unless agreed otherwise.
- (2) The main office and housing units shall be completed, fully-equipped, and ready for occupation by the Engineer within 90 days of the Commencement Date.
- (3) If the Contractor fails to make the above offices and accommodation available within the stipulated periods, he shall at his own cost rent, or otherwise provide, temporary facilities which are acceptable to the Engineer, and the Employer shall be entitled to deduct liquidated damages from monies due to the Contractor in the amount of USD 200 per day per building or unit.

(4) From the day the Contractor commences work on the Site, the Contractor shall provide for the Engineer's use an office and accommodation for a minimum of three persons, in a location as directed or approved by the Engineer. The office shall be air-conditioned and equipped with normal fixtures and furnishings to similar standard to that specified for the main office and accommodation, including a telephone, facsimile, photocopier and computers. The photocopier and computers may be relocated to the main office.

(5) Acceptable temporary facilities shall be provided by the Contractor at no additional cost to the Engineer if, in the opinion of the Engineer, the Contractor's work programme is such that the full-time presence of the Engineer and his staff is required on the Site before the expiration of the periods mentioned in (1), (2) and (3) above.

(6) The field equipment and the other services for the Engineer shall be made available to the Engineer within 28 days of the Commencement Date. The Contractor shall at his own expense rent or otherwise arrange, as from the Commencement Date equivalent temporary equipment, transport and services as required and approved by the Engineer.

104.08.2 Right of Ownership

(1) The Engineer's main office, mobile offices, field equipment, accommodation, vehicles, motor-cycles, radio communications units and all appurtenances, fixtures, fittings, furniture, materials and equipment required by this Section 104 shall be the property of the Employer at all times.

(2) When the Employer has agreed that facilities can be rented (e.g. mobile offices, vehicles), the concerned facilities shall not be covered by this Clause on 'Right of Ownership'.

(3) Before completion of the Contract, the Contractor shall clean, repair and, as necessary, re-paint all the facilities provided for the Engineer, and generally restore them to as near their original condition as is reasonable in the opinion of the Engineer, fair wear and tear excepted.

104.09 MEASUREMENT

(1) Measurement will be as follows:

Item No.	Description	Unit
104-1	Provision of Main Office and Facilities	Lump Sum
104-2	Maintenance of Main Office and Facilities	Month
104-3	Provision of Mobile Office	Month
104-4	Maintenance of Mobile Office	Office-Month
104-5	Field Equipment	Lump Sum
104-6	Provision of Housing Unit - Type A	Number
104-7	Provision of Housing Unit - Type B	Number
104-8	Provision of Single Persons Quarters	Number
104-9	Provision of Mess Hall	Number
104-10	Maintenance of Housing Units	Unit-Month
104-11	Maintenance of Single Persons Quarters and Mess Hall	Month
104-12	Provision of Vehicle - Type A	Number
104-13	Provision of Vehicle - Type B	Number
104-14	Provision of Vehicle - Type C	Number
104-15	Maintenance of Vehicles	Vehicle Month
104-16	Provision of Motorcycle	Number
104-17	Maintenance of Motorcycle	Cycle Month
104-18	Other Services for the Engineer	Lump Sum

(2) For items 104-1, 104-6, 104-7, 104-8 and 104-9 the items' description shall be as shown if permanent construction is to be used, and noted as "(Semi-permanent Construction)" or "(Prefabricated Module Construction)" as appropriate if other construction is required.

104.10 PAYMENT

- (1) Payment for all work items required by this Section of the Specifications will be made at the unit rates and lump sum prices entered in the Bill of Quantities which rates will be full compensation for all specified items and activities.
- (2) Payment for Item 104-1 shall include, in addition, for the development of the complete Site Office Complex area including layout proposals and building floor plans, boundary wall, gates, security, lighting, main and secondary access roads, all parking areas and car ports, landscaping, paved areas, outdoor recreational area and all other features and facilities to provide a functional and complete facility.
- (3) Payment for Item 104-1 will be made in instalments corresponding to the state of completion of the each office. Completion shall be deemed to include all fixtures, fittings, equipment, furniture and all items necessary to constitute a fully operational office facility. Payment shall include temporary office accommodation and facilities as specified, and for the cleaning, repair and re-painting and for hand-over to the Employer.
- (4) Payment for Item 104-3 will be made in monthly instalments.
- (5) Payment of Items 104-2 and 104-4 shall include for all maintenance, supplies, utilities, cleaning, messing and all other work/requirements specified or implied to maintain each office in a condition and in an operational state acceptable to the Engineer. Payment shall commence on the date that the Engineer accepts or occupies (whichever is the earlier) each office until the date the Engineer hands the office to the Contractor to carry out the specified cleaning, repair and re-painting prior to hand-over to the Employer, which dates shall be recorded in writing by the Engineer and agreed by the Contractor.
- (6) Payment for Item 104-5 will be made when the Field Equipment is provided and accepted by the Engineer, and shall include payment for all surveying instruments, equipment and labourers, maintenance repair and the temporary and permanent replacement.
- (7) Payment for Items 104-6 through 104-9 shall be made when the facilities are accepted by the Engineer, and shall include payment for furniture, fittings, equipment, and all incidental items as specified or required. Payment shall also include for cleaning, repair and repainting and hand-over to the Employer.
- (8) Payment for Items 104-10 and 104-11 shall include payment for all maintenance and the provision of mess staff. Payment shall commence on the date(s) that the Engineer accepts or occupies (whichever is the earlier) each of facilities until the date(s) the Engineer hands the set of facilities to the Contractor to carry out the specified cleaning, repair and repainting prior to hand-over to the Employer, which dates shall be recorded in writing by the Engineer and agreed by the Contractor.
- (9) Where in the opinion of the Engineer, the condition or operational state of any facility, at any time, is unacceptable, the Engineer may reduce the monthly payment by such amount(s) as the Engineer considers appropriate taking into consideration all factors pertaining to the condition and state of the office and the period of non-acceptability.
- (10) Payment for Items 104-12, 104-13 and 104-14 shall include payment for provision of each vehicles complete as specified. Payment for each vehicle shall be made when the same is accepted by the Engineer.
- (11) Payment for Item 104-16 shall include payment for the provision of each motorcycle complete as specified including crash helmets.

(12) Payment for Items 104-15 and 104-17 shall be made from the date of acceptance of each unit by the Engineer to the date of hand-over of each unit on completion of use when it will be returned to the Contractor for cleaning and repair prior to hand-over to the Employer. The above dates will be recorded in writing by the Engineer and agreed by the Contractor. Payment will include for licensing costs, insurance, fuel, running costs, servicing, cleaning, repair and maintenance costs, provision of alternative approved transport, driver (salary, per-diems and all allowances) and replenishment of first aid kits.

(13) Payment for Item 104-18 shall include for all other services for the Engineer and for all other obligations of the Contractor under Section 104 of the Specifications whether explicitly stated or implied. Payment will be made in equal instalments commencing three (3) months after the Contract Commencement Date. The number of instalments will equal the Time for Completion (in months) less three (3).

SECTION 105

TESTING AND CONTROL

105.01 LABORATORY FACILITIES

105.01.1 General - Production Control / Acceptance Testing

(1) The Contractor shall provide, staff and maintain laboratory testing facilities for as long as the progress of the Works requires (in the opinion of the Engineer), and shall provide all utility services, furniture, equipment, apparatus, fittings, materials and supplies necessary. The facilities shall be equipped to carry out all standard production control and acceptance tests required by the Contract. The facilities shall include running potable water, electric parts and lights, air-conditioning and toilet facilities.

(2) The facilities shall be operated by the Contractor under the supervision and control of the Engineer. The Contractor's laboratory staff shall provide the Engineer with all the assistance he may require in supervising and checking their sampling and testing work.

(3) The main laboratory shall be a separate building, located in the Engineer's Site Office Complex (Clause 104.01 of the Specifications) with a gross floor area of not less than 200 m². Construction of the main and audit laboratories shall be as specified in Clause 104.01 of the Specifications. Any office for the use of the Contractor within the laboratory shall be exclusive of the minimum specified floor area.

(4) The laboratory shall be divided into three parts (bitumen, concrete and remainder) with a fire resistant wall and door separating all parts. All parts shall have external access. The bitumen laboratory shall have a fume cupboard with external venting. The methyl chloride still shall be housed in a completely separate building attached to the bitumen laboratory. Concrete testing laboratory shall have facility to cure moulded specimens of concrete and CBR samples at control room temperature etc.

(5) The Contractor shall before he places any orders, submit to the Engineer for approval layout plans, drawings and other relevant details of the facilities which he proposes to provide. The submission shall include a complete list of the equipment, apparatus and supplies the Contractor proposes to furnish, together with the manufacturers' names and descriptive literature. All items will be subject to the approval of the Engineer, and any additional equipment, apparatus and/or supplies considered necessary by the Engineer shall be provided by the Contractor.

105.01.2 Mobile Laboratories

(1) The Contractor shall provide, furnish and maintain mobile laboratories suitably equipped to carry out those production control/acceptance tests which can conveniently be performed in the field.

(2) Each mobile laboratory shall be an approved weather-tight movable building, trailer or converted bus, and shall be positioned at a location instructed/approved by the Engineer. Each mobile laboratory shall consist of two sub-units, each sub-unit shall have a gross floor area of not less than 10 m², and shall be furnished with running potable water, portable stove, electric light and air-conditioning. Adequate and constant electricity and water supplies, and toilet facilities shall be provided. One sub-unit shall be equipped as a laboratory and the other as an office, with a door between.

105.01.3 Acceptance Testing

(1) Where approved by the Engineer, Acceptance Testing may be subcontracted to independent testing laboratories whose facilities and testing procedures have been approved by the Engineer. The Contractor's submission shall include full details of these subcontract facilities, including test procedures and suitable national standard endorsements. The Contractor shall retain full responsibility for the delivery of these testing services including programming and quality assurance issues. Where the delivery of any testing services are not to the approval of the Engineer or as required under the Contract, the Contractor shall make alternative testing arrangements suitable to the Engineer at his own cost.

(2) Acceptance Tests required under the Contract which are of a special and non routine nature may be carried out by approved independent laboratories approved by the Engineer. The Contractor may select to utilise such testing services on a subcontracted basis, but will retain full responsibility for the results, and for ascertaining the extent of testing services available, and shall allow for all tests and associated costs in the rates in his Bill of Quantities. In that event Engineer shall have the full authority to get access and inspect the facility and testing standards at any time during project runs.

105.01.4 Laboratory Equipment

(1) The laboratory equipment, apparatus, materials and supplies to be provided by the Contractor either directly or by subcontract shall include (but not necessarily be limited to) those required to perform the tests listed below. Manufacturer's specifications and certificates of guarantee, or test results from independent laboratories approved by the Engineer, will be accepted for those tests marked with an asterisk.

(2) The Contractor shall be required to provided the equipment listed under item (b) Bituminous Materials, sections (i) Tests on Penetration Graded Bitumen and (iv) Bituminous Mixtures only if the Bill of Quantities includes items for Bituminous Concrete Surface Courses (i.e. items 305-1, 305-2, 305.3 or 305-4).

Test	Description
(a) Hydraulic Cement	
AASHTO T 106	Compressive Strength of Hydraulic Cement Mortar (Using 2 inch or 50 mm Cube Specimens)
AASHTO T 127	Sampling and Amount of Testing of Hydraulic Cement
AASHTO T 128	Fineness of Hydraulic Cement by the 0.150 mm (No. 100) and 0.075 mm (No. 200) Sieves
AASHTO T 129	Normal Consistency of Hydraulic Cement
AASHTO T 131	Time of Setting of Hydraulic Cement by Vicat Needle
AASHTO T 153*	Fineness of Portland Cement by Air Permeability Apparatus
ASTM C 150*	Portland Cement
(b) Bituminous Materials	
(i) Tests on Penetration Graded Bitumen	
AASHTO T 40	Sampling of Bituminous Materials
AASHTO T 44	Solubility of Bituminous Materials
AASHTO T 47 *	Loss on Heating of Oil and Asphaltic Compounds
AASHTO T 48 *	Flash and Fire Points by Cleveland Open Cup
AASHTO T 49*	Penetration of Bituminous Materials
AASHTO T 51*	Ductility of Bituminous Materials
AASHTO T 53*	Softening Point of Bitumen. (Ring-and-Ball Apparatus)
AASHTO T 55*	Water in Petroleum Products and Bituminous Materials by Distillation
AASHTO T 102*	Spot Tests of Asphaltic Materials
AASHTO T 179*	Effect of Heat and Air on Asphalt Materials (Thin-Film Oven Test)
AASHTO T 228	Specific Gravity of Semi-Solid Bituminous Materials
(ii) Tests on Cut-Back Bitumen	
AASHTO T 40	Sampling Bituminous Materials
AASHTO T 44*	Solubility of Bituminous Materials
AASHTO T 49*	Penetration of Bituminous Materials
AASHTO T 51*	Ductility of Bituminous Materials
AASHTO T 55*	Water in Petroleum Products and Bituminous Materials by Distillation
AASHTO T 72*	Saybolt Viscosity
AASHTO T 78*	Distillation of Cutback Asphalt Products

AASHTO T 79*	Flash Point with Tag Open Cup Apparatus for Use with Material Having a Flash Point Less Than 93°C (200°F)
AASHTO T 102*	Spot Tests of Asphaltic Materials
AASHTO T 201*	Kinematic Viscosity of Asphalts (Bitumen)
AASHTO T 202*	Viscosity of Asphalts by Vacuum Capillary Viscometer
AASHTO T 228	Specific Gravity of Semi-Solid Bituminous Materials
(iii) Tests on Emulsified Bitumen	
AASHTO T 40	Sampling Bituminous Materials
AASHTO T 59*	Testing Emulsified Asphalt
(iv) Bituminous Mixes	
AASHTO T 110*	Moisture of Volatile Distillates in Bituminous Paving Mixtures
AASHTO T 164	Quantitative Extraction of Bitumen from Bituminous Paving Mixture
AASHTO T 165	Effect of Water on Cohesion of Compacted Bituminous Mixtures
AASHTO T 166	Bulk Specific gravity of Compacted Bituminous Mixtures
AASHTO T 168	Sampling Bituminous Paving Mixtures
AASHTO T 170	Recovery of Asphalt from Solution by Abson Method
AASHTO T 182	Coating and Stripping of Bitumen-Aggregate Mixtures
AASHTO T 195	Degree of Particle Coating of Bituminous-Aggregate Mixtures
ASTM D2727*	Coating and Resistance to Stripping of Bituminous-Aggregate Mixtures Containing Adhesion Promoting Agents
AASHTO T 209	Maximum Specific Gravity of Bituminous Paving Mixtures
AASHTO T 230	Degree of Pavement Compaction of Bituminous Aggregate Mixture
AASHTO T 245	Resistance to Plastic Flow of Bituminous Paving Mixture Using Marshall Apparatus
(c) Soils and Gravels	
AASHTO T 87	Dry Preparation of Disturbed Soil and Soil Aggregate Samples for Test
AASHTO T 88	Particle Size Analysis of Soils
AASHTO T 89	Liquid Limit of Soils
AASHTO T 90	Plastic Limit and Plasticity Index of Soils
AASHTO T 92	Shrinkage Factors of Soils
AASHTO T 100	Specific Gravity of Soils
AASHTO T 146	Wet Preparation of Disturbed Soil Samples for Test
AASHTO T 99	Moisture-Density Relations of Soils Using a 2.5 kg Rammer and a 305 mm Drop
AASHTO T 180	Moisture-Density Relations of Soils Using a 4.5 kg Rammer and a 457 mm Drop
AASHTO T 191	Density of Soil In-Place by the Sand-Cone Method
AASHTO T 193	The California Bearing Ratio
AASHTO T 204	Density of Soil In-Place by the Drive Cylinder Method
AASHTO T 208	Unconfined Compressive Strength of Cohesive Soil
AASHTO T 224	Correction for Coarse Particles in the Soil Compaction Test
AASHTO T 265	Laboratory Determination of Moisture Content of Soils
ASTM D 4253	Maximum Index Density and Unit Weight of Soils Using a Vibratory Table
ASTM D 5874	Impact Value (IV) of a Soil
(d) Aggregates and Gravels	
AASHTO T 2	Sampling Aggregates
AASHTO T 11	Materials Finer Than 0.075 mm (No. 200) Sieve in Mineral Aggregates by Washing
AASHTO T 180	Moisture Density Relations of Soils Using a 4.5 kg Rammer and a 457 mm Drop
AASHTO T 19	Unit Weight and Voids in Aggregate
AASHTO T 21	Organic Impurities in Fine Aggregates for Concrete

AASHTO T 27	Sieve Analysis of Fine and Coarse Aggregates
AASHTO T 37	Sieve Analysis of Mineral Filler for Road and Paving Materials
AASHTO T 84	Specific Gravity and Absorption of Fine Aggregate
AASHTO T 85	Specific Gravity and Absorption of Coarse Aggregate
AASHTO T 96	Resistance to Degradation of Small Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
AASHTO T 104	Soundness of Aggregate by Use of Sodium Sulphate or Magnesium Sulphate
AASHTO T 112	Clay Lumps and Friable Particles in Aggregate
AASHTO T 176	Plastic Fines in Graded Aggregates and Soils by Use of Sand Equivalent Test
ASTM C566	Total Evaporable Moisture Content of Aggregate by Drying
BS EN 933-3	Geometrical properties of aggregates. Determination of particle shape. Flakiness index
BS 812-105.2	Elongation Index
BS 812-114*	Polished Stone Value
AASHTO T 84	Specific Gravity and Absorption of Fine Aggregate
AASHTO T 85	Specific Gravity and Absorption of Coarse Aggregate
(e) Concrete	
AASHTO T 22	Compressive Strength of Cylindrical Concrete Specimens
AASHTO T 23	Making and Curing Concrete Test Specimens in the Field
AASHTO T 26	Quality of Water to be used in Concrete
AASHTO T 71*	Effect of Organic Impurities in Fine Aggregate on Strength of Mortar
AASHTO T 119	Slump of Hydraulic Cement Concrete
AASHTO T 121	Weight per Cubic Foot, Yield and Air Content (Gravimetric) of Concrete
AASHTO T 126	Making and Curing Concrete Test Specimens in the Laboratory
AASHTO R 60	Sampling Freshly Mixed Concrete
AASHTO T 231	Capping Cylindrical Concrete Specimens
AASHTO T 24	Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
AASHTO T 148	Measuring Length of Drilled Concrete Cores
ASTM C939*	Flow of Grout for Preplaced-Aggregate Concrete (Flow Cone Method)
(f) Miscellaneous	
ASTM D882*	Tensile Properties of Thin Plastic Sheeting
ASTM D689*	Internal Tearing Resistance of Paper

(3) A nuclear density meter shall be provided.

105.01.5 Audit Laboratory

(1) Where specified in the Contract Documents, the Contractor shall provide an Audit Laboratory with a gross floor area of not less than 100 m². This laboratory shall be located immediately adjacent to the main laboratory. Within the audit laboratory there shall be located an office of minimum area 12m² for the exclusive use of the Engineer. This shall be furnished with a desk, chair, layout table, filing cabinet, 3 No lockable steel cupboards and 2 No hard back chairs all identical to the furniture provided for the main office. The building shall be furnished and fitted out in a similar manner to the main laboratory building.

(2) The Audit Laboratory shall be equipped to carry out the following tests:

- AASHTO T 87 Dry Preparation of Disturbed Soil and Soil Aggregate Samples for Test
- AASHTO T 88 Particle Size Analysis of Soils
- AASHTO T 89 Liquid Limit
- AASHTO T 90 Plastic Limit and Plasticity Index of Soils
- AASHTO T 191 Density of Soil In-Place by the Sand-Cone Method
- AASHTO T 205 Field Density by Balloon Densometer

- AASHTO T 193 California Bearing Ratio (at least 30 moulds, and associated equipment for performing soaked tests)
- pH testing of Soil Aggregates and Water Samples

(3) The Contractor shall provide the test equipment for the audit laboratory separate from that supplied to the main laboratory. The Contractor shall also provide any necessary ancillary items which, in the opinion of the Engineer, are necessary for these tests. Where the Engineer wishes to make use of test equipment contained in the main laboratory for audit testing, then the Contractor shall make this available with no time or cost increases to the Contract.

105.01.6 Period for Procurement

(1) The laboratory testing facilities required by this Section of the Specifications shall be procured, completed and made available to the Engineer within 56 days of date of award and before any ground works, pavement works or structural works commence on the Contract.

(2) If the Contractor fails to make the facilities available within the stipulated period, he shall at his own cost rent, or otherwise provide, temporary facilities which are acceptable to the Engineer.

(3) Equivalent temporary facilities shall be provided by the Contractor if, in the opinion of the Engineer, the Contractor's work programme is such that testing and control facilities are required before the expiration of the aforementioned periods.

(4) Under no circumstances will the Contractor be permitted to commence items of work for which the necessary testing and control facilities have not been made available.

105.01.7 Right of Ownership

(1) The laboratories and all items, equipment, instruments and materials required by this Section of the Specifications shall be the property of the Employer at all times.

(2) Before completion of the Contract, the Contractor shall clean, repair and re-paint all the facilities provided for the Engineer, and generally restore them to as near their original condition as is reasonable in the opinion of the Engineer, fair wear and tear excepted.

105.02 LOTS OF WORK

105.02.1 Definition

(1) A lot of work shall be a section of work or quantity of material which is essentially uniform in nature with respect to materials, location, method of construction, time of construction, and any other factor which would have a significant effect on the finished product. Unless specifically approved otherwise by the Engineer, each portion of a lot of work shall be immediately adjacent to the other portions of a lot. Samples from a lot can therefore be taken as representative of the entire lot.

(2) If the Engineer considers that a lot of work completed by the Contractor is not uniform in nature, the Engineer may order that the Contractor's proposed lot be sub-divided into two or more smaller lots and the Contractor shall carry out any additional works or testing to ensure that these lots comply with the relevant Clauses of the Specifications at his own cost.

105.02.2 Lot Identification

(1) All lots of work shall be clearly identified by an approved unique numbering system, which shall enumerate information such as the type of work, the section of road and the lot sequence number and the chainage.

(2) All test reports, survey documents and other documents produced by the Contractor to indicate that the lot of work complies with the requirements of the relevant Clause of the Specifications shall be marked with this unique lot number. The Contractor shall maintain such lot registers and other forms detailing all lots of work and make it available to the Engineer as and when required by the Engineer. No separate payment will be made for this provision of this lot identification.

105.02.3 Lot Sizes

(1) Maximum lot sizes for acceptance shall be as shown in below table or as otherwise directed by the Engineer.

Table 105.1 – Maximum Lot Sizes

Clearing and Grubbing	1000 linear metres along the centre-line
Cut Sub-grade	600 linear metres along the centre-line
Embankment Fill	400 cubic metres
Embankment Sub-grade	800 linear metres along the centre-line
Sub-base Material	1000 cubic metres as stockpiled or one days production from the central batching plant whichever is the lesser quantity
Completed Sub-base	600 linear metres along the centre-line
Reconditioning of Existing Pavement	600 linear metres along the centre-line
Base Materials	1000 cubic metres as stockpiled or one days production from the central batching plant whichever is the lesser quantity
Completed Base	400 linear metres along the centre-line
Asphalt	One days production from the batch plant or 500 square metres or part thereof whichever is the lesser quantity

105.03 FREQUENCY OF SAMPLING AND TESTING

105.03.1 Sampling

(1) The Contractor shall be responsible for sampling of the product in accordance with the requirements of the Specifications. Sampling, testing and acceptance of materials shall be undertaken on a lot by lot basis. Except with the specific approval of the Engineer all sampling and testing required for a lot shall be carried out concurrently. No completed lot of work will be subdivided into two or more different lots without the specific approval of the Engineer being obtained. In addition to sampling and testing frequency shown in section 105.03.2, minimum 3 set of tests for each source material shall be done before approval of borrow pit for embankment, subgrade, subbase, stone quarry material for base course, surfacing, concrete works and other factory made materials from different source within the country or imported from other country. Contractor shall made necessary arrangements at his own expense so that Engineer can witness the sampling testing for all relevant materials, if he proposes testing of material for which test facility is not available at project laboratory.

105.03.2 Frequency

(1) Minimum test frequencies for a lot of work are as shown in below table or as otherwise specified in the other Sections of the Specifications.

Table 105.2 – Minimum Test Frequencies for a Lot of Work

Cut Sub-grade	3 Tests
Embankment Fill	2 Tests
Embankment Sub-grade	3 Tests
Sub-base material	3 Test
Completed Sub-base	3 Tests
Reconditioning of Existing Pavement	3 Tests
Base material	3 Test
Completed Base	3 Tests
Asphalt	1 Test

(2) Frequencies for work or materials not tabulated above shall be as given elsewhere in the Specifications or as determined/approved by the Engineer.

105.04 TEST METHODS

105.04.1 Embankment and Cut Sub-grade

(1) Complete analysis of the sub-grade material shall be taken at the specified frequency. Every borrow pit or cut, where the material is to be incorporated in the Works, shall be initially tested, with a minimum of three samples per borrow pit or cut, taken at different locations vertically and/or horizontally, except for excavated rock, or at every change of material or as reasonably requested by the Engineer.

(2) The sampling of embankment and cut Sub-grade and shall be taken in-place at Sub-grade level, while for fill material the analysis shall preferably be performed prior to the opening of any borrow pit or cut, but not later than on stockpiled material prior to its hauling.

(3) The complete material analysis shall consist of the following tests:

AASHTO T 11	Material passing 0.075 mm sieve
AASHTO T 27	Sieve analysis
AASHTO T 88	Mechanical analysis
AASHTO T 89	Liquid limit
AASHTO T 90	Plastic Limit and Plasticity Index of Soils
AASHTO T 180	Moisture-Density relationship(4.5kg hammer and 450 mm free fall for top 300mm)
AASHTO T 193	California Bearing Ratio
AASHTO T 265	Moisture content
AASHTO M 145	Classification

(4) The field density and moisture content shall be determined by the following tests for each compacted layer, or as required by the Engineer:

AASHTO T 180	Moisture-Density relationship(4.54kg hammer and 450 mm free fall for top 300mm or material from full thickness of embankment/subgrade)
AASHTO T 191	Density of Soil In-Place by the Sand-Cone Method
AASHTO T 265	Moisture content

(5) There is to be one-to-one correlation between laboratory compaction and field density, unless the Engineer considers the material's maximum laboratory density to be uniform enough to allow laboratory samples to be taken at up to 600 m intervals.

105.04.2 Sub-Base Material

(1) Material to be used as lower sub-base material shall be subjected to the complete analysis specified for embankment with a minimum of three analyses per borrow pit. Aggregate to be used as sub-base material shall be subjected to the complete analysis specified for aggregates in Sub-clause 105.04.4 herein.

(2) The following tests shall be carried out on each compacted layer, or as required by the Engineer:

AASHTO T 11	Material passing 0.075 mm sieve
AASHTO T 27	Sieve analysis
AASHTO T 89	Liquid limit
AASHTO T 90	Plastic Limit and Plasticity Index of Soils
AASHTO T 180	Method D. Moisture-density relationship, 4.54 kg hammer, (but for each day test at approximately 600 m intervals per layer)
AASHTO T 191	Density of Soil In-Place by the Sand-Cone Method
AASHTO T 265	Moisture content

(3) If required by the Engineer the following tests shall be carried out for each compacted layer or as required by the Engineer:

AASHTO T 193 (4 day soaked if no further evidence of swelling)

105.04.3 Base Material

(1) Aggregate to be used as base material shall be subjected to the complete analysis specified for aggregates in Sub-clause 105.04.4 herein.

(2) The following tests shall be carried out for each compacted layer, or as required by the Engineer:

AASHTO T 11	Material passing 0.075 mm sieve
AASHTO T 27	Sieve analysis
AASHTO T 89	Liquid limit
AASHTO T 90	Plastic Limit and Plasticity Index of Soils
AASHTO T 265	Moisture Content
AASHTO T 180,	Method D. Moisture-density relationship, 4.54 kg hammer, (but for each day a test at approximately 400 m intervals per layer)
AASHTO T 191	Density of Soil In-Place by the Sand-Cone Method

The use of AASHTO T 224 to correct for oversize particles may be required.

(3) If required by the Engineer the following tests shall be carried out for each compacted layer or as required by the Engineer:

AASHTO T 193 (4 day soaked if no further evidence of swelling)

105.04.4 Aggregates

(1) Aggregates shall be subjected to a complete analysis prior to the opening of any borrow pit or quarry, or using any stockpile or at the frequency specified in Clause 105.02 of the Specifications, or as required by the Engineer.

(2) A complete analysis shall include the following tests:

AASHTO T 2	Sampling aggregates
AASHTO T 11	Material finer than 0.075 mm sieve
AASHTO T 19	Unit weight and voids in aggregate
AASHTO T 21	Organic Impurities in Fine Aggregates for Concrete
AASHTO T 27	Sieve analysis
AASHTO T 37	Sieve analysis of mineral filler (for asphalt work only)

AASHTO T 89	Liquid Limit
AASHTO T 90	Plastic Limit and Plasticity Index of Soils
AASHTO T 71	Effect of organic impurities in fine aggregate
AASHTO T 84	Specific gravity and absorption of fine aggregate
AASHTO T 85	Specific gravity and absorption of coarse aggregate
AASHTO T 96	Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
AASHTO T 104	Soundness of aggregate by use of sodium sulphate
AASHTO T 112	Clay lumps and friable particles
AASHTO T 182 *	Coating and stripping (for paving work only)
	Chemical analysis of aggregates (if required)
ASTM C295*	Standard Guide for Petrographic Examination of Aggregates for Concrete (if required)
BS EN 933-3	Geometrical properties of aggregates. Particle shape. Flakiness index
BS 812-105.2	Elongation Index

(3) Tests marked with an asterisk (*) may be carried out in an approved independent laboratory.

105.04.5 Cement

(1) Each delivery of cement shall be accompanied by a certificate of guarantee from the supplier or a test certificate from an approved independent laboratory.

(2) The following tests shall be performed on the Site if required by the Engineer:

AASHTO T 106	Compression strength of mortars
AASHTO T 127	Sampling hydraulic cement
AASHTO T 128	Fineness by the 0.075 mm (No. 200) sieve
AASHTO T 131	Time of setting by Vicat needle

105.04.6 Water

(1) The following test shall be carried out for every source and 1,000 m³ of water or as deemed necessary by the Engineer:

AASHTO T 26	Quality of water for concrete
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105.04.7 Concrete

(1) A minimum of six cylindrical specimens shall be taken from every 50 m³ (every 100 m³ for mass concrete) of plant-mixed concrete or for every new construction part or as required by the Engineer. Slump tests shall be taken for each site batch delivered. Site batch delivered is the total load delivered in a vehicle when the concrete is batched remote from the work site, or, each batch produced by a concrete batcher when site batchers are set up at the work site.

AASHTO T 22	Compressive strength
AASHTO T 23	Making and curing specimens in the field
AASHTO T 119	Slump
AASHTO T 121	Unit weight
AASHTO T 126	Making and curing laboratory specimens
AASHTO T 141	Sampling freshly mixed concrete
AASHTO T 231	Capping cylindrical concrete specimens
AASHTO T 97	Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)

(2) Tests may also be required with respect to the compressive strength of concrete by means of taking cores from the finished structure conforming to AASHTO T 24 and T 148 as directed by the Engineer at the cost of the Contractor. For this procedure the Contractor shall provide a core drilling machine, adaptable to take 150 and 100 mm cores from the concrete.

105.04.8 Conformance

(1) Material within a lot shall not be incorporated into the Works until the material has been shown to conform to the requirements of this specification.

105.04.9 Steel Reinforcement

- (1) Each delivery shall be accompanied by a certified mill test report and a certificate of compliance signed by the manufacturer.
- (2) If required by the Engineer further tests shall be conducted at an approved laboratory in the Lao PDR or neighbouring country when a specific test facility is not available in Lao PDR and at the cost of the Contractor.

105.04.10 Bitumen

- (1) Each delivery shall be accompanied by a certified test report and a certificate of compliance from the manufacturer.
- (2) The following tests shall be performed in the main laboratory on the Site, when required by the Engineer:

AASHTO T 40	Sampling bituminous materials
AASHTO T 47	Loss on heating
AASHTO T 49	Penetration

105.04.11 Density Testing

- (1) All density testing is to be carried out on a lot by lot basis with the basis of acceptance being the characteristic value of the lot. In addition to In-Situ density tests by Sand Replacement Method (AASHTO T 191), the Characteristic Impact Value of completed work has to be checked to confirm the strength of the layer tested as per value specified in relevant work items.

- (2) The characteristic impact value (CIV) of the lot is defined as:

$$\text{Characteristic Impact Value (CIV)} = \bar{X} - k_2 \times S$$

$$\text{Where } \bar{X} = \frac{1}{n} \times \sum_{i=1}^n X_i$$

$$\text{and } S = \sqrt{\frac{\sum_{i=1}^n [X_i - \bar{X}]^2}{[n - 1]}}$$

Where X_i is the individual Relative Dry Density for $i = 1, 2, 3 - n$

That is \bar{X} is the mean of the lot of density results

S is the sample Standard Deviation

And k_2 is an acceptance constant dependant on the number of tests or measurements. The relevant value of k_2 is selected from the table below:

Table 105.3 - Acceptance Constants (k_2) for CIV Calculations

Number of Tests	k_2	Number of Tests	k_2
2	0.511	10	1.017
3	0.639	11	1.041
4	0.743	12	1.063
5	0.818	13	1.081
6	0.875	14	1.099
7	0.920	15	1.114
8	0.958	20	1.175
9	0.990	25	1.250

Where the appropriate value for k_2 cannot be selected from above table then the Engineer shall determine an appropriate k_2 to be used in the calculation.

(3) Where the characteristic value of the lot is less than that specified in the relevant Clause of the Specifications, then all material covered by that lot shall be rejected, and the Contractor at his own expense shall carry out such additional rework and testing as is necessary to ensure that the characteristic value of the lot complies with the requirements of the relevant Clause of the Specifications.

(4) The method of testing will be determined by the Engineer

105.04.12 Non-Compliance Reports

(1) Where any test, survey, or any other inspection indicates that the lot of work does not comply with the requirements of the relevant clause of the Specifications, the Contractor shall submit a non-compliance report to the Engineer detailing his proposed method of rectification and remedial actions necessary to prevent further reoccurrence. Approval of the Engineer shall be obtained before any rectification or remedial actions are carried out.

(2) Non-compliant work shall not be covered up or in any way proceed until approval of the remedial and preventative actions is gained and carried out to the satisfaction of the Engineer. Where such approval is not gained, or remedial works are not to the satisfaction of the Engineer, then the Contractor shall carry out such works as are necessary in the opinion of the Engineer to comply with the requirements of the relevant Clause of Specifications at his own cost.

(3) The Contractor shall submit for approval a pro-forma of the proposed non-compliance report, and shall make available to the Engineer wherever requested all non-compliance reports together with the register of the same which shall be maintained by the Contractor.

(4) The Contractor shall nominate a person who has suitable authority to administer the non-compliance reports. This person shall have sufficient authority over the Contractor's staff to ensure that the remedial and preventative actions as approved by the Engineer are carried out. Where in the opinion of the Engineer this person is not carrying out these duties satisfactorily, then the Contractor shall replace this person.

(5) No separate payment will be made for this provision of the non-compliance reports.

105.05 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
105-1	Provision of Main Laboratory	Lump Sum
105-2	Maintenance of Main Laboratory	Month
105-3	Provision of Mobile Laboratory	Number
105-4	Maintenance of Mobile Laboratory	Lab-month
105-5	Provision of Audit Laboratory	Number
105-6	Maintenance of Audit Laboratory	Lab-month
105-7	Acceptance Testing	Month
105-8	Providing Full Time Laboratory Technician	Month
105-9	Providing Full Time Laboratory Assistant	Month

(2) For items 105-1 and 105-5 the items' description shall be as shown if permanent construction is to be used, and noted as "(Semi-permanent Construction)" or "(Prefabricated Module Construction)", as appropriate, if other construction is required.

(3) Item 105-7 shall be provisional and shall be invoked only where the Contractor proposes to sub-contract all acceptance testing to independent laboratories. In any other situation the costs of acceptance testing shall be included in items 105-2 and 105-4.

(4) Item No. 105-8 shall be provisional. Contractor shall provide full time qualified, experienced and capable Laboratory Technician approved by the Engineer to work in the Engineer's Laboratory, a facility provided by the contractor under pay item 105-1.

(5) Item No. 105-9 shall be provisional. Contractor shall provide full time experienced Laboratory Assistants approved by the Engineer to work in the Engineer's Laboratory, a facility provided by the contractor under pay item 105-1.

105.06 PAYMENT

(1) Payment for all work items required by this Section of the Specifications will be made at the unit rates and lump sum prices entered in the Bill of Quantities which rates will be full compensation for all specified items and activities. Provision for 105-1, 105-3 and 105.5 shall include supply of approved quantity and quality of laboratory equipment as specified and approved by the Engineer.

(2) Payment for Item 105-1 will be made in instalments corresponding to the state of completion of the Main Laboratory. Completion shall be deemed to include all fixtures, fittings, equipment, furniture, and all items necessary to constitute a fully operational laboratory facility. Payment shall include for equivalent temporary facilities as specified/required, and for the cleaning, repair and re-painting and for hand-over to the Employer

(3) Payment for Items 105-3 and 105-5 shall be made when the laboratories are accepted by the Engineer, and shall include for furniture, fittings, equipment, and all incidental items as specified or required. Payment shall also include for cleaning, repair and repainting and hand-over to the Employer.

(4) Payment for Item 105-3 shall also include the costs of moving the mobile laboratory, or laboratories, to alternative locations during the execution of the Works. Such moves shall be carried out in an efficient manner to cause the minimum of inconvenience.

(5) Payment of Items 105-2, 105-4 and 105-6 shall include for all maintenance, supplies, utilities, cleaning and all other work/requirements specified or implied to maintain each laboratory in a condition and in an operational state acceptable to the Engineer. Payment shall commence on the date that the Engineer accepts or occupies (whichever is the earlier) each laboratory until the date the Engineer hands the laboratory to the Contractor to carry out the specified cleaning, repair and re-painting prior to hand-over to the Employer, which dates shall be recorded in writing by the Engineer and agreed by the Contractor.

(6) Where in the opinion of the Engineer, the condition or operational state of any facility, at any time, is unacceptable, the Engineer may reduce the monthly payment by such amount(s) as the Engineer considers appropriate taking into consideration all factors pertaining to the condition and state of the laboratory and the period of non-acceptability.

(7) Payment for Item 105-7 shall commence at from the time the first acceptance test is required until the end of the Contract Period.

SECTION 106

PERMANENT BUILDINGS

106.01 GENERAL

(1) The provisions of this Section indicate basic standards and quality requirements for the construction of all permanent buildings which are to become the property of the Employer upon completion of the Contract.

(2) Any details regarding construction or quality of materials or workmanship not specifically mentioned shall be regarded as meaning that good engineering practice is to be used, to the satisfaction of the Engineer.

106.02 EXCAVATION, FILLING AND GRADING

106.02.1 Excavation

(1) Building footings shall be laid over soil of approved bearing capacity at least 500 mm below natural ground with the finished floor a minimum of 300 mm above natural ground. Foundation material shall be inspected and approved by the Engineer before any concrete is placed.

(2) Excavation for footings may be cut to accurate sizes and the side forms omitted, if concrete can be poured without earth cave-ins or moisture/grout loss. Excavation for foundation walls shall be of sufficient width to permit erection and removal of conventional double forms. Excavation or fills for floor slabs shall be made or constructed to sub-grade elevation.

(3) Over-depth excavation resulting from any cause, including removal of unsuitable material as ordered, shall be backfilled as follows: Over-depth excavation 50 mm or less below sub-grade elevations shall be backfilled with concrete; over-depth excavation of greater depth may be corrected by backfilling (with approved suitable material) as specified for earth fill and backfill within the limits of building construction.

106.02.2 Earth Fill and Backfill inside Building Limits

(1) Earth fill and backfill within the limits of building construction shall be select, clean, moist earth, obtained from excavation for the building or from borrow, placed in uniform layers, properly moistened to approximate optimum requirements and thoroughly compacted to at least 90 MDD.

(2) Wherever practical fills and back fills shall be rolled with power equipment and shall be placed in uniform layers not to exceed 200 mm in depth. Fills and backfills which have be hand-tamped shall be placed in layers not to exceed 100 mm in depth.

106.02.3 Backfill Outside Building Limits

(1) Backfill or excavations outside the limits of the building or entrance slabs shall consist of suitable material, moistened and compacted to a density not less that of adjacent undisturbed earth and such that no further settlement or shrinkage will occur.

(2) Backfills under slabs, walks and similar permanent construction shall be placed and compacted as specified for backfills within the building limits.

106.02.4 Grading

(1) The construction site shall be graded to uniform slopes, conforming to existing adjacent contours. It shall be properly drained without ponding, and shall present a neat and workmanlike finished appearance. All excess and unsuitable materials shall be removed from the site and all ruts, holes and depressions caused by construction activities shall be graded to match adjacent surfaces.

(2) During construction, the Contractor shall control grading in the vicinity of buildings so the ground surface is properly pitched to prevent water from running into excavated areas. Water entering excavated areas shall be removed, the excavation dried out, and the sub-grade re-compacted to its proper bearing capacity.

106.03 CONCRETE WORK

106.03.1 General

(1) Concrete shall consist of cement, coarse aggregate, fine aggregate, and water, proportioned and mixed to produce a plastic workable mixture suitable to specific conditions of placement.

(2) All reinforcement and embedded items shall be installed and secured in place to achieve the required cover by ties, nails or supports prior to placing concrete.

106.03.2 Strength of Concrete

(1) Concrete shall have an average minimum 28-day strength of 20 MPa, or as directed by the design or the Engineer. The strength shall be determined in accordance with AASHTO T 22 and T 23.

(2) Operating mixes shall be adjusted if the 7-day strength falls below 75 % of the specified 28-day strength. Water-cement ratios and cement contents shall fall within specified ranges.

(3) Concrete made from rapid-hardening cement shall have a 7-day strength not less than the specified minimum 28-day strength for standard Portland cement concrete.

106.03.3 Sampling and Testing

(1) All materials shall be subject to testing and inspection prior to incorporation, and all samples and test specimens shall be truly representative of material proposed to be furnished. The Contractor shall furnish and provide all samples and test specimens required.

(2) Test cylinders shall be taken as work progresses, at such intervals as to represent the whole structure. They shall be made, cured and tested in accordance with AASHTO T 22 and T 23 at an approved laboratory at the cost of the Contractor.

106.03.4 Concrete Quality

(1) The materials, mixes, placement, finishing and curing of concrete used shall meet the requirements for concrete work given in Section 500 of the Specifications, except that the steel reinforcement need not be deformed.

106.03.5 Reinforcement

(1) All concrete shall be reinforced with reinforcing bars or mesh according to a qualified engineer's design to provide the necessary strength and to control cracking.

(2) Minimum reinforcement in slabs shall be 200 mm²/m in each direction.

106.04 MASONRY WORK

106.04.1 Masonry Materials

(1) Exterior walls shall be 200 mm x 200 mm x 490 mm, -or any other dimensions as directed by the design or the Engineer-, hollow load-bearing masonry units or equal approved.

(2) Interior walls shall be 150 mm x 200 mm x 490, -or any other dimensions as directed by the design or the Engineer-, mm hollow load-bearing masonry units or equal approved.

(3) The masonry material shall comply with ASTM C90.

(3) All masonry units must be approved for strength and conformity before they are incorporated in the Works.

(4) At the Contractor's option lintels may be either pre-cast or cast in-place. The concrete and steel used in lintel construction shall be as specified in Section 500 of the Specifications.

106.04.2 Mortar Materials

(1) Cement for mortar shall be Portland cement conforming to AASHTO M 85 (Type I), or masonry cement consisting of an inter-ground mixture of Portland cement clinker and limestone conforming to ASTM C150 (Type II).

(2) Hydrated hydraulic lime shall comply with ASTM C141, and at least 92% of the lime shall have been hydrated.

(3) Quick-lime shall comply with ASTM C5, all passing a 0.850-mm sieve.

(4) Lime putty shall consist of quick-lime or hydrated lime mixed with water to a stiff consistency. Putty made from quick-lime shall be slaked and allowed to soak not less than 72 hours before use. Putty made from hydrated lime shall be used immediately. Quick-lime putty shall be maintained moist until used.

(5) Sand shall be clean and sharp, free from loam, acids, alkalis, soluble salts and organic matter in injurious amounts. The gradation shall be such that 100 % will pass the 2.36-mm sieve and not more than 35 % will pass the 0.300-mm sieve.

(6) Water shall be potable and shall be free from oil or strong acids, alkalis and organic matter.

106.04.3 Mortar Proportions

(1) Mortar proportions shall be by volume. Mortar shall be one part Portland cement, one part lime putty or hydrated lime, and six parts clean sand, or one part masonry cement to the proportion of clean sand recommended by the cement manufacturer.

106.04.4 Laying Masonry Units

(1) All masonry work shall be constructed plumb, square and with level courses all carried up together. No portion of any wall shall be extended more than 1.50 metres above adjacent work and, in every case shall be racked back to insure proper connection of following work.

(2) Concrete masonry units shall not be wetted before laying. All metal work shall be built-in as the work progresses, and suitable recesses shall be provided for built-in work or for installation of equipment and fixtures. Each masonry unit shall be shoved into a full bed of unfurrowed mortar and all joints filled, leaving no voids. Joints shall be struck flush. Special care shall be used in laying masonry units to keep mortar off the face of units and out of wall cavities.

(3) Mortar that falls and is trapped between scaffold members and walls shall be removed daily. Tops of unfinished walls exposed to weather shall be kept covered at all times when work is not in actual process, and all masonry work shall be protected. Upon completion of the work, exposed joints shall be pointed and the wall face cleaned down.

(4) Concrete masonry units shall have uniform joints, not more than 14 mm thick. Units shall be laid in common bond. Units shall be properly bonded at corners, connections and intersections. Concrete brick shall be used for bearing courses to maintain proper coursing and where standard size block units cannot be used. All joints shall be struck flush.

(5) Where masonry units must be cut to accommodate pipe, conduits, electrical switches or convenience outlets, and adjoining materials, all cuts shall be made with carborundum masonry saws. Space around all pipes extending through walls and partitions shall be tightly caulked. Vertical joints, where masonry abuts concrete columns and walls, shall be plumb with blocks carefully sawed on ends and joints raked out and caulked.

106.04.5 Curing

(1) Each section of completed masonry work shall be continuously sprayed or otherwise wet down in order to remain in a moist condition for a period of not less than 3 days, or as otherwise directed by the Engineer.

106.05 PLASTERING

106.05.1 General

(1) All exterior and interior masonry wall surfaces shall receive a plaster finish. In lieu of plaster, all exterior building walls may be stuccoed. The minimum thickness of plaster shall be 14 mm where applied directly to concrete. All plaster work shall be 2 coats.

(2) Plaster materials shall be standard products of manufacturers approved by the Engineer. Sand shall conform to ASTM C35.

106.05.2 Mixing of Plaster

(1) Scratch coat for direct application on concrete shall be bond plaster mixed in strict accordance with the manufacturer's instructions.

(2) Gypsum plaster shall be 1 part gypsum neat plaster to 3 parts sand by weight.

106.05.3 Application of Plaster

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

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

(3) Gypsum plaster finish shall be applied only after the scratch coat has set and seasoned. The scratch coat shall be evenly dampened by use of fog spray prior to application of finish coat. The finish coat shall be first floated to a true and even surface then trowelled leaving the surface burnished smooth, free of rough areas, trowel marks or other blemishes.

106.05.4 Patching

(1) Patching of plaster shall match existing work in texture and finish, and shall finish flush and smooth at joint with previously applied work.

106.06 ACOUSTICAL AND INSULATION TREATMENT

106.06.1 General

(1) Acoustical treatment shall consist of acoustical ceiling tiles installed on a suspension system. Insulation treatment shall consist of thermal insulation placed above the ceiling tiles.

106.06.2 Materials

(1) Acoustical tiles shall be finely-fissured surface, mineral tile units, nominal size 20 mm x 300 mm x 300 mm, with noise reduction coefficients within the ranges of 0.7 to 0.8 for suspended application. Units shall have square edges and a white factory finish. Units shall be kerfed for concealed splines.

(2) Insulation shall be fibreglass batt or blanket with a paper vapour barrier, at least 7.5 mm thick.

106.06.3 Installation

- (1) Acoustical units shall be laid out in a square pattern symmetrical about the centrelines of each room space, or panel. During installation, the joints around electric outlets, ducts, pipes and other work extending through the acoustical treatment shall be sealed tight with plastic caulking compound.
- (2) Following completion of the acoustical treatment, joints shall be straight and true to line, and the exposed surfaces shall be flush and level.
- (3) Wood moulding shall be used at intersections of units with walls and beams. All wood components exposed in the finished installation shall be painted white.
- (4) Insulation material shall be stapled or tacked to the upper side of the suspension system prior to the installation of the ceiling tile.

106.06.4 Cleaning

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

106.07 CERAMIC TILE WORK

106.07.1 General

- (1) All interior floors shall consist of ceramic floor tiles. Ceramic tile wall finishes shall be installed at locations directed by the Engineer. Samples of tile to be furnished shall be submitted to the Engineer for approval of quality, colour, finish and texture. Floor tiles shall not be slippery (wet or dry).
- (2) Where wall tiles are not required; floor tiles shall cover the bottom 150 mm of the wall.

106.07.2 Installation of Floor Tiles

- (1) Patterns shall be laid out to permit setting of tiles with a minimum of cutting. Floors shall be laid out from one side and end, with adjustment made at opposite walls. Dimensions shall be controlled to avoid setting tiles smaller than one-half size.
- (2) Floor tiles shall be installed according to standard industry practice. For all floor tile areas, straight-edges shall be set to the lines established and re-set at suitable intervals to keep the joints parallel over the entire area. Tiles shall be laid to the straight-edges. The tile layout shall eliminate cut tile to the greatest extent possible. Fractional changes in dimensions without varying the uniformity of joint widths will be permitted. Where tile cuttings is required, tiles shall be cut with a suitable cutting tool and rough edges shall be rubbed smooth. Cut tile misfits shall be replaced with properly cut tiles.
- (3) Grouting of floor tiles shall not be done until the setting bed has hardened sufficiently. The joints shall be completely filled with grout by screeding and brushing grout over the tile until joints are thoroughly filled. All excess grout shall be removed. Not less than 48 hours shall elapse before ordinary foot traffic is permitted on the floor. Grout shall be a thick, soupy mix of neat waterproofed Portland cement.

106.07.3 Protection of Floors

- (1) Before foot traffic is permitted over finished tile floors, the floors shall be covered with building paper. Board walkways shall be laid on floors to be continuously used as passageways by workers. Tiled floor areas to be trucked over shall have suitably constructed continuous plank runways of required width placed over the building paper. Cracked, broken, or damaged tile shall be removed and replaced.

106.07.4 Installation of Ceramic Wall Tiles

- (1) Joints shall be straight, level, perpendicular and of even width. Vertical joints shall be maintained plumb for the entire height of the tile work. Tiles that are out of true plane or misplaced shall be removed and reset. Damaged or defective tile shall be replaced.
- (2) Joints in ceramic mosaic wall tiles, after the edges of tiles have been thoroughly wet, shall be grouted full with a plastic mix of neat, white, waterproofed Portland cement immediately after a suitable area of tile has been set and the dry set mortar has cured sufficiently to maintain the tile in place.
- (3) Joints shall be tooled slightly concave and the excess mortar shall be cut off and wiped from the face of tile. Interstices or depressions in the mortar joints after the grout has been cleaned from the surface shall be roughened at once and filled to the spring line of the cushion edge before the mortar begins to harden.
- (4) Immediately after the grout has taken its initial set, wall surfaces shall be given a protective coat of non-corrosive soap or other approved material and joints shall be damp-cured for a minimum of 72 hours.

106.07.5 Cleaning of Tiles

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

106.08 CARPENTRY AND MILLWORK

106.08.1 Lumber Materials

- (1) Lumber shall be of good quality and of the type required for its specific use. Quality, type and size must be approved by the Engineer prior to installation in the building.

106.08.2 Doors and Windows

- (1) All wooden doors and windows shall be of a size, thickness and type approved by the Engineer and shall be fabricated in accordance with high quality standards. Hardware shall be furnished and installed as approved by the Engineer. Doors and windows shall be hung and fitted so as to be free acting without binding. Screen doors and windows shall be bug-tight.
- (2) Windows shall be fitted with external fine mesh fly screens and locking devices as standard by the manufacturer. Internally, all windows shall have fitted palmers and curtains with the exception of bathrooms, which shall have translucent “non-see-through” glass.
- (3) External doors shall also be fitted with an additional outside screen door of a standard type made of wood with fine mesh, which shall be complete with all necessary fittings and a silent automatic closing device.

106.08.3 Cabinet Work

- (1) All items of cabinet work including cabinets, cases, casework, bookcases, desks, counters, lockers, shelving and miscellaneous cabinet work items shall have solid stock facing and frames with tongue and groove or dovetailed joints.
- (2) The bottoms of drawers shall be plywood or pressed wood inserted in closely fitting grooves and tacked in place. Drawers shall be provided with rabbited sides to slide on hard wood cleats.
- (3) Surfaces designated to receive laminated plastic shall be covered with general-purpose, acid-resistant, alcohol-proof, wear-resistant, laminated plastic with a nominal thickness of 1.6 mm of the manufacturer's standard pattern and colour as selected by the Engineer.

(4) Plastic covering shall be cemented in place with waterproof cement in accordance with the manufacturer's recommendations and good trade practice. Plastic trim and splash backs shall be provided for edges and openings in counters receiving plastic protection tops. Sink openings shall be cut in countertops and shall conform to dimensions required by the plumbing fixtures to be installed.

106.08.4 Millwork and Trim

(1) Doors, windows, and other finish lumber and trim shall be kiln-dried or air-seasoned at the mill to a maximum moisture content of 10 % and shall be protected from moisture thereafter.

(2) All finish wood shall be sanded smooth for painter's finish. Where practicable work shall be assembled and finished at the mill. All millwork and trim shall be finished smooth and free from machine or tool marks that will show through the finish. All nail heads shall be set to receive putty. All joints shall be tight and formed to conceal shrinkage. Shop mitres 100 mm or more from heel to point shall be glued and locked.

106.08.5 Hardware

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

106.08.6 Building Keys

(1) The Contractor shall hand over at least 3 keys for all locks to the Engineer upon completion of the buildings. At least 4 keys shall be supplied for each lock in entrance doors to housing units, and 10 keys for each lock in entrance doors to main offices and laboratories.

106.09 PAINTING AND FINISHING

106.09.1 General

(1) Exterior walls shall receive 1 coat of lime-proof sealer and 2 coats of high-quality, flat exterior latex paint.

(2) Interior walls shall receive 1 coat of lime-proof sealer and 2 coats of high-quality, flat interior latex paint except for kitchen and bathroom walls which shall be painted with 2 coats of high-quality, semi-gloss enamel paint.

(3) Woodwork, trim, cabinets, etc., shall receive 1 coat of primer and 2 coats of high-quality, semi-gloss enamel paint.

106.09.2 Paint Materials

(1) All paint shall be approved by the Engineer and shall be products of reputable manufacturers. All paint shall be ready-mixed and delivered to the site in the manufacturer's sealed containers. Thinning shall be done only in accordance with the direction of the manufacturer. Job mixing or job tinting will not be permitted.

106.09.3 Colours and Samples

(1) Colours will be selected by the Engineer. The Contractor shall submit job samples of the different kinds of finishes and colours and, after the samples have been approved, all work shall be finished to match the approved samples.

106.09.4 General Requirements

- (1) Paint shall be spread on evenly and brushed out. Enamel shall be spread on evenly and show no sags or runs. During painting operations all surrounding surfaces shall be adequately protected from splattering and dripping of paint, and any damage occurring to other work shall promptly be made good.
- (2) Paint shall not be applied when conditions are such that wind-blown dust, dirt, debris, or insects will collect or adhere to the freshly applied paint or finished surfaces.

106.09.5 Preparation of Surfaces

- (1) Wood shall be sand papered to a smooth even surface and then dusted off. After primer has been applied, nail and other holes and cracks shall be thoroughly filled using plastic wood filler or putty for painted work. Knots and sap spots in wood to be painted shall be given a thin coat of shellac before priming. The prime coat may be omitted for specific paints which do not require a primed surface.
- (2) Plastered surfaces to be painted shall not be sand papered. Paint or sealer shall not be applied on plaster that is not thoroughly dried out and cured. Cracks and holes shall be repaired with patching plaster, properly keyed to existing plaster, and finished smooth.
- (3) Grease, oil and dust shall be removed from concrete and concrete masonry surfaces.

106.09.6 Painting

- (1) All finish carpentry and millwork shall receive 1 coat of primer and 2 finish coats of semi-gloss enamel, except for wood items in closets and storage rooms which shall receive 1 coat of primer and 2 coats of flat oil paint or as otherwise required to match adjacent surfaces.
- (2) For plaster, the first coat shall be lime-proof sealer. The second and third coats in toilet rooms and kitchen shall be semi-gloss enamel paint. In other areas, the second and third coats shall be latex base paint.
- (3) Concrete and masonry units shall be primed with 1 coat of lime-proof sealer and finished with 2 coats of flat latex base paint.

106.10 GROUND IMPROVEMENTS

- (1) Gravel walks and driveways shall be of screened or natural gravel, as approved by the Engineer. The thickness of the surfacing shall be that required to eliminate dust conditions for the particular camp site selected. The minimum thickness shall in no case be less than 150 mm.

106.11 ELECTRICAL FACILITIES

106.11.1 General

- (1) Electricity shall be provided by the Contractor 24 hours per day for the duration of the Contract and shall be 220-volt, 50-cycle, single-phase.

106.11.2 Sockets and Plugs

- (1) All rooms shall have a minimum of two electrical plug sockets, three for offices, over and above any sockets required on a separate circuit, on which will be service the air conditioning, ventilation units and refrigeration units.
- (2) Sockets shall be of an approved standard type fully insulated and earthed. Socket units fitted in bathrooms shall also be fully water-proofed and steam resistant.
- (3) Electrical plugs shall be provided as required by the Engineer.

106.11.3 Power Supply

(1) In order to provide continuous service, and in case of emergency, and notwithstanding that the camp may be connected to the local electricity supply, the Contractor shall provide, maintain, and operate 2 generators on stand-by. The generators shall be housed in a separate building, well away from the Engineer's office and housing.

106.11.4 System

(1) The Contractor shall submit to the Engineer for approval plans and details for the electrical system of the camp. The plans shall include supply, circuitry, fusing, wire size and type, grounds, etc., necessary to provide basic and safe electrical services.

106.12 WATER SUPPLY AND PLUMBING

106.12.1 General

(1) The Contractor shall provide and maintain an adequate and continuous supply of pure filtered water for the entire facilities.

(2) Prior to use, the source(s) of water proposed shall be tested by the Contractor for purity and approved by the Engineer. The Engineer may at any time he deems necessary direct the Contractor to re-test the water source(s). All testing of the water source(s) shall be at the Contractor's cost.

106.12.2 Storage

(1) The Contractor shall construct an approved storage tank of ample capacity for the needs of the entire facility. The elevation of the storage tank shall be set to provide the distribution system with an operating pressure of 100 kPa.

(2) In addition, the Contractor shall for each housing unit provide an emergency water supply, consisting of a water tank of 2000 litres capacity set at roof height (but not directly on the roof). The emergency system shall have valves and bypasses so it may be divorced from the main distribution system in case of a contamination emergency. Each of the storage facilities shall have an electric pump and riser for filling.

106.12.3 Distribution System

(1) The Contractor shall submit to the Engineer, for his approval, plans, and details for the water distribution system for the Engineer's facilities. The plans shall include details of the storage tank, piping diagrams, pipe sizes, etc., and meet the following minimum basic criteria:

- (a) The main supply line from the water tower to the building area shall have a minimum internal diameter of 75 mm.
- (b) The supply system within the building area shall have a minimum internal diameter of 50 mm.
- (c) Water lines shall not be placed within 5 metres of a sewer line and under no circumstances shall a water line cross above or below a sewer line.

106.12.4 Testing

(1) The water distribution system shall be tested for acceptance under the supervision of the Engineer. The test procedure shall be as follows:

- (a) The Contractor shall place the system under a pressure equal to the ultimate operational pressure for a period of 8 hours.
- (b) All leaks shall be repaired and the system re-tested.
- (c.) Tests for acceptance may be conducted on each of the individual parts of the system and need not necessarily include the entire system at one time.

- (d) Tests shall be conducted prior to the plastering over or otherwise covering up of the piping to be tested.
- (e) Untested piping which has been covered up, shall if the Engineer so requires be re-exposed for testing.

106.12.5 Plumbing and Fixtures

(1) Plumbing shall be done in a neat workmanlike manner. Fixtures shall be of high quality and of a size and type approved by the Engineer. Fixtures shall be approved by the Engineer prior to their installation. Fixtures broken or damaged during installation shall be replaced. On completion of the plumbing work, the Contractor shall clean all fixtures to the satisfaction of the Engineer.

106.13 WASTE DISPOSAL

106.13.1 General

(1) The Contractor shall provide and maintain adequate septic tanks and sewage disposal systems. He shall also provide garbage and trash removal service at least once daily.

106.13.2 Septic Tanks

(1) The Contractor shall construct an adequate number of septic tanks. All septic tanks shall be constructed well away from the Engineer's office and housing and in no case shall be less than 15 m from any building. There shall be no odours from any sewage disposal facility.

(2) The Contractor shall be responsible for cleaning the septic tanks when in the opinion of the Engineer it is necessary. Outfall laterals shall be installed as appropriate. Tanks and lateral systems shall be plainly marked and vehicles shall be prevented from driving over them.

106.13.3 Sewer System

(1) The Contractor shall submit to the Engineer for his approval, plans and details for an adequate sewer system. The plans shall include piping diagrams, clean out locations, venting, traps, etc.

(2) Horizontal sewer lines within the buildings shall be minimum 150 mm inside diameter, cast iron soil pipe and have a slope of between 1 % minimum and 3 % maximum. The lines shall be supported or anchored at intervals not to exceed 3 m.

(3) Horizontal sewer lines outside the buildings shall be a minimum 150 mm inside diameter cast iron soil pipe and have a slope of between 0.6 % minimum and 2 % maximum.

(4) Outfall laterals shall be perforated concrete pipe with a minimum internal diameter of 150 mm, and shall have a slope of between 0.2 % minimum and 0.4 % maximum.

(5) Adequate vents and clean outs shall be included in the system. All drains and fixtures shall be adequately trapped from sewer gas.

(6) Sewer lines shall be joined only by "Y" connections. "T" connections shall not be used.

106.13.4 Testing

(1) The sewer system shall be tested for acceptance under the supervision of the Engineer. The test procedure shall be as follows:

- (a) The Contractor shall place the sewer lines system under 1 metre of head above the highest drain for a minimum period of 4 hours.
- (b) Any leaks shall be repaired and the system re-tested for approval. The encasement of a leaking joint in concrete shall not be accepted as repair.

- (c) Tests for acceptance may be conducted on each of the individual parts of the system and need not necessarily include the entire system at one time. The test pressure for a section shall however be that which would be experienced by that section of the system as a whole was tested.
- (d) Tests shall be conducted prior to the covering up of any portion of the system.
- (e) Untested piping which has been covered up shall be re-exposed for testing.

106.13.5 Plumbing and Fixtures

- (1) Plumbing shall be done in a neat workmanlike manner. Fixtures shall be of high quality and of a size and type approved by the Engineer. Fixtures shall be approved by the Engineer prior to their installation. Fixtures broken or damaged during installation shall be replaced. On completion of the plumbing work, the Contractor shall clean all fixtures to the satisfaction of the Engineer.

106.14 MEASUREMENT AND PAYMENT

- (1) No measurement or payment will be made under this Section 106.

SECTION 107

GENERAL ENVIRONMENTAL AND SOCIAL IMPACT REQUIREMENTS

107.01 GENERAL REQUIREMENTS

- (1) The Works are required to be carried out with a minimum of disruption to the environment and minimum negative impact on the socio-economic conditions of the local population along and adjacent to the alignment corridor. Contractor's vehicle operators shall operate their vehicles taking into account their own safety as well as the safety of all other road users. The contractor shall install all necessary temporary traffic signs as well as providing staff when needed for up-keeping the road safety during the contractual works.
- (2) The Contractor shall comply with all the laws of Lao PDR and with the relevant published , Ministry of Public Works and Transport (MPWT), and Ministry of Natural Resources and Environment (MONRE) environmental-, social impact- and resettlement guidelines. Decree No. 122/PM, 2010 and PM Decree No. 84/NA on the Compensation and Resettlement (2016) shall be complied with, together with the respective project's EMP.
- (3) When required by international financiers, their respective safeguard policies shall be complied with. When seen feasible, the application of the more stringent international guidelines and standards shall be considered for any project, regardless of the financier.
- (4) A Contractor Environmental Management Action Plan (CEMAP) shall be prepared incorporating proposals concerning the implementation, management and monitoring of the proposed environmental components of the project. The Plan shall comply with the requirements of the Environmental Management Plan that applies to the Contractor. The content of Environmental Management Plan is included in the IEE/ EIA Report and the updated Environmental Management Plan will be given to the Contractor at the Commencement Date of the Contract.
- (5) Reference shall be made to Clause 102.06 of the Specifications for the general requirements for environmental control for the Contract.
- (6) The following Sub-clauses highlight certain of the more critical mitigation measures which are to be adopted. The listing does not include every requirement of the Specifications.

107.02 CLEARING AND GRUBBING/TREE AND SHRUB REMOVAL

- (1) Clearing and grubbing shall be limited to the minimum possible extent compatible with undertaking the Works, and in no case will excessive clearing and grubbing be allowed. The extent of clearing and grubbing shall comply with the EMP and will be subject to the approval of the Engineer as will the trees and shrubs to be removed and those to remain and be protected by the Contractor.
- (2) No tree or substantial shrub or bush or part thereof shall be removed without the approval of the Engineer, and salvage logging shall be strictly prohibited.
- (3) Wherever large trees or substantial shrubs/bushes would have to be removed to allow construction of the Works, the Engineer and the Contractor will carry out a joint survey to establish whether it would be possible to locally realign the road or provide protection structures to maintain such trees and shrubs/bushes.
- (4) Every effort shall be made to retain existing ground cover/vegetation as close to the edge of the road as possible (subject to sight distance requirements) and to maintain any existing cover over the roadway. Low-hanging, unsound and unsightly branches shall only be removed where specifically approved by the Engineer.
- (5) Reference shall also be made to Section 201 of the Specifications.

107.03 QUARRIES

(1) Quarries shall not be located in National Biodiversity Conservation Areas (NBCAs), Provincial or district protected areas, pristine forests or other ecologically sensitive areas, nor shall they be sited on agricultural land (particularly paddy land), nor, unless so approved by the Engineer, shall they be sited such that they are visible from the road or from potential tourist routes/sites after completion of the Works.

(2) Access roads to quarries shall, wherever possible, be routed to avoid villages and shall have the minimum practical impact on the environment. Where it proves impractical to avoid routing an access road through or immediately adjacent to a village, the Contractor shall, at his own cost, surface seal the road (by an approved method) through and in the vicinity of the village to minimise dust nuisance, and shall institute necessary safety measures, such as strictly controlled speed limits, and shall advise his drivers/operators and those of his Sub-contractors on a regular basis of the need to exercise extreme care when driving through villages and especially in areas where children and other pedestrians are likely to use the road.

(3) Reference shall also made to Sub-clause 103.03.3 of the Specifications.

107.04 BORROW AREAS (PITS)

(1) Unless specifically approved otherwise in writing by the Engineer, the same conditions shall apply to borrow areas as those outlined above for quarries.

(2) Reference shall also be made to Clause 203.06 of the Specifications.

107.05 CONTRACTOR'S FACILITIES

(1) The Contractor shall ensure that his Facilities are not located within or adjacent to any National Biodiversity Conservation Area, Provincial or district protected area, pristine forest or other ecologically sensitive area.

(2) The location, construction and operation of the Contractor's Facilities which shall be approved by the Engineer, shall at all times be such as to ensure the minimum of environmental and social intrusion/impact, and the Contractor shall ensure that his employees and those of his Sub-contractors are advised on a regular basis of the need to operate the Facilities in an environmentally and socially friendly manner. The Contractor shall apply good environmental management to his facilities, including but not limited to the sanitation system, waste management, drinking water supply to labour, all to be inspected and approved by the Engineer. In particular the Contractor shall ensure that all rubbish and debris is properly collected and disposed of in a manner and at a location approved by the Engineer. The Contractor shall note that the burning of rubbish and debris will not be allowed unless in an approved incinerator.

(3) The Contractor shall also ensure that contractor's facilities are located at reasonable distance from villages and settlements.

(4) The Contractor shall, if so required by the Engineer, provide adequate and approved vehicle washing facilities at exit points from his Facilities to ensure that mud and other contaminants are removed from plant and equipment before they leave the Facilities.

107.06 CONTRACTOR'S/SUB-CONTRACTORS' WORKERS AND EMPLOYEES

(1) The Contractor shall supply his workers and other employees, and shall ensure that those of his Sub-contractors are supplied with, an adequate supply of foodstuffs and non-wood fuels such as kerosene for cooking and heat.

(2) The Contractor shall furnish workers and other employees with adequate water supply and sanitation facilities that enable acceptable and gender specific personal hygiene and prevent pollution of the environment. The Contractor shall ensure that the same conditions are provided for workers and employees of the Sub-contractor.

(3) The Contractor shall ensure adequate Occupational Health and Safety conditions for his workers and other employees in accordance with international standards. The Contractor shall ensure that the same conditions are provided for workers and employees of the Sub-contractor.

(4) Workers and other employees of the Contractor and his Sub-contractors shall be strictly prohibited from hunting, trapping, fishing, dealing in wildlife, gathering of wood (for burning or other purposes) and of non-timber forest products or any similar activities whilst employed on the Works, and any breach of these restrictions shall be considered as due cause for instant dismissal from the Site. The possession of any equipment for such activities, such as guns, bows and/or arrows, traps, cages, fishing nets or rods, etc., shall be considered as proof that the person is engaged in prohibited activities.

(5) Reference shall be made to Conditions of Contract in respect of information and educational programmes to be implemented by the Contractor relating to sexually transmitted diseases and other mobility related negative impacts such as human trafficking

(6) The Contractor shall take all reasonable precautions to minimise social contact between his workers and employees and those of his Sub-contractors and the local population.

107.07 CONTRACTOR'S PLANT AND EQUIPMENT

(1) Plant and equipment operated by the Contractor and his Sub-contractors shall be maintained in satisfactory working condition at all times. Any plant and equipment which, in the opinion of the Engineer:

- a) is excessively noisy;
- b) emits excessive exhaust fumes;
- c) emits excessive dust

or is in any other way excessively intrusive in respect of the environment shall be withdrawn and will not be allowed to be reused on the Works until repairs or remedial work have been completed to the satisfaction of the Engineer.

(2) Plant and equipment which conventionally utilises mufflers or dust collectors or similar attachments to minimise pollution shall be fitted and operate with such attachments at all times.

(3) Plant and equipment shall be utilised and operated by the Contractor and his Sub-contractor with due care and attention being given to the safety and well being of the local population and wildlife. Any of the Contractor's/Sub-contractors' employees found driving or operating any plant or equipment in a reckless or dangerous manner shall, if so instructed by the Engineer, be immediately removed from the Site by the Contractor and will not be allowed to return to the Contract. Driving or operating plant or equipment whilst under the influence of alcohol or drugs shall be deemed to constitute reckless or dangerous behaviour and shall be due cause for instant dismissal from the Site.

(4) Particular care shall be exercised in the vicinity of villages and other settlements or areas of population, and the Contractor shall ensure that his drivers/operators and those of his Sub-contractors observe strict speed limit restrictions in such sensitive areas and that they are advised on a regular basis of the need to exercise extreme care in areas where pedestrians, especially children, are likely to be using the roadway.

(5) The Contractor shall ensure that his employees and those of his Sub-contractor do not dispose of rubbish and debris other than at designated locations within his Facilities. On no account shall personal rubbish or other debris be disposed of along the road corridor by dumping or throwing from vehicles.

107.08 CONSTRUCTION ACTIVITIES

(1) The Contractor shall ensure that all construction activities are undertaken with the maximum consideration of the environmental and social impacts that insensitive or irresponsible procedures may endanger. In particular the Contractor shall ensure:

- a. all operations are undertaken in accordance with the best international standards of practice;
- b. earthworks operation are undertaken, as far possible, in the dry season when risks of erosion and silt runoff are minimised;
- c. cleaning and grubbing is only carried out immediately prior to earthworks activities in an area/length such that the risk of erosion of exposed earthworks surfaces is minimised;
- d. drainage provisions are maintained operational at all times and that earthworks and other operations are organised and carried out such that formed surfaces are properly and adequately drained at all times;
- e. suitable interceptor drains, retention/settlement ponds, etc, are provided to ensure that storm water run-off carrying excessive waste matter, pollutants or silt is not allow to flow directly into natural or man-made water courses;
- f. drainage channels are regularly cleaned, cleared and graded so that unimpeded discharge is available at all times;
- g. dust and noise suppression measures are implemented effectively at all times;
- h. safety plans are formulated and implemented for the protection of the workforce, the Engineer's and Employer's personnel and the general public, complying with the national and international safety and health guidelines;
- i. all spoil and surplus material arising from construction activities is properly and responsible disposed of according to procedures which complies with the EMP and approved by the Engineer;
- j. no interference with or degradation of village water supplies occur as a direct or indirect consequence of the construction activities;
- k. any encroachment on historical, cultural and religious sites such as wats (temples) and shrines is immediately reported to the Engineer and to the Provincial Department of Information and Culture, and that work in such areas is immediately suspended whilst any necessary investigations are implemented;
- l. no interference with or degradation of villagers use of culverts or roadside ponds occurs, and that the potential for such interference/degradation be immediately reported to Engineer for investigation and action;
- m. stagnant areas of water are not created which would provide potential mosquito breeding habitats, especially in or nearby residential areas as well as in or nearby the contractor's camp;
- n. contractor's workers and employees and his Sub-contractors are instructed in procedures to be adopted in the event of discovery of UXO;
- o. the contractor shall keep records of all accidents of his workers and road users in connection with his contractual works.

(2) Environmental mitigation measures have been classified into Categories 1, 2 or 3, depending on the importance and impact of the mitigation measure. Category 1 is High impact, Category 2 is Moderate impact and Category 3 is Minor impact. The required mitigation measures and the applicable penalties for not implementing the required mitigation measures under the Contract are specified in the Particular Specifications.

107.09 MEASUREMENT AND PAYMENT

(1) There will be no separate measurement and payment for general environmental and social impact requirements, the costs of which are deemed incidental to the construction works.

SECTION 108

REMOVAL AND DISPOSAL OF PAVEMENTS, BRIDGES, CULVERTS, OTHER STRUCTURES AND ROAD FURNITURE

108.01 GENERAL

- (1) This work shall consist of dismantling and removing, as hereinafter specified, existing pavements (including shoulders), bridges, culverts and other structures such as manholes, catch basins, inlets, etc., and road furniture (e.g. guard-rails, fences, utility poles, signs, kerbs, etc.) and salvaging/disposing of the resulting materials.
- (2) Existing pavements, bridges, culverts and other structures and road furniture, which are within the right-of-way and which have to be removed, shall be removed down to the limits and extent specified hereinafter or as shown in the Drawings or as directed by the Engineer.
- (3) Dismantling and removal operations shall be carried out with such equipment and in such a manner as to leave undisturbed the adjacent pavement, structures and any other work which are to remain.
- (4) All operations necessary for the removal of any existing structure which might endanger new construction shall be completed prior to the start of new work.

108.02 REMOVAL OF EXISTING PAVEMENT SURFACING

- (1) This work shall comprise removing the existing surfacing for the lengths shown on the Drawings, or as directed by the Engineer. The surfacing shall be removed by mechanical means unless approval is given by the Engineer to the use of manual methods. The materials arising from the removal shall be stockpiled at locations agreed with/approved by the Engineer and shall be safeguard by the Contractor until instructions are given as to eventual disposal.

108.03 DISMANTLING OF STRUCTURES AND FURNITURE

- (1) Structures and road furniture shall be dismantled carefully and the resulting materials so removed as not to cause any damage to the serviceable materials to be salvaged, the parts of the structures/furniture (if any) to be retained and any other properties or structures nearby.
- (2) Unless otherwise specified in the Contract Documents, the superstructure portions of bridges shall be entirely removed and the substructures and other structures (culverts etc.) shall be removed to 1 metre below the ground level or 1 metre below finished road level (whichever is lower) or to such greater depth as is directed by the Engineer depending upon the interference they cause with the new construction. Removal of overlying or adjacent material if required in connection with the dismantling of the structures or road furniture, shall be incidental to this item.
- (3) Pipe culverts shall be carefully removed in such a manner as to avoid damage to the pipes.
- (4) Steel structures shall, unless otherwise provided, be carefully dismantled in such a manner as to avoid damage to members thereof.
- (5) If specified on the Drawings or if so directed by the Engineer structures shall be removed in such manner as to allow for re-erection, and all members shall be match-marked by the Contractor in an approved manner before dismantling. End pins, nuts, loose plates, etc., shall be similarly marked to indicate their proper location in the structure, and all pins holes, machined surfaces and the like shall be protected in an approved manner and all loose parts shall be securely wired to adjacent members of packed in boxes.

108.04 MATERIALS OBTAINED FROM DISMANTLING

- (1) All materials arising from the dismantling of existing pavements, structures and road furniture shall remain the property of the Employer.
- (2) The existing pavement materials including (but not restricted to) bituminous surfacing, stone aggregate and lateritic materials may be taken over by the Contractor for use in the Works provided the same is approved by the Engineer. The rates to be paid by the Contractor for such materials shall be agreed with the Engineer.
- (3) Materials arising from the dismantling of existing structures will include structural steel, reinforced concrete materials, stone/rubble masonry materials, bearing, parapet rails, etc. Only the concrete materials stone/rubble masonry materials may be taken over by the Contractor for use in the Works in accordance with paragraph (2) above.
- (4) Materials salvaged from dismantling which may be taken over by the Contractor may not comply fully with the Specifications. The salvaged materials shall be first sorted out as directed, with material which may be used directly being stockpiled separately from that which requires processing before reuse. The materials selected for processing should be of such quality as will meet the Specifications after breaking, screening and/or mixing with better quality materials, as necessary. The responsibility of selecting salvaged materials for processing and/or incorporating in the Works shall lie entirely with the Contractor.
- (5) Acceptability of the materials (after processing or otherwise) shall be determined by the Engineer and only such materials that fully satisfy the Specifications in all respects shall be permitted for incorporation in the Permanent Works. Materials failing to satisfy the Specifications may be used in Temporary Works like diversion roads etc.
- (6) Existing pavement materials containing bitumen, an excess of clay, soil or organic materials will not normally be considered suitable for reuse in the Permanent Works.
- (7) The materials not required by the Contractor for incorporation in the Works but which are designated by the Engineer as being of use to the Employer shall be neatly stockpiled as directed by the Engineer.
- (8) Structural/reinforcing steel obtained from dismantling of the existing structures shall not be considered suitable for use in the Works and shall be stored in a neat and presentable manner in locations suitable for loading. Structures or portions thereof which are specified in the Contract for re-erection shall be stored in separate stockpiles/areas.
- (9) Pipes from culvert sections shall be cleaned and neatly stacked at points designated by the Engineer.
- (10) All of the materials arising from dismantling operations which, in the opinion of the Engineer, cannot be used or auctioned shall be disposed of in approved spoil areas in accordance with the requirements of the Specifications.
- (11) In undertaking removal and disposal works, the Contractor shall comply with all laws, ordinances, building regulations etc., as prevailing in Lao PDR. Unless otherwise permitted by the Engineer, the Contractor shall furnish, erect and maintain suitable barricades and safety measures to prevent personal injury or property damage during removal works.

108.05 BACKFILLING

- (1) Holes and depressions caused by dismantling operations shall be backfilled with excavated or other approved materials and thoroughly compacted in line with surrounding areas to the satisfaction of the Engineer.

108.06 MEASUREMENT AND PAYMENT

(1) Measurement and payment for the removal and disposal of pavements, bridges, culverts and other structures and road furniture shall only be measured and paid for where specific requirements are given in other sections of these Standard Specifications, otherwise the work will be considered to be incidental to other items in the Bill of Quantities.

SECTION 109

CLEARANCE OF UNEXPLODED ORDNANCE

109.01 GENERAL

- (1) This work shall consist of the detection and disposal of unexploded ordnance (UXO) that exist within the confines of the site and a Handover Certificate has been completed in accordance with the Lao PDR National UXO/Mine Action Standards issued by the National Regulatory Authority.
- (2) When required, MPWT/DPWT will commission an accredited Clearance Team to undertake clearance of UXO as a nominated sub-contractor (the Clearance Team).
- (3) Road embankments, bridges and culverts which were constructed after the conflicts in UXO contaminated areas, are generally regarded as offering little danger. However land to be occupied by new roads, realignments, road widenings, borrow pits, quarries, camps, stockpile areas and the like in UXO contaminated areas, will have to be surveyed, checked, and cleared before they can be used.
- (4) Clearance will be arranged in accordance with the Contractor's Sub-Programme, submitted in accordance with the Particular Conditions of Contract.

109.02 UXO CLEARANCE

- (1) All UXO clearance activities shall be done according to National Regulatory Authority's regulations and decrees (as updated from time to time). Inter alia this includes the requirements on accreditation of the UXO clearing company, the accreditation of the clearance team members, as well as the accreditation of the Standard Operation Procedures (SOP) of the UXO clearance company.
- (2) The National Standards (NS) of the National Regulatory Authority has to be complied with regarding the Personnel, Search Instruments, Vegetation Reduction, Search and Clearance Requirements, Quality Control, Standard of Clearance, Storage of Explosives, Documentation, Quality Assurance for UXO Clearance, Safety and Reporting.

109.06 MEASUREMENT

- (1) Measurement for clearance of unexploded ordnance will be as follows:

Item No.	Description	Unit
109-1	Non-Technical Survey	Lump Sum
109-2	Technical Survey/ UXO Clearance	Provisional Sum

- (2) Measurement shall be done when notification of cleared areas has been received.

109.07 PAYMENT

- (1) Payment will be at the rates entered the Bill of Quantities.
- (2) Payment shall be deemed to be full compensation for all personnel, mobilisation costs, equipment, materials, transportation etc. and all associated costs, including disposal of ordnance as well as all ordnance detection incidental to site investigation, all in accordance with this Specification and to the satisfaction of the Engineer.

SERIES 200
EARTHWORKS

SECTION 201

CLEARING AND GRUBBING/ TREE REMOVAL

201.01 DESCRIPTION

(1) Clearing and grubbing shall consist of clearing, grubbing, removing and disposing of vegetation and debris within designated limits within the right-of-way and easement areas, -in general for common soil removal, the removal of top soil shall be not less than 15 cm-, as ordered by the Engineer, but excluding objects and vegetation which are designated to remain. The existing road surface is excluded from the clearing and grubbing. Excessive clearing and grubbing is prohibited.

(2) The work shall include the preservation from injury or defacement of all vegetation and objects designated to remain.

(3) When specified, it will also include the preparation of land outside the area occupied by the roadway for reforestation.

201.02 CONSTRUCTION REQUIREMENTS

201.02.1 General

(1) In order to reduce the risk of erosion no topsoil shall be removed from outside the limits of the earthworks. Any topsoil removed from outside these limits shall be replaced by the Contractor.

(2) All removed topsoil shall be stockpiled at locations approved by the Engineer and protected and safeguarded by the Contractor for later reuse.

(3) The limits of clearing and grubbing in the field shall be 2 m from the toe of an embankment and 1 m from the ditch edge (top of the back slope) or as established by the Engineer. Where applicable, the Engineer will designate trees, shrubs and other vegetation and features to remain.

(4) The Contractor shall preserve all trees, shrubs and other items designated to remain.

(5) All surface objects, trees, stumps, roots and other obstructions, not designated to remain, shall be removed and disposed of as follows:

- (a) In cut areas and in areas where the formation level is less than 1.0 metre above the original surface, all trees, stumps, roots and other organic debris shall be removed entirely to a depth of at least 1.0 metre below formation level.
- (b) In areas where the formation level is more than 1.0 metre above the original surface, all trees, stumps and roots and other organic debris shall be removed at the original surface level.
- (c) all non-perishable solid objects shall be removed to at least 1.0 m below formation level and embankment slopes.

(6) Excavation areas from which fill is to be taken shall also be cleared and grubbed.

(7) Low-hanging, unsound and unsightly branches on remaining trees or shrubs shall be carefully removed by skilled personnel using an approved method and in accordance with good tree surgery practice without damage to the parent tree/shrubs.

(8) Except in areas to be excavated, stump-holes and other holes from which obstructions have been removed, shall be backfilled with suitable material and compacted in accordance with Sections 204 and 205 of the Specifications. Any area where embankment is to be constructed shall have the top 150 mm of material compacted in accordance with Section 205 of the Specifications.

(9) All materials arising from clearing and grubbing and tree removal shall be the property of the Employer, and shall be disposed of or kept at locations and in a manner approved by the Engineer.

201.02.2 Reforestation

(1) Areas for reforestation by others outside the roadway will be designated by the Engineer. In these areas the Contractor shall deep rip the existing ground having carried out partial clearing of undergrowth and small shrubs and trees.

201.02.3 Disposal Locations

(1) The Contractor shall make all arrangements with property owners and government authorities and pay all fees and costs for disposal locations outside the right-of-way. The locations of all such areas shall be approved by the Engineer.

(2) Disposal areas will not be approved within National Biodiversity Conservation Areas (NBCAs), Provincial or district protected areas, pristine forests or other ecologically sensitive areas.

201.03 MEASUREMENT

(1) Measurement for clearing and grubbing will be as follows:

Item No.	Description	Unit
201-1	Clearing and Grubbing	Metre Square
201-2	Preparation for Reforestation	Metre Square
201-3	Removal of Trees	Number

(2) Measurement for the Clearing and Grubbing item will be for the area acceptably cleared and grubbed within the limits shown on the Drawings or ordered by the Engineer. The measurement will be for the plan area (horizontal projection) or otherwise as decided by the Engineer. Areas not shown on the Drawings or ordered by the Engineer will not be measured for payment.

(3) Measurement for the Clearing and Grubbing item will not be done in cut areas, including cutting for ditches.

(4) No separate measurement will be made for clearing and grubbing of borrow pits, the measurement of which shall be deemed to be covered by Item 204-2 of the Bill of Quantities.

(5) The existing road surface shall be excluded from the clearing and grubbing quantity. The existing road surface shall be deemed to be the full width between the edges of the road formation as given on surveyed cross sections or as otherwise determined by the Engineer.

(6) Measurement for the Preparation for Reforestation item will be the area within the limits ordered by the Engineer.

(7) Measurement for the Removal of Trees item shall be for trees of a diameter greater than 300 mm, measured at a height of 1.0 metres above ground. Trees less than 300 mm in diameter shall not be measured but shall be considered included under item 201-1 of the Bill of Quantities.

201.04 PAYMENT

- (1) Payment will be at the rates entered the Bill of Quantities.
- (2) Payment for the Clearing and Grubbing item shall include for clearing, grubbing, removal of topsoil and setting aside, protecting and safeguarding and future reuse, removal of objects, trees less than 300 mm in diameter, stumps, shrubs and other obstructions, removal of timber structures as per Clause 202.04 paragraph (4) of the Specifications, provision of material for backfilling and backfilling and compaction of all holes and specified, removal and disposal of all debris and for payment of all fees and costs for disposal areas.
- (3) Payment for the Preparation for Reforestation item shall include for partial clearing as specified, removal and disposal of all debris, payment of the fees and costs for disposal areas and for deep ripping.
- (4) Payment for the Removal of Trees items shall include for the felling and disposal of the tree/branches. The tree stump shall be measured and paid for under item 201-1 of the Bill of Quantities.

SECTION 202

DEMOLITION WORK

202.01 DESCRIPTION

- (1) Demolition shall consist of the removal, wholly or in part, and satisfactory disposal of all pavements, buildings, fences, culverts, bridges, abandoned pipelines or utilities, and any other obstructions which are not designated or permitted by the Engineer to remain, except for the obstructions specifically designated to be removed and disposed of under other items in the Specifications.
- (2) Demolition work shall include the salvaging of designated materials and the backfilling and compaction of the resulting cavities.
- (3) The Contractor shall perform all demolition work required within and adjacent to the roadway, as shown elsewhere in the Contract or as directed by the Engineer.
- (4) The breaking out of concrete on structures in order to carry out a patch repair is not deemed to be demolition work.

202.02 DEMOLITION REQUIREMENTS

- (1) Bridges, culverts, and other drainage structures to be removed but which are in use by traffic shall not be removed until alternative arrangements satisfactory to the Engineer have been made to accommodate traffic.
- (2) Substructures of existing structures spanning watercourses shall be removed down to the natural stream bottom and those parts outside of the stream shall be removed to at least 300 mm below the natural ground surface unless shown otherwise in the Contract Documents.
- (3) Where a structure to be demolished lies wholly or in part within the limits for a new structure, it shall be removed to the extent necessary to accommodate the construction of the new structure and to ensure unimpeded use of the new structure.
- (4) Blasting will only be permitted where it can be done safely and in a controlled manner by experienced personnel and in accordance with a method statement approved by the Engineer. The requirements of Sub-clause 203.03.2 of the Specifications will apply. Blasting or other operations necessary for the removal of an existing structure or obstruction, which may damage new construction, shall be completed prior to placing the new work, unless otherwise permitted by the Engineer.
- (5) Basements or cavities left by the removal of structures shall be filled with approved material to the level of the surrounding ground and shall be compacted in accordance with Section 205 of the Specifications. Trench excavation remaining after the removal of pipes shall be backfilled and compacted in accordance with the requirements of Section 207 of the Specifications.
- (6) All designated salvable material shall be carefully dismantled and removed, without unnecessary damage, in sections or pieces which may be readily transported, match marked as necessary, transported to and offloaded and stored at the Employers facilities designated by the Engineer, which facilities will be within 50 kilometres of the Site. All salvable materials shall at all times remain the property of the Employer.
- (7) All existing metal and concrete pipe culverts are designated as salvable material.

(8) Unless waived in writing by the Engineer, all material removed which is suitable for rip-rap and not needed immediately on the Works shall be stockpiled within the limits of work for future use. Where such material is surplus to the requirements of the Contract it shall be disposed of as designated by the Engineer.

(9) Material not considered as salvable or not considered as suitable for incorporation into the Works shall be removed and disposed of in disposal location as per Sub-clause 201.02.3 of the Specifications.

(10) Gravel, bituminous material, or other surfacing materials designated as salvable shall be stockpiled at locations designated by the Engineer and protected from contamination by dirt or foreign material by the Contractor until utilised in the Works or designated by the Engineer to be disposed of.

(11) All concrete pavement, sidewalks, steps, kerbs, gutters, etc., designated for removal, shall be:

- (a) broken into pieces and used for riprap on the Contract, or
- (b) broken into pieces, the size of which shall not exceed 300 mm (12 inches) in any dimension and stockpiled at designated locations for use by the Government, or
- (c) otherwise disposed of, as per (9) above.

(12) The Engineer will determine which option ((a), (b) or (c)) is to be adopted.

202.03 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
202-1	Removal of Structures	Metre Cube
202-2	Removal of Bailey Bridges	Metre
202-3	Removal of Metal Pipe Culverts, < 600 mm	Metre
202-4	Removal of Metal Pipe Culverts, 600 - 1000 mm	Metre
202-5	Removal of Metal Pipe Culverts, > 1000 mm	Metre
202-6	Removal of Concrete Pipe Culverts, < 600 mm	Metre
202-7	Removal of Concrete Pipe Culverts, 600 - 1000 mm	Metre
202-8	Removal of Concrete Pipe Culverts, > 1000 mm	Metre
202-9	Removal of Timber Structures > 6 m ²	Metre Square

(2) The volume of demolished and removed structures of concrete, brick, and masonry, including box culverts, will be computed in cubic meters of solid concrete, brick, or masonry from measurements taken in the field prior to demolition.

(3) The quantity of bailey bridges removed will be measured as the length of bailey bridge.

(4) The quantity of metal and concrete pipe culverts removed will be measured as the length of pipe along its centreline.

(5) Timber or bamboo structures which are able to be demolished during clearing and grubbing will not be measured or paid for but will be deemed included under Bill of Quantities Item 201-1. Such structures which are demolished when ordered by the Engineer at a later time will be measured in square metres of plan area, but only for structures with a plan area of more than 6 sq.m.

(6) Timber or bamboo structures with a plan area of less than 6 sq.m; timber, bamboo, wire, or metal fences, and isolated posts of any material will not be measured and paid for separately.

(7) Measurement for pavement courses to be removed shall be as per Sub-clause 203.01.2 of the Specifications.

202.04 PAYMENT

- (1) Payment will be at the rates entered in the Bill of Quantities.
- (2) Payment for the Removal of Structures item shall include blasting, provision of material for backfilling, and backfilling and compaction of remaining cavities of removed structures, salvaging all salvable materials, transportation, offloading and storage at the Employers facility, stockpiling and protection of material for rip-rap, gravel, bituminous material or other surfacing materials and disposal of all non-salvable or surplus materials.
- (3) Payment for the Removal of Metal Pipe Culverts and the Removal of Concrete Pipe Culverts items shall include excavation, backfilling and compaction of the remaining trench, salvaging the pipes, match marking, transportation, offloading and storage at the Employer's facility or at a designated storage area if to be reused in the Works, including all necessary protection and safeguarding or disposal if designated by the Engineer as unsuitable for salvaging. Payment shall also include for the removal of any associated headwalls, inlet/outlet structures, slope protection and the like, including excavation backfilling and compaction of the voids so resulting.

SECTION 203

ROADWAY EXCAVATION

203.01 DESCRIPTION

203.01.1 General

(1) Roadway excavation shall consist of excavating, removing and reusing for embankment/filling work and/or satisfactorily disposing of all surplus materials encountered within the limits of the work necessary for the construction of the roadway. The work includes all excavation necessary for side ditches, cut-off ditches on top of cut slopes, turn outs, and inlet and outlet ditches for structures.

(2) Roadway excavation includes all excavation, shaping and sloping necessary for the construction, preparation and completion of all sub-grade, shoulders, slopes, intersections, and approaches in acceptable conformity to the alignment, levels and cross sections shown on the Drawings or ordered by the Engineer.

203.01.2 Common Excavation

(1) “Common Excavation” shall comprise excavation and disposal of all materials of whatever character encountered within the right-of-way that is not classified as rock excavation or which is not otherwise classified.

(2) When the Engineer orders such work to be done, the removal of landslides not attributable to the carelessness or negligence of the Contractor, the removal of deep top soil in embankment areas, and the removal of paved courses, sidewalks, steps, grouted rip-rap ditches, kerbs and gutters and unsuitable soil, shall be considered to be common excavation unless specific items are included elsewhere in the Contract Documents for the removal and reuse of such materials.

(3) When the Engineer orders such work to be done, benches or ditches constructed in or outside cut slopes, and the flattening of cut slopes beyond the limits shown on the Drawings, shall also be considered as common excavation.

203.01.3 Rock Excavation

(1) “Rock Excavation” shall comprise the excavation of material that cannot be excavated without blasting or which cannot be removed by ripping by the use of single-shank hydraulic ripper mounted on a bulldozer (Caterpillar D9H or equivalent).

(2) Where it is impractical to classify rock excavation by the above method, the limit of rock excavation shall be determined by the Engineer.

(3) Individual boulders and detached stones over 1 cubic metre in volume which cannot be removed by the Contractor’s equipment available on the Site shall be classified as rock excavation.

(4) The flattening of cut slopes in rock excavation, when ordered by the Engineer, shall be classified as rock excavation.

203.01.4 Borrow Excavation

(1) “Borrow Excavation” shall comprise the excavation of approved material required for constructing embankments and other portions of the work, taken from locations outside the right-of-way. The Contractor shall be responsible for making arrangements and paying any costs involved in obtaining approved borrow sources.

203.01.5 Sub-grade in Cuts

(1) The CBR of the material in the top 300 mm of sub-grade in cuts shall be tested when compacted to 100% of MDD (AASHTO T99 Method D). If the 4 days soaked value is less than 8% or if the other requirements of Clause 204.02 paragraph (3) of the Specifications are not satisfied, the material shall be removed to a depth as specified by the Engineer and replaced with material complying with Clause 204.02 paragraph (3) of the Specifications. Such replacement material shall be placed and compacted in accordance with the requirements of Section 205 of the Specifications.

203.01.6 Classification of Excavation for Ditches

(1) Material removed from the standard ditches to be constructed along the roadway as shown on the Drawings shall be classified as common, rock or unsuitable excavation by the Engineer.

(2) Material removed from other ditches which the Engineer orders to be constructed within the right-of-way shall be classified in the same manner as material from standard ditches.

203.01.7 Removal of Landslides

(1) "Removal of Landslides" shall comprise excavation and disposal of all materials of whatever character encountered within the right-of-way. The Engineer will assess and decide if a landslide was triggered by natural causes or by the Contractor's activities. If the landslide was triggered by natural causes, the Contractor will get paid for the removal of the landslide.

(2) When the Engineer orders the removal of landslides under this item and the landslide is not attributable to the carelessness or negligence of the Contractor, the Contractor will be paid under this item 203.01.7. If the landslide occurs during the rainy season and the Engineer is of the opinion that the landslide occurred due to carelessness or negligence of the Contractor during the preceding dry season the Contractor has to remove the landslide at his own cost.

203.02 MATERIALS

(1) Suitable material shall comprise all material which is acceptable in accordance with the Specifications for use in the Works and which is capable of being compacted in the manner required by the Specifications to form a stable embankment or fill having side slopes as indicated on the Drawings.

(2) Unsuitable material shall comprise all material which, in the opinion of the Engineer, is not suitable for embankment material, such as deep topsoil not removed by clearing and grubbing, highly organic clays, silts and peat; soils containing large amounts of roots, grass and other vegetable matter.

(3) Materials which are soft or unstable merely because they are too wet or dry shall not be classified as unsuitable, unless otherwise directed by the Engineer.

203.03 CONSTRUCTION REQUIREMENTS

(1) Excavation operations shall be conducted without disturbing the material outside the staked construction limits.

(2) Prior to the start of excavation operations, all necessary clearing, grubbing and top soil removal in that area shall be completed.

(3) All excavated material shall be used, as far as is reasonably practical, in the formation of the embankment and sub-grade and at such other places as directed by the Engineer, unless it is declared unsuitable.

- (4) No excavated suitable material shall be wasted without permission from the Engineer, and when such material is permitted to be wasted, it shall be so placed in locations approved by the Engineer that it will present a neat appearance and not be an injury to abutting property or to the general environment.
- (5) Stockpiles of suitable material for reuse shall be neatly and compactly constructed in an approved manner.
- (6) In steeply side-sloping terrain, unless otherwise specifically approved by the Engineer in writing, surplus material blasted or excavated from the upper side slope shall not be allowed to be deposited over the lower side slope, and special care shall be taken to preserve vegetation on the lower side slope for the purpose of erosion protection. No material shall be disposed of close to culvert or bridge locations or adjacent to any water course or irrigation facility or at locations where any private properties or crops etc. on the lower side slope, could be damaged.
- (7) Excavated materials wasted by the Contractor without permission of the Engineer shall not be measured or paid for.
- (8) During the construction of the roadway, the formation shall be maintained in such a condition that it will be well-drained at all times. Care shall be taken to ensure that side berms are not created at the edges of the excavation trapping water within the excavation. Side ditches emptying from cut to embankment areas shall be so constructed to prevent damage to embankment area by erosion.
- (9) In order that the embankment, sub-grade, sub-base and or base shall not be subject to wetting, during or after construction, the Contractor shall at all times provide adequate drainage by scheduling ditch work or outlet construction so as to prevent such wetting. The Contractor shall clean and trim all such ditches from time to time and or when directed by the Engineer, so that there may be a free water flow throughout the execution of the Works.
- (10) Damage to the Works attributable to wetting through failure to provide such adequate drainage shall immediately be made good by the Contractor at his own expense.
- (11) Excavation shall proceed in such sequence and manner and shall be so co-ordinated with other phases of construction that suitable conditions for the maximum drainage discharge will be provided at all times.
- (12) Excavation shall be discontinued when climatic conditions prevent the placing and compacting of the excavated material in embankment in accordance with the Specifications.
- (13) The sub-grade shall be prepared in accordance with the requirements of Clause 205.03 of the Specifications.
- (14) Earth or rock material on slopes, at or outside the limit of the cross sections shown on the Drawings, which has become loose as a result of the Contractor's operations, shall, if so required by the Engineer, be removed by the Contractor at his own cost.
- (15) Removal of loose material up to 2.0 metres outside the limit of cut slopes as required by the Drawings will not be paid for separately, but shall be deemed to be included in the unit rate for roadway excavation.
- (16) If services or obstructions not shown on the Drawings are discovered prior to or during roadway excavation, the Engineer shall be notified immediately.
- (17) The Contractor shall be responsible for obtaining service locations from all appropriate Authorities in advance of roadway excavation, and shall allow in his rates for removal of all services located above the final excavation level. Excavation by machine within one meter of known existing underground services shall not be commenced without prior approval of the appropriate Authority and the Engineer.

203.04 ROCK EXCAVATION

203.04.1 General Requirements

(1) Rock cuts shall be executed by mechanical means, expanding agents or by blasting, proceeding across the whole width of the section starting from the top. The thickness of the strata to be excavated shall be established in relation to the nature and the state of fracturing of the rock, so as not to jeopardise the stability of the sides of the cut.

(2) Before starting excavation, the Contractor shall consult with the Engineer regarding the cut slopes shown on the Drawings, and the nature, stratification, and weathering of the rock actually encountered at the site.

203.04.2 Blasting

(1) Where rock is encountered in the excavation and the Contractor proposes to use explosives, blasting shall be carried out in accordance with the following requirements, subject to the prior approval of the Engineer.

(2) The Contractor shall obtain all necessary permits and licenses required from the relevant Authorities in relation to the use of explosives and blasting on the Site.

(3) The Contractor shall give at least seven (7) days notice in writing of intention to commence drilling for blasting and shall provide details of the methods he intends to adopt, indicating the position, size and depth of holes to be drilled, the type of explosive, the size of charges, the timing, and the firing sequence.

(4) The Engineer may accept or reject the proposal and may place limitations on the maximum size of charges. The Contractor shall be entirely responsible for the design of drilling and blasting patterns. In the event of rejection of a proposal it shall be revised and resubmitted. Drilling and blasting operations shall not commence before approval of the revised proposal.

(5) During blasting operations, signs shall be erected and audible warnings shall be used to warn the general public and all site personnel of the operations.

(6) Blasting in the vicinity of public utilities shall be subject to any limitations imposed by the relevant Authorities. Clearance from relevant Authorities shall be obtained by the Contractor before blasting within 10 metres of any public utility. The requirements of this Clause and the Engineer's approval of blasting proposals shall not relieve the Contractor of his responsibility to plan and conduct blasting operations safely and with a minimum of inconvenience to the public.

(7) Excessive blasting will not be permitted and the Contractor shall discontinue any method of blasting which leads to over-shooting or is dangerous or potentially destructive to property, personnel or natural features. All loose rock on cut slopes shall be cleared immediately after blasting.

(8) In all blasting operations the depth and size of holes and the size and characteristics of charges shall be subject to the Engineer's approval. The amount and type of explosives shall be consistent with the ground conditions encountered. As excavations approach their final lines, the depth of holes for blasting and the amount of explosive used per hole shall be reduced progressively. When further blasting may damage the rock the use of explosives shall be discontinued and the excavation shall be completed by the use of mechanical rock breakers or other means.

(9) Drill holes shall be drilled along the slope line, maintaining the drill holes at an angle designated on the Drawings and ensuring that all drill holes are in the same plane.

(10) Any damage caused by the Contractor when blasting shall be corrected by the Contractor at his own cost. Slopes shattered or loosened beyond the required excavation lines shall be cleaned immediately with all over-excavations and damage being made good by the Contractor. No payment for over-breakage will be made.

(11) All blasting operations shall be done in a continuous and orderly manner and no cuts shall be loaded or partially loaded and left for any length of time prior to firing.

(12) The Contractor shall take all measures as may be necessary to stop traffic, and to generally warn the public prior to the firing of each and every shot to the satisfaction of the Engineer.

(13) Where approval to blasting is not given, for any reason, the Contractor shall utilise other methods to carry out the excavations, and no claim will be entertained by the Engineer for any additional cost on account thereof.

203.05 UNSUITABLE EXCAVATION AND BACKFILLING

(1) Unsuitable material encountered in excavations outside the limit of cuttings as shown on the Drawings shall be removed when so instructed by the Engineer to the depths and extents directed by the Engineer and shall be backfilled and compacted with approved material as specified.

(2) When the Contractor is required to excavate unsuitable material below the existing ground surface in fill areas, the depth to which these unsuitable materials are to be removed will be determined by the Engineer. The Contractor shall schedule the work so that the authorised cross section can be taken before and after the material has been removed.

(3) Muck excavation shall be accomplished without entrapping muck within the back fill. The backfilling of the excavated area shall follow immediately behind the muck excavation so the material displaced by the backfill can be removed. The excavation shall be backfilled to the ground line or water level, whichever is higher, with rock or suitable granular material. Backfilling with rock shall consist of crushed or un-crushed rock as decided by the Engineer.

(4) Material used for temporary access or diversion roads shall not be re-used in embankment or elsewhere without the permission of the Engineer.

203.06 BORROW EXCAVATION

(1) Borrow areas shall meet the requirements of the approvals under the National Forestry Law and shall not be located in any National Biodiversity Conservation Area, Provincial or local protected areas or other ecologically sensitive areas.

(2) The Contractor shall comply with local laws and regulations regarding public health and safety in respect for the operation of borrow pits and quarries, and in the absence of, or in addition to such laws and regulations, shall comply with the following conditions:

(3) The Provincial Department of Information and Culture must be notified and their procedures followed if during the excavation of borrow areas or elsewhere on the Site, any of the items covered by the Conditions of Contract (fossils, items of antiquity etc.) are discovered.

(4) Village headmen shall be consulted regarding the design and location of all borrow areas in the vicinity of villages and if possible the borrow areas shall incorporate beneficial post construction facilities (e.g. fish ponds) for the use of villages.

(5) The Contractor shall confine his operations solely to the areas provided or acquired by the Contractor and shall demarcate the boundary of the area and erect temporary or permanent fencing as instructed by the Engineer.

(6) As directed by the Engineer, the Contractor shall remove topsoil and/or overburden from borrow pits and quarries. The Engineer shall direct whether topsoil shall be stripped and stockpiled separately or shall be excavated and spoiled together with the overburden. If suitable, the Engineer may direct that overburden be used in the Works.

(7) The design of borrow excavation shall include drainage measures to prevent silt laden water entering nearby water bodies, wetlands or paddy areas.

(8) Unless otherwise approved by the Engineer, borrow areas shall be sited out of sight of the road and off hill slopes facing roads or settlements, so as to minimise visual impact.

- (9) The side slopes of borrow pits shall be constructed as directed by the Engineer.
- (10) Where the height of any face exceeds 1 metre, the Contractor shall provide, erect and maintain at his own expense stock-proof fencing and gates to prevent unauthorised access to the top of the working face.
- (11) On completion of work temporary fences and all temporary structures shall be demolished and removed, and the site top soiled and left neat and tidy.
- (12) Upon abandonment of a borrow pit or quarry area, the Contractor shall, at his own cost, clean and trim the borrow pits or quarry area, the right-of-way area, and any adjoining properties which were occupied during the execution of the work, and, if required by the Engineer, make the borrow/quarry area free draining, all to the satisfaction of the Engineer.
- (13) Except where a borrow has been designed for a future beneficial use such as a fish pond, the side slopes shall be battered to a maximum slope of 1V : 3H. Where this is impracticable or where the working face is to be left exposed, the edge shall be permanently fenced, as instructed by the Engineer, and measurement and payment for such fencing shall be in accordance with the requirements of Section 615 of these Specifications.
- (14) On completion of work in any borrow pit or quarry the overburden and/or topsoil which has not been used in the Works shall be pushed back, spread and landscaped over the area of the borrow pit or quarry. Where topsoil has been stockpiled separately it shall be pushed back and spread over the borrow pit or quarry after landscaping, unless the Engineer has instructed that it shall be used for top soiling other ways.

203.07 SLOPES

- (1) All slopes shall be trimmed accurately to the slopes shown on the Drawings, and care shall be taken that no material is loosened outside the slopes.
- (2) Side drains shall be trimmed before the wet season so that the drain is clear and so that vegetation established during the wet season is not disturbed by later trimming. If the base course has been laid, this should be a final trim, otherwise a preliminary trim shall be done leaving sufficient embankment width for the construction of further layers.

203.08 TOLERANCES

- (1) All slopes, lines and grades shall be true, correct and accurate, and according to those shown on the Drawings or otherwise directed and approved by the Engineer.
- (2) The top of sub-grade level in cuts shall be within +10 mm or -30 mm of the specified levels.
- (3) All humps and depressions and deficiencies exceeding the specified tolerances shall be corrected by the Contractor by methods approved by the Engineer. Adding new material to low areas in the form of skin patching will not be permitted.

203.09 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
203-1	Common Excavation	Metre Cube
203-2	Rock Excavation	Metre Cube
203-3	Unsuitable Excavation and Backfilling	Metre Cube
203-4	Backfilling with rock	Metre Cube
203-5	Removal of Landslides	Metre Cube

(2) The volumes of the Common Excavation and Rock Excavation items shall be computed by the Contractor and checked by the Engineer. Quantity computations shall be based on the original cross sections taken by the Contractor, which were observed by and attested by the Engineer and final cross sections developed from the typical sections in the Drawings. Any materials removed or excavated before these measurements have been taken and approved by the Engineer will not be paid for. Volumes will be computed by the average end area method.

(3) Measurement for the Removal of Landslide item will only be made for those materials excavated and removed on the instruction of the Engineer. The volume of the material removed shall be computed by the Contractor and checked by the Engineer. Quantity computations shall be based on the cross sections taken by the Contractor following a Landslide, which were observed by and attested by the Engineer and final cross sections determined by the Engineer. Any materials removed or excavated before these measurements have been taken and approved by the Engineer will not be paid for. Volumes will be computed by the average end area method.

(4) Measurement for the Unsuitable Excavation item will only be made for those materials excavated and removed on the instruction of the Engineer below or beyond excavation levels in cut sections and in foundations for embankment. The volume of unsuitable material shall be computed from modifications to the approved cross sections, or from a set of separate approved cross sections applicable only to unsuitable material. No measurement will be made of any suitable material temporarily removed and subsequently replaced to facilitate compaction of the material replacing the excavated unsuitable material.

(5) Backfill with Rock shall include backfilling to any depth, width and length as required by the actual site conditions; and the volume shall be measured as decided by the Engineer.

(6) Where it is impractical to measure material by the cross-sectional method due to the erratic location of isolated deposits, methods involving three-dimensional measurements may be used, when approved by the Engineer.

(7) The Engineer will check all or any part of the work, as he deems necessary, to determine conformance to the lines, grades, elevations and cross sections submitted by the Contractor. The Contractor shall, at his own cost, provide the equipment and labour, including field parties, to assist the Engineer in checking the work.

(8) No separate measurement will be made for borrow excavation, including the removal of topsoil or unsuitable material in borrow pits. Payment for borrow excavation will be included in the relevant item for construction of embankment (Section 204 of the Specifications).

203.10 PAYMENT

(1) Payment will be made at the rates entered in the Bill of Quantities.

(2) Payment of the Common Excavation and Removal of Landslide items shall include for excavation, haulage to the location of reuse, intermediate stockpiling and double handling as needed, disposal in approved areas of unsuitable materials and surplus suitable materials arising from the excavations, benching as required, shaping and maintenance of the formation, drainage, clearing and trimming of side ditches, removal of loose material within the excavation limits, removal of services, remedial works and all other items needed to provide excavation to the levels and grades shown on the Drawings or instructed by the Engineer.

(3) Payment for the Rock Excavation item shall include for all items in (2) above plus drilling, blasting, expanding agents, ripping, removal of over-break and loose rock, meeting all requirements of the relevant Authorities, correction of damage and traffic control and safety measures.

(4) Payment of the Unsuitable Excavation item shall include for excavation, removal and disposal of unsuitable materials, provision of suitable replacement materials, placing and compaction.

(5) If in connection with Unsuitable Excavation the provision of suitable replacement material requires Backfilling with rock (crushed or un-crushed), payment will be incurred with this item.

SECTION 204

CONSTRUCTION OF EMBANKMENTS

204.01 DESCRIPTION

(1) This work shall consist of constructing roadway embankments, including preparation of the areas upon which they are to be placed; the placing and compacting of approved material within roadway areas where unsuitable material has been removed and the placing and compacting of embankment material in cavities, holes, pits and other depressions within the roadway area, in accordance with the Specifications and in acceptable conformity with the lines, grades, thickness and typical cross sections shown on the Drawings or directed by the Engineer.

204.02 MATERIALS

204.02.1 General

- (1) Only approved materials shall be used in the construction of embankments and backfills.
- (2) Logs, trees, stumps, weeds, grass or other organic or undesirable material shall not be placed in embankments.
- (3) Materials placed in the top 300 mm of embankments shall comply with the following requirements:

Liquid limit	AASHTO T 89	maximum 40%
Plasticity index	AASHTO T 90	maximum 14%
CBR (4 days soaked)	AASHTO T 193	minimum 8%
Maximum particle size		100 mm

- (4) Materials placed more than 300 mm below sub-grade elevation shall comply with the following requirements:

Liquid limit	AASHTO T 89	maximum 45%
Plasticity index	AASHTO T 90	maximum 18%
CBR (4 days soaked)	AASHTO T 193	minimum 4%
Maximum particle size		150 mm

- (5) Subject to approval by the Engineer rock pieces may be used in embankment formation up to a level not more than 1200 mm below formation (i.e. finished embankment level).

- (6) Suitable material (except rock) arising from excavations which has a CBR value of 8% or more and/or borrow pit materials which have CBR values of 8% or more shall, unless otherwise approved by the Engineer, be reserved for the top 300 mm of embankments so that a stronger sub-grade can be assured.

204.02.2 Swampy- and Flooded Areas

- (1) In order to provide more stability on flood prone embankments the 4 days soaked CBR (AASHTO T 193) shall be minimum 10% at 95% of MDD (AASHTO T 180).
- (2) Selected embankment materials for swampy areas and for situations where placing under saturated or flooded conditions cannot be avoided, shall be rock, sand or gravel or other clean granular material with a maximum Plasticity Index of 6 % (six percent).

(3) Below table shows material gradings that provide better embankment stability during flooding. When instructed by the Engineer below material gradings shall be used.

Table 204.1 - Grading of Material Stabilizing Embankments in Flooded Areas

Sieves, mm	Grading A	Grading B
50	-	-
25	100	100
10	-	-
2	40 - 100	55 - 100
0.425	20 - 50	30 - 70
0.075	6 - 20	8 - 25

(4) The weight of material fractions passing 0.075mm sieve shall not be greater than 2/3rd of that passing 0.425mm sieve (AASHTO T 27).

(5) If requested by the Engineer sodding (see Section 609), -for additional erosion protection-, shall be provided on the embankment slopes.

(6) In order to allow satisfactory drainage of infiltrated water from the subbase to the subgrade without loss of fine materials and to block the spread of contamination between the two layers, appropriate geotextile fabric (see Section 601) shall be used between subgrade and subbase layers, when instructed by the Engineer.

(7) In case of serious erosion and scouring problems on the embankment, gabion mattresses (see Section 601) shall be provided, when instructed by the Engineer.

204.03 CONSTRUCTION REQUIREMENTS

204.03.1 Benching

(1) When embankment is to be placed and compacted on hillsides, or where new embankment is to be compacted against existing embankments, or when an embankment is on side-sloping ground with slopes that are steeper than 1V : 4H or at such other locations as the Engineer may direct, the surface of the existing ground shall be benched (in horizontal steps) or trenched as shown on the Drawings, or as directed by the Engineer.

(2) Benching shall be of sufficient width to permit placing and compacting equipment to operate effectively. Each horizontal cut shall begin at the intersection of the original ground and the vertical side of the previous bench. Excavation from benching shall be compacted with the new embankment material. If the compacted benching fill is more than 150 mm thick, it shall be filled in two or more layer as applicable and width shall be equal to the width of the compacting equipment plus 300mm for easy movement. The cost for benching and re-compaction shall be included in the unit rate for excavation.

(3) The benching shall be kept free of water.

204.03.2 Cleaning and Scarifying

(1) All sod and organic matter shall be removed from the surface upon which the embankment is to be placed, and the cleared surface unless designated under paragraph (2) herein shall be completely broken up by ploughing, or scarified to a minimum depth of 150 mm, watered as necessary and compacted to the specified embankment density, except where the surface is within 500 mm of formation level when the depth so treated shall be a minimum of 300 mm.

(2) Where the surface upon which the embankment is to be placed is an existing pavement containing granular or rock material, concrete, or other hard material within 1.0 metre of the formation level, unless otherwise ordered by the Engineer, the old surface shall be scarified to a minimum depth of 150 mm and finely broken up in order that the new fill material may be well bonded with the old surface, watered and compacted to the specified embankment density. This does not apply where the existing pavement is to be prepared for overlay in accordance with Section 209 of the Specifications.

(3) Immediately prior to placing fill, the complete surface of the existing ground after treatment as specified in paragraphs (1) and (2) above shall be proof rolled. Proof rolling shall comprise at least 2 passes of a 10 tonne vibratory roller or an equivalent loading regime approved by the Engineer. Compliance of proof rolling shall be when an area withstands proof rolling without visible deformation or springing. The Contractor shall carry out any additional compaction, or replacement and compaction, and testing to achieve compliance with the requirements for proof rolling at his own cost, except for any instructed removal and replacement of material which shall be measured and paid for as unsuitable excavation under Clause 203.05 of the Specifications.

204.03.3 Filling against Structures

(1) If the embankment is deposited on one side only of abutments, wingwalls, piers or culvert wingwalls, care shall be taken that the area immediately adjacent to the structure is not compacted to an extent which will cause overturning of, or excessive pressure against, the structure.

(2) When an embankment is to be constructed over an area previously occupied by an irrigation canal, well, water pipe, any previous excavation or other such construction that will not permit the use of normal compaction equipment, the embankment construction shall conform to the back filling requirements specified in Section 207 of the Specifications until normal compaction equipment can be used.

204.03.4 Execution

(1) The Contractor shall have in operation a sufficient number of motor graders to properly spread and maintain the surface of each layer of freshly placed embankment prior to and during rolling and compaction operations.

(2) When it is feasible, trucks, tractors or other heavy hauling equipment shall be routed over the fill in such a manner as to take advantage of the compaction thereby afforded.

(3) The Engineer shall have full authority at any time to require the suspension of the delivery of material to the embankment until previously delivered materials are properly placed and preceding layers are satisfactorily compacted, finished and tested.

(4) The Contractor shall be responsible for the stability of all embankments and shall replace all parts which, in the opinion of the Engineer, have been damaged or displaced due to carelessness or neglect on the part of the Contractor, or due to natural causes such as storms, and are not due to the unavoidable movement of the natural ground under the embankment.

(5) During construction, the roadway shall be kept shaped and drained at all times. When unsuitable material has been placed in the embankment, its removal shall be at the cost of the Contractor.

(6) Embankments shall be constructed of material spread in successive layers for compaction, each layer extending over the full width of the embankment at the height of the layer. The Contractor shall ensure that the required compaction is obtained throughout each layer, including the material which after trimming will form the side slopes.

(7) Embankment shall be placed in horizontal layers not exceeding 200 mm (loose measurement) and compacted to the specified density before the next layer is placed. Compaction up to 250 mm (loose measurement) layers can be done, if the Contractor in the opinion of the Engineer has satisfactorily proved that his equipment is capable compacting up to 250 mm (loose measurement).

(8) Any hard material that is not broken down by the passage of the compacting equipment shall either be removed or be broken down by harrowing or other means into individual pieces not exceeding in any dimensions the size specified in Clause 204.02 herein.

(9) When the excavated material consists predominantly of rock, too large to be placed in 250 mm layers in the lower portions of embankments, the material may be placed in thickness up to the average rock dimension but not to exceed 450 mm. Rock shall not be end dumped directly on the previously completed layer of embankment. Rock shall be dumped on the layer being constructed, pushed into place, and such finer material added so as to produce a dense material which can be compacted.

(10) Rock, broken concrete, or other solid materials shall not be placed in embankment areas where piling is to be placed or driven.

(11) The Contractor shall, at points to be determined by the Engineer, suspend work on embankments forming the approaches to structures until such time as the construction of the latter is sufficiently advanced to permit the completion of the approaches without the risk of interference or damage to the structural work.

(12) In the event of any slip, slide or subsidence in the earthworks extending beyond the required profile of embankment, the Contractor shall dispose of the material in the slip, and make good as required by the Engineer. The classification of material from slips or slides will be in accordance with its condition at the time of removal, irrespective of its previous condition.

(13) Side slopes shall be neatly trimmed to the lines and slopes shown on the Drawings or as directed by the Engineer, and the finished work shall be left in a neat and acceptable condition.

(14) The Contractor shall protect the sub-grade from damage by exercising such precautions as the Engineer may deem necessary including overfilling and re-trimming to grade immediately prior to installation of the sub-base. At all times the sub-grade surface shall be kept in such condition that it will drain readily and correctly. The sub-grade shall be checked and approved before any sub-base material is placed thereon.

204.03.05 Scheduling of Work

(1) The Contractor shall schedule roadway excavation, embankment work and drainage work so that they complement each other. If the Contractor's earthwork progress exceeds the progress of his drainage work to the point where the roadway becomes a hindrance to cross drainage, the Engineer will order the Contractor to open, at the Contractor's own cost, adequate waterways through the roadway at the locations where drainage structures are to be installed. Any damage to the roadway caused by water passing through these openings shall be made good at the Contractor's cost. Any damage to private property shall be made good by the Contractor and compensation claimed will be at the cost of the Contractor.

204.03.6 Tolerances

(1) All slopes, lines and grades shall be true, correct and accurate, and according to those shown on the Drawings or otherwise directed and approved by the Engineer.

(2) The top of embankment sub-grade level shall be within +10 mm and -40 mm of the specified level.

(3) Batters and drains shall be trimmed before the wet season so that the drain is clear and so that vegetation established during the wet season is not disturbed by later trimming. If the base course has been laid, this should be a final trim, otherwise a preliminary trim shall be done leaving sufficient embankment width for the construction of further layers.

(4) All humps and depressions and deficiencies exceeding the specified tolerances shall be corrected by the Contractor by methods approved by the Engineer. Adding new material to low areas in the form of skin patching will not be permitted.

204.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
204-1	Embankment from Excavated Materials	Metre Cube
204-2	Embankment from Borrow Materials	Metre Cube
204-3	Selected Fill Material in Flooded Areas	Metre Cube

(2) "Embankment from excavated material" means embankment constructed of material excavated from within the right-of-way, meeting specification requirements and the material is approved for use in the project. "Embankment from borrow material" means embankment constructed of material excavated from outside the right-of-way, meeting specification requirements and the material is approved for use in the project.

(3) The volume of the embankment shall be computed by the Contractor and checked by the Engineer. Quantity computations shall be based on the cross sections after clearing and grubbing has been done, taken by the Contractor and observed and attested by the Engineer and the final cross sections developed from the typical sections in the Drawings. Any material placed before these measurements have been taken and approved by the Engineer will not be paid for. Volumes will be computed by the average end area method.

(4) The Engineer will check all or any part of the work, as he deems necessary, to determine conformance to the lines, grades, elevations and cross sections submitted by the Contractor. The Contractor shall, at his own cost, provide the equipment and labour, including field parties, to assist the Engineer in checking the work.

(5) Measurement shall include the provision and placing of structural backfill to abutments, retaining walls and wingwalls in accordance with Section 208 of the Specifications.

(6) No measurement will be made under the above items for filling of voids created by the removal of unsuitable material and all work therein, including provision and haulage of material, laying, watering, compaction and trimming, shall be deemed included under Item 203-3 of the Bill of Quantities.

(7) No deduction to embankment fill quantities will be made for pipe culverts or other void of less than 10 square metre cross section.

204.05 PAYMENT

(1) Payment will be made at the rates entered in the Bill of Quantities.

(2) Payment shall include loading and haulage of suitable materials from excavation and/or borrow areas, depositing in layers, breaking down, grading, watering, levelling, compaction and trimming, overfilling and re-trimming/compaction as required, disposal of surplus materials from trimming and re-trimming, sub-grade protection, drainage and all other items necessary to provide the finished embankments to the levels, grades and slopes shown on the Drawings or instructed by the Engineer.

(3) In addition, payment for measurement Item No.204-2 Embankment from Borrow Materials shall include all activities for obtaining (winning) borrow materials, consultations with Provincial Authorities and all other measures itemised under Sub-clause 203.06 of the Specifications.

SECTION 205

COMPACTION OF EARTHWORKS

205.01 DESCRIPTION

(1) This work shall consist of the compaction of earthworks by rolling or tamping or any combination of these methods in accordance with the requirements of the Drawings and the Specification, or as ordered by the Engineer.

205.02 MATERIALS

205.02.1 Moisture-Density Tests

(1) Moisture-density tests and preliminary studies will be made of each type of soil to be used in the construction of the Works to determine the maximum dry density, the optimum moisture content and the moisture range required for satisfactory compaction. The field density and actual moisture content of the compacted embankment shall be determined by field tests.

(2) The maximum dry density, as determined by the specified moisture-density test, shall be the density to which the field density is referred to for comparison.

(3) The optimum moisture content, shall be the moisture content corresponding to the maximum dry density on the moisture-density curve.

(4) The moisture range shall be the limits of the moisture content for each type of soil within which the required density can be attained.

(5) The field density shall be the density of the compacted embankment determined by the field density test.

(6) The moisture content shall be the actual moisture content of the soil in the compacted embankment at the time of compaction.

205.02.2 Sampling and Testing

(1) Sampling and testing shall be performed in accordance with the following AASHTO test methods:

<u>Test</u>	<u>Description</u>
AASHTO T 99	Moisture-Density Relationship (2.5 kg rammer)
AASHTO T 180	Moisture-Density Relationship (4.54 kg rammer)
AASHTO T 191	in-place Density, Sand-Cone Replacement
AASHTO T 265	Moisture Content

205.02.3 Compaction Trials

(1) The precise manner in which the earthworks are to be compacted shall be the subject of field compaction trials to establish the type, sequence and numbers of passes of the Contractor's compaction equipment necessary to obtain the degree of compaction specified, the optimum moisture content associated with such equipment, and the loose thickness of layers which can be effectively compacted.

(2) The Contractor shall perform compaction trials prior to the commencement of compaction work, and put forward in writing to the Engineer for his approval a detailed work method statement including a list of equipment he proposes to use.

(3) The soil and compaction equipment used in the trials shall be approved by the Engineer.

(4) The field compaction trials shall proceed until such time as the Engineer and the Contractor have agreed on the procedure necessary to obtain the specified degree of compaction. The agreed procedure, embracing the type, sequence and nominal number of passes of the equipment required to compact a layer of given thickness, and the limits within which the moisture content of the soil shall lie at the time of compaction, shall be recorded and shall thereafter form the basis of the field control of the compaction equipment on that material.

(5) A field compaction trial shall be carried out on each type of material, including material exposed in cuts, and for each standard of compaction, as determined by the Engineer. The Engineer may stop the work or order further field compaction trials if the required degree of compaction is not being obtained consistently in the Works.

205.03 CONSTRUCTION REQUIREMENTS

205.03.1 General

(1) The provisions of Section 204 of the Specifications shall apply to the construction of embankments that are to be compacted except as specifically of the Specifications superseded herein with respect to preparation of the areas upon which the embankment is to be placed and to the thickness of the layers of embankment being placed.

(2) Compacting operations shall include adequate blading with motor graders to ensure uniformity of the layers being compacted. The number of graders and rollers in use shall be sufficient to blade and compact adequately all material being delivered to the job site.

(3) The Engineer shall have full authority to suspend the delivery of materials to the embankment until previously delivered materials are properly placed and satisfactorily compacted.

205.03.2 Compaction Equipment

(1) All compaction equipment shall be approved by the Engineer, and proven satisfactory performance shall be the basis for such approval.

(2) The weight of rollers shall be increased as necessary to obtain the degree of compaction required by the Drawings and Specifications.

205.03.3 Sub-grade Preparation in Earth Cuts

(1) Unless otherwise directed by the Engineer, the soil below sub-grade level in earth cuts shall be thoroughly scarified, broken up and the moisture content increased or decreased to obtain the specified moisture content, and compacted to the designated degree of compaction to a depth of 300 mm and for the full width of the roadbed sections or as ordered by the Engineer.

(2) If the soil encountered in earth cuts at the sub-grade level is found by test to be unstable, or that its 4 day soaked CBR (AASHTO T 193) when compacted to 98% MDD in accordance with AASHTO T 180 Method D, is less than that shown on the Drawings, the soil shall be declared as unsuitable and shall be removed to the depth directed by the Engineer, and the unsuitable material replaced with suitable stable material as directed by the Engineer.

(3) The volume of such unsuitable material shall be measured and paid for under Item No. 203-3 of the Bill of Quantities. This measurement and payment shall include the costs of the replacement suitable material.

205.03.4 Sub-grade Preparation in Rock Cuts

(1) Where required by the Engineer the surface of the rock shall be lightly ripped or otherwise scored to a depth approved by the Engineer to form a key for the pavement construction layers.

205.03.5 Compaction Control Requirements

- (1) Roadway embankment shall be placed in uniform layers and shall be compacted as specified and shall be approved by the Engineer before the next layer is placed.
- (2) The thickness of the layers and the necessary number of passes of compacting equipment shall be in accordance with the results of the compaction trials.
- (3) Effective spreading equipment shall be used on each layer to obtain uniform thickness prior to compacting. As the compaction of each layer progresses, continuous levelling and manipulating shall be carried out to achieve uniform density.
- (4) Construction equipment shall be routed uniformly over the entire surface of each layer. A motor grader or bulldozer shall be used on the embankment at all times during the placing and compacting of the earth material.

205.03.6 Tamping

- (1) Whenever embankments are placed adjacent to structures or at locations where it is not practicable to use a roller, the embankment material shall be tamped by the use of mechanical rammers or tampers acceptable to the Engineer.
- (2) Each layer shall be compacted to a density equal to or greater than that obtained under the rolling procedure for the type of compaction designated.
- (3) The loose thickness of each successive layer when placed shall be such as to ensure that proper compaction is obtained. In no case shall the loose thickness of a layer be greater than 150 mm.
- (4) Each compacted layer shall be approved by the Engineer before the next layer is placed.
- (5) When the area to be compacted is small, hand tampers may be used if the Engineer so permits.

205.03.7 Special Provisions for Heavy Rollers

- (1) When very heavy rollers are used, the compacted thickness of the layer may be increased, subject to the approval of the Engineer, provided that a uniform density equal to or greater than the specified density is obtained throughout the entire depth of the layer.
- (2) The maximum compacted thickness of the layer shall be established by the Engineer for each type of heavy roller used and for the various types of soil encountered. The Engineer may vary the compacted thickness of the layer as the work progresses to ensure adequate compaction, or to withdraw approval of the heavy rollers if, in the opinion of the Engineer, the compaction achieved is non-uniform or if the requirements of the Specifications are not being achieved or if the rollers are causing damage or disturbance to adjacent properties or installations.

205.03.8 Moisture Content Requirements

- (1) The moisture content of the soil at the time of compaction shall be uniform and shall be such that the soil can be compacted to the requirements of this Section of the Specifications.
- (2) Work on compaction of materials in embankments shall only be carried out when the material has a moisture content within the limits agreed in the compaction trials.
- (3) Moisture content shall be increased or decreased as necessary to obtain the required density and stability. When the moisture content of the material has to be increased the Contractor shall water the top of the underlying layer before depositing the fill. The bulk of the water required to increase the moisture content shall be added before the material is spread, and the material shall be mixed during spreading to ensure a uniform distribution of moisture content in the compacted layer.

205.03.9 Compaction Requirements

- (1) In earth cuts, the material located within 300 mm below sub-grade level shall be compacted to a characteristic value of 98% of the maximum dry density as determined according to AASHTO T 180 Method D
- (2) All layers in embankment shall be compacted to 95% of the maximum dry density as determined according to AASHTO T 180, except for the top 300 mm of the Sub-grade where compaction shall be 98% of the maximum dry density as determined according to AASHTO T 180 Method D.
- (3) In-place field density measurements shall be determined using AASHTO T 191.
- (4) Density requirements do not apply to portions of embankment constructed of materials (such as rock) which in the opinion of the Engineer cannot be tested by approved testing methods. Where the Contractor is of the opinion that the proposed material is of this nature, then he shall notify the Engineer of this opinion and submit his proposed work procedure for approval by the Engineer. The Engineer at his discretion may require the Contractor to carry out compaction trials at the Contractor's expense. The Contractor shall at his own cost modify his work procedures and methods to compact this material to the satisfaction of the Engineer. Where in the opinion of the Engineer this material cannot be adequately compacted, then this material will not be used.

205.03.10 Maintenance of Earthworks during Construction

- (1) The Contractor shall protect finished earthworks from traffic, weather and erosion and keep them free of rubbish and debris and repair and re-establish grades in settled, eroded and rutted areas to the specified tolerances. Where completed compacted areas are disturbed by subsequent construction operations or adverse weather, the Contractor shall scarify the surface, reshape and compact to the required density in accordance with the Specifications prior to further construction.

205.04 MEASUREMENT AND PAYMENT

- (1) No separate measurement or payment will be made for complying with the requirements of this Section 205 of the Specifications.

SECTION 206

DISPOSAL OF SURPLUS MATERIALS

206.01 DESCRIPTION

(1) This work comprises the disposal of surplus materials as directed by the Engineer, except that disposal of materials arising from demolition work under Section 202 of the Specifications is covered under that Section.

206.02 CONSTRUCTION REQUIREMENTS

(1) All suitable surplus excavated materials shall be disposed of in the by Engineer approved spoil dumps.

(2) Before starting any earth-moving operation on any job site, the Contractor shall obtain the Engineer's approval to the areas he proposes to use as spoil dumps. In formulating his proposals the Contractor shall have due regard of the need to protect the environment. Spoil dumps shall not be located in National Biodiversity Conservation Areas, Provincial or district protected areas or other ecologically sensitive areas, unless specifically approved in writing by the Engineer.

(3) All spoil dumps shall be sited and utilised in such a way as to ensure that they do not hinder subsequent excavation, eliminate the possibility of future landslides and do not form areas where water can collect and stagnate. Spoil dumps shall not cause any damage to farms, crops or properties.

(4) Surplus materials shall not be placed in wetlands.

206.03 MEASUREMENT AND PAYMENT

(1) No separate measurement or payment will be made for complying with the requirements of this Section 206.

SECTION 207

STRUCTURAL EXCAVATION

207.01 DESCRIPTION

(1) This work comprises excavation of material necessary for the construction of foundations for bridges and retaining walls, box culverts, pipe culverts and other major and minor structures, and shall include all necessary clearing and grubbing, bailing, drainage, pumping, sheeting, bracing, and the construction of cofferdams or cribs, if necessary, and other incidentals required for the proper execution of the work, and their subsequent removal. It includes the disposal of all material obtained from such excavation, and backfilling to the level of the original ground.

(2) Ditches at inlets and outlets of culverts and any other ditches indicated in the Drawings shall be constructed under roadway excavation items.

207.02 MATERIALS

(1) Suitable material for backfilling of structural excavations shall be as defined in Clause 204.02 paragraphs (3) and/or (4) of the Specifications except that the maximum particle size shall be 50 mm. All other materials shall be deemed unsuitable for structural backfill but may be used, if considered suitable by the Engineer, for construction of embankments under Section 204 of the Specifications.

207.03 CONSTRUCTION REQUIREMENTS

207.03.1 General

(1) If required by the Engineer and before any structural excavation is started, the Contractor shall submit for the Engineer's approval a program of his proposed operations, together with equipment lists and a description of the methods intended to be adopted.

(2) The Contractor shall notify the Engineer sufficiently well in advance of the start of any structural excavation work which constitutes a pay item in the Bill of Quantities so that the Engineer may, if he so requires, witness the taking of measurements of the existing ground. Any materials removed or excavated before these measurements have been taken and approved by the Engineer will not be paid for.

(3) Foundation pits shall be excavated to correspond to the outlines of the footings shown on the Drawings and shall be sufficiently large to permit the placing of the full width and length of the footings shown with full horizontal beds. Rounded or undercut corners and edges of footings will not be permitted.

(4) The elevations of the bottoms of footings, as shown on the Drawings, shall be considered as approximate only and the Engineer may order such changes in dimensions and elevation of footings as may be necessary to secure a satisfactory foundation.

(5) Excavation shall be carried to such a depth that the bottom of the excavation is approximately 100 mm above the bottom of footing elevation. No further excavation shall be carried out until the Engineer has examined the excavation and ascertained that at the level of excavation the design bearing pressure stated on the Drawings can safely be attained. After permission to continue with the excavation is given, the Contractor shall excavate to the required excavation level and immediately place blinding concrete.

(6) If after excavating to the required excavation level, the blinding concrete is not placed immediately, and as a consequence the material becomes unsuitable, additional excavation and backfilling with concrete shall be carried out as directed by the Engineer, at the Contractor's expense.

- (7) Over-depth excavation below the required bottom of concrete blinding elevation approved by the Engineer shall be backfilled with the same class of concrete designated for the footing and poured monolithically with the footing. No payment will be made for unauthorised over-depth excavation and the concrete backfill shall be at the Contractor's cost.
- (8) All spaces excavated and not occupied by the substructure shall be re-filled with suitable material up to the surface of the surrounding ground. All backfill shall be compacted to the density of the surrounding ground, and its top surface neatly graded. No payment will be made for unauthorised over-width excavation and the backfill shall be at the expense of the Contractor.
- (9) All surplus excavated material not required for backfilling shall, if considered suitable by the Engineer, be deposited in embankments or otherwise disposed of as directed by the Engineer.
- (10) Where foundation piles are used, the excavation of each pit shall be completed before the piles are driven. All the foundation piling in any one pier or abutment shall be driven before concrete is poured in any column or footing of that pier or abutment. After the driving is completed, all loose and displaced material shall be removed at the Contractor's expense, leaving a smooth solid bed to receive the concrete.
- (11) When a foundation is to rest on rock, the excavation shall be done in such manner as to allow the solid rock to be exposed, the rock freed of all loose material, cleaned and cut to a firm surface, and prepared in horizontal beds or roughened as directed by the Engineer. All seams shall be cleaned out and filled with concrete, mortar or grout before the blinding concrete is placed.
- (12) All blasting necessary in any one pier or abutment shall be performed prior to placing any concrete.
- (13) Adequate vertical sheeting shall be used until completion of the work to protect employees, to avoid subsidence and to prevent damage to adjacent ground and structures. If the Contractor instead choose and if so approved by the Engineer, to carry out open excavation with flatter side slopes, no extra measurement and payment will be made. All sheeting and bracing used in structural excavation shall be removed upon completion of the work.
- (14) All cofferdams shall be carried to adequate depths and heights, be safely designed and constructed and be made as watertight as is necessary for the proper performance of the work done inside them. The cofferdams shall be of sufficient height to protect from sudden rising of the stream and to prevent erosion of the foundation.
- (15) At least four weeks before he proposes to work on a cofferdam the Contractor shall furnish the Engineer with drawings of the cofferdam and supporting calculations for the Engineer's review. Work shall not commence until the Engineer's consent in writing has been obtained.
- (16) All shoring (providing support to a structure with a beam or timber by propping it against the structure) and timbering must be carried out in an effective and substantial manner and to the approval of the Engineer. No timber bracing shall be left inside any excavation so as to extend into the substructure concrete.
- (17) While the excavation is being carried out, all excavations shall be kept free from water. Where excavation has to be made and foundations formed below the groundwater level, the Contractor shall submit a full and clear description, supported by such drawings as may be necessary, of the methods he proposes to use in respect of each foundation to enable the whole of the work to be executed in the dry, and such measures shall be adopted as the Engineer approves. All such work shall be deemed to be included in the unit rate quoted for the appropriate pay item.
- (18) If approved by the Engineer, excavations under water can be carried out.
- (19) Maintenance of natural waterways and allowance for the passage of surface water during construction shall be the Contractor's responsibility, and any damage occurring shall be made good at the Contractor's expense.

(20) For structural excavation near adjoining structures, the Contractor shall ensure the stability of the existing structures by carrying out at his own cost, all necessary protection and stabilisation works which shall be subject to the approval of the Engineer.

207.03.2 Box Culverts

(1) Excavation for box culverts shall conform to the general requirements of this Section 207 and the requirements of Section 401 of the Specifications.

207.03.3 Pipe Culverts

(1) Excavation for pipe culverts shall conform to the general requirements of this Section 207 and the requirements of Section 402 of the Specifications.

207.03.4 Scheduling of Work

(1) The Contractor shall so schedule the work that no excavation will be left in an exposed condition for a period longer than specified or permitted by the Engineer. If the Contractor fails to meet this requirement, the Engineer may order the Contractor to suspend further excavation until the Contractor's construction progress enables him to meet the requirement.

207.03.5 Backfilling

a. General

(1) All structures shall be backfilled in accordance with these construction requirements. Only suitable materials that will produce a dense, well-compacted backfill shall be used for backfilling. Materials such as sod, debris, and soil containing organic matter shall not be used. The Contractor shall remove all debris, spoil and waste construction materials from excavations prior to placing backfill.

(2) No backfill shall be placed against any structure without the permission of the Engineer. In general, no structure, or cast-in-place culvert shall be subjected to the pressures of backfilling or to live loads for a period of 14 days or until the minimum required concrete compressive strength specified for the structure has been achieved. Special care shall be taken to prevent any wedging action against the structure. The slopes bounding the excavation shall be stepped when necessary, to prevent such wedge action.

(3) Jetting of fills, or other hydraulic methods involving or likely to involve liquid or semi-liquid pressure, shall be prohibited.

(4) The fill material at retaining walls, abutments, wing-walls, and all bridge bents shall be placed in horizontal layers of uniform thickness and compacted by means of suitable equipment, or by tamping with mechanical tampers acceptable to the Engineer. Each layer shall be compacted to the same density as required for embankments or as specified on the Drawings. The loose thickness of each successive layer when placed shall be such as to ensure that proper compaction is obtained. In no case shall the loose thickness of a layer be greater than 200 mm. Each successive layer shall contain only that amount of material which will allow proper compaction, but in no case shall any layer be greater than 150 mm (compacted measurement) in depth. The moisture content of backfilling material shall be uniform, and shall be within the moisture range designated by the compaction testing. Unless otherwise approved by the Engineer, hand tamping will not be accepted.

(5) Water shall be drained from the areas to be backfilled whenever practicable. In cases where, in the opinion of the Engineer, it is not practicable to drain the areas to be backfilled, the backfill material shall be free draining material as specified in Section 208 of the Specifications and shall be deposited in the water in thin layers. Compaction shall be by a method approved by the Engineer.

(6) Where shown on the Drawings or required by the Engineer, free draining structural backfill to structures shall be provided in accordance with the requirements of Section 208 of the Specifications.

(7) The free draining backfill material shall be covered by at least 300 mm of general fill material or better, to prevent entry of surface water runoff into the structural backfill.

b. Culverts

(1) The Contractor shall complete the backfill around culverts, as specified above and in Sections 401 and 402 of the Specifications, to the level of the original ground line or to the level of top of sub-grade at that point, as shown on the Drawings. Backfill shall be placed across the full width of the excavation area.

(2) If the top of the culvert extends above the original ground line, the Contractor shall continue the compacted backfill to the top of the culvert and for a width of 3 metres on each side of the culvert or for a total width of 3 times the height of the culvert, whichever is the greater. The backfill shall be placed across the full width of the roadway embankment.

(3) No heavy vehicles or construction plant shall pass over a culvert with less than 0.6 metre cover. The Contractor may place and later remove temporary compacted additional cover material at his own cost, if he wishes his vehicles and plant to cross a culvert on the condition that the Contractor will remedy any defects in the culvert at his own cost.

c. Bridges

(1) The Contractor shall backfill bridge abutments in accordance with the requirements of this Clause 207.03 and Section 208 of the Specifications, to the level of the original ground or to the top elevation of any adjacent embankment which may be in place.

(2) Backfill within embankments, within the roadway excavated areas, or in front of abutments and retaining walls or wing-walls shall be compacted to the same density as required for embankment.

(3) Backfill around piers shall be placed on both sides to approximately the same elevations at the same time and compacted to the same density as the adjacent natural soil except where rip-rap is used for backfill.

d. Inlets, Outlets and Miscellaneous Structures

(1) These structures shall be backfilled in accordance with the methods specified in Clause 207.03 of the Specifications except that backfill outside the roadway area shall be placed in layers not more than 250 mm in depth (loose measurement) and shall be compacted to a density not less than that of the adjacent undisturbed material.

207.04 MEASUREMENT

207.04.1 Method of Measurement

(1) Measurement shall be as follows:

Item No.	Description	Unit
207-1	Structural Excavation (Common)	Metre Cube
207-2	Structural Excavation (Rock)	Metre Cube
207-3	Structural Excavation for Pipe Culverts, Inlet & Outlet Structures on Pipe Culverts (Rock)	Metre Cube
207-4	Structural Excavation under Water	Metre Cube

(2) Measurement for the Structural Excavation items shall be limited to excavation for footings or foundations for bridges, concrete and masonry retaining walls, wing-walls, box culverts and other major structures shown on the Drawings or as directed by the Engineer.

(3) Measurement for excavation in common material for pipe culverts, inlet and outlet structures and incidental structures shall not be made under this Section but under Section 402 of these Specifications.

(4) Measurement for rock excavation for pipe culverts, pipe culvert inlet and outlet structures and incidental structures will be made under this Section 207.

(5) Structural Excavation shall be measured by the cubic metre of material removed in its original position, computed by the average end area method. Measurements shall be made by the Contractor in the presence of the Engineer. No measurement will be made for structural excavation outside the prescribed limits.

(6) Structural Excavation under Water shall be measured as decided by the Engineer

207.04.2 Limits of Measurement

(1) The upper limits shall be the original ground surface as recorded on the approved cross sections or the top of the required grading cross section, whichever is lower. The upper limits for river/stream channels shall be the bed level of channel as shown on the Drawings or as otherwise directed by the Engineer.

(2) When no excavation dimension details appear on the Drawings, the limits of excavation shall be from the upper limit plane to the bottom of the footing or base of structure, and vertical planes 450 mm outside the neat lines of footings or structures without footings or as otherwise directed by the Engineer.

(3) Concrete blinding shall not be considered as structure for the purpose of defining the limits of structural excavation.

(4) When the Contractor encounters special or unusual conditions he shall notify the Engineer who may order changes to structural excavation limits where he deems them necessary. Any additional excavation performed by the Contractor without prior approval of the Engineer, shall be at the Contractor's expense and no subsequent measurement or payment will be made.

207.05 PAYMENT

(1) Payment will be made at the rates in the Bill of Quantities.

(2) Payment for Structural Excavation items shall include full compensation for controlling and removing water from excavations and for furnishing and installing or constructing cofferdams, shoring and all other facilities necessary to the operations, except concrete seal courses which are shown on the Drawings, and their subsequent removal.

(3) Payment will also include the placing and compacting to the level of original ground of all backfill materials, obtained from excavation, and the disposal of all surplus or unsuitable excavation.

(4) The furnishing and compacting of backfill material (including structural backfill under Section 208 of the Specifications) to the level of original ground from sources other than excavation shall not be paid for separately, but shall be deemed to be included in the unit rate for structural excavation.

SECTION 208

STRUCTURAL BACKFILL (FREE DRAINING)

208.01 DESCRIPTION

(1) The work covered by this Section comprises the placing of free draining structural backfill material against the rear faces of abutments, wing-walls and retaining walls within the limits as indicated on the Drawings or ordered by the Engineer.

208.02 MATERIALS

(1) Porous backfill material shall be hard, durable clean gravel or crushed rock or sand and shall be free from organic material, clay balls and other deleterious substances. Laterite or concretionary materials shall not be used.

(2) Sand used for porous backfill material shall conform to the following grading requirements.

Table 208.1 - Grading Requirements of Sand used for Porous Backfill Material

AASHTO Sieve (mm)	Percent Passing (by weight)
	Type A
10	100
4.75	95 – 100
1.18	45 – 80
0.300	10 – 30
0.150	2 – 10

(3) Gravel and crushed rock shall conform to one of the following grading requirements:

Table 208.2 - Grading Requirements of Gravel and Crushed Rock

AASHTO Sieve (mm)	Percent Passing (by weight)			
	Type B	Type C	Type D	Type E
50.0	100			
37.5	70 – 100	100		
25.0	55 – 85	75 – 100	100	
19.5	50 – 80	60 – 90	70 – 100	100
10.0	40 – 70	45 – 75	58 – 75	-
4.75	30 – 60	30 – 60	35 – 65	45 – 80
2.0	20 – 50	20 – 50	25 – 50	30 – 60
0.425	10 – 30	10 – 30	15 – 30	20 – 35
0.075	0 – 2	0 – 2	0 – 2	0 – 2

(4) Where one or more of the gradings shown above are indicated on the Drawings or other Contract Documents, material conforming to the gradings indicated shall be used, otherwise the Contractor may select any one of the above gradings.

208.03 CONSTRUCTION REQUIREMENTS

- (1) Free draining structural backfill material shall be placed in layers by the methods specified in Clause 205.03 of the Specifications. Compaction shall be to 95% MDD to AASHTO T 99 Method D. The maximum loose thickness of the layer is to be 150 mm and the moisture content is to be adjusted as required to achieve satisfactory compaction.
- (2) Irrespective of the details shown on the Drawings, in no case shall any abutment, retaining wall or wing-wall have less than 300 mm thickness (measured perpendicular to the rear face) of free draining structural backfill behind the rear face unless so directed by the Engineer.
- (3) Any excavation necessary to enable the placing of structural backfill material shall be at the cost of the Contractor.

208.04 MEASUREMENT AND PAYMENT

- (1) No separate measurement and payment will be made for free draining structural backfill which shall be deemed to be included in the measurements made under Items Nos. 204-1, 204-2, 207-1 and/or 207-2 of the Bill of Quantities.

SECTION 209

RECONDITIONING OF EXISTING PAVEMENT

209.01 DESCRIPTION

- (1) This section covers preliminary work to be done on the surface or pavement of an existing road prior to upgrading the pavement by either the overlay method or the reconstruction method.
- (2) The overlay method may be used where the existing pavement (including all pavement layers and an appropriate depth of subgrade) is shown to have strength and stiffness equivalent to that of the material below the base course layer in new construction, as specified in Section 301.
- (3) The objective of the reconstruction method is to produce, by reworking the existing pavement, a layer of material which satisfies the specification for subbase specified in Section 301 in terms of strength, stiffness, durability and surface finish, and at the required level.

209.02 MATERIALS

- (1) If the grading of the existing pavement base materials do not satisfy the grading for subbase given in Clause 301.02 2(1), because of an excess of oversized particles. Additional finer material may be mixed with the course material to achieve the required grading and other properties.

209.03 INVESTIGATION OF EXISTING PAVEMENT

- (1) At least 28 days before commencing work on a particular lot of work, the Contractor shall dig test pits of not less than 1 square metre in extent at intervals of approximately 250m along the centre line, or where there is a change in the condition of the existing pavement, or as directed by the Engineer. The Contractor shall notify the Engineer in writing of his intention to carry out these test pits and afford the Engineer every opportunity to monitor and inspect these pits. The Contractor shall excavate sufficient materials to carry out all tests required as well as obtain any audit testings samples required by the Engineer.
- (2) No work shall proceed on any length of the road without the prior agreement of the Engineer.

209.03.1 Existing Pavement Material

- (1) Average depth of the pavement layers computed by taking the average of the minimum depth of materials measured anywhere on each of the four sides.
- (2) The following tests shall be carried out on the materials from the test pits:

Table 209.1 - Tests on Materials from Test Pits on Existing Pavements

Test	Standard
CBR (4 day soaked)	AASHTO T 193 at 95% of MDD
Particle Size Distribution	AASHTO T 88
Liquid Limit	AASHTO T 89
Plasticity Index	AASHTO T 90

- (3) All results of these test pits shall be submitted to the Engineer at least 7 days before any work on a lot commences.

209.03.2 Existing Subgrade

- (1) The following tests shall be carried out on the materials from the test pits:

Table 209.2 - Tests on Materials from Test Pits on Existing Subgrades

Test	Standard
CBR (4 day soaked)	AASHTO T 193 at 95% of MDD
Particle Size Distribution	AASHTO T 88
Liquid Limit	AASHTO T 89
Plasticity Index	AASHTO T 90
Dynamic Cone Penetrometer to 1 m depth	ASTM D6951

- (2) All results of these test pits shall be submitted to the Engineer at least 7 days before any work on a lot commences.

209.03.3 Existing Base

- (1) The minimum requirements are that the depth of the existing base material below the proposed surface of the existing pavement shall be at least 150mm, and that material for a further depth of 300mm shall comply with clause 203.01 6(1). The wet/dry strength variation of the coarse aggregate in the existing base shall not exceed 45%. These requirements are to be satisfied by subgrade adjacent to the paved surface onto which existing base material might be spread.

209.04 PREPARATION FOR OVERLAY

- (1) This clause applies if the results of the tests in clause 209.03 are acceptable and construction by the overlay method is approved by the Engineer.
- (2) Any soil overlying and at the edge of the bituminous paved surface shall be carefully removed so that the paved surface is not damaged. Soil other than the existing pavement material shall be removed from depressions and potholes. Holes deeper than 100mm shall be trimmed to nearly square edges and filled with compacted subbase material complying with Section 301.
- (3) Rough, loose, or broken edges shall be broken back to sound material so that the existing pavement can be keyed-in to produce a strong interface with the new pavement material which will be placed beside it.
- (4) The prepared surface will then be subject to the requirements of clause 301.03,1 before subbase may be placed in accordance with Section 301.
- (5) The ground adjacent to the existing pavement will need to be prepared for new pavement construction in accordance with appropriate sections of the Specification.

209.05 RECONDITIONING FOR RECONSTRUCTION

209.05.1 Cutting and Scarifying

- (1) Soil above the existing paved surface shall be cut to the paved surface and removed. Soil beside the existing paved surface shall be cut to the required depth and width and removed.
- (2) Any excavation on embankment in an area of road widening adjacent to the pavement which is to be reconditioned shall be carried out so that the adjacent area is brought to the required subgrade level prior to scarification of the pavement. This then allows the scarified soil to be spread onto the adjacent area.
- (3) The existing pavement, including the shoulders, shall be scarified to the depth and width required to achieve the reconditioned pavement structure as shown on the Drawings, or as approved by the Engineer. Material below that depth shall be left undisturbed as much as possible

- (4) The resultant material shall be broken down until all lumps and cobbles are reduced to a size not greater than the maximum aggregate size for subbase or, otherwise, are removed.

209.05.2 Mixing and Spreading

- (1) The resultant material may be mixed with other imported or existing material such that the combined material satisfies the requirements for grading and other properties for subbase, as given in Section 301.
- (2) The combined material shall be spread over the full width of the formation for the final road and at the required level such that, when shaped and compacted, a uniform surface is produced, parallel to the final road surface.
- (3) The Contractor shall employ construction methods which produce a uniform mixture of materials. Areas which appear by inspection to be segregated or otherwise non-uniform shall be taken out and reinstated with complying material at the Contractor's cost.

209.05.3 Compaction

- (1) The combined material shall be moistened, graded, and compacted as for subbase. Blending and watering of the surface shall continue if required during compacting operations.
- (2) The surface shall be maintained until covered by the subbase. Water shall be added as required to prevent checking or ravelling.

209.06 PREPARATION FOR NEW CONSTRUCTION

- (1) Where the existing pavement is not found to be suitable for neither overlay nor reconstruction it may be determined by the Engineer to be equivalent in strength to the design subgrade strength. In that case the existing pavement shall be cleaned of any unsuitable material before work proceeds with preparation for placing subbase in accordance with sub-section 301.03,1.

209.07 OTHER REQUIREMENTS

209.07.1 Tolerances

- (1) The variation of the reconditioned surface of finished subbase from any two points of contact with a 3m straight-edge shall in no case exceed 15mm when placed on or parallel to the centreline or 15mm when placed perpendicular to the centreline of the roadway.
- (2) The finished surface shall not vary by more than 5mm above or 25mm below the required elevation.
- (3) All humps and depressions and thickness deficiencies exceeding the specified tolerances shall be corrected by removing the defective work or by adding new material as directed by the Engineer.

209.07.2 Final Acceptance

- (1) The prepared or reconditioned pavement shall not be finally accepted until it has satisfied the proof of rolling and Characteristic Impact Value requirements of clauses 301.03,1.
- (2) Where the Contractor is unable to recondition the existing pavement successfully, no payment will be made under this section. The Engineer will consider an alternative pavement design and road alignment. Work will then be executed and paid for under other sections of the specification. The Contractor is warned not to proceed with long lengths of pavement reconditioning without the Engineer's approval.

209.08 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
209-1	Preparing existing pavement for overlay	Metre Square
209-2	Reconditioning of pavement surface	Metre Square

(2) Preparation of existing pavement for overlay shall be measured in square metres of prepared pavement.

(3) Reconditioning shall be measured by the square metre of finished reconditioned pavement surface and shall include pavement investigation, cutting soil above the existing pavement, scarifying the surface, spreading, addition of subbase material, moistening, grading, compaction, and finishing and maintenance of the surface.

209.09 PAYMENT

(1) Payment will be made at the rates entered in the Bill of Quantities, and shall include for all operations necessary to prepare an existing pavement for overlay and/ or reconditioning of a pavement surface, to the requirements specified herein.

**SERIES 300
PAVEMENT**

SECTION 301

AGGREGATE SUB-BASE

301.01 DESCRIPTION

(1) This work shall consist of furnishing and placing one or more courses of aggregate, including binder soil if required, on a prepared sub-grade in conformity with the lines, grades, thickness and typical cross sections shown on the Drawings or established by the Engineer.

301.02 MATERIALS

301.02.1 General

(1) All material shall be free from dirt, organic matter, shale or other deleterious matter and shall be of such quality that it will bind readily to form a firm, stable course.

301.02.2 Grading Requirements

(1) The material shall be tested according to AASHTO T 27, and shall consist of uniform mixtures of naturally occurring or processed materials comprising gravel and/or crushed rock fragments with sand, silt and clay conforming to the following grading requirements:

Table 301.1 - Grading Requirements of Aggregate Subbase

AASHTO Sieve (mm)	Percent Passing (by weight)		
	Sub-base Type A	Sub-base Type B	Sub-base Type C
100			
75			
50.0		100	100
37.5	100	85 – 95	80-100
25.0	75 - 90		
19.0	60 - 82	60 – 80	60-100
9.5	45 - 66		
4.75	34 – 55	25 – 55	30-100
2.0	25 – 43	15 – 35	17-75
0.425	12 – 25	7 – 20	9-50
0.075	6 – 15	2 – 10	5-25

(2) Depending on the availability of material at the Works site or in reasonable proximity the Contractor shall select material Type A, Type B or Type C for the Aggregate Sub-base, as approved by the Engineer.

(3) Each location where Aggregate Sub-base is applied shall receive only one type of material (Type A, Type B or Type C). However, it is permissible to use different type of Sub-base materials on different sections of the road. If Sub-base material of one type is scarce, different types of Sub-base materials can be used in the same location of the road. In this case Type B and Type-C shall be used for the Lower Sub-base and the better quality material, grading Type A, shall be used for the Upper Sub-base. In all cases the selection and application of Sub-base material type shall be done in close coordination with the Engineer and is always subject to his final approval.

301.02.3 Other Requirements

- (1) Coarse aggregate shall comprise material retained on a 4.75 mm (AASHTO No. 4) sieve and shall consist of hard, durable particles or fragments of stone or gravel. Materials that break when wetted and dried shall not be used.
- (2) The coarse aggregate for sub-base shall be crushed rock (with a minimum of 50% of particles having at least two crushed faces), that for lower sub-base may comprise natural gravel materials.
- (3) Fine aggregate (material passing the 4.75 mm sieve) shall consist of natural or crushed sand.
- (4) The various fractions shall have properties according to the following table:

Table 301.2 – Properties of Coarse and Fine Aggregates

Property/Test	Sub-base
Fraction passing 19 mm sieve	
CBR (4 days soaked), @ 95% of MDD AASHTO T 193	min 30%
Coarse aggregate, material retained on a 4.75 mm sieve	
Wet/Dry Strength Variation	max 45%
Los Angeles Abrasion, AASHTO T 96	max 45%
Fraction passing 0.425 mm sieve	
Liquid Limit, AASHTO T 89	max 25%
Plasticity Index, AASHTO T 90	max 12%, min 4%
Plasticity Modulus	max 175
Linear Shrinkage, AASHTO T 92	max 5%

- (5) When the material is sourced from a borrow pit, the Contractor shall demonstrate to the satisfaction of the Engineer, that the material can be excavated without being contaminated by unacceptable material. The Contractor at his own cost shall take such actions the Engineer considers necessary to ensure that the material being excavated is not being contaminated. Where in the opinion of the Engineer, the Contractor cannot extract the material from the borrow without contamination, then the Contractor shall obtain material from another source at his own cost.

301.02.4 Acceptance of Production Materials

- (1) When the stationary blend method is used, the aggregate will be accepted immediately following mixing, based on periodic random samples taken from the pugmill output.
- (2) When the aggregate is a single source aggregate, it may be accepted at the borrow pit or crusher. Acceptance of the materials by the Engineer does not constitute acceptance of the sub-base, only that the materials are approved for use as sub-base.

301.02.5 Capping Layer

- (1) This material shall be used to provide sufficient cover on weak subgrades and shall be used in the lower part of the sub-base as a substitute for a thick sub-base to reduce costs. The requirements are less strict than for an ordinary sub-base.
- (2) The 4 days soaked CBR shall be at least 15 % (AASHTO T 193) compacted in the laboratory at the minimum of 95 % of the maximum dry density (AASHTO T 180).
- (3) The fraction of material passing the 0.425 mm sieve shall have a Liquid Limit (LL) not greater than 35% and a Plasticity Index (PI) between 4% and 12%.

- (4) The quantity of the fraction passing the 0.075 mm sieve shall be not greater than two-thirds of the quantity of the fraction passing the 0.425 mm sieve.

301.03 CONSTRUCTION REQUIREMENTS

301.03.1 Surface Preparation

- (1) Existing pavement shall have been prepared in accordance with Section 209 of the Specifications. Other areas shall have been prepared in accordance with Sections 203, or 204 and 205 or 208 of the Specifications, as appropriate.

- (2) Immediately prior to placing sub-base the complete surface of the sub-grade or reconditioned existing pavement shall be proof rolled. All subgrade and embankment layers, cuttings, benches and original ground shall be proof rolled with a loaded truck or similar with a minimum axle load of 8 tonnes. Proof rolling shall be satisfactorily completed before the layer is submitted to the Engineer for approval and shall be carried out in the presence of the Engineer. Compliance of proof rolling shall be when an area withstands proof rolling without visible deformation or springing. Such proof rolling shall be at the Contractor's own expense. The Contractor shall at his own cost carry out any additional compaction and testing necessary to achieve the requirements specified herein for proof rolling.

- (3) Where specified or where so directed by the Engineer placement of sub-base shall not commence until the sub-grade strength has achieved a Characteristic Impact Value as determined by ASTM D 5874 of 30 or greater, or such value as may be determined by the Engineer through field trials correlated and verified to other tests, such as the sand replacement. The impact values shall be determined at a minimum of 9 locations per lot or as directed by the Engineer. The locations shall be selected on a random basis or as required by the Engineer.

- (4) The Characteristic Impact Value (CIV) is defined by the expression:

$$CIV = IV_m - 0.59.S$$

Where IV_m = the mean of the results of Impact Value on the lot being assessed reported to the nearest 1.0

S = is the standard deviation of the results of the Impact Value on the lot being assessed, calculated using the following relationship and reported to the nearest 0.1

$$IV_m = \frac{1}{n} \times \sum_{i=1}^n X_i$$

$$S = \sqrt{\frac{\sum_{i=1}^n [X_i - \bar{X}]^2}{[n-1]}}$$

Where X_i is the individual Impact Value for test no. i
 and n is the total number of tests for the lot
 and \bar{X} is the mean of the n test results (i.e. = IV_m).

301.03.2 Spreading

- (1) Sub-base material shall be spread only when the underlying surface has been approved by the Engineer. Any material which has been placed on a surface not approved by the Engineer, shall be removed at the Contractor's expense.

- (2) The sub-base shall be constructed in compacted layers no thinner than 75 mm or 2.5 times the nominal size of the material (whichever is the greater) and no thicker than 150 mm.

(3) The materials shall be handled so as to avoid segregation and to place the material in uniform depth. Segregated materials shall be re-mixed until uniform. Suitable measures shall be taken to prevent rutting of the sub-grade during the spreading of the sub-base material. No hauling or placement of material will be permitted when, in the opinion of the Engineer, the weather or road conditions are such that the hauling operations will cause cutting or rutting of the sub-grade or cause contamination of the sub-base material.

301.03.3 Mixing

(1) When the stationary blend method is used, the aggregate shall be mixed in a pugmill capable of incorporating water to provide the optimum moisture content for compaction and homogenous blending. Immediately after mixing, the material shall be transported and placed on the roadbed by a mechanical spreader unless otherwise approved by the Engineer.

(2) When the road mix method is used, after placement on the roadway, the aggregate shall be uniformly mixed by motor graders or other approved equipment adding water during the mixing operation to provide optimum moisture content for compaction.

301.03.4 Compaction

(1) The moisture content of the material shall be adjusted prior to compaction, by watering with approved sprinkler trucks or by drying out, to that appropriate to obtain the specified density for sub-base with the Contractor's equipment. Sub-base shall be compacted to 95% of maximum dry density as determined by AASHTO T 180 Method D, except where the layer forms the pavement running surface when compaction shall be to 98% of the maximum dry density. During compaction the moisture content shall be so controlled that moisture content uniformly throughout the finished layer shall be within the limits of + 2% of the optimum moisture content as determined in AASHTO test T180, or such other moisture content as shall be agreed with the Engineer as a result of compaction trials. Density determinations shall be carried out for each layer of subbase constructed, in accordance with the requirements of AASHTO test T191, at a rate of 5 tests for every 2,000 square metres of completed layer or part thereof. For density results to be acceptable, four of the five densities measured shall be equal to or greater than the required level of compaction, and the fifth shall be not less than the required relative density minus 3 percent. The use of AASHTO T 224 to correct for oversize particles may be required.

(2) The material shall be compacted by means of approved compaction equipment progressing gradually from the outside towards the centre with each succeeding pass uniformly overlapping the previous pass. Rolling shall continue until the entire thickness of each layer is thoroughly and uniformly compacted to the specified density. Rolling shall be accompanied by sufficient blading, in a manner approved by the Engineer, to ensure a smooth surface free from ruts or ridges and having the proper section and crown. The Contractor shall ensure that the required compaction is obtained throughout each layer and for the full finished width of the material. Filling outside the finished width will be necessary in order to achieve the required compaction for the full finished width of the course.

(3) Any areas inaccessible to normal compaction equipment shall be compacted by means of mechanical tampers until satisfactory compaction is obtained.

(4) Each layer of material shall be completely compacted and approved by the Engineer prior to the delivery of materials for a succeeding layer.

(5) Samples shall be taken from the compacted layers for testing to ensure that the compacted material complies with the requirements of Clause 301.02 of the Specifications.

301.03.5 Compaction Trials

(1) Prior to the commencement of his sub-base operations, the Contractor shall construct trial lengths as directed by the Engineer. The materials used in the trials shall be those approved for use in the Works and the equipment used shall be that which the Contractor intends to use for the work proper.

(2) The objective of these trials shall be to determine the adequacy of the Contractor's equipment, the loose depth necessary to result in the specified compacted layer depths, the field moisture content, and the relationship between the nominal number of compaction passes and the resulting density of the material.

(3) The Contractor shall not proceed with sub-base work until the methods and procedures established in the compaction trials have been approved by the Engineer.

(4) Each trial length shall be 100 metres long, and trials shall be repeated as necessary until compaction procedures acceptable to the Engineer are achieved. The trial lengths will be incorporated in the Works provided the requirements of this Section are met.

(5) Further trials shall be conducted if the materials comprising the sub-base are significantly amended, or if the Engineer considers that the approved methodology is not achieving satisfactory and/or consistent and acceptable results. Contractor shall perform all such compaction trials at his own expense.

301.03.6 Finishing

(1) The Contractor shall programme his operations to avoid the drying out or damage by traffic of the sub-base. If any layer of sub-base material, or part thereof, is permitted to dry out after compaction, or does not conform to the required density or finish, the Contractor shall, at his own expense, re-work, water or re-compact the material, as directed by the Engineer, to the density/finish specified, before the next layer is placed.

(2) The Contractor shall ensure that proper drainage of the pavement and shoulder area is maintained at all times.

(3) Immediately prior to the placing of the first layer of base on the sub-base the final layer of sub-base shall be at the specified density and to the required grade and section. In order to maintain these requirements while placing the base, the Contractor shall, if necessary, water, reshape and re-compact the surface of the sub-base at his own cost.

301.03.7 Tolerances

(1) The thickness of the layer at any point shall not vary by more than ± 20 mm from that specified.

(2) The variation of the surface of the finished course from any two points of contact with a 3 metre long straight-edge shall in no case exceed 10 mm when placed on or parallel to the centreline or when placed perpendicular to the centreline of the roadway.

(3) When to be overlain by a subsequent layer, the finished sub-base shall not vary by more than 10 mm above or 20 mm below the required elevation.

(4) When the sub-base course is to form the running surface of the finished pavement (as in the case of gravel pavements), the finished sub-base shall not be more than 10 mm below the required elevation.

(5) All humps and depressions and thickness deficiencies exceeding the specified tolerances shall be corrected by removing the defective work or by adding new material as directed by the Engineer.

301.04 MEASUREMENT

(1) Measurement will be as follows:

Item No.	Description	Unit
301-1	Sub-base Type A	Metre Cube
301-2	Sub-base Type B	Metre Cube
301-3	Sub-base Type C	Metre Cube
301-4	Capping Layer	Metre Cube

(2) Materials shall be measured as compacted to the required density on the approved sub-grade, according to the theoretical dimensions shown on the Drawings or as otherwise specified by the Engineer.

(3) No measurement for over-depth shall be made even when such over-depth of material is permitted to remain in place by the Engineer. Unauthorised over-depth shall be at the Contractor's own expense.

301.05 PAYMENT

(1) Payment will be made at the rates entered in the Bill of Quantities, and shall include for all operations necessary to achieve the finished course to the requirements specified herein.

SECTION 302

CRUSHED AGGREGATE BASE COURSE

302.01 DESCRIPTION

(1) This work shall consist of furnishing and placing one or more layers of crushed aggregate base course, bound by means of controlled moisture content, on a prepared sub-grade or sub-base and in conformity with the lines, grades, thickness and typical cross sections shown on the Drawings or established by the Engineer. No base course shall be placed on a section of road unless all drainage works within that section are completed as shown on the Drawings unless otherwise approved by the Engineer.

302.02 MATERIALS**302.02.1 General**

(1) The coarse and fine aggregates for base shall consist of crushed rock, clean, tough, durable, sharp-angled fragments free of any excess of thin or elongated pieces, and reasonably free of soft, disintegrated or decomposed stone, dirt or other deleterious matter.

(2) The aggregate shall be obtained by crushing material, which if so directed by the Engineer, has first been screened in such a manner that not less than 90% of the material to be crushed is retained on a 6.3 mm sieve. The amount of crushing shall be regulated so that at least 80% by weight of the pieces retained on a 4.75 mm sieve have at least two mechanically fractured faces.

302.02.2 Grading Requirements

(1) Material for base course shall be crushed rock and the combined aggregate shall have the following grading. Testing of grading is to be done according to AASHTO T 27:

Table 302.1 - Grading Requirements of Crushed Aggregate Base Course

AASHTO Sieve (mm)	Percent Passing (by weight)		
	Type A	Type B	Type C
50.0	100	–	-
37.5	90 – 100	100	-
25.0	75 – 95	85 – 100	100
19.0	60 – 90	70 – 90	70 – 100
9.5	40 – 75	50 – 85	50 – 85
2.36	20 – 45	25 – 45	20 – 50
0.425	10 – 26	10 – 25	15 – 30
0.075	4 – 12	5 – 15	5 – 15

302.02.3 Other Requirements

(1) The combined material passing the 19 mm sieve shall have a 4 days soaked CBR not less than 80% (AASHTO T 193) at 95% of Maximum Dry Density (AASHTO T 180).

(2) Aggregate retained on the 2.36 mm sieve shall have a percentage of wear, by Los Angeles Abrasion test AASHTO T 96, of not more than 40%.

(3) Coarse aggregate flakiness and elongation indices, determined by BS EN 933-3 (Flakiness index) and BS 812-105.2 (Elongation Index), shall not be greater than 35%. Soundness loss shall not be greater than 12% as determined by AASHTO T 104.

(4) The fraction passing the 0.425 mm sieve shall have a liquid limit (AASHTO T 89) not greater than 20 and plasticity index (AASHTO T 90) not greater than 6 nor less than 2 and the Plasticity Product (PI x percentage passing the 0.425 mm sieve) shall not exceed 90.

(5) The aggregate shall have a 10% Fines Value (wet) [AASHTO T 176] of not less than 130 kN and the Wet Dry Variation of the 10% Fines Value shall not exceed 40%.

302.02.4 Acceptance of Production Materials

(1) The aggregate will be accepted immediately following mixing, based on periodic random samples taken from the mixing plant output. Acceptance of the material by the Engineer does not constitute acceptance of the base, only that the material is approved for use in the base.

302.03 CONSTRUCTION REQUIREMENTS

302.03.1 General

(1) The surface on which base is to be placed shall be well compacted, smooth, hard and uniform, with all irregularities having been bladed out and rolled down, and approved by the Engineer prior to the placing of base material.

(2) Immediately prior to placing base, the complete surface of the sub-base shall be proof rolled. The proof-rolling will be performed on newly completed sub base using either a smooth wheel steel roller with a load intensity on the rear wheels of not less than 52.5 kN per linear metre width of roll, or a pneumatic-tyred roller loaded to 2.5 kN per tyre and each tyre inflated to 7 bar. Any areas which show visible movement shall be scarified and re-compacted at the contractor's expense. Any areas which have been allowed to stand for more than 24 hours prior to proof-rolling and which have not been maintained at approximately the optimum moisture content shall be watered and given at least 8 passes of the test roller before proof-rolling is carried out. The cost of this additional work in preparation for proof-rolling shall be at the contractor's expense.

(3) Where specified or where so directed by the Engineer placement of base shall not commence until the sub-base strength has achieved a Characteristic Impact Value of 40 or greater as determined by ASTM D 5874, or such value as may be determined by the Engineer through field trials correlated and verified to other tests, such as the sand replacement. The impact values shall be determined at a minimum of 9 locations per lot or as directed by the Engineer. The locations shall be selected on a random basis or as required by the Engineer.

(4) The Characteristic Impact Value (CIV) is defined by the expression:

$$CIV = IV_m - 0.59.S$$

Where IV_m = the mean of the results of Impact Value on the lot being assessed reported to the nearest 1.0

S = is the standard deviation of the results of the Impact Value on the lot being assess, calculated using the following relationship and reported to the nearest 0.1

$$\text{Where } IV_m = \frac{1}{n} \times \sum_{i=1}^n X_i = \bar{X}$$

$$\text{And } S = \sqrt{\frac{\sum_{i=1}^n [X_i - \bar{X}]^2}{[n - 1]}}$$

Where X_i is the individual Impact Value for test no. $i = 1, 2, 3 - n$

and n is the total no. of tests for the lot.

and \bar{X} is the mean of the n test results (i.e. = IV_m).

302.03.2 Placing

(1) When the thickness of base exceeds 150mm, the base shall be compacted in two equal layers. The compacted thickness of any layer shall not be less than 75mm, nor exceed 150mm.

302.03.3 Combining Aggregates and Water

(1) Aggregates for base shall be combined into a uniform mixture and water added in a central mixing plant in a manner approved by the Engineer.

(2) Mixing for smaller roads, -below road class 4 as defined in Road Design Manual-, can be done by a Loader/ Excavator, if approved by the Engineer.

(3) When binder is to be added, it shall be combined in the central mixing plant.

(4) The amount of water added to the aggregate shall be that required to obtain the specified density, giving a mixture which is completely ready for compaction after spreading. In no case will the wetting of aggregates in stockpiles or trucks be permitted.

302.03.4 Spreading

(1) Immediately after mixing, the base mix material shall be delivered to the roadbed as a uniform mixture and shall be placed on the prepared sub-base or sub-grade in a uniform layer or layers. On roads below road class 4 as defined in Road Design Manual, the mixture can be spread with a grader, if approved by the Engineer.

(2) The material shall be so handled as to avoid segregation. All segregated material shall be removed and replaced with well-graded material. No “skin-patching” shall be permitted.

(3) Unless otherwise approved by the Engineer spreading shall be done by an approved self-propelled paving machine or spreader box which distributes the material to the required width and uniform depth without delay. If the paving machine or spreader causes segregation or leaves ridges or other objectionable marks on the surface which cannot be eliminated easily or prevented by adjustment of the paving machine or spreader operation, the use of such a paving machine or spreader shall be discontinued and replacement equipment provided.

(4) If works are to be carried out on mountainous and/or narrow roads, grader could be used for spreading the material, provided Engineer's approval. If the base course is covered by an AC pavement (which takes most of the traffic load) grader could be used for the spreading, as decided by the Engineer.

(5) No hauling or placing of material will be permitted when, in the opinion of the Engineer, the weather or road conditions are such that hauling operations will cause cutting or rutting of the surface or contamination of the base material.

302.03.5 Compaction

(1) Immediately after placing, the base material shall be compacted to not less than 98% of maximum dry density as determined by AASHTO T 180 Method D.

(2) During compaction the moisture content shall be so controlled that moisture content uniformly throughout the finished layer shall be within the limits of $\pm 2\%$ of the optimum moisture content as determined in AASHTO T 180, or such other moisture content as shall be agreed with the Engineer as a result of compaction trials. Density determinations shall be carried out for each layer of base constructed, in accordance with the requirements of AASHTO T 191, at a rate of 5 tests for every 2,000 square metres of completed layer or part thereof. For density results to be acceptable, four of the five densities measured shall be equal to or greater than the required level of compaction, and the fifth shall be not less than the required relative density minus 3 percent.

(3) The use of AASHTO T 224 to correct for oversize particles may be required.

- (4) Rolling shall be carried out until the entire thickness of each layer is thoroughly and uniformly compacted to the density specified. Rolling shall be accompanied by sufficient blading in a manner approved by the Engineer, to ensure a smooth surface, free from ruts or ridges and having the proper section. When additional water is required it shall be added in a manner approved by the Engineer. The Contractor shall ensure that the required compaction is obtained throughout each layer and for the full finished width of the base. Filling outside the finished base width will be necessary in order to achieve the required compaction for the full finished base width.
- (5) The Contractor shall plan the work and handle the various operations so that the least amount of water will be lost by evaporation from non-compacted surfaces.
- (6) If the material is laid and compacted in two layers, the Contractor shall plan and coordinate the work in such a manner that the previously placed and compacted layer shall be allowed ample time for drying and development of sufficient stability before vehicles hauling materials for the succeeding layer, or other heavy equipment, are permitted on the base.
- (7) Each layer of base shall be completely compacted, and approved by the Engineer, prior to the delivery of material for a succeeding layer.
- (8) Prior to placing the succeeding layer of material, the top of the under-layer shall be made sufficiently moist to ensure bond between the layers.
- (9) Samples shall be taken from the compacted layers for testing to ensure that the compacted material complies with the requirements of Clause 302.02 herein.
- (10) If after the base is compacted, any areas fail to meet the specified density and grading requirements, or are outside the specified tolerances, such areas shall be loosened and after having had additional materials added or excess material removed, as the case may be, shall be reconstructed as described herein.
- (11) Edges and edge slopes shall be bladed or otherwise dressed to conform to the lines and dimensions shown on the Drawings and present straight, neat and workmanlike lines and slopes as free of loose materials as practicable.
- (12) Where there has been 4 hours or more between laying adjoining layers, the joints (transverse and longitudinal) shall be cut back to a full height vertical face. The material arising from this cut back may be spread in a thin layer under the layer being laid.
- (13) Pins supporting wire guidance of the paver shall be spaced at a maximum of 5 metres.

302.03.6 Compaction Trials

- (1) Prior to the commencement of his base course operations, the Contractor shall construct trial lengths as directed by the Engineer. The material used in the trials shall be that approved for use as base and the equipment used shall be that which the Contractor intends to use for the work proper.
- (2) The objective of these trials shall be to determine the adequacy of the Contractor's equipment, the loose depth necessary to result in the specified compacted layer depth, the field moisture content, and the relationship between the nominal number of compaction passes and the resulting density of the material.
- (3) The Contractor may proceed with base course work only after the methods and procedures established in the trials have been approved by the Engineer.
- (4) Each trial length will be 100 metres long and trials shall be repeated as necessary until compaction procedures acceptable to the Engineer are achieved. The trial lengths will be incorporated in the Works provided the requirements of this Section are met, and no additional payment will be made for them.

302.03.7 Tolerances

- (1) The thickness of the layer at any point shall not vary by more than ± 10 mm from that specified.

(2) The variation of the surface of finished base from any two points of contact with a 3 metre long straight-edge shall in no case exceed 10 mm when placed on or parallel to the centreline or 10 mm when placed perpendicular to the centreline of the roadway.

(3) Finished base shall not be lower than the required elevation by more than 6 mm, nor exceed it by more than 10 mm.

(4) All humps and depressions and thickness deficiencies exceeding the specified tolerances shall be corrected by removing the defective work or by adding new material as directed by the Engineer. Adding new material to areas of thickness deficiency, or segregated areas in the form of skin patching will not be permitted.

302.03.8 Maintenance of Base

(1) Following construction, the compacted base shall be maintained by the Contractor at his own expense. The Contractor shall blade, broom and otherwise maintain the base, keeping it free from ravelling, and other defects until such time as the prime coat is applied. Water shall be applied at such times as is necessary or as directed by the Engineer.

(2) The Contractor shall ensure that proper drainage of the pavement and shoulder area is maintained at all times.

(3) The surface of the base shall be approved by the Engineer before the prime coat is applied. The surface shall be hard, dense, tight mosaic, free from dust and caked fines.

302.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
302-1	Base Course Type A	Metre Cube
302-2	Base Course Type B	Metre Cube
302-3	Base Course Type C	Metre Cube

(2) Base Course shall be measured by the cubic metre as placed and compacted to the required density on the approved sub-grade or sub-base, according to the theoretical dimensions shown on the Drawings or otherwise directed by the Engineer. No measurement for over-depth shall be made even where such over-depth of material is permitted to remain in place by the Engineer.

302.05 PAYMENT

(1) Payment will be made at the rate entered in the Bill of Quantities and shall include for all operations necessary to achieve the finished course to the requirements specified herein.

(2) Aggregate base course will not be paid for complete in-place until the subsequent surfacing is constructed thereon. However, the Engineer may authorize payment of 85 percent of the quantity of base course on current estimates of volumes in advance of the succeeding operations, provided it has been completed in accordance with these Specifications and is properly maintained to the acceptance of the Engineer, pending the placing of the surfacing.

SECTION 303

PRIME COAT

303.01 DESCRIPTION

(1) This work shall consist of the cleaning, preparing and treating the existing base surface or any other surface with a low viscosity bituminous binder and, if required, any blotter material in conformity with the extents shown on the Drawings.

303.02 MATERIALS

(1) Prime coat shall consist of a medium curing cut-back, MC-30, MC-70 asphalt produced by fluxing an asphaltic base with suitable petroleum distillates or Cationic Slow Setting Emulsified Asphalt CSS-1 (AASHTO M 208). MC-30 and MC-70 shall be free from water, show no separation prior to use, and shall conform to all the requirements for Grade MC-30 and MC-70 medium-curing cutback asphalt specified in AASHTO M 82.

303.03 CONSTRUCTION REQUIREMENTS

303.03.1 Preparation of Surface

(1) Prior to the application of prime coat, the surface shall be shaped to the required grade and section, free from all ruts, corrugations, segregated materials and uniformly compacted, and cleaned by means of approved mechanical sweepers or blowers, until it is as free from dust as is deemed practicable.

(2) Immediately prior to spraying of the prime coat, the complete surface of the base shall be proof rolled. Proof rolling shall comprise 2 passes of a 6 wheeled truck with the rear 4 wheel single axle loaded to 8.2 tonnes as approved by the Engineer. Compliance of proof rolling shall be when an area withstands test rolling without visible deformation or springing. The Contractor shall at his own cost carry out any additional compaction and testing necessary to achieve the requirements specified herein for proof rolling. The proof-rolling will be performed on newly completed base using either a smooth wheel steel roller with a load intensity on the rear wheels of not less than 52.5 kN per linear metre width of roll, or a pneumatic-tyred roller loaded to 2.5 kN per tyre and each tyre inflated to 7 bar. Any areas which show visible movement shall be scarified and re-compacted at the contractor's expense. Any areas which have been allowed to stand for more than 24 hours prior to proof-rolling and which have not been maintained at approximately the optimum moisture content shall be watered and given at least 8 passes of the test roller before proof-rolling is carried out. The cost of this additional work in preparation for proof-rolling shall be at the contractor's expense. In absence of Pneumatic tyred or smooth wheel steel rollers of specified weight and type, loaded truck having axle load not less than 8 tonnes may be used for the purposes, if approved by the engineer.

(3) Where specified or where so directed by the Engineer spraying of the prime coat shall not commence until the base strength has achieved a Characteristic Impact Value of 60 or greater as determined by ASTM D 5874, or such value as may be determined by the Engineer through field trials correlated and verified to other tests, such as the sand replacement. The impact values shall be determined at a minimum of 9 locations per lot or as directed by the Engineer immediately before the spraying of prime occurs. The locations shall be selected on a random basis or as required by the Engineer.

- (4) The Characteristic Impact Value (CIV) is defined by the expression:

$$\text{CIV} = \text{IV}_m - 0.59.S$$

Where IV_m = the mean of the results of Impact Value on the lot being assessed reported to the nearest 1.0

S = is the standard deviation of the results of the Impact Value on the lot being assessed, calculated using the following relationship and reported to the nearest 0.1

$$\text{Where } \text{IV}_m = \frac{1}{n} \times \sum_{i=1}^n X_i$$

$$\text{and } S = \sqrt{\frac{\sum_{i=1}^n [X_i - \bar{X}]^2}{[n - 1]}}$$

Where X_i is the individual Impact Value for test no. i

and n is the total number of tests for the lot

and \bar{X} is the mean of the n test results (i.e. = IV_m).

- (5) Delays in priming may require re-processing or re-shaping the roadway to provide a smooth and clean surface.

- (6) No traffic shall be permitted on the surface after it has been prepared to receive the prime coat.

- (7) Prime coat shall be applied only when the surface to be treated is dry, or contains moisture not in excess of that which will permit uniform distribution and the desired penetration of the prime coat. Prime coat shall not be applied in dusty conditions.

- (8) If deemed necessary by the Engineer, the cleaned surface shall be given a light application of water and allowed to dry to a surface-dry condition before the bituminous material is applied.

- (9) Priming shall not proceed if in the opinion of the Engineer rain is threatening. If any rain falls while priming is underway, the Contractor shall immediately stop spraying.

303.03.2 Heating Equipment

- (1) Heating equipment for heating the prime coat shall be of adequate capacity to heat the material thoroughly and uniformly by circulating steam or hot oil through coils of a tank or by circulating the material around a system of heated coils or pipes, or by circulating the material through a system of coils or pipes enclosed in a heated jacket or other approved means.

- (2) Heating equipment shall be operated in a manner that will not damage the prime coat material.

- (3) Heating equipment shall be so constructed that it will prevent the direct flame from a burner from striking the surface of the coils, pipes, or jacket through which the material is circulated.

- (4) If storage tanks are used, thermometers with a range of 0 to 200 °C shall be fixed to the tanks so that the temperature of the material may be determined at all times.

- (5) Material which has been heated above 125 °C will be rejected, and shall be removed from the Site and disposed of by the Contractor.

(6) All storage tanks, piping, retorts, booster tanks and distributors used in storing, handling or heating material shall be kept clean and in good condition at all times, and shall be operated in such manner that there will be no contamination by foreign material.

303.03.3 Pressure Distributors

(1) Pressure distributors shall be self-propelled, pneumatic-tyred and so designated and equipped as to distribute the prime coat uniformly in variable widths at readily determined and controlled rates. They shall be operated by skilled workmen. The equipment shall include instruments for measuring the speed of travel accurately at low speeds, the rate of flow of bituminous material through the nozzles, the temperature of the contents of the tank, and the pressure and remaining contents. If after beginning the work, the distribution of bituminous material is found to be in error, the equipment shall be withdrawn from the work and calibrated to the satisfaction of the Engineer or replaced before proceeding with the work.

(2) The manufacturing details of the pressure distributor, spray bar, and nozzles shall be provided to the Engineer for approval before the equipment is mobilised to Site. Details shall include the height of the spray bar and the angle of the nozzles so that a preliminary check can be made of the uniformity of coverage.

(3) The distributor shall be so designed that, when not spreading, it does not drip.

(4) The nozzles and spray bar shall be adjusted so that uniform distribution is achieved, and checked before each spraying run. Spraying shall cease immediately upon any clogging or interference of any nozzle, and corrective measures shall be taken before spraying is resumed.

(5) The Contractor at his own expense shall arrange for the pressure distributor to be calibrated to the satisfaction of the Engineer at intervals of not less than 12 months or as required by the Engineer. Such calibration tests are to be done in the presence of the Engineer and are to demonstrate that the pressure distributor is capable of performing adequately in service. The Contractor shall gain the Engineer's approval of these tests before arranging for them to be carried out. Where in the sole opinion of the Engineer, the pressure distributor does not perform adequately, then it shall be removed from service and either repaired or replaced at the Contractor's cost.

303.03.4 Application

(1) Prime coat shall be applied by a pressure distributor in a uniform and continuous spread at the rates directed by the Engineer after the field trials (Sub-clause 303.03.5 herein). Any application so determined may be divided into two applications where necessary to prevent prime coat flowing off the surface and additional material shall be applied where localised surface conditions indicate it to be necessary.

(2) Prime coat shall not be applied when the surrounding temperature is below +15 °C, or windy and/or possibility to rain soon, unless otherwise permitted by the Engineer. The temperature of prime coat at the time of spraying shall be in the range of 30 °C – 90 °C for MC-30, 50 °C – 100 °C for MC-70 and 25 °C – 55 °C for CSS-1.

(3) Distribution of the prime coat shall be so regulated and sufficient material shall be left in the distributor at the end of each application so that there is a uniform distribution of material. In no case shall the distributor be allowed to expel air, thereby causing uneven coverage.

- (4) Where traffic is maintained on one side of the road while the other side is primed, not more than one half the width of the road shall be treated in one application. Care shall be taken so the application of asphalt at the junctions of spread is not in excess of the specified amount.
- (5) Any skipped areas or recognised deficiencies shall be corrected by means of approved hand sprays. The use of hand sprays will only be allowed for correcting such deficiencies and for priming small patches or areas which are inaccessible to the distributor.
- (6) Building paper shall be placed over the end of the previous applications, and the joining shall start on the building paper. Used building paper shall be removed and satisfactorily disposed of.
- (7) Subject to the Engineer's approval, the Contractor shall spread blotting material on all areas which show an excess of prime. Blotting material shall be applied sparingly and only on areas which have not dried. Blotting material aggregate shall comply with the grading requirements of AASHTO M 43, size 10, and comprise clean non-plastic sand or fine aggregate, free from organic or deleterious material.
- (8) The rate of application and areas to be treated shall be approved by the Engineer before application of prime coat.

303.03.5 Field Trials

- (1) Calibration of Bitumen Distributor: The Contractor shall, before he commences the work proper, calibrate the equipment by field trials to permit the Engineer To achieve the targeted application rate contractor will need to maintain the specified application temperature, determine the speed of the distributor truck per minute and check individual nozzle spray ability during each trials to ascertain the rate of application to be ordered and to test the suitability of the proposed distributor. The trial methods shall be approved by the Engineer and the trials performed by the Contractor in the presence of the Engineer. Trial spray shall be conducted outside the project roads to avoid surface damage and spillage. Necessary trials shall be carried out at contractors own expense to confirm the spray rates.
- (2) The rate of application in the field trials shall vary between be 0.60 l/m² minimum and 1.20 l/m² maximum. Temperatures of bituminous materials at the time of each application shall be recorded.
- (3) The Engineer may order subsequent field trials and/or change the previously established rates of application when he deems it necessary.

303.03.6 Protection of Adjacent Structures

- (1) When prime coat is being applied, the surfaces of all structures, guard rails, kerbs and other roadway appurtenances and trees shall be protected in a manner approved by the Engineer to prevent them from being splattered or damaged.
- (2) The Contractor shall at his own cost make good to the satisfaction of the Engineer any appurtenances which are splattered or damaged.

303.03.7 Traffic Control and Maintenance of Primed Surfaces

- (1) The Contractor shall provide all necessary detours for the public and his own construction traffic in areas where prime coat is to be applied. Where no convenient detour can be constructed or if so directed by the Engineer, the application operation shall be confined to one-half of the roadway at a time, and the Contractor shall provide traffic control as directed by the Engineer, at his own cost. When the asphalt has been absorbed by the

surface and, in the opinion of the Engineer, is sufficiently dry not to be picked up by traffic, but in no case less than 24 hours, traffic shall be transferred to the treated portion and the remaining width of the section shall be primed.

(2) The Contractor shall protect all primed surfaces and keep them in acceptable condition until they are covered by succeeding courses.

(3) All areas where the prime surface has been damaged by traffic or by the Contractor's operations shall be cleaned of all loose materials, re-primed, and made good to the satisfaction of the Engineer, at the Contractor's own cost.

303.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
303-1	Prime Coat	Litre

(2) The measurement shall be computed by multiplying the areas to be treated as shown on the Drawings and any other areas ordered by the Engineer, by the appropriate rate or rates of application specified by the Engineer, corrected to +15 °C.

303.05 PAYMENT

(1) Payment will be made at the unit rate entered in the Bill of Quantities and shall include for preparation of the underlying surface, field trials, blotting material, traffic management, protection of primed surfaces, repair of damaged surfaces and all operations necessary to achieve the prime coat to the requirements specified herein.

SECTION 304

SURFACE DRESSING

304.01 DESCRIPTION

(1) This work shall consist of the application of a) a single course of asphalt seal coat followed by a single layer of 10 / 12.5 mm nominal size aggregate cover material (single bituminous surface treatment (SBST) or b) 16 / 19 mm nominal size aggregate cover material (lower layer of double bituminous surface treatment (DBST)) overlain by a second course of asphalt seal coat followed by (10 / 12.5 mm) aggregate cover material (upper layer of double bituminous surface treatment (DBST)) all to an existing surface in conformity with the lines and extents shown on the Drawings or ordered by the Engineer.

(2) This work shall also consist of an application of bituminous material without an application of aggregate on an existing bituminous surface course in accordance with the extents shown on the Drawings.

304.02 MATERIALS

304.02.1 Seal Coat

(1) Bituminous materials used in Seal Coat shall be one of the types and grades listed in the following table and approved by the Engineer.

Table 304.1 - Bituminous Materials for Seal Coats

Designation	Type of Material	Application Temperature
60 - 70	Penetration grade bitumen	160°C – 17°C
80 - 100 Bitumen	Penetration grade bitumen	160°C – 170°C
RC - 250	Cutback Bitumen, Rapid Curing	80°C – 90°C
RC - 800	Cutback Bitumen, Rapid Curing	100°C - 115°C
RC - 3000	Cutback Bitumen, Rapid Curing	125°C - 135°C
RS - 2	Emulsified Bitumen	80°C - 90°C
CRS - 2	Cationic Emulsified Bitumen	75°C - 85°C
CRS - 3	Cationic Emulsified Bitumen	75°C - 85°C

(2) The materials shown above shall be in compliance with AASHTO M 20, AASHTO M 81, AASHTO M 140 or AASHTO M 208, as applicable.

(3) The use of emulsified bitumen shall be considered when the aggregate is dirty.

(4) As the process of using emulsified bitumen is very sensitive extreme care shall be taken during the process of applying emulsified bitumen.

(5) Road sections where emulsified bitumen has been used shall be kept closed for traffic at least 48 hours. In lower temperatures the closure shall be longer duration, as decided by the Engineer.

(6) Emulsified bitumen with cationic charges, CRS1 or CRS2, could have repulsive effects on some stone aggregates and therefore this could necessitate testing of the emulsified bitumen before use, as decided by the Engineer

304.02.2 Adhesion Agent

(1) A proprietary additive that enhances the adhesion of the bitumen to the aggregate shall be added at the doses recommended by the Manufacturer. The additive shall be subject to the approval of the Engineer which approval shall be conditional on satisfactory field trials.

304.02.3 Aggregate Pre-coating Material

(1) Aggregate pre-coating material shall be distillate or distillate based product, cutback bitumen, or proprietary product as approved by the Engineer.

304.02.4 Cover Material

(1) Aggregates shall meet the requirements of Sub-clauses 305.02.1 and 305.02.2 of the Specifications.

(2) Grading Requirements

Aggregate for SBST and DBST shall conform to the following grading requirements:

Table 304.2 – Grading of SBST and DBST

AASHTO M 92 Sieve Size (mm)	Percentage Passing (by weight)	
	SBST (First Course [DBST]) (19 mm nominal size)	DBST (12.5 mm nominal size)
25.0	100	–
19.0	90 – 100	100
12.5	0 – 30	90 – 100
9.5	0 – 8	0 – 40
4.75	–	0 – 8
2.36	0 – 2	0 – 2
1.18	0 – 0.5	0 – 0.5

(3) Alternatively below grading can be used, as decided by the Engineer.

Table 304.3 – Alternative Grading of SBST and DBST

Sieve Designation BS Sieve Size, (mm)	Percentage Passing (by weight)	
	SBST (First Course [DBST]) (16 mm nominal size)	DBST (Second Course [DBST]) (9.5 mm nominal size)
25.0	-	-
19.0	100	-
16.0	85 – 100	100
9.5	10 - 30	85 – 100
6.35	0 - 7	0 – 10
2.00	-	0 – 2

(4) When tested in accordance with AASHTO T 182, aggregate shall have a retained asphalt film above 95%.

(5) Aggregate stockpiled ready for use shall be kept in a concrete floored bin with side walls and shall be kept covered. Drainage measures to prevent water entering the stockpile shall be provided. The bin shall have sufficient capacity to supply aggregate for 14 days' use.

304.03 PRECOATING OF AGGREGATE

(1) Aggregate which has not been previously pre-coated shall be pre-coated with material as specified in Sub-clause 304.02.3 of these Specifications. Such pre-coating shall be carried out so that each aggregate particle is uniformly coated. Pre-coating shall be applied, when using Straight Run Bitumen for the sealing chips. The need for applying pre-coating when Bitumen Emulsion is used for

the sealing chip, is decided at the discretion of the Engineer. However, when emulsified asphalt is used as binder, proper cleaning of aggregate by washing is required.

304.04 CONSTRUCTION REQUIREMENTS - FIRST COURSE

304.04.1 Preparation of Surface

(1) Immediately prior to applying the bituminous material, the surface shall be cleaned of all dirt, sand, dust and objectionable material. This cleaning shall be effected by means of a rotary power broom or a power blower, unless other methods are authorised by the Engineer. Dried mud or other foreign material which cannot be removed otherwise shall be removed by hand methods.

(2) In no event shall bituminous seal coat be placed on newly constructed or reconditioned surfaces less than ten (10) days after such surface has been laid and opened to traffic, unless otherwise ordered in writing by the Engineer.

304.04.2 Equipment

(1) Heating equipment shall comply with the requirements of Sub-clause 303.03.2 of the Specifications.

(2) The pressure distributor, including spray bar and nozzles, shall comply with the requirements of Sub-clause 303.03.3 of the Specifications.

304.04.3 Application of Seal Coat

(1) Seal coat shall be applied by means of a pressure distributor in a uniform, continuous spread over the section to be treated and within the temperature range specified. The quantity of material per square metre shall be within the limits hereinafter specified and as directed by the Engineer.

(2) A strip of building paper, at least 1 metre wide and with a length equal to that of the spray bar of the distributor plus 300 mm, shall be used at the beginning of each spread. If the cut-off is not positive, the use of paper may be required by the Engineer at the end of each spread. The paper shall be removed and disposed of in an approved manner. The distributor shall be moving forward at proper application speed at the time the spray bar is opened. Any skipped areas or deficiencies shall be corrected in an approved manner. Junctions of spreads shall be carefully made to assure a smooth riding surface.

(3) The length of spread of seal coat shall not be in excess of that which trucks loaded with cover material can immediately cover (maximum elapsed time of 2 to 4 minutes between binder application and spreading of sealing aggregate and commencing rolling for compaction).

(4) The width of spread of seal coat shall not be more than 150 mm wider than the width covered by the cover material from the spreading device. Under no circumstances shall operations proceed in such a manner that seal coat is allowed to cool or otherwise impair retention of the cover material.

(5) Distribution of the seal coat shall be so regulated and sufficient material shall be left in the distributor at the end of each application so that there is a uniform distribution of material. In no case shall the distributor be allowed to expel air, thereby causing uneven coverage.

(6) The angle of the spray nozzles and the height of the spray bar shall be so adjusted and frequently checked that uniform distribution is obtained. If the raise of the spray bar as the load is removed is excessive and contributes to drilling and streaking of the seal coat/ bituminous material, the frame of the distributor shall be blocked or snubbed to the axle of the truck to maintain a constant height of the spray bar above the road surface. The distribution shall cease immediately upon any clogging or interference of any nozzle and corrective measures shall be taken before distribution is resumed.

(7) Application temperature of binder shall be maintained within the range as specified in sub-clause 304.02.1 (1).

304.04.4 Application of Cover Material

- (1) Immediately following the application of the seal coat (within 2 to 4 minutes), cover material shall be uniformly spread with an approval self-propelled aggregate spreader, supported by at least four wheels equipped with pneumatic tyres on two axles, in quantities ordered by the Engineer and within the limits specified herein. Spreading shall be accomplished in such a manner that the tyres of the trucks or aggregate spreader at no time come in contact with uncovered and newly applied seal coat. The spreader shall produce a uniform closely packed carpet of chippings one stone thick.
- (2) Sufficient trucks and loading equipment shall be employed to ensure an adequate, prompt and continuous supply of chippings.
- (3) Should it become apparent that the supply of chipping is about to run out, the seal coat spraying shall be immediately stopped and not recommenced until an adequate supply of chippings is assured.
- (4) The aggregate shall be clean and dust free when spread.
- (5) The aggregate for SBST and DBST shall have been pre-coated at least 4 days and not more than 28 days prior to the use of the aggregate. Where in the opinion of the Engineer the pre-coating of the aggregate is not satisfactory, or for any reason the aggregate is not satisfactory then the Contractor shall either pre-coat the aggregate again or replace the sealing aggregate at his own cost.
- (6) Starting, stopping or turning any piece of equipment which results in displacement of the cover material or damage to the seal coat shall be prohibited.
- (7) The spreading equipment shall be of such width and arrangement that as the aggregate is placed, complete coverage is obtained. No brooming of the cover material shall be permitted prior to initial rolling. Any rearrangement of the cover material shall be done by manual methods. Overlapping applications of cover material shall be avoided and all spillage shall be removed from the surface. Before rolling commences, the seal coat shall be uniformly covered. Any deficient areas shall be covered by additional material.

304.04.5 Rates of Application

- (1) The rate of application of seal coat shall be as specified by the Engineer following the construction of the trial lengths. When spraying seal coat in lanes, the applications should provide full coverage of the surface, but should not overlap.
- (2) The rate of application of cover material shall be as specified by the Engineer following the construction of the trial lengths.
- (3) Application rates for both aggregate and bitumen to be used for the initial field trials shall be determined as follows:
 - (a) Aggregate

A preliminary value of the aggregate quantity to provide for a thickness equal to the average least size dimension with 20% voids is as follows:

$$A \text{ (kg/sq-m)} = 0.8 F \times G \times H; \text{ where}$$

F is the Wastage Factor 1.07 for 9.5mm and 12.5mm aggregate
 1.02 for 19.0mm and 25.0mm aggregate

G is the Bulk specific gravity (AASHTO test Method T 85) and

H is the Average Least Dimension (mm)

The above equation assumes voids in the loose aggregate to be 50%. Control tests shall be carried out to determine the loose density according to AASHTO T 19 and the loose voids content determined as follows:

$$V = 1 - J / G \text{ where}$$

V is the loose voids content

J is the loose unit weight (t/cu-m.)

G is the Bulk specific gravity

The final design aggregate quantity shall then be calculated as:

$$A \text{ (kg/sq-m)} = (1 - 0.4 V) F \times G \times H$$

The design quantity shall be checked by packing the aggregate one stone thick on a sample tray and by field trials.

(b) Bitumen

The theoretical bitumen application rates for each layer to embed the aggregate to about 70% of its average least size dimension can be determined from the following formula:

$$B \text{ (litres/sq-m)} = [(0.4 \times H \times V \times T) + S] / R \text{ where}$$

B is the theoretical "cold" bitumen application rate for each layer.

T is the Traffic factor (0.70 - 0.75)

R is the Residual bitumen factor

S is the Surface texture correction for first layer only.

= -0.1 to -0.3 litre / sq.m., for black flushing surface;

= nil for smooth surface, good priming;

= +0.1 to +0.3 litre / sq.m., for absorbent and rough surfaces.

For double surface treatment, the theoretical bitumen quantities for each layer shall be added together and converted to "hot" rates at the spraying temperature (ASTM D1250-56). For warm season construction, 60% of this combined rate shall be applied for the first layer and 40% for the second. For cool season construction, 50% of the combined rate shall be applied for the first layer and 50% for the second layer.

The final design quantity shall be determined by field trials. The actual quantity to be used in the work shall be as directed by the Engineer.

- (4) The Engineer may alter the rates of application whenever he deems it necessary or desirable.

304.04.6 Manipulation

(1) Rollers shall be self-propelled, pneumatic tired, multi-wheeled rollers having an un-ballasted weight not less than 8 tonnes and tyres of equal size. Rear wheels be offset relative to the front wheels to give overlapping tyre paths and complete coverage for the effective width of the roller. Rollers will be capable of providing a wheel load from 1,000kg per wheel with a maximum tyre pressure of 6 Bar.

(2) Rolling shall commence immediately after spreading and continue, in conjunction with drag brooming, until the aggregate is well embedded in the binder and a uniform surface is obtained. At least 4 passes of the roller over all parts of the surface shall take place and in the first layer may be followed by 2 passes of a steel wheeled roller not exceeding 8,000 kg to make a smooth surface without any crushing of the aggregate for the second layer. Rolling shall continue until the aggregate is bound properly to the binder. If satisfactory embedment does not occur, then further rolling shall be carried out the following day. When the binder has hardened to the stage that not more aggregate can be pressed into it by rolling, all loose aggregate shall be removed by sweeping. If the Engineer considers that the adhesion of the binder to the aggregate is unsatisfactory, he shall reject the work and direct that no further work be carried out until the conditions improve.

- (3) Steel wheel rollers shall be operated at a maximum speed of 5 km/h and pneumatic-tyre rollers at a maximum speed of 8 km/h. The weight of rollers may be varied as directed by the Engineer to obtain the most satisfactory embedment of the cover material without undue crushing of the aggregate.
- (4) After the aggregate has been rearranged as may be necessary to provide uniform and complete coverage, it shall be thoroughly embedded in the seal coat by rolling in the manner described below.
- (5) The initial rolling shall begin immediately behind the spreader and shall consist of one complete pass with a self-propelled pneumatic-tyre roller. The initial rolling shall be accomplished within ten (10) minutes of the seal coat being sprayed.
- (6) Pneumatic-tyre manipulation rolling shall begin immediately after the completion of the initial rolling.
- (7) The number of passes of the roller shall be as directed by the Engineer based on the results of the trial lengths, but shall be at least four. Minor crushing of the cover material is permissible, but should any general shattering occur, the Engineer may direct that rolling shall cease, regardless of the number of passes completed.
- (8) The sequence of rolling may be varied by the Engineer at any time, if in his opinion satisfactory results are not being obtained.
- (9) Rolling shall be longitudinal and shall generally be commenced at the outer edges and progress towards the centre, but from the lower edge to the upper edge on super-elevated sections. The speed of the rollers or the rolling sequence shall be so controlled that it is unnecessary for one roller to turn out to permit another roller to pass. Turning of rollers on the surface is prohibited.
- (10) If, in the opinion of the Engineer, the cover material furnished is subject to excessive crushing under the steel wheel rollers, pneumatic-tyre rollers may be substituted for finishing work.
- (11) If necessary, and when ordered by the Engineer, additional cover material shall be added and the additional material shall receive additional rolling.
- (12) Two additional passes of previously completed section may be given by the pneumatic-tyred roller in the heat of the day (termed "back rolling") as may be ordered by the Engineer.

304.04.7 Maintenance of Completed Work

- (1) After manipulation of cover material, the surface shall be lightly broomed or otherwise maintained for 4 days.
- (2) When directed by the Engineer, the Contractor shall make good defective areas by further applications of seal coat and/or cover material, and further manipulation as described above, at his own cost.
- (3) Maintenance of the surface shall include the distribution of cover material to absorb free asphalt and cover any area deficient in cover material. The maintenance shall be conducted so that embedded material is not displaced.
- (4) After all other work has been completed, the excess loose cover material along the edges of the surface shall be swept by means of rotary brooms, at a time determined by the Engineer.

304.05 CONSTRUCTION REQUIREMENTS - SECOND COURSE OF DBST

304.05.1 Equipment

- (1) Heating equipment shall comply with the requirements of Sub-clause 303.03.2 of the Specifications.

- (2) The pressure distributor, including spray bar and nozzles, shall comply with the requirements of Sub-clause 303.03.3 of the Specifications.

304.05.2 Application of Seal Coat

- (1) The second seal coat shall not be applied until the first seal coat has been under traffic for 28 days or such other length of time as specified by the Engineer.
- (2) Immediately prior to application of the second seal coat, the surface of the first course shall be cleaned in an approved manner of all dust and loose cover material. Care shall be taken that no embedded material is dislodged.
- (3) The application of the second seal coat shall conform to the requirements specified for the first seal coat.
- (4) The Contractor shall give 28 days written notice of his intention to carry out second seal coat of a section of work in order to allow the Engineer to carry out an inspection and any required testing of the completed seal. At his own cost, the Contractor shall provide such traffic control devices as the Engineer deems necessary and any additional labour and plant to carry out this inspection/testing.
- (5) Where in the opinion of the Engineer the results of this inspection/testing warrant further investigation, or indicate that the completed pavement may not be meeting the design criteria, then he shall have full authority to suspend further works in that area.
- (6) At his own cost, the Contractor shall provide any additional plant and labour the Engineer deems necessary to carry out these additional tests and investigations.

304.05.3 Application of Cover Material

- (1) The application of cover material shall conform to the requirements specified for the first course.

304.05.4 Rates of Application

- (1) The rate of application of seal coat shall be such rate as is ordered by the Engineer following the construction of the trial lengths according to 304.07.
- (2) The rate of application of cover material shall be such coverage as is ordered by the Engineer following the construction of the trial lengths according to 304.07
- (3) The Engineer may alter the rates of application whenever he deems it necessary or desirable.

304.05.5 Manipulation

- (1) The second course shall be manipulated in the manner specified for the first course.

304.05.6 Maintenance of Completed Work

- (1) The second course shall be maintained in the manner specified for the first course.

304.06 TOLERANCES

- (1) The final average overall width of the dressed surface measured at seven equidistant points over any length of 100 m shall be at least equal to the width specified or ordered. At no point shall the distance between the centre-line of the road and the edge of the bitumen surface be narrower than that specified or ordered by more than 25 mm.
- (2) The rate of application of seal coat and cover material along or across the road shall not vary by more than 10% of the rate ordered. The average rates of application of the seal coat and the cover material, calculated over a length of 200 metres shall be at least equal to the rates ordered.

- (3) The completed surface dressing shall be of uniform mosaic without bleeding or balding and shall be free of any loose cover material or seal coat spillage.
- (4) Any area showing signs of bleeding or loss of cover material after opening of the section to traffic shall be rectified to the satisfaction of the Engineer at the cost of the Contractor.
- (5) The corrective work may be effected as a third seal, by removal and replacement of the defective work or by other approved measures, and the Contractor shall carry out these promptly to the satisfaction of the Engineer. The corrective works shall be executed in such a manner that they blend in colour, textures and finish with the adjacent work.

304.07 TRIAL LENGTHS

- (1) The Contractor shall, before he commences the work proper, construct a trial length of at least 30 metres to check all operations he proposes to use in the Permanent Works and to ascertain all necessary information to establish application rates and manipulation requirements. The trial shall be undertaken, in the presence of the Engineer, using the same materials, plant and equipment and shall mirror the application and manipulation procedures proposed for the Permanent Works.
- (2) Prior to the trial the Contractor shall prepare and submit to the Engineer a draft Technical Method Statement (in accordance with Sub-clause 101.04.4 of the Specifications) for this work, and will obtain the approval of the Engineer thereto before he commence the trial.
- (3) The trial length shall be repeated if in the opinion of the Engineer the previous trial was unsatisfactory and/or failed to provide the necessary information for determination of application rates and manipulation requirements.
- (4) Trial lengths shall be constructed for SBST and DBST as required, and trial lengths shall not form part of the Permanent Works. Trial length shall be done outside project road on a surface approved by the Engineer. They may, however, form part of a temporary traffic detour subject to the approval of the Engineer.
- (5) Construction of trial lengths shall continue until all aspects are, in the opinion of the Engineer, fully satisfactory, following which the Contractor shall finalise and submit to the Engineer for approval the Technical Method Statement for the work.
- (6) This Method Statement is to be approved by the Engineer before the Permanent Works for the work commence. The Method Statement will define the rates of application of seal coat and cover material, the number of manipulation passes and all other aspects to clearly and unambiguously specify the procedures to be used in the Permanent Works.
- (7) All work carried out for Permanent Works construction will follow the approved final Technical Method Statement and deviations thereto will not be allowed except with the specific written approval of the Engineer. Deviations will not only cover the procedures adopted but will also encompass changes of equipment, and replacement of personnel including distributor and spreader operators and roller drivers.
- (8) Where, in the opinion of the Engineer, deviations are of such magnitude that the results of the trial length are no longer applicable and/or where the quality of the finished work is being prejudiced, the Engineer will order the works to cease until such time as further trial length(s) are constructed and approved.

304.08 OTHER REQUIREMENTS

304.08.1 Weather and Temperature Limitations

- (1) Seal coat shall not be applied on a damp surface or when the surrounding surface temperature is below 15 °C or when, in the opinion of the Engineer, weather conditions prevent the proper construction of the seal coat.

304.08.2 Protection of Adjacent Structures

(1) When bituminous materials are being applied, the surface of all structures, guard rails, kerbs and gutters, and other roadway appurtenances and trees shall be protected in an approved manner to prevent them from being splattered with bituminous material or marred by equipment operation. In the event that any appurtenances become splattered or marred, the Contractor shall at his own expense, remove all traces of bituminous materials, and repair all damage, and leave the appurtenances in an approved condition.

304.08.3 Working Periods

(1) Surface dressing operations shall be so conducted that all manipulation work specified can be completed before sunset and under favourable weather conditions as determined by the Engineer.

304.08.4 Traffic Control

(1) Traffic shall be prevented from running on the surface courses until at least 24 hours after the manipulation work has been completed, unless otherwise ordered or permitted by the Engineer.

(2) When directed by the Engineer the Contractor shall direct both the construction traffic and the passing traffic onto the completed first seal (in case of SBST or DBST).

(3) The Contractor shall at his own cost provide any necessary speed restriction and warning and diversion signs and barriers for traffic control, and traffic shall be so regulated to ensure that it causes no damage to the seal.

(4) The Contractor shall post signs restricting the speed of traffic to 20 km/h on the surface dressing for such periods as directed by the Engineer. When instructed by the Engineer for the first two weeks the Contractor shall erect barriers restricting the width of the road and daily move them such that traffic runs across the complete width of the aggregate in the course.

(5) The Contractor shall make good at his own cost and in a manner approved by the Engineer any defects or damage to the seal for a period of 14 days, or other such period specified by the Engineer, before the application of any additional surface dressing courses or asphalt.

304.09 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
304-1	First Seal Coat	Litre
304-2	Cover Material (19 mm nominal size)	Metre Cube
304-3	Second Seal Coat	Litre
304-4	Cover Material (12.5 mm nominal size)	Metre Cube
304-5	Cover Material (16 mm nominal size)	Metre Cube
304-6	Cover Material (10 mm nominal size)	Metre Cube

(2) Measurement for the Seal Coat item shall be computed by multiplying the areas to be dressed as shown on the Drawings and any other areas ordered by the Engineer, by the appropriate rate or rates of application ordered by the Engineer, corrected to +15 °C.

(3) Measurement for the Cover Material shall be computed by multiplying the areas to be dressed as shown on the Drawings and any other areas ordered by the Engineer, by the appropriate rate or rates of application ordered by the Engineer.

(4) Tray test is a reliable means to control the application rate for both binder and cover aggregate. Sample for tray test can be collected during application of binder and spreading of cover aggregate at an interval of 50 to 75m along the travel path of bitumen distributor and cover aggregate spreader maintaining their calibrated and approved speed.

(5) No measurement will be made for areas dressed outside the limits specified, nor will any measurement be made for material in excess of the rates of application ordered by the Engineer.

304.10 PAYMENT

(1) Payment will be made at the rates entered in the Bill of Quantities and shall include for trial lengths, maintenance, traffic control and all operations to achieve the surface dressing to the requirements specified herein.

SECTION 305

BITUMINOUS PAVEMENT COURSES (ASPHALT CONCRETE)

305.01 DESCRIPTION

(1) This work shall consist of furnishing of plant, labour, equipment and materials for, and performing all operations in connection with, the construction of bituminous pavement courses.

305.02 MATERIALS

305.02.1 Coarse Aggregate

(1) Course aggregate, which is the material retained on a 4.75mm (ASTM No. 4) sieve, shall consist of crushed un-weathered rock.

(2) It shall be clean, hard, tough, durable and sound, and shall be of uniform quality and free from decomposed stone, shale, clay lumps and other deleterious substances. Organic impurities when tested in accordance with AASHTO T 21 shall not fail the colour comparison of being darker than the colour of Organic Colour No. 3 (Gardner No.11). Coarse aggregate for each pavement course shall be from a single source of supply. Mixing of aggregates from different sources will not be allowed.

(3) River boulders will only be approved as a source of supply for coarse aggregate if the Contractor can prove, to the satisfaction of the Engineer, that suitable quarry sources are unavailable within the vicinity of the Contract. For the purposes of these specifications, “within the vicinity” shall be taken to mean within a radius of 50 km of any point within the Site. Under no circumstances will natural uncrushed gravel be allowed to be incorporated into bituminous mixes.

(4) The percentage of particles with a minimum of one crushed face shall be 100%. In addition, at least 85 % by weight for quarry material and 65 % for river boulders of each separate stockpile of aggregate shall have all faces crushed.

(5) Coarse aggregate shall have properties which comply with the following values:

Los Angeles Abrasion Loss (AASHTO T 96)	
Binder Course	30% max
Wearing Course	25% max
Aggregate Crushing Value (BS 812-110)	
Binder Course	25% max
Wearing Course	20% max
Aggregate Impact Value (BS 812-112)	
	25% max
Soundness Loss (AASHTO T 104)	
Sodium Sulphate	12% max
Flakiness Index (BS EN 933-3)	
Binder Course	25% max
Wearing Course	25% max
Elongation Index (BS 812-105.2)	
Binder Course	25% max
Wearing Course	25% max
Polished Stone Value (BS 812-114)	
	75 min
Water Absorption (ASTM C128/ 127)	
	2% max

(6) Coarse aggregate shall show no detrimental amount of stripping when tested in accordance with AASHTO T 182. The minimum value of non-stripped area shall be 95 %. If stripping occurs, the aggregate shall be rejected or, with the agreement of the Engineer, a method of treatment shall be proposed by the Contractor for the approval of the Engineer to change the material from a hydrophilic to a hydrophobic state, or an approved (anti-stripping) additive shall be proposed by the Contractor for use with the bituminous binder.

(7) The approved additive shall be added to the bituminous material in such a proportion as required to obtain satisfactory results in the affinity with bitumen test performed in accordance with AASHTO T 182. The approved additive shall be used in strict accordance with the technical specifications issued by the additive manufacturer.

305.02.2 Fine Aggregate

(1) Fine aggregate shall consist of the material passing the 4.75 mm sieve.

(2) Fine aggregate shall be obtained from 100 % crushed rock or boulders pre-screened to exclude natural uncrushed fine material or weathered unsound fines. The use of natural sand will not be permitted. The use of river gravel as a source of supply for fine aggregate will not be permitted unless specifically approved by the Engineer.

(3) Fine aggregate shall have properties which comply with the following values:

Sand Equivalent	
Binder Course	50% min
Wearing Course	40% min
Soundness Loss (AASHTO T 104)	
Magnesium Sulphate	15% max
Plasticity Index (BS 1377: Part 2: Test 5)	Non-Plastic
Acid Soluble Chlorides (BS EN 1744-1)	0.1% max
Acid Soluble Sulphates (BS EN 1744-1)	0.5% max

305.02.3 Storage of Aggregates

(1) Sufficient storage space shall be provided for each size of aggregate.

(2) Aggregates for bituminous pavement courses shall be stored on specially prepared paved (asphaltic or concrete) surfaces sloped to provide satisfactory drainage. Storage arrangements shall be such that inter-mixing of difference size aggregates cannot take place.

(3) Stockpiles of aggregates shall be protected to the satisfaction of the Engineer to avoid contamination from wind blown fine particles and debris.

305.02.4 Mineral Filler

(1) When necessary to meet gradation requirements and/or to satisfy the design requirements specified, mineral filler shall be added to the coarse and fine aggregates.

(2) Mineral filler shall consist of finely ground particles of limestone or cement in accordance with AASHTO M 17 or an approved cement manufacturing by-product. It shall be thoroughly dry and free from organic substances and clay, and shall meet the following grading requirements:

Table 1 - Grading Requirements of Mineral Filler

MINERAL FILLER			
ISO	BS SIEVE	ASTM SIEVE	PERCENTAGE BY MASS PASSING
600 micron	25	No.30	100
300 micron	52	No.50	95-100
150 micron	100	No.100	90-100
75 micron	200	No.200	70-100

- (3) Filler shall be non plastic when tested by AASHTO T 90.

305.02.5 Combined Aggregate

- (1) The combined mineral aggregate/fill shall meet the following physical requirements:

Sand Equivalent (ASTM D2419) determined after
all processing except for addition of asphalt binder 65 minimum

Plasticity Index
(BS 1377: Part 2: Method 5) Non plastic

- (2) When tested in accordance with AASHTO T 11 and T 27, the combined mineral aggregate shall conform to Table 2.

Table 2 - Aggregate Grading for Asphalt Concrete

Mix Class		Class A	Class B	Class C	Class D
Mix Use		Binder Course	Binder Course	Binder/Wearing Course	Wearing Course
Minimum Compacted Thickness		70 mm	50 mm	40 mm	30 mm
U.S Standard Sieve mm alternative		Percent Passing By Weight			
37.50	(1½ in)	100			
25.00	(1 in)	95-100	100		
19.00	(¾ in)	75-95	80-100	100	
12.50	(½ in)	-	-	80-100	100
9.50	(¾ in)	54-75	60-80	70-90	80-100
4.75	(No. 4)	36-50	48-65	50-70	55-75
2.36	(No. 8)	25-45	35-50	35-50	35-50
0.600	(No.30)	11-28	19-30	18-29	18-29
0.300	(No.50)		13-23	13-23	13-23
0.150	(No.100)		7-15	8-16	8-16
0.075	(No.200)	1-8	1-8	4-10	4-10

- (3) The gradings given in Table 2 represent the extreme limits which shall determine suitability of aggregate for use from any source of supply.

- (4) Aggregate shall not vary from the low limit on one sieve to the high limit on the adjacent sieve, but shall be uniformly graded.

305.02.6 Additives

(1) When necessary to meet the requirements of the Specifications (in particular the bitumen mortar softening point and retained stability), additives may be used subject to the prior written approval of the Engineer. Such additives shall be certified by the Contractor as having no detrimental effects on the bituminous mixture, its properties, durability or load carrying characteristic under all anticipated environment and traffic induced conditions relevant to the Site.

305.02.7 Bitumen Binder

(1) Bitumen binder for binder and wearing courses shall be penetration grade 60 - 70 unless grade 40-50 is specified in the Contract Documents.

(2) The bitumen shall be prepared by refining crude petroleum by suitable method and shall be homogenous, free from water and shall not foam when heated to 175 °C (347 °F).

(3) The bitumen shall conform to the requirements of Table 3.

Table 3 – Bitumen Requirements

Test	AASHTO / ASTM	60	70	PEN	40	50	PEN
		Min	Max		Min	Max	
Penetration at 25 °C (100 g, 5 sec)	T 49 / D5	60	70		40	50	
Flash Point, Cleveland Open Cup. °C	T 48 / D92	232	-		232	-	
Loss on Heating (5 hr. at 163 °C), %	T 179 /-	-	0.80		-	0.80	
Ductility at 25 °C, cm	T 51 / D113	100	-		100	-	
Solubility tricolour ethylene, %	T 44 / D2402	99	-		99	-	
Thin film over test 3.2 mm, 163 °C, 5 hr. loss on heating, %	D2872	-	0.80		-	0.80	
Penetration of residue % of original	T 49 / D5	54	-		53	-	
Ductility at 25 °C (50 mm/min), cm	T 51 / D113	100	-		100	-	
Ductility of residue at 25 °C, (50 mm/min), cm	T 51 / D113	50	-		50	-	
Kinematic Viscosity (Centistokes) at 135 °C	D 2170	240	-		280	-	
Softening Point, Ring & Ball apparatus	T 53 / D36	49	54		51	55	
Paraffin content, %	-	-	2		-	2	

(4) The bitumen mortar (bitumen binder plus filler plus additives) shall have a softening point (AASHTO T 53) not less than 60 °C.

(5) A sample of the bitumen that the Contractor proposes to use in the work, together with a statement as to its source and properties shall be submitted to and approved by the Engineer at least 45 days before the asphalt work begins.

(6) No bitumen other than that represented by the approved sample shall be used by the Contractor except with the written consent of the Engineer. Blending of bitumen from different refineries will not be permitted.

(7) Each consignment brought to Site shall be accompanied by the manufacturer's certificate and a test report stating the shipment number, date of shipment, purchase order number, net weight and the results of the tests specified in Table 3 above.

(8) For each delivery of bitumen, the bitumen shall be checked for compliance with the requirements of Table 3 and the bitumen mortar shall be checked for softening point. Any delivery not satisfying the above requirements shall be rejected and removed from the Site.

(9) The percentage range of bitumen by weight of total mix, for both binder- and wearing courses, to be added to the aggregate shall be in the range 4 – 6 %.

305.03 JOB MIX FOR BITUMINOUS PAVING COURSES

305.03.1 Laboratory Job Mix Formula

(1) At least forty five (45) days prior to the date he intends to begin production of plant-mix bituminous pavement courses, and after receiving approval from the Engineer to the aggregates, additive(s) (if any) and bitumen, the Contractor shall make a written request for the approval of the laboratory job mix formula (LJMF). The LJMF will be prepared by the Contractor under the supervision of the Engineer using the Marshall method of mix design (Asphalt Institute MS-2).

(2) The LJMF shall fix a single definite percentage of aggregate passing each required sieve size, a single definite percentage of filler, a single definite percentage of any additives, a single definite percentage of bitumen binder to be added to the mix, a single definite temperature at which the mix is to be emptied from the mixer and a single definite temperature at which the mix is to be delivered to the work site.

(3) The LJMF shall display the Marshall characteristics specified in Tables 4 and 5.

Table 4 - Marshall Test Criteria for Bituminous Binder Course

Compaction, number of blows each end of specimen	75
Stability (kg)	1200 min
Flow (mm)	2 – 4
Stiffness (stability/flow) kg. F/mm	500 min
Percent air voids in mix	5 – 9
Percent voids filled with bitumen	55 – 65
Percent voids in mineral aggregate	13 min
Loss of Stability at 60 °C	25% max
Retained Stability at 60 °C (kg)	1000 min
Filler/Bitumen ratio	0.6 – 1.5
Refusal Air Voids	3% min

Table 5 - Marshall Test Criteria for Bituminous Wearing Course

Compaction, number of blows each end of specimen	75
Stability (kg)	1200 min
Flow, (min)	2 – 4
Stiffness (stability/flow) (kg f/mm)	500 min
Percent air voids in mix	5 – 8
Percent voids filled with bitumen	60 – 70
Percent voids mineral aggregate	14 min
Loss of Stability at 60 °C	25% max
Retained Stability at 60 °C (kg)	1000 min
Refusal Air Voids	3% min

(4) The Loss of Stability shall be measured as that loss recorded by immersion of a specimen in water at sixty (60) degrees centigrade for twenty-four (24) hours as compared to that stability measured after immersion in water at sixty (60) degrees centigrade for twenty (20) minutes.

(5) The Retained (Marshall) Stability shall be measured as that stability recorded after immersion of a specimen in water at sixty (60) degrees centigrade for twenty-four (24) hours.

(6) If the mixture fails to meet the specified criterion, the LJMF shall be modified.

(7) Refusal air void shall be determined as follows on a LJMF mix but with a bituminous content at the upper percentage limit (see Table 6). Samples shall be compacted initially by 75 blows each end at 140-145 °C and then with additional blows each end at 90 °C as follows:

Sample 1	125 blows each end
Sample 2	225 blows each end
Sample 3	325 blows each end

(8) The air void in the mix for each sample shall be determined.

(9) For each sample the bitumen shall then be extracted and a gradation analysis (AASHTO T88) shall be undertaken. Where, in the opinion of the Engineer, the gradation results indicate that excessive crushing of the aggregate has occurred, the air voids result for that sample shall be discarded as unrealistic.

(10) The air voids for all acceptable samples shall not be less than 3 % unless otherwise directed by the Engineer.

(11) It shall be noted that the purpose of the LJMF is to establish a mix that, within the tolerances stated, will perform satisfactorily in the particular environmental conditions, geometric alignments and anticipated traffic loadings and speeds of the Contract location. Production of a LJMF which simply meets the Specification requirements without due regard to the above noted factors may not result in a satisfactory mix. Such a LJMF will be unacceptable to the Engineer.

(12) The mix proposed for use in the Works shall be designed to ensure the minimum bitumen binder content to satisfy durability, stability and voids contents requirements.

305.03.2 Trial Areas

(1) A trial area for each LJMF and for each paver proposed to be used by the Contractor shall be constructed by the Contractor prior to commencing the permanent works to check that the proposed LJMF can be mixed, laid and compacted in full accordance with the requirements of the Specifications. The trial area shall be used to assess the appropriateness of the mixture and the equipment, plant and labour the Contractor proposes to use for the permanent works, and to test the mixing, laying, finishing and compaction processes. The equipment, plant and labour and procedures proposed for use in construction of the trial areas shall be those intended for the permanent works and shall be fully detailed in a preliminary method statement prepared by the Contractor. Trial area construction shall not commence until the preliminary method statement has been approved by the Engineer.

(2) A trial area shall be of such a length as to be able to ensure that all anticipated permanent works situations are adequately reproduced. In no case will a trial area be less than 50 metres long, and in all cases the widths and course/layer thickness shall be those required for the permanent works.

(3) At least three (3) samples of non-compacted material from each trial area shall be taken in accordance with AASHTO T 168 and shall be analysed in the presence of the Engineer to determine the aggregate grading, binder content, stability, retained stability (at 60 °C), flow, Marshall density, the voids in the mineral aggregate (VMA), percentage voids filled with bitumen, voids in the mix (VIM) and air voids at refusal.

(4) After compaction, at least four samples shall be taken from the compacted material after 12 hours and tested for thickness, field density, asphalt content and aggregate grading.

- (5) The results of (3) and (4) above shall be submitted to the Engineer and shall be approved by him before mixing or laying of the permanent works is commenced.
- (6) Special trial areas shall be constructed for transverse joints and, if so required by the Engineer, for longitudinal joints.
- (7) All trial areas shall be at the expense of the Contractor and the costs thereof shall be deemed to be included in the rates for the permanent works.
- (8) Trial areas shall not form part of the permanent works, but may form part of a temporary traffic detour subject to the approval of the Engineer. Compaction trials shall be performed on the trial sections in accordance with the requirements specified herein.
- (9) Should the LJMF as laid in accordance with the above requirements fail, in the opinion of the Engineer, to produce a satisfactory trial area, the mix proportions shall be modified by the Contractor in agreement with the Engineer and within the requirements of Tables 4 and 5 as applicable to produce a mix of satisfactory workability and acceptable surface finish subject to the mix satisfying all preceding requirements for the LJMF.
- (10) Where, in the opinion of the Engineer, the trial area construction indicates that the equipment, plant, labour and/or procedures used by the Contractor are deficient in any way, notwithstanding that the bituminous mixture as laid meets the requirements of the Specifications, further trial areas shall be constructed until the Engineer is satisfied that all aspects of the works are optimised. Once an approved trial area has been attained, the equipment, plant, labour and procedures used shall be recorded in a final Technical Method Statement, which shall be subject to the approval in writing of the Engineer.
- (11) The initial day's bituminous paving course laying for the permanent works will be used to confirm that the final Technical Method Statement produces a bituminous paving course/layer in accordance with the Specifications requirements. Where necessary the final Technical Method Statement shall be amended in light of the experience with the permanent works construction. All such amendments shall be subject to the written approval of the Engineer.
- (12) All work carried out for permanent work construction will follow the approved final Technical Method Statement and deviations thereto will not be allowed except with the specific written approval of the Engineer. Deviations will not only cover the procedures adopted but will also encompass changes of equipment and plant, and replacement of personnel including batching plant and paver operators, roller drivers and asphalt gangs.
- (13) Where, in the opinion of the Engineer, deviations are of such magnitude that the results of the trial area are no longer applicable and/or where the quality of the finished work is being prejudiced, the Engineer will order bituminous pavement course construction to cease until such time as further trial areas are constructed and approved.

305.03.3 Job Standard Mix

- (1) After approval of the trial area(s) by the Engineer the relevant mix shall be designated the "Job Standard Mix" (JSM).
- (2) All mixes produced thereafter shall conform to the JSM within the ranges of tolerance specified in Table 6 and within the limits of Tables 2 and 3 and meeting the requirements of Tables 4 and 5. Each day the Engineer shall take as many samples of the material and mix as he considers necessary (minimum of one sample for every 200 tons or part thereof) for checking compliance with the required characteristics. When, in the Engineer's opinion, unsatisfactory results or changed conditions make it necessary, the Engineer shall instruct the Contractor to establish a new LJMF/JSM in accordance with the provisions noted above. Should a change in any constituent material be encountered or should a change in a source of material be made, a new LJMF/JSM shall be submitted by the Contractor for the written approval of the Engineer. Such approval must be received before the mix containing the new material is produced. JSM materials will be rejected if they are found not to have the specified characteristics.

Table 6 - Job Mix Tolerances for Bituminous Pavement Courses

Aggregate retained on 4.75 mm sieve	±5%
Aggregate passing 4.75 mm sieve and retained on 2.38 mm sieve	±4%
Aggregate passing 2.38 mm sieve and retained on 0.075 mm sieve	±2%
Aggregate passing 0.75 mm sieve	±1%
Additives	±0.25%
Bitumen Binder	Wearing Course ±0.2%
	Binder Course ±0.3%
Temperature of mixing and placing	±10°C

(3) The assistance of the Engineer in the preparation of a LJMF/ JSM in no way relieves the Contractor of the responsibility of producing bituminous mixes meeting the requirements of the Specifications.

305.04 JOB MIX ACCORDING SUPERPAVE MIX DESIGN METHOD

305.04.1 Materials

305.04.1.1 Asphalt Concrete Aggregate

(1) The aggregate shall be hard, durable particles or fragments of crushed stone, crushed slag, or crushed gravel conforming to the following:

Los Angeles Abrasion Loss, AASHTO T 96	35% max
Soundness of Aggregate using Sodium Sulphate, AASHTO T 104 (5 cycles):	
Coarse Aggregate	12% max
Fine Aggregate	12% max
Fractured Faces, ASTM D 5821	90% min
Fine Aggregate Angularity, AASHTO T 304, Method A	40% min
Flat and Elongated Particles, ASTM D4791 (1:5 ratio, 9.5-mm sieve, Calculated by mass, weighted average)	10% max
Sand Equivalent, AASHTO T 176, Alternative Method No. 2, Reference Method	45% min

(2) The aggregate fractions shall be combined in mix proportions that result in a composite blend conforming to the specified gradation. Nominal maximum size shall be one sieve size greater than the first sieve to retain more than 10 % of the combined aggregate. Testing shall be according to AASHTO T 27 and AASHTO T 11. The requirements of volumetric asphalt concrete aggregate gradation are shown in below Table 7.

(3) For the surface course aggregates known to polish or carbonate aggregates containing less than 25 % by mass of insoluble residue when tested according to ASTM D3042, shall not be used.

(4) Asphalt concrete pavement nominal maximum size aggregate size shall be according to Tables 7, 8 and 9.

Table 7 – Superpave Aggregate Gradation

Sieve Size	Nominal Maximum Aggregate Size – Percent Passing									
	Grading Designation									
	25 mm		19 mm		12.5 mm		9.5 mm		4.75 mm	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
50 mm										
37.5 mm	100									
25 mm	90	100	100							
19 mm	*	90	90	100	100					
12.5 mm	*	*	*	90	90	100	100			
9.5 mm	*	*	*	*	*	90	90	100	100	
4.75 mm	*	*	*	*	*	*	*	90	95	100
2.36 mm	19	45	23	49	28	58	32	67	70	80
1.18 mm	*	*	*	*	*	*	*	*	*	*
600 µ	*	*	*	*	*	*	*	*	*	*
300 µ	*	*	*	*	*	*	*	*	*	*
75 µ	1.0	7.0	2.0	8.0	2.0	10.0	2.0	10.0	4.0	10.0

* Contractor specified target values. See below Table X for allowable deviations

Table 8 – Allowable Deviations Based on Target Values

Percent by Mass Passing	Allowable Deviation
Range	
70.1 – 89.9	4
60.1 – 70.0	5
55.1 – 60.0	6
45.1 – 55.0	7
40.1 – 45.0	6
30.1 – 40.0	5
21.1 – 30.0	4
8.1 – 21.0	3
0 – 8.0	2

Table 9 - Superpave Concrete Mix Design Requirements, AASHTO R 35

Design ESAL (Million)	Gyratory Compaction Level (% Theoretical Maximum Specific Gravity, G _{mm}) AASHTO T 312			Minimum Voids-in-the Mineral Aggregate (VMA), % ⁽¹⁾					Voids Filled with Asphalt (VFA), %	Dust-to-Binder Ratio ⁽³⁾	Minimum Tensile Strength Ratio, AASHTO T 283
				Nominal Maximum Size Aggregate ⁽²⁾							
	N _{initial}	N _{design}	N _{max}	25 mm	19 mm	12.5 mm	9.5 mm	4.75 mm			
< 0.3	6 (≤91.5%)	50 (96.0%)	75 (≤98.0%)	12.0-15.0	13.0-16.0	14.0-17.0	15.0-18.0	–	70.0 - 80.0	0.8 - 1.6	0.80
0.3 to < 3	7 (≤90.5%)	75 (96.0%)	115 (≤98.0%)						65.0 - 78.0		
3 to 30	8 (≤89.0%)	100 (96.0%)	160 (≤98.0%)						65.0 - 78.0		
–	6 (≤91.5%)	50 (96.0%)	75 (≤98.0%)	–	–	–	–	16.0 - 19.0	76.0 - 80.0	0.6 - 2.0	

(1) When mineral filler or hydrated lime is used, include in the calculation for compliance with the VMA.

(2) The nominal maximum size aggregate is one size greater than the first sieve to retain more than 10 percent of the combined aggregate.

(3) Dust to binder ratio is the effective asphalt content divided by the total percent of material passing the No. 200 (75 μ m) sieve. Dust includes lime, bag house fines, and other mineral matter.

(5) Equivalent single axle loads (ESAL) or number of gyrations at design (N_{design}) shall be according to Table 9.

(6) Asphalt binder shall be according to AASHTO M 226 or AASHTO M 320.

305.04.1.2 Antistrip additive

(1) Antistrip additive type shall conform to the following types.

Type 1: Commercially produced, heat stable liquid products that when added to an asphalt have the chemical and physical properties to prevent separation of the asphalt from aggregates.

Type 2: Hydraulic Cement shall be either (i) Portland cement, conforming to AASHTO M 85 or (ii) blended hydraulic cement, conforming to AASHTO M 240. Cement brands or types shall not be mixed.

Fly Ash consisting of pozzolans, Class C or Class F conforming to AASHTO M 295. Maximum 1.5 percent can be used to mitigate alkali-silica reactivity

Type 3: Lime conforming to AASHTO M 303

When no type is specified use Type 3 (Lime).

305.04.1.3 Mineral Filler

(1) Mineral filler shall conform to AASHTO M 17.

305.04.2 Job Mix Formula (JMF)

(1) The Contractor shall provide asphalt concrete mixes of aggregate, asphalt binder, Recycled Asphalt Pavement (RAP) and additives that meet the applicable material requirements and the appropriate design parameters in Table 9 and are capable of being placed and compacted as specified. Volumetric mix properties shall be determined at N_{design} according to AASHTO T 312 and AASHTO R 35.

(2) Asphalt concrete mix design requirements for Hot Mix Asphalt (HMA) shall be applied to develop the Warm Mix Asphalt (WMA) mix design. Modifications to the process required for WMA technology shall be provided to the Engineer for his review and approval. The Contractor shall submit modifications to the asphalt concrete mix design process according to Appendix X.2 of AASHTO R 35, *Special Mix Design Considerations and Practices for Warm Mix Asphalt (WMA)* for approval by the Engineer.

(3) The quantity of Recycled Asphalt Pavement (RAP) by mass in the JMF shall not exceed 20 percent.

(4) If Baghouse Fines are used, the Contractor shall document how these are reintroduced and measured. If the baghouse fines are from a separate stockpile, the target values for the percent of baghouse fines reintroduced to the JMF shall be submitted.

305.04.2.1 Submission

(1) A JMF and associated material with the Engineer agreed *Worksheet for Superpave Asphalt Concrete Mix Design* for verification shall be submitted at least 30 days before the control strip. A signed statement prepared by the testing laboratory that certifies the proposed JMF meets requirements and can be compacted in the field during production, shall be included. For each proposed JMF, following shall be submitted:

(1) Aggregate and mineral filler

(a) Target values:

(1) Target value for percent passing each specified sieve size for the aggregate blend;
and

(2) Designate target values within the gradation band specified for the nominal maximum size aggregate grading shown in Table 8;

(b) Source and percentage of each stockpile to be used;

(c) Average gradation of each stockpile;

(d) Representative samples from each stockpile. Split samples of material taken at the same time samples are taken for testing by the Contractor's laboratory shall be used.

(1) 270 kg of aggregates proportioned by each stockpile according to the JMF; and

(2) 4.5 kg of mineral filler, if proposed for the JMF; and

(e) Results of aggregate quality tests performed within 1 year of use.

(2) Asphalt binder

(a) Target asphalt binder content;

(b) 4 litre samples of the asphalt binder;

(c) Test results from the manufacturer according to AASHTO M 320 for the asphalt binder including a temperature-viscosity curve; and

(d) Mixing temperature range and minimum compaction temperature for the asphalt binder.

(3) Antistrip additives (If part of the JMF)

(a) 0.5 litre of liquid antistrip additive or 0.9 kg of cement or lime antistrip additive;

(b) Name of product;

(c) Manufacturer; and

(d) Manufacturer's Material Safety Data Sheet (MSDS) and product data sheets.

(4) Recycled Asphalt Pavement, RAP (If part of the JMF)

(a) Source and percentage of RAP;

(b) Gradation of the RAP;

(c) Effective specific gravity of each stockpile;

(d) Percent asphalt binder in RAP by total mass according to AASHTO T 308; and

(e) 45 kg representative sample of each RAP stockpile.

(5) Warm Mix Asphalt (WMA) technology and additive information.

(a) 4 litre WMA additive sample with method for incorporating it in the asphalt concrete mix design process;

(b) WMA manufacturer's usage recommendations including additive target rates;

(c) Documentation of past WMA technology field applications including project type, project owner, tonnage placed, asphalt concrete mix design, mixture volumetrics, and performance;

(d) Laboratory mixing and compacting temperature;

(e) Asphalt binder performance grade test data over the range of WMA additive percentages proposed for use if applicable;

- (f) Compatibility of WMA additive with asphalt binder and antistrip additive; and
- (g) Temperature range for field asphalt concrete mix production, delivery, lay-down and compaction.

305.04.2.2 Verification

(1) The verification process shall begin when required documentation and material are received. When the JMF is verified, asphalt concrete mix production for the control strip shall begin.

(1) Aggregate gradations

(1) The Contractor's aggregate gradation is verified if the gradation on a combined asphalt concrete mix using the Contractor's aggregate and RAP stockpile percentage recommendations is within the Contractor's target value gradation plus or minus the following tolerance for each sieve:

Table 9 – Tolerances on Contractor's Combined AC Mix

Sieve Size	Tolerance, %
25 mm	±3.0
19 mm	±3.0
12.5 mm	±3.0
9.5 mm	±3.0
4.75 mm	±3.0
2.36 mm	±3.0
600 µm	±2.0
300 µ	±2.0
75 µm	±1.0

(2) Recycled Asphalt Pavement (RAP) asphalt binder content and gradation

(1) The Contractor's RAP asphalt binder content results are verified if the result for each stockpile is within ±0.75% by total mass using AASHTO T 308. The Contractor shall submit the RAP dry gradation, burned gradation, asphalt content, and specific gravity information as shown on the RAP data sheet in the format as agreed with the Engineer.

(3) Bulk Specific Gravity of Aggregate (G_{sb})

(1) The Contractor's coarse and fine G_{sb} is verified if the results are within 0.013 for AASHTO T 85 and 0.030 for AASHTO T 84.

(4) Voids in the Mineral Aggregate (VMA)

(1) The Contractor's VMA result is verified if the result is above the minimum specification limit in Table 9.

(5) Voids Filled with Asphalt (VFA)

(1) The Contractor's VFA result is verified if the result is within the specification limit in Table 9.

(6) Air Voids (V_a)

(1) The Contractor's V_a result is verified if the result at the same design asphalt binder content is between 3.0 and 5.0 percent.

(7) Tensile Strength Ratio (TSR)

- (1) The Contractor's TSR result is verified if the result is above the minimum specification limit in Table 9.
- (2) If a JMF is rejected or the source of material is changed, a new JMF shall be submitted for verification. Up to 30 days may be required to evaluate a change after receipt of required documentation and material.

305.05 CONSTRUCTION REQUIREMENTS

305.05.1 Bituminous Mixing Plant

- (1) Mixing plants used for the preparation of bituminous pavement course mixtures shall be weigh batch types conforming to AASHTO M 156, of adequate capacity to ensure continuous operation of the paving equipment for the course being constructed and to ensure the specified minimum lengths per day can be readily achieved. The plant shall be operated to produce mixtures within the limits of the Specifications.
- (2) The plant shall be operated by qualified and experienced operatives approved by the Engineer. At no time will operation of batching plants by unapproved operatives be allowed. The Contractor shall demonstrate in writing to the Engineer's satisfaction before each paving operation commences that the batching plant capacity, the number of hauling trucks (in relation to the required hauling distance and route accessibility/conditions), the paver and compaction equipment are fully compatible and are capable of ensuring, at all times, continuous operation of the paver, the specified minimum length of paving per day and satisfactory compaction of the as-laid materials at the specified temperatures.
- (3) Where in practice continuous operation of the paver cannot be ensured, paving operations shall cease immediately and the necessary amendments to procedures, equipment and resources approved by the Engineer before paving recommences.
- (4) Mixing plant shall have proper and approved thermometers and shall be equipped with a dust collector.

305.05.2 Preparation of Aggregates and Bitumen

- (1) Before being fed to the dryer, aggregates for bituminous pavement courses shall be clean and uncontaminated and shall be separated into two or more sizes and stored separately in cold bins. Where two bins are utilised, one bin shall contain aggregate of such size that eighty (80) percent will pass sieve No.4 and the other bin shall contain aggregate of such size that eighty (80) percent will be retained on sieve No.4.
- (2) Filler and additive(s) shall be stored separately and measured accurately before being fed into the mixer.
- (3) Dried aggregate weighed and drawn to the pugmill shall be combined with the proportionate amount of bitumen according to the JSM.
- (4) In placing the materials in bins or in moving them from bins to the mixer, any method which causes segregation or uncontrolled combination of materials of different gradings, shall be discontinued and the segregated or degraded materials shall be rescreened, and if necessary washed and passed through the dryer, before being reused.
- (5) Each aggregate ingredient shall be heated and dried at a temperature not exceeding one hundred and sixty three (163) degrees centigrade. If the aggregate contains sufficient moisture to cause foaming in the mixture or if the temperature of the aggregate is in excess of one hundred and sixty three (163) degrees centigrade, the aggregate shall be removed from the bins and returned to the respective stock piles.
- (6) Immediately after heating, the aggregates shall be screened to required sizes and stored in separate bins for batching and mixing with the bituminous material.

(7) Bitumen shall be heated within a temperature range of one hundred and thirty five to one hundred and sixty three (135-163) degrees centigrade at the time of mixing. Any bitumen heated to more than one hundred and seventy five (175) degrees centigrade shall be considered overheated and shall be rejected until it is sampled and tested to prove its acceptability.

(8) The temperature of the bitumen, shall not be lower than fifteen (15) degrees centigrade below the temperature of the aggregate at the time materials enter the pugmil.

(9) Bituminous mixtures exceeding one hundred and sixty three (163) degrees centigrade when discharged from the pugmil shall be rejected and shall not be used in the Works.

305.05.3 Hauling Equipment

(1) Dump trucks used for hauling bituminous mixtures shall have tight, clean, smooth metal beds which shall be thinly coated with a minimal amount of paraffin oil, lime solution or other approved material to prevent adherence of the bituminous mixture to the truck beds. Each truck shall have a cover of canvas or other suitable material of sufficient size as to protect the mixture from the weather and from contamination. Unless otherwise agreed by the Engineer, all bituminous mixture shall be transported with the cover in place. The mixture shall be delivered on the road at a temperature not less than one hundred and thirty (130) degrees centigrade.

(2) Loads which have segregated, or formed a crust, or contain lumps which will not flatten, or partially remain in the vehicle when the mixture is dumped, shall be rejected.

(3) Loads which are below the specified laying temperature or have been wetted by rain shall be rejected.

(4) No loads shall leave the mixing plant unless it is certain that they can be placed and compacted satisfactorily during daylight hours, unless adequate and dependable artificial lighting, to the approval of the Engineer, is provided at the job site.

(5) Truck beds shall be drained prior to loading.

305.05.4 Bituminous Pavers

(1) Bituminous pavers shall be self-contained power-propelled units, provided with an automatically controlled activated heated tamper and vibratory screed or strike-off assembly, capable of spreading and finishing courses of bituminous pavement material in widths applicable to the specified typical sections and thicknesses shown on the Drawings and in accordance with these Specifications. Pavers used for shoulders and similar construction shall be capable of spreading and finishing courses of bituminous pavement material in the widths required to achieve the layouts shown on the Drawings.

(2) Pavers shall be equipped with a receiving hopper having sufficient capacity for a uniform spreading operation. The paver shall be equipped with automatic feed controls, properly adjusted to maintain a uniform depth of material ahead of the screed.

(3) The screed or strike-off assembly shall be capable of producing a finished surface of the required evenness and texture without tearing, shoving or gouging the mixture.

(4) When laying the mixture, the paver shall be capable of being operated at forward speeds consistent with satisfactory continuous laying of the mixture. The paver shall be operated at speeds which will give the best results for the type of mixture being laid.

(5) The paver shall be equipped with automatic screed controls capable of automatically maintaining the screed at the required elevation/slope. Sensors on both sides of the paver, capable of sensing grade from an outside taut wire reference line, sensing the transverse slope of the screed and providing the automatic signals which operate the screed to maintain the desired grade and transverse slope will be acceptable.

- (6) Long (9 metre plus) ski operation will only be allowed where, in the opinion of the Engineer, the levels and surface regularity of the underlying layer are such that a satisfactory finish can readily be attained. Under no circumstances will short ski operation be allowed.
- (7) The transverse slope controller shall be capable of maintaining the screed at the desired slope within plus or minus 0.1 percent variation.
- (8) Whenever during laydown operations a breakdown or malfunction of the automatic controls occurs, the equipment may be operated manually or by other approved methods in order to allow the Contractor to use the material already being mixed at the plant or in transit, provided always that the method of operation will produce results otherwise meeting the Specifications.
- (9) When such a breakdown or malfunction occurs no further mixing of bituminous materials shall be commenced, and bituminous pavement course construction shall be abandoned until the paver is repaired or replaced.
- (10) Otherwise, manual operation will only be permitted in the construction of irregularly shaped and minor areas.
- (11) Horizontal control utilising the reference line will be permitted. The Contractor shall furnish and install all pins, brackets, tensioning devices, wire and accessories necessary for satisfactory continuous operation of the automatic control equipment.
- (12) The Contractor shall ensure that the reference (guide) lines are set out and installed sufficiently in advance of paving operations to ensure that continuity of such paving operations is achieved. The number and spacing of pins shall be such as to minimise undulations in the paving due to vertical deflection of the guidelines. The Engineer's decision on the length of reference lines set-out/installed and on the number and spacing of pins will be final.

305.05.5 Rollers

- (1) Rollers shall be self propelled, steel wheel, pneumatic tyre or vibratory, or a combination thereof. The rollers shall be in good working condition, capable of reversing without backlash, and shall be operated at speeds slow enough, and shall be reversed, to avoid displacement of the bituminous mixture. Where flat 3 point steel wheel rollers are used, the wheels shall be evenly balanced with sand or water to the manufacturer's recommendations. The number and weight of rollers shall be sufficient to compact the mixture to the required density while it is still in a workable condition. The use of equipment which results in excessive crushing of the aggregate will not be permitted.
- (2) The wheels of the rollers shall be equipped with adjustable scrapers and the rollers shall have water tanks and sprinkling apparatus which shall be used to keep the wheels sufficient wet to prevent the surface paving material from sticking. Manual wetting of the wheels will not be permitted. Where found necessary the water may be mixed with very small quantities of detergent or other approved material. The minimum amount of water shall be used to avoid unnecessary cooling of the bituminous mixture. Before each paving operation all rollers shall be checked by the Contractor and approved by the Engineer as being in a satisfactory condition for the requirements of the Specifications to be achieved. Rollers with slow punctures, wobbly wheels, inadequate brakes, unsatisfactory clutches, loose steering, inoperative or unsatisfactory water sprinkling systems or other defects which could result in the requirements for compaction being breached shall not be used, and acceptable repairs or replacement equipment shall be provided by the Contractor to the satisfaction of the Engineer before laying of bituminous materials commences.
- (3) All rollers will be charged with water and the sprinkling systems checked immediately before commencement of paving to ensure that excessive quantities of water will not be distributed to the wheels.

305.05.6 Paving Operations

- (1) For single carriageway roads with a travelled way of 7.5 metres or less in paved width, bituminous courses for the travelled way shall be laid full width with no central joint unless traffic or site conditions necessitate half width laying. Half width laying will only be allowed with the prior written approval of the Engineer.
- (2) For full width laying, echelon paving will be allowed with the prior approval of the Engineer. In such case each paver shall be pave half width and the pavers shall be co-ordinated to ensure that full compaction of the complete width of the travelled way can be achieved before the material laid first has cooled to below the minimum rolling temperature. Special attention shall be paid to ensuring the central 'joint' area is properly formed and compacted to provide a fully waterproof pavement.
- (3) Half width paving using one paver paving alternative half widths of the travelled way will not be accepted as a method of full width paving.
- (4) The Contractor's attention is drawn to the fact that to achieve satisfactory echelon paving adequate batching plant capacity and transportation (hauling) facilities are mandatory, and very careful management and control of supply to the pavers will be required to ensure that continuous operation of both pavers together with satisfactory co-ordination of the pavers is maintained.
- (5) Where, in the opinion Engineer, the Contractor is unable to achieve satisfactory echelon paving, approval for such paving will be withdrawn and full width paving will be mandatory.
- (6) The Contractor's proposed system for echelon paving shall be fully detailed in a comprehensive Technical Method Statement which, when approved by the Engineer, shall be proven, to the satisfaction of the Engineer, by the construction of trial areas as specified herein.
- (7) Where half width paving is allowed, the longitudinal joint shall at the centre line of the travelled way. For multi-lane roadways the longitudinal joints shall be along the lane lines.
- (8) The Contractor shall demonstrate, by the construction of trial areas as specified herein, that the equipment and methods he proposes to use for paving are consistently capable of producing pavement courses in full compliance with the requirements of the Specifications.

305.05.7 Minimum Pavement Lengths

- (1) The minimum amount of bituminous mixture (wearing course or binder course) to be (continuously) laid and compacted within a working day will be 50 cubic metres, except in extraordinary circumstances which will be subject to the prior written approval of the Engineer.
- (2) The capacity of the complete bituminous pavement course equipment (batching plant, hauling trucks, pavers, rollers etc) shall be such that the specified minimum amount of bituminous mixture can be laid in one continuous uninterrupted operation within a working day. No laying of bituminous mixture will be allowed in the hours of darkness or when conditions, in the opinion of the Engineer, are unsuitable to ensure that the bituminous mixtures can be laid and compacted in full accordance with the requirements of the Specifications.
- (3) The attention of the Contractor is drawn to the need for careful preparation and planning of his bituminous pavement course operations to ensure that the minimum amounts of bituminous mixture can be laid and compacted within the working day. Factors to be considered include pre-preparation of the surface on which the mixture is to be laid, pre-establishment of level controls, wire guides, etc, an early start to mixing operation to allow laying at the earliest practical time, organisation, inspection and approval of all required equipment, plant and labour etc, etc.

305.05.8 Restrictions on Commencing Paving Operations

- (1) Laying of bituminous mixtures will not be allowed until, in the Engineer's opinion, all necessary equipment, plant and labour is available, in satisfactory working condition, at the site of operations, and an adequate length of reference (guide) lines for paving operations has been established.

305.05.9 Communications

(1) The Contractor shall provide, to the Engineer's satisfaction, an acceptable system of communications between the batching plant and the paver such that continuous contact can be maintained, and mixing and laying operations co-ordinated. No paving operations will be allowed to commence unless and until the system of communication is in satisfactory operating condition.

305.05.10 Preparation of Base or Existing Pavement Surface

(1) Before spreading bituminous materials the surface of the underlying layer or existing pavement on which the mixture is to be placed shall be thoroughly cleaned (by mechanical brushing for existing pavement courses) to the approval of the Engineer, and shall be conditioned by application of a prime or tack as specified.

(2) After a prime coat is applied, it shall be left undisturbed for not less than twenty four (24) hours. The Contractor shall maintain the primed surface until the bituminous material has been placed. The maintenance shall include the spreading of sand or other approved material, if necessary, to prevent adherence of the prime coat to the tyres of vehicles using the primed surface, patching any breaks in the primed surface with additional bituminous material and repairing any damaged areas of primed surface with additional bituminous material.

(3) After a tack coat is applied, it shall be allowed to dry until it is in the proper condition of tackiness to receive the bituminous mixture. The tack coat shall be applied only as far in advance of the placing of the mixture as is necessary to obtain the proper condition of tackiness. Any breaks in or damage to the tack coat shall be repaired before the bituminous mixture is laid.

(4) The Contractor shall ensure that only the minimum necessary amount of tack coat is used.

(5) When the surface of the existing pavement or old base is irregular, it shall be brought to uniform grade and cross-section by a levelling course as directed. The levelling course mixture shall conform to the requirements of the Specifications.

(6) A thin coating of cut back bitumen shall be applied to contact surfaces of kerbing, gutters, manholes and other structures prior to bituminous mixture being placed against them.

305.05.11 Spreading and Finishing

(1) The bituminous mixtures shall be laid upon an approved surfaces, spread and struck off to the section and elevation established.

(2) Transverse joints in one layer/course shall be offset from those in the layer/course immediately below by a minimum of 3 metres.

(3) On areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impracticable, the mixture shall be spread, raked and luted by hand tools. For such areas the mixture shall be dumped, spread and screened to give the required compacted thickness. The extent of such areas shall be the minimum possible.

305.05.12 Compaction

(1) After spreading and strike off and as soon as the condition of the mixture permits rolling to be performed without excessive shoving or tearing, the mixture shall be thoroughly and uniformly compacted. Should cracks appear on the surface during compaction, rolling shall be discontinued immediately. The reason(s) for formation of the cracks shall be investigated (rolling at too high a temperature, overheating, thin layer, over compaction etc) and such measures as may be approved by the Engineer taken to avoid the occurrence of such cracking.

(2) Initial or breakdown rolling shall be done by means of either a tandem steel roller or a three wheeled steel roller which shall follow the paver as closely as possible. Rolling shall begin as soon as the mixture will bear the roller without undue displacement.

(3) Intermediate rolling with pneumatic-tyred rollers shall be carried out behind the initial rolling.

- (4) Final rolling with steel rollers shall eliminate marks from the previous rolling.
- (5) Initial rolling shall be commenced when the temperature of the mixture is such that the sum of the air temperature plus the temperature of the mixture is between 165 degrees and 190 degrees centigrade. In no case shall the temperature of the mixture be less than hundred and twenty (120) degrees on completion of initial breakdown rolling and all other compaction operations shall be completed before the temperature of the mixture drops below one hundred and ten (110) degrees centigrade.
- (6) The number and weight of rollers shall be sufficient to obtain the required compaction while the mixture is still at the specified temperatures and in a workable condition. The sequence of rolling and the roller types shall be selected on the basis of the trial area results.
- (7) Unless otherwise directed or approved, rolling shall begin at the lower side and proceed longitudinally, parallel to the road centreline, with each trip overlapping the previous one by one-half of the roller width, gradually progressing to the crown of the road. When paving in echelon or abutting a previously placed lane, the longitudinal joint shall be rolled first to ensure that a water tight joint is formed with the existing pavement following which the regular rolling procedure shall be implemented. On super elevated curves the rolling shall begin at the low side and progress to the high side by overlapping of longitudinal trips parallel to the centreline.
- (8) The locations of reversal of rolling shall be varied to minimise the possibility of the formation of ridges in the finalised pavement. All roller position changes across the carriageway shall be made on the cooler areas of asphalt and not the more recently laid hotter areas.
- (9) Any displacement resulting while reversing the direction of a roller, or from other causes, shall be corrected at once, with the additional of fresh mixture when required. Care shall be exercised in rolling not to displace the line and grade of the edges of the bituminous mixture.
- (10) Rollers shall move at a slow but uniform speed with the drive roll or wheels nearest the paver. Rolling shall be continued until all roller marks are eliminated.
- (11) Along forms, kerbs, headers, walls and other places not accessible to the main rollers the mixture shall be thoroughly compacted with hand operated rollers or, where this not possible, with hot hand tampers, smoothing irons or with mechanical tampers.
- (12) Any mixture that becomes loose and broken, mixed with dirt, or is in any way defective in finish or density shall be removed and replaced with fresh hot mixture, which shall be compacted to conform to the surrounding area. Any area showing an excess or deficiency of bitumen shall be removed and replaced.
- (13) Skin patching of an area that has been rolled will not be permitted.
- (14) Necessary precautions shall be taken to prevent dropping of oil, grease, petrol or other foreign matters, when the rollers are operating or standing.

305.05.13 Joints

- (1) All longitudinal and lateral joints in bituminous pavements unless formed in an approved method by stops ends, shall be formed by sawing the laid pavement straight, square and vertical. Hand cutting of joints will not be allowed.
- (2) Immediately prior to laying of bituminous mixture the joints surfaces shall be fully covered by a thin layer of cut-back bitumen.
- (3) For transverse joints the heated paver screed shall be placed in contact with the previously laid bituminous mixture, and the course sufficient heated to ensure the optimum bond to new mixture will be attained. Paving operations shall then be commenced.
- (4) Rolling of transverse joints shall be both traverse and longitudinal to ensure that a water-light joint is formed with the minimal practical vertical discontinuity across the joint.

305.06 ACCEPTANCE SAMPLING AND TESTING

305.06.1 Sampling and Marshall Density

(1) For the permanent works samples of bituminous paving course mix shall be taken from the mixing plant and/or behind the paver prior to compaction, as determined by the Engineer, to check compliance with the approved JSM requirements including Tables 2, 4, 5 and 6, as well as what is stated in 305.02.7 (9).

(2) The density of the compacted mix shall be related to the Daily Marshall Density (DMD) which shall be determined by making four standard Marshall specimens from samples of the mix taken from the mixing plant or paver. The density of each specimen shall be determined and compared with the mean value. Any individual result which varies from the mean by more than 0.015 gm/cc shall be rejected.

(3) The average density of the acceptable specimens shall be designated as the DMD for that day's production. Marshall tests shall be repeated on a daily basis to establish the Daily Marshall Density for that particular day's production. Where the DMD varies from the JSM density by more than 1.0 % bituminous pavement course mixing shall be suspended and the reasons for the discrepancy investigated by the Contractor and reported to the Engineer who will determine what action (if any) is required and whether or not the bituminous pavement laid with a non-compliant DMD is acceptable. Where the bituminous pavement is deemed by the Engineer to be unacceptable it shall be removed and replaced at the expense of the Contractor.

305.06.2 Frequency of Density Requirements and Cores

(1) The minimum density to be achieved shall be ninety seven (97) percent of a laboratory compacted specimen made from bituminous mixture obtained for Daily Marshall Density.

(2) Each bituminous pavement course shall be tested separately, and where a course is laid in more than one layer each shall be tested separately.

(3) One core shall be taken for each five hundred (500) square metres of bituminous course/layer or fraction thereof. If the core so taken fails to meet the specified density, then two (2) additional cores shall be taken in the longitudinal alignment of the road at an interval of three (3) metres on either side of the failing core. If these cores meet the specified density requirements then the area represented by the original core will be acceptable if a) the individual compaction of the 'failed' core is not less than ninety three (93) percent and b) the average of the three cores is not less than ninety six (96) percent. In case the results do not satisfy these requirements, the area represented by the original core shall be removed and replaced at the expense of the Contractor. Areas of failed pavement shall be removed in an approved manner with the edges of the failed areas saw cut straight and vertically.

305.06.3 Pavement Level Tolerances

a) General Requirements

(1) Immediately after completion of final rolling, the finished surface of each bituminous course shall be tested by the Engineer using a three (3) metres straight edge. The variation of finished surface from the testing edge of the straight edge between any two (2) contacts shall not exceed six (6) mm for binder courses and five (5) mm for wearing courses. Testing shall be undertaken at locations selected by the Engineer, with the straight edge placed parallel and/or perpendicular to centreline of roadway.

(2) The cross fall (camber) shall be within ± 0.2 percent of the specified, and the level at any point shall be within ± 6 mm of the level required for binder courses and ± 5 mm for wearing courses.

b) Rectification

(1) Where the bituminous pavement course levels fail to meet the requirements specified above, the relevant failed areas shall be removed and replaced (at the expense of the Contractor) unless another rectification method(s) has been proposed by the Contractor and approved by the Engineer in writing.

305.06.4 Surface Regularity

a) General Requirements

(1) The longitudinal regularity of the surfaces of binder and wearing courses shall be such that the numbers of surface irregularities within any 300 metre or 75 metre lengths selected by the Engineer are within the relevant limits stated in Table 7.

(2) An irregularity is a variation of not less than 4 mm or 7 mm in the profile of the course surface as measured by the rolling straight-edge, of the type designed by the Transport and Road Research Laboratory (UK) set at 4 mm or 7 mm as appropriate, or equivalent apparatus capable of measuring irregularities within the same magnitudes over a 3 m length.

Table 10 - Maximum Permitted Number of Surface Irregularities

	Surfaces of carriageways, hard strips and surfaced shoulders.		Surface of lay-bys, service areas, all bituminous binder courses and road bases in pavements without binder courses	
Irregularity	≥4 mm <10 mm	≥7 mm <10 mm	≥4 mm <10 mm	≥7 mm < 10 mm
Length (m)	300 75	300 75	300 75	300 75
No. variations (max)	20 9	2 1	40 18	4 2
	No irregularity greater than 10 mm shall be permitted.			

(3) Prior to checking any wearing course, binder course or road base for surface regularity, it shall be cleaned of all loose and extraneous materials. Checking operations shall be carried out, without damaging the surface of the pavement, as soon as possible and no more than 3 working days after construction of the pavement course.

(4) Compliance with Table 10 shall be checked along any line or lines parallel to the edge of pavement on sections of 300 metres selected by the Engineer. Sections shorter than 300 metres which will eventually form part of a longer pavement shall be assessed using the number of irregularities for a 300 metres length pro-rata to the nearest whole number.

(5) Where the total length of pavement is less than 300 metres, the measurement shall be taken on 75 metre lengths.

b) Rectification

(1) Any irregularities that exceed the specified tolerances or for the wearing course or finished road surface that will retain water on the surface shall be corrected by removing the defective area and replacing with a new, full depth, bituminous pavement course all at the expense of the Contractor.

(2) For other areas which fail the surface regularity test, remedial proposals shall be submitted by the Contractor to the Engineer for approval.

305.05.5 Course Thickness

(1) For determination of the thickness of each pavement course, (6) cores per kilometre shall be taken at random locations directed or approved by the Engineer. Cores extracted for thickness measurement shall not be used for density determination and density cores shall not be used for thickness measurements. The location of the thickness and density cores shall not coincide.

(2) Each section of a course will be acceptable if the thickness of the course/layer, as measured from the core sample relevant to that section, is within ±5 mm of the specified thickness. Each core will be treated separately.

(3) When the thickness of the bituminous pavement course is deficient by more than five (5) millimetres from that specified, the deficiency shall be rectified by replacement of the defective area or made up by additional bituminous material in the overlying course all at the expense of the Contractor. Where the former procedure is used additional cores shall be taken after placing of the overlying course. If deficiencies are corrected by this method full payment for the lower course will be made to the Contractor, but no additional payment will be made for the increase of thickness of the overlying course.

305.05.6 Backfilling of Core Holes

(1) Each core hole shall be backfilled with approved material by a procedure approved by the Engineer within one week of the taking of the core.

305.06 WEATHER LIMITATIONS

(1) Bituminous mixtures shall be placed only when the air temperature is four (4) degrees centigrade or above and no mixtures shall be laid in dusty, foggy or rainy weather conditions or on a moist surface.

305.07 MEASUREMENT

(1) Measurement will be as follows:

Item No.	Description	Unit
305-1	Bituminous Concrete Surface Course, Hot-laid _____ mm thick Binder Course	Metre Square
305-2	Bituminous Concrete Surface Course, Hot-laid _____ mm thick Binder Course	Metre Square
305-3	Bituminous Concrete Surface Course, Hot-laid _____ mm thick Wearing Course	Metre Square
305-4	Bituminous Concrete Surface Course, Hot-laid _____ mm thick Wearing Course	Metre Square

(2) Measurement will be for the width of the upper surface of the course as shown on the Drawings, multiplied by the length of the course.

305.08 PAYMENT

(1) Pavement will be made at the rates given in the Bill of Quantities, which rates will be full compensation for furnishing all materials, mixing, transportation, placing, compaction and finishing, and will also include for LJMF/JMF development, trial areas, all sampling and testing, compaction trials, method statements, and all plant, equipment and labour and all incidentals to complete the work as specified.

SECTION 306

TACK COAT

306.01 DESCRIPTION

- (1) This item shall consist of preparing and treating an existing bituminous or cement concrete surface with bituminous material preparatory to the construction of a bituminous surface course.

306.02 MATERIALS

- (1) Tack coat shall be emulsified asphalt SS-1 in accordance with AASHTO M 140. Alternatively emulsified asphalt CRS-1 can be used as Tack Coat, if approved by the Engineer.

306.03 CONSTRUCTION REQUIREMENTS

306.03.1 Preparation of Surface

- (1) Immediately before applying the tack coat, the full width of the surface to be treated shall be cleaned of loose and foreign materials by means of a power broom or power blower, supplemented as necessary by hand sweeping. Where required by the Engineer, immediately prior to the application of the tack coat, the surface shall be lightly sprayed with water but not saturated.
- (2) Tack coat shall be applied only to surfaces which are dry or slightly moist.
- (3) Application of tack coat shall not proceed if in the opinion of the Engineer rain is threatening. Tack coat application shall immediately stop when rain begins to fall.

306.03.2 Heating Equipment

- (1) Heating equipment for heating the tack coat shall be of adequate capacity to heat the material thoroughly and uniformly by circulating steam or hot oil through coils of a tank or by circulating the material around a system of heated coils or pipes, or by circulating the material through a system of coils or pipes enclosed in an heated jacket or by other approved means.
- (2) Heating equipment shall be operated in a manner that will not damage the tack coat material.
- (3) Heating equipment shall be so constructed that it will prevent the direct flame from a burner from striking the surface of the coils, pipes or jacket through which the material is circulated.
- (4) If storage tanks are used, thermometers with a range of 0 to 200 °C shall be fixed to the tanks so that the temperature of the material may be determined at all times.
- (5) Material which has been heated above 125 °C will be rejected, and shall be removed from the site and disposed of by the Contractor.
- (6) All storage tanks, piping, retorts, booster tanks and distributors used in storing, handling or heating material shall be kept clean and in good condition at all times, and shall be operated in such manner that there will no contamination by foreign material.

306.03.3 Pressure Distributors

- (1) Pressure distributors shall be self-propelled, pneumatic-tyred and so designated and equipped as to distribute the tack coat uniformly in variable widths at readily determined and controlled rates. They shall be operated by skilled workmen. The equipment shall include instruments for measuring the speed of travel accurately at low speeds, the rate of flow of bituminous material through the nozzles, the temperature of the contents of the tank, and the pressure of the remaining contents. If

after beginning the work, the distribution of bituminous material is found to be in error, the equipment shall be withdrawn from the work and calibrated to the satisfaction of the Engineer or replaced before proceeding with the work.

(2) The manufacturing details of the pressure distributor, spray bar and nozzles shall be provided to the Engineer for approval before the equipment is mobilised to Site. Details shall include the height of the spray bar and the angle of the nozzles so that a preliminary check can be made of the uniformity of coverage.

(3) The distributor shall be so designed that, when not spreading, it does not drip.

(4) The nozzles and spray bar shall be adjusted so that uniform distribution is achieved, and shall be checked before each spraying run. Spraying shall cease immediately upon any clogging or interference of any nozzle, and corrective measures shall be taken before spraying is resumed.

(5) The Contractor at his own expense shall arrange for the pressure distributor to be calibrated to the satisfaction of the Engineer at intervals of not less than 12 months or as required by the Engineer. Such calibration tests are to be done in the presence of the Engineer and are to demonstrate that the pressure distributor is capable of performing adequately in service. The Contractor shall gain the Engineer's approval of these tests before arranging for them to be carried out. Where in the sole opinion of the Engineer, the pressure distributor does not perform adequately, then it shall be removed from service and either repaired or replaced at the Contractor's cost.

306.03.4 Application

(1) The rate of application and areas to be treated shall be approved by the Engineer before application of tack coat.

(2) Tack coat shall be applied by a pressure distributor in a uniform and continuous spread at the rates directed by the Engineer after the field trials (Sub-clause 306.03.5 herein).

(3) Tack coat shall not be applied when the surface temperature is below +15 °C, unless otherwise permitted by the Engineer. The temperature of tack coat at the time of spraying shall be in the range of 57 °C to 71 °C.

(4) Distribution of the tack coat shall be so regulated and sufficient material shall be left in the distributor at the end of each application so that there is a uniform distribution of material. In no case shall the distributor be allowed to expel air, thereby causing uneven coverage.

(5) When directed, the tack coat shall be applied in spray runs of approximately one half or less of the width of the completed surface and when so applied there shall be an overlap of 20 cm of tack coat along the adjoining edges of lanes.

(6) Any omitted areas or recognised deficiencies shall be corrected by means of approved hand sprays. The use of hand sprays will only be allowed for correcting such deficiencies and for tacking small patches or areas which are inaccessible to the distributor.

(7) Care shall be taken that the application of tack coat is not in excess of the specified amount; any excess shall be blotted by sand or removed by a method approved by the Engineer. Blotting material shall comply with the grading requirement of AASHTO M 43, size 10, and comprise clean non-plastic sand or fine aggregate, free from organic or deleterious material.

306.03.5 Field Trials

(1) The Contractor shall, before he commences the work proper, carry out field trials to permit the Engineer to ascertain the rate of application to be ordered and to test the suitability of the proposed distributor. The trial methods shall be approved by the Engineer and the trials shall be performed by the Contractor in the presence of the Engineer.

(2) The rate of application in the field trials shall vary between be 0.20 l/m² minimum and 0.80 l/m² maximum.

- (3) The Engineer may order subsequent field trials and/or change the previously established rates of application when he deems it necessary.

306.03.6 Protection of Adjacent Structures

- (1) When tack coat is being applied, the surfaces of all structures, guard rails, kerbs and other roadway appurtenances and trees shall be protected in a manner approved by the Engineer to prevent them from being splattered or damaged. No bituminous material shall be discharged into drains, side ditches, gutters or borrow pits.
- (2) The Contractor shall at his own cost make good to the satisfaction to the Engineer any appurtenances which are splattered or damaged.

306.03.7 Traffic Control and Maintenance of Primed Surfaces

- (1) Traffic shall be kept off the tack coat at all times.
- (2) The Contractor shall provide all necessary detours for the public and his own construction traffic in areas where tack coat is to be applied. Where no convenient detour can be constructed or if so directed by the Engineer, the application operation shall be confined to one-half of the road way at a time, and the Contractor shall provide traffic control as directed by the Engineer, at his own cost.
- (3) The surface course shall not be placed over the tack coat until the tack coat is in a proper condition of tackiness to receive it. Tack coat shall be applied only so far in advance of surface course placement as is necessary to obtain this proper condition of tackiness. The overlaying bituminous course shall be applied before the Tack Coat has lost its tackiness through over-drying, oxidation, wind-blown dust or otherwise.
- (4) The Contractor shall protect all tack coat surfaces and keep them in acceptable condition until they are covered by succeeding courses.
- (5) All areas where the tack surface has been damaged, shall be cleaned of all loose materials, re-tacked and made good to the satisfaction of the Engineer, at the Contractor's own cost.

306.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
306-1	Tack Coat	litre

- (2) The measurement shall be computed by multiplying the areas to be treated as shown on the Drawings and any other areas ordered by the Engineer, by the appropriate rate of application specified by the Engineer, corrected to +15 °C.

306.05 PAYMENT

- (1) Payment will be made at the unit rate entered in the Bill of Quantities and shall include for preparation of the underlying surface, field trials, blotting material, traffic management, protection of tack coat surfaces, repair of damaged surfaces and all operations necessary to achieve the tack coat to the requirements specified herein.

SECTION 308

CEMENT STABILISED BASE AND SUB-BASE

308.01 DESCRIPTION

(1) This work shall consist of furnishing and mixing aggregate, cement and water and spreading and compacting the mixture, all as specified in these Specifications and to the lines, levels, grades, dimensions and cross sections shown on the Drawings and as required by the Engineer.

308.02 MATERIALS

308.02.1 Aggregate

(1) Natural gravels and coarse (clayey) sands shall be stabilized with cement (or lime – see Section 309) if they comply with the specified requirements. Three types of cement stabilized layers can be used and the strengths required for each layer after stabilization are defined in below table.

Table 308.1 - Strengths Requirements after Stabilization

	Unconfined Compressive Strength, UCS (MPa)
Cement stabilised Base Course 1, CB 1	3.0 – 6.0
Cement stabilised Base Course 2, CB 2	1.5 – 3.0
Cement stabilised Sub-Base, CS	0.75 – 1.5

(2) Samples for strength tests shall be mixed, followed by compaction in a cylinder (Modified AASHTO T 180) and then cured for 7 days in a room with a temperature of 19.5 °C – 22.5 °C, with moisture (humidity) of 95 % to 100 %. After 7 days curing in the room, the samples shall be soaked in water for at least 4 hours, before the UCS testing.

(3) Below two tables shows desirable properties of material before stabilization.

Table 308.2 - Desirable Grading of Material before Stabilization

ASTM Test Sieve, mm	Percent passing (by weight)	
	CB 1	CB 2
50	100	100
37.5	85 – 100	80 - 100
19	60 – 90	55 – 90
4.75	30 – 65	25 – 65
2.36	20 – 50	15 – 50
0.425	10 – 30	10 – 30
0.075	5 – 15	5 - 15

Table 308.3 - Desirable Properties of Material before Stabilization

	Maximum allowable values		
	CB 1	CB 2	CS
Liquid Limit (LL), %	25	30	
Plasticity Index (PI), %	6	10	20
Linear Shrinkage (LS), %	3	5	

(4) Materials to be stabilized shall have a Coefficient of Uniformity of at least 5. The Coefficient of Uniformity is defined as the ratio of the sieve size through which 60 per cent of the material passes, to the sieve size through which 10 percent passes (D60 / D10).

- (5) The Plasticity Index and the Liquid Limit shall be measured on the fraction passing the 0.425 mm sieve.

308.02.2 Cement

- (1) Cement shall conform to the requirements of Portland cement in Section 507 of these Specifications.

308.02.3 Water

- (1) Water shall be clean and free from harmful matter and may be tested in accordance with AASHTO T 26 at the Engineer's discretion. Water thus tested and found to have a pH value less than 5.0 or more than 8.5 shall not be used.

- (2) Furthermore water shall not contain more than 400 parts per million by weight of sulphate.

308.3 CONSTRUCTION REQUIREMENTS

308.03.1 Mix Design

- (1) The cement content of the mix shall be determined as a percentage by dry weight of soil. The actual cement content shall be determined by the Engineer on site, -depending on the type of soil being present and the specified UCS-, and may be varied by him from time to time. Generally the cement content does not exceed 5 %.

- (2) The strength of the cement stabilised base shall be as specified in the Particular Specifications or as indicated on the drawings.

- (3) The strength of the cement stabilised sub-base shall be as specified in the Particular Specifications or as indicated on the drawings.

308.03.2 Equipment

- (1) The equipment used for mixing the soil and cement shall be as approved by the Engineer and shall be capable of constructing the soil-cement mixture to meet the requirements specified.

308.03.3 Initial Testing

- (1) The Engineer will make and test trial mixes using different proportions of cement and will select mix proportions that give strengths of test cylinders, made and cured in the laboratory of not less than 110 percent of the required strength indicated in sub-clause 308.03.1 of these Specifications.

308.03.4 Mix Control

- (1) The entire operation of mixing and compacting the cement stabilised base and sub-base shall be subject to close control and frequent testing will be required as the work proceeds to ensure that the strength and density requirements are being maintained.

- (2) The mix proportions and uniformity of mixing of the soil-cement shall be such that of any 20 consecutive samples of the mixed material taken before compaction on any one day and compacted in the laboratory, the average strength shall be not less than the required strength. Not more than two of these samples shall have less than 90% of the required strength. If because of low production on any particular day less than 20 samples are taken, then all samples must be up to the minimum specified standard. In particular, extra material needed to make up losses in handling and from wear and to allow for non-uniformity of mixing shall be supplied by the Contractor at its own expense.

(3) The Contractor shall assist the Engineer in all ways to sample soil for stabilising at least 30 days in advance of its use so that necessary adjustment to the mix design may be made. To ensure good sampling it will normally be necessary to remove overburden and stockpile sufficient soil for construction 30 days ahead at all times.

308.03.5 Mixing

(1) Mixing of the soil aggregate with cement shall be accomplished by the central plant method only. The mix-in-place travelling plant method shall not be employed nor will it be permissible to blend the materials by the motor grader/windrow method.

(2) The aggregate shall be proportioned and mixed with cement and water in a central mixing plant. The plant shall be equipped with feeding and metering devices that will introduce the cement, aggregate and water into the mixer in the quantities specified. Mixing shall continue until a uniform and homogeneous mixture of aggregate, cement and water has been obtained.

(3) Mixed material shall be transported to the roadway in suitable vehicles and spread on a moistened sub-grade or sub-base in a uniform layer by a self-propelled or other approved spreader or where necessary, by the use of a motor grader. Not more than 60 minutes shall elapse between the start of mixing and the time of starting compaction of the cement treated mixture on the prepared sub-grade or sub-base

308.03.6 Spreading and Compacting

(1) After the cement treated mixture has been spread, the mixture shall be compacted to at least 95% in the case of sub-base, and 98% in the case of base, of the maximum dry density determined in accordance with AASHTO T 180. Any mixture of aggregate, cement and water that has not been compacted shall not be left undisturbed for more than 30 minutes. The percentage of moisture in the completed mixture shall not vary from the optimum by more than 2 percentage points, as determined by AASHTO T 180. Compaction shall be completed, the compacted surface shall be brought to the required cross section, and all irregularities shall be removed and the surface re-compacted, all within two hours of the time when the water was first time added to the mixture.

(2) Density determinations shall be carried out for each layer constructed, in accordance with the requirements of AASHTO T 191, at a rate of 5 tests for every 2,000 square metres of completed layer or part thereof. For density results to be acceptable, four of the five densities measured shall be equal to or greater than the required level of compaction and the fifth shall be not less than the required relative density minus 3%.

308.03.7 Construction Joints

(1) At the end of each day's work and when cement stabilised base and sub-base operations are delayed or stopped for more than 2 hours, a construction joint shall be made in thoroughly compacted material, normal to the centreline of the road alignment, with a vertical face. Additional mixture shall not be placed until the construction joint has been approved by the Engineer.

(2) Where cement stabilised base and sub-base has been finally compacted more than one hour, longitudinal joints shall be constructed by cutting vertically into the existing edge for approximately 80 mm. The face of the cut joints shall be moistened in advance of placing the adjacent base.

308.03.8 Curing

(1) The completed cement stabilised base and sub-base shall be covered with an asphaltic curing seal on the same day as final compaction is performed and as soon after said compaction as practicable. The surface shall be kept moist until the seal is applied. The asphaltic curing seal shall be furnished and applied in accordance with the provisions in Section 307 of these Specifications. Damage to the curing seal or cement stabilised base and sub-base shall be promptly repaired by the Contractor at his own expense as directed by the Engineer

308.03.9 Traffic

(1) Heavy equipment except for equipment required for constructing adjoining sections will not be permitted to drive over completed portions until curing is completed. Traffic control shall be as required by the Engineer.

308.03.10 Protection

(1) The base and sub-base shall be protected as necessary to maintain the surface within the tolerances specified and to prevent failure from traffic or other causes.

308.03.11 Determination of Thickness

(1) After final compaction, test holes shall be dug in the mixture to determine the thickness at intervals not greater than 100 metres. Any part of the base or sub-base which fails to meet the requirements of the Specifications or which originally having met the requirements of the Specifications subsequently suffers damage or deformation shall be rebuilt to these requirements to the full depth of the layer at the Contractor's expense. The addition of thin layers to raise the level of low areas will not be permitted.

308.03.12 Surface Requirements

(1) Surface deviation in excess of 10 mm from a straight edge 3 metres long applied to the surface parallel to the centre line of the road and 12.5 mm from a template laid transversely, shall be corrected by loosening, adding or removing material, reshaping and re-compacting, provided this is done within the time allowed for compaction. The level of the finished base shall not, at any point, be lower than the designed level.

(2) The base or sub-base completed in each day's work shall be not less than the required thickness.

308.03.13 Acceptance

(1) The engineer may test by generally recognised methods not mentioned herein. Any test result which shows that the work does not comply with this Specification may be grounds for rejection of the work.

308.04 MEASUREMENT

(1) Measurement will be as follows:

Item No.	Description	Unit
308-1	Cement Stabilised Base	Metre Cube
308-2	Cement Stabilised Sub-Base	Metre Cube
308-3	Cement for stabilising Base or Sub-Base	Tonne

(2) This item will be measured as the number of cubic metres of material complete in place, and approved (no deduction will be made for the quantity of cement used). Measurement will be based on the cross section area of the base or sub-base shown in the Drawings and the actual length measured horizontally along the centre line of the surface of the road. Any cement used in excess of the specified mix proportions, whether used in order to obtain the specified strength or for any other reason will be provided by the Contractor at his own expense. Test sections shall be regarded as incidental to the work and shall not be paid for.

(3) Cement will be measured separately as the number of tonnes of material either as the actual quantities used or as the quantity calculated from the approved mix proportions expressed as tonnes per cubic metre of compacted finished layer, whichever is the lesser.

308.05 PAYMENT

- (1) Payment will be made at the rates entered in the Bill of Quantities, which rates shall include full compensation for all materials, all equipment, handling, placing, mixing, compacting, all labour, tools and incidentals necessary to proper completion of the work.
- (2) The cement measured as provided above shall include all purchase costs, delivery to site, storage and wastage.

SECTION 309

LIME STABILISED BASE AND SUB-BASE

309.01 DESCRIPTION

- (1) This work shall consist of the addition and mixing of lime with natural materials, the spreading and compacting of the treated material all as specified in these Specifications and to the lines, levels, grades, dimensions and cross sections shown on the Drawings and as required by the Engineer.
- (2) Following the addition and mixing in of the stabiliser the material is referred to as “treated material”.

309.02 MATERIALS

309.02.1 Natural Materials

- (1) Natural materials shall be stabilized with lime (or cement – see Section 308) if they comply with the specified requirements. Three types of lime stabilized layers can be used and the strengths required for each layer after stabilization are defined in below table.

Table 309.1 - Required Strengths After Stabilization

	Unconfined Compressive Strength, UCS (MPa)*
Lime stabilised Base Course 1, CB ¹ 1	3.0 – 6.0
Lime stabilised Base Course 2, CB 2	1.5 – 3.0
Lime stabilised Sub-Base, CS	0.75 – 1.5

- (2) Samples for strength tests shall be mixed and left for two hours before being compacted into 150 mm cubes at 97 % of the maximum dry density (MDD) obtained after a similar two hour delay. These samples shall then be moist cured for 21 days and soaked for 7 days in accordance with Modified AASHTO T 180.

- (3) Below two tables shows desirable properties of material before stabilization.

Table 309.2 – Desirable Properties of Material Before Stabilization

ASTM Test Sieve, mm	Percent passing (by weight)	
	CB 1	CB 2
50	100	100
37.5	85 – 100	80 - 100
19	60 – 90	55 – 90
4.75	30 – 65	25 – 65
2.36	20 – 50	15 – 50
0.425	10 – 30	10 – 30
0.075	5 – 15	5 - 15

¹ Same abbreviation as used in Section 308 “Cement Stabilised Base and Sub-Base” is used here, in order to have conformity with the Road Design Manual.

Table 309.3 – Desirable Properties of Material Before Stabilization

Properties	Maximum allowable values		
	CB 1	CB 2	CS
Liquid Limit (LL), %	25	30	
Plasticity Index (PI), %	6	10	20
Linear Shrinkage (LS), %	3	5	

(4) Materials to be stabilized shall have a Coefficient of Uniformity of at least 5. The Coefficient of Uniformity is defined as the ratio of the sieve size through which 60 per cent of the material passes, to the sieve size through which 10 percent passes (D60 / D10).

(5) The Plasticity Index and the Liquid Limit shall be measured on the fraction passing the 0.425 mm sieve.

309.02.2 Lime

(1) Lime for treatment of road materials shall be Hydrated Calcium Lime and, unless otherwise instructed by the Engineer, shall comply with the following requirements:

Fineness	Hydrated lime
Residue on 0.2 mm sieve – Maximum	1 %
Residue on 0.075 mm sieve – Maximum	10 %
Chemical requirements	
Free lime content – Minimum	50 %
Hydrated lime content – Maximum	-

(2) All lime shall be kept under cover and protected from moisture. Consignments shall be used in the same sequence as they are delivered. Stocks which become damaged or which are stored on the Site for more than 3 months shall not be used, and shall be replaced at the Contractor's expense.

(3) Operators and labour shall be provided with protective clothing, masks and goggles.

309.02.3 Water

(1) Water shall be clean and free from harmful matter and shall be tested in accordance with AASHTO T 26 at the Engineer's discretion. Water thus tested and found to have a pH value less than 5.0 or more than 8.5 shall not be used.

(2) Furthermore water shall not contain more than 400 parts per million by weight of sulphate.

309.03 CONSTRUCTION REQUIREMENTS

309.03.1 Mix Design

(1) The amount of lime to be added shall be determined, as a dry weight of soil, by the Engineer following laboratory trials and site trials carried out by the Contractor.

309.03.2 Mix-in-Place Method of Construction

(1) The mix-in-place method may be used for the addition and mixing in of lime.

(a) *Mixing equipment*

(1) The equipment for pulverising the material and mixing in the lime shall be purpose- built equipment, capable of pulverising the materials and mixing in the lime to the full depth of the loose layer necessary to give the specified thickness of compacted material mixed and compacted in accordance with Section 205 of these Specifications.

(2) The equipment may be either single or multi-pass machines and shall only be acceptable if, during the site trials, it can produce material that is a uniform and intimate mixture of aggregate, lime and water that meets all the specified requirements.

(3) The mixers shall be equipped with a device for controlling the depth of processing and mixing blades shall be maintained or reset periodically so that the correct depth of mixing is obtained at all times.

(4) Mixing by grader will not be permitted.

(b) Preparation of the layer

(1) Before the lime is applied, the material to be treated shall be spread and broken down and oversize material removed so that the maximum size of the particles is not greater than specified. The material shall first be pulverised to the required consistency by successive passes. The material shall then be shaped true to line, grade and cross-section and, if required, lightly compacted. The loose thickness shall be such as to give the specified thickness after full compaction has been carried out.

(2) The moisture content of the layer before the addition of the lime shall be adjusted to within the range of 70% to 85% of the Optimum Moisture Content (AASHTO T 180).

(c) Spreading the lime

(1) After the layer to be treated has been prepared to the satisfaction of the Engineer, the lime shall be uniformly spread at the specified rate over the width to be worked. If a spreader is used to spread the lime ahead of the mixer, it shall be fitted with a device to ensure a uniform and controllable rate of spread both transversely and longitudinally.

(2) Only sufficient lime for immediate use shall be spread ahead of the mixing operation and any lime which, in the opinion of the Engineer, becomes defective, shall be replaced at the Contractor's expense.

(3) Only equipment actually used in the spreading or mixing operation shall be allowed to pass over the lime, when so spread, before it has been thoroughly mixed into the material to be treated.

(d) Mixing and watering

(1) Immediately after the lime has been spread, it shall be thoroughly and homogeneously mixed into the material for the full depth of the layer. Mixing shall continue until the resulting mixture forms a homogenous layer. The mixing machine shall be set so that it cuts at least 100 mm into the edge of any adjoining lane processed previously so as to ensure that all the material forming the layer has been properly processed.

(2) Care shall be taken both during this and subsequent watering operations that the underlying layer is not disturbed and that no material from the underlying layer or shoulders is mixed with that being processed.

(3) If watering is necessary to bring the mixture to the required moisture content, then this shall be done after spreading and mixing in the stabilizer (lime). Water shall be added in a uniform and controllable manner and, where necessary, in successive increments. Each increment shall be mixed in as a separate mixing operation. Care shall be taken to avoid a concentration of water at any point or a flow of water over the surface.

(4) Any part of the mixture which becomes too wet after the stabiliser has been added and before the mixture is compacted will be rejected and any such part shall be allowed to dry out until its moisture content is satisfactory and shall be retreated with fresh stabiliser and finished off in accordance with the requirements of this sub- clause.

(5) Throughout the process of mixing in the stabiliser and water, a uniform thickness of the mixture shall be maintained and, if necessary, the mixture shall be graded to maintain the correct uncompacted thickness and shape. Any part of the mixture that becomes segregated shall be removed and replaced.

309.03.3 Stationary Plant Method of Construction

(a) Mixing Equipment

(1) Stationary mixing plant shall be of the power driven paddle or pan type and may be of the batch or continuous type.

(2) If batch mixers are used, the appropriate measured amounts of material and lime shall first be placed in the mixer, water being then added as necessary to bring the moisture content of the resulting mixture within the range determined in the laboratory and site trials. Special care shall be taken with batch type paddle mixers to ensure that the lime is spread uniformly in the loading skip so that it is fed evenly along the mixing trough. With both paddle and pan mixers the lime shall be proportioned accurately by a separate weighing or proportioning device, from that used for the material being stabilised. Mixing shall be continued until the mixture has the required uniformity and for not less than 1 minute, unless a shorter minimum period is permitted by the Engineer after satisfactory trials.

(3) If continuous mixing is used, the paddles, baffles and rate of feed of materials shall be adjusted to give uniformly mixed material.

(4) If a spray is used for distributing water into the mixer, it shall be adjusted to give uniformity in moisture content throughout the mix.

(b) Transporting

(1) Mixed material shall be transported to the road in suitable vehicles. Material that becomes segregated or is affected by weather shall be removed and replaced at the Contractor's expense.

(c) Laying

(1) The mixed material shall be spread to the required width and thickness by means of a mechanical paver such that the specified tolerance requirements are achieved after final compaction. Segregation shall be avoided and the layer shall be free from pockets of coarse or fine material.

309.03.4 Compaction and Finishing

(1) For lime treated materials, final compaction and finishing shall be completed within 12 hours after the lime comes into contact with the material to be treated.

(a) Thickness limitations

(1) The compacted thickness of any treated layer laid, processed and compacted at one time shall not exceed 180 mm. Where a greater thickness is required, the material shall be laid in two or more layers.

(2) The compacted thickness of any base layer shall not be less than twice the maximum particle size of the material.

(b) Compaction requirements

(1) The minimum density for all lime treated materials shall be 95% MDD (AASHTO T 180). The moisture content at the time of compaction shall be between 95% and 105% of Optimum Moisture Content (AASHTO T 180).

(2) Immediately after placing, the base material shall be compacted to not less than 98% of maximum dry density as determined by AASHTO T 180 Method D.

(3) During compaction the moisture content shall be so controlled that moisture content uniformly throughout the finished layer shall be within the limits of $\pm 2\%$ of the optimum moisture content as determined in AASHTO T 180, or such other moisture content as shall be agreed with the Engineer as a result of compaction trials. Density determinations shall be carried out for each layer of base

constructed, in accordance with the requirements of AASHTO T 191, at a rate of 5 tests for every 2,000 square metres of completed layer or part thereof. For density results to be acceptable, four of the five densities measured shall be equal to or greater than the required level of compaction, and the fifth shall be not less than the required relative density minus 3 percent.

(c) *Finishing*

(1) The surface finish after compaction of any treated layer shall be free from ridges, compaction planes, laminations, loose and segregated material; and other surface irregularities. The surface regularity of pavement layers and the formation shall be tested at points decided by the Engineer with a rigid, steel straightedge 3 m long placed parallel to or at right angles to the centreline of the road. The maximum allowable deviation of the surface below the straightedge shall be as given in below Table. In addition the longitudinal slope or transverse cross-fall shall not deviate from that shown on the drawings by more than the tolerances shown in below Table.

Table 309.4 – Maximum Allowable Deviation of Surface

Description	3 m Straight- edge (mm)	Cross-fall (%)	Longitudinal Grade in 30m (%)
Basecourse / Sub-base (Granular or Stabilised)	6	+ 0.25	+ 0.1

(2) The average thickness of any pavement layer measured at five points in any length of 100 m shall not be less than 100 % nor more than 120 % of the thickness specified or ordered by the Engineer. In addition the thickness of any pavement layer measured at any point shall not be less than 98 % nor more than 125 % of the thickness specified or ordered by the Engineer

(3) If the surface fails to meet the requirements of these Specifications the Contractor shall take the action set out in below two paragraphs or any other action, as instructed or agreed by the Engineer.

(4) The full depth of the layer shall be removed from the pavement and replaced to specification. The area treated shall be at least 5 m long and the full width of the paving laid in one operation. If areas are corrected within 7 days of laying, no construction traffic or compaction plant shall use the surrounding satisfactory areas.

(5) Where the results of the construction control tests for the materials are less than that specified, the full depth of the layer shall be removed and replaced to specification. The area treated shall be the whole section submitted for approval or, following a retest, a length of at least 50 m both sides of each test and retest failure or such area to be determined by the Engineer as necessary to obtain compliance with these Specifications.

309.03.5 Joints between New and Existing Work

(1) The forming of construction joints and the protection of previously treated or other work shall be carried out so as to produce a uniformly compacted and homogeneous layer free from ridges or other irregularities.

(2) Full width working, without longitudinal joints, will generally be required. Half-width working may be instructed by the Engineer to pass traffic. When forming longitudinal joints, with the mix-in-place method at least 100 mm of the first laid half-width layer shall be retreated and mixed in with the second half-width layer.

(3) When forming transverse joints, with the mix-in-place method, at least 1.0 m length of the previously laid treated work shall be incorporated into the new treated layer and the Engineer may instruct that the percentage of lime be increased at these places.

(4) When forming longitudinal or transverse joints with the stationary plant method of construction, previous work shall be cut back to expose fully treated and compacted material.

309.03.6 Protection and Curing

- (1) Treated layers shall be kept continuously damp by lightly spraying with water, from completion of compaction until one of the curing systems specified below is placed.
- (2) Treated layers shall be protected within 8 hours by one of the following methods:-
 - i) Completely covering the layer with clear or light coloured approved polythene sheeting of minimum thickness 0.1 mm. The sheeting shall be laid to cover the whole of the surface of the layer. At joints the sheeting shall be lapped by at least 500 mm and any damaged sheeting shall be replaced at the Contractor's expense. The sheeting shall be securely held in contact with the layer by an approved method.
 - ii) Completely covering the treated material with a layer of damp uncompacted gravel or soil material of minimum thickness 100 mm. This material, which may be that forming the next layer, shall be kept continuously damp.
 - iii) Spraying the layer with a curing seal at a rate of 1.5 l/sq-m, or such other rate as shall be instructed by the Engineer, to be applied in accordance with Section 303 (Bituminous Prime Coat) of these Specifications.
- (3) Unless otherwise instructed by the Engineer, no prime coat will be required where method (iii) is adopted and the Contractor shall comply with the requirements of Section 303 and Section 303 of these Specifications.
- (4) Plant used for dumping and spreading material, and the application of water or curing seal shall be approved by the Engineer and shall have individual axle loads not exceeding 6 tonnes. Immediately prior to placing protection methods (i) or (iii) the surface of the treated layer shall be made thoroughly damp by lightly spraying with water.
- (5) The curing system shall be kept in place and intact for a minimum of 7 days after completion of compaction, although small areas may be temporarily removed for the purposes of carrying out control testing, but only for the minimum amount of time required for the testing.

309.03.6 Traffic

- (1) Traffic or equipment, other than that actually engaged in the various treatment or protection processes, shall not run over the layer being processed or compacted.
- (2) On completion of curing no traffic or equipment shall be allowed on the treated layer with the exception of that required for proof-rolling, priming or construction of the subsequent layer.

309.03.7 Tolerances

(a) Geometric tolerances

- (1) The treated base shall be constructed within the tolerances specified in Section 302 of these Specifications.

(b) Amount of lime

(i) Mix-in-place method of construction.

The average amount of lime, measured before mixing, over a length of 100 m, shall not be less than the amount instructed by the Engineer.

The average amount of lime in the treated material, measured at five points over a length of 100 m, shall not be less than the amount instructed by the Engineer.

The amount of lime, measured after mixing, shall at no point be less than 70% or more than 130% of the amount instructed by the Engineer.

(ii) Stationary plant method of construction

The average amount of lime in the treated material measured at five points over a length of 100 m, shall not be less than the amount instructed by the Engineer.

The amount of lime measured after mixing shall at no point be less than 90% or more than 110% of the amount instructed by the Engineer.

(iii) Determination of lime content

The lime content in mixed materials shall be determined according to BS 1924 Test 15.

309.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
309-1	Mix in Lime	Metre Cube
309-2	Lime	Tonne

(1) For the purpose of measurement and payment no distinction shall be made between the mix-in-place and stationary plant methods of construction.

(2) The work of providing, hauling, placing, spreading, mixing, watering, compacting and shaping the materials to be stabilised will be measured in Section 302 of these Specifications.

(3) Mixing lime into the materials to be stabilised shall be measured by the cubic metre of treated material calculated as the product of the compacted sectional area specified to be treated and the length instructed.

(4) The provision of the stabiliser shall be measured by the tonne calculated as the specified weight of stabiliser added to the material.

309.05 PAYMENT

(1) Payment will be made at the rates entered in the Bill of Quantities, which rates shall include full compensation for furnishing all materials, mixing-in the lime, curing the treated material and for all labour, equipment, tools and incidentals necessary to complete the work.

(2) The work of providing, hauling, placing, spreading, mixing, watering, compacting and shaping the materials to be stabilised will be paid in Section 302 of these Specifications.

(3) The rate for lime shall include for the cost of provision, storage, handling, transport and spreading of the lime at any point on the Works and complying with the requirements of this Section 309 of these Specifications.

SECTION 310

COLD MIXED ASPHALT

310.01 DESCRIPTION

- (1) This work shall consist of the manufacture and placement of a cold, plant mixed asphaltic material suitable for cold placement and /or for stockpiling for subsequent use.
- (2) The cold asphalt shall be suitable for use as asphaltic road base and surface courses, for levelling course and for patching in accordance with the specific requirements for each type under the contract and in conformity with the required lines, levels, grades and dimensions and typical cross sections and as required by the Engineer.
- (3) The relevant provisions of SERIES 300 – PAVEMENT, as they relate to the individual components and methods of placement shall form a part of these Specifications unless otherwise stipulated herein.

310.02 MATERIALS

310.02.1 General

- (1) The materials shall conform to the requirements of SERIES 300 – PAVEMENT, of these Specifications with the additional requirements noted below.
- (2) The cold asphalt, often referred to as “premix” or “coldmix”, shall be produced from a mixture of mineral aggregates (including mineral filler) which is mixed cold to a workable condition suitable for stockpiling and/or immediate spreading and compaction.
- (3) Cold asphalt shall be manufactured in an approved stationary mixing plant or approved mobile mixing plant, or by mixing in place, if approved and in accordance with the requirements of sub-clause 310.03.2 of these Specification

310.02.2 Bituminous Materials

- (1) Bituminous materials for cold asphalt shall be a fluxed bitumen or a cutback bitumen or a bitumen emulsion as follows:
- (2) Fluxed bitumen shall be a residual bitumen, 80/100 pen, the dynamic viscosity of which has been reduced by the addition of a bitumen fluxing agent (e.g. diesel fuel oil)
- (3) Cutback bitumen shall be a residual bitumen, 80/100 pen, the dynamic viscosity of which has been reduced by the addition of bitumen cutter of an approved type (e.g., kerosene, avtur)
- (4) Bitumen emulsion shall be a slow setting, cationic emulsion (CSS) of a type which complies with the specified requirements of AASHTO M 208.

310.02.3 Bitumen Additive

- (1) Bitumen additives shall be used if and when directed by the Engineer. Prior approval must be obtained from the Engineer regarding the type of additive to be used.

310.02.4 Coarse Mineral Aggregates

- (1) Coarse aggregates shall consist of crushed stone produced from rock or boulders or crushed gravel particles larger than 2.36 mm in size. The originating rock or boulder material shall be at least four times the maximum size of the final crushed stone.

- (2) The aggregate shall be clean, hard, angular, durable and free from clay or other aggregations of fine material, silt, soil, organic matter, or other deleterious substance.
- (3) Coarse aggregate shall, unless otherwise stipulated, conform to the quality requirements of AASHTO M 80. Only one source of coarse aggregate shall be used except by written permission from the Engineer.
- (4) The crushed aggregate shall also meet the relevant requirements of Section 2.1 of AASHTO M 147 and not less than 75 percent by weight of the particles retained on the 4.75 mm sieve shall have at least two fractured faces and 90 percent one or more fractured faces.
- (5) The abrasion loss (AASHTO T 96) shall not exceed 40 percent. Any aggregates liable to polish shall not be used for the coarse aggregate fraction. The coarse aggregate shall be of such gradation that when combined with other required aggregate fractions in proper proportion, the resultant mixture will meet the gradation required for the composition of the mix.
- (6) The coarse aggregates shall be tested in accordance with British Standards BS EN 933-3 to determine Flakiness index and BS 812-105.2 to determine Elongation Index. When so tested, the Flakiness Index and the Elongation index shall not exceed 35 percent.
- (7) When subjected to Coating and Stripping Tests, AASHTO T 182, the aggregates shall have a coated area of not less than 95 percent

310.02.5 Fine Mineral Aggregates

- (1) Fine aggregate (passing the 4.75 mm sieve) shall consist of natural sand, stone, screenings, or a combination thereof, and unless otherwise stipulated shall conform to the quality requirements of AASHTO M 29 (ASTM D1073). Fine aggregate shall be of such gradation that when combined with other required aggregate fractions in proper proportion, the resultant mixture will meet the gradation required for the composition of the mixture. The sand equivalent, tested in accordance with AASHTO T 176, shall be greater than 50.

310.02.6 Mineral Filler

- (1) Filler material for asphaltic materials shall conform to the requirements in AASHTO M 17 and shall generally consist of finely ground particles of limestone, hydrated lime, Portland cement, fly-ash or other approved non-plastic material.
- (2) When the Strength Index as determined according to the Ontario Vacuum Immersion Marshall Test or the U.S. Army Corps of Engineers - Asphalt Institute Immersion Marshall Test is less than 75%. Either 1 to 2 per cent of hydrated lime or 2 to 4 per cent of Portland cement by weight may be added to the mix.
- (3) Hydrated lime and Portland cement shall be properly stored to prevent the lime and cement becoming moist. Lime or cement that is partially hard and contains lumps shall not be used and must be removed from the site.

310.03 MIXING

310.03.1 Mix Proportions

- (1) The grading of the combined mineral aggregates shall be such as to comply with the requirements of Table 310.1 of these Specifications
- (2) The aggregate grading curve shall not exhibit any sharp irregularities and shall lie smoothly within the grading limits shown in Table 310.1.
- (3) In addition to meeting the above requirements the shape of the lower portion of the grading curve (material smaller than 2.36 mm) shall be such that nowhere shall the percentage passing consecutive sieve sizes vary from at or near one limit to at or near the opposite limit.

Table 310.1 - Combined Mineral Aggregate Grading Limits

Sieve Size (mm / μm)	Passing by mass (%)
26.50	100
19.00	76 - 100
13.20	60 – 85
9.50	45 – 70
4.75	30 – 50
2.36	19 – 35
600 μm	7 – 18
300 μm	4 – 12
150 μm	1 – 7
75 μm	0 – 6

(4) The residual binder content in the mix shall be between 5 percent and 7 percent by mass of the mix. The actual binder content employed in the mix shall be approved before manufacture of the mix commences.

(5) During manufacture and placement the Engineer shall obtain samples and carry out tests on the mix produced in accordance with the general requirements of sub-clause 310.04.4 of these Specifications.

310.03.2 Mixing Procedure

(1) Cold asphalt shall be manufactured as follows:

- in a rotary drum mixer (e.g. concrete mixer), or
- in a single or twin shaft pugmill mixer, or
- mixed in place (subject to Engineer's approval)

(2) Mixers shall be of an approved type and shall be capable of providing a consistently uniform mixing of the aggregates, the filler and the binder.

(3) Aggregates shall be handled and stored in a manner that prevents contamination and effectively minimises segregation.

(4) Filler shall be handled and stored in a manner that ensures it remains dry and in a free flowing state at all times.

(5) Bituminous materials shall be stored in containers that effectively prevent contamination. Except for mixes employing a bitumen emulsion binder, the aggregates shall be preheated to remove any surface moisture.

(6) Materials shall be batched by weight, unless otherwise approved in which case volume batching will be carried out only using approved gauging boxes.

(7) When rotary drum mixers or pugmill mixers are employed the aggregates and filler shall be deposited in the mixer and given a "dry" mixing run prior to the addition of the bitumen binder.

(8) The mixing time shall be such as to ensure that the aggregates and the filler are uniformly coated with the bitumen binder. Over mixing, resulting in stripping of the binder coating shall not be allowed to occur.

(9) When the mix-in-place process is approved, the bitumen binder shall be sprayed on to the surface of the combined aggregates. The constructional plant employed for this operation and the mixing procedure adopted shall be such as to provide a uniform distribution of the bitumen binder throughout the aggregate and ensure even coating of the individual aggregate particles.

(10) If the bitumen binder is a bitumen emulsion care shall be taken to ensure that the above requirements are met whilst still retaining the property of rapid breaking of the emulsion.

310.04 COSTRUCTION REQUIREMENTS

310.04.1 Preparation of the Pavement

(1) Prior to the placement of the cold asphalt the surface of the existing pavement shall be dried and thoroughly broomed and/or otherwise treated to remove all loose material and any adhering foreign matter.

(2) Any depressions or uneven areas on the surface shall be tack coated in accordance with Section 306 of these Specifications and brought to the general level of the surface by means of a corrective layer of the cold asphalt. The corrective layer shall be compacted to the requirements of sub-clause 310.04.3 of these Specifications.

310.04.2 Tack Coat

(1) The whole area upon which the cold asphalt is to be spread shall be given a light, even tack coat of rapid setting bitumen emulsion of a type which complies with the requirements of Section 306 of these Specifications.

(2) The emulsion coat shall be finely applied using a spray bar. The rate of application shall be between 0.3 and 0.6 litres per square metre or as otherwise directed by the Engineer.

(3) Warming of the bitumen emulsion or dilution with water prior to application (in order to facilitate spraying) shall be undertaken with extreme care at the Contractor's risk.

(4) The tack coat shall be allowed to "break" prior to spreading the mix.

310.04.3 Spreading, Compaction and Finishing.

(1) Cold asphalt shall be spread in uniform layers not exceeding 65 mm compacted, unless specifically directed otherwise. The layers shall be spread by means of hand spreaders or approved mechanical spreaders for larger areas.

(2) Spreading of cold asphalt will not be permitted if the pavement is wet.

(3) Initial compaction of the cold asphalt shall be undertaken using an approved steel wheel roller having a mass of not less than 8 tonnes, or an approved vibratory roller. Subsequent compaction shall be undertaken using an approved self-propelled pneumatic tyred roller having a mass of not less than 10 tonnes.

(4) The finished surface of the cold asphalt shall be given a light sprinkling of an approved mineral filler. The quantity of filler provided shall be just sufficient to ensure that the finished surface will not be tacky and pick up under traffic.

310.04.4 Control and Testing

(1) The following test results and records of tests carried out on each day's production together with the exact location of each day's production in the finished work are required:

- i. Temperature of asphalt materials when sampled at the plant and on the road;
- ii. Density of laboratory mix (Marshall Density, ASTM D6927);
- iii. Compacted density and percentage compaction of cold asphalt;
- iv. Marshall Stability and Flow, and Strength Index, ASTM D6927;
- v. Asphalt content and aggregate grading of mix;
- vi. Air voids in mix.

310.04.5 Tolerances

(1) The surface of the finished cold asphalt shall be tested for evenness by the Engineer using a 3.5 metre straight edge. The surface will be considered acceptable providing the deviation from the straight edge, placed either longitudinally or transversely, does not exceed 3 mm between two contact points.

(2) Cold asphalt surfaces not conforming to this tolerance may be rejected by the Engineer. Rejected areas shall be removed and replaced at the Contractor's own expense.

(3) Where the cold asphalt is required to be placed within a defined alignment and dimensional tolerances these shall be as specified on the drawings or in the relevant sections of the Specifications

310.04.6 Storage of Cold Asphalt

(1) Cold asphalt which has been manufactured using a fluxed bitumen binder may be stored for future use. The mix shall be stored on clean, hard-surfaced areas and sheltered from sun and wind, preferably covered with a suitable tarpaulin. The stored cold asphalt shall be heaped so as to minimise the exposed surface area. The exposed surfaces shall be lightly compacted (smoothed) to further minimise the loss of volatiles.

(2) Prior to use, the outer "crust" of the stockpiled material shall be removed and discarded or otherwise softened by the application of bitumen fluxing agent or bitumen cutter.

310.05 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
310-1	Cold Asphalt (fluxed)	Metre Cube
310-2	Cold Asphalt (cutback)	Metre Cube
310-3	Cold Asphalt (emulsion)	Metre Cube
310-4	Bitumen Additive: Specify Type (provisional)	Litre

(2) Cold asphalt shall be measured on a cubic metre basis, the dimensions of which shall comprise the thickness and width specified on the typical cross section and the length of completed and accepted construction, measured horizontally, and, where appropriate, along the centre-line of the road.

(3) Additives used in accordance with sub-clause 310.02.3 of these Specifications shall be measured by the number of litres of each type used at the rate instructed or the actual litres used whichever is the lesser.

310.06 PAYMENT

- (1) Cold asphalt, measured as provided for in clause 310.05 of these Specifications, shall be paid for at the rates entered in the Bill of Quantities, complete in place, which price shall be complete compensation for all aggregates, mineral fillers, bitumen, crushing, heating and mixing plant, and shall include all material, labour, equipment, tools, cleaning and preparation of the area to be levelled or patched, removal of deleterious material or loose existing asphalt and all incidentals necessary for the satisfactory completion of the work.
- (2) With the approval of the Engineer, payment will be made at the rates entered in the Bill of Quantities, regardless of the mix bitumen content finally determined and agreed on the site, provided said bitumen content is within the range specified in sub-clause 310.03.1 of these Specifications.
- (3) Payment will be made for the use of bitumen additive, if directed by the Engineer, at the rates entered in the Bill of Quantities for each type of additive measured in accordance with Clause 310.05 of these Specifications.

SECTION 311

SLURRY SEAL

311.01 DESCRIPTION

(1) This work consists of applying an emulsified asphalt slurry seal mix, - i.e. a mixture of bitumen emulsion, fine aggregate, cement or lime and water-, on a pavement surface.

311.02 MATERIALS**311.02.1 Asphalt**

(1) Asphalt shall be emulsified asphalt CSS-1h which shall have properties according to the following table:

Table 311.1 – Required Properties of Emulsified Asphalt CSS-1h

Property / Test		Test Procedure (AASHTO)	Specification	
			Min	Max
Viscosity, Saybolt-Furol, 25°C (77°F), sec		T 59, T 72	20	100
Sieve Test, %		T 59	—	0.1
Particle Charge		T 59	Positive	
Distillation Test	Residue by distillation, % by weight	T 59	57	—
	Oil Distillate, % by volume		—	3
Tests on Residue from Distillation	Penetration, 25°C, 100 g, 5 sec	T 49, T 59	40	90
	Ductility, 25°C, 5 cm/min, cm	T 51, T 49	40	—

(2) Approximate residue of emulsified asphalt shall be according to Table 311-1.

311.02.2 Additives

(1) Additives are used to make the breaking of emulsified asphalt faster or slower or to enable the asphalt to better coat the aggregate. Quantity to be used shall be appropriate such that the road can be opened to traffic within the required time. Use of additives depends on design which shall be approved by the Engineer.

311.02.3 Water

(1) Water shall be clean and free of substance which may harm slurry mixture.

311.02.4 Mineral Filler

(1) Mineral filler which is part of aggregate mixture shall be used when workability needs to be improved or fines in the gradation of aggregate are not sufficient. However mineral filler shall be kept at as small quantities as possible. Mineral filler may be Portland cement, lime or any material which is approved by the Engineer.

311.02.5 Aggregate

(1) Aggregate shall be crushed rock. However, if it is necessary, crushed rock may be mixed with sand but not over 50 percent by mass of the aggregate. Sand shall have water absorption value not greater than 1.25 percent.

- (2) For a surface with average daily traffic (ADT) over 500 vehicles per day, only crushed rock shall be used. The aggregate shall be hard, durable, clean, and free of soil or objectionable materials.
- (3) Gradation of aggregate shall be according to below Table 311-2.

Table 311.2 - Gradation of Aggregate, Asphalt Residue Content and Rate of Sealing

Type of Slurry Seal	1	2	3
Sieve Size, mm	% Passing Sieve by Mass		
12.5		100	100
9.5		100	100
4.75	100	90 - 100	70 - 90
2.36	90 - 100	65 - 90	45 - 70
1.18	65 - 90	45 - 70	28 - 50
0.600	40 - 60	30 - 50	19 - 34
0.300	25 - 42	18 - 30	12 - 25
0.150	15 - 30	10 - 21	7 - 18
0.075	10 - 20	5 - 15	5 - 15
Asphalt Residue Content % by Mass of Dry Aggregate	10.0 - 16.0	7.5 - 13.5	6.5 - 12.0
Rate of Sealing by weight of the Slurry Mixture kg / sq.m.	3.0 - 5.5	5.5 - 10.0	10.0 - 16.0

- (5) There are 3 types of slurry seal mixtures, as shown in above table, which differ from each other by the purpose of use, the size of aggregate, and the application rate. The selection of slurry seal type depends on the existing surface condition, the environment and the purpose of use, as described below.
- (6) Slurry seal type 1 can be used to efficiently seal cracks and it is highly suitable for the works like (i) crack sealing (ii) temporary surfacing waiting for construction of the next layer (iii) surfacing for low traffic and low speed roads, which have a well-drained base course.
- (7) Slurry seal type 2 can be used for satisfactorily sealing cracks and is suitable for works like (i) spreading on and sealing an existing surface with moderate roughness, e.g. surface treatment, penetration macadam, (ii) providing a thin surface for protection against water seepage into the base course, and (iii) providing a single surface treatment.
- (8) Slurry seal type 3 can be used on a relatively rough surfaces, and is capable of sealing raveled surfaces and it can provide minor levelling on existing roads. In addition slurry seal type 3 is suitable for works like (i) spreading on and sealing existing surfaces with relatively heavy roughness, (ii) providing the first or second layer of multiple slurry seals, (iii) adjusting crown slopes which need correction.

311.03 JOB MIX FOR SLURRY SEAL

- (1) Prior to beginning the work, the Contractor shall submit the mix design of the slurry seal to the Engineer for his approval.
- (2) Mix Design shall be done according to the method specified in "The Asphalt Institute Manual Series No. 19; by C.K.E. Determination Method (Centrifuge Kerosene Equivalent Test) or according to ASTM D3910 "Standard Practices for Design, Testing and Construction of Slurry Seal" or any other method approved by the Engineer.
- (3) All material used in the mix shall be according to the specifications. Mix design shall be suitable to the volume of traffic, weather conditions and curing.

- (4) The slurry mixture shall have following properties:
1. Flow shall be between 20 - 30 mm
 2. Initial set shall be maximum 12 h
 3. Cure time shall be maximum 24 h
 4. Wet track abrasion loss shall be maximum 800 gr/ sqm

311.04 CONSTRUCTION REQUIREMENTS

311.04.1 Preparation

- (1) If material is going to be stockpiled, the area for stockpiling shall be free of any objectionable materials and approved by the Project Engineer.
- (2) Caution has to be taken when loading and unloading emulsified asphalt in drum containers, to avoid spill and polluting the environment.
- (3) Before using emulsified asphalt in the drum container which has been in storage for a long period, the container shall be rolled back and forth for a least 5 times prior to feeding into the mixing plant. This procedure allows the emulsified asphalt to be homogeneously distributed throughout the tank. If the container is opened for use, it shall be completely consumed or shall be tightly closed after use. If this is not done, the water in the container will evaporate making the emulsion to lose its beneficial properties.
- (4) Each time a slurry mix has been prepared, the mixing plant shall be thoroughly cleaned to prevent asphalt from adhering to the plant, thus promoting easier future use of the mixing plant.
- (5) The area of construction shall be checked and any damages to be repaired before sealing, e.g. by applying deep patching or skin patching.
- (6) Quantity measuring devices shall be checked prior to commencing the work to ensure that the quantities of materials loaded into the mixing tank are correctly measured.
- (7) Equipment shall be checked to ensure that they are in good working condition and producing slurry mixture according to the design.
- (8) Before slurry is applied, the road surface shall be thoroughly cleaned, e.g. using a broom, sweeping away dirt and loose material (for example loose rock), soil adhered to the surface. Water may be used to clean the surface, if required.
- (9) Spreading of the slurry seal is not permitted, when it is raining or the air temperature is below 10 degree Celsius.
- (10) Before applying the slurry, the surface shall be uniformly wetted with spraying or fogging, but no free water shall be present on the surface when the slurry is applied.
- (11) Tray tests shall be carried out at least once a day during slurry seal operations.

311.04.2 Application of Slurry

- (1) After applying the slurry mixture on the surface, it shall be evenly spread throughout the surface.
- (2) The mixture shall not be piled or lumped. There shall be no aggregate without bound with emulsified asphalt, no breaking of emulsified asphalt and segregation of fine and coarse aggregates. There shall be no sedimentation of coarse aggregate at the bottom of the mixture. If there are such cases, the slurry operations shall be immediately discontinued and any defective material removed from the road.

- (3) There shall be no streaking, e.g. too large coarse aggregate visible on the finished surface of the slurry seal. If there is such a case, it shall be correctly shaped or improved. The Engineer may order to screen aggregate before mixing.
- (4) Where slurry is spread by hand, the squeegee shall be allowed to be used for completing the spreading of each batch discharged onto the road, before the next batch is discharged.
- (5) Where spreading is carried out by means of the spreader box, the slurry shall be discharged into the spreader box by means of a chute, which shall be so directed that an even supply of slurry is maintained against the full width of the strike-off blade of the spreader box. At all times the mixture shall be uniformly distributed in the spreader at sufficient quantity for sealing.
- (6) Areas where an excess of slurry has been applied by the spreader box shall be corrected by squeegees being used immediately after the passage of the spreader box.
- (7) Successive strips of slurry shall overlap transversely by not less than 25 mm nor more than 150 mm. Any overlapping on the longitudinal joints and any omitted areas shall be rectified with squeegees.
- (8) The Contractor shall ensure that either edge of the road surface is finished to the specified widths and lines. All stones dislodged in the process of applying the slurry shall be removed on the same day on which the slurry seal has been applied. All spillage of slurry or excess slurry shall be neatly removed from the road and buried in an approved waste site.
- (9) If the slurry is spread with a spreader box, a moist burlap drag shall be drawn behind the spreader box to ensure an overall even texture.
- (10) If applied by hand (in case the spreader cannot be used, due to confined area), the slurry shall be worked from side to side and criss-cross with the aid of squeegees so as to fill as many spaces as possible. In this case the final layer of slurry shall be struck off flush with the tops of the stone chippings so as to leave the chippings to be visible after the emulsion has stiffened and hardened.
- (11) The work must be so programmed, that the two half road widths of slurry shall be applied on two successive days to complete a full road width section in two days.
- (12) The Engineer will decide on the time necessary for proper curing, which will in any case be not less than 24 hours.
- (13) Normally traffic is not allowed on the slurry seal before curing is completed, but if prior to completion of the curing it is necessary to allow for vehicle traffic (e.g. at intersections, connecting roads), stone dust or sand may be spread on the area to accommodate for the traffic.
- (14) Absence of water in the mixture indicates that the curing has been completed. This shall be checked by using water absorbent paper on the slurry seal. If the paper indicates there is no water remaining in the slurry, it can be opened to traffic. Breaking of emulsified asphalt in the slurry seal shall be checked by observing the change of colour of the mixture from brown to black, in which case a black colour indicates completion of the curing.
- (15) If a second layer of slurry is applied, the surface of the first slurry layer shall be thoroughly cleaned of all dust, dirt or foreign materials before the second layer of slurry is applied.
- (16) When the slurry is applied in two layers, the first layer of slurry shall be struck off level with the tops of the stones in the aggregate layer so that, after application, the tops of the stones will be just visible.
- (17) The second layer of slurry shall not be applied until the first layer has dried. If required by the Engineer, the Contractor shall open the road to traffic before the second layer of slurry is applied. The second layer shall be applied only after sufficient time has been allowed for the first layer to cure.

(18) Any damage to the slurry seal by rain or traffic before the slurry has cured shall be rectified by the Contractor at his own expense.

(19) Construction of slurry seal type 1, type 2 and type 3 do not need rolling, but parking areas and airport runways shall be rolled.

311.05 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
311-1	Slurry Seal	Metre Square

(2) Quantity of slurry seal work shall be measured from the actual area of work done according to the Drawings.

311.06 PAYMENT

(1) Pavement will be made at the rates given in the Bill of Quantities, which rates will be full compensation for furnishing all materials, mixing, transportation, placing and finishing, and will also include for JMF development, trial areas, all sampling and testing, method statements, and all plant, equipment and labour and all incidentals to complete the work as specified.

SECTION 312

GRAVEL WEARING COURSE

312.01 DESCRIPTION

(1) This work shall consist of furnishing and placing a gravel wearing course on the formation of a new road where no pavement and final bituminous surface is included, or placed on the formation of any other road in conformity with the lines, grades, thickness and typical cross sections shown on the Drawings or established by the Engineer.

312.02 MATERIALS

312.02.1 Sources of Material

(1) Material for gravel wearing course may be obtained from (i) Borrow pits, (ii) Spoil areas, (iii) Excavation in cuttings (widened if necessary) or Crusher.

(2) If crushed aggregate is used, it shall first be screened in such a manner that not less than 90% of the material to be crushed is retained on a 6.3 mm sieve. The amount of crushing shall be regulated so that at least 80% by weight of the pieces retained on a 4.75 mm sieve have at least one mechanically fractured face.

(3) Where a source of material is available for inspection during the Tender Period the Contractor shall satisfy himself as to the nature and amount of work involved, particularly in respect of the volume of overburden, the quality of material, the degree of selection necessary, the method of extraction, and access to the source of the material.

(4) The Contractor shall comply with all the requirements of Section 107.4 of this Specification in respect of borrow pits and spoil areas.

312.02.2 Grading Requirements

(1) The material shall consist of natural soil or a mixture of natural soils, containing mainly gravel and coarse sand or can consist of a crushed aggregate. The gravel wearing course shall contain a higher clay content than granular base course and shall have a higher plastic limit in order to provide for sufficient binding and cementing of the gravel wearing course. Sometimes natural gravel will meet these specifications, but often the natural gravel has to be screened or two materials be mixed to improve the gradation.

(2) The gravel material shall conform to the following grading requirements and the grading shall be a smooth curve within and approximately parallel to the below envelope. Testing of grading shall be done according to AASHTO T 27.

Table 312.1 – Grading Requirements

AASHTO Sieve (mm)	Percent Passing (by weight)		
	< 50 mm*	< 25 mm	< 9.5 mm
50.0	100		
37.5	95 – 100		
25.0	70 – 100	100	
19.0	55 – 100	85 – 100	
9.5	50 – 80	65 – 100	100
4.75	40 – 60	50 – 85	80 – 100
2.36	30 – 50	40 – 70	50 – 80
0.425	15 – 30	25 – 45	25 – 45
0.075	5 – 15	10 – 25	10 – 25

* This gravel material (<50 mm) should be used only in areas with lack of better materials and after decision by the Engineer.

312.02.3 Other Requirements

(1) Materials shall comply with the following requirements:

Gradation	According to Table 312.1	AASHTO T 27
CBR (4 days soaked)	minimum 30 %	AASHTO T 193
Liquid limit	maximum 40 %	AASHTO T 89
Plasticity index	6 – 15 %	AASHTO T 90
Compaction	95 % MDD	AASHTO T 180, Method D
Maximum size of aggregate	25 mm	

(2) In dry areas, ideally the Plasticity Index shall be 10 %, otherwise corrugation and gravel loss could be excessive.

(3) Minimum three tests, -covering Gradation, CBR, Liquid Limit and Plasticity Index-, on the material in each borrow pit are required. After the material has been placed on the road, as least 2 tests per kilometre shall be made.

(4) When the material is sourced from a borrow pit, the Contractor shall demonstrate to the satisfaction of the Engineer, that the material can be excavated without being contaminated by unacceptable material. The Contractor at his own cost shall take such actions the Engineer considers necessary to ensure that the material being excavated is not being contaminated. Where in the opinion of the Engineer, the Contractor cannot extract the material from the borrow pit without contamination, then the Contractor shall obtain material from another source at his own cost.

(5) Every reasonable effort shall be made to prevent segregation of material during the loading, hauling, dumping, spreading, mixing, trimming and compacting operations.

(6) The Contractor shall make the tests required to achieve the specified quality and prior to usage of materials, approval must be given by the Engineer.

312.03 CONSTRUCTION REQUIREMENTS

312.03.1 Surface Preparation

(1) Existing formation shall have been prepared in accordance with Sections 203, 204, 205 or 208 of the Specifications, as appropriate. The surface shall be shaped and compacted to the right camber and ditches shall be cleared before the gravel wearing source is placed.

(2) The formation shall be cleaned of all foreign matter, and any potholes, loose material, ruts, corrugations, depressions and other defects which have appeared due to improper drainage, traffic or any other cause, shall be corrected, and if considered necessary by the Engineer, the Contractor shall scarify, water, grade and re-compact the subgrade to line and level all at his own expense.

(3) Immediately prior to placing gravel wearing coarse the complete surface of the sub-grade shall be proof rolled. All subgrade and embankment layers, cuttings, benches and original ground shall be proof rolled with a loaded truck or similar with a minimum axle load of 8 tonnes. Proof rolling shall be satisfactorily completed in the presence of the Engineer and for his approval. Compliance of proof rolling shall be when an area withstands proof rolling without visible deformation or springing. Such proof rolling shall be at the Contractor's own expense. The Contractor shall at his own cost carry out any additional compaction and testing necessary to achieve the requirements specified herein for proof rolling.

312.03.2 Placing and Spreading

(1) Unless otherwise instructed by the Engineer, the Contractor shall commence placing wearing course, starting as close as possible to the source and shall work away from it so that the maximum amount of compaction is given to the wearing course by the Contractor's vehicles. The Contractor shall route his vehicles to give even wear and compaction over the whole width of the wearing course.

(2) Where black cotton, or other high-swelling material, is used in the upper subgrade layers, the Contractor shall place wearing course material upon this section immediately after compaction of formation level.

(3) Gravel wearing course material shall be spread only when the underlying surface has been approved by the Engineer, according to section 312.03.1. Any material which has been placed on a surface not approved by the Engineer, shall be removed at the Contractor's expense.

(4) The gravel wearing course shall be constructed in compacted layers with minimum compacted thickness 100 mm and the maximum compacted thickness 150 mm. Where a greater compacted thickness is required, the material shall be laid and processed in two or more layers. The minimum gravel wearing coarse thickness shall in all cases not be less than 150 mm.

(5) The gravel material shall be deposited in such quantity and spread in a uniform layer across the full width required, so that the final compacted thickness is nowhere less than shown upon the Drawings or instructed by the Engineer.

(6) When spreading the material the moisture content shall be adjusted by either uniformly mixing in water or drying out the material so that the moisture content during compaction will be between 80% and 105% of the Optimum Moisture Content (AASHTO T 180). The material shall be graded and trimmed to final line and level. Light compaction may be applied before the final trim is carried out but once approximately 25% of the compactive effort has been applied no further trimming or correction of surface will be allowed.

(7) The final trim shall be done by cutting and the Contractor shall ensure that material from the trim is neither deposited in low areas nor spread across the section but graded clear of the works.

(8) Following the final trim the material shall be compacted to a dry density of at least 95% MDD (AASHTO T 180). During the grading, trimming and compaction of the material the Contractor shall ensure that the surface and/or the material does not dry out by applying fog sprays of water or other approved means sufficient to maintain the surface and material within the specified limits of moisture content.

(9) The material shall be handled so as to avoid segregation and the material shall be placed in uniform depth. Segregated materials shall be re-mixed until uniform. Suitable measures shall be taken to prevent rutting of the sub-grade during the spreading of the gravel wearing course material.

(10) No hauling or placement of material will be permitted when, in the opinion of the Engineer, the weather or road conditions are such that the hauling operations will cause cutting or rutting of the sub-grade or cause contamination of the gravel wearing course material.

(11) Gravel materials which are naturally excessively coarse needs to be brought to the required gradation as specified in section 312.02.2. This shall be done on the road by using grid-, cleat- or sheep foot rollers. Oversized particles which cannot be broken down to the required size shall be removed.

312.03.3 Mixing

(1) Mechanical stabilization of the gravel wearing course, if required, shall be done by using a grader for mixing the gravel wearing course with sand or stone or both.

312.03.4 Compaction

(1) The moisture content of the material shall be adjusted prior to compaction, by watering with approved sprinkler trucks or by drying out, so that the specified density for Gravel wearing course can be achieved with Contractor's compaction equipment. During compaction the moisture content shall be so controlled that moisture content uniformly throughout the finished layer shall be within the limits of $\pm 2\%$ of the Optimum Moisture Content as determined in AASHTO T 180, or such other moisture content as agreed with the Engineer as a result of compaction trials. Density determinations shall be carried out in accordance with the requirements of AASHTO T 191, at a rate of 5 tests for every 2,000 square metres of completed layer or part thereof. For density results to be acceptable, four of the five densities measured shall be equal to or greater than the required level of compaction, and the fifth shall be not less than the required relative density minus 3 percent. The use of AASHTO T 224 to correct for oversize particles may be required.

(2) The material shall be compacted by means of approved compaction equipment progressing gradually from the outside towards the centre with each succeeding pass uniformly overlapping the previous pass. Rolling shall continue until the entire thickness of each layer is thoroughly and uniformly compacted to the specified density. Rolling shall be accompanied by sufficient blading, in a manner approved by the Engineer, to ensure a smooth surface free from ruts or ridges and having the proper section and crown. The Contractor shall ensure that the required compaction is obtained throughout the Gravel wearing course layer and for the full finished width of the material. Filling outside the finished width will be necessary in order to achieve the required compaction for the full finished width of the gravel wearing course.

(3) Any areas inaccessible to normal compaction equipment shall be compacted by means of mechanical tampers until satisfactory compaction is obtained.

(4) Samples shall be taken from the compacted layers for testing to ensure that the compacted material complies with the requirements of Clause 312.02.3 of the Specifications.

312.03.5 Compaction Trials

(1) Prior to the commencement of his gravel wearing course operations, the Contractor shall construct trial lengths as directed by the Engineer. The materials used in the trials shall be those approved for use in the Works and the equipment used shall be that which the Contractor intends to use for the work proper.

(2) The objective of these trials shall be to determine the adequacy of the Contractor's equipment, the loose depth necessary to result in the specified compacted layer depths, the field moisture content, and the relationship between the nominal number of compaction passes and the resulting density of the material.

(3) The Contractor shall not proceed with gravel wearing course work until the methods and procedures established in the compaction trials have been approved by the Engineer.

(4) Each trial length shall be 100 metres long, and trials shall be repeated as necessary until compaction procedures acceptable to the Engineer are achieved. The trial lengths will be incorporated in the Works provided the requirements of this Section are met.

(5) Further trials shall be conducted if the materials comprising the gravel wearing course are significantly amended, or if the Engineer considers that the approved methodology is not achieving satisfactory and/or consistent and acceptable results. Contractor shall perform all such compaction trials at his own expense.

312.03.6 Finishing

(1) If the gravel wearing course, or part thereof, does not conform to the required density or finish, the Contractor shall, at his own expense, re-work, water and re-compact the material, as directed by the Engineer, to the density/finish specified.

(2) The Contractor shall ensure that proper drainage of the gravel wearing course is maintained at all times.

(3) The gravel wearing surface shall be maintained by the Contractor in its finished condition and shall be watered, graded, reshaped, or re-compacted as necessary, until the Certificate of Completion is issued, or until the Engineer instructs that the road shall be opened to public traffic, whichever is sooner.

312.03.7 Tolerances

(1) The average thickness of the gravel wearing course measured at five points in any length of 100 m shall not be less than 100% nor more than 120% of the thickness specified or ordered by the Engineer. In addition the thickness of the gravel wearing course measured at any single point, shall not be less than 95% nor more than 125% of the thickness specified or ordered by the Engineer.

(2) Provided that the specification in above paragraph is complied with, the thickness of the gravel wearing course at any point shall not vary by more than ± 20 mm from that specified. Measurements of surface levels will be taken at points selected by the Engineer.

(3) The variation of the surface of the finished the gravel wearing course from any two points of contact with a 3 metre long straight-edge shall in no case exceed 15 mm when placed on or parallel to the centreline or when placed perpendicular to the centreline of the roadway. The surface regularity shall be tested at points decided by the Engineer.

(4) Where any tolerances are exceeded, the Contractor shall determine the full extent of the area which is out of tolerance and shall rectify the gravel wearing course by removing and replacing the full depth of the layer so that it complies with the specifications. The area treated shall be the whole section submitted for approval or, following a retest, a length of at least 50m both sides of each test and retest failure or such area as determined by the Engineer.

(5) All humps and depressions and thickness deficiencies exceeding the specified tolerances shall be corrected by removing the defective work or by adding new material as directed by the Engineer.

312.04 MEASUREMENT

(1) Measurement will be as follows:

Item No.	Description	Unit
312-1	Gravel Wearing Course	Metre Cube

(2) Materials shall be measured as compacted to the required density on the approved formation of a road, according to the theoretical dimensions shown on the Drawings or as otherwise specified by the Engineer.

(3) No measurement for over-depth shall be made even when such over-depth of material is permitted to remain in place by the Engineer. Unauthorised over-depth shall be at the Contractor's own costs, and shall not form a request for additional compensation.

312.05 PAYMENT

(1) Payment will be made at the rates entered in the Bill of Quantities, and shall include for all operations necessary to achieve the finished gravel wearing course to the requirements specified herein.

SECTION 313

SAND LAYER UNDER CONCRETE PAVEMENT

313.01 DESCRIPTION

(1) This work shall consist of furnishing, placing and compacting sand layer cushion on prepared and accepted subbase or other specified layer in accordance with these Specifications and the lines, levels, grades, dimensions and cross sections as shown on the Drawings.

313.02 MATERIALS

(1) The material used for sand cushion underneath the concrete pavement shall be coarse sand consisting of hard and durable particles, without any clay lumps or deleterious material and selected from the locations approved by the Engineers.

(2) Material used for sand cushion shall conform to the following requirements:

- i) As determined by AASHTO T 27, maximum size shall not be greater than 9.5 mm and the portion passing 0.075 mm sieve shall not be greater than 10 percent
- ii) The material shall be non-plastic.

313.03 CONSTRUCTION REQUIREMENTS

313.03.1 General

(1) When the sand material, which is approved by the Engineer, is not placed directly on subbase or other specified layers, it shall be stock-piled in sufficient amount in a clean area as approved by the Engineer. The sand, which is not approved by the Engineer, shall not be allowed to be placed on subbase or other specified layer, and shall be removed from the site.

(2) Subbase or other specified layer under sand cushion shall be spread and compacted in lines, levels, grades, dimensions and cross section and density as shown on the Drawings.

(3) The Contractor may install formworks before placing sand cushion.

(4) After the preparation according to above, subbase or other layers under sand cushion shall be sprayed with water thoroughly on its surface, after that the sand cushion material shall be transported and spread on the subbase or specified layer by suitable equipment. Water shall be sprayed on the material until suitable moisture content is accomplished.

(5) After the sand cushion layer has been spread and shaped satisfactorily, it shall be compacted uniformly at least 90% of MDD (AASHTO T 180) with suitable equipment over the surface. The sand cushion shall have lines, levels, grades, dimensions and cross section as shown on the Drawings.

(6) When the sand cushion has been constructed to a length as decided by the Engineer, the level of sand cushion shall be checked. If it conforms to the requirements, the Contractors shall proceed to pour concrete.

313.03.2 Tolerances

(1) Surface deviation in excess of 10 mm from a straight edge of 3 meters long applied to the surface parallel and perpendicular to the centreline of the road or deviation of elevation in excess of 15 mm from the Drawings, shall be corrected by loosening, adding, removing, reshaping and compacting or reconstructing. Inspections shall be carried out at 25 m intervals or less as decided by the Engineer.

313.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
313-1	Sand Layer	Metre Cube

(2) This item will be measured as the number of cubic meters of material complete in place and accepted. Measurement will be based on the actual compacted volume as shown in the Drawings or otherwise directed by the Engineer.

313.05 PAYMENT

(1) Payment will be made at the rate entered in the Bill of Quantities and shall include for all operations necessary to achieve the finished Sand Layer to the requirements specified herein.

SECTION 314

RIGID PAVEMENTS / CONCRETE PAVEMENTS

314.01 DESCRIPTION

(1) This Work shall consist of a pavement composed of Portland cement concrete, with or without reinforcement as specified, constructed on a prepared subgrade, subbase or base course in accordance with the specifications and in conformity with the lines, grades, thicknesses, and typical cross sections shown on the plans or established by the Engineer. Both plain and reinforced concrete shall include deformed bars for contraction joints and dowel bars for expansion joints as shown on the plans.

314.02 MATERIALS

314.02.1 General

(1) Materials shall conform to the requirements specified in Section 507“Structural Concrete” and as specified hereinafter.

314.02.2 Portland Cement

(1) Portland cement shall conform to the requirements specified in Section 507.03.6 of these Specifications.

314.02.3 Water

(1) Water used for mixing and curing of concrete shall conform to the requirements specified in Section 507.03.5 of these Specifications.

314.02.4 Coarse Aggregate

(1) Coarse aggregate used in concrete shall conform to the requirements specified in Section 507.03.4 of these Specifications.

314.02.5 Fine Aggregate

(1) Fine aggregate used in concrete shall conform to the requirements specified in Section 507.03.3 of these Specifications.

314.02.6 Reinforcement

(1) All reinforcement used in concrete shall conform to the requirements specified in Section 506 of these Specifications.

314.02.7 Wire Mesh

(1) Welded steel wire mesh shall conform to the requirements of AASHTO M 55.

314.02.8 Admixtures

(1) Any admixtures used in concrete shall conform to the requirements specified in 507.03.7 of these Specifications.

314.02.9 Jointing Materials

(1) All jointing materials used in concrete shall conform to following requirements:

- (2) Joint Fillers - non-extruding and resilient types shall conform to the requirement of AASHTO M 153, or M 213. Bituminous type filler shall conform to the requirement of AASHTO M 33.
- (3) Joint Primer - Joint priming compound shall be Expandite No. 3 or other approved equal primer.
- (4) Joint Sealing Compound - Horizontal joint sealing material shall be Expandite Plastic hot poured rubber-bitumen sealing compound Grade 99 or other approved equal compound. Vertical or inclined joint sealing material shall be Expandite Plastijoint bituminous putty or other approved equal compound.
- (5) Alternatively joints shall be sealed with a hot applied joint sealant conforming to the Specification for Joint and Crack Sealants, Hot-Applied, for Concrete and Asphalt Pavements, ASTM D 6690, Type II.
- (6) Prior to applying any Jointing Material, the Contractor shall furnish a Certification of Compliance to the Engineer.

314.03 EQUIPMENT

- (1) Equipment shall conform to the requirements specified in Section 101.08 "Contractor's Equipment". In addition to these requirements the spreader shall be equipped with approved attachments capable of placing the concrete uniformly on the subgrade. The Contractor shall provide all details in the Contractor's Program of Work, as approved by the Engineer.

314.04 CONSTRUCTION REQUIREMENTS

314.04.1 Pavement Base

- (1) The base upon which the concrete pavement is laid shall have been constructed or prepared under other items of the Contract and shall be smooth, compacted and true to the grades and cross sections shown on the plans and shall be so maintained, as provided under such other items, throughout the period of placing concrete pavement.
- (2) To ensure the proper depth and section, a scratch template true to depth and section and resting on accurately set side forms shall be moved over the surface immediately before placing concrete, and any irregularities shall be immediately corrected. High spots shall be planed down, and the Contractor shall have the option of either filling low spots to the proper elevation with approved material, which shall be watered, compacted and struck-off to the required grade, or of placing additional concrete. No measurement or payment will be made for such additional concrete. Until the subgrade has been checked and approved, no material shall be deposited thereon.
- (3) Storing or stockpiling of materials on the subgrade will not be allowed. The placing of concrete paving materials or laying of pavement on a muddy or sodden subgrade will not be permitted.

314.04.2 Forms

- (1) Forms shall be made of steel of an approved section, with a base width of at least twenty (20) cm and the depth shall be equal to the thickness of the pavement at the edge as shown on the plans. The forms shall be staked with steel stakes, and stakes shall be of a length approved by the Engineer. Each section of forms shall have a stake pocket at each end and at intervals of not more than one and one-half (1.5) m between ends. The stake pockets shall have approved devices for locking the form to the steel stakes. Each section of forms shall be straight and free from bends and warps at all times. No section shall show a variation greater than three (3) mm in three (3) m from a true plane surface on the top of the form, and the inside face shall not vary more than six (6) mm from a plane surface.
- (2) Before placing forms, the underlying material shall be excavated to the required grade, and shall be firm and compact. The forms shall have full bearing upon the foundation throughout their length and shall be placed with exactness to the required grade and alignment of the edge of the finished pavement. They shall be so supported during the entire operation of placing, tamping and finishing the pavement that they will not deviate vertically at any time more than three (3) mm from the proper elevation. Forms shall be set to the required lines and grades well in advance of placing concrete, preferably not less than two hundred (200) m.

(3) Forms shall not be removed for at least twelve (12) hours after the concrete has been placed. Forms shall be carefully removed in a manner to avoid damage to the pavement. Under no circumstances will the use of pry bars between the forms and the pavement be permitted. Pavement, which in the opinion of the Engineer, is damaged due to the careless removal of forms shall be repaired by the Contractor, at directed by the Engineer, at the Contractor's own expense.

(4) Forms shall be thoroughly cleaned and oiled each time they are used. When pavement is placed adjoining an existing concrete pavement upon which the finishing machine will travel, any irregularities in the old pavement shall be ground down to a true, uniform surface, of sufficient width to accommodate the wheels of the finishing equipment, if necessary to obtain proper smoothness of the pavement.

314.04.3 Composition, Proportioning, Consistency, and Mixing

(1) The composition, proportioning, consistency, and mixing of the concrete or early strength concrete for concrete pavement, shall conform to the requirements provided in Section 507.04 and 507.05 of these specifications. In addition, the slump shall not exceed nine (9) cm.

314.04.4 Placing Concrete

General

(1) The mixer shall be operated outside of the forms at all times except at locations where the Engineer deems it not feasible to do so. When ordered by the Engineer, the subgrade shall be moistened as directed, prior to the placement of the subgrade paper. The concrete shall be deposited on the subgrade in successive batches for the full width between forms and in a manner that will require as little re-handling as possible. Spreading shall be done by an approved mechanical spreader in a manner that will prevent segregation and separation of the materials. Necessary hand spreading shall be done with shovels, not rakes. Workmen shall not be allowed to walk in the freshly mixed concrete with boots or shoes coated with earth or foreign substances. The amount of material deposited shall be sufficiently in excess of that required to form the pavement to the required cross section after consolidation in order to provide a roll of concrete ahead of the front screed of the finishing machine for the full length of the screed. Concrete shall be thoroughly consolidated against and along the faces of all forms and along the full length and on both sides of all expansion joint assemblies, by means of vibrators inserted in the concrete. Vibrators shall not be permitted to come in contact with a joint assembly, the grade, or a side form. In no case shall the vibrator be operated longer than fifteen (15) seconds in any one location.

(2) Concrete shall be deposited as near to expansion and contraction joints as possible without disturbing them, but shall not be dumped from the discharge bucket or hopper onto a joint assembly unless the hopper is well centred on the joint assembly. Damage to joint assemblies caused by dumped concrete shall be repaired immediately, as directed by the Engineer, at the Contractor's expense. Should any concrete materials fall on or be worked into the surface of a completed slab, they shall be removed immediately by methods approved by the Engineer. Placement of concrete ahead of the initial spreader strike-off shall not be more than fifteen (15) minutes ahead of final spreader strike-off; if concrete is placed in one (1) layer only, the placement of concrete shall not be more than twenty (20) minutes ahead of the spreader strike-off.

Adverse Weather Conditions

Concreting in Cold Weather

(1) No concrete shall be mixed at an air temperature of less than 7° C on a falling thermometer or 3° C on a rising thermometer unless proposals to counteract the effect of cold weather have been submitted by the Contractor and agreed in writing by the Engineer. Exposed surfaces of concrete shall be efficiently protected to maintain its temperature above 5° C until it has hardened.

(2) The Contractor shall provide a thermometer suitable for measuring the temperature of aggregates and a maximum and minimum thermometer that shall be hung in a position indicated by the Engineer.

Concreting in Hot Weather

- (1) The Contractor shall take great care during hot weather to prevent the cracking or shrinking of concrete. The Contractor shall arrange for concrete to be placed in the early morning or late evening as directed by the Engineer.
- (2) The Contractor shall have particular regard to the requirements specified herein for curing.
- (3) Formwork shall be shaded from direct exposure to the sun both prior to the placement of concrete and during its setting. The Contractor shall take appropriate measures to ensure that reinforcement in and projecting from the section to be concreted is maintained at the lowest temperatures practicable. Concrete, immediately after compaction has ceased, shall have a temperature of not less than 5° C and not more than 25° C. If necessary the Contractor shall cool the aggregates and mixing water by methods approved by the Engineer.

314.04.5 Placing Reinforcement

- (1) All pavement reinforcement shall be placed as shown on the plans. Reinforcement shall have 60mm cover from the surface, except for slabs less than 150mm thick where 50mm cover shall be provided. The reinforcement shall terminate at least 40mm and not more than 80mm from the edge of the slab and from all joints except where reinforcing mats are used to span longitudinal joints instead of tie bars. At the transverse overlap of reinforcing mats the first transverse wire of one mat shall lie within the last complete mesh of the previous mat and the overlap shall be not less than 450mm. Unless otherwise directed by the Engineer, no overlap will be needed longitudinally between mats. When deformed bar reinforcement is used the overlap of the bars shall not be less than 40 bar diameters.
- (2) All marginal bars, dowel bars, and tie bars required by the plans shall be held in proper position by sufficient number of metal bar supports or pins as approved by the Engineer. If the centre joint is to be sawed instead of placing the metal centre strip, the tie bars may be installed mechanically by means of equipment and methods approved by the Engineer. The satisfactory placement of the tie bars shall depend upon the ability of the mechanical device to place the tie bars in their true position. The Engineer may require, when satisfactory placement is not obtained by mechanical means, that the tie bars be installed ahead of placing the concrete and that they be securely staked and tied if necessary to hold them in their exact position. The use of removable devices, supporting the bars from the forms, will not be permitted.
- (3) Following the placing of the concrete, it shall be struck-off to conform to the cross section shown on the plans and to an elevation such that when the concrete is properly consolidated and finished, the surface of the pavement will be at the elevation shown on the plans. When reinforced concrete pavement is placed in two (2) layers, the entire width of the bottom layer shall be struck-off to such length and depth that the sheet of fabric or bar mat may be laid full length on the concrete in its final position without further manipulation. The reinforcement shall then be placed directly upon the concrete, after which the second layer of the concrete shall be placed, struck-off and screeded. Any portion of the bottom layer of concrete which has been placed more than thirty (30) minutes without being covered with the top layer shall be removed and replaced with freshly mixed concrete at the Contractor's expense. Only plain concrete and bar reinforced bridge approach pavement may be placed in one (1) layer.
- (4) Where two (2) layers of wire mesh are required, as at bridge approaches, the bottom layer shall be supported in the required position with bar chairs and separators shall be used for the top layer if the strike-off cannot be properly used for the operation. Laps in adjacent sheets or mats of reinforcement shall be as shown on the plans. Laps parallel to the centreline of the pavement will not be permitted except for unusual widths of pavement lanes or for irregular areas. If the plans do not show dimensions for laps, the minimum lap either perpendicular or parallel to the centreline of the pavement shall be fifteen (15) cm. The adjacent sheets shall be fastened or tied together to hold all parts of the sheets in the same plane.
- (5) Reinforcing steel shall be free from detrimental amounts of dirt, oil, paint, grease, loose mill scale, and loose or thick rust which could impair bond of the steel with the concrete.

314.04.6 Joints

(1) Joints shall be constructed in accordance with the details shown on the drawings and the specifications or as directed by the Engineer and with the best of workmanship. The maximum permitted spacing of joints for reinforced concrete slabs is shown in Table 314.01. Failure to construct the joints as called for and in the best possible manner, as determined by the Engineer, will be cause for suspension of Work until the cause of the defective Work is remedied.

Table 314.1 - Maximum Spacing of Joints for Reinforced Concrete Slabs

Minimum Weight of Mesh Reinforcement, Kg/m ²	Maximum Spacing of Joints, m
2.0	12
3.0	19
4.0	25
5.0	30
6.0	35

(2) If removal of existing pavement of any type is required to connect with the new pavement, and the termination of the removal is not at an existing joint, the new joint shall be made by sawing the existing pavement not less than five (5) cm deep before removal.

Expansion Joints

(1) The subgrade at expansion joints shall be accurately trimmed to the required cross section and to the proper depth of the pavement. A string line shall be stretched between the pavement forms along the centreline of the joint. One-half of the length of each dowel bar shall be painted in accordance with the directions shown on the plans, and then thoroughly coated with hard grease, or lubricant as approved by the Engineer, to prevent the concrete from bonding to that portion of the dowel.

(2) The entire joint assembly shall be of a type designated on the plans and shall be installed in such a position that the centreline of the joint assembly is perpendicular to the centreline of the pavement slab and the dowels lie parallel to the centreline of the slab. Finished joints shall not deviate more than six (6) mm in the horizontal alignment from a straight line. No plugs of concrete shall be permitted anywhere within the expansion space.

(3) A slip sleeve of the dimensions shown on the plans shall be placed on the greased end of each dowel. The greased ends shall be free to slide in the dowel holder and shall extend in the direction as indicated on the plans. Any excess grease on the dowel holder shall be removed. The joint shall be securely staked or fastened in place prior to placing the concrete and in a manner to ensure the joint and the dowel bars will remain in their proper position after the concreting and finishing operations are completed.

(4) Joints for pavement designed for two (2) or less lanes of traffic shall be assembled and installed in one (1) continuous piece or the connections between sections shall be made rigid and tight to prevent offsets in sections of the joints. The length of individual pieces of the expansion joint filler shall be not less than the width of one (1) traffic lane of the pavement.

(5) The finishing machine shall be operated in a manner that will prevent displacement of the joint. If for any reason it is necessary to straighten a joint, any depressions caused by this operation shall immediately be filled with fresh concrete, respaded and to create a transverse slope prior to finishing. Any fluid laitance or mortar caused by this operation shall be removed and replaced with fresh concrete. As the finishing machine approaches the joint on the first trip, the excess concrete shall be shovelled ahead and the tamper and each screed, in turn, shall be lifted over the joint. On the second trip of the finishing machine, the screed may be operated over the joint.

Contraction Joints

- (1) Contraction joints shall be of the type and dimensions and at the spacing shown on the plans. Sawed contraction joints shall be cut by means of an approved Concrete saw.
- (2) The joints shall not be sawed until the concrete has hardened to the extent that tearing and ravelling is eliminated. All joints shall be sawed during the initial curing period as described in subparagraph 314.04.9 “Protecting and Curing of Concrete Pavement - Initial Curing”, and the sawing shall begin before the pavement starts shrinking and before uncontrolled cracking takes place.
- (3) Any procedure which results in premature and uncontrolled cracking shall be revised immediately by adjusting the sequence of cutting the joints or the time interval involved between the placing of the concrete or the removal of the curing media and the cutting of the joints. In no case shall the pavement be left overnight without having the joints sawed. The joints shall be sawed at the depth, spacing, and lines shown on the plans. Guidelines or devices approved by the Engineer shall be provided to ensure cutting the joint in a straight line and perpendicular to the centreline of the pavement.
- (4) The dust resulting from sawing shall be completely removed from the joint and adjacent areas by means of an air jet or a combination of air and water applied under pressure immediately after the joint has been cut, and before filling with joint compound. When the plans specify that dowels be installed through contraction joints, the subgrade at the contraction joints shall be accurately trimmed to the required cross section and to the proper depth of the pavement. A string line shall be stretched between the pavement forms along the centreline of the joint. Each dowel shall be painted and thoroughly coated with hard grease, or lubricant, in accordance with the directions shown on the plans or as approved by the Engineer, to prevent the concrete from bonding to that portion of the dowel. The entire joint assembly shall be of the type designated on the plans and shall be installed in such a position that the centreline of the joint assembly is perpendicular to the centreline of the slab and the dowels lie parallel to the slab surface and parallel to the centreline of the slab. The greased ends of the dowels shall be placed in the direction as indicated on the plans and shall be free to slide in the dowel holder. Any excess hard grease on the dowel holder shall be removed.

Longitudinal Joints

- (1) Longitudinal joints shall be constructed in conformance with the details shown on the plans. When a fabricated steel strip is specified, it shall be held rigidly in place with an adequate number of pins driven into the subgrade to ensure that it will remain true to line and grade during concreting and finishing operations. On multiple lane pavements where longitudinal joints are constructed at the form line, an approved recessed form and tie bars will be required. The full depth fabricated steel strip designated for other longitudinal joints will not be permitted. When sawed joints are specified or used, suitable guidelines or devices shall be furnished to ensure cutting the longitudinal joint on the true line as shown on the plans. The sawing of longitudinal joints shall be performed at a time that will eliminate erratic or uncontrolled cracking. Sawed joints shall be filled with the type of joint compound indicated on the plans. The dust resulting from sawing shall be completely removed from the joint and adjacent areas by means of an air jet or a combination of air and water applied under pressure immediately after the joint has been cut and before filling with joint compound.

Construction Joints

- (1) A butt construction joint shall be made perpendicular to the centreline of the pavement at the close of each day's work and also when the process of depositing concrete is stopped for a length of time such that, in the opinion of the Engineer, the concrete will have taken its initial set. This joint shall be formed by using a clean plank header having a nominal thickness of five (5) cm, a width of not less than the thickness of the pavement and a length of not less than the width of the pavement. The header shall be cut true to the crown of the finished pavement and shall be accurately set and held in place in a plane at right angles to centreline and perpendicular to the surface of the pavement.
- (2) The top surface of the header shall be protected with steel as approved by the Engineer. On the face along the centre of the header there shall be fastened a trapezoidal piece of metal or wood the full length of the header, five (5) cm wide and at least twenty- five (25) mm in depth to form a grooved joint. The header shall have drilled holes to accommodate the dowel or tie bars hereinafter specified.

(3) Upon resumption of work any surplus concrete remaining upon the subgrade shall be removed. The header shall then be carefully removed and fresh concrete deposited against the old in such a manner as to avoid injury to the edge of the old concrete. The fresh concrete shall be vibrated into the groove in a manner to ensure an interlocking joint. Dowel bars or load transfer devices shall be used in all construction joints in accordance with the details shown on the plans. The edges of the joint shall be grooved, edged, and sealed with the material used for sealing expansion and contraction joints. No construction joint shall be placed within three (3) m of an expansion, contraction, or other construction joint.

Permanent Header Board

(1) Immediately after the forms are removed from the ends of concrete pavement that will be exposed to other than permanent type surfacing and temporary and permanent traffic, a header board having dimensions of not less than eight (8) cm (nominal) by twenty (20) cm shall be bolted securely to the end of the pavement in a manner to protect the edge of the pavement from damage. The header board shall extend the full roadway width, but may be in two (2) sections. At the time of placing the concrete, thirteen (13) mm by twenty (20) cm bolts (three for each lane), shall be embedded in the end of the pavement in a manner that will hold the header board securely. The header board shall be shaped to conform to the crown of the pavement and shall be installed flush with the concrete pavement surface. The finishing and installing of the header board shall be considered incidental to the other items in the Bill of Quantities and will not be paid separately. The header board will not be required on concrete base course Work.

314.04.7 Consolidating and Finishing

(1) After being spread and struck-off, as provided in section 501.04, subparagraph D.5. "Placing Concrete," the concrete shall be further struck-off and consolidated with an approved finishing machine to such an elevation that when finishing operations are completed, the surface will conform to the required grade and crown. The finishing machine shall operate over the entire surface at least twice, the first time with the finishing machine tamper and both screeds in operation. Excessive tamping or finishing resulting in bringing an excess of mortar to the surface will not be permitted.

(2) After the last pass of the finishing machine, a mechanical longitudinal finisher shall be operated over the concrete surface.

(3) The forward motion of the longitudinal finisher shall be so adjusted that the screed will pass over each portion of the surface at least twice. The longitudinal finisher shall be operated in a manner that will prevent excessive slumping of the concrete at the form lines or the metal centre strip or the loss of the crown of the pavement. If necessary or when ordered by the Engineer, the finisher shall be operated in one direction only or shall be operated from only the form to the centreline in order to ensure that the proper cross section of the pavement is obtained. The leading edge of the screed shall clear the forms upon completion of each transverse pass in order to clear the pavement surface of any laitance or thin mortar.

(4) In general, the addition of superficial water to the surface of the concrete to assist in finishing operations will not be permitted. If the application of water to the surface is permitted by the Engineer, it shall be applied as a fog spray by means of approved spray equipment.

(5) As an alternative to the longitudinal finisher, the Contractor may use a machine composed of a cutting and smoothing float, or floats, suspended from and guided by a rigid frame. The frame shall be carried by four (4) or more visible wheels riding on, and constantly in contact with, the side forms.

(6) When directed by the Engineer, following one of the preceding methods of longitudinal finishing, long-handled floats having blades not less than one and one-half (1.5) m in length and fifteen (15) cm in width shall be used to smooth and fill in open-textured areas in the pavement. Long-handled floats shall not be used to float the entire surface of the pavement in lieu of, or supplementing, one of the preceding methods of longitudinal finishing.

(7) When the longitudinal finishing has been completed, the entire surface shall be tested with straightedges not less than three (3) m in length. The straightedges shall be operated parallel to the pavement centreline starting at the centre and progressing toward the forms. Advance along the pavement shall be in successive stages of not more than one-half (1/2) the length of the straightedges. All laitance, surplus water, and inert material shall be removed from the surface. All high places shall be worked down and all low places filled by combined operations of floats and straightedges until no irregularities exist. The

proper crown of the pavement shall be maintained throughout the operations. After floating and straight-edging has been completed, the concrete shall be finished by using a belt made of canvas, rubber, or other approved belting not less than fifteen (15) cm in width, nor less than sixty (60) cm longer than the width of the pavement. This belt shall be worked with a longitudinal and crosswise motion. Care shall be exercised in the use of the belt to ensure that the edges of the belt do not dig into the surface of the concrete or work the crown out of the pavement. Either machine belting or hand belting will be permitted.

(8) As soon as all excess moisture has disappeared, and while the concrete is still plastic enough to make a granular surface possible, a drag shall be used which shall consist of a seamless strip of damp burlap or cotton fabric, which shall produce a uniform surface of gritty texture after dragging it longitudinally along the full width of pavement. For pavement five (5) m or more in width, the drag shall be mounted on a bridge that travels on the forms. The dimensions of the drag shall be such that a strip of burlap or fabric at least one and one-half (1.5) m wide is in contact with the full width of pavement surface while the drag is used. The drag shall consist of not less than two (2) layers of burlap with the bottom layer approximately fifteen (15) cm wider than the upper layer. The drag shall be maintained in such condition that the resultant surface is of uniform appearance and reasonably free from grooves over two (2) mm in depth, as determined by the Engineer. Drags shall be maintained clean and free from encrusted mortar. Drags that cannot be cleaned shall be discarded and new drags substituted.

(9) After dragging the surface with burlap, the concrete over the expansion joint filler shall be completely removed and the joint finished. The edges of the concrete at expansion joints shall be grinded with an edger to the radius shown on the plans. The exposed edge of the pavement shall be finished with an edger to a radius of six (6) mm. Any tool marks appearing on the slab adjacent to the joints or on the edge of slab shall be eliminated by dragging the surface. In doing this, the rounding of the corner of the slab shall not be disturbed.

Hand Finishing

(1) Unless otherwise specified, hand-finishing methods will not be permitted except under the following conditions:

- (i) In the event of breakdown of the mechanical equipment, hand methods may be used to finish the concrete already deposited on the grade when the breakdown occurs, and no additional concrete shall be placed until such equipment is repaired to the satisfaction of the Engineer.
- (ii) Narrow widths or areas of irregular dimensions where operations of the mechanical equipment is impractical as determined by the Engineer, may be finished by approved hand methods.
- (iii) Short lengths of pavement, where in the opinion of the Engineer it is unreasonable to mobilize mechanical finishers and at bridge approach pavements, where the operation of mechanical equipment is impractical may be finished by approved hand methods.

(2) Concrete, as soon as placed, shall be struck-off and screeded. An approved portable screed shall be used. A second screed shall be provided for striking-off the bottom layer of concrete if reinforcement is used.

(3) The screed for the surface shall be longer than the maximum width of the slab to be struck-off. It shall be of approved design, sufficiently rigid to retain its shape, and be constructed either of metal or other suitable material shod with metal.

(4) Consolidation shall be attained by the use of a suitable vibrator or other approved equipment.

(5) In operation the screed shall be moved forward on the forms with a combined longitudinal and transverse shearing motion, moving always in the direction in which the work is progressing and so manipulated that neither end is raised from the side forms during the striking-off process. If necessary, this shall be repeated until the surface is of uniform texture, true to grade and cross section, and free from porous areas.

(6) After the concrete has been struck-off, it shall be further smoothed, made true to line and level, and consolidated by means of a longitudinal float. The hand-operated longitudinal float shall be not less than three and one-half (3.5) m in length and fifteen (25) cm in width, properly stiffened to prevent flexing and warping. The longitudinal float, operated from foot bridges resting on the side forms and spanning but not touching the concrete, 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. Movement ahead along the centreline of the pavement shall be in successive advances of not more than one-half (1/2) the length of the float. Any excess water or soupy material shall be wasted over the side forms on each pass. At the option of the Engineer, the long-handled floats having blades not less than one and one-half (1.5) m in length and fifteen (15) cm in width may be substituted for the hand-operated longitudinal float. All other operations after this substitution for the mechanical equipment shall be performed in the manner previously described. Concreting operations shall be performed only in daylight. Under no circumstances shall concrete pavement be placed or finished at night.

314.04.8 Removing Forms

(1) Unless otherwise provided, forms shall not be removed from freshly placed concrete until it has set for at least twelve (12) hours, except auxiliary forms used temporarily in widened areas. Forms shall be removed carefully so as to avoid damage to the pavement. After the forms have been removed, the sides of the slab shall be cured as specified for the surface. Major honeycombed areas will be considered as defective work and shall be removed and replaced at the Contractor's expense, as directed by the Engineer. Any area or section so removed shall not be less than three (3) m in length nor less than the full width of the lane involved. When it is necessary to remove and replace a section of pavement, any remaining portion of the slab adjacent to the joints that is less than three (3) m in length, shall also be removed and replaced.

314.04.9 Protecting and Curing of Concrete Pavement

Initial Curing

(1) As the surface of the newly laid pavement is progressively finished, the initial curing and protection operations shall be started. Upon completion of the finishing operation and while the surface of concrete is still moist, but no free water remains, a liquid curing membrane, as specified in AASHTO M 148 (Type 2) shall be applied to the exposed surfaces of the pavement at the rate of not less than one (1) litre per 3.67 square meters of surface area when mechanical pressure distributors are used. The curing membrane, except on irregular areas, shall be applied by means of approved self-propelled mechanical pressure distributors or approved hand sprays. Satisfactory means shall be provided for thoroughly mixing the curing membrane compound before and during its use. The mechanical spraying equipment may be either a full width spray bar equipped with multiple nozzles or a traversing spray that travels from one edge of the pavement to the other. In either case the path of adjacent nozzles or passes of the traversing spray shall overlap a minimum of one-half (1/2) the width of the spray pattern so that all portions of the surface shall receive double applications from adjacent nozzles or passes. The pumping, pressure, and distribution arrangement shall be correlated with the forward speed to provide adequate and uniform coverage of the pavement at not less than the minimum rate required.

(2) Irregular areas to which the mechanical distributor cannot be adapted may be covered with hand sprays. When hand sprays are used, the curing membrane shall be applied in two (2) applications, each at a rate of not less than one (1) litre per five (5) square meters of surface area so as to provide a total rate of application of one (1) litre per two and one-half (2-1/2) square meters of surface area. The path of the spray on the second application shall be at right angles to the path of the spray on the first application. When hand operated sprays are permitted, the equipment supplying the pressure to the spray nozzle shall be capable of supplying a constant and uniform pressure to provide uniform and adequate distribution of the curing membrane compound at the rates required. If from any cause, such as rainfall soon after its application, the curing membrane is damaged, the Contractor shall immediately apply another application of curing membrane to the surface of the pavement. The rate of application for the replacement membrane shall be the same as for the original membrane.

(3) Unless otherwise directed by the Engineer, immediately following the application of the curing membrane, if approved, shade-canvas shall be placed approximately thirty (30) cm above the pavement surface. The shade-canvas shall be constructed of materials and in a manner approved by the Engineer. In no case shall any portion of the shade-canvas come in contact with the pavement. The initial curing shall be continued for a period of twenty-four (24) hours from the time the curing membrane is applied. When forms are removed, whether during the initial or the final curing period, the edges of the pavement shall receive curing membrane at the rate of coverage specified for the pavement surface. The curing membrane may be applied to the vertical edges of the pavement by means of hand sprays or by nozzles attached to the mechanical distributor, but the edges of the pavement shall be covered with curing membrane at the rate specified within thirty (30) minutes after removal of the forms.

(4) When cold-poured joint compound is used, all joints shall be sawed during the initial curing period. The shade-canvas may be moved at joint locations for short periods of time to permit the sawing. Before being sealed, the joints shall be thoroughly cleaned of all loose saw dust, laitance, dirt, other foreign matter, and made free of water. As the method of final curing is different from that of the initial curing, the cleaning, and sealing of joints shall be performed immediately following the removal of the shade-canvas at the end of the initial curing period and prior to the application of the plastic sheeting.

(5) When hot-poured joint compound is used, the joints shall be sawed, cleaned, and filled with jute or other acceptable protective material in the same time sequence as for cold-poured joints. In no case shall any portion of the concrete pavement be exposed to the direct rays of the sun for more than one (1) hour.

(6) Following jointing operations, curing membrane shall be applied to the joint area at the rate specified for the pavement surface.

Final Curing

(1) Upon completion of the initial curing period and after the shade-canvas has been removed and jointing operation has been completed, the pavement shall be completely covered with White Opaque Polyethylene Film as specified in AASHTO M 171. Adjoining sheets shall be lapped a minimum of forty-five (45) cm. The sheeting shall be held in place in a manner approved by the Engineer.

(2) Final curing shall be continued until the concrete reaches an age of fourteen (14) days. During this period, the curing membrane and polyethylene film shall be protected from damage from any cause. Any damage from any cause, shall be repaired immediately, by the Contractor at his expense. No traffic, not even workmen, pedestrians, or animals shall be allowed on the surface of the pavement until the expiration of the fourteen (14) day curing period.

Cold Weather Curing

(1) When concrete is being placed during the time that the air temperature may be expected to drop below fifteen (15) degrees C, a sufficient supply of burlap, straw, hay, or other suitable blanketing material shall be provided along the work to protect the concrete and maintain a minimum temperature of fifteen (15) °C in the concrete as measured on the surface of the pavement. An approved moisture barrier such as wet burlap or plastic sheeting shall be placed on the concrete prior to placing the blanketing material. This type cure shall be maintained for a period of seventy-two (72) hours as the initial cure. After the initial cure as specified above, a final cure as specified in 314.04.9 "Protecting and Curing of Concrete Pavement - Final Curing" may be used. The final cure shall be maintained for a period of fourteen (14) days, thus making a seventeen (17) day curing period for cold weather concreting.

Early Strength Concrete Curing

(1) The curing of early strength concrete pavement shall conform to the requirements specified for concrete pavement except that the total curing period shall be a minimum of seven (7) days.

314.04.10 Sealing Joints

(1) Joint sealing shall consist of cleaning the joint in preparation for sealing and sealing all contraction and expansion joints in the concrete pavement with hot or cold applied joint sealing material. The work shall be in accordance with the Drawings and as follows.

- (2) Application of the joint sealer shall be made when the joint surfaces are clean and dry, but joints shall not be sealed until they have been inspected and approved by the Engineer.

Materials

- (1) Joints shall be sealed with material of the type designated on the drawings and these specifications or as directed by the Engineer.

Hot-Poured Joints

- (1) The joints shall be sawed as provided in Section 314.04.06 “Contraction Joints” and covered as provided in Section 314.04.06. After the fourteen (14) or seventeen (17) days curing period for the pavement has elapsed, the jute or other protective covering shall be removed from the joint.

- (2) Immediately before sealing the joint thoroughly clean the joints of all laitance, curing compound and other foreign material. Exposed joint faces shall be cleaned by sandblasting, or by water blasting with sufficient pressure to thoroughly and completely clean the joint. A multiple-pass technique shall be used until the surfaces are free of material that might prevent bonding. For final cleaning immediately prior to installation of the sealer, the joints shall be blown clean with oil-free compressed air. The joint faces must be surface dry when sealant is applied.

- (3) The sealing compound shall be heated to the pouring temperature recommended by the manufacturer in an approved kettle or tank, constructed as a double boiler, with the space between the inner and outer shells filled with oil or other satisfactory heat transfer medium. The heating kettle shall be equipped with a mechanical agitator, positive temperature control and an approved dial thermometer for checking temperatures of the compound. The heating kettle, if and when operated on concrete, shall be properly insulated against the radiation of heat to the concrete surface.

- (4) The sealing compound shall not be heated above the maximum safe heating temperature. The maximum safe heating temperature shall be determined from tests made on samples from each lot or shipment of the material delivered to the project. When so approved by the engineer, the manufacturer's recommended maximum safe heating temperature may be used in lieu of test determinations where relatively small quantities of sealer are used. Any material heated above the maximum safe heating temperature shall be discarded.

- (5) Pouring of joints shall be made when the sealing material is at the required temperature and, insofar as practicable, the sealing compound shall be maintained at a uniform temperature during pouring operations. Pouring shall not be permitted when the temperature of the sealing compound in the applicator, as it is applied to the joint, is more than the recommended pouring temperature. Pouring of the molten sealer in the joint opening shall be done with such equipment that the sealer completely fills the joint opening without overflowing on the adjoining pavement surface and when finished, after shrinkage, the sealer is approximately flush with the adjoining pavement surfaces.

- (6) In the event satisfactory sealing of a joint is not accomplished in a single pouring, the sealing compound shall be placed in two pourings. At least one-half of the required amount shall be placed in the first pouring, and the second pouring shall follow the first as soon as practicable after the first pouring has attained maximum shrinkage but not later than one hour after the first pouring..

- (7) Any joint with a depth greater than twenty-five (25) mm shall be filled with a minimum of two (2) layers, each layer being approximately equal in depth.

Cold-Poured Joints

- (1) The joints shall be sawed as provided in Section 314.04.06 “Contraction Joints”, and cleaned of all loose saw dust, laitance, dirt, other foreign matter, and free water.

- (2) The joints shall be filled immediately after cleaning. The nozzle used must be so designed that the joint is filled completely from bottom to top. The joint shall be filled so it is rounded on top about six (6) mm above the pavement surface. Immediately after the joints have been filled, they shall be covered with a strip of non absorptive paper at least four (4) cm wide. The paper shall remain on the joint until it weathers or wears off.

314.04.11 Surface Trueness

(1) As soon as the concrete has hardened sufficiently, the pavement surface shall be tested with a three (3) m straightedge or other specified devices. Areas showing high spots of more than three (3) mm, but not exceeding twelve (12) mm in three (3) m between any two contact points, shall be marked and immediately ground down with an approved grinding tool to an elevation at which the area or spot will not show surface deviations in excess of three (3) mm when tested with a three (3) m straightedge. Where the departure from correct cross section exceeds twelve (12) mm, the pavement shall be removed and replaced by and at the expense of the Contractor.

(2) Any area or section so removed shall be not less than three (3) m in length nor less than the full width of the lane involved. When it is necessary to remove and replace a section of pavement, any remaining portion of the slab adjacent to the joints that is less than three (3) m in length, shall also be removed and replaced at the Contractor's expense.

314.05 PAVEMENT TOLERANCES

(1) The thickness of the pavement will be determined by average calliper measurement of cores. The tolerance allowed for concrete pavement thickness shall be no more than 5 mm less than the approved design thickness. The Engineer may reject any pavement that is either less than an average of 20 mm from the centre line than the specified width over a 100m section or an average of 5mm less than the specified thickness measured at five (5) points in an area of 100m².

314.06 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
314-1	Plain Concrete Pavement, ____ mm thick	Metre Square
314-2	Reinforced Concrete Pavement, ____ mm thick	Metre Square

(2) Only concrete with iron bars is measured as reinforced concrete. All other concrete, -including concrete with or without wire mesh-, is measured as plain concrete.

(3) The area to be paid for under this item will be the number of square meters of "Concrete Pavement" completed and accepted as measured complete in place. The width for measurement will be the width of pavement shown on the typical cross sections on the plans and any additional widening directed in writing by the Engineer. The length will be measured horizontally along the centreline of each roadway.

(4) The quantity of concrete pavement accepted for measurement shall not include areas where the concrete pavement is thinner than the accepted minimum thickness or any cracked or tapered portions along the edges of the pavement, poorly cured or otherwise damaged. When the average thickness of the pavement is deficient by more than five (5) mm, based on the thickness required by the typical cross sections shown on the plans or as directed by the Engineer an adjusted unit price will be paid based on the average measured core thickness, as follows:

(5) Unit price adjustment factor = (accepted average core thickness / approved design thickness)

(6) No measurement will be made of unauthorized areas or for extra thickness. The Contractor shall be paid for the calculated quantity based on the design width and thickness.

314.07 PAYMENT

(1) The amount of completed and accepted Work, measured as provided above, will be paid for at the unit price(s) bid in the Bill of Quantities per square meter for “Plain Concrete Pavement,” or for “Reinforced Concrete Pavement”, which price(s) shall be full compensation for furnishing, quarrying, preparing, transporting, delivering and placing all materials, including forms, reinforcing steel, contraction and expansion joint assemblies, joint sealant, etc., for all curing, and for all labour, equipment, tools and all other items necessary for the proper completion of the Work.

SERIES 400
DRAINAGE

SECTION 401

BOX CULVERTS

401.01 DESCRIPTION

- (1) The work covered by this Section consists of the construction of new concrete box culverts, headwalls, wing-walls and aprons, the extension of existing box culverts and the extension of existing headwalls and wing-walls (with or without extension of the culvert itself).
- (2) It also includes the resealing of damaged joints in existing culverts, as required.

401.02 MATERIALS

- (1) All materials shall comply with the requirements prescribed elsewhere in the Specifications for the various items which constitute the complete structures.

401.03 CONSTRUCTION REQUIREMENTS

401.03.1 Preliminaries

- (1) Existing culverts and roadside ponds are currently used by the local population for a variety of uses. Prior to starting work at any culvert location the Contractor shall consult with the village head and take steps to ensure the work has a minimum detrimental impact on the use by the local population. The findings of each consultation shall be reported in writing to the Engineer and work shall not proceed without the Engineer's approval.
- (2) Proposed culvert locations/levels as shown on the Drawings are approximate only and may need to be adjusted to best suit the existing topographic conditions at the site.
- (3) At least 4 weeks before the Contractor proposes to commence construction at a culvert location (existing or proposed) he shall conduct a detailed topographical area of the culvert location including the upstream and downstream stream channels. The Contractor shall document the survey as a plan with appropriate cross sections, and submit the same to the Engineer who will instruct the exact levels/extends to which the culvert works are to be constructed.

401.03.2 Excavation of Trenches

- (1) Excavation of foundation trenches and backfilling shall conform to the requirements of Section 207 of the Specifications.
- (2) Aprons and key walls shall generally be carried down to the depth shown on the Drawings at both ends, but the Engineer may order such additional depth as is necessary to prevent undermining.
- (3) Where, in the opinion of the Engineer, the bearing capacity at the foundation level is insufficient or the foundation material is otherwise unsuitable, the Contractor shall remove the unsuitable material to at least 0.50 metres below foundation level and replace it with an approved free draining material, or a granular backfill and compacted as directed by the Engineer.
- (4) Where rock, hardpan or other unyielding material is encountered less than 0.30 metres below the bottom of the base slab under box culverts, or in rock cuts where rock is not uniform over the whole length of culvert, trenches for box culverts shall be excavated down to 0.30 metres below the bottom of the base slab. This extra depth excavation shall be backfilled with an approved free draining material, or a granular backfill. The backfill material shall be uniformly distributed in layers not exceeding 150 mm and compacted to the required density.

(5) Where rock is uniform over the whole length of a box culvert, trench excavation shall be carried down only to the bottom of the slab. If the Contractor excavates below the required levels, he shall backfill the over-depth excavation with Grade 15 blinding concrete at his own cost.

(6) Where the Contractor is instructed to replace an existing roof slab on an existing culvert, excavation will be measured in the same way as structural excavation for a footing having the same plan area as the slab to be replaced, in accordance with Clauses 207.04 and 207.05 of the Specifications. The volume shall be that between the top of the slab and the surveyed section through the existing road along the centreline of the culvert. Removal of the roof slab will be measured as removal of structure in accordance with Clauses 202.03 and 202.04 of the Specifications. Payment will be made under Item 202-1 of the Bill of Quantities.

401.03.3 General

(1) After the foundation material has been approved by the Engineer and before the foundation deteriorates in any way, it shall be covered with Grade 15 blinding concrete with a minimum thickness of 50 mm.

(2) Box culverts shall be cast in-situ in general accordance with the details shown on the Drawings, as adapted to the actual site conditions.

(3) The construction methods used shall conform to the requirements of Sections 505, 506, 507 and 512 of the Specifications subject always to the requirements of this Section 401.

(4) In general, the base slab of box culverts shall be placed and allowed to set before the culvert is constructed. The side walls and top slab may be constructed as a monolith.

(5) If the concrete in the walls and top slab is placed in two separate operations, special care shall be exercised in order to secure bonding in the construction joint and appropriate keys shall be left in the sidewalls for anchoring the top slab.

(6) Each wing-wall shall be constructed, if possible, as a monolith. Construction joints where unavoidable, shall be horizontal and so located that no joints will be visible in the exposed face of the wing-wall above the ground line.

(7) Vertical construction joints shall be at right angles to the axis of the culverts.

(8) Masonry works on headwalls, wing-walls and aprons shall be done according to applicable parts of Section 602.

401.03.4 Inlet and Outlet Structures

(1) The layout of the inlet and outlet structures may be modified at the discretion of the Engineer, based on the actual natural conditions at each site, and the standard details shown on the Drawings.

(2) The inlet and outlet scour and erosion protection measures shall be constructed from gabions, mattresses or masonry as specified on the Drawings and shall be adapted to the drainage system to form a natural and smooth watercourse.

401.03.5 Extension of Existing Box Culverts

(1) Existing box culverts shall be extended in reasonably close conformity with the details shown on the Drawings.

(2) Concrete and reinforcement details and dimensions shall be as shown on the Drawings for new box culverts, but adapted to the size of the culvert to be extended.

(3) Where required, existing inlet or outlet structures and culvert barrels shall be removed to the satisfaction of the Engineer.

(4) The joints between existing and new parts shall be deformation joints conforming to the details shown on the Drawings and specified herein.

401.04 CULVERT JOINTS

- (1) The existing wing-walls and headwall shall be broken out carefully and to the extent necessary to expose sound concrete the end face of the barrel. Any longitudinal steel through the joint shall be cut back to give 30 mm of cover to the new end faces. The exposed end shall be made good to a vertical plane in accordance with the requirements specified for cementitious patch repairs Section 512 of the Specifications.
- (2) The joint between the existing concrete and the extension shall consist of an approved 12 mm thick, bitumen impregnated fibre board that remains resilient when saturated.

401.05 REPAIRS AND REFURBISHMENT

- (1) Any other repair or refurbishment to box culverts instructed by the Engineer, will be deemed to be refurbishment of structure and will covered and paid for in accordance with Sections 511 and 512 of the Specifications.

401.06 MEASUREMENT

- (1) Measurement will be as follows:

Item No.	Description	Unit
401-1	Concrete for Box Culverts	Metre Cube
401-2	Steel Reinforcement for Box Culverts	Tonne
401-3	Masonry for Headwalls, Wing-walls and Aprons	Metre Cube

- (2) The removal of structures for the extension of existing culverts or the replacement of roof slabs shall be measured and paid for under Section 202 of the Specifications.
- (3) Excavation and backfilling shall be measured under Section 207 of the Specifications.
- (4) Concrete shall be measured for the several structural members involved; including barrels, precast soffits, headwalls, wing-walls and aprons for box culverts. Measurements shall be based on the dimensions shown on the Drawings or as directed by the Engineer. No deduction shall be made for the volume occupied by reinforcing steel, anchors, conduits, weep-holes, or chamfers.
- (5) Steel reinforcement shall be measured as detailed in Section 506 of the Specifications.
- (6) Measurements of stone masonry shall be based on the dimensions shown on the Drawings or as directed by the Engineer. No deduction shall be made for the volume of any weep-holes.
- (7) Culvert joints at culvert extensions shall not be measured.
- (8) No measurement shall be made for unauthorised areas, making good over-break of demolition, or extra thickness.
- (9) No measurement shall be made for blinding concrete.

401.07 PAYMENT

- (1) The cost of all structural excavation and backfill, replacement of unsuitable material and providing backfill over excavations in rock, will be paid for under Series 200 of the Specifications.
- (2) Apron protection for inlets and outlets will be paid for under Section 404 of the Specifications.
- (3) No payment will be made for making joints between new and existing concrete.
- (4) No payment will be made for blinding concrete.

SECTION 402

PIPE CULVERTS

402.01 DESCRIPTION

(1) The work covered by this Section shall consist of furnishing and installing precast and/or cast-in-place reinforced concrete pipe culverts as well as extending existing pipe culverts, of various diameters as and where shown on the Drawings, or as instructed by the Engineer, including all necessary excavation, bedding, and backfilling, all in accordance with the lines, grades and profiles shown on the Drawings or established by the Engineer.

(2) The work also includes the construction of concrete or masonry inlet and outlet structures of pipe culverts, i.e. aprons, wing-walls and headwalls; and the re-sealing of joints in existing culverts.

402.02 MATERIALS

402.02.1 General

(1) Reinforced concrete pipe culvert shall be precast unless cast-in-place construction is shown on the Drawings or approved by the Engineer.

(2) All materials shall comply with the requirements prescribed elsewhere in the Specifications for the various items which constitute the complete structures.

402.02.2 Precast Pipes Manufactured Off-Site

(1) Precast pipes shall meet all applicable requirements of AASHTO M 170 or ASTM C76 (these two standards are the same), Classes I to V, or otherwise as shown on the Drawings or directed by the Engineer.

(2) Acceptability of pipe shall be based on inspection of the finished pipe by the Engineer and/or the results of one or more of the following AASHTO T 280 tests as may be deemed necessary by the Engineer:

- (a) the three-edge bearing test for the load to produce a 0.25 mm crack and/or the ultimate load, performed on not less than 2% of all pipes furnished;
- (b) the loading to destruction of selected pieces of pipe to determine ultimate strength, area and placement of steel and absorption characteristics of the concrete; and
- (c) absorption tests on selected samples from the wall of the pipe.

402.02.3 Precast Pipes Manufactured On-Site

(1) The Contractor shall, in addition to the requirements specified herein, comply with all of the requirements of those sections of Section 500 of the Specifications as deemed applicable by the Engineer. Pipe cast on the site shall be as detailed on the Drawings.

(2) The acceptability of pipes manufactured on-site shall be based on results obtained from laboratory-cured concrete compressive strength cylinders tested in accordance with AASHTO T 22, and conforming to the other requirements stated herein.

(3) Pipes represented by tests cylinders which fail to meet the strength requirements shown on the Drawings (but are in no case below 80% of the specified design strength), shall be marked accordingly, and may be used provided that the full length of the culvert in which they are used shall be carefully bedded in a Grade 15 concrete cradle. The minimum thickness of the cradle under the pipe shall be 1/4 of the nominal internal diameter of the pipe, and it shall extend up the sides of the pipe to a height equal to 1/4 of the external diameter of the pipe. The concrete cradle shall extend the full width of the trench, or as ordered by the Engineer, but in no case shall it extend, at its narrowest point, less than 150 mm from the outside of the pipe on each side. Concrete cradle bedding installed for the purpose of counteracting under-strength pipe shall be at the cost of the Contractor.

(4) Pipes represented by test cylinders that fail to meet 80% of the specified design strength shall be destroyed and disposed of by the Contractor as directed by the Engineer.

402.02.4 Cast-in-Place Pipes

(1) Cast-in-place pipes shall be constructed to the details shown on the Drawings or as otherwise proposed by the Contractor and approved by the Engineer. Where the Engineer determines that there has been a deviation from the approved manner of construction, this will be a basis for rejection, and the subsequent removal and reconstruction of the culvert. Cast-in-place pipes shall conform to the requirements of the appropriate Clauses of Section 500 of the Specifications.

(2) Acceptability of cast-in-place pipes shall be based on results obtained from laboratory-cured concrete compressive strength cylinders tested in accordance with AASHTO T 22, and conformance to the other requirements stated herein.

402.02.5 Testing of Precast Concrete Pipe

(1) If the Contractor elects to purchase pipe from a source off the Contract, all relevant provisions of these Specifications shall apply. Pipe not available for testing and inspection during manufacture shall be tested on the Site.

(2) The Contractor shall at his own cost, when directed by the Engineer, provide three-edge bearing test equipment to allow on-site testing in accordance with AASHTO T 280.

(3) The test equipment shall remain on-site until such time as the Engineer releases it. The Contractor shall carry out the three-edge bearing tests as ordered by, and in the presence of, the Engineer.

402.02.6 Requirements for Finished Products

(1) Pipe ends shall be perpendicular to the walls and the longitudinal axis of the pipe.

(2) The inner and outer surface of the pipe shall be even and smooth. The whole pipe shall be free from fractures, cracks, honeycombing, open texture, spalls and surface roughness.

(3) The permissible variations in dimensions shall be as specified in AASHTO M 170, unless otherwise permitted by the Engineer.

(4) A wall thickness more than that required by the Drawings shall not be a cause for rejection. Pipes having local variations in wall thickness exceeding those specified in AASHTO M 170 may be accepted if the three-edge bearing strength and minimum steel cover requirements are met.

(5) The following information shall be clearly marked on each section of the precast concrete pipe:

- pipe class and internal diameter
- date of manufacture
- name or trademark of the manufacturer

402.02.7 Inspection and Rejection

- (1) The quality of all materials, the process of manufacture and the finished pipes shall be subject to inspection, testing and approval at the place of manufacture. The Contractor shall make the necessary arrangements to set aside, in a separate area, all pipes for which he desires approval.
- (2) Pipes shall be rejected if they fail to conform to any of the specified requirements or if they have:
- (a) serious fractures or cracks; or
 - (b) defects that indicate imperfect proportioning, mixing and moulding; or
 - (c) surface defects indicating honeycombed or open texture or exposure of reinforcement; or
 - (d) exposed or seriously misplaced reinforcement (verified by checking with an approved concrete reinforcement cover-meter); or
 - (e) damaged or cracked ends where such damage would prevent a satisfactory joint.
- (3) Precast pipes with minor damage resulting from imperfections in manufacture or from handling and transporting may be repaired in the field, subject to the approval of the Engineer. The repairs shall be sound, properly finished and cured and the repaired pipe shall conform to the requirements of the Specifications in all respects. The repairs shall be subject to the approval of the Engineer before being utilised in the works.

402.03 CONSTRUCTION REQUIREMENTS

402.03.1 Preliminaries

- (1) Existing culverts and roadside ponds are currently used by the local population for a variety of uses. Prior to starting work at any culvert location the Contractor shall consult with the village head and take steps to ensure the work has a minimum detrimental impact on the use by the local population. The findings of each consultation shall be reported in writing to the Engineer.
- (2) Proposed culvert locations/levels as shown on the Drawings are approximate only and may need to be adjusted to best suit the existing topographic conditions on site.
- (3) At least 4 weeks before the Contractor proposes to commence construction at a culvert location (proposed or existing) he shall conduct a detailed topographical area measurement of the culvert location including the upstream and downstream stream channels. The Contractor shall document the survey as a plan with appropriate cross sections and submit the same to the Engineer who will instruct the exact levels/extends to which the culvert works are to be constructed.

402.03.2 General

- (1) Pipe culverts shall be installed in trenches excavated through previously constructed and compacted embankment or natural ground.
- (2) Trenches shall be excavated straight and true to the lines and levels shown on the Drawings, and in conformity with the requirements of Section 207 of the Specifications.
- (3) When pipes are placed in embankment, the trench shall be made after completing the embankment to the height above the pipes as shown on the Drawings or directed by the Engineer.
- (4) All trenches shall be excavated to such width as will give adequate room in the trench for the proper support of the sides of the trench, and shall be excavated to a sufficient depth and width to enable the pipe and any specified or agreed joint, bedding, haunching and surround to be accommodated. If not shown otherwise on the Drawings, trenches shall be of sufficient width to accommodate Contractor's available compaction equipment (e.g. plate compactor) in the trench at both sides of the culvert for proper compaction, up to a level 300 mm above the top of the pipe barrel, to facilitate backfilling.

(5) The Contractor shall replace at his own cost any pipes damaged by compaction equipment when embankment is placed over previously installed pipes.

(6) Once a trench has been excavated, the laying of bedding and pipes and the backfilling shall be performed as soon as practicable. If delay is inevitable for any reason, the Contractor shall take all necessary steps to protect the exposed trench.

(7) Masonry works on headwalls, wing-walls and aprons shall be done according to applicable parts of Section 602.

402.03.3 Additional Requirements

(1) Before any pipes are laid or any bedding material placed in the trench, the base of the excavation shall be trimmed true to cross section and gradient.

(2) Any part of the trench bottom which is disturbed or damaged shall be excavated to such additional depth as may be required by the Engineer and be made up to the proper level with suitable material and compacted to the approval by the Engineer.

(3) A layer of soil of adequate thickness above the base level shall be left to be compacted down to the designated level. The base of the excavation shall be tamped or rammed firm.

(4) Where a firm foundation is not encountered or where rock is, excavation of unsuitable material or rock and backfilling shall be performed in accordance with Sub-clause 401.03.2 of the Specifications.

402.03.4 Bedding

(1) The type of bedding shall be as ordered by the Engineer, and will vary depending on the type of soil encountered.

(2) The shape, dimensions and the construction requirements for the bedding type shall be in acceptable conformance with the Drawings.

402.03.5 Installation

(1) The pipe shall be carefully laid true to the lines and grades given, with groove ends upstream, and with the tongue end entered the full length into the adjacent section of pipe.

(2) The pipe placement shall begin at the downstream end.

(3) Each segment of pipe shall be in contact with the shaped bedding throughout its full length. Where variable shell thickness are encountered, the interior surface of those pipes shall be reasonably flush and even.

(4) Any pipe which is not in true alignment or which shows any undue settlement after laying shall be taken up and re-laid at the Contractor's cost. When shown on the Drawings or directed by the Engineer, sufficient camber shall be built into the pipe structure to allow for settlement from fill loads.

402.03.6 Joints in New Culverts and Culvert Extensions

(1) All joints shall be sealed with an approved jointing mortar consisting of 1 part Portland cement to 2 parts sand by volume. The quantity of water in the mixture shall be sufficient to produce a stiff workable mortar, but shall in no case exceed 27 litres per 50 kg sack of cement. Sand shall conform to AASHTO M 45 and cement shall conform to AASHTO M 85.

(2) The contact areas shall be clean and damp when mortar is applied. After applying mortar to the entire interior surface of the groove, the tongue end shall be forced into position. Any remaining voids in the groove shall be filled with a bead of mortar built-up around the joint. Internal joints shall be finished flush with the surface of the pipe. The external surface of joints shall be cured with burlap, and kept thoroughly moist for a minimum of 3 days.

(3) If rubber-gasket type of pipe is used, the joints shall be installed in accordance with the manufacturer's recommendations and care shall be taken that the gasket is not displaced.

(4) The interiors of pipes shall be kept free from all dirt, excess mortar and other foreign material as the laying work progresses, and shall be left clean on completion.

(5) At joints between existing culverts and culvert extensions, the head wall shall be broken out carefully to expose the end of the pipe. The joint between the new pipe and the existing shall be as detailed for the joints between new pipes.

402.03.7 Existing Joints Sealed with Sand/Cement Mortar

(1) These joints are generally to be found in pipes with diameters greater than 1 metre.

(2) Where instructed by the Engineer the existing joint shall be raked out to a minimum depth of 50 mm and the joint cleaned with a high pressure hose of water or otherwise to the satisfaction of the Engineer.

(3) The joint shall be backfilled with a cement sand mortar with proportions in the range of 1:2 to 1:2.5. The amount of water shall be no more than is required to produce a stiff mix with sufficient workability to be applied so as to fill the joint.

402.03.8 Existing Joints Sealed with Bituminous Material

(1) These joints are generally to be found in pipes of 1 metre diameter or less.

(2) Where instructed by the Engineer the existing joint shall be raked out to a minimum depth of 20 mm or to sound existing joint material, and the joint cleaned. The method of cleaning shall be in accordance with the printed instructions of the manufacturer of the replacement material and good practice, as approved by the Engineer.

(3) The replacement material shall be a proprietary rubberised bituminous joint sealant manufactured specifically for the intended purpose by a reputable manufacturer, supported by documentary evidence of test results, and approved by the Engineer.

402.03.9 Handling

(1) During loading and unloading operations pipes must be handled by approved lifting tackle. Unloading by rolling down planks or any other form of inclined ramp will not be allowed without the specific written approval of the Engineer.

(2) Lifting devices shall have a sufficient bearing area on the pipe to prevent damage resulting from a concentration of stresses.

(3) Movement of construction equipment over a culvert shall be at the Contractor's risk. Any pipe damaged thereby shall be repaired or replaced to the satisfaction of the Engineer at the Contractor's cost.

402.03.10 Cast-in-Place Concrete Pipe

(1) The pipes shall be constructed in accordance with the details shown on the Drawings, or in an alternative manner proposed by the Contractor and approved by the Engineer. The pipe shall be carefully formed true to the required lines and grades.

(2) When the Contractor elects to construct the pipe in a trench with no external vertical forms, 40 mm of additional reinforcing steel clearance shall be provided. No additional payment will be made for the increased quantity of concrete required.

(3) Longitudinal construction joints will only be permitted as shown on the Drawings. Transverse construction joints may be permitted subject to the prior approval of the Engineer. Continuance of such approval shall be contingent on the construction of the joints in a satisfactory and acceptable manner.

(4) All forms for cast-in-place pipe shall be approved by the Engineer prior to their use. The internal forms shall be of metal suitably stiffened and supported so as not to yield during the placing of the concrete. The face of the forms shall be such as to provide a smooth and even internal surface.

402.03.11 Pipe Culvert Inlet and Outlet Structures

(1) Inlet and outlet structures shall be of concrete or stone masonry as specified on the Drawings, and shall be adapted to the drainage system to form a natural and smooth water course. Concrete work shall conform to the requirements of Sections 505, 506, and 507 of the Specifications in addition to this Section. Stone masonry shall conform to the requirements of Section 602 of these Specifications.

402.03.12 Backfilling

(1) Backfilling shall conform to the requirements of Section 207 of the Specifications, and as specified herein.

(2) Whenever practicable, backfilling shall be undertaken immediately after the preceding operations have been inspected and approved by the Engineer, so as to reduce the length of trenches open at any one time.

(3) Materials for backfill on each side of the culvert for the full trench width and to an elevation of 300 mm above the top of the culvert shall be fine, readily compatible soil or granular material selected from excavation or from a source of the Contractor's choice, and shall not contain stones that would be retained on a 50 mm sieve, lumps of highly plastic clay, or other objectionable material.

(4) Granular backfill material shall have not less than 95 percent passing a 12.5 mm sieve and not less than 95 percent retained on a 4.75 mm sieve. Oversized material, if present, shall be removed at the source of the material unless otherwise approved by the Engineer.

(5) Backfill material shall be placed at or near optimum moisture content and compacted in layers not exceeding 150 mm (compacted) on both sides to an elevation 300 mm above the top of the pipe. Care shall be exercised to thoroughly compact the backfill under the haunches of the pipe. The backfill shall be brought up evenly on both sides of the pipe for the full required length.

402.04 MEASUREMENT

(1) Measurement will be as follows:

Item No.	Description	Unit
402-1	Pipe Culvert, 600 mm diameter	Metre
402-2	Pipe Culvert, 750/800 mm diameter	Metre
402-3	Pipe Culvert, 900 mm diameter	Metre
402-4	Pipe Culvert, 1000 mm diameter	Metre
402-5	Pipe Culvert, 1200/1250 mm diameter	Metre
402-6	Pipe Culvert, 1500/1550 mm diameter	Metre
402-7	Concrete (Grade 25) for Headwalls, Wing-walls and Aprons	Metre Cube
402-8	Reinforcing Steel in Headwalls, Wing-walls and Aprons	Tonne
402-9	Reseal Mortar Joints	Metre
402-10	Reseal Bituminous Joints	Metre
402-11	Masonry for Headwalls, Wing-walls and Aprons	Metre Cube

- (2) The removal of structures for the extension of existing culverts will be measured and paid for under Section 202 of the Specifications.
- (3) Excavation and backfilling will not be measured separately but will be considered incidental to the Items No. 402-1 to 402-11.
- (4) Precast or cast-in-place pipe culverts will be measured along the centreline between the exterior faces of the headwalls as defined on the Drawings, and from end to end for pipe culverts without headwalls.
- (5) If the culvert constructed consists of double or triple pipes, then each pipe will be measured separately.
- (6) Cast-in-place concrete for inlet and outlet headwalls, wing-walls and aprons. will be measured as detailed in Section 507 of the Specifications.
- (7) Steel reinforcement shall be measured as detailed in Section 506 of the Specifications.
- (8) Joints between new culverts and culvert extensions will not be measured.
- (9) Blinding concrete, cradles supporting pipe culverts and mortar/ bituminous material for joining culvert segments will not be measured.
- (10) Measurements of stone masonry shall be based on the dimensions shown on the Drawings or as directed by the Engineer. No deduction shall be made for the volume of any weep-holes.

402.05 PAYMENT

- (1) Payment will be made at the rates entered in the Bill of Quantities.
- (2) The cost of excavation in common material will be deemed included in the unit rates entered for Items No. 402-1 to 402-6 in the Bill of Quantities.
- (3) The cost of excavation in rock material will be measured and paid for under Section 207 of the Specifications.
- (4) The cost of all backfilling, including replacement of unsuitable material and providing backfill over excavations in rock, and blinding concrete will be deemed to be included in the unit rates entered for Items No. 402-1 to 402-6 in the Bill of Quantities.
- (5) Payment for the “Pipe Culvert” items will include for steel reinforcement, formwork, concrete and other items required for construction of the pipe units.

SECTION 403

SUB-SURFACE DRAINS

403.01 DESCRIPTION

- (1) This work consists of constructing sub-surface drains as shown on the Drawings or instructed by the Engineer.

403.02 MATERIALS

- (1) All granular material required for the construction of sub-surface drains and other sub-drainage purposes shall consist of hard, durable, clean sand, gravel, or crushed stone. The material shall be free from organic material, clay balls, or other deleterious substances. Clay lumps and friable particles in the material shall be a maximum of 3% and the coarse aggregates shall have an abrasion loss of not more than 50%.

- (2) Coarse aggregate shall comply with the gradation requirements as follows:

AASHTO T 27 Sieve Size (mm)	Percentage Passing (by weight)
12.5	100
9.5	90 - 100
4.75	20 - 55
2.36	5 - 30
1.18	0 - 10
0.30	0 - 5

- (3) Fine aggregate shall comply with the gradation requirements of as follows:

AASHTO T 27 Sieve Size (mm)	Percentage Passing (by weight)
9.5	100
4.75	95 - 100
1.18	45 - 80
0.300	10 - 30
0.150	2 - 10

- (4) Pipes for sub-drains shall be perforated polyvinyl chloride (PVC) conforming to AASHTO M 278 or made of other material of at least the same quality, as detailed in the drawings or as directed by the Engineer.

- (5) Geotextile filter fabric shall be in accordance with the requirements of Sub-clause 601.02.3 of these Specifications.

403.03 CONSTRUCTION REQUIREMENTS

- (1) Trenches shall be excavated in the position and to the depth, width and grade as shown in the drawings or as directed by the Engineer. The base shall be carefully excavated and smoothed to be within 50 mm of the required levels and the walls sufficiently smooth to allow the geotextile fabric to be everywhere in close contact.

(2) The trench shall be lined with the geotextile filter fabric. There shall be no longitudinal laps. Transverse laps shall be avoided as much as possible. The minimum transverse lap length shall be 200 mm unless a greater overlap is recommended by the manufacturer.

(3) A nominal 150 mm thick layer of fine aggregate bedding material shall be placed in the trench and tamped and screeded to the required grade and level. The pipe shall then be embedded firmly in the bedding material, with a minimum grade of 1 in 250.

(4) The perforated pipe shall be installed with the perforations down. The last 3 metre section at the outlet may be non-perforated pipe. Pipe sections shall be joined securely with the manufacturer's recommended coupling fittings or bands.

(5) The perforated pipe shall be laid with the bell end upgrade. Upgrade ends of pipe installations shall be securely plugged by an approved means.

(6) Coarse aggregate shall be placed around the pipe to 150 mm above the crown of the pipe after the pipe installation has been inspected and approved by the Engineer. The backfill material shall be carefully compacted to avoid displacing the pipe. The remainder of the trench filled with fine aggregate and compacted in 150 mm maximum layers to the required height. The backfill shall be compacted in a manner approved by the Engineer.

(7) On completion, the pipe shall be flushed in the presence of the Engineer with sufficient water to remove material which has entered the pipe during installation and to ensure the pipe is free of obstruction.

403.04 MEASUREMENT

(1) Measurement will be as follows

Item No.	Description	Unit
403-1	Perforated PVC Pipe, ____mm diameter	Metre

403.05 PAYMENT

(1) Payment will be made at the rates entered in the Bill of Quantities.

(2) Payment shall include excavation, coarse and fine granular material for sub-surface drains, geotextile fabric, bedding, backfilling and flushing.

SECTION 404

DITCHES, APRON PROTECTION, INLET AND OUTLET STRUCTURES

404.01 DESCRIPTION

(1) The work covered by this Section consists of the construction of grouted rip-rap ditch lining, grouted rip-rap wash checks, reinforced concrete ditches, grouted rip-rap, stone masonry or gabion mattress apron protection, reinforced concrete wash checks, reinforced concrete inlet and outlet structures, grouted rip-rap or stone masonry inlet and outlet structures, and box gabions for slope protection at drainage structures. The work includes the construction of reinforced concrete toes for drainage chutes.

404.02 MATERIALS

(1) Material for grouted rip-rap shall conform to the requirements of Section 602 of the Specifications.

(2) Material for reinforced concrete shall conform to the requirements of Sections 506 and 507 of the Specifications.

(3) Material for and gabion mattresses shall conform to the requirements of Section 601 of the Specifications.

(4) Material for grouted rip-rap and stone masonry shall conform to the requirements of Section 602 of the Specifications.

404.03 CONSTRUCTION REQUIREMENTS

404.03.1 Excavation

(1) The excavation for side ditches shall be in accordance with Section 203 of the Specifications.

(2) Over-depth excavation below the elevation approved by the Engineer and over-width excavation beyond the lateral limits shown on the Drawings or directed by the Engineer, shall be backfilled with grouted rip-rap or concrete, at the Contractor's cost.

404.03.2 Reinforced Concrete for Drains, Wash Checks, and Inlet and Outlet Structures

(1) These shall be constructed to the dimensions shown on the Drawings with Grade 25 concrete in accordance with the requirements of Sections 506 and 507 of the Specifications.

(2) The locations shown on the drawings may be subject to variation based on the final road alignment and therefore all locations shall be confirmed by the Engineer prior to construction.

(3) The foundation surface shall be compacted to not less than 95% of maximum dry density as determined by AASHTO T 180.

(4) Reinforcement for drains shall be 8 mm bars at 150 mm C-C in either direction, both faces.

(5) Reinforcement for inlet and outlet structures shall be as indicated on the drawings.

(6) Construction joints for drains shall be provided at intervals of 4 metres or as otherwise directed by the Engineer.

404.03.3 Grouted Rip-rap or Stone Masonry Ditch Lining, Aprons, Wash Checks, and Inlet and Outlet Structures

- (1) The construction shall be in accordance with the requirements of Section 602 of the Specifications.
- (2) The foundation surface shall be compacted to not less than 95% of maximum dry density as determined according to AASHTO T 180.
- (3) The stones shall be placed in rows transversely to the centreline of the ditch and be placed with ends and sides abutting and the joints between stones in each row breaking with the joints in the preceding row.
- (4) After completing the laying work, the edges of the paved ditch adjoining the ground surface and shoulders shall be shaped and compacted to the required cross section.
- (5) The stones for wash checks shall be laid to form a structure of the dimensions shown on the Drawings. The sides and ends of the stones shall be in contact as much as the sizes and shapes of the stones will permit.

404.03.4 Loose Rip-rap Erosion Protection

- (1) The construction of loose rip-rap erosion protection shall be in accordance with the requirements of Section 602 of the Specifications.

404.03.5 Gabion Apron Protection

- (1) The construction shall be in accordance with the requirements of Section 601 of the Specifications.
- (2) The foundation surface shall be compacted to not less than 95% of maximum dry density determined according to AASHTO T 180.

404.04 MEASUREMENT

- (1) Measurement will be as follows:

Item No.	Description	Unit
404-1	Concrete (Grade 25)	Metre Cube
404-2	Reinforcement Steel	Tonne
404-3	Grouted Rip-rap	Metre Cube
404-4	Stone Masonry	Metre Cube
404-5	Loose Rip-rap	Metre Cube
404-6	Box Gabions	Metre Cube
404-7	Gabion Mattresses	Metre Cube
404-8	Geotextile Sheeting	Metre Square
404-9	Concrete Kerbs	Metre

- (2) Concrete (Grade 25) shall be measured as the volume required for reinforced concrete drains, inlets structures, and outlet structures in accordance with the dimensions shown on the drawings.
- (3) Grouted rip-rap and stone masonry ditch lining shall be calculated as the area ordered by the Engineer multiplied by the specified minimum thickness.
- (4) Ditch checks will not be measured separately.
- (5) Gabion mattresses shall be measured from the specified area and nominal thickness.

- (6) Geotextile sheeting shall be measured without consideration of overlaps.
- (7) Concrete kerbs shall be measured in linear metres and shall include only those kerbs required for the drainage structures as shown on the drawings.

404.05 PAYMENT

- (1) Payment will be made at the rates entered in the Bill of Quantities and shall include excavation, backfilling and compaction, grouting, blinding concrete, formwork, mortar, concrete, steel reinforcing, ditch checks and all incidental items.

SECTION 405

MINOR DRAINAGE STRUCTURES

405.01 DESCRIPTION

(1) The work covered by this Section consists of furnishing, constructing and/or installing miscellaneous types of drainage structures built according to the Specifications for concrete structures and in conformance with the Contract Drawings. Included are such items as inlet boxes, manholes, urban drains, irrigation slide gates, flap gates, spring boxes, pipe encasement, platforms, barriers and other incidental items not specified elsewhere.

405.02 MATERIALS

(1) Concrete shall conform to the requirements of Section 5.7 of these Specifications. Reinforcement, where required, shall conform to the requirements of Section 5.6 of these Specifications. Iron castings for frames, covers and gratings for manholes and inlets shall conform to the requirements of AASHTO M 105 Class 30.

(2) The Class of concrete for miscellaneous structures, shall be as shown on the Drawings.

(3) Concrete units may be cast-in-place or precast.

(4) Manhole and inlet steps shall meet the requirements of the latest edition of the ASTM A 207.

405.03 CONSTRUCTION REQUIREMENTS

(1) Construction methods given under Sections 5.7 and 5.6 of these Specifications for Concrete shall apply for this item except as noted herein or in the Special Provisions.

(2) Assemble precast concrete manhole sections with flexible gaskets or fillers in the tongue and groove joints. Handle the precast units carefully after the gasket has been attached to avoid damaging the gasket or contaminating the joint. Ensure gasket is uniformly applied and firmly fixed in place. Attain the proper alignment before the joints are fixed. Space ladder rungs in the manhole vertically aligned and 300 mm centre to centre. Grout ladder rungs into precast concrete walls.

(3) Underground drainage structures, including earthwork and backfilling incidental thereto, shall be completed before the adjacent roadway surfacing is placed, but pipe end-walls shall not be constructed until adjacent works has been completed, as developments during construction may justify alterations in design or location of such end-walls. Also manholes, catch basins and inlets shall not be completed to final grade until after the relevant operations have been finished and all necessary arrangements have been made to ensure suitable connections at proper grade and alignment with pavements, gutter, curbs, etc.

(4) Grates, and frames for grates, and covers for inlets and manholes shall be set in full beds of mortar or to be otherwise properly secured as indicated in the Drawings, so as to be held rigidly in place to proper grade and alignment.

(5) Inlet and outlet pipes at inlets and manholes shall be set or cut flush with the inside faces of the walls of such structures and shall extend a sufficient distance beyond the outside faces of the walls to provide ample room for making proper connections. The joint around the pipe in the structure wall shall be completely and neatly closed with mortar, or other material as may be specified, so as to make it watertight.

405.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
405-1	Precast U-Drain and Cover Slab	Metre
405-2	Side Drain Access Slab including Foundation	Metre
405-3	Manhole, Type _____	Metre Cube
405-4	Manhole, Type _____	Metre Cube
405-5	Manhole, Type _____	Metre Cube
405-6	Catch Basin, Type _____	Number
405-7	Drop Inlet	Metre Cube
405-8	RC Side Ditch, Type _____	Metre
405-9	RC Side Ditch, Type _____	Metre
405-10	RC Side Ditch, Type _____	Metre
405-11	(additional items as necessary)	

405.05 PAYMENT

(1) Payment will be made at the rates entered in the Bill of Quantities, which rates shall include full compensation for all necessary excavation, backfilling, formwork, concrete, reinforcement, all materials including cast iron and steel, transportation to site and fixing of precast units, welding, equipment, tools and labour and all incidentals necessary for proper completion of the work.

SECTION 406
BRIDGE DRAINAGE

406.01 DESCRIPTION

(1) The work covered by this Section consists of furnishing and installing drain outlets on viaducts, approach structures and other structures, at interchanges, overpasses and underpasses including piping, gullies, gratings, inserts, fittings and other incidental parts necessary to provide for supports of drain pipes in accordance with the lines, levels, grades, sizes, dimensions and types shown on the Drawings.

406.02 MATERIALS

406.02.1 Gully and Grating

(1) The size and strength of gullies shall be as indicated on the Drawings. The Contractor is at liberty to propose alternative gullies of similar quality. Gratings shall be made of structural steel galvanised in accordance with AASHTO M 111. All gullies shall be approved by the Engineer.

406.02.2 Cast Iron Piping

(1) Cast iron piping and fittings shall comply with international standards to the satisfaction of the Engineer.

406.02.3 PVC Pipes

(1) All PVC pipes and fittings shall comply with international standards to the satisfaction of the Engineer.

406.02.4 Inserts

(1) Inserts shall be carried out of steel conforming to AASHTO M 183 (ASTM A36) or as approved by the Engineer.

406.02.5 Fittings and other Incidentals

(1) Material is to be as indicated on the Drawings or as approved by the Engineer.

406.03 CONSTRUCTION REQUIREMENTS

406.03.1 Storage and Handling of Materials

(1) The steel and PVC parts shall be carefully handled and stored on blocking, racks or platforms so as not to be in contact with the ground and the steel parts shall be protected from corrosion. Materials shall be kept free from dirt, oil, grease and other foreign matter.

406.03.2 Gullies

(1) Gullies are to be cast into the structure at the location as indicated on the Drawings. Special care must be taken to avoid displacement of gullies during concreting operations.

406.03.3 Cast Iron Piping

(1) The pipes shall be provided with suitable joints that prevent lateral displacement. The pipes shall be embedded in the locations as indicated on the Drawings. During casting of concrete the piping shall be kept in the correct position by means approved by the Engineer.

406.03.4 PVC Pipes

(1) The jointing shall be of a type recommended by the manufacturer of the pipes. Bends shall be of long sweep, free from kinks.

(2) Embedded pipes shall be cast into the structure in the locations indicated on the Drawings. During casting of concrete the piping shall be kept in the correct position by means approved by the Engineer.

(3) Exposed pipes shall be parallel or at right angles to walls, slabs and girders. All exposed pipes shall be attached to concrete, steel, masonry or timber by galvanised malleable iron or galvanised steel straps, clamps or hangers of an approved type, held at not less than two points by galvanised steel bolts or lag screws. The runs shall be supported at not greater than 1 metre centres on horizontal or near horizontal runs, unless otherwise specified and not less than 50 mm clear of the supporting members.

(4) All ends of pipes installed during construction shall be closed against the intrusion of foreign material.

406.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
406-1	Gully	Number
406-2	Grating (Sizes and Types shall be stated)	Number

(2) This work shall be measured as the actual number of gullies and gratings of size indicated and shall include all cast iron piping, fittings, inserts, relevant erosion protection (if any) and other incidental parts necessary to provide for further support of drain pipes, satisfactorily completed and accepted.

(3) No measurement or payment shall be made for the drain pipes and any other drain facilities shown on the Drawings, which shall be considered incidental to the gullies.

406.05 PAYMENT

(1) Payment will be made at the rates entered in the Bill of Quantities, which rates shall include full compensation for furnishing all materials as indicated on the Drawings including delivery, erection, surface treatment and finishing and for all labour, equipment, tools and incidentals necessary for the completion of the work.

**SERIES 500
STRUCTURES**

SECTION 501

GENERAL REQUIREMENTS

501.01 DESCRIPTION

(1) The provisions of this Section relate to the construction of bridges, retaining walls, culverts, other drainage structures, slope protection structures, miscellaneous structures and incidental construction.

(2) These general provisions shall apply whenever they are relevant to any structure, in addition to the particular provisions given for different types of structure.

501.02 MATERIALS

(1) All materials furnished and used shall comply with the provisions of the relevant Sections of the Specifications.

501.03 CONSTRUCTION REQUIREMENTS

501.03.1 General

(1) All structures shall be constructed in close conformity with the lines, grades, dimensions and details shown on the Drawings.

(2) All construction details shall be in accordance with the detailed requirements described in the Specifications and shown on the Drawings.

501.03.2 Temporary Diversions at Bridges

(1) Where the construction work will interfere with an existing bridge, a temporary diversion road with temporary bridge or culvert facilities shall be constructed to the satisfaction of the Engineer before the existing bridge is removed.

(2) The location and layout of the diversion, shall be approved by the Engineer before the start of its construction.

(3) Diversions shall be constructed in accordance with the requirements of Section 102 and other relevant sections of the Specifications.

501.03.3 Clearing of Site

(1) The Contractor shall clear the site for each proposed structure in accordance with the requirements of Section 201 of the Specifications. Any existing bridges, culverts and other structures shall be removed in accordance with the requirements of Sections 102 and 202 of the Specifications.

(2) The removal or relocation of public or private utilities such as telephone and telegraph lines, power lines, sewer and water pipe lines and their appurtenances shall be in accordance with the requirements of Section 102 of the Specifications.

501.03.4 Re-survey of Original Ground Surface at Bridge Structures

(1) The Contractor shall survey the original ground surface in the general vicinity of each bridge structure at least 4 weeks before any work is due to commence on construction to verify that the structure location and levels given on the Drawings are appropriate for the existing conditions. The results of the survey shall be precisely recorded. This record shall be submitted to the Engineer for agreement and to enable him to make any necessary amendments to the line and level of the structure before any excavation is undertaken.

501.03.5 Alignment and Grades

(1) Special care and attention shall be paid by the Contractor to the elevation and alignment of railings and kerbs on structures on vertical curves, on structures which have super-elevated roadways, and on bridge spans on which a definite finished camber is necessary in order to form a uniform grade line.

(2) Bridge railings shall be installed after the completion of the entire superstructure slab. The railings shall be adjusted with respect to the plan and profile of the bridge in order to produce the appearance of a straight line or smooth curve, as relevant.

(3) The adjustments shall be carried out at the Contractor's cost.

501.03.6 Casting Yard

(1) The pre-casting of concrete structures and prestressed concrete structural members may be done at any location on or off the Site selected by the Contractor, subject to the approval of the Engineer. The Contractor shall obtain all approvals from the relevant Lao authorities for the establishment of a casting yard off the Site. The Engineer shall have full access to the casting yard, wherever it is located, and all operations at the casting yard shall be in accordance with this Contract.

(2) Before any site is approved for use as a casting yard, the Contractor shall submit to the Engineer for approval a plan of operation showing any anticipated levelling or altering of the selected area.

(3) Upon completion of the work the site shall be cleared of equipment and rubbish, and restored as nearly as possible to its original condition.

501.03.7 Aesthetics

(1) The finished surface of any given structure shall be of uniform texture and colour. The same type of formwork and finish, including mould oils shall be used and the Contractor shall obtain all cement for any given structure from the same manufacturing plant, unless otherwise permitted in writing by the Engineer.

501.03.8 Tolerances

(1) The dimensions of finished work shall, unless otherwise specified, be within the tolerances given below and the Contractor shall bear the cost of all corrective measures required when work is not within these tolerances:

- longitudinal/ transverse dimensions (3 metres or more) +/- 10 mm
- longitudinal/ transverse dimensions (less than 3 metres) +/- 5 mm
- cross-sectional dimensions +/- 5 mm
- slab thickness +/- 5 mm
- tops of beams, slabs, pier caps +/- 6 mm
- vertical lines out-of-plumb 0.5%, max. 150 mm
- inclined faces out-of-true line 0.5%, max. 150 mm

501.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
501-1	Re-survey for Bridge Structure	Number

(2) Measurement shall be made for each location at which a new bridge structure is to be constructed.

(3) Measurement of the various items comprising the construction of the completed structures shall not be made under this Section.

501.05 PAYMENT

(1) Payment will be made at the rate entered in the Bill of Quantities.

SECTION 503

PRECAST CONCRETE PILES

503.01 DESCRIPTION

(1) The work covered by this Section consists of precast concrete piling conforming with the dimensions and details shown on the Drawings or as directed by the Engineer, and driven to the specified penetration and bearing values.

503.02 MATERIALS

(1) Portland cement concrete shall conform to the requirements in Section 507 of the Specifications.

(2) Steel reinforcement shall conform to the requirements in Section 506 of the Specifications.

503.03 CONSTRUCTION REQUIREMENTS

503.03.1 Supplementary Soil Investigations and Test Piles

(1) The Contractor shall perform supplementary soil investigations at each support to be a basis for the determination of the length of the piles to be supplied for driving.

(2) Prior to casting piles in significant quantities, test piles shall be made and driven by the Contractor at locations designated by the Engineer in order to verify whether the ground conditions are consistent with the results of the soil investigation, and to ensure that the designed piles can be driven successfully, and to determine the required length of piles.

(3) The ground at each test pile shall be excavated to the elevation of the bottom of the footing before the pile is driven.

(4) The Contractor shall promptly submit to the Engineer all information obtained from the supplementary soil investigations and test piles.

(5) If the Contractor considers that the results of the supplementary soil investigation and test piles render the type of foundation shown on the Drawings to be inappropriate, he shall inform the Engineer without delay and propose an alternative type of foundation. The Engineer will review the type of foundation once the additional information from the supplementary soil investigation and test piles is available.

503.03.2 Precast Piling Schedule

(1) The Contractor shall prepare a precast piling schedule for approval by the Engineer. The schedule shall be based on information obtained from the supplementary soil investigations, the driving of the test piles, and other available data for each support. The schedule shall show the number and length of piles required.

(2) The length shown on the list shall be the length required below cut-off and the Contractor shall, at his own expense, increase the lengths by the necessary amounts to provide for cutting off concrete after driving to expose the reinforcing steel to be embedded into the pile cap or footing.

503.03.3 Preparation for Driving

(1) Before driving, foundation trenches shall be excavated in accordance with Section 207 of the Specifications, unless otherwise permitted by the Engineer.

(2) When allowed by the Engineer, the Contractor may pre-bore holes at pile locations specified. Pre-bore holes shall be smaller than the diagonal of the pile cross section and sufficient to allow penetration of the pile. If subsurface obstructions such as boulders or rock layers are encountered, the hole may be increased to the least dimension which is adequate for pile installation. The voids remaining around the pile after driving shall be filled with sand or other approved material.

(3) Piles driven through newly constructed embankment shall be driven in holes drilled through the embankment. The hole shall have a diameter of not less than the greatest pile dimension plus 150 mm. After driving, the space around the pile shall be filled with dry sand or pea gravel up to ground surface.

503.03.4 Precasting

(1) The manufacture, storage, and handling of precast piles shall comply in all respects with the requirements of Sections 505, 506 and 507 of the Specifications.

(2) The casting yard shall conform to the requirements of Sections 501 and 507 of the Specifications.

(3) Piles shall be cast in a horizontal position, in approved forms supported on a suitable platform.

(4) Piles shall be cast separately. If cast in a contiguous series, the intermediate piles shall not be cast until 4 days after the adjacent piles have been poured. Piles cast in series shall be separated by tar paper or other suitable separating material.

(5) Forms for precast concrete piles shall conform to the general requirements of Section 505 of the Specifications. Forms shall permit access for compaction of the concrete.

(6) Reinforcing bars, hoops, shoes and steel splice connections shall be placed as shown on the Drawings. All parts shall be well wired and tied together and placed to the spacing shown. All reinforcement shall be in place in the forms before any concrete is poured.

(7) A 25 mm chamfer strip shall be used in all corners.

503.03.5 Casting

(1) Concrete shall not be deposited in the forms until the Engineer has inspected and approved the placing of the reinforcement.

(2) Piles shall be cast in a continuous pour, filling the forms with a slight excess of concrete, the surplus concrete screeded off, and the top surfaces finished to a uniform, even texture.

(3) Special care shall be exercised to vibrate and tamp the concrete around the reinforcement to secure complete compaction. The use of internal vibrating tampers will be required when placing concrete in forms.

(4) Each pile shall be marked indelibly to show its identification number, length and date of casting.

503.03.6 Curing

(1) Precast piles shall be cured as provided in Section 507 of the Specifications. The piles shall be removed from the forms and stacked in a curing pile separated from each other by wooden spacing blocks.

(2) Concrete shall be protected from freezing until the compressive strength reaches at minimum $0.80 f'_c$, i.e. until it reaches 80% of the design 28-days compressive strength.

503.03.7 Storage, Transport and Handling

(1) Forms shall not be removed until least 24 hours after the concrete has been placed.

- (2) Removal of forms, storage, transporting and handling of precast concrete piles shall at all times be carried out in such a manner as to avoid excessive bending stresses, cracking, spalling or other injuries.
- (3) When removed from the forms, the pile shall present a true, smooth, even surface, free from honeycombs, stone pockets or other such defects. The pile shall be essentially straight such that the distance between a line stretched from butt to tip on any face of the pile will not be more than 0.2% of the length of the pile on any point.
- (4) Extreme care shall be exercised in handling and moving piles. Piles shall be lifted at specified lifting points. When raising or transporting piles, the Contractor shall provide slings or other equipment to prevent any appreciable bending of the pile or cracking of the concrete. The angle between the slings and the pile shall not be less than 60 degrees. Piles shall be so handled at all times as to avoid breaking or chipping the edges.
- (5) Piles determined by the Engineer to be materially damaged in handling or driving shall be either repaired to the Engineer's satisfaction or, if so directed by the Engineer, replaced by the Contractor at his own expense.
- (6) When concrete piles are lifted or moved or stacked, they shall be supported at the points shown on the Drawings. Piles of identical length may be stacked up to 5 piles high provided the bearers are directly in line and the bearers under the bottom pile rest on a firm foundation so that the pile is well clear of the ground.
- (7) Piles shall not be moved until the tests indicate that the concrete has attained a compressive strength of at least 80 percent of the design 28-day compressive strength and they shall not be transported or driven until the design 28-day compressive strength has been attained.
- (8) If testing equipment is not available, as in isolated areas, piles shall not be moved until after fourteen (14) days after casting and shall not be transported or driven prior to 28 days after casting. If high early-strength cement is used, piles shall not be moved, transported or driven prior to 7 days after casting.

503.03.8 Driving

- (1) At least 21 days before piling equipment is dispatched to site, the Contractor shall submit to the Engineer a Pile Installation Technical Method Statement, which shall contain full details of the proposed pile driving equipment and method. This shall include: pile support frame and leads, hammer, drive head, hammer and pile cushions, including modulus of elasticity and coefficient of restitution, pile cutting off method, driving procedure and expected set.
- (2) Pile driving shall not commence until the Pile Installation Technical Method Statement has been approved by the Engineer. The Engineer's approval does not constitute a comprehensive check of the proposed method, for which the Contractor retains full responsibility.
- (3) The Engineer shall be notified 24 hours before the commencement of driving.
- (4) Piles shall be driven in the locations shown on the Drawings to the depth required to develop the specified bearing capacity as approved by the Engineer. The set shall be taken in the presence of the Engineer unless otherwise permitted in writing.
- (5) Piles shall be driven in the sequence approved by the Engineer.
- (6) The driving of individual piles, once driving has commenced, shall be a continuous operation.
- (7) Any material forced up between the piles shall be removed to the correct elevation before concrete for the foundation is placed.
- (8) Piles shall not be driven within 7 metres of concrete less than 7 days old.

503.03.9 Equipment

- (1) All pile driving equipment shall be subject to the approval of the Engineer.
- (2) The equipment for driving piles shall, unless otherwise authorised by the Engineer, be adequate for the driving of piles at least 3 metres longer than the longest length shown on the Drawings.
- (3) Piles shall be driven with a steam or compressed air gravity hammer, or with a diesel hammer.
- (4) Hammers shall develop an energy per blow of not less than 0.3 kg-m per kg of weight driven. In no case shall the total energy developed by the hammer be less than 1,400 kg-m per blow.
- (5) Diesel hammers which have a fully enclosed ram shall be equipped with a gauge and accompanying charts which evaluate the equivalent manufacturer's rated energy being produced under any driving condition.
- (6) All hammers shall be maintained in an approved first-class mechanical condition so that maximum efficiency will be obtained at all times. Hammers deemed inefficient by the Engineer shall be removed from the Site.

503.03.10 Protection of Head and Splicing of Piles

- (1) The tops of all precast piles shall be protected from injury by the impact of the hammer in a manner approved by the Engineer. The protection shall be so designed, maintained and used as to cause the minimum absorption of energy consistent with adequate protection.
- (2) Piles longer than 12 metres may be spliced in accordance with details shown on the Drawings or where no details are shown by one of the following methods.
- (3) By using an approved prefabricated joint mounted in the forms and cast together with the pile sections and joined together as specified by the manufacturer and approved by the Engineer.
- (4) By cutting away the concrete at the end of the pile, leaving the reinforcing steel exposed for a length of 40 bar diameters for deformed bars and 60 bar diameters for plain bars. The final cut of the concrete shall be perpendicular to the axis of the pile. Reinforcement of the same size as that used in the pile shall be spliced to the projecting steel and the necessary formwork shall be placed, care being taken to prevent leakage along the pile. The concrete shall be of the same quality as that used in the pile. Just prior to placing concrete, the top of the pile shall be wetted thoroughly and covered with a thin coating of neat cement, retempered mortar or other suitable bonding material to the satisfaction of the Engineer. The forms shall remain in place for not less than seven (7) days. Curing and finishing of extensions shall be the same as in the original pile. The pile shall not be driven until the requirements of Sub-clause 503.03.7 herein have been satisfied.
- (5) Pile lengths shall be planned so that, in the installed pile, the splice is located at least 4 metres below cut-off level.

503.03.11 Tolerances

- (1) All piles shall be driven as shown on the Drawings or as ordered by the Engineer. They shall be driven within an allowed variation of 20 mm per metre of pile length from the vertical or batter specified.
- (2) The maximum allowable variation at the butt end of the pile shall be 75 mm in any direction from the location shown on the Drawings or as directed by the Engineer.
- (3) Each pile shall, after driving, be within 150 mm from the theoretical location underneath the pile cap.
- (4) Piles materially out of line shall, where ordered by the Engineer, be withdrawn and re-pitched until the proper line is obtained. No forcible method of correction of the position or line of any pile will be permitted.

(5) Piles which have risen as a result of the driving of adjacent piles shall be re-driven to the requirements of the Engineer.

(6) A pile shall be relocated to the best possible alternative location if due to obstructions underground and which cannot be removed, a pile cannot be driven to the designed level. For the rearranged pile schedule the Contractor shall submit drawings and calculations, which shall be approved by the Engineer prior to re-starting pile driving.

503.03.12 Falsework and Defective Piles

(1) Defective, damaged, or falsework piles, or piles driven out of place, shall be removed, or cut off below exposed surfaces, in a manner satisfactory to the Engineer.

(2) A pile will be considered defective if it has a visible crack, extending around more than 50% of the periphery, or any defect which, in the opinion of the Engineer, will affect the strength, moment capacity, or durability of the pile.

(3) Any pile damaged in driving by reason of internal defects or by improper driving, or driven out of its proper location, or driven below the cut-off level given on the Drawings or by the Engineer shall be corrected by the Contractor at his own cost by one of the following methods as approved by the Engineer for the pile in question:

- (a) the pile shall be withdrawn and replaced by a new and, when necessary, longer pile;
- (b) a second pile shall be driven adjacent to the defective pile;
- (c) if top of pile is less than 1 metre below the bottom of the footing, the pile may be lengthened in a manner approved by the Engineer.

(4) When a new pile is driven to replace a rejected one, the Contractor at his own cost shall enlarge the footing as necessary to incorporate the new pile, all as approved by the Engineer.

503.03.13 Piling Record

(1) A record of all piles driven shall be kept by the Contractor and a copy of the record of the work done each day shall be submitted to the Engineer within 24 hours.

(2) The format of the record shall be as shown in Sub-clause 503.03.14 herein or as otherwise agreed.

503.03.14 Form of Piling Record

PILING CONTRACTOR:
PROJECT:
PILE TYPE/SIZE :
DATE OF DRIVING:

RIG NO:
STRUCTURE:
PILE NO:

GENERAL

Rig moved from Pile No.
Length of Pile as Driven
Elevation of Ground
Elevation of Cut-off
Elevation of Bottom
Pay Length
Cross Section of Pile or Casing Driven
Weight (or Material) of Pile or Casing Driven

HAMMER

Type and Weight
Type and Condition of Pile Head Packing
Type and Condition of Helmet Dolly
DRIVING

Record the number of blows for every 0.25 m penetration intervals.

<u>Penetration</u>	<u>Blows</u>
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Final set for the 3 last sequences of 10 blows mm/blow

Reason for any delay during driving
Details of any re-driving

Final depth of driving
Final Bottom Elevation

RECORDS

Details of any Interruptions in Driving
Elevation of Theoretical Pile Top
Elevation of Driven Pile Top
Details of Re-driving

REMARKS (including further details required by the Engineer)

.....
.....

SUPERVISOR'S SIGNATUREDATE

503.03.15 Determination of Bearing Capacity

(1) Piles shall be driven to the bearing capacity specified on the Drawings. The bearing capacity of piles will be determined by the Engineer using one or more of the following methods.

A. Dynamic Load Tests

(1) When ordered by the Engineer, the bearing capacity of a pile shall be determined by dynamic measurements during the driving of piles designated as dynamic load test piles using pile analyser instruments. The dynamic testing procedure will be applied when driving and/or re-driving on approximately 20% of the piles.

(2) Prior to placement in the leads, the Contractor shall pre-drill the required instrument attachment holes. The Contractor shall attach the instruments to the pile after the pile is attached to the leads.

(3) The Contractor shall furnish electric power to the dynamic test equipment. A platform with minimum size of 1.2 metre by 1.2 metre designed to be raised to the top of the pile while in the leads shall be provided by the Contractor.

(4) The pile shall be driven to the depth at which the dynamic test equipment indicates that the design bearing capacity shown on the Drawings has been achieved, unless otherwise directed by the Engineer.

B. Static Load Tests

(1) Instead of dynamic testing, the Engineer may order the Contractor to perform static load testing on any pile. The static load test shall be performed by procedures in ASTM D1143 using quick load compression test method except that the test shall be taken to plunging failure or three times design load or 1,000 tonnes whichever occurs first.

(2) Static load testing shall generally consist of a test load placed upon a suitable platform supported by the pile, together with suitable approved instruments for the accurate determination of the load and the settlement of the pile under each increment of load.

(3) The Contractor shall submit to the Engineer for approval, detailed plans of the loading apparatus.

(4) The apparatus shall be so constructed as to allow the various increments of the load to be placed gradually without causing vibration to the test piles.

(5) Suitable approved apparatus for determining accurately the load on pile and the settlement of the pile under each increment of load shall be supplied by the Contractor.

(6) When approved method requires the use of anchor (tension) piles which, will later be used as permanent pile, such anchor piles shall be the same type as the permanent piles and driven in the permanent pile location when feasible.

(7) Alternatively, hydraulic jacks with suitable yokes and pressure gauges may be used when approved by the Engineer.

(8) Piling being not a part of the structure shall be removed or cut off at least 300 mm below the bottom of the footing or finished elevation of the ground upon completion of the test load.

(9) Permanent piling used as anchor piling which is raised during the test load shall be redriven to original grade and bearing.

(10) After the completion of loading tests, the load used shall be removed and the piles, including tension piles, shall be utilised in the structure if found by the Engineer to be satisfactory for such use. Test piles not loaded shall be utilised similarly. If any pile, after serving its purpose as a test or tension pile, is found unsatisfactory for utilisation in the structure, it shall be removed if so ordered by the Engineer or otherwise shall be cut off below the ground line of footings.

(11) The design bearing capacity shall be defined as 50% of the failure load. The failure load of a pile tested under axial compressive load is that load which produces a settlement at failure of the pile head equal to:

$$S_f = S + (3.81 + 0.008 D)$$

where, S_f = settlement at failure, mm

D = pile width or diameter, mm

S = elastic deformation of total unsupported pile length, mm

C. Empirical Pile Formulas

(1) When piles are not driven to refusal, and if dynamic load tests and static load tests are not required by the Engineer, an approved empirical pile formula shall be used to determine the bearing capacity of piles.

(2) Parameters such as the fall height of the hammer, weight of striking parts of hammer, energy produced by the hammer per blow and the average penetration in mm/blow for the last 10 blows, shall be determined on site.

(3) In the absence of any special provisions to the contrary, the following empirical formula shall be used.

$$P = \frac{2WH}{S + 25.4} \quad \text{for drop (gravity) hammers}$$

$$P = \frac{2E}{S + 2.54} \quad \text{for all other hammers}$$

where

P =	Bearing capacity, kg
W =	Weight of striking parts of hammer, kg
H =	Height of fall, mm
E =	Energy produced by the hammer per blow, kg-mm, with value based on actual hammer stroke or bounce chamber pressure observed (double acting diesel hammer)
S =	Average penetration in mm/blow for the last 5 to 10 blows for gravity hammers, and the last 10 to 20 blows for all other hammers.

503.03.16 Pile Cut-off

(1) After piles have been driven and accepted, the pile head shall be cut off accurately to a true plane at the level shown on the Drawings, and the required length of longitudinal bars exposed for anchorage into the pile cap or footing.

(2) Care shall be taken to avoid spalling below the cut-off level, by using such method as sawing a notch at the required level, clamping a steel band just below the cut-off level, and directing percussion tools inward towards the centre of the pile.

(3) If a pile is damaged below cut-off level, the Contractor shall repair the pile to the satisfaction of the Engineer.

(4) When the cut off elevation is below the elevation of the bottom of the pile cap, the pile may be built-up from the butt of the pile to the elevation of the bottom of the cap by means of reinforced concerted extension constructed in accordance with the relevant requirements for splicing of piles, if so approved by the Engineer.

503.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
503-1	Precast Concrete Piles (_____ mm x _____ mm)	Metre
503-2	Pile Splices	Number
503-3	Dynamic Load Testing (Precast Concrete Piles [_____ mm x _____ mm])	Number
503-4	Static Load Testing (Precast Concrete Piles [_____ mm x _____ mm])	Number

(2) Piles shall be measured as the actual length of piles permanently placed and accepted in the structure. The measured length shall be the length from the pile tip to the cut-off level and shall not include the length of the reinforcing steel extending beyond the pile and into the pile cap or footing.

(3) All test piles ordered to be driven and accepted by the Engineer shall be measured as the actual length of piles as driven.

(4) Excavation will be measured in accordance with Section 207 of the Specifications.

(5) No measurement will be made for furnishing or driving falsework for piles, pre-boring nor other methods to facilitate pile driving, nor will any measurement be made for rejected piles (e.g. piles driven out of place, defective piles or piles which are damaged in handling or driving).

503.05 PAYMENT

(1) Payment will be made at the rates entered in the Bill of Quantities.

(2) Payment for the Precast Concrete Piles item shall include mobilisation and de-mobilisation of plant and equipment, production of piles including reinforcement, storage, transportation and handling, splicing, driving, repairs to piles, cutting off of piles, and pile records.

(3) Excavation will be paid for under Item No. 207-1 in the Bill of Quantities.

SECTION 504

BORED PILES

504.01 DESCRIPTION

504.01.1 General

(1) This work consists of constructing bored foundation piles and shafts, including the placing of reinforcing steel and concrete all in accordance with the Drawings.

504.01.2 Technical Method Statement

(1) At least 56 days before work is to begin, the Contractor shall submit to the Engineer for his review and approval a Bored Pile Technical Method Statement which shall include an installation plan for the piles, the list of proposed equipment including cranes, drills, augers, buckets, final cleaning equipment, slurry pumps, sampling equipment, tremies, concrete pumps and casings; details of overall construction sequence; details of shaft excavation methods; the proposed methods to mix, circulate and de-sand slurry; methods to clean the shaft excavation; details of steel reinforcement placement; details of casting concrete, curing and protection; and details of any load tests. Work shall not proceed until the Bored Pile Technical Method Statement is approved by the Engineer.

504.02 MATERIALS

504.02.1 Concrete

(1) Concrete shall conform to the requirements of Section 507 of the Specifications.

504.02.2 Reinforcing Steel

(1) Reinforcing steel shall conform to the requirements of Section 506 of the Specifications.

504.02.3 Casings

(1) Steel casings which are to be incorporated in the permanent work shall be AASHTO M 270 Grade 36 unless otherwise specified by the Engineer.

504.03 CONSTRUCTION REQUIREMENTS

504.03.1 Construction Sequence

(1) All excavations for foundation for bored piles shall be complete before bored pile construction starts.

(2) When bored piles are to be installed in conjunction with embankment placement, the bored piles shall be constructed after the placement of fill unless otherwise shown on the Drawings.

504.03.2 General Methods and Equipment

(1) Excavations required for piles shall be performed through whatever materials are encountered, to the dimensions and elevations shown on the Drawings or ordered by the Engineer. The methods and equipment used shall be suitable for the intended purpose and materials encountered.

(2) Either the dry method, wet method, temporary casing method, or permanent casing shall be used as necessary to produce sound, durable concrete foundation piles.

504.03.3 Dry Method

(1) The dry method consists of drilling the shaft excavation, removing accumulated water and loose material from the excavation, and placing the pile concrete in a dry excavation.

504.03.4 Wet Method

(1) This method consists of using water or mineral slurry to maintain the stability of the hole perimeter while advancing the excavation to final depth, placing the reinforcing cage and shaft concrete. This may require desanding and cleaning the slurry; final cleaning of the excavation by means of bailing bucket, air lift, submersible pump or other devices; and placing the shaft concrete with a tremie or concrete pump. Temporary surface casings shall be provided to aid shaft alignment and position, and to prevent sloughing of the top of the shaft excavation.

504.03.5 Temporary Casing Method

(1) This method consists of advancing the excavation through caving material by the wet method. When a nearly impervious formation is reached, a casing shall be placed in the hole and sealed in the nearly impervious formation. After the drilling fluid is removed from the casing, drilling may proceed as with the dry method except that the casing shall be withdrawn when the shaft concrete is placed. If seepage prevents the use of the dry method, excavation shall be continued using the wet method.

(2) Before the casing is withdrawn and while the casing is being withdrawn, the level of fresh concrete in the casing shall be at such level that all fluid trapped behind the casing is displaced upward without contaminating the shaft.

504.03.6 Permanent Casing Method

(1) This method consists of driving or drilling a casing to a prescribed depth before excavation begins. If full penetration cannot be attained, the Engineer may require either excavation of material within the embedded portion of the casing and/or excavation of a pilot hole ahead of the casing until the casing reaches the desired penetration.

(2) The casing shall be continuous between elevations shown on the Drawings.

(3) After the installation of the casing and the shaft excavation is complete, the casing shall be cut off at the prescribed elevation and the reinforcing steel and pile concrete placed within the portion of the casing left in place.

504.03.7 Other Methods

(1) The Contractor may propose alternative methods to prevent caving and control ground water. Such proposal shall be accompanied by supporting technical data and submitted to the Engineer for his review and approval as part of the Technical Method Statement.

504.03.8 Excavations

(1) The bottom of the bored pile shown on the Drawings may be adjusted during construction if the Engineer determines the foundation material encountered during excavation is unsuitable or differs from that anticipated in the design of the pile.

(2) The Contractor shall take soil samples or rock cores when shown on the Drawings or as directed by the Engineer.

(3) Excavated materials removed from the pile excavation and any drilled fluids used shall be disposed of as approved by the Engineer.

504.03.9 Casings

- (1) Casings shall be metal, smooth, clean, watertight, and of sufficient strength to withstand both handling and driving stresses and pressure from both concrete and earth materials surrounding the shaft.
- (2) Temporary casings shall be removed while the concrete remains workable. Casing extraction shall be at slow, uniform rate with the pull in line with the pile axis.
- (3) A sufficient head of concrete shall be maintained above the bottom of the casing to overcome the hydrostatic pressure of water or drilling fluid outside the casing.

504.03.10 Slurry

- (1) Slurry used in the drilling shall be a mineral slurry. The slurry shall have a mineral grain size that will remain in suspension and sufficient viscosity and gel characteristics to transport excavated material to a suitable screening system.
- (2) The percentage and specific gravity of the material used to make the suspension shall be sufficient to maintain the stability of the excavation and to allow proper concrete placement.
- (3) The mineral slurry shall be premixed thoroughly with clean fresh water and adequate time allotted for hydration prior to introduction into the shaft excavation.
- (4) Control tests shall be carried out by the Contractor on the mineral slurry to determine density, viscosity and pH, and shall be done during the shaft excavation.
- (5) The acceptable range of values for those physical properties at 20 °C shall be as follows:

Table 504.1 - Acceptable Values on Properties of Mineral Slurry

Property (unit)	During Slurry Introduction	During Concreting in hole	Test Method
Density (t/m ³)	1.0 to 1.1	1.0 to 1.2	Density Balance
Viscosity (sec/quart)	28 to 45	28 to 45	Marsh Cone
pH	8 to 11	8 to 11	pH paper

- (6) Prior to placing pile concrete, slurry samples shall be taken from the bottom and at intervals not exceeding 3 m for the full height of slurry. Any heavily contaminated slurry that has accumulated at the bottom of pile shaft shall be eliminated. The mineral slurry shall be within the above requirements immediately before shaft concrete placement.

504.03.11 Reinforcing Steel Cage and Placement

- (1) The reinforcing steel cage plus cage stiffener bars, spacers, centralisers and other appurtenances shall be completely assembled and placed as a unit immediately after the shaft excavation is inspected and accepted by the Engineer prior to concrete placement.
- (2) The reinforcing steel in the shaft shall be tied and supported so that the reinforcing steel will remain within allowable tolerances until the concrete will support the reinforcing steel.
- (3) When concrete is placed by tremie method, temporary hold-down devices shall be used to prevent uplifting of the steel cage during concrete placement.

504.03.12 Concrete Placement, Curing and Protection

(1) Concrete shall be placed as soon as possible after the reinforcing steel cage placement. Concrete placement shall be continuous in the shaft from the bottom to the top elevation of the shaft. Placement shall continue after the shaft is full, until good quality concrete is evident at the top of the shaft. Concrete to be placed in water or slurry shall be placed through a tremie or concrete pump as specified in Section 507 of the Specifications.

(2) For piles less than 2.5 metre in diameter, the elapsed time from the beginning of concrete placement in the shaft to completion shall not exceed 2 hours. For piles and shafts greater than 2.5 metres, the concrete placing rate shall be not less than 10 metres of shaft height per each 2-hour period. The concrete mix shall be such design that the concrete remains in workable plastic state throughout the 2-hour placement limit.

(3) For at least 48 hours after shaft concrete has been placed, no construction operations that would cause soil movement adjacent to the shaft, shall be conducted.

504.03.13 Tolerances

(1) The following tolerances shall be maintained:

- (a) Shaft shall be within 75 mm of the plan position in the horizontal plane at the plan elevation for the top of shaft.
- (b) Vertical alignment of shaft excavation shall not vary from the plan alignment by more than 6 mm per 300 mm of depth.
- (c.) Top of reinforcing steel cage shall be not more than 150 mm above and not more than 75 mm below plan position.
- (d) Top elevation of shaft shall be within 25 mm of the plan top of shaft elevation.
- (e) Bottom of shaft excavation shall be normal to the axis of the shaft within 19 mm per 300 mm of shaft diameter.

504.03.14 Pile Integrity Testing (PIT)

(1) When required by the Contract, the completed shaft shall be subjected to a non-destructive Integrity testing to determine the extent of any defects that may be present in the shaft.

(2) The PIT, a low strain impact integrity test, shall be done according to ASTM D5882.

(3) The testing shall be carried out by an approved and independent specialist, who must supply all necessary personnel and equipment for the testing.

(4) Piles designated for integrity testing shall be specified by the Engineer.

(5) Integrity testing shall not be performed until the concrete has cured for a minimum of 7 days, unless otherwise approved by the engineer.

(6) The pile head shall be accessible, free from water, dirt or other debris. The concrete at the pile top surface must be relatively smooth and provide sufficient space for attaching the motion sensing device and for the hammer impact area. Any type of contamination shall be removed by using a grinder, to reach solid and sound concrete surface, thus ensuring firm contact between the sensor and concrete.

(7) The location of the sensor shall be selected away from the edges of the pile. A hammer (with or without force measurement unit) shall be used for impacting the pile top and the impact shall be applied axially with the pile. The impact location shall not be more than 300 mm away from the sensor.

(8) Motion transducer shall be capable of detecting and recording the reflected echoes over the pile top. Acceleration, velocity, or displacement transducers can be used for this purpose. The acceleration transducer shall provide signal conditioning and integrate acceleration to obtain velocity. The apparatus shall balance the velocity signal to zero between impact events.

- (9) The Pile Integrity Tester equipment shall at the minimum fulfil following requirements:
- The analog to digital shall be at least 24 bits;
 - The sample frequency shall be at least 25 KHz;
 - Data shall be stored such that additional processing or further wave analysis is possible;
 - Data shall be displayed in the field for evaluations of preliminary data quality and interpretation;
 - The equipment shall allow attachment of a motion sensing device capable of measuring acceleration, velocity or displacement due to the impact on the pile top with a hand held hammer.
- (10) The testing engineer shall present a report with the final test results and integrity evaluations, within 5 working days after performing the field tests. For each pile tested, the averaged, amplified velocity versus time record shall be included in the report, with a table summarizing results and conclusions.

504.03.15 Sonic Testing

- (1) Before concreting, the Contractor shall install 4 nos. (which may be reduced to 3 nos. if the pile is too congested to accommodate 4 nos.) watertight steel tubes of not less than 50 mm internal diameter and without internal projection over the full depth of each the bored cast-in-situ piles. The tubes shall extend from between 0.2 m to 0.5 m above the pile head to within 0.1 m to 0.2 m of the pile toe. The tubes shall be firmly tied to the reinforcement cage, placed parallel to each other, equally spaced around the circumference, and at a constant cover (75 mm minimum to 100 mm maximum) to the external face of the pile. The tubes shall be straight and continuous and shall be filled with water and adequately sealed at both ends before concreting.
- (2) Sonic tests shall be carried out for all bored cast-in-situ piles unless otherwise agreed by the Engineer. An independent specialist-testing consultant appointed by the Contractor and approved by the Engineer shall conduct the tests to verify the homogeneity and integrity of the hardened concrete. The Contractor shall submit the proposed procedures for sonic tests to the Engineer for approval at least 14 days before concreting.
- (3) The equipment for sonic testing shall consist of a signal transmitter probe and a signal receiver probe, which may be lowered into the tubes installed in the piles either in tandem or singly. The results of the sonic testing shall be displayed on a recording oscilloscope at the top of the pile.
- (4) The signal emitted by the transducer shall be in the spectrum of 100 Hz to 60 kHz and of variable emission pulse rate between 1 and 20 cycles per second to suit the testing requirements.
- (5) The recording oscilloscope shall be of the storage type with signal modulation representation of the received signal on a horizontal tracing: bright spots correspond to peaks and signal blanks to troughs.
- (6) For one-tube installation, a single log shall be taken with probes set 1 m apart in the same tube. For two or more tubes, measurements shall be taken between adjacent tubes plus one diagonal where applicable.
- (7) The Contractor shall ensure that the probe matches the tube diameter to minimize concrete-tube-probe signal alternation or misleading results will arise.
- (8) Results shall be in the form of time delay versus pile depth. The results shall be recorded on the oscilloscope screen and the results shall be photographed. The testing consultant shall submit the test reports and photographic traces directly to the Engineer within 48 hours of making the tests. The submitted materials shall become the property of the Employer.
- (9) Voids formed by the steel tubes shall be pressure-grouted at such times as agreed with the Engineer.

504.03.16 High Strain Dynamic Load Testing

- (1) When required by the Contract, high strain dynamic load testing shall be completed before construction of production bored piles.
- (2) High-strain dynamic testing is performed by obtaining and analysing records of pile force and velocity under drop weight impacts for evaluations of shaft load carrying capacity, structural integrity, and load movement and shaft-soil load transfer relationships. Testing procedures shall conform to ASTM D4945 - Standard Test Method for High-Strain Dynamic Testing of Deep Foundations.
- (3) The locations of load test piles, maximum loads to be applied, test equipment to be furnished and actual performance of the load test shall be as specified in the Particular Specifications of Contract Documents.

504.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
504-1	Bored Pile, _____ mm diameter	Metre
504-2	Casing (remaining and not reused)	Metre Square
504-3	Bored Pile Integrity Test	Number
504-4	Bored Pile Sonic Test	Number
504-5	Bored Pile High-Strain Dynamic Load Test	Number

- (2) Bored piles will be measured for each size of pile. Measurement will be along the centreline of the pile based on the tip and cut-off elevations shown on the Drawings or ordered by the Engineer.

504.05 PAYMENT

- (1) Payment will be made under the rates entered in the Bill of Quantities.
- (2) Payment for the Bored Pile items shall include shaft excavation, disposal of excavated materials and the furnishing and placing of concrete and reinforcing steel.
- (3) Payment will not be done for casings that can be reused, but payment shall be done for casings that cannot be reused, e.g. casings that are permanently left in place under water where they were used during construction.
- (4) Payment for the Bored Pile Integrity Test items shall include for all test equipment, testing and reporting and removal of the test equipment.
- (5) Payment for the Bored Pile High-Strain Dynamic Load Test items shall include for piles, all test equipment, testing and reporting, removal of the test equipment and removal of the lengths of pile as specified.

SECTION 505

FALSEWORK AND FORMWORK

505.01 DESCRIPTION

505.01.1 General

(1) The work covered by this Section consists of furnishing all plant, equipment, materials and labour and performing all operations in connection with the construction and removal of falsework and formwork for all concrete structures.

505.01.2 Working Drawings

(1) Whenever specified or requested by the Engineer, the Contractor shall provide working drawings with design calculations in sufficient detail to permit a structural review of the proposed design of a temporary work.

(2) The Contractor shall not start the construction of any temporary work for which working drawings are required until the drawings have been approved by the Engineer.

505.01.3 Design

(1) The structural design of falsework and formwork shall conform to the relevant sections of AASHTO “Standard Specifications for Highway Bridges”, and “Guide Design Specifications for Bridge Temporary Works”.

505.02 MATERIALS

505.02.1 Formwork

(1) All forms and formwork with supporting falsework, struts and stagings shall be of suitable quality timber or of any other approved material and of such substantial strength with ample scantling as will ensure that the shuttering remains rigid and without distortion throughout the placing, ramming, compacting and setting of the concrete.

505.02.2 Timber

(1) Shuttering shall be good quality timber of 20 mm minimum thickness, free from loose knots, shakes or warped surfaces, with a moisture content less than 25%. All timber shuttering or moulds used for forming the face of exposed concrete shall be either wrought timber (timber planed smooth on one side and two edges), or rough timber backed with plywood lining.

(2) Timber in the round shall be sound, straight and well-seasoned, free from rot, worm, beetle, decayed knots or other defects.

(3) Green timber or semi green timber cut from the forest shall not be used for any purpose connected with the Works.

505.02.3 Metal Forms

(1) Metal forms may be used.

(2) The metal shall be of such thickness that the forms remain true to shape. All bolt and rivet heads shall be countersunk. Clamps, pins or other connecting devices shall be designed to hold the forms rigidly together and to allow removal without injury to the concrete. Metal forms which do not present a smooth surface or line up properly shall not be used.

505.02.4 Internal Ties or Spacers

(1) The use of internal steel ties or steel or plastic spacers will be permitted subject to the approval of the Engineer. All fittings for metal ties shall be of such a design, that upon their removal, the cavities which are left will be of the smallest possible size.

505.03 CONSTRUCTION REQUIREMENTS

505.03.1 Falsework and Temporary Staging

(1) Temporary works, including staging or falsework, shall be provided by the Contractor to enable structures to be constructed according to the approved erection programme.

(2) The falsework shall be of sufficient rigidity and strength to safely support all loads imposed and produce in the finished structure the lines and grades indicated on the Drawings.

(3) Falsework shall be founded on solid footings safe against undermining and capable of supporting the imposed loads. The bearing capacity of the foundation soils (stabilised if necessary) shall be such that a sensibly uniform ground pressure loading is attained on all bases to the temporary falsework or staging.

(4) The design of the falsework shall consist of the sum of dead and live vertical loads, and any horizontal loads. Dead loads shall include the weight of the falsework and all construction material to be supported. Live loads shall consist of the actual weight of any equipment to be supported applied as a concentrated load and a uniform load of not less than 1 kN/m² applied over the supported area, plus 1.1 kN/m applied at the outside edge of deck overhangs. The horizontal loads shall be the sum of the horizontal loads due to equipment, construction sequence, unbalanced hydrostatic forces from fluid concrete, stream flow when applicable, and wind. In no case shall the horizontal load resisted in any direction be less than 2% of the total dead load.

(5) Falsework shall not be supported on any part of the structure except the footings, without the written permission of the Engineer.

(6) Falsework or centring shall, after allowance for shrinkage and settlement, give the finished structural camber indicated on the Drawings.

(7) Settlement of falsework and footings shall be measured and recorded by the Contractor during concreting. The Engineer may require the Contractor to employ screw jacks or approved wedges to take up any settlement in the formwork either before or during the placing of concrete.

505.03.2 Formwork Requirements

(1) The design of the formwork shall be such as to enable it to be struck and removed without damage to the concrete. No shutter fixings or supports, other than certain internal ties, will be allowed to be incorporated in the finished concrete.

(2) The forms shall be substantial and unyielding and shall be so designed that the finished concrete will conform to the prescribed dimensions and contours.

(3) Forms shall be of wood, metal or other approved material and shall be built mortar-tight with sufficient rigidity to prevent distortion due to the pressure of the concrete and other loads incidental to the construction operations. Forms shall be constructed and maintained so as to prevent warping and the opening of joints due to shrinkage of the lumber.

(4) Forms for exposed surfaces shall be made of dressed lumber of uniform thickness, or other approved material, with or without a form liner of an approved type, and shall be mortar-tight. Forms shall be filleted or chamfered 20 x 20 mm at all sharp corners and shall be given a bevel or draft at all projections such as girders and copings, to ensure easy removal.

- (5) 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. If ordinary wire ties are permitted, all wires, upon removal of the forms, shall be cut back to provide the specified clear cover from the face of the concrete.
- (6) Formwork shall be constructed so that the side forms of members can be removed without disturbing the soffit forms. If props are to be left in place when the soffit forms are removed, these props shall not be disturbed during the striking.
- (7) For pre-stressed units the side forms shall be eased as early as possible and the soffit forms shall be designed to allow for the deformation of the member, when the pre-stress is applied.
- (8) Forms shall be set and maintained true to the line designated until the concrete is sufficiently hardened. Forms shall remain in place for the specified periods.
- (9) When forms appear to be unsatisfactory in any way, either before or during the placing of concrete, the Engineer will order the work stopped until the defects have been corrected.
- (10) The shape, strength, rigidity, water tightness, and surface smoothness of reused forms shall be maintained at all times. Any warped or bulged lumber must be re-sized before being re-used. Forms which are unsatisfactory in any respect shall not be re-used.
- (11) All curved surfaces shall be formed with approved plywood or steel.
- (12) Structural concrete shall not be poured against vertical or inclined rubble fill or earth surfaces in lieu of shuttering.
- (13) The shuttering shall be cleaned out prior to concreting and the bottom thoroughly freed from sawdust, shavings, rust, dirt, mud, tie-wire off cuts and other debris.
- (14) For narrow walls and columns, where the bottom of the 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.
- (15) The inside of all forms shall be oiled with a light, clear paraffin base oil approved by the Engineer. The oil shall when practicable be applied after the completion of the forms and immediately prior to placement of reinforcement. It shall be fully absorbed by the wood and must not discolour the surface of the concrete.
- (16) Chemical release agents, if approved by the Engineer as a substitute to oil, shall be applied strictly in accordance with the manufacturer's instructions and shall not come into contact with the reinforcement, pre-stressing tendons and anchorages. Different release agents shall not be used in the formwork for concrete which will be visible in the finished Works.
- (17) When absorbent timber forms are used in high temperatures they shall be thoroughly wetted on both sides to close shrinkage cracks in advance of placing the concrete.
- (18) Metal forms which do not present a smooth surface or line up properly, shall not be used.
- (19) Special care shall be exercised to keep metal forms free from rust, grease or other foreign matter which might tend to discolour the concrete.
- (20) All joints in shuttering or moulds shall be in either horizontal or vertical planes to an agreed pattern and shall be of such a design as to ensure that there is no loss of fine materials or cement during the placing or compaction of the concrete.
- (21) All formwork joints for exposed surfaces of concrete finish shall form a regular pattern with horizontal and vertical lines continuous throughout each structure and all construction joints shall coincide with these horizontal or vertical lines.

(22) No reinforcement shall be placed until the formwork has been inspected and approved by the Engineer, and no concrete shall be placed until the reinforcement has been positioned and approved and the formwork re-inspected and approved.

505.03.3 Removal of Forms and Falsework

(1) Falsework and forms shall not be removed without approval of the Engineer. The approval of the Engineer to falsework/forms removal shall not relieve the Contractor of responsibility for the Works.

(2) A small portion of the formwork shall be removed initially to ascertain that the concrete has set sufficiently hard before the whole area of the formwork is removed. Supports shall be removed in such a manner as to permit the concrete to uniformly and gradually take its own weight.

(3) The removal of formwork shall be effected in such a manner as will ensure that no damage to the concrete occurs. No formwork shall be removed before the concrete has attained adequate compressive strength to ensure the safety of the Works and compliance with the Specifications. The minimum periods for removal of formwork as given below, as may be specified on the Drawings or as may be noted elsewhere in the Contract Documents are a guide but will not relieve the Contractor from his obligation to delay removal of the formwork until the concrete has attained adequate compressive strength.

(4) When field operations are not controlled by cylinder tests, falsework and forms shall remain in place for minimum periods of time elapsed after placement of concrete, exclusive of days when the temperature is below 4 °C, as stated below, unless otherwise directed by the Engineer:

Falsework for:

Spans over 4 m	14 days
Spans of 4m or less	10 days
Bent caps not yet supporting girders	10 days

Forms:

Not supporting the dead weight of concrete	24 hours
Interior cells of box girders and for railings	12 hours

(5) When field operations are controlled by cylinder tests, the removal of forms and falsework shall not begin until the concrete has attained the specified compressive strength, but in no case shall supports be removed in less than 7 days after placement of concrete. The specified strength shall be 80% of the 28 day concrete compressive strength.

(6) In continuous structures, falsework shall not be released in any span until the first and second adjoining spans on each side have reached the strength specified herein.

(7) In addition to the above time requirements, falsework for post-tensioned portions of structures shall not be released until the pre-stressing steel has been tensioned.

(8) Unless otherwise specified in the Contract or approved by the Engineer, falsework shall be released before railings, kerbs or copings or similar are placed.

(9) In order determine the condition of column concrete, forms shall be removed from columns before releasing supports from beneath beams and girders.

(10) The forms for footings constructed within cofferdams or cribs may be left in place when, in the opinion of the Engineer, their removal would endanger the safety of the cofferdam or crib, and when the forms so left intact will not be exposed to view in the finished structure. All other forms shall be removed whether above or below the ground line or water level.

(11) All forms shall be removed from the cells of concrete box girders.

(12) To facilitate finishing, forms used on ornamental work, railings, parapets and exposed vertical surfaces shall be removed in not less than 12 nor more than 48 hours, depending upon weather conditions.

(13) When elements are prefabricated, they may be removed from the forms and moved to storage, when the strength of concrete has reached at least 75 % of the compressive strength required at 28 days. Pre-stressed elements may be moved after the first cables have been tensioned with sufficient pre-stress to safely carry the dead weight, including handling impact, of the element.

505.04 MEASUREMENT AND PAYMENT

(1) No separate measurement and payment will be made for complying with the requirements of this Section 505.

SECTION 506

STEEL REINFORCEMENT

506.01 DESCRIPTION

- (1) The work covered by this Section consists of supplying, cutting, bending and placing steel reinforcement in concrete structures in conformity with the Drawings.

506.02 MATERIALS

506.02.1 Bars

- (1) All reinforcing bars shall be deformed and shall conform to the requirements of AASHTO M 31, as required on the Drawings.

506.02.2 Wire and Wire Mesh

- (1) Cold-drawn steel wire shall conform to the requirements of AASHTO M 32.
- (2) Welded steel wire mesh shall conform to the requirements of AASHTO M 55.

506.02.3 Bar Mats

- (1) Steel bar mats shall conform to the requirements of AASHTO M 54.

506.02.4 Binding Wire

- (1) Binding wire shall be high-quality black annealed mild steel wire, approximately 1.6 mm in diameter.

506.02.5 Certification

- (1) A manufacturer's certified mill test report showing physical and chemical analysis for each lot of reinforcing bars delivered shall be provided to the Engineer.

506.02.6 Identification

- (1) The bars in each lot shall be legibly tagged by the manufacturer before being offered for inspection. The tag shall show the manufacturer's test number and lot number or other designation that will identify the material with the mill certificate issued for that lot of steel.
- (2) The manufacturer shall furnish certificates showing the heat number or numbers from which each size of bar in the shipment was fabricated.

506.03 CONSTRUCTION REQUIREMENTS

506.03.1 Sampling and Testing

- (1) Sampling and testing may be made at the source of supply when the quantity to be shipped or other conditions so warrant.
- (2) Bars not inspected before shipment will be inspected on arrival on the Site.
- (3) Test samples obtained at the destination of the steel shall consist of pairs of specimens cut from a single bar. Each specimen shall be not less than one metre in length. Bars from which such samples are taken shall be replaced at the Contractor's expense.

- (4) The Engineer has the right to re-sample and inspect all reinforcement steel upon its arrival at the Work site.
- (5) Tests of the mechanical properties will be performed when mill test reports from the manufacturers have not been attached or when the reinforcement is suspected to be of inferior quality.
- (6) All batches of reinforcement delivered on the Site may be subject to testing. Reinforcement in one batch shall consist of bars with the same cross-sectional area and the same heat number.
- (7) One set of samples (two specimens) will be taken from three bars of each batch. From each set of samples, one specimen shall be subjected to a tensile test (yield point, tensile strength and elongation rate) and one to a cold-bending test.
- (8) All tests shall be performed in accordance with the relevant standards. If any specimen fails a test, two additional specimens will be taken for a repeat test. If either of the two specimens fails, the batch shall either be rejected, or, if the Engineer so allows, the grade shall be lowered in accordance with the test results.

506.03.2 Storage, Cutting and Bending

- (1) Steel reinforcement shall be stored above the ground on platforms, skids, or other supports and shall be protected as far as practicable from mechanical injury and surface deterioration caused by exposure to conditions producing rust. It shall be properly marked and stored in a manner to facilitate inspection.
- (2) When used, reinforcement shall be free from cracks, laminations, dirt, loose or detrimental rust, loose scale, mortar, paint, grease, oil or other materials that would reduce bond.
- (3) Rust, mill scale, surface seams, surface irregularities or nicks will not be cause for rejection, provided the minimum dimensions, cross-sectional area and tensile properties of a hand wire-brushed specimen meet the physical requirements for the size and grade of steel specified.
- (4) All cutting and bending shall be done by competent workmen and with equipment and in a manner approved by the Engineer. Unless shown otherwise on the Drawings or unless written approval is obtained from the Engineer, all bars shall be cut and bent in an on-site fabrication shop.
- (5) Reinforcement shall be bent cold to the shapes shown on the Drawings.
- (6) Bars partially embedded in concrete shall not be field bent except as shown on the Drawings or specifically permitted by the Engineer.
- (7) The minimum bend diameters for primary reinforcement shall be as shown on the Drawings, or if not shown, as specified below:

For Grade 60:

10 mm to 25 mm bars	6 x bar diameter
28 mm to 36 mm bars	8 x bar diameter

For Grade 40:

10 mm to 36 mm bars	5 x bar diameter
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- (8) If not otherwise shown on the Drawings, stirrups of 10 mm to 16 mm bars shall have minimum bend diameters of 4 times the bar diameter.

506.03.3 Placing, Supporting and Fastening

- (1) All reinforcement shall be accurately placed, firmly held in place by use of mortar blocks, wire supports, supplementary bars or other approved supports so that it will not be displaced during the pouring of concrete. Bars shall be securely fastened together. Laying or driving bars into concrete after pouring will not be permitted.

(2) Unless otherwise permitted by the Engineer, all bar intersections around the perimeter of each mat shall be securely tied together, at not less than 600 mm centres, and all other intersection shall be tied together except where spacing is less than 300 mm in each direction in which case alternate intersections shall be tied. The ends of binding wire shall be turned into the main body of the concrete.

(3) Bundled bars shall be tied together at not more than 1000 mm centres.

(4) Mortar blocks shall have a compressive strength not less than that of the concrete upon which they are to be embedded. The mortar blocks shall not exceed 50 mm by 50 mm and shall have a colour and texture that will match the concrete surface. Binding wire shall be cast into the blocks for the purpose of tying it to the reinforcement.

(5) The use of pebbles, pieces of broken stone or brick, metal pipe, wooden blocks or similar will not be permitted.

(6) All reinforcement shall be inspected and approved by the Engineer before any concrete is poured. Concrete in which the reinforcement has not been inspected by the Engineer shall be removed and replaced.

506.03.4 Mesh Reinforcement

(1) Sheets of mesh or bar mat reinforcement shall overlap each other sufficiently to maintain a uniform strength and shall be securely fastened at the ends and edges. The edge lap shall not be less than one mesh in width.

(2) All bar intersections shall be tied or welded, as approved by the Engineer.

506.03.5 Substitutions

(1) Substitution with reinforcement of different sizes or higher quality than that specified may be permitted by the Engineer at his discretion.

506.03.6 Splicing

(1) Whenever possible reinforcement shall be furnished in the full lengths indicated on the Drawings.

(2) Splicing of bars, except where shown on the Drawings, will not be permitted without the written approval of the Engineer. Drawings showing the location of each splice shall be submitted to the Engineer for approval before the reinforcement is placed.

(3) Splices shall be avoided at points of maximum stress. They shall, where possible, be staggered with a minimum separation of not less than 40 bar diameters. Splices shall be designed to develop the strength of the bar without exceeding the allowable unit bond stress.

(4) Not more than one-third of the bars may be spliced in the same cross-section, except where shown on the Drawings.

(5) Unless otherwise shown on the Drawings, lapped splices shall be in accordance with the latest edition of AASHTO LRFD (Load and Resistance Factor Design), or as otherwise approved by the Engineer.

(6) Lapped splices shall not be used for 40 mm bars and larger.

(7) In lapped splices, the bars shall be placed in contact and wired together.

(8) Lapped splices will not be permitted at locations where the concrete section is insufficient to provide a minimum clear distance of one and one-third times the maximum size of coarse aggregate between the splice and the nearest adjacent bar.

(9) Spiral reinforcement shall be spliced by lapping at least one and a half turn unless otherwise shown on the Drawings.

(10) Welded splices shall be used only if shown on the Drawings or if permitted in writing by the Engineer.

(11) All welding procedures shall conform to the Structural Welding Code, Reinforcing Steel, AWS D1.4 of the American Welding Society.

(12) Proprietary mechanical coupler splice devices shall be used only if shown on the Drawings or permitted in writing by the Engineer. Such couplers shall develop in tension or compression at least 125% of the specified yield strength of the bar.

506.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
506-1	Steel Reinforcement	Tonne

(2) Reinforcement will be measured by computing the total weight of all bar sizes and lengths, wire or welded wire fabric as shown on the Drawings or ordered by the Engineer.

(3) Binding (tie) wire shall not be measured separately.

(4) Laps not shown on the Drawings will not be measured.

(5) The weight of reinforcing bars will be computed using the following table:

Diameter (mm)	Area (mm ²)	Weight/Metre (kg/m)
6	28.3	0.222
8	50.3	0.395
10	78.5	0.616
12	113.1	0.888
14	153.9	1.208
16	201.1	1.579
18	254.5	1.998
20	314.2	2.466
22	380.1	2.984
25	490.9	3.854
28	615.8	4.833
32	804.3	6.313
36	1017.9	7.990

506.05 PAYMENT

(1) Payment will be at the rate entered in the Bill of Quantities which shall include for cutting, bending, wastage, fixing in place, binding (tie) wire, spacer blocks, cleaning, welding, splices, couplings, sampling and testing.

SECTION 507

STRUCTURAL CONCRETE

507.01 DESCRIPTION

(1) The work covered by this Section consists of supplying, placing, finishing and curing concrete in bridges, culverts and other drainage structures and in incidental construction. The work includes structural elements constructed by cast-in-place and precast methods using plain, reinforced or prestressed concrete or any combination thereof.

507.02 GRADES AND USES OF CONCRETE

507.02.1 Main Concrete Grades

(1) The various concrete grades required are shown on the Drawings and/or specified herein for the different items of which structural concrete is an integral part. The different concrete grades are listed below.

Table 507.1 - Concrete Grades

Concrete grade	Minimum cement content (kg/m ³)	Maximum water cement ratio	Maximum size of coarse aggregate (mm)	Specified Compressive Strength (MPa)
15	200	0.65	20	15
20	250	0.60	63 / 50	20
25	325	0.55	37.5 / 25 / 20	25
30	375	0.50	25 / 20	30
40	420	0.45	20	40

(2) The concrete grade is denoted by the 28-day compressive strength specified, expressed in MPa, based on cylindrical concrete specimens 6 inches (152 mm) in diameter and 12 inches (304 mm) in height, cured and tested at 28 days of age in accordance with AASHTO T 22 and the maximum aggregate size.

(3) The size of coarse aggregate for any mix shall not exceed the maximum given above and shall be appropriate for the intended usage, section size and reinforcement spacing.

507.02.2 No-fines Concrete (Light Weight Concrete)

(1) No-fines concrete shall have the aggregate grading specified below. The cement/aggregate ratio shall be not greater than 1:15. The cylinder compressive strength at 28 days shall be not less than 7.0 MPa.

Table 507.2 - No-fines Concrete Aggregate Grading

AASHTO T 27 Sieve (mm)	Percentage Passing (by weight)
90	100
37.5	80 – 100
19.0	0 – 20
9.5	0 – 5

507.02.3 Uses of Concrete

(1) The various grades of concrete are intended to be used as indicated below, or as otherwise shown on the Drawings:

Table 507.3 - Intended Use of Various Grades of Concrete

Grade	Main Use
15	Blinding and levelling concrete, minor unreinforced concrete works
20	Structural mass concrete
25	Structural concrete for drainage structures and bridge sub-structures. Concrete bridge parapets
30	Structural concrete where specified
40	Prestressed girders, diaphragms, precast deck panels, cast-in-place bridge decks, precast concrete piles.

507.03 MATERIALS

507.03.1 Test Methods

(1) The standard test methods to be adopted shall be those stipulated herein.

507.03.2 Aggregates

(1) The combined aggregate should be as coarse-grained and densely-graded as possible. It shall be well-graded between the limits and the size or sizes specified herein, or ordered by the Engineer.

(2) The maximum particle size should be chosen so as to be compatible with mixing, handling, placing and working the concrete.

(3) Aggregate shall not contain harmful materials such as iron pyrites, coal, mica, shale or similar laminated materials such as flat and elongated particles, or any materials which may attack the reinforcement, in such a form or in sufficient quantity to affect adversely the strength and durability of the concrete. If necessary, aggregate shall be washed and sieved to remove deleterious substances.

507.03.3 Fine Aggregate

(1) Fine aggregate shall conform to the requirements of AASHTO M 6, except as otherwise specified herein, and shall consist of natural sand or, subject to the approval of the Engineer, of a combination of not more than 50% by weight of stone screenings and natural sand, having hard, strong, durable particles.

(2) Fine aggregate from different sources shall not be mixed or stored in the same stockpile nor used alternatively in the same class of construction or mix without written permission from the Engineer.

- (3) Fine aggregate shall have the following grading:

Table 507.4 - Grading of Fine Aggregate

AASHTO T 27 Sieve (mm)	Percentage Passing
9.5	100
4.75	95 - 100
2.36	80 - 100
1.18	45 - 80
0.60	25 - 60
0.3	10 - 30
0.15	2 - 10

- (4) The above grading requirements represent the extreme limits which shall determine suitability for use from all sources of supply. The grading from any one source shall be reasonably uniform, and not subject to the extreme percentages of grading specified.

- (5) To determine the degree of uniformity, a fineness modulus determination shall be made by the Contractor upon representative samples from such sources as he proposes to use. The fineness modulus shall be determined in accordance with AASHTO M 6. The fineness modulus shall be within the range of 2.3-3.1.

- (6) Fine aggregate from any one source having a variation in fineness modulus greater than 0.20 either way from the fineness modulus of the representative samples submitted by the Contractor may be rejected, until suitable adjustments can be made in the mix proportions to compensate.

- (7) When tested by the calorimetric method for organic matter according to AASHTO T 21, the colour shall be lighter than standard. The content of sulphide and sulphate (converted into SO₃) shall not be more than 0.5% by weight. The maximum loss when tested to 5 cycles for sodium sulphate soundness according to AASHTO T 104 shall be 10%.

507.03.4 Coarse Aggregate

- (1) Coarse aggregate shall conform to AASHTO M 80, except as otherwise specified herein, and shall consist of gravel, crushed gravel or crushed stone free from deleterious substances.

- (2) Crushed stones of lime-rock corroded by mineral water, especially acid water, and stone material containing such irremovable foreign matter as coal, cinder coal, lime, broken bricks or burnt stones shall not be used.

- (3) Coarse aggregate shall have the following grading, depending on the permissible maximum particle size:

Table 507.5 - Grading of Coarse Aggregate

AASHTO T 27 Sieve (mm)	Percentage Passing (by weight)				
	Class A	Class B	Class C	Class D	Class E
63	100	-	-	-	-
50	95 - 100	100	-	-	-
37.5	-	95 - 100	100	-	-
25	35 - 70	-	95 - 100	100	-
19	-	35 - 70	-	95 - 100	100
12.5	10 - 30	-	25 - 60	-	90 - 100
9.5	-	10 - 30	-	20 - 55	40 - 70
4.75	0 - 5	0 - 5	0 - 10	0 - 10	0 - 15
2.36	-	-	-	-	0 - 5

- (4) The content of clay lumps and friable particles when tested according to AASHTO T 112 shall not be more than 1% by weight.
- (5) Flakiness index and elongation index shall not exceed 25% when tested in accordance with BS EN 933-3 (Flakiness index), respective BS 812-105.2 (Elongation Index).
- (6) The maximum loss when tested according to AASHTO T 104 (5 cycles) for sodium sulphate soundness shall be 10%.
- (7) When tested for abrasion according to AASHTO T 96, after 500 revolutions, the maximum loss shall be 35%.

507.03.5 Mixing Water

- (1) A thorough chemical water analysis shall be made before using water from any particular source for concrete mixing. Testing shall be in accordance with AASHTO T 26.
- (2) Mixing water shall be reasonably clean and free from injurious amounts of oil, acid, alkali, sugar, salt, vegetable, organic matter or other deleterious substances.
- (3) The chloride ion concentration of the mixing water, when tested according to ASTM D512 shall not exceed 1,000 ppm.
- (4) Acid water with a pH-value of less than 4, when tested according to AASHTO T 26 shall not be used.
- (5) Water with a sulphate ion concentration (measured in SO_4) of more than 1,300 ppm, when tested according to ASTM D516 shall not be used.
- (6) Water known to be of potable quality may be used without testing, subject to the approval of the Engineer.
- (7) These provisions apply only for mixing water and not for water used for washing the aggregates and curing the concrete.
- (8) When comparative tests are made with water of known satisfactory quality, in conformance with AASHTO T 106, any indications of unsoundness, marked change in time of set (not exceeding 30 minutes when tested in accordance with AASHTO T 131) or reduction of more than 10% in mortar strength shall be sufficient cause for the rejection of the water under test.
- (9) Water obtained from a source which is liable to seasonal variation in water quality shall be re-tested at intervals not exceeding 3 months or as required by the Engineer.

507.03.6 Cement

- (1) Cement used in concrete shall be ordinary Portland cement conforming to AASHTO M 85 or ASTM C150, Type I.
- (2) Blast furnace cement (slag cement) shall not be used without the written permission of the Engineer.
- (3) Test reports from the manufacturer shall be attached when cement is delivered to the Site, and checked for brand, grade and test results.
- (4) At the time of use, all cement shall be free-flowing and free of lumps. Cement that has been in storage for a period of 3 months if bagged, or 6 months if bulk, or if the Engineer is in doubt about its quality, shall be tested by the standard mortar test of AASHTO T 106 to determine its suitability for use and such cement shall not be used without approval by the Engineer.
- (5) All cement shall have a compressive strength of standard cement mortar samples at 28 days of not less than 25.0 MPa, tested in accordance with AASHTO T 131.

(6) When factory tests or field tests subsequent to the original approval tests, show that the cement does not comply with the Specifications, the entire consignment from which the sample was taken will be rejected and the Contractor shall immediately remove the rejected material from the Site and replace it with cement which meets the required specifications.

507.03.7 Admixtures and Additives

(1) The consent of the Engineer shall be obtained in writing prior to the use of admixtures or cement containing additives.

(2) Chemical admixtures shall conform to AASHTO M 194. Unless otherwise specified, only Type A (water-reducing), Type B (retarding) and Type D (water reducing-retarding) shall be used.

(3) Water-reducing admixture shall be added to concrete for precast prestressed girders to improve the workability if ordered by the Engineer.

(4) The Contractor shall submit the manufacturer's certified formula for the proposed admixture with sufficient evidence that the proposed admixture has given satisfactory results on other similar work. Permission to use the admixture may be withdrawn at any time when unsatisfactory results are obtained.

(5) The amount of admixture to be used shall be in accordance with the manufacturer's specification and it shall be verified by testing to the approval of the Engineer.

(6) Admixture containing chloride ion exceeding 1% by weight of the admixture shall not be used in reinforced concrete.

(7) The Contractor shall introduce the admixture in the mix in a water solution and the water so included shall be calculated as effective mix water.

(8) Concrete with a retarding admixture must reach initial set at least 1 hour later, but not more than 3 hours later than the reference concrete and must reach final set not more than 3 hours later than the reference concrete, when tested in accordance with AASHTO T 197.

507.04 CONCRETE MIX DESIGN

507.04.1 General Requirements

(1) The mix shall be proportioned so as to secure a workable, finishable, durable, watertight and wear resistant concrete of the required strength.

(2) Mixes for the grades of concrete required for the Works shall be designed by the Contractor, and shall be subject to approval by the Engineer.

(3) Durable concrete of suitably low permeability shall be obtained by the use of strong dense aggregates, a sufficiently low water/cement ratio, complete compaction and proper curing methods to ensure sufficient hydration of the cement.

(4) The mix shall be designed to allow it to be properly placed, and the difficulty in mixing and/or transportation shall not be considered in the mix acceptability.

(5) Concrete as dry as it is practical to place with the available equipment shall be used.

(6) The quantity of mixing water once approved shall not be varied without the prior written approval of the Engineer.

507.04.2 Strength Requirements

(1) In calculating the water/cement ratio of the mix, the weight of water shall be the total free water in the mix which includes the mixing water, the water in any admixture solution and any water in the aggregates.

(2) The consistency of fresh concrete shall be monitored by testing the slump in accordance with AASHTO T 119. The quantity of water used shall not exceed that required to produce a concrete with sufficient workability to be placed and compacted in the particular location as required, and to produce concrete of the following consistencies or as otherwise approved by the Engineer.

Table 507.6 - Slump of Concrete

Type of Work	Nominal slump (mm)	Maximum slump (mm)
Formed elements		
Sections over 300mm	60	100
Sections under 300mm	80	120
Slabs with crossfall	60	80
Cast-in-place piles and drilled shafts, not vibrated	125 -200	230
Precast piles	80	120
Concrete placed underwater	125 -200	230

(3) The cement content in any mix shall not exceed 500 kg/m³ if not otherwise specified or directed.

(4) Unless otherwise approved by the Engineer, the mix designs shall be on the basis of continuously graded aggregates.

507.04.3 Trial Mixes

(1) At least 56 days before the commencement of concreting the Contractor shall, have trial mixes designed and prepared in the laboratory for the approval of the Engineer. The concrete from each mix shall be tested in accordance with Clause 507.15 herein and shall satisfy the strength requirements specified.

(2) The Contractor shall furnish single-use cylinder moulds conforming to AASHTO M 205, or when approved by the Engineer, reusable vertical moulds made from heavy gauge metal.

(3) A minimum of ten test cylinders taken from a trial batch of the proposed mix shall be made with the materials approved for use by the Engineer, with five tested at 7 days and five at 28 days. Testing shall be witnessed by the Engineer.

(4) The average strength of the cylinders tested at 7 days shall not be less than 70% of the specified 28-day strengths.

(5) The average strength of the cylinders tested at 28 days shall be at least 20% greater than the specified 28 days strength.

(6) The Engineer will review the Contractor's trial mixes and cylinder strengths at 7 and 28 days. The Engineer will then determine which of the trial mixes shall be used. If none of the mixes for a given grade meets the Specifications or is acceptable to the Engineer, the Contractor shall prepare additional trial mixes.

(7) No structural concrete shall be placed in the Works until the relevant trial mix has been approved by the Engineer.

(8) When a trial mix has been approved, no variations shall be made in the proportions, the source of the cement and aggregates, or in the type, size and grading of the latter without the consent of the Engineer.

(9) Should any variations be made which, in the opinion of the Engineer, could influence the strength or characteristics of the concrete, concreting operations shall cease and further trials undertaken by the Contractor. Concreting shall not recommence until a new mix has been approved by the Engineer.

(10) When the Contractor intends to purchase factory-made precast concrete units, the Engineer may dispense with trial mixes and laboratory tests provided that evidence is given which satisfies him that the factory regularly produces concrete which complies with the Specifications. The evidence shall include details of mix proportions, water/cement ratios, workability and strengths obtained at 28 days.

507.05 BATCHING AND MIXING CONCRETE

507.05.1 Delivery and Storage of Materials

(1) The batching site shall be of adequate size to permit the stockpiling of sufficient base materials, having proper and uniform moisture content to ensure continuous and uniform operation.

(2) Aggregates shall be stockpiled in such quantities that sufficient material approved by the Engineer is available to complete any continuous pour necessary for structures.

(3) All aggregates shall be stockpiled for at least 12 hours before use in order to promote a uniform moisture content and to provide uniform conditions for proportioning plant control. Segregation shall be avoided.

(4) Aggregate for concrete shall not be contaminated by other materials during transport and during storage on Site, and shall be stockpiled, preferably on a concrete slab, in such a manner that will preclude the intrusion of foreign material. If aggregates are stored on the ground, the bottom 200 mm minimum thickness layer of aggregates shall not be disturbed or used without re-cleaning, and an approved system of permanent gauges shall be installed to indicate that minimum thickness.

(5) Coarse aggregate, unless otherwise permitted by the Engineer, shall be delivered to the Site in separate sizes.

(6) Aggregates of different sizes shall be stored in different hoppers, or different stockpiles which shall be separated from each other.

(7) Stockpiles of coarse aggregate shall be built in horizontal layers not exceeding one metre in depth to avoid segregation. Should the coarse aggregate become segregated it shall be re-mixed to conform to the grading requirements.

(8) Fine aggregate from different sources of supply shall not be mixed or stored in the same stockpiles nor used alternatively in the same class of construction or mix without written permission from the Engineer.

(9) Cement shall be protected from moisture during transport and storage. Bulk transport vehicles and bins or silos for cement shall not contain any residues of a different type, or of a lower strength class or of any other materials.

(10) Cement shall be delivered and stored in quantities sufficient to ensure that there is no suspension or interruption of the work at any time. Each consignment shall be kept separate and distinct in accordance with its mark, grade and date of production.

(11) Cement in sacks shall be stored in a suitable weatherproof structure which shall be as airtight as practicable. Floors shall be wooden and elevated above the ground a sufficient distance to prevent the absorption of moisture. Sacks shall be stacked close together to reduce circulation of air but shall not be stacked against outside walls. The manner of storage shall permit easy access for inspection and identification of each consignment.

(12) Bulk cement shall be transferred to elevated airtight and weatherproof bins.

(13) In cases where only a small amount of concrete work is required, cement storage in the open may be permitted by the Engineer, in which case a raised platform and ample waterproof covering shall be provided.

507.05.2 Mixing Concrete

(1) All weighing and water-dispensing plant shall be maintained in good order. Their accuracy shall be checked against accurate weights and volumes when required by the Engineer. They shall be accurate to within 0.5% throughout the range of use.

(2) The weight of each size of aggregate indicated by the mechanisms employed shall be within a tolerance of $\pm 2\%$ of the respective weight per batch agreed by the Engineer. Quantities of water, cement, and water-reducing admixture shall be within a tolerance of $\pm 1\%$ respectively.

(3) The weight of the fine and coarse aggregates shall be adjusted to allow for the free water contained in them. The water to be added to the mix shall be reduced by the quantity of free water contained in the fine and coarse aggregates, which shall be determined by the Contractor by the method of AASHTO T 255 immediately before mixing begins.

(4) Concrete shall be mixed only in the quantities required for immediate use. Concrete that has developed initial set shall not be used. Re-tempering concrete by adding water or by other means will not be permitted. Concrete that is not within the specified slump limits at the time of placement shall not be used and shall be disposed of as directed by the Engineer.

(5) Concrete may be mixed at the site of the work, in a central-mix plant or in truck mixers. The mixer shall be of an approved type and capacity. Mixing time shall be measured from the time all materials are in the drum. Ready-mixed concrete shall be mixed and delivered in accordance with the requirements of Sub-clause 507.05.3 herein.

(6) Mixing of concrete shall be performed until a well-distributed mixture of the various constituent materials appears with consistent colour.

(7) When mixed at the job site or in a central-mixing plant, the mixing time shall not be less than 1.5 minutes nor more than 3 minutes. Five seconds shall be added to the specified mixing time if timing starts the instant the skip reaches its maximum raised position. Mixing time ends when the discharge chute opens. Different limiting mixing times may be allowed or directed by the Engineer, based on field trials or the experience of production.

(8) The mixer shall be operated at the drum speed shown on the manufacturer's rating plate on the mixer.

(9) The timing device on stationary mixers shall be equipped with a bell or other suitable warning device adjusted to give a clearly audible signal each time the lock is released. In case of failure of the timing device, the Contractor will be permitted to continue operations while it is being repaired, provided he furnishes an approved timepiece equipped with minute and seconds hands. If the timing device is not placed in good working order within 24 hours, further use of the mixer will be prohibited until repairs are made.

(10) Any concrete which, in the opinion of the Engineer, is mixed more or less than the specified time shall be discarded and disposed of by the Contractor at his expense.

(11) The volume of concrete mixed per batch should not exceed the mixer's nominal capacity, as shown on the manufacturer's rating plate on the mixer. The mixer shall have a rated capacity sufficient to mix a batch of concrete containing at least one full bag of cement.

(12) The batch shall be so charged into the drum that a portion of the mixing water shall enter in advance of the cement and aggregates. The flow of water shall be uniform and all water shall be in the drum by the end of the first 15 seconds of the mixing period. The throat of the drum shall be kept free of such accumulations as may restrict the free flow of materials into the drum.

(13) Unless otherwise agreed by the Engineer, immediately before any session of batching concrete, a preliminary part batch shall be mixed having the masses of fine aggregate, cement and water in correct proportion and no coarse aggregate. The purpose of this is to avoid loss of mortar from the first batch of concrete as specified. The preliminary batch shall be passed through all delivery equipment but not placed in the forms except with the specific approval of the Engineer.

(14) The entire contents of the mixer shall be removed from the drum before materials for the next batch are placed therein. Mixers which have been out of use for more than 30 minutes shall be thoroughly cleaned before any fresh concrete is mixed. Mixing plant shall be thoroughly cleaned before changing from one type of cement to another.

(15) Truck mixers, unless otherwise authorised by the Engineer, shall be of the revolving drum type, water-tight, and so constructed that the concrete can be mixed to ensure a uniform distribution of materials throughout the mass.

(16) All solid materials for the concrete shall be accurately measured and charged into the drum at the proportioning plant.

(17) Except as subsequently provided, the truck mixer shall be 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, in which case a tank is not required.

(18) Truck mixers may be required to be provided with a means by which the mixing time can be readily verified by the Engineer.

(19) The maximum size of batch in truck mixer shall not exceed the maximum rated capacity of the mixer as stated by the manufacturer and stamped in metal on the mixer.

(20) Truck mixing shall unless otherwise directed be continued for not less than 100 revolutions after all ingredients, including water, are in the drum. The mixing speed shall not be less than 4 rpm, nor more than 6 rpm.

(21) Mixing shall begin within 30 minutes after the cement has been added either to the water or aggregate, but when cement is charged into a mixer drum containing water or surface wet aggregate and when the temperature is above 32 °C, this limit shall be reduced to 15 minutes. The limitation in time between the introduction of the cement to the aggregate and the beginning of the mixing may be waived when, in the judgement of the Engineer, the aggregate is sufficiently free from moisture, so that there will be no harmful effects on the cement.

(22) When a truck mixer is used for transportation of centrally-mixed concrete, the mixing time specified in paragraph (7) herein may be reduced to 30 seconds and mixing completed in a truck mixer. The mixing in the truck mixer shall be as specified for truck mixing.

(23) During hot weather, the Contractor shall ensure that the constituent materials of the concrete are sufficiently cool to prevent the concrete from stiffening in the interval between its discharge from the mixer and compaction in its final position.

(24) Manual mixing shall be only permitted with the prior approval of the Engineer for concrete in small amounts. Mixing concrete by hand shall be performed on a steel plate. Cement and fine aggregates shall be mixed uniformly in advance and then mixed with coarse aggregate and water. The mixing shall continue until a well-distributed mixture of the constituent materials with uniform colour is obtained.

507.05.3 Ready-Mixed Concrete

(1) Ready-mixed concrete batched off the Site may be used only with the approval of the Engineer and shall comply with all relevant requirements of the Specifications for structural concrete.

507.05.4 Transporting Mixed Concrete

- (1) Mixed concrete may only be transported to the delivery point in truck agitators or truck mixers operating at the speed designated by the manufacturers of the equipment as agitating speed, or in non-agitating hauling equipment, provided the consistency and workability of the mixed concrete upon discharge at the delivery point is suitable for adequate placement and consolidation in place.
- (2) Track agitators shall be loaded not to exceed the manufacture's guaranteed capacity. They shall maintain the mixed concrete as a thoroughly mixed uniform mass during hauling.
- (3) No additional mixing water shall be incorporated into the concrete during hauling or after arrival at the delivery point.
- (4) The rate of discharge of mixed concrete from truck mixers or agitators shall be controlled by the speed of rotation of the drum in the discharge direction with the discharge gate fully open.
- (5) When a truck mixer or agitator is used for transporting concrete to the delivery point, discharge shall be completed within one hour, or before 250 revolutions of the drum or blades, whichever comes first, after the introduction of the cement to the aggregates. Under conditions contributing to quick stiffening of the concrete or when the temperature of the concrete is 30 °C, or above, a time less than one hour will be required as directed by the Engineer.

507.06 PROTECTION OF CONCRETE

507.06.1 General

- (1) Precautions shall be taken to protect concrete structures from damage due to weather or other environmental conditions during placing and curing operations.
- (2) The temperature of the concrete mixture immediately before placement shall be between +10°C and +32 °C.

507.06.2 Hot Weather Concreting

- (1) Hot weather concreting shall conform to the requirements of "Recommended Practice for Hot Weather Concreting" (American Concrete Institute 305-R77).
- (2) Unless otherwise directed, when the air temperature in the shade is expected to reach + 32 °C or more, the Contractor shall schedule his operations to place and finish the concrete during the hours when the air shade temperature is below + 32 °C. This shall preferably be in the latter part of the day after the maximum temperature has been reached and outside normal working hours.
- (3) The temperature of concrete at the time of placement shall be maintained within the specified temperature range by any combination of: shading the materials storage areas or production equipment; cooling the aggregates by sprinkling with water; cooling the aggregates or water by refrigeration or replacing the mix water with ice that is flaked or crushed.
- (4) The time available for handling and placing concrete during periods of high temperature may be considerably reduced and the Contractor shall take appropriate measures and precautions at his own cost. Concrete shall be protected during transportation by use of damp hessian or similar.
- (5) No additional water shall be added at the time of mixing without the approval of the Engineer, as this may lead to additional shrinkage of the concrete. On no account shall water be added during transportation or placing of the concrete.

507.06.3 Cold Weather Concreting

- (1) When there is a probability of the air temperatures below 2 °C, the Contractor shall submit for approval by the Engineer prior to concrete placement, a cold weather concreting plan detailing the methods and equipment which will be used to ensure that the required concrete temperatures are maintained. The concrete shall be maintained at temperatures of not less than 8 °C for the first six days after placement.
- (2) If external heat is used, the heat shall be applied and withdrawn gradually and uniformly so that no part of the concrete is heated more than 32 °C or caused to change the temperature by -7 °C in 8 hours.
- (3) When the air temperature is below 2 °C, the temperature of the concrete at the time of placement in sections less than 300 mm thick shall be not less than 16 °C.
- (4) When necessary to produce concrete of specified temperature, either the mix water or the aggregates, or both, shall be heated before batching.

507.07 HANDLING AND PLACING CONCRETE

507.07.1 General

- (1) The methods of transporting and placing concrete shall be to the approval of the Engineer. Concrete shall be so transported and placed that there is no contamination, segregation or loss of the constituent materials.
- (2) 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 method of delivery and handling shall be such as will facilitate placing with a minimum of re-handling and without damage to the structure or the concrete.
- (3) The Engineer may delay or suspend the mixing and placing of concrete at any job site for which he considers the Contractor's delivery and compaction equipment inadequate, until such time as the Contractor provides additional approved delivery and compaction equipment.
- (4) The formwork and reinforcement shall be clean and free from standing water immediately before the placing of the concrete and all sawdust, construction debris and other extraneous matter shall have been removed.
- (5) Concrete shall not be placed in any part of the structure until the Engineer's approval has been obtained.
- (6) The pouring operation shall be performed continuously. Should an intermission occur, it shall immediately be reported to the Engineer.
- (7) Concrete shall be compacted in its final position within 30 minutes of discharge from the mixer unless, with the approval of the Engineer, it is placed in a purpose-made agitator, operating continuously, in which case it shall be compacted in its final position within 2 hours of the introduction of cement to the mix and within 30 minutes of discharge from the agitator. These limiting times may be adjusted by the Engineer to take into account factors such as temperature and mix design, including admixtures.

507.07.2 Handling Concrete

- (1) A leak-proof, non-absorbent vessel shall be used for transporting concrete. It should be cleaned frequently from the remains of adhering concrete.
- (2) A cover shall be provided for the vessel in order to prevent sunshine, rain or cold weather affecting the quality of the concrete.

507.07.3 Placing Concrete

- (1) Concrete shall be placed so as to avoid displacement of the reinforcement, and shall be placed as nearly as possible to its final position.
- (2) The use of long troughs, chutes and pipes for conveying concrete to the forms shall be permitted only on written authorisation of the Engineer. The Engineer shall reject the use of equipment for concrete transportation that will allow segregation, loss of fine materials or which in any other way will have an adverse effect on the concrete quality.
- (3) Open troughs and chutes shall be metal lined; where steep slopes are required, the chutes shall be equipped with baffles or be in short lengths that reverse the direction of movement to avoid segregation.
- (4) 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.
- (5) Where Site conditions make it unavoidable that concrete has to be dropped more than 1.5 metres, the concrete shall be dropped through a tube fitted with a hopper head, or through other approved devices to avoid segregation.
- (6) As far as practicable, the pipes shall be kept full of concrete during placing and their lower end shall be kept buried in newly placed concrete
- (7) Except where otherwise agreed by the Engineer, concrete shall be deposited in horizontal layers to a compacted depth not exceeding 450 mm where internal vibrators are used, and 300 mm in all other cases. Each layer shall be placed and consolidated before the preceding batch has taken its initial set to prevent injury to the green concrete and to avoid surfaces of separation between the batches.
- (8) After the initial set of the concrete, the forms shall not be jarred and no force shall be applied to projecting reinforcing bars.
- (9) When concreting the bottom layer of footings, precautions shall be taken to prevent the concrete from absorbing moisture from the foundation or being permeated. Drainage measures shall be provided in the foundation trench. No standing water on the bottom of the trench shall be allowed prior to the concreting. A 100 mm thick layer of blinding concrete shall generally be used unless otherwise permitted by the Engineer, such as in the case of a foundation of clean, hard, impermeable rock.
- (10) Pumping will not be permitted from the inside of the foundation forms while concrete is being placed. If necessary to prevent flooding, a seal of concrete shall be placed through a closed chute or tremie and allowed to set.
- (11) Where there is dense top reinforcement, some straight bars may be displaced temporarily to facilitate the concrete placement. The bars shall be repositioned before placing the top layer.
- (12) Concrete for columns, substructure and culvert walls, and other similar vertical members shall be placed and allowed to set and settle for a period of time before concrete for integral horizontal members, such as caps, slabs or footings is placed. These shall be not less than 12 hours for vertical members over 4.5 metres in height and not less than 30 minutes for members over 1.5 metres but not over 4.5 metres in height.
- (13) Concrete for T-beam or deck girder spans whose depth is less than 1.2 metres may be placed in one continuous operation or in two separate operations; first, to the top of girder stems, and second, to completion. For T-beam or deck girder spans whose depth is greater than 1.2 metres, concrete shall be placed in two operations, with the deck slab concrete placed at least five days after concrete placement in the stems.

(14) Embedded items (bolts and anchor bars) shall be inspected regularly during the casting operation and any displacements shall be rectified. Care shall be taken to ensure the concrete fills up properly under horizontal plates, e.g. expansion joint plates.

507.07.4 Additional Requirements for Prestressed Concrete Members

(1) No concrete shall be used more than 45 minutes after the water has been introduced into the mix. This interval can be prolonged upto one hour when water-reducing admixture with a retarding effect is used. The time interval shall be subject to the approval of the Engineer.

(2) Concrete shall be placed continuously in one operation and in horizontal layers. The time between depositing two adjoining layers of concrete shall not be more than 30 minutes. with an ambient temperature of more than +30 °C and 45 minutes when the ambient temperature is less than +30 °C, unless otherwise permitted by the Engineer.

(3) Vibrators shall be handled with care in order not to displace, damage or deform pre-formed ducts or other inserts.

(4) In the anchoring zones at the ends of girders enhanced vibrating by means of approved external vibrators shall be used if necessary to ensure the density of the concrete and to prevent honeycombing.

507.07.5 Placing Concrete Under Water

(1) Concrete shall be deposited in water only with the permission of the Engineer.

(2) No concrete shall be placed in running water. Forms which are not reasonably watertight shall not be used for holding concrete deposited under water.

(3) The minimum cement content of the grade of concrete being deposited in water shall be increased by at least 10% without financial compensation.

(4) When depositing in water is allowed, the concrete shall be carefully placed in the space in which it is to remain in a compact mass, by means of a tremie, bottom-dumping bucket, concrete pump or other approved method.

(5) A tremie shall consist of a tube having a diameter of not less than 250 mm constructed in sections having flanged couplings fitted with gaskets with a hopper at the top. The tremie shall be supported so as to permit free movement of the discharge and over the entire top surface of the work and so as to permit rapid lowering when necessary to retard or stop the flow of concrete. The discharge end shall be closed at the start of work so as to prevent water entering the tube and shall be completely submerged in concrete at all times; the tremie tube shall be kept full to the bottom of the hopper. When a batch is dumped into the hopper, the flow of concrete shall be induced by lightly raising the discharge end, but always keeping it in the placed concrete. The flow shall be continuous until the work is completed.

(6) When the concrete is placed with a bottom-dump bucket, the top of the bucket shall be open. The bottom doors shall open freely downward and outward when tripped. The buckets shall be completely filled and slowly lowered to avoid backwash. It shall not be dumped until it rests on the surface upon which the concrete is to be deposited and when discharged shall be withdrawn slowly until well above the concrete.

(7) The concrete shall not be disturbed after being deposited.

507.07.6 Pumping Concrete

(1) Placement of concrete by pumping will be permitted only if authorised by the Engineer in writing after approval of a modified mix design and preliminary trials as specified.

(2) Where concrete is conveyed and placed by mechanically applied pressure, the equipment shall be suitable in kind and adequate in capacity for the work, and shall be so arranged that no vibrations result that might damage freshly placed concrete. The operation of the pump shall be such that a continuous stream of concrete without air pockets is produced. When pumping is completed, the concrete remaining in the pipeline, if it is to be used, shall be ejected in such a manner that there will be no contamination of the concrete or separation of the ingredients.

(2) After the operation, the entire equipment shall be thoroughly cleaned.

507.07.7 Casting Columns, Slabs and Girders

(1) Concrete in columns shall be placed in one continuous operation, unless otherwise directed. The concrete shall be allowed to set for at least 24 hours before the caps are placed.

(2) Unless otherwise permitted by the Engineer, no concrete shall be placed in the superstructure until the column forms have been stripped sufficiently to determine the condition of the concrete in the columns. The load of the superstructure shall not be allowed to come upon the bents until they have been in place at least 14 days, unless otherwise permitted by the Engineer.

(3) Concrete in slab spans shall be placed in one continuous operation for each span unless otherwise required by the Drawings.

(4) Concrete in T-beam or deck girder spans shall be placed in one continuous operation unless otherwise directed. If it is permitted to place the concrete in two separate operations, each of the operations shall be continuous: first, to the top of the girder stem, and second, to completion. In the latter case, the bond between stem and slab shall be secured by means of suitable shear keys which may be formed by the use of timber blocks approximately 50 mm x 100 mm in cross-section having a length of 100 mm less than the width of the girder stem. These key blocks shall not be greater than 300 mm centre to centre. The blocks shall be bevelled and oiled in such a manner as to ensure their ready removal, and they shall be removed as soon as the concrete has set sufficiently to retain its shape.

(5) If the Contractor wishes to place the concrete in two separate operations, he shall, with his request for permission to do so, submit plans and proposals of the required changes to the reinforcement, which plans and proposals shall be subject to the approval of the Engineer.

(6) In box girders, the concrete in the bottom slab shall be poured first, as a separate operation. The concrete in the webs and the top slab shall be placed in one continuous operation unless otherwise specified. If it is permitted to place the concrete in more than one operation, the requirements as specified for T-beams shall apply.

507.07.8 Compaction of Concrete

(1) All concrete, except concrete placed under water, during and immediately after depositing, shall be thoroughly compacted to produce a dense homogeneous mass. Unless otherwise permitted by the Engineer it shall be compacted with the assistance of mechanical vibration subject to the following provisions.

(2) The vibration shall be internal except that external vibrators may be used for thin sections when forms have been specifically designed for external vibration.

(3) Vibrators shall be of a type and design approved by the Engineer. They shall be capable of transmitting vibrations to the concrete at frequencies of not less than 4,500 impulses per minute. The intensity of vibration shall be such as visibly to affect a mass of concrete of 50 mm slump over a radius of at least 450 mm.

(4) A sufficient number of vibrators in serviceable condition shall be present at the site of concreting operations so that spare equipment is always available in the event of breakdown. Concrete placing shall not commence until approval is given by the Engineer to the number of vibrators in serviceable condition available at the place of concreting.

- (5) Vibration shall be applied at the point of deposit and in the area of freshly deposited concrete. The vibrators shall be inserted and withdrawn slowly to avoid creating voids.
- (6) Vibrators shall be inserted vertically into the concrete and to a sufficient depth to ensure that the newly-poured concrete is worked into the previous layer. The penetration of the vibrator into the previous layer should be approximately 50 mm.
- (7) Application of vibrators shall be at points uniformly spaced and not further apart than twice the radius over which the vibration is visibly effective.
- (8) The vibration shall be of sufficient duration and intensity to thoroughly compact the concrete, but shall not be continued so as to cause segregation. Vibration shall not be continued at any one point to the extent that localised areas of grout are formed.
- (9) Where immersion type vibrators are used, contact with reinforcement, formwork and all inserts shall be avoided, so far as is practicable.
- (10) Vibration shall not be applied directly to or by way of the reinforcement to sections or layers of concrete which have hardened to the degree that the concrete ceases to be plastic under vibration.
- (11) Vibrators shall not be used to make concrete flow in the forms and shall not be used to transport concrete in the forms. Where necessary, concrete shall be redistributed in the forms by spading.
- (12) Vibration shall be supplemented by such rodding as is necessary to ensure smooth surfaces and dense concrete, along surfaces and in corners and locations difficult or impossible to reach with the vibrators.
- (13) Concrete shall not be subjected to vibration between 2 and 24 hours after compaction, unless otherwise permitted by the Engineer.

507.08 CONSTRUCTION JOINTS

507.08.1 General

- (1) Joints in concrete work due to stopping work shall be avoided to the degree possible. If not detailed on the Drawings, or in an emergency, construction joint locations shall only be formed with the prior approval of the Engineer. Joints shall not be allowed within 500 mm of the top of any face.
- (2) Shear keys or inclined reinforcement shall be used where necessary to transmit shear and bond the two sections together. When shear keys or inclined reinforcement are not provided, the concrete shall be roughened as directed.

507.08.2 Construction Requirements

- (1) The upper surface of lifts of concrete walls and columns shall be horizontal unless otherwise described on the Drawings.
- (2) Immediately following the discontinuance of placing concrete, all accumulations of mortar splashed upon the reinforcing steel and the surfaces of forms shall be removed. Dried mortar chips and dust shall not be puddled into the unset concrete. Care shall be exercised during the cleaning of the reinforcing steel, not to injure or break the concrete-steel bond at and near the surface of the concrete.
- (3) Where a construction joint contains a formed surface, that surface shall be roughened to expose the aggregate without damaging the aggregate and the surface of the joint. The roughened surface shall then be washed with clean water under pressure to remove loose particles.
- (4) Where sections of the work are carried out in lifts, the reinforcement projecting above the lift being cast shall be adequately supported so as to prevent movement of the bars during the casting and setting of the concrete.

(5) Whenever possible laitance and all loose material shall be removed while the concrete is still green and no further roughening will then be required. When this is not possible, it shall be removed by mechanical means when the concrete has been in position for more than 24 hours. Extreme care shall be taken to avoid the mechanical devices hitting the reinforcement as this may result in the loss of bond between the reinforcement and the concrete. The roughened surface shall then be washed with clean water under pressure.

(6) To compensate for loss of mortar at the juncture of the hardened and the newly deposited concrete, the cleaned and saturated surfaces, including vertical and inclined surfaces, shall first be thoroughly painted with a thick coat of 1:2 cement/sand mortar or neat cement grout against which the new concrete shall be placed before the grout has attained its initial set. Where this is not possible, other approved means shall be adopted.

(7) The placing of concrete shall be carried continuously from joint to joint. The face edges of all joints that are exposed to view shall be carefully finished true to line and elevation.

(8) Suitable keys may be formed by the use of timber blocks approximately 50 mm deep by 100 mm wide in cross section and having a length of 100 mm less than the width of the member. The key blocks shall be spaced along the member as required, but the spacing shall be not greater than 300 mm centre to centre. The blocks shall be bevelled and oiled in such manner as to ensure their ready removal, and they shall be removed as soon as the concrete has set sufficiently to retain its shape.

(9) Immediately following the discontinuation of placing concrete, all accumulations of mortar splashed on the reinforcing steel and the surface of forms shall be removed. Dried mortar chips and dust shall not be puddled into the unset concrete. If the accumulations are not removed prior to the concrete setting, extreme care shall be exercised not to injure or break the concrete-steel bond at and near the surface of the concrete, while cleaning the reinforcing steel.

507.09 FINISHING PLASTIC CONCRETE

507.09.1 General

(1) After the concrete has been compacted and prior to the application of curing, all surfaces of concrete which are not placed against forms shall be struck-off to the given grade, superelevation or crown specified on the Drawings and the surface finished by floating with wooden floats.

(2) Exposed surfaces of substructure caps, kerbs and other surfaces, if directed by the Engineer, shall be finished with a wood float. When the moisture film has disappeared and the concrete has hardened sufficiently to prevent laitance from being worked to the surface, it shall be steel-trowelled under firm pressure to produce a dense, smooth, uniform surface free from trowel marks.

507.09.2 Roadway Surface Finish

(1) Bridge deck, and other concrete surfaces for use by traffic shall be finished to a skid-resistant surface.

(2) During finishing operations the Contractor shall provide suitable and adequate work bridges for performance of the work.

507.09.3 Striking Off and Floating

(1) After the concrete is placed and compacted, bridge decks or top slabs of structures serving as finished pavements shall be finished using approved power driven finishing machines.

(2) All surfaces shall be struck-off by equipment supported by and travelling on rails or headers. Rails or headers shall be adjustable for elevation and shall be set to allow for anticipated settlement, camber, and deflection of falsework, as necessary to obtain a finished surface true to the required grade and cross section.

- (3) Before the delivery of concrete is begun, the finishing machine or, if used, the hand-operated strike-off tool shall be operated over the entire area to be finished to check for excessive rail deflections, for proper deck thickness and cover on reinforcing steel.
- (4) A slight excess of concrete shall be kept in front of the cutting edge of the screed at all times. This excess concrete shall be carried all the way to the edge of the pour or form and shall not be worked into the slab, but shall be wasted.
- (5) After strike-off, the surface shall be finished with a float, roller or approved device as necessary to remove any local irregularities and to leave sufficient mortar at the surface of the concrete for later texturing.
- (6) During finishing operations, excess water, laitance, or foreign materials brought to the surface shall not be re-worked into the slab, but shall be removed immediately upon appearance.
- (7) After finishing, the entire surface shall be checked by the Contractor with a 3 metre long metal straightedge operated parallel to the centreline of the bridge and shall show no deviation in excess of 3 mm from the testing edge. Deviations in excess of these requirements shall be corrected before the concrete sets.

507.09.4 Texturing

- (1) The surface shall be given a skid-resistant texture by either burlap or carpet dragging, brooming, tining, or by a combination of this methods. This operation shall be done after floating.
- (2) If the surface is to be drag finish, the surface shall be finished by dragging a seamless strip of damp burlap over the full width of the surface. The burlap drag shall consist of sufficient layers of burlap and have sufficient length in contact with the concrete to slightly groove the surface.
- (3) If the surface texture is to be broom finish, the surface shall be broomed when the surface has hardened sufficiently. The strokes shall be square across the slab, from edge to edge, with adjacent strokes slightly overlapped, and shall be made by drawing the 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.
- (4) If the surface is to be tined, the tining shall be in transverse direction using a wire broom, comb or finned float having a single row of tines or fins. The tining grooves shall be between 2 mm and 5 mm deep, spaced 12 mm to 40 mm on centres.

507.09.5 Surface Testing and Correction

- (1) After the concrete has hardened, the finished deck roadway surfaces will be inspected by the Engineer. The surface shall be tested with a 3 metre long straight-edge. Areas showing high spots of more than 3 mm but not exceeding 12 mm in 3 metres between any two contact points shall be marked. The Contractor shall correct such irregularities by the use of concrete planing or grooving equipment which produces a textured surface in equal roughness to the surrounding unground concrete.
- (2) Where the departure from correct cross section exceeds 12 mm the Engineer may direct the Contractor to remove and re-do the work at the Contractor's own cost.
- (3) The Contractor shall request the Engineer's approval of all finished surfaces.

507.09.6 Concrete Surface Finish for Sidewalk

- (1) After the concrete has been deposited in place, it shall be compacted and the surface shall be struck off by means of a strike board and floated with a wooden or cork float. An edging tool shall be used on all edges and at all expansion joints.
- (2) The surface shall not vary more than 3 mm under a 3 m straight-edge.
- (3) The surface shall have a granular or matted texture which will not slick when wet.

507.10 CURING CONCRETE

507.10.1 General

- (1) In all cases the method of curing shall be approved by the Engineer before concreting of any element commences and concreting shall not be commenced until all curing materials are available at the site of the concreting operations and have been approved by the Engineer.
- (2) Immediately after the free water has left the surface and finishing operations are completed. Curing by other than steam method shall continue for 7 days thereafter, or as directed by the Engineer. The concrete shall be protected against harmful effects of weather, including rain, rapid temperature change and from drying out.
- (3) The methods of curing and their duration shall be such that the concrete will have satisfactory durability and strength and the member will suffer a minimum of distortion, be free from excessive efflorescence (becoming powdery by loss of water or crystallization) and will not leak due to shrinkage cracking in the structure. If necessary the concrete shall be insulated so that it is maintained at a suitable temperature, or so that the rates of evaporation of moisture from the surfaces are kept to appropriate values. Different curing or drying treatments will be appropriate to different members and products. Where necessary special care should be taken to ensure that similar components are cured as far as practicable under the same conditions.
- (4) The top surfaces of bridge decks shall be cured by the water curing method. The water cure shall be applied progressively immediately on completion of a section of deck finishing. Sections shall be agreed with the Engineer. Curing of concrete shall commence no later than 4 hours after placement.
- (5) The liquid membrane curing method shall not be used on surfaces where a rubbed finish is required or on surfaces of construction joints. It may however be used on concrete surfaces which are to be buried under ground and surfaces where only an ordinary surface finish is to be applied and on which a uniform colour is not required and which will not be visible from public view.
- (6) When deemed necessary by the Engineer during periods of hot weather, water shall be applied to concrete surface being cured by the curing compound method or by the forms-in-place method until the Engineer determines that a cooling effect is no longer required.
- (7) Formed structure members, prior to removal of forms, shall be kept continually wet regardless of the method of curing.
- (8) For prestressed concrete the period of curing may have to be extended until prestressing force sufficient to overcome shrinkage and temperature strains can be applied.
- (9) Where structural members are of considerable depth or bulk or have an unusually high proportion of cement or are precast units subjected to special or accelerated curing methods, special methods of curing shall be implemented and shall be approved by the Engineer.

507.10.2 Water Curing

- (1) Water curing shall consist of maintaining formwork in place and closely covering the unformed concrete surface with a material such as straw, hessian, sand or with an absorbent material which is kept continually damp. The type of covering provided shall be that which in the opinion of the Engineer is best suited to the conditions.
- (2) On formed surfaces, if the forms are removed before the end of the curing period, curing shall be continued as for on the unformed surfaces.
- (3) When sand, burlap, or other approved fabric materials are used, they shall not cause any undesirable finish such as a rough surface and discolouring of parts which will be exposed to view.

507.10.3 Liquid Membrane Curing

- (1) The curing membrane shall be in accordance with the requirements specified for curing membrane material AASHTO M 148, Type 2.
- (2) The curing membrane shall be applied in 2 applications in conformance with the manufacturer's instructions and to the satisfaction of the Engineer.
- (3) The first coat shall be applied immediately after removal of the forms and the Engineer's acceptance of the finish and after the disappearance of free water on unformed surfaces.
- (4) If the concrete is dry or becomes dry, it shall be thoroughly wetted with water and the curing compound applied just as the surface film of water disappears. In such case the Engineer shall be informed of the situation to allow a decision to be taken as to the acceptability of the concrete that has been allowed to dry prior to the application of curing.
- (5) The second application shall be applied immediately after the first application has set.
- (6) During curing operations, any unsprayed surfaces shall be kept wet with water. The curing membrane will not be allowed on areas against which more concrete is to be placed.
- (7) Curing membrane shall be protected against marring for the entire specified curing period. Any coating marred or otherwise disturbed shall be made good immediately.

507.10.4 Waterproof Membrane Curing

- (1) The exposed finished surfaces of concrete shall be sprayed with water, using a nozzle that so atomises the flow that a mist and not a spray is formed, until the concrete has set, after which a curing membrane of waterproof paper or plastic sheeting shall be placed.
- (2) The curing membrane shall remain in place for a period of not less than 7 days.
- (3) Waterproof paper and plastic sheeting shall conform to the AASHTO M 171.
- (4) The waterproof paper or plastic sheeting shall be formed into sheets of such width as to cover completely the entire concrete surface.
- (5) All joints in the sheets shall be securely cemented together in such a manner as to provide a waterproof joint. The joint seams shall have a minimum lap of 100 mm.
- (6) The sheet shall be securely weighed down by placing a bank of earth on the edges of the sheets or by other means approved by the Engineer.
- (7) Should any portion of the sheets be broken or damaged after being placed, the broken or damaged portions shall be immediately repaired with new sheets properly cemented into place.
- (8) Sections of membrane which have lost their waterproof qualities or have been damaged to such an extent as in the opinion of the Engineer to render them unfit for curing the concrete shall not be used.

507.10.5 Forms-in-Place Method

- (1) Formed surfaces of concrete may be cured by retaining the form-in-place. The forms shall remain in place for a minimum period of 7 days after the concrete has been placed. Wooden forms shall be kept continually wet by watering during the curing period.

507.10.6 Steam Curing

- (1) After placement of the concrete, members to be steam cured shall be held for a minimum 4-hour pre-steaming period.

- (2) To prevent moisture loss on exposed surfaces during the pre-steaming period, members shall be covered immediately after casting or the exposed surface shall be kept continually wet by fog spray or wet blankets.
- (3) Enclosures for steam curing shall allow free circulation of steam about the member and shall be constructed to contain the live steam with a minimum moisture loss. The use of tarpaulins or similar flexible covers will be permitted, provided they are kept in good condition and secured in such a manner to prevent the loss of steam and moisture.
- (4) Steam at jets shall be low pressure and in a saturated condition. Steam jets shall not impinge directly on the concrete, test cylinders or forms.
- (5) During application of the steam, the temperature rise within the enclosure shall not exceed 20 °C per hour. The curing temperature throughout enclosure shall not exceed 65 °C and shall be maintained at a constant level for a sufficient time to develop the required compressive strength.
- (6) Control cylinders shall be covered to prevent moisture loss and shall be placed in a location where temperature of the cylinders will be the same as that of the concrete.
- (7) Temperature recording devices that will provide an accurate continuous permanent record of the curing temperature shall be provided. A minimum of one temperature recording device per 50 m of continuous bed length will be required for checking temperature.
- (8) Curing of pre-cast concrete will be considered completed after the termination of the steam curing cycle.

507.11 FINISHING FORMED CONCRETE SURFACES

507.11.1 General

- (1) Surface finishing shall be classified as follows:

Class 1.	Ordinary Finish
Class 2.	Rubbed Finish
- (2) All concrete shall be given Class 1, Ordinary Finish and additionally any further finish as specified or as directed by the Engineer.
- (3) Unless otherwise specified, the following surfaces shall be given a Class 2, Rubbed finish:
 - a) The exposed faces of piers, abutments, wingwalls and retaining walls
 - b) The outside faces of girders, T-beams, slabs, columns, brackets, kerbs, headwalls, railings, arch rings, spandrel walls and parapets.

Excluded, however, are the bottoms of floor slabs and sidewalks, bottoms of beams and girders, sides of interior beams and girders, backwalls above bridge seats or the underside of copings.
- (4) The surface finish on piers and abutments shall include all exposed surfaces below the bridge seats to 20 cm below low water elevation or 50 cm below finished ground level when such ground level is above the water surface.
- (5) Wingwalls shall be finished from the top to 50 cm below the finished slope lines on the outside face and shall be finished on top and for a depth of 20 cm below the top on the back sides.
- (6) If on the removal of the forms there is any honeycombing or other significant defect apparent in the concrete, the Engineer shall be informed immediately. No making good or other treatment shall be carried out except with the prior approval of the Engineer.

(7) Where so approved by the Engineer, in areas with honeycombing and/or exposed reinforcement or other such defects, the defective concrete and individual projecting stones shall be chiselled away to the full depth of the defects. The concrete surface shall be cleaned with wire brushes and/or water under high pressure, filled with fine aggregate concrete (one grade higher than the defective concrete), compacted and cured.

(8) Methods proposed for making good defects shall be approved by the Engineer.

(9) If, in the opinion of the Engineer, defects are of such extent or character as to materially affect the strength of the structure or to endanger the life of the steel reinforcement, he may declare the concrete defective and require the removal and replacement of the part of the structure affected.

507.11.2 Ordinary Surface Finish

(1) Immediately after the removal of forms, fins and irregular projections shall be removed from the surfaces, except those which are not to be exposed. On all surfaces, the cavities produced by form ties, minor blemishes, broken corners or edges and other minor defects shall be thoroughly cleaned, and after thorough saturation with water shall be carefully pointed and made good 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 1 hour old.

(2) Any mortar or concrete patching or pointing to make good significant holes or depressions, honeycombing, etc., shall only be carried out when allowed by the Engineer and shall use methods/materials as approved by the Engineer.

(3) Exposed surfaces not protected by forms shall be struck off with a straight-edge and finished with a wood float to a true and even surface. The use of additional mortar to provide a grout finish will not be permitted.

(4) The mortar patches shall be cured as specified in Clause 507.10 herein.

(5) All construction and expansion joints in the completed work shall be left carefully tooled and free of all mortar and concrete. The joint filler shall be left exposed for its full length with a clean and true edge.

(6) The resulting surfaces shall be true and uniform. Repaired surfaces of which, in the opinion of the Engineer, the appearance is not satisfactory, shall be rubbed as specified for rubbed finish.

507.11.3 Rubbed Finish

(1) Exposed concrete surfaces except the soffits of superstructures and the interior faces and bottoms of concrete girders shall be given a rubbed finish.

(2) After removal of forms, the rubbing of concrete shall be started as soon as its condition will permit. 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.

(3) Rubbing shall be continued until marks, projections and irregularities have been removed, voids have been filled and a uniform surface has been obtained. After other work which could affect the surface has been completed, 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 smooth texture and uniform colour.

(4) After the final rubbing is finished and the surface has dried, it shall be rubbed with burlap to remove loose powder.

507.12 PRECAST CONCRETE MEMBERS

507.12.1 General

- (1) Precast concrete members shall be constructed and placed in the work in conformity with the details shown on the Drawings, specified or shown on the approved working drawings.
- (2) Whenever specified or requested by the Engineer, the Contractor shall provide working drawings for precast members. Such drawings shall include all details not shown on the Drawings for the construction and erection of the members.
- (3) The method of manufacture shall be approved by the Engineer before work is started. No changes shall subsequently be made without the consent of the Engineer.
- (4) The Contractor shall inform the Engineer in advance of the date of commencement of manufacture for each type of precast member.

507.12.2 Materials and Manufacture

- (1) The materials and manufacturing processes used for precast concrete members shall conform to the requirements of the relevant Sections of the Specifications.
- (2) The foundation for the precasting moulds shall be solid, cast on unyielding beds or pallets and, if necessary, improved and drained to obtain sufficient bearing capacity to avoid settlements and subsequent deformation of the members.
- (3) Precast prestressed units may be cast in one continuous line and stressed at one time.
- (4) The side forms may be removed as soon as their removal will not cause distortion of the concrete surface, and provided that curing is not interrupted. Members shall not be lifted from their casting beds until their strength is sufficient to prevent damage.
- (5) When cast-in-place concrete will later be cast against the top surfaces of precast beams or girders, these surfaces shall be finished to a coarse texture by brooming with a stiff coarse broom. Prior to transport, such surfaces shall be cleaned of laitance or other foreign materials by sandblasting or other approved methods.
- (6) When precast members are designed to be abutted together in the finished work, each member shall be match-cast with its adjacent segments to ensure proper fit. The segments must be precisely aligned to achieve final structure geometry, and during alignment, adjustments to compensate for deflections shall be made.
- (7) Unless otherwise specified, precast members shall be cured by the water method or steam method.

507.12.3 Storage and Handling

- (1) Members shall be firmly supported at such bearing positions as will ensure that the stresses induced in them are always less than the permissible design stresses. Members shall be lifted or supported only at the points specified on the Drawings and shall be handled and placed without impact.
- (2) Precast girders shall be transported in an upright position, and points of support and directions of the reactions with respect to the girder should be approximately the same during transportation and storage as when the girder is in its final position.
- (3) Care shall be taken during storage, hoisting, and handling of the precast units to prevent cracking or damage. Units damaged by improper storing or handling shall be replaced by the Contractor at his own cost.

507.12.4 Erection

- (1) Lifting devices shall be used in a manner that does not cause damaging bending stresses or torsional forces. After the member has been erected and until it is secured to the structure, temporary braces shall be provided as necessary to resist wind or other loads.
- (2) Precast deck form panels, if used, shall be erected and placed so that the fit of mating surfaces shall be such that grout leakage will not occur. If such fit is not provided, joints shall be dry-packed or sealed with acceptable caulking compound prior to placing the cast-in-place concrete. End panels of skewed structures may be sawed to fit the skew.

507.12.5 Tolerances

- (1) The following tolerances shall apply:

• Length	±12 mm
• Width and depth	± 6 mm
• Bow in the vertical plane	±15 mm
• Bow in the horizontal plane	±12 mm
• Difference between longest and shortest dimensions in any plane	6 mm
• Twist (measured by the deviation of any corner from the plane containing the other three corners)	6 mm
• Flatness (the maximum deviation from a 1.5 m straight edge placed in any position on a nominally plane surface)	6 mm
• Cover to reinforcement	0/+5 mm
• Prestressing tendons (in any direction)	3 mm
• Dowel holes (in any direction)	3 mm

507.13 MORTAR AND GROUT

- (1) This work consists of making and placing of mortar and grout for use in concrete structures other than in prestressing ducts.
- (2) Materials for mortar and grout shall conform to the requirements of Clause 507.03 herein. The grading of sand for use in mortar or grout when the width and depth of void to be filled is less than 40 mm shall be modified so that all material passes the 2.36 mm sieve.
- (3) Unless otherwise specified or ordered by the Engineer, the proportion of cement to sand for mortar shall be 1 to 2 and for grout shall be 1 to 1, by loose volume.
- (4) Sufficient water shall be used to permit placing and packing. Mixing shall be by hand methods or with rotating paddle-type mixing machines and shall be continued until all ingredients are thoroughly mixed. Once mixed, mortar or grout shall not be re-tempered by the addition of water and shall be placed within one hour.
- (5) No load shall be allowed on mortar until after 72 hours, unless otherwise permitted by the Engineer.
- (6) Mortar and grout shall be cured by an approved method.

507.14 EARLY LOADING

507.14.1 General

(1) The Contractor shall ensure that no loads are applied until the concrete has attained sufficient strength and when applicable, sufficient prestressing has been completed, so that it will not cause damage to newly constructed work. Any damage caused by such overloading shall be made good by the Contractor at his own cost to the satisfaction of the Engineer.

507.14.2 Earth Loads

(1) When the placement of backfill will cause flexural stresses in the concrete, the placement shall not begin until the concrete has reached at least 80% of its specified strength.

507.14.3 Construction Loads

(1) Light equipment and materials may be carried on the bridge decks only after the concrete has been in place at least 24 hours, providing curing is not interfered with and the texture is not damaged.

(2) Precast concrete or steel girders shall not be placed on substructure elements until the substructure concrete has attained 70% of its specified strength.

(3) Construction vehicles weighing between 500 and 1,500 kg., and comparable material loads, will be allowed on the bridge deck only after the last concrete placed has attained a compressive strength of at least 17 MPa.

(4) Loads imposed on existing, new or partially completed portions of structures due to construction operations shall not exceed the load-carrying capacity of the structure as determined by the Load Factor Design methods of AASHTO using Load Group IB. The concrete compressive strength (f_c') to be used shall be the smaller of the actual compressive strength at the time of loading or the specified compressive strength of concrete.

507.14.4 Opening to Traffic

(1) Traffic shall not be permitted on concrete bridge decks until 21 days after the last placement of concrete and until such concrete has attained its specified strength, and the written permission of the Engineer has been obtained prior to opening.

507.15 TESTING

507.15.1 General

(1) A strength test shall consist of the average strength of three compressive strength test cylinders fabricated from material taken from a single randomly selected batch of concrete, except that, if any cylinder should show evidence of improper sampling or testing, the said cylinder shall be discarded and the strength test shall consist of the strength of the remaining cylinders.

(2) From any batch, 3 samples shall be taken, and 2 test cylinders shall be made from each of the 3 samples. Three test cylinders shall be tested at 7 days and the other three test cylinders tested at 28 days. The six test cylinders shall constitute a set of test specimens.

(3) The average value of the compressive strengths of the three test specimens will be taken as the compressive strength of the set.

507.15.2 Field Cured Specimens

(1) For determining the adequacy of curing and protection, and for determining when loads or stresses can be applied to concrete structures, test cylinders shall be cured at the structure site under conditions that are not more favourable than the most unfavourable conditions for the structure which they represent as described in Section 9.4 of AASHTO T 23.

507.15.3 Acceptance of Concrete

(1) For determining compliance with a specified 28-day compressive strength, test cylinders shall be cured under controlled conditions as described in Section 9.3 of AASHTO T 23 and tested at 28 days.

507.15.4 Sampling

(1) At least one set of test specimens shall be taken once every day on which concreting work is in progress.

(2) Test specimens shall be made from each separate concrete grade and mix ratio, and shall be typical for the portion of concrete they represent.

(3) For mass concrete structures, at least one set of test specimens shall be made from each 100 cubic metres of concrete.

(4) For reinforced concrete and prestressed concrete, at least one set of test specimens shall be made from each 50 cubic metres of concrete.

(5) At least one set of test specimens shall be taken from each pier cap, column and abutment.

(6) For precast concrete girders, at least one set of test specimens shall be taken from each precast element.

(7) For small scattered work, such as minor culverts and incidental structures, at least one set of test specimens shall be taken from each grade of concrete in the structure.

(8) Where an identical mix is being placed in different parts of the same work (e.g. a bridge), sampling may be limited to one set of test specimens with the prior approval of the Engineer.

507.15.5 Strength Requirements

(1) No individual 28-day test cylinder from any set of test specimens shall be less than the specified 28-day compressive strength by more than 3 MPa, and the average value of the 28-day compressive strengths of any set of test specimens shall be not less than the specified 28-day compressive strength.

(2) A series of test specimen sets shall comprise sets of test specimens from each structural member of an integral structure, or sets of test specimens from one or more prefabricated members having similar mixes.

507.15.6 Test Results and Additional Tests

(1) Should the compressive strength value obtained from the tests fail to comply with the specified requirements, the Engineer may require core samples to be taken and tested in accordance with the standard methods of AASHTO T 24. The Contractor shall, at his own expense, furnish all equipment required for such sampling and testing.

(2) Direct loading tests may also be ordered for examination of the load capacity of the structure or member.

(3) No member shall be used until a satisfactory test result has been obtained or the specified requirement is achieved by means of strengthening methods, and approval has been given by the Engineer.

507.16 MEASUREMENT

(1) Measurement shall be as follows:

Item no	Description	Unit
507-1	Concrete Grade 15 (for minor unreinforced concrete works)	Metre Cube
507-2	Concrete Grade 20 (for mass concrete)	Metre Cube
507-3	Concrete Grade 25 (for piers, abutments, retaining walls and approach slabs, etc.)	Metre Cube
507-4	Concrete Grade 30	Metre Cube
507-5	Concrete Grade 40 (for precast post-tensioned girders)	Metre Cube
507-6	Concrete Grade 40 (for diaphragms and decks)	Metre Cube
507-7	Concrete Grade 40 (for precast deck panels)	Metre Cube

(2) Measurement shall be based on the dimensions shown on the Drawings, or as otherwise ordered by the Engineer.

(3) The quantity of concrete involved in fillets and chamfers 600 mm² or less in cross sectional area will not be deducted.

(4) Deductions for the volume of concrete displaced by concrete piles embedded in the concrete will be made.

(5) Deductions for other embedded materials including reinforcing, structural and prestressing steel, prestressing ducts, water stops and deck drains will not be made.

(6) Measurement for seal course in cofferdams will include the actual volume of concrete seal course in place, but in no case will the measurement exceed the cubical contents between the vertical surfaces 300 mm outside the neat lines of the seal course as shown on the Drawings. The measurement for the thickness of the seal course will be the thickness shown on the Drawings or ordered by the Engineer.

(7) Structural excavation, reinforcing and prestressing steel, expansion joint assemblies and others required for the concreting of structures will be measured as specified in the relevant Sections of the Specifications.

(8) Whenever an alternative is permitted by the Specifications, the quantities of concrete will be computed on the basis of the dimensions shown on the Drawings and no change in quantities measured for payment will be made because of the use by the Contractor of such alternative.

(9) No measurement will be made for unauthorised areas or thickness.

(10) No measurement will be made for the blinding or levelling concrete.

507.17 PAYMENT

(1) Payment will be made at the rates entered in the Bill of Quantities.

(2) Payment shall include all materials, falsework and formwork, embedded items, expansion joint fillers, sealed joints, waterstops, drains, vents, miscellaneous metal devices, concrete placing, finishing, curing, and all launching, erection, placing, and jointing operations for precast concrete members.

(3) Structural excavation will be paid under Items Nos. 207-1 and 207-2 in the Bill of Quantities.

(4) Steel reinforcement will be paid under Item No. 506-1 in the Bill of Quantities.

(5) Prestressing steel will be paid for under Item No. 508-1 in the Bill of Quantities.

SECTION 508

PRESTRESSING OF CONCRETE

508.01 GENERAL

508.01.1 Scope

(1) The work covered by this Section consists of furnishing all plant, equipment, materials and labour, and performing all operations in connection with the prestressing of concrete structures.

508.01.2 Original Records

(1) During prestressing operations proper records shall be kept of the inspections of ducts and prestressing steel, post-tensioning, and pressure grouting.

(2) Copies of the above records shall be submitted to the Engineer.

508.01.3 Terminology

(1) Following terminology is used regarding different forms of Prestressing Steel

Wires - Prestressing Wire is a single unit, made of steel;

Strands - Two, three or seven wires are wound together to form a prestressing Strand;

Tendon - A group of Strands or wires are wound together to form a prestressing Tendon;

Cable - A group of Tendons form a prestressing Cable;

Bars - A Tendon can be made up of a single steel Bar. The diameter of a Bar is much larger than that of a Wire.

508.02 PRESTRESSING SYSTEM

508.02.1 General

(1) The method of prestressing to be used shall be as shown on the Drawings or an equivalent method approved by the Engineer, subject to all requirements hereinafter specified.

(2) Before commencing work with members which are to be prestressed, the Contractor shall submit a Technical Method Statement giving full details of the methods, materials and equipment he intends to use for the approval of the Engineer.

(3) Such details shall describe the method and sequence of stressing, give a complete specification and details of the prestressing steel and anchoring devices proposed for use, anchoring stresses, additional bursting reinforcement if required, type of enclosures and all other data pertaining to the prestressing operations, including the proposed arrangement of the prestressing units in the members, pressure grouting materials and equipment, grouting trials, procedures for checking that prestressing tendon ducts are unobstructed, procedures for clearing blocked ducts, procedures and equipment for flushing partly grouted ducts, procedures for prevention of accidents during stressing operations, and providing details on all other aspects likely to be encountered in the prestressing operations.

508.02.2 Modifications of Design

(1) If the system proposed by the Contractor requires any modification in the number, form or dimensions of the detailed reinforcement and anchorages shown on the Drawings, he shall submit sufficiently detailed drawings and calculations for the approval of the Engineer.

- (2) Notwithstanding any approval of the Contractor's proposals by the Engineer, the Contractor shall remain solely responsible for the system.

508.02.3 Equipment and Supervision

- (1) The Contractor shall provide all equipment necessary for the prestressing.
- (2) Stressing shall be done with jacking equipment of the type applicable to the system adopted.
- (3) Prestressing operations shall be carried out only under the direction of an experienced and competent supervisor and all personnel operating the stressing equipment shall have been properly trained in its use.
- (4) In addition to the normal precautions against accidents for the whole of the Works, special precautions shall be taken when working with or near tendons which have been tensioned or are being tensioned.

508.03 MATERIALS

508.03.1 Concrete

- (1) Concrete for prestressed members shall conform to the requirements of Section 507 of the Specifications.

508.03.2 Reinforcing Steel

- (1) Reinforcing bars shall conform to the requirements of Section 506 of the Specifications.

508.03.3 Prestressing Steel

- (1) Prestressing strand shall be high-strength uncoated seven-wire stress-relieved steel strand meeting the requirements of AASHTO M 203. Supplement S1 (Low Relaxation) shall apply when specified. Strand shall be delivered in coils of sufficiently large diameter to ensure that it pulls off straight.
- (2) Prestressing bar shall be super grade in accordance with AASHTO M 722.
- (3) All steel shipped to the Site shall be assigned a lot number and tagged for identification purposes.
- (4) All steel shall be protected against physical damage and rust or other results of corrosion at all times from manufacture to grouting. Steel that has sustained physical damage at any time shall be rejected.
- (5) Before approval, steel shall be tested for chemical composition, mechanical strength, stress-strain relationship, relaxation and physical characteristics. Subsequently, the Engineer will require samples for verification testing, selected at random by the Engineer from each batch (coil or bar shipment) supplied, representative of the lot to be similarly tested. When compression grips are used not less than 6, selected at random, shall be tested to failure using strands to be used in the Works. The tests shall be witnessed by the Engineer.
- (6) All materials specified for testing and the testing itself shall be at the Contractor's cost.
- (7) The manufacturer shall furnish samples for testing from each lot. If so ordered by the Engineer, the selection of samples will be made at the manufacturer's premises by an independent inspector. For each 20 tonnes of strand, or portion thereof, a sufficient length of strand to make up one parallel-lay cable 1.5 m long consisting of the same number of wires as the cable shall be furnished.

508.03.4 Prestressing Steel Certification

- (1) Each reel of strand shall be accompanied by a manufacturer's certificate of compliance, a mill certificate, and a test report. The mill certificate and test report shall include the cross sectional area, yield and ultimate strengths, elongation at rupture, modulus of elasticity, and stress strain curve for the actual prestressing steel intended for use. All values certified shall be based on test values and nominal sectional areas of the material being certified.
- (2) Prestressing steel strand without the above mentioned certificates shall not be used and shall be removed from the Site.
- (3) Each shipment shall be identified with a metal tag showing the manufacturer, steel quality, dimensions, heat number, elastic modulus for prestressing strands, and the date.

508.03.5 Tendon Ducts

- (1) Ducts shall be galvanised ferrous metal or of a type approved by the Engineer, mortar-tight and accurately positioned and fixed at the locations shown on the Drawings or approved by the Engineer.
- (2) Ducts may be fabricated with either welded or interlocked seams. Galvanising of the welded seam will not be required. Ducts shall have sufficient strength to maintain their correct alignment and shape during placing of concrete. Joints between sections of ducts shall be positive metallic connections, which do not result in angle changes at the joints. Waterproof tape shall be used at the connections.
- (3) The inside diameter of ducts shall be at least 6 mm larger than the nominal diameter of strand tendon.
- (4) Ducts shall be kept free of any matter detrimental to the bond between the duct and the grout and, except for material sealing a joint, between the duct and the concrete.

508.03.6 Anchorages

- (1) All post-tensioned steel shall be secured at the ends by means of approved permanent type anchoring devices.
- (2) All anchorages shall be cast anchorages complying with the requirements of BS 4447, or an approved equivalent standard.
- (3) The load from the anchoring device shall be effectively distributed to the concrete by means of approved devices.
- (4) If proprietary forms of anchorage are used, the anchoring procedure shall be strictly in accordance with the manufacturer's instructions and recommendations.
- (5) The manufacturer shall furnish samples selected from each lot for testing at no cost to the Employer.
- (6) The Engineer has the right to test to destruction one anchorage for each span or in the case of single span bridges, two anchorages.
- (7) When prestressing systems have been previously tested and approved for similar projects by an agency acceptable to the Engineer, complete cable samples need not be furnished provided there is no change whatsoever in the materials, design or details previously approved.
- (8) All anchorage devices for post-tensioning shall be capable of holding the steel at the load producing a stress of not less than 100% of the guaranteed minimum ultimate tensile strength of the prestressing steel.

508.03.7 Grout

- (1) Unless otherwise directed or agreed as a result of grouting trials, the grout shall consist only of ordinary Portland cement according to AASHTO M 85, Type I, and water conforming to the requirements of Section 507 of the Specifications, and an expanding admixture, if approved by the Engineer.
- (2) Admixtures containing chlorides in excess of 0.005 percent of the weight of cement used, fluorides, sulphites or nitrates shall not be used. Other admixtures may be used only with the written permission of the Engineer and shall be applied strictly in accordance with the manufacturer's instructions.
- (3) Grout shall have a water/cement ratio as low as possible consistent with the necessary workability, and under no circumstances exceeding 0.45.
- (4) Grout shall not be subject to bleeding in excess of 1% of the volume of grout after 3 hours or 3% maximum when measured at 20 °C in a covered glass cylinder approximately 100 mm diameter with a height of grout of approximately 100 mm. The water shall be re-absorbed after 24 hours.
- (5) The maximum unrestrained expansion shall not exceed 10%.
- (6) The compressive strength of grout shall be not less than 40 MPa.
- (7) The grout shall be mixed for a minimum of 2 minutes and until a uniform consistency is obtained.
- (8) The pumpability of the grout shall be tested when ordered by the Engineer in accordance with the US Corps of Engineers Method CRD-C79. The efflux time of the grout sample immediately after mixing shall be not less than 11 seconds.

508.04 EQUIPMENT

508.04.1 Post-Tensioning Equipment

- (1) All hydraulic jacks used to stress tendons shall be equipped with either a pressure gauge or a load cell for determining the jacking stress, and an accurately reading dial at least 150 mm in diameter or a digital display. The load cell shall be provided with an indicator by means of which the stressing force in the tendon may be determined.
- (2) At full jacking load, pressure gauges or load cells shall be at 50% to 90% of their full capacity.
- (3) The accuracy of the load-metering equipment shall be checked to the satisfaction of the Engineer at intervals of not more than 7 days using calibrated master equipment kept on Site for this purpose and no other.
- (4) Documentary proof shall be provided confirming that all jacks and gauges have been fully overhauled and checked by an agent approved by the manufacturer of the equipment. Each jack and its gauge shall be accompanied by a certificate indicating that it has been tested and calibrated, as a unit, by the manufacturer or by an approved testing laboratory up to a load equal to full capacity of the jack within a period of 6 months prior to the commencement of the work. Jacks and gauges shall be re-calibrated within 12 months of the previous calibration.
- (5) The combination of jack and its gauge shall be calibrated as a unit and a graph or table showing the calibration shall be furnished to the Engineer. Should other types of jacks be used, calibrated proving rings or other devices shall be furnished, so that the jacking forces may be accurately known.
- (6) Post-tensioning shall be done only with calibrated and approved jacking equipment.

508.04.2 Grouting Equipment

- (1) The grout mixer shall produce a grout of colloidal consistency. The grout injector shall be capable of continuous operation with a constant pressure up to 0.7 MPa (7 kg/cm²) and shall circulate or agitate the grout when actual grouting is not in progress. All baffles to the pump shall be fitted with sieve strainers of 1.0 mm nominal aperture size.
- (2) The equipment shall be capable of maintaining pressure on completely grouted ducts and shall be fitted with a nozzle which can be locked off without loss of pressure in the duct.
- (3) The pressure gauges shall be calibrated before they are used in the Works and thereafter as required by the Engineer. All equipment shall be thoroughly washed with clean water at least once every 3 hours during the grouting operations and at the end of use each day.
- (4) Grout injection pipes shall be fitted with positive mechanical shut-off valves. Vents and ejection pipes shall be fitted with valves, caps, or other devices capable of withstanding the pumping pressure. Valves and caps shall not be removed or opened until the grout has set.
- (5) Standby flushing equipment capable of developing a pumping pressure of 1.5 MPa (15 kg/cm²) and of sufficient capacity to flush out any partially grouted ducts shall be provided.

508.05 TRANSPORTING AND STORAGE

508.05.1 Transporting

- (1) Trucks used to transport prestressing equipment components shall be weatherproof. Care shall be taken in loading or unloading to ensure that the components are not damaged.

508.05.2 Storage

- (1) Prestressing components shall be stored off the ground in clean dry waterproof conditions with some ventilation.
- (2) Prestressing components shall be handled and stored so that mechanical damage and corrosion are prevented.

508.06 HANDLING AND PLACING TENDONS

508.06.1 Fabrication of Tendons

- (1) Each cable shall be tagged with its number and the coil number or numbers of the steel used.
- (2) Tendons shall not be welded within the length to be tensioned and, unless other methods of cutting are permitted by the Engineer, shall be sawn or cropped.
- (3) Tendons shall be assembled in accordance with the system which is being employed.
- (4) Cables shall not be kinked or twisted and individual wires or strands shall be readily identifiable at each end of the member. No strand which has become unravelled shall be used in the Works.

508.06.2 Placing of Tendon Ducts

- (1) Ducts shall be rigidly supported at intervals not greater than 600 mm in the positions shown on the Drawings or approved by the Engineer.
- (2) After placing of ducts, reinforcement and formwork is complete, an inspection shall be made to locate possible duct damage.

- (3) All unintended holes or openings in ducts shall be repaired prior to concrete placing, unless the Engineer orders the removal and replacement of the damaged length of ducting.
- (4) The number of joints in the ducting shall be kept to a practicable minimum, and each joint shall be adequately sealed against the ingress of any material. Joints in adjacent sheaths shall be staggered by at least 300 mm.
- (5) The ends of all ducts shall be sealed and protected until the tendon is inserted shortly before the stressing operation is commenced.
- (6) Where members are made up of precast units stressed together, the ducts in the joints between the units shall be in accurate alignment and joined securely so as to allow unimpeded cable threading and pulling and to prevent the ingress of the epoxy mortar used for gluing the several units together before stressing. Details of such joints shall first be approved by the Engineer. The tolerance in the location of the duct shall be ± 3 mm.

508.06.3 Placing Tendons and Anchorages

- (1) All units shall be accurately placed in the positions shown on the Drawings.
- (2) Tendons shall be built into the work strictly in accordance with the system which is being employed.
- (3) Wires, wire groups, parallel-lay cables and any other prestressing elements shall be straightened to ensure proper positioning in the enclosures.
- (4) Anchor cones, blocks and plates shall be positioned and maintained during concreting, so that the centreline of the duct passes axially through the anchorage assembly.
- (5) Where the end of the post-tensioned assembly will not be covered by concrete, the anchoring devices shall be recessed, so that the ends of the prestressing steel and all parts of the anchoring devices will be at least 50 mm inside the end surface of the members, unless a greater embedment is shown on the Drawings. Following approval to the post-tensioning, the recesses shall be scabbled, coated with an approved epoxy bonding agent, filled with Grade 26 concrete and finished flush.
- (6) All bearing surfaces of the anchorages shall be clean prior to concreting and tensioning.

508.06.4 Placing Concrete

- (1) Concrete shall be placed in the forms, vibrated and cured in accordance with the requirements of Section 507 of the Specifications.
- (2) Concrete shall not be deposited in the forms until the Engineer has inspected the placing of the reinforcement, ducts, anchorages, and prestressing steel, and given his approval.
- (3) Immediately prior to placing concrete, the Contractor shall demonstrate to the satisfaction of the Engineer that all ducts are unobstructed.
- (4) Immediately the end forms are removed, the ducts shall be checked again for obstructions which, if found, shall be cleared by a pre-approved method. The ducts shall then be sealed.

508.07 TENSIONING OF TENDONS

508.07.1 Post-Tensioning Method

- (1) Tensioning shall be carried out in the presence of the Engineer unless written permission has been given otherwise.
- (2) Immediately before tensioning, the Contractor shall prove that all prestressing steel are free and unbonded in the ducts, and that members are free to accommodate the horizontal and vertical movements due to the application of prestress.

- (3) The tensioning process shall be conducted so that the tension being applied and the elongation may be measured at all times. All strands in each tendon shall be stressed simultaneously with a multi-strand jack.
- (4) The Contractor shall add to the specified forces allowances, where necessary, for anchorage friction, wedge pull-in, jack losses and friction due to duct alignment and curvature. The total forces and calculated extensions shall be agreed with the Engineer before stressing is commenced.
- (5) Computations of calculated extensions shall utilise the modulus of elasticity, based on nominal area, as furnished by the manufacturer for the lot of steel being tensioned.
- (6) Concrete shall not be stressed until it has reached at least the age at which 1 set of test cylinders taken from it attains the specified compressive strength at transfer. The test cylinders shall be made and tested in accordance with Section 507 of the Specifications but shall be cured under similar conditions as the concrete to which they relate. The Contractor shall provide sufficient number of cylinders to demonstrate that the required strength of the concrete at transfer has been reached.
- (7) Where members consist of jointed elements, the strength at transfer of the jointing material shall be at least equivalent to the specified transfer strength of the member.
- (8) Immediately after anchoring, the stresses in the tendons shall not exceed 70% of their ultimate tensile strength. During stressing the value shall not exceed 85% of their yield point stress.

508.07.2 Post-Tensioning Procedure

- (1) The tendons shall at first be stressed to a preliminary force as necessary to eliminate any take-up in the tensioning system before extension readings are started. The preliminary force shall be 5% to 25% of the final jacking force. The preliminary force shall be measured by a dynamometer or by other approved method.
- (2) Each strand shall be marked prior to final stressing to permit measurement of extension and to ensure that all anchor wedges set properly.
- (3) The tendons shall be stressed at a gradual and steady rate. The force in the tendons shall be obtained from readings on two load cells or pressure gauges incorporated in the equipment. The extension of the tendons under agreed jacking forces shall be within 5% of the agreed calculated extension. If there is appreciable variation between the calculated extension, the entire operation shall be carefully checked and source of error determined and corrected before further tensioning proceeds.
- (4) Stressing sequence shall be as shown on the Drawings.
- (5) When stressing from one end only, the wedge pull-in at the end remote from the jack shall be accurately measured and the appropriate allowance made in the measured extension at the jacking end.
- (6) When the prestressing has been applied to the satisfaction of the Engineer, the tendons shall be anchored. The jack pressure shall then be released in such a way as to avoid shock to the anchorage or tendons.
- (7) The Contractor shall keep full records of all tensioning operations including the measured extensions, pressure gauge or load cell readings and the amount of pull-in at each anchorage and all such data observed during the tensioning operation shall be immediately recorded. Copies of these records shall be submitted to the Engineer within 24 hours of each tensioning operation.
- (8) In the event of individual wire failures, strand sliding in the anchorage, rupture or anchorage damage during tensioning, the operation shall be stopped immediately and remedial action taken to the satisfaction of the Engineer. Full records shall be kept by the Contractor of all such instances.
- (9) If the wedge pull-in of the tendons at completion of anchoring is greater than that stipulated by the Engineer, tensioning shall be released and reapplied unless the Engineer determines that the initial tensioning is acceptable.

(10) If it is necessary to cut the tendons to enable the ducts to be grouted, this shall be delayed as long as practicable up to the time of grouting. In all other cases, unless permitted otherwise by the Engineer, the tendons shall not be cropped less than 3 days after grouting.

(11) When anchorages are damaged or insufficient prestressing force has been applied the Contractor shall redo the work at his own cost and to the satisfaction of the Engineer.

508.08 GROUTING

508.08.1 Preparation Work

(1) Grouting trials shall be undertaken before the prestressing work commences to demonstrate the efficiency of the proposed equipment and procedures and the suitability of the grout. The arrangements for the trials shall be agreed with the Engineer and all trials shall be undertaken in the presence of the Engineer. No prestressing work shall be commenced until the grouting trials have been approved by the Engineer.

(2) As soon as practicable after the cables have been stressed to the required tension and the Engineer's permission to proceed has been obtained, each duct encasing the prestressing steel shall be blown out with compressed oil-free air and the grouting shall be commenced.

(3) No grouting shall be carried out until the preparatory work has been inspected by the Engineer.

(4) When for any reason (approved by the Engineer) grouting will not be carried out for a long period, temporary protection against corrosion shall be provided by the use of vapour-phase inhibitors, emulsifiable oils, by ventilating with dry air, or by other approved means.

508.08.2 Temperature Considerations

(1) Grout shall not be above +32 °C during mixing and pumping. When grouting under high temperatures, suitable arrangements shall be made to cool the mixing water and, if necessary, the structural members.

508.08.3 Injection of Grout

(1) All grout and high-point vent openings shall be open when grouting starts.

(2) Grout shall be placed in the duct within 45 minutes of mixing. The grout shall be constantly agitated prior to injection so as to prevent the flowability from decreasing.

(3) Grouting shall be carried out from the lower ducts to the upper ducts.

(4) The pumping pressure at the tendon inlet shall not exceed 1.7 MPa.

(5) Grout shall be injected in one continuous operation and allowed to be wasted at the outlet until no visible slicks of water or air are ejected and the consistency is equivalent to that being injected (i.e. the efflux time of ejected grout is not less than 11 seconds). All vents and openings shall then be closed and the grouting pressure at the injection end shall be raised to a minimum of 0.7 MPa for a minimum of 10 seconds before the inlet vent is closed.

(6) Vents shall be sealed consecutively in the direction of flow and the injection tube sealed under pressure until the grout has set. The filled ducts shall be protected to the satisfaction of the Engineer to ensure that they are not subjected to shock or vibration for at least 48 hours after grouting. Two days after grouting, the level of grout in the injection and vent tubes shall be inspected and made good if necessary.

508.08.4 Records and Testing

- (1) The Contractor shall keep full records of grouting including the date each duct was grouted, the proportions of the grout and any admixtures used, the pressure, with details of any interruptions and topping up required. Copies of the records shall be submitted to the Engineer within 3 days of grouting.
- (2) Where required by the Engineer the Contractor shall test the ducts by radiographic methods.

508.09 MEASUREMENT

- (1) Measurement will be as follows:

Item No.	Description	Unit
508-1	Prestressing Steel	Tonne

- (2) Prestressing steel shall be measured by weight for strand furnished, installed and accepted. The length of prestressing steel strand will be computed as the theoretical length of the tendons, measured between the outside faces of the anchorages. The nominal weight and nominal cross sectional area of strand as given in AASHTO M 203 shall be used to compute the total weight. No measurement shall be made of excess tendon length required for testing, threading or stressing, nor for anchorages, ducts, or other components.

508.10 PAYMENT

- (1) Payment will be made at the rate entered in the Bill of Quantities which rate shall include for all materials and operations specified, testing, reporting and safety precautions.

SECTION 509

BEARINGS

509.01 DESCRIPTION

(1) The work covered by this Section consists of fabricating, testing, furnishing and installing bridge bearings, conforming with the dimensions and details shown on the drawings or as directed by the Engineer

509.02 GENERAL

- (1) Fabrication of bearings shall conform to:
- The American Association of State Highway and Transport Officials (AASHTO) LRFD Bridge Construction Specifications;
 - AASHTO's Standard Specifications for Transportation Materials and Methods of Sampling and Testing M251 Standard Specification for Plain and Laminated Elastomeric Bridge Bearings; and
 - The American Welding Society (AWS) - Bridge Welding Code D1.5.
- (2) The design of bearings shall be carried out by the bearing supplier. Shop drawings shall be stamped, signed and sealed by the bearing supplier's design engineer. The shop drawings shall clearly indicate all material properties, dimensions, connection attachments, fasteners and accessories, the bearing identification, and the load capacity at the serviceability and ultimate limit states as follows:
- a) Maximum vertical permanent and total load;
 - b) Maximum lateral load and corresponding vertical load;
 - c) Maximum rotational capacity about any horizontal axis and about the vertical axis at the centre of the bearing.
- (3) When bearings for more than one bridge are included, individual shop and erection drawings shall be submitted for each bridge.
- (4) Each bearing shall be marked with the fabricator's name, date of manufacture and unique identification number. The characters shall be not less than 10 mm in height.
- (5) The Contractor shall also submit to the Consultant prior to shipping to the site, the manufacturer's certification, as a written affidavit, that the material supplied meets the contract requirements.
- (6) The Contractor shall provide a written five (5) year Warranty for the bearing assemblies. The Warranty period shall commence on the date of Contract Completion, and shall provide for complete replacement of the bearing assemblies including but not limited to, all necessary traffic control, superstructure jacking, grout pads, concrete, and attachments to girders as required at no cost to the Employer if any portion of the bearing assembly fails to perform satisfactorily within the designed range of movement or loading.

509.03 ELASTOMERIC BEARINGS

509.03.1 Description

(1) Elastomeric bearings shall include laminated bearings (consisting of layers of elastomer restrained at their interfaces by bonded laminates).

509.03.2 Materials

509.03.2.1 General

(1) The raw elastomer shall be either virgin Neoprene (polychloroprene) or virgin natural rubber (polyisoprene). The elastomer compound shall meet the minimum requirements of Tables 18.2.3.1A and B of AASHTO Standard Specifications for Highway Bridges, Division II.

(2) Steel laminates used for reinforcement shall be made from rolled mild steel conforming to ASTM A36, A570, or equivalent.

509.03.2.2 Laminated Bearings

(1) Laminated bearings shall be shop fabricated in accordance with the details shown on the Drawings. These details indicate only the minimum requirements as to the dimensions of the bearings. Any standard bearing with approximately the same dimensions, at least the same area and effective thickness may be used, provided that the materials conform to the specified requirements.

(2) The steel laminates shall be at least 3 mm thick. The thickness of each layer of elastomer between the laminates shall be at least 8 mm. The steel laminates shall be sandblasted and cleaned of all surface coatings, rust, mill scale, and dirt before bonding and shall be smooth. All components shall be cast as a unit in a mould and shall be bonded and vulcanised under heat and pressure. The laminates shall be totally covered by a minimum of 2.5 mm of elastomer.

(3) Steel laminated bearings shall develop a peel strength of 40 kN/m² as performed according to ASTM D 429 Method B.

509.03.2.3 Tolerances

(1) For both plain and laminated bearings, the permissible tolerances are:

Overall Height	-0/+ 3 mm
Overall horizontal dimensions	-0/+ 6 mm
Thickness of individual layers of elastomer	± 3 mm
Parallelism with opposite face	
Top and bottom	0.005 radians
Sides	0.02 radians
Edge cover of embedded laminates	-0/+ 3 mm
Size and position of holes	± 3 mm
Edge Cover	-0/+3 mm

509.03.3 Testing

(1) Where a prototype bearing has been satisfactorily tested and the Engineer is satisfied that the materials and workmanship in the bearings comply with this Specifications, no further acceptance testing of whole bearings will be required.

(2) The Engineer may require shear stiffness tests on material from random sample of the finished bearing in accordance with Annex A of ASTM D4014, or a comparable non-destructive stiffness test. The shear modulus shall fall within 15 % of the specified value, or within the range for its hardness if no shear modulus is specified.

509.04 POT BEARINGS

509.04.1 General

(1) The pot bearing shall be designed for the loadings, translations and rotations specified on the contract drawings and the exceptions noted in this specification.

(2) The average stress in the elastomer at serviceability limit state loads shall not exceed 30 MPa.

- (3) Sole plates and base plates shall be supplied by the bearing supplier, and shall conform to the details shown on the contract drawings. Any adjustments of these details shall be reviewed and accepted by the Engineer prior to fabrication.

509.04.2 Displacements and Rotations

- (1) Provision for displacement shall be through sliding of a stainless steel surface against a mating PTFE element. The capacity for displacement in an unrestrained direction shall be as specified on the contract drawings.
- (2) Provision for rotation about any horizontal axis shall be by means of a single disc of confined elastomer. Brass rings shall not be considered in determining the effective thickness of the elastomeric disc. The effective thickness of the elastomeric disc to evaluate the rotational capacity shall be limited to the thickness of the disc excluding the brass rings.
- (3) The rotational capacity about any horizontal axis shall be as specified on the contract drawings. The rotational capacity about the vertical axis through the centre of the bearing shall be as specified or $\pm 1^\circ$, whichever is greater.
- (5) Rotational bearings shall be capable of resisting the specified lateral loads in any direction in combination with the applicable vertical loads.
- (6) Brass sealing rings shall be flat and smooth on all surfaces.
- (7) The depth of the pot wall shall be such that a minimum vertical distance of 2.5 mm remains between top of the pot wall and the closest point of contact of the brass sealing rings with the pot wall upon rotating the piston an amount equal to the specified rotation at ULS
- (8) The pot and piston surfaces in contact with the confined elastomer shall be lubricated with silicone grease. The bearing shall be sealed by a one-piece continuous preformed closed-cell compressible ring against entry of dirt, dust, and moisture between the elastomer and the pot and piston contact surfaces. Any joint in the ring shall be bonded and the strength shall be at least equal to the strength of the ring.

509.04.3 Sliding Surfaces

- (1) Sliding surfaces shall allow translation by sliding of a metal surface against a mating PTFE element. For plane surfaces, the metal surface shall be stainless steel. The metal surface shall overlap the PTFE by at least 25 mm at extremes of movement on each side and, except for guides for lateral restraint, shall be positioned above the PTFE element.
- (2) Except when used as mating surfaces for guides for lateral restraint, the PTFE resin shall be virgin material and shall be used as unfilled sheets and shall contain spherical reservoirs for lubricant pressed into its surface. The diameter of the reservoirs shall not exceed 8 mm measured at the surface of the PTFE, and the depth shall not be less than 2 mm nor more than half the thickness of the PTFE. The reservoirs shall be evenly distributed across the surface of the PTFE and shall occupy 20% to 30% of the surface. PTFE used as mating surface for guides for lateral restraint shall not be dimpled or lubricated. All PTFE elements shall be fully bonded and recessed in a rigid backing material.
- (3) All PTFE surfaces except those that act as mating surfaces for guides for lateral restraint or that are subjected to a contact pressure of less than 5 MPa shall be permanently lubricated with silicone grease.
- (4) The average contact pressure for unfilled PTFE elements based on the gross area of the PTFE shall not exceed the values given in below table.

Table 509.1 - Average Contact Pressure for unfilled PTFE Elements

Limit State	Permanent Load, MPa	Total Load, MPa
Serviceability	25	35
Ultimate	40	55

(5) The maximum contact pressures at the extreme edges of flat and curved PTFE elements shall not exceed 1.2 times the values indicated above.

(6) The average contact pressure at serviceability limit state loads for PTFE elements filled with up to 15% mass of glass fibres used to face mating surfaces of guides for lateral restraints shall not exceed 45 MPa.

(7) The coefficient of friction between stainless steel sliding surfaces and lubricated virgin PTFE shall be as per clause 14.7.2.5 and Table 14.7.2.5-1 of the 2012 AASHTO LRFD Bridge Design Specifications.

509.04.4 Fasteners, Anchorages, and Guides for Lateral Restraint

(1) Fasteners, anchorages and translational elements with lateral restraints shall be capable of resisting either of the following lateral loads:

- For bearings with a capacity of 5,000 kN or less at serviceability limit state, 10% of the vertical load capacity.
- For bearings with a capacity over 5,000 kN at serviceability limit state, 500 kN plus 5% of the vertical load in excess of 5,000 kN.

(2) Guides for lateral restraint shall be arranged to permit the required rotations about both the horizontal and vertical axis. The translational elements of guides for lateral restraint shall be faced with stainless steel and shall provide lateral restraint by sliding against mating surfaces faced with PTFE.

(3) The beneficial effect of friction shall be neglected in proportioning fasteners and anchors, except for slip resistant connections which shall be designed to the requirements of AASHTO LRFD Bridge Design Specifications.

509.04.5 Replaceability

(1) The entire bearing assembly, between the sole plate and the base plate shall be replaceable without damage to the structure and without removal of any concrete, welds or anchorages permanently attached to the structure and without lifting the superstructure more than 5 mm. Bearings shall not be recessed into plates that are permanently attached to the structure.

509.04.6 Durability

(1) Bearings shall be designed to prevent moisture and dirt from entering the internal surfaces. The bearings shall be fabricated from materials that are durable and are protected against corrosion so as to perform the intended function.

509.04.7 Fabrication

(1) Stainless steel sheets in contact with PTFE shall be continuously welded around the perimeter to its backing plate to prevent ingress of moisture. The weld shall be clean, uniform, and without overlaps and located outside the area in contact with PTFE.

(2) The threaded portion of the bolts shall be coated with silicone grease prior to installation.

(3) Virgin or glass filled PTFE elements shall be recessed in a rigid backing material and shall be bonded over the entire area with an adhesive. The rigid backing material shall be grit blasted and cleaned with oil free compressed air prior to applying the adhesive.

- (4) The PTFE elements used as mating surfaces for guides for lateral restraint shall extend to within 10 mm from the ends of the backing plates.
- (5) The pots and pistons shall be machined from solid metal plate or castings. There shall be no openings or discontinuities in the metal surfaces in contact with the confined elastomer or PTFE.
- (6) The surface finish of metal plate in contact with any metal plate or confined elastomer in pot bearings shall be machined to a surface finish of 6.4 μm and a flatness tolerance of 0.001 x bearing dimension.
- (7) The pot and piston plates, except surfaces in contact with elastomer, shall be metallized as per ASTM A780, Method A3. The thickness of metallizing shall not be less than 180 microns

509.04.7.1 Tolerances

- (1) Pot bearing tolerances shall be as follows:
- a) The deviation from flatness of PTFE surfaces shall not exceed:
- i) 0.2 mm, when the diameter or diagonal is equal to or less than 800.
 - ii) 0.00025 of the diameter or diagonal, when the diameter or diagonal is greater than 800 mm.
- b) The deviation from flatness of stainless steel in contact with PTFE for plane surfaces and from the theoretical surface for spherical surfaces shall not exceed:
- i) 0.0003 LH mm for a rectangular PTFE element.
 - ii) 0.0006 RH mm for a circular PTFE element
- where:
- L = the greater plan dimension for a rectangular bearing;
 - R = the radius of a circular bearing; and
 - H = the free height of PTFE element
- c) For confined elastomer bearings, the tolerance of fit between the piston and the pot shall be +0.75 to +1.25 mm. The inside diameter of the pot cylinder shall be the same as the nominal diameter of the elastomer and shall be machined to a tolerance of:
- i) 0 to +0.125 mm for diameters up to and including 500 mm.
 - ii) 0 to +0.175 mm for diameters over 500 mm.
- d) The plan dimensions of the recess for PTFE shall be the same as the nominal plan dimensions of the PTFE and shall be machined to a tolerance of 0 to +0.2% of the diameter or diagonal.
- i) Overall bearing plan dimension ± 3 mm
 - ii) Overall bearing height ± 3 mm
 - iii) Machined surface dimensions ± 0.4 mm
- e) Elastomeric components shall meet the following requirements:
- Diameter: 0.0 to -1.5 mm for diameters \leq 500 mm
 0.0 to -2.0 mm for diameters $>$ 500 mm
- Thickness: 0.0 to +1.0 mm
- f) Brass rings shall meet the following requirements:
- i) Difference between internal diameter of brass ring and diameter of recess in the moulded elastomer shall be 0 to +0.5 mm.
 - ii) Difference between sum of thicknesses of brass rings and recess depth in the moulded elastomer 0 to +0.25 mm
- g) Recessed Guide Bars shall meet the requirements of the American Standard Clearance Locational Fit Class LC3 according to ANSI B4.1.

- h) Guides for lateral restraints shall have a 0.50 mm \pm 0.25 mm gap between metal restraints surfaces and mating PTFE elements.
- i) PTFE components shall meet the following requirements:
 - i) The plan dimension of the PTFE shall be 0 to -0.2% of diameter or diagonal difference between internal diameter of brass ring and diameter of recess in the moulded elastomer shall be 0 to +0.5 mm.
 - i) The thickness of the PTFE shall be within 0 to +10.0% of the design thickness. The depth of recess of the PTFE shall be 0 to +0.3 mm

509.05 SPHERICAL BEARINGS

509.05.1 Bronze or Copper-Alloyed Plates for Bearings

509.05.1.1 *Bronze Bearing and Expansion Plates*

(1) Bronze bearing and expansion plates shall conform to the Specification for Bronze Castings for Bridges and Turntables, AASHTO M 107 (ASTM B22) alloy C91100, C86300, or C90500. Alloy C91100 shall be furnished unless otherwise specified on the Drawings. Components may be cast, rolled, or forged. Castings shall be free of blow-holes larger than 3mm and contact surfaces shall be free of all blow-holes of any size.

(2) Bronze plates shall be cast according to details shown on the Drawings. Sliding surfaces shall be planed parallel to the movement of the spans and polished unless detailed otherwise in the contract documents.

509.05.1.2 *Rolled Copper-Alloy Bearings and Expansion Plates*

(1) Rolled copper-alloy bearing and expansion plates shall conform to the Specification for Wrought Copper-Alloy Bearing and Expansion Plates and Sheets for Bridge and Other Structural Use, AASHTO M 108 (ASTM B100). Alloy C51000 or C51100 shall be furnished unless otherwise specified on the Drawings.

(3) Copper-alloy plates shall be furnished according to details shown in the contract documents. Finishing of the rolled plates shall not be required provided they have a plane, true, and smooth surface.

509.05.1.3 Test Requirements

(1) Material certification tests for bronze or copper-alloy bearings shall be performed to verify the properties of the material.

(2) Bearing friction tests may be required by the Engineer

509.05.2 Masonry, Sole, and Shim Plates for Bearings

509.05.2.1 *Materials*

(1) Metal plates used in masonry, sole, and shim plates, unless otherwise specified in the contract documents, shall conform to AASHTO M 270/M 270M (ASTM A709/ A709M) Grade 36 (Grade 250). Bronze or copper-alloy bearing and expansion plates shall conform to the requirements of this specifications

509.05.2.2 *Fabrication*

(1) Holes in bearing plates may be formed by drilling, punching, or accurately controlled oxygen-cutting. All burrs shall be removed by grinding.

509.05.2.3 *Installation*

(1) Bearing plates shall be accurately set in level position as shown on the Drawings and shall have a uniform bearing over the whole area. When plates are to be embedded in concrete, provision shall be made to keep the plates in correct position as the concrete is being placed.

509.05.3 **Polytetrafluorethylene (PTFE) Surfaces for Bearings**

509.05.3.1 *General*

(1) PTFE sheet and strip shall be manufactured either from pure virgin (not reprocessed), unfilled PTFE resin; from PTFE resin uniformly blended with either 15 percent glass fibre or 25 percent carbon (maximum filler, percent by weight (mass)); or from fabric containing PTFE fibres.

(2) Horizontally installed PTFE sheet shall be bonded to and recessed into its steel substrate. Vertically installed PTFE sheet shall be bonded to and recessed into or bonded to and mechanically fastened to its steel substrate. PTFE sheet shall have a minimum thickness of 3 mm and shall be recessed for at least one-half of its thickness into its steel substrate.

(3) Finished PTFE sheet and strip shall be resistant to all acids, alkalis, and petroleum products; stable at temperatures from -180 °C to 260 °C; non-flammable; and non-absorbing of water. The epoxy used to bond the PTFE to its steel substrate shall be a heat-cured, high-temperature epoxy capable of withstanding temperatures of -190 °C to 260 °C.

509.05.3.2 *Materials*

Polytetrafluorethylene (PTFE) Sheet and Strip

(1) PTFE resin sheets, PTFE fabric, interlocked bronze and PTFE structures, PTFE-perforated metal composite, back-up materials, and all other parts of fixed or expansion bearings containing PTFE materials shall have the friction, mechanical, physical, and weathering properties as specified in the contract documents.

PTFE Resin

(1) PTFE resin shall be 100 percent pure, new material meeting the requirements of ASTM D4894 or D4895. No reclaimed material shall be used.

- (2) Finished PTFE sheet, strip, and fabric shall be:
- Resistant to acids, alkalis and petroleum;
 - Products stable at temperatures from -200 °C to 260 °C, non-flammable; and
 - Non-absorbing of water.

Filler Material

(1) Filler material, when used, shall be milled glass fibre, carbon fibre, or other approved filler material. The filler shall not react chemically but shall act compositely with the PTFE.

Adhesive Material

(1) Adhesive material used for bonding sheet PTFE shall be an epoxy resin satisfying the requirements of AASHTO M 235 (ASTM C881), FEP film or equal, as approved by the Engineer.

Unfilled PTFE Sheet

(1) Finished, unfilled PTFE sheet shall be made from virgin PTFE resin and shall conform to the ASTM test methods for tensile strength and elongation shall conform to ASTM D2256.

Filled PTFE Sheet

- (1) Filled PTFE sheet shall be made from virgin PTFE resin uniformly blended with approved inert filler. The maximum filler content shall be 15 percent for fiberglass and 25 percent for carbon fibres. The maximum filler content for other materials shall be determined by the Engineer.
- (2) Finished filled PTFE sheets containing glass fibre or carbon shall conform to the requirements of below Table 509-1 with the exception that the ASTM test methods for tensile strength and elongation shall conform to ASTM D638 (D 2256 is not an option).

Table 509-2: Filled PTFE Sheet

Mechanical	ASTM Method	Sheet Unfilled	Sheet with 15% Glass Fibres	Sheet with 25% Carbon Fibres	Woven Fabric
Tensile Strength min. MPa	D638 or D2256	19.3	13.8	9.0	16.5
Elongation min. %	D638 or D2256	200	150	75	35
Specific Gravity, min.	D792	623 ± 2	2.20 ± 0.03	2.10 ± 0.03	-
Melting Point, Celsius	D4894, D4895 or D5977	164 ± 2	164 ± 10	164 ± 10	-

- (3) Values for intermediate filler contents may be obtained by interpolation.

Fabric Containing PTFE Fibres

- (1) Woven Fabric PTFE shall be manufactured from oriented multi-filament PTFE fluorocarbon fibres or from a mixture of PTFE fibres made from twisted, slit PTFE tape and other fibres as required by proprietary designs. Typical physical properties of the PTFE fibres shall be taken from Table 509-1 with the exception that the ASTM Test Methods for tensile strength and elongation shall conform to ASTM D2256 (D638 is not an option).

Lubricants

- (1) Lubricants, if used, shall consist of a combination of solids which does not react chemically or electrolytically with the PTFE and its mating surface and shall remain stable in the environmental conditions expected at the bridge site.

Interlocked Bronze and Filled PTFE Structures

- (1) Interlocking bronze and filled PTFE structures shall consist of a phosphor bronze plate with a 0.25 mm thick porous bronze surface layer into which is impregnated a lead/PTFE compound. There shall be an overlay of compounded PTFE not less than 25 mm thick. The phosphor bronze back plate shall conform to AASHTO M 108 (ASTM B100) and the porous bronze layer shall conform to ASTM B103/ B103M.

Surface Treatment

- (1) Where PTFE sheets are to be epoxy-bonded, one side of the PTFE sheet shall be factory-treated by an approved manufacturer by the sodium naphthalene or sodium ammonia process

Stainless Steel Mating Surface

- (1) Stainless steel shall conform to the requirements of these Specifications.

509.05.4 Fabrication Requirements

509.05.4.1 General

- (1) Expansion bearings shall be manufactured to the dimensions and to meet the requirements of the method of fastening to the structure as shown on the Drawings.

509.05.4.2 Attachment of PTFE Material

General

- (1) When mechanically fastened, PTFE sheet shall be fastened as shown in the contract documents with the size, type, and number of fasteners required. The fastener used in the PTFE sheet and back-up material shall be installed to provide full bearing.

Flat Sheet PTFE

- (1) All flat sheet PTFE attached to a metal backing plate shall be attached by recessing into the backing of the plate for one-half of the PTFE thickness and bonding. PTFE attached to other materials, such as elastomers, shall be attached by a method specified in the contract documents or approved by the Engineer.

- (2) The PTFE shall be factory-bonded, using an adhesive that is approved by the Engineer, in accordance with the instructions of the adhesives Manufacturer. Prior to bonding, the surface shall be etched by an approved Manufacturer using sodium naphthalene or sodium ammonia process. When the backing plate is metal, the bonding shall be conducted under a uniform pressure greater than 6.8 MPa.

- (3) The peel strength of the bond shall not be less than 3.5 N/mm², tested in accordance with ASTM D429, Method B. The finished surface of the PTFE shall be smooth, free from bubbles, and shall conform to the tolerances specified. Filled PTFE sheets shall be polished after bonding.

Curved Sheet

- (1) Curved sheet PTFE, such as used in spherical bearings, shall be attached by recessing for one-half the PTFE thickness. The dimensions of the PTFE element shall be selected so that it fits tightly in the recess even when the bearing is subjected to its lowest design temperature.

Fabric Containing PTFE Fibres

- (1) Fabric made from woven PTFE fibres shall be bonded or mechanically attached to a rigid substrate. The fabric shall be capable of carrying unit loads of 68.9 MPa without cold flow. The fabric-substrate bond shall be capable of withstanding, without delamination, a shear force equal to $(0.1 + \mu)P$ at the same time as the normal load P , where μ is the design coefficient of friction between the PTFE and its mating surface and P is the design load acting perpendicularly to the interface.

Stainless Steel Mating Surface

- (1) Each stainless steel element specified in the contract documents as a single piece shall be so supplied. Each sheet shall be attached to its backing material by seal-welding around the entire perimeter so as to prevent entry of moisture between the stainless steel and the backing material. Welds shall conform to the current AASHTO / AWS D1.5M / D1.5 Bridge Welding Code. After welding, the stainless steel sheet shall be flat, free from wrinkles, and in continuous contact with its backing plate.

Lubrication

- (1) Lubrication shall be applied to the entire PTFE surface if specified in the contract documents or by the Engineer. If the PTFE is dimpled, enough lubricant shall be used to fill all the dimples.

509.05.5 Testing and Acceptance

- (1) Inspection of the completed bearings or representative samples of bearings with PTFE surfaces shall be required by the Engineer. Inspectors, if appointed, shall be allowed free access to the necessary part of the Manufacturer's plant and test facility. When testing is performed by the Manufacturer, copies of the test results shall be submitted to the Engineer.
- (2) The Manufacturer is required to perform material tests on the materials used in the sliding surface. A minimum of one test shall be performed for each lot of bearings.
- (3) If requested by the Engineer and available test facilities permit, complete bearings shall be tested for complete bearing friction. If the test facility does not permit testing complete bearings, at the direction of the Engineer, extra bearings may be manufactured by the Contractor and samples of at least 445-kN capacity at normal working stresses prepared by sectioning the bearings. As soon as all bearings have been manufactured for a given project, notification shall be given to the Engineer who will select the prescribed test bearings at random from the lot. Manufacturer's certification of the steel, elastomeric pads, preformed fabric pads, PTFE, and other materials used in the construction of the bearings shall be furnished along with notification of fabrication completion.
- (4) Bearings represented by test specimens passing the above requirements shall be approved for use in the structure subject to on-site inspection for visible defects.

509.05.6 Anchor Bolts

509.05.6.1 Materials

- (1) Anchor bolts shall meet the requirements of ASTM A307, or as shown on the Drawings. Anchor bolts shall be provided with anchorage details that permit development of the full tensile strength of the bolt. Hooks or end plates are recommended.

509.05.6.2 Fabrication

- (1) Anchor bolts shall be swedged or threaded to secure a satisfactory grip upon the material used to embed them in the holes.

509.05.6.3 Installation

- (1) The Contractor shall drill holes for anchor bolts and set them in Portland cement grout, or pre-set them as shown in the contract documents or as specified or directed by the Engineer.
- (2) Location of anchor bolts shall take into account any variation from mean temperature of the superstructure at time of setting and anticipated lengthening of bottom chord or bottom flange due to dead load after setting; the intention being that, as near as practicable, at mean temperature and under dead load, the anchor bolts at expansion bearings will centre their slots. Care shall be taken that full and free movement of the superstructure at movable bearings is not restricted by anchor bolts or nuts.

509.05.7 Bedding of Masonry Plates

509.05.7.1 General

- (1) Filler or fabric materials shall be placed as bedding material under masonry plates when shown in the contract documents. Such material shall be of the type specified in the contract documents or as ordered or approved by the Engineer and shall be installed to provide full bearing on contact areas.
- (2) Immediately before placing the bedding material and installing bearings or masonry plates, the contact surfaces of the concrete and steel shall be thoroughly cleaned.

509.05.7.2 *Materials*

- (1) Preformed fabric pads used as bedding shall be composed of multiple layers of 270 g/m² cotton duck impregnated and bonded with high-quality natural rubber or of equivalent and equally suitable materials compressed into resilient pads of uniform thickness. The number of plies shall be such as to produce the specified thickness, after compression and vulcanizing. The finished pads shall withstand compression loads perpendicular to the plane of the laminations of not less than 44.5 MPa without detrimental reduction in thickness or extrusion.
- (2) Sheet lead used as bedding shall be common, de-silverized lead conforming to ASTM B29. The sheets shall be of uniform thickness and shall be free from cracks, seams, slivers, scale, and other defects. Unless otherwise specified, lead sheets shall be 3 mm thick with a permissible tolerance of ± 0.8 mm.
- (3) Caulking material used as bedding shall be a non-sag polysulfide or polyurethane material conforming to the provisions of ASTM C920, Type II.
- (4) Grout and mortar used for filling under masonry plates shall conform to "Mortar and Grout" specifications.

509.05.8 *Fabrication Requirements for Guides*

509.05.8.1 *Guide Bars*

- (1) Guide bars shall be attached to the body of the bearing by a method which minimizes distortion and allows the flatness tolerance on all parts of the bearing to be met after attachment. The sliding surfaces of the guide system shall be flat and parallel.
- (2) Bolts or threaded fasteners used to attach the guide bars to their supporting plates shall have an embedded thread length adequate to develop their strength. If low-friction material is used at the contact interface, it shall be attached to its backing piece by two or more of the following methods simultaneously:
 - Bonding;
 - Recessing; and
 - Mechanical attachment with countersunk fasteners.
- (3) If the material is bonded, it shall be etched by the method recommended by the Manufacturer of the material or bonding agent. Recessing shall be one-half of the material thickness. Fasteners shall be countersunk to a depth which ensures that they will not touch the mating material after allowing for wear.

509.05.9 *Load Plates*

- (1) Load plates shall be made from a single plate or they may be built up from several steel laminates, each oriented in the plane perpendicular to the direction of the load. Built-up load plates shall be joined by complete seal-welding to prevent ingress of moisture. Such welds shall also provide sufficient shear strength to resist the applied loads. The load plates shall have no sharp corners or edges. Holes may be formed by drilling, punching, or accurately controlled oxygen cutting. All burrs shall be removed by grinding

509.07 *HANDLING, TRANSPORTATION AND STORAGE*

- (1) Care shall be taken in packing, transportation, storage and handling of bearings to avoid any form of mechanical damage, contamination with oil, grease or dirt, or undue exposure to sunlight and weather.
- (2) Any damage to bearings shall be immediately notified to the Engineer who will instruct whether repair of the bearing is acceptable or whether replacement with a new bearing is required.

(3) Repairs to bearings shall be carried out by approved methods which are recommended by the bearing manufacturer. All materials used for repair of bearings shall be as approved/recommended by the bearing manufacturer.

(4) The Engineer reserves the right to reject and require replacement of any bearing which has been damaged and repaired if, in the opinion of the Engineer, the repair is unsatisfactory or if further faults or more extensive damage becomes apparent during repair or for any other reasons which, in the opinion of the Engineer, renders the bearing unsatisfactory for use or prejudices its long term durability and/or performance.

(5) All repaired bearings shall be subject to the approval of the Engineer prior to incorporation in the Works.

509.08 CONSTRUCTION REQUIREMENTS

509.08.1 Installation of Bearings

(1) Prior to installation of any bearings the Contractor shall submit for approval a Technical Method Statement, in accordance with Sub-clause 101.04.4 of the Specifications, detailing all procedures and materials for installation of the bearings.

(2) The Technical Method Statement shall be endorsed by the bearing manufacturer.

(3) Prior to bearing placement the bearing plinth shall be free from any loose materials, projections or significant depressions and shall be sand blasted to remove any traces of oil, grease or other deleterious substances.

(4) Bearings shall be placed on surfaces that are plane to within 1.6 mm, and unless placed in opposing pairs, horizontal to within 0.01 radians. The interface between the top of the bearing and the underside of girder shall be formed by approved bedding mortar or as otherwise approved by the Engineer. Where recommended by bearing manufacturer, the bearing shall also be bedded on mortar.

(5) Mortar materials shall be specially formulated for the applications and shall be used strictly in accordance with the mortar manufacturer's recommendations.

(6) Bearings shall be maintained in their correct position during placing of the bridge girders. Mating surfaces of bearings shall be kept free from contamination and, after the deck has been completed, each bearing and the area around it shall be left clean and tidy, to the satisfaction of the Engineer.

509.08.2 Certification

(1) Manufacturer's test certificates shall be provided for all materials incorporated in the bearings. Each bearing shall be marked showing the orientation, the order number, lot number, bearing identification number and elastomer type and grade number.

(2) The properties and performance of proprietary bearings shall be verified by an independent testing laboratory or by documented tests performed on identical bearings within the preceding year. Testing of the finished bearings shall be completed in accordance with requirements of *18.3.4 of the latest version of AASHTO LRFD Bridge Construction Specifications*. Supplier's test certificates shall be provided for each lot of bearings. The verification document should give a full description of the bearings tested, setting out material properties, tolerances, conditions of fit up, assembly and installation and all other such data which, if departed from, could affect the performance of the bearing.

(3) Such facilities as are necessary for the inspection during manufacture and on completion of bearings shall be provided at all reasonable times.

509.09 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
509-1	Elastomeric Bridge Bearings, Type _____	Number
509-2	Pot Bearings	Number
509-2	Spherical Bearing Assembly, Fixed	Number
509-3	Spherical Bearing Assembly, Free	Number
509-4	Spherical Bearing Assembly, Guided	Number

509.10 PAYMENT

(1) Payment will be made at the rates entered in the Bill of Quantities, and shall include full compensation for furnishing all labour, materials, tools, equipment, and incidentals and for doing all the work involved in furnishing, testing, and installing said bearing devices, complete in place, as shown on the Drawings, as specified in these Specifications, and as directed by the Engineer.

SECTION 510

BRIDGE RAILINGS

510.01 DESCRIPTION

- (1) The work covered by this Section consists of supplying and installing bridge railing comprised of precast reinforced concrete posts and galvanised steel pipe rails.

510.02 MATERIALS

510.02.1 Concrete

- (1) Concrete in precast concrete posts shall be in accordance with the relevant provisions of Section 507 of the Specifications.

510.02.2 Steel Reinforcement

- (1) Steel reinforcement shall be in accordance with Section 506 of the Specifications.

510.02.3 Steel Pipe Rails

- (1) Pipe rails shall be steel tubing conforming to the requirements of ASTM A500.

510.02.4 Precast Concrete Posts

- (1) Precast concrete posts shall be manufactured in formwork complying with Section 505 of the Specifications, using concrete manufactured, placed, cured, and treated in accordance with Section 507 of the Specifications, and steel reinforcement placed in accordance with Section 506 of the Specifications.

- (2) Precast concrete posts shall be handled and stored in a careful manner in order to avoid detrimental loading and localised damage during lifting. Slings, if passed through the holes in the posts, shall be cushioned to avoid damage to the edges of the concrete. Posts shall be stored clear of the ground. Posts may be stacked on their sides up to 6 posts high provided all support points are directly in line.

510.02.5 Galvanised Steel Pipes

- (1) Steel pipes shall be hot-dipped galvanised, after manufacture, in accordance with AASHTO M111.

510.03 CONSTRUCTION REQUIREMENTS

- (1) After the deck slab is complete on the full span, precast posts shall be carefully adjusted prior to fixing in place to ensure matching at abutting joints, correct alignment, and camber, and set to a straight or smoothly curved line and level as approved by the Engineer.
- (2) The rails shall be inserted through the holes in the posts and the alignment checked.
- (3) The posts shall be fixed firmly in position while the base concrete is placed and for at least 3 days afterwards.
- (4) The rails shall be fixed in position by filling the annulus between the rail and the post with mortar.

(5) The rails and posts shall be inspected for any defects. Minor damage to the galvanising shall be made good with at least 2 coats of approved zinc-rich paint applied in accordance with the manufacturer's recommendations. Any rail for which the damage to the galvanisation cannot, in the opinion of the Engineer, be made good by the above method shall be removed and replaced by the Contractor at his own expense. Damage to concrete shall be made good in accordance with Section 507 of the Specifications.

(6) Guard-rail as specified in Section 603 of the Specifications shall be bolted to the concrete posts if so shown on the Drawings or ordered by the Engineer.

510.04 MEASUREMENT

(1) Measurement will be as follows:

Item No.	Description	Unit
510-1	Bridge Railing	Metre

(2) Bridge railing will be measured between the ends of the railing or the outside of end posts, whichever is greater. Each side of a bridge shall be measured separately.

510.05 PAYMENT

(1) Payment will be made at the rate entered in the Bill of Quantities, which rate shall include for the posts (including reinforcement) and steel pipes rails.

(2) Guard rail fixed to the bridge parapet posts shall be measured and paid for under Section 603 of the Specifications.

SECTION 513

EXPANSION JOINT SYSTEM

513.01 DESCRIPTION

(1) The work shall consist of furnishing and installation expansion joints in different categories, i.e. Small Movement Joints (Total Movement Range < 4.5 cm), Medium Movement Joints (4.5 cm < Total Movement Range < 12.5 cm), Large Movement Joints (Total Movement Range > 12.5 cm), all as indicated on the Drawings and required by these Specifications.

513.02 GENERAL REQUIREMENTS

- (1) The expansion joints to be installed shall satisfy the following functional requirements.
- Expansion joints must accommodate the movements of the bridge due to concrete shrinkage, thermal variation, and long-term creep (the three primary sources of movement), without creating unacceptable stresses in the joints or other parts of the structure.
 - To withstand all traffic loads and resist a minimum 1 N/mm² truck tyre pressure.
 - To have smooth riding quality not causing any inconvenience to the road users nor causing skidding hazard.
 - Not generating excessive noise or vibration nor causing any damage during the passage of vehicles at a speed of 80 km/hr.
 - To be tightly sealed not allowing any seepage of water and collection of debris.
 - To be easy to install, inspect and maintain and all parts liable to wear must be easy to replace.
 - The certified licences of construction supervisory authorities or certificates of authorised laboratory shall be submitted by the Contractor to the Engineer for approval.
 - Each unit of expansion joint must be marked with the manufacturer's trade mark and type.
 - The expansion joints installed shall be maintenance free and should last for 5 years after opening to traffic.

513.02.1 Small Movement Joints

- (1) Small Movement Joints shall be compression seals or rapid-cure silicone sealants.
- (2) If an overlay of HMA has been constructed atop an existing concrete deck, headers must be constructed on each side of the expansion joint, providing a rigid lateral support to the expansion joint device and serving as a transition between the HMA overlay material and the expansion joint itself. Either polyester concrete or elastomeric concrete shall be used for expansion joint headers, providing enhanced durability to impact compared to other concrete mixes.

513.02.1.1 Compression Seals

- (2) Compression seals shall be continuous manufactured preformed elastomeric elements, with extruded internal web systems, installed within an expansion joint gap to effectively seal the joint against water and debris infiltration.
- (3) Compression seals shall be held in place by mobilizing friction against adjacent vertical joint faces. Compression seals shall be sized and installed to always be in a state of compression.

(4) Compression seals shall be installed against smooth vertical concrete faces or against steel armouring. When installed against concrete, special concrete nosing material having enhanced impact resistance shall be used. The expansion joint supplier shall be consulted for suitable nosing material.

(5) Each elastomeric compression seal shall be furnished and installed as a single, continuous piece across the full width of the bridge deck. No field splices of the compression seal shall be allowed.

(5) For widening projects, a new compression seal shall be furnished and installed as a single, continuous piece across the full width of the original and widened portions of the roadway. Field splicing to the original elastomeric compression seal shall not be allowed.

(6) The expansion gap width shall be set so that the compression seal can be replaced over a reasonably wide range of construction temperatures. Manufacturers' catalogues provides the dimension of the minimum expansion gap widths into which specific size compression seals can be installed.

513.02.1.2 *Rapid-Cure Silicone Sealants*

(1) Rapid-cure silicone sealants can be installed against either concrete or steel.

(2) It is of utmost importance that concrete or steel substrates are thoroughly cleaned before the sealant is installed.

(3) If advised by the manufacturer of the rapid-cure silicone sealant, an application of specific primer shall be applied onto the underlying layer surface prior to sealant installation in order to enhance bonding.

(4) Rapid-cure silicone sealants shall be designed based upon the manufacturer's recommendations.

(5) A minimum recess, as shown on the drawings, is required between the top of the roadway surface and the top of the sealant surface, in order to assure that vehicle tires will not contact the top surface of the sealant and initiate its de-bonding from substrate material.

513.02.2 *Medium Movement Joints*

513.02.2.1 *Strip Seal Joints*

(1) The elastomeric strip seal system shall consist of a preformed elastomeric gland mechanically locked into metallic edge rails embedded into the concrete deck on each side of an expansion joint gap, these metal edge rails effectively armouring the edges of the expansion joint, all in accordance with ASTM D5973.

(2) Elastomeric strip seal elements shall not be field spliced. Each elastomeric strip seal element shall be furnished and installed as a single, continuous piece across the full width of the bridge deck.

(3) Damaged or worn glands shall be replaced with minimal traffic disruption.

(4) Steel studs shall be welded to the steel extrusions (edge rails) to facilitate anchorage to the concrete deck.

(5) Metal edge rails may be field spliced using weld procedures provided by the strip seal expansion joint manufacturer.

513.02.3 Large Movement Joints

513.02.3.1 Steel Finger Joints

- (1) Steel finger joints shall be fabricated from steel plates and shall be installed in cantilevered configurations.
- (2) The steel fingers must be constructed to support traffic loads with sufficient stiffness to eliminate excessive vibration.
- (3) In addition to longitudinal movement, finger joints must also accommodate any rotations or differential vertical deflection across the joint.
- (4) As finger joints do not provide an effective seal against water infiltration, elastomeric and metal troughs must be installed beneath steel finger joints to catch and redirect runoff water.

513.02.3.2 Modular Expansion Joints

- (1) Modular expansion joints shall be shipped in a completely assembled configuration, if not otherwise directed by the design or Engineer.
- (2) When modular expansion joints are shipped and installed in two or more pieces and subsequently spliced together, splicing shall be done after concrete is cast into the blockouts. The centre beams are the elements that must be connected and they shall be connected by either welding, bolting, or by a combination of both.
- (3) Modular expansion joints can be either single support bar systems or multiple support bar systems.
- (4) Modular expansion joints must provide watertight wheel load transfer across wide expansion joint openings. Elastomeric strip seals or box-type seals attached to adjoining centre beams, shall prevent infiltration of water and debris.
- (5) Polytetrafluoroethylene (PTFE) - stainless steel interfaces between elastomeric support bearings and support bars shall facilitate the free movement of the support bars as the expansion gap opens and closes.
- (6) Welded connections of centre beams to support bar shall be applied (bolted connections have demonstrated poor fatigue endurance), but these must be carefully designed, fatigue tested, fabricated, and inspected to assure satisfactory fatigue resistance.
- (7) To minimize impact and wear on bearing elements, the maximum gap between adjacent centre beams should be 9 cm.
- (8) The manufacturer's engineer shall perform the structural design of modular expansion joints. The manufacturer must submit structural calculations, detailed fabrication drawings, and applicable fatigue tests for approval by the Engineer. All structural elements must be designed and detailed for both strength and fatigue. Additionally, modular expansion joints should be designed to provide access for inspection and periodic maintenance activities, including replacement of seals, control springs, and bearing components.
- (9) The manufacturer must also provide shop drawings, material certifications, general fabrication methods, as well as information on corrosion protection, shipping and handling, storage, installation, applicable welding codes and certifications; and description of his quality control and quality assurance system.

513.03 MATERIALS

513.03.1 Preformed Elastomeric (Neoprene) Joint Seals [Compression and Strip Seal]

(1) Preformed joint seals shall be manufactured from a vulcanized elastomeric compound using crystallization resistant polychloroprene (neoprene) as the only polymer. The preformed neoprene joint seal shall meet the requirements specified in below table. All tests will be made on specimens prepared from the extruded seals.

Table 513.1 - Physical Requirements

Property	Physical Requirements	Test Procedure
1.Tensile Strength	Minimum 13.5 MPa	ASTM D412
2.Elongation at Break	Minimum 250%	ASTM D412
3.Hardness, Type A Durometer	55 +7 Points -5 Points	ASTM D2240
4. Oven Aging Test 70 Hrs at 100°C Reduction in Tensile Strength Reduction in Elongation Increase in Hardness	Maximum 20% Maximum 20% Maximum 10 Points	ASTM D573
5. Permanent Set at Break	Maximum 10 %	ASTM D412
6. Low Temperature Stiffening Hardness, Type A Durometer	Maximum 15 Points	ASTM D2240
7. Oil Swell, ASTM Oil No. 3 70 Hrs at 40°C (wipe with toluene to remove surface contamination)	No Cracks	ASTM D1149
9. *Safe Compressibility Test (Z min) Bridge Seal ≤ 63.5 mm > 63.5mm	Min. 50% Min. 55%	
10. **Pressure Generation at 15% Deflection	Min. 20 kPa	
11. *Recovery 22 hrs at -28 °C 70 hrs at -10 °C 70 hrs at + 100 °C	Min. 80% No Cracking Min. 88% Splitting or Min. 85% Sticking	

* This physical requirement not applicable to lock-in type joint seals

513.03.2 Steel Components

(1) Steel for railings of the expansion joints, extrusions, anchor studs, rods, brackets and washer plates, and all other associated steel items shown on the Drawings shall be fabricated from steel conforming to ASTM A36.

(2) Steel used for all construction parts shall be accompanied by a manufacturer's certificate.

(3) Exposed parts of steel units shall be protected against corrosion.

513.04 CONSTRUCTION REQUIREMENTS

513.04.1 Storage and Preparation

(1) Expansion joint materials delivered to the bridge site shall be stored, under cover, on platforms above the surface of the ground. It shall be protected at all times from damage, and when placed it shall be free from dirt, oil, grease or other foreign substance.

513.04.2 Expansion Joints

(1) The position of all bolts cast into concrete and all holes shall be accurately determined from templates and drawings.

(2) The mixing, application and curing of all proprietary materials shall comply with the manufacturer's requirements.

(3) All joints shall be constructed according to details shown on the Drawings.

(4) During the placing and hardening of concrete or mortar under expansion joint components, relative movement shall be prevented between them and the supports to which they are being fixed.

(5) When one half of the joint is being set, the other half shall be completely free from longitudinal restraint. In particular where strongbacks or templates are used to locate the two sides of a joint, they shall not be fixed simultaneously to both sides. Screw threads shall be kept clean and free from rust.

(6) Ramps shall be provided and maintained to protect all expansion joints from vehicular loading, until the Engineer permits their removal.

513.04.3 Epoxy Mortar Nosings

(1) Epoxy mortar nosings shall be formed under the direction of a competent supervisor experienced in the use of the material. The work shall be carried out in dry weather. The air temperature around the joint shall be not less than 10°C.

(2) Concrete surfaces to which the nosings are applied shall be dry, sound and free from laitance. Before application of the priming coat, loose material and dust shall be removed by an air jet, tested to ensure that no oil is carried over from the compressor.

(3) Unless otherwise described in the Drawings or these Specifications surfacing shall be carried across the joint and then cut back to accommodate the nosing. The cutting shall be done with a diamond saw to give a clean edge throughout the depth of the material to be removed. Masking material provided to prevent surfacing materials adhering to the deck where nosings are to be formed shall be adequately located to prevent displacement by the paving machine.

(4) A priming coat of unfilled epoxy resin composition shall be well worked in by brush to all surfaces with which the nosings will be permanently in contact at a uniform rate of not less than 250 grams per square metre. The mortar shall then be applied as quickly as possible while the priming coat is still tacky.

(5) The composition and mix proportions of the epoxy mortar shall be submitted for the Engineer's prior approval. Aggregate shall be either silica sand, calcined bauxite or other approved synthetic or natural aggregate of suitable grading. The particle size distribution shall be that which produces a mortar with adequate workability and minimum void volume. Aggregates shall be clean and completely dry.

(6) Whichever type of aggregate is used, the epoxy mortar components shall be thoroughly mixed in a suitable mechanical mixer. The sequence, duration and temperature of mixing shall be in accordance with the manufacturer's instructions.

(7) The mortar shall be placed in position within the time recommended by the manufacturer. It shall be well worked against the primed surfaces and trowelled flush with the adjacent road surface to form a dense mortar to the profiles described in the Drawings or these Specifications.

(8) Epoxy mortar shall generally be compacted in courses of thickness not exceeding 50 mm. Where an underlying course is more than 1 hour old it shall, unless otherwise agreed by the Engineer, be primed with an unfilled epoxy resin priming coat before placing the next course.

(9) Traffic shall not be permitted to run on the mortar until agreed by the Engineer.

513.05 MEASUREMENT

(1) Measurement will be as follows:

Item No.	Description	Unit
513-1	Compression Seals	Metre
513-2	Rapid-Cure Silicone Sealants	Metre
513-3	Strip Seal Joints	Metre
513-4	Steel Finger Joints	Number
513-5	Modular Expansion Joints	Number
513-6	Header (Polyester- or Elastomeric Concrete)	Metre Cube

(2) Compression seals, rapid-cure silicone sealants and strip seal joints shall be measured in linear metre along the centreline of the joint at the surface of the roadway and up into the parapet, and accepted by the Engineer .

(3) Steel finger joints and modular expansion joints shall be measured in numbers installed and accepted by the Engineer.

(4) Headers will be measured using the length and width shown on the plans and the header depth measured in place.

513.06 PAYMENT

(1) Payment will be made at the rates entered in the Bill of Quantities

(2) The expansion joints and headers measured as shown above shall be paid for at the unit rate for the particular item. Payment made shall be full compensation for furnishing and installation of all materials including stainless steel stud, nut, anchorage unit, sealing material, epoxy mortar nosing, labour, tools, equipment and incidentals necessary to complete the works as prescribed and to the satisfaction of the Engineer.

SECTION 514

BRIDGE LOADING TESTS

514.01 DESCRIPTION OF WORK

514.01.1 Scope

(1) Upon completion of any prestressed, composite girder bridge, the Contractor shall test load the structure or any part thereof, when so directed by the Engineer. The Contractor shall satisfy the Engineer as to the sufficiency of the structure to carry the design loading by measuring stresses, strains and deflections in accordance with arrangements to be approved by the Engineer.

(2) The Contractor shall submit for approval a detailed description, including necessary drawings and specifications of the testing method he intends to use.

514.02 METHOD AND PROCEDURE OF TESTING

514.02.1 General

(1) The test loading shall be provided by:

- i. Applying previously measured wheel loads at predetermined points; or
- ii. Loading the structure with sand, gravel, bagged cement, or other materials of known density; or
- iii. A combination of the above.

(2) The Contractor may at his option propose alternative methods and procedures of test loading.

(3) The test loading shall be applied to give the most unfavourable load distribution to the specific span, as designated by the Engineer.

(4) The Contractor shall supply all mechanical or other stress and strain gauges of approved types, accurate dial gauges measuring to 1/100 mm, and all other special testing instruments as may be required for the test, together with the scaffolding, labour and assistance required for recording the measurements under load.

(5) The Engineer will check for acceptance the method of applications and increments of the loading and the position at which stresses, strains or deflections are to be measured.

(6) The Engineer will analyze the test results of the loading.

514.03 REMEDYING DEFECTS

514.03.1 General

(1) If the Engineer's interpretation of the test results is that any member or part of a structure appears inadequate for any reason whatsoever the Contractor shall, at his own costs, rectify all defects and inadequacies by strengthening such member or part or by demolishing and rebuilding, in an approved manner to the acceptance of the Engineer.

(2) The Contractor shall submit his proposed methods for the remedying actions to be taken to be checked and agreed with the Engineer.

514.04 MEASUREMENT

- (1) Measurement will be as follows:

Item No.	Description	Unit
514-1	Bridge Loading Tests	Number

- (2) Load testing shall be measured by the number of spans (inclusive of the adjacent supports) which are tested. Measurement of Bridge Loading Test will be done on inspection on site upon completion of the test, including reporting, to the acceptance of the Engineer.

- (3) Rectifying, demolishing and rebuilding will not be measured.

514.05 PAYMENT

- (1) The cost of loading tests will be agreed between the Engineer and the Contractor before the work is started.

- (2) No separate payment will be made for any other work required by this Section.

SECTION 520

STEEL STRUCTURES

520.01 DESCRIPTION

- (1) This work shall consist of constructing steel bridge structures in conformance with the details shown on the Drawings and as specified in these specifications.
- (2) The Contractor shall furnish, fabricate and erect the structural steel or metalwork, construct and remove the temporary construction and do all work required in completing the bridge.
- (3) Details of connections for highway bridges selected for use by the Contractor shall conform to the AASHTO LRFD Bridge Design Specifications, 4th edition 2007.

520.02 DRAWINGS

- (1) The Contractor shall submit working drawings for structural steel to the Engineer for approval. For initial review, 3 sets of the drawings shall be submitted.
- (2) After review, 3 sets shall be submitted to the Engineer for final approval and for use during construction.
- (3) The working drawings shall show details of any permitted options proposed in the work, details for connections not dimensioned on the plans, the direction of rolling of plates where specific orientation is required, the sequence of shop and field assembly and erection, welding sequences and procedures, the location of all butt welded splices on a layout drawing of the entire structure, the location of any temporary supports that are to be used and the vertical alignment of the girder at each stage of the erection. Substantiating camber calculations shall be submitted with the working drawings.
- (4) The working drawings shall be supplemented by a written Quality Control program listing methods and personnel to satisfy the requirements of Part 6 of ANSI/AASHTO/AWS D1.5.
- (5) Working drawings shall be A3 or A4 in size and each drawing and calculation sheet shall include the name of the structure as shown on the Drawings.
- (6) Working drawings shall be submitted sufficiently in advance of the start of the affected work to allow time for review by the Engineer and correction by the Contractor of the drawings without delaying the work. The time shall be proportional to the complexity of the work, but in no case shall the time be less than 6 weeks.
- (7) At the completion of each structure on the contract, one set of reduced prints on A4 paper of the corrected original tracings of all working drawings for each structure shall be furnished to the Engineer.

520.03 INSPECTION

- (1) Structural steel shall be inspected at the fabrication site. The Contractor shall notify the Engineer when materials have been delivered to the fabrication site and shall give the Engineer at least 10 days' notice after delivery, before commencing the fabrication of any structural steel.

(2) The Contractor shall furnish to the Engineer a copy of all mill orders, certified mill test reports and Certificates of Compliance for all fabricated structural steel to be used in the work, and other reports or certificates required by the Specifications. Certified mill test reports for steels with specified impact values shall include, in addition to other test results, the results of Charpy V-notch impact tests. When fine grain steel is specified, the test report shall include the grain size. Copies of mill orders shall be furnished at the time orders are placed with the manufacturer. Certified mill test reports shall be furnished prior to the start of fabrication. The Certificate of Compliance shall be signed by the fabricator and shall certify to the Engineer the specifications to which the material has been fabricated and tested, and that the material is in conformance with those specifications and test requirements.

(3) Material to be used shall be made available to the Engineer so that each piece can be examined. The Engineer shall have a free access at all times to any portion of the fabrication site where the material is stored or where work on the material is being performed.

520.04 SHIPPING, HANDLING AND STORING MATERIALS

(1) Members weighing more than 2.7 tonnes shall have the mass marked thereon.

(2) In handling and shipping of the steel work, every care shall be taken to avoid bending, scraping or overstressing the pieces. All pieces bent or otherwise injured will be rejected.

(3) The loading, transporting and unloading of structural material shall be so conducted that the metal will be kept clean. Material to be stored shall be placed above the ground upon platforms, skids or other supports and shall be kept free from dirt, grease and other foreign material and properly drained and protected from corrosion. Girders and beams shall be placed upright and shored. Long members, such as columns and chords, shall be supported on skids, placed near enough together to prevent damage from deflection.

520.05 FALSEWORK

(1) Falsework used for the erection of structural steel shall conform to the provisions in Section 505, "Falsework and Formwork", except that dead loads shall consist of the mass of the structural steel and any other portions of the structure which are supported by the falsework.

(2) Falsework and forms supporting the concrete work on steel structures shall be constructed so that any loads applied to girder webs shall be applied within 150 mm of a flange or stiffener and shall be distributed in a manner that will not produce local distortion of the web. Temporary struts and ties shall be provided as necessary to resist lateral loads applied to the girder flanges and to prevent appreciable relative vertical movement between the edge of deck form and the adjacent steel girder.

(3) Construction methods and equipment employed by the Contractor shall be within load limits. Loads imposed on existing, new or partially completed structures shall not exceed the load carrying capacity of the structure, or portion of structure, as determined by the Load and Resistance Factor Design methods of AASHTO using Load Combination Limit State Strength.

520.06 CONTINUOUS MEMBERS

(1) Unless otherwise noted on the Drawings, structural steel girders have been designed for continuity in supporting girder dead load. The Contractor may, as an option, erect the girders in such a manner that the girder continuity for dead load is or is not as assumed in design. Furnishing and erecting the girders shall be subject to the requirements in this section.

(2) If erection procedures are to be used which will provide the designed girder continuity for dead load, the Contractor shall furnish to the Engineer for review a statement of intended steel erection procedures with calculations in sufficient detail to substantiate that the girder geometry will be correct.

(3) If erection procedures are to be used which will provide the designed girder continuity for dead load, members with field joints shall be preassembled in a no-load condition in a horizontal or an upright position.

(4) If erection procedures are to be used which will result in steel girders not attaining the continuity for dead load assumed in design, the Contractor shall furnish to the Engineer for review a statement of steel erection procedures with calculations, in sufficient detail to substantiate that girder capacity and geometry will be correct.

(5) If erection procedures are to be used which will result in steel girders not attaining the continuity for dead load assumed in design, the structure shall, after erection, have a load carrying capacity at least equal to the designed structure shown on the Drawings. The Contractor may increase the cross-sectional area or change the grades of steel to provide the specified load carrying capacity, subject to approval by the Engineer. Any additional steel or higher strength steels required to accommodate the method of erection selected shall be considered to be for the convenience of the Contractor and no additional payment will be made therefor.

520.07 MATERIALS

520.07.1 Description

(1) The various structural steel materials shall conform to the requirements in ASTM as listed in the below table.

Table 520.1 - Structural Steel Material Standards

Material	Specification
Carbon and High-Strength Low-Alloy Structural Steel	ASTM A709 / A709M: Grade 50 [345] or
High-Strength Low-Alloy Columbium-Vanadium Structural Steel	ASTM A572 / A572M: Grade 50 [345] } ^a
Carbon and High-Strength, Low-Alloy Structural Steel	ASTM A709 / A709M: Grade 50W [345W] or
High-Strength, Low-Alloy Structural Steel	{ASTM A588 / A588M} ^a
<u>Steel fastener components for general applications</u>	
Bolts and studs	ASTM A307
Headed anchor bolts	ASTM A307, Grade B, including S1 supplementary requirements
High-strength bolts and studs	ASTM A449, Type 1
High-strength threaded rods	ASTM A449, Type 1
Nuts	ASTM A563, including Appendix X1 ^b
Washers	ASTM F844
<u>Components of high strength steel fastener assemblies for use in structural steel joints:</u>	
Bolts	ASTM F3125, Type 1
Tension control bolts	ASTM F3125, Type 1
Nuts	ASTM A563, including Appendix X1 ^b
Hardened washers	ASTM F436, Type 1
Direct tension indicators	ASTM F959, Type 325, zinc-coated
Carbon steel for forgings, pins and rollers	ASTM A668/ A668M, Class D
Alloy steel for forgings	ASTM A668/ A668M, Class G
Pin nuts	ASTM A36/ A36M
Carbon-steel castings	ASTM A27/ A27M, Grade 65-35 [450-240], Class 1
Malleable iron castings	ASTM A47, Grade 32510 or ASTM A47M, Grade 22010

Material	Specification
Gray iron castings	ASTM A48, Class 30B
Carbon steel structural tubing	ASTM A500, Grade B or A 501
Steel pipe (Hydrostatic testing will not apply)	ASTM A53, Type E or S, Grade B; or ASTM A106, Grade B; or ASTM A39, Grade B
Stud connectors	ASTM A108 and ANSI/AASHTO/AWS D1.5

a Grades that will be substituted for the equivalent ASTM A709 steel, at the Contractor's option, subject to the modifications and additions specified and to the requirements of ASTM A709.

b Zinc coated nuts that will be tightened beyond snug or wrench tight shall be furnished with a dry lubricant conforming to Supplementary Requirement S2 in ASTM A563.

(2) Coiled steel plate shall not be used for the fabrication of flanges, eye bars and hanger plates or for splice plates for flanges and eye bars.

(3) All structural steel pre-cut prior to arrival at the fabrication site shall be cut so that the plate orientation conforms to the provisions in Section 520.11.4, "Orientation of Plates.

(4) All structural steel plate used for the fabrication of tension members, tension flanges, eye bars and hanger plates and for splice plates of tension members, tension flanges and eye bars shall meet the longitudinal Charpy V-notch impact value requirements specified herein. Sampling procedures shall conform to the requirements in ASTM A673. The H (Heat) frequency of testing shall be used for structural steels conforming to the requirements in ASTM A709/ A709M, 50 [345] and 50W [345W]. Charpy V-notch impact values shall be determined in conformance with the requirements in ASTM E23.

(5) Charpy V-notch (CVN) impact values shall conform to the following minimum values for non-fracture critical members:

Table 520.2 - Required CVN Impact Values for Non-fracture Critical Members

Material Conforming to ASTM A709/ A709M	CVN Impact Value (Joules at Temp.)
Grade 50* (50 mm and less in thickness)	20 at 4°C
Grade 50W* (50 mm and less in thickness)	20 at 4°C
Grade 50* (Over 50 mm to 100 mm in thickness)	27 at 4°C
Grade 50W* (Over 50 mm to 100 mm in thickness)	27 at 4°C

* If the yield point of the material exceeds 450 MPa, the temperature for the CVN impact value for acceptability shall be reduced by 8°C for each increment of 70 MPa above 450 MPa.

520.07.2 Structural Steel

(1) Unless otherwise specified or shown on the Drawings, all structural steel plates, shapes and bars shall conform to ASTM Designation: A 709/A 709M, Grade 50 [345]. At the option of the Contractor, girder flange plates shown on the Drawings may be increased in thickness, and may be increased in length provided that the change does not involve a decrease in detailed thickness of any portion of the plates. For continuous girders, increases in length of girder flange plates which involve changes in locations of butt welds between different thicknesses of flange plates shall be approved in writing by the Engineer prior to fabrication.

520.08 BEARINGS

- (1) Bearings shall conform to the provisions for Section 509, "Bearings."
- (2) The Contractor shall supply bridge bearings to the requirements of this specification or as show on the Drawings. The bearing devices shall be capable of transmitting the loads and movement shown on the Drawings. All expansion bearings shall have a maximum friction coefficient of 3%. All steel shall conform to AASHTO M270 Grade 345.
- (3) The dimension "H" in the bearing table represents the assumed total height of bearing mechanism between the sole plate and bearing assembly used by the designer to establish elevations.
- (5) All exposed metal components of the bearing system shall be either be painted or metalized.
- (6) The bearing design shall conform to the provisions of the latest editions of AASHTO.
- (7) Whenever jacking of the superstructure is needed to reset the bearings, the Contractor shall submit a jacking sequence for the Engineer's approval.

520.09 FABRICATION

520.09.1 Quality of Workmanship

- (1) Workmanship and finish shall be equal to the best general practice in modern bridge shops.

520.09.2 Straightening Material

- (1) Rolled material before being laid out or worked shall be straight. Sub-assemblies and completed members shall be straight before being incorporated into the work. If straightening is necessary, it shall be done by methods acceptable to the Engineer. Details for methods proposed for straightening shall be submitted in writing to the Engineer prior to their use. After straightening, evidence of fracture or other damage will be cause for rejection of the material.

520.09.3 Orientation of Plates

- (1) Steel plates for flanges, eye bars, hanger plates and splice plates for flanges and eye bars shall be cut and fabricated so that the primary direction of rolling is parallel to the direction of the main tensile stress or main compressive stress in the member.

520.09.4 Mechanical Cutting

- (1) Edges cut by mechanical methods shall be clean cut, without torn or ragged edges.

520.09.5 Flatness of Faying and Bearing Surfaces

- (1) Surfaces of bearing and base plates and other metal surfaces that are to come in contact with each other or with ground concrete surfaces shall be flat to within one mm tolerance in 300 mm and to within 2 mm tolerance overall. Surfaces of bearing and base plates and other metal bearing surfaces that are to come in contact with preformed fabric pads, elastomeric bearing pads or Portland cement mortar shall be flat to within 3 mm tolerance in 300 mm and to within 5 mm tolerance overall.
- (2) Steel slabs where not in contact with other metal bearing surfaces may be heat straightened in lieu of machining at the option of the Contractor, provided the above tolerances are met.

520.09.6 Fit of Stiffeners

(1) Girder stiffeners designated on the plans as bearing stiffeners shall be welded in conformance with details shown on the Drawings. Where the end of a stiffener is shown as "Tight-fit" on the Drawings, the end of the plate shall be so fitted that it bears on the girder flange with at least point bearing. Local clearances between the end of the stiffener and the girder flange shall not exceed 2 mm. Except where stiffeners are cut back, local clearances between the end of the stiffener and the girder flange which are too great to be sealed by the paint film shall be caulked prior to painting.

520.09.7 Bent Plates

- (1) Cold-bent load-carrying rolled steel plates shall conform to the following:
- (2) The plates shall be so taken from the stock plates that the direction of bending will be at right angles to the direction of rolling.
- (3) The radius of bend, measured to the concave face of the metal, shall be as specified in the Manual of Steel Construction published by the AISC.
- (4) Before bending, the corners of the plate shall be rounded to a radius of 2 mm throughout that portion of the plate at which the bending is to occur.
- (5) If a shorter radius is essential, the plates shall be bent hot. Hot-bent plates shall conform to Item A, above.

520.09.8 End Connection Angles

(1) Floor beams, stringers and girders having end connection angles shall be built to exact length back to back of connection angles. If end connections are faced, the finished thickness of the angle shall not be less than that shown on the detail drawings.

520.09.9 Finished Members

(1) Finished members shall be true to line and free from twists, bends and open joints.

520.09.10 Fastener Threads

- (1) Fastener threads for general applications shall conform to the following:
- (2) External threads, prior to zinc coating, shall conform to the Unified Coarse Thread Series requirements in ANSI Standard: B1.1 with Class 2A tolerances, or the Metric Coarse Thread Series requirements in ANSI Standard: B1.13M with Grade 6g tolerances.
- (3) Internal threads shall conform to the requirements in ASTM A563 or A563M.
- (4) Threads for pin ends and pine nuts, 36 mm and greater in diameter, shall conform to the following:
- (5) External threads shall be Unified Inch Screw Threads, UN Series with 6 threads per 25.4 mm conforming to the requirements in ANSI Standard: B1.1 with Class 2A tolerances or Metric Screw Threads-M Profile-with 4-mm thread pitch conforming to the requirements in ANSI Standard: B1.13M with Grade 6G tolerances.
- (6) Internal threads shall be Unified Inch Screw Threads, UN Series with 6 threads per 25.4 mm conforming to the requirements in ANSI Standard: B1.1 with Class 2B tolerances or Metric Screw Threads-M Profile-with 4-mm thread pitch conforming to the requirements in ANSI Standard: B1.13M with Grade 6H tolerances.

520.09.11 Match-Marking

(1) Connecting parts pre-assembled for the purpose of setting up for welding or for drilling or reaming holes for field connections shall be match-marked, and a diagram showing the marks shall be furnished on the working drawings.

520.09.12 Finish

(1) Portions of the work exposed to view shall be finished neatly. Shearing, flame cutting and chipping shall be done carefully and accurately. All sharp corners and edges, and edges that are marred, cut or roughened in handling or erection, shall be slightly rounded by grinding or other suitable means.

520.09.13 Painting

(1) All iron and steel surfaces shall be cleaned and painted in conformance with the provisions in Section 521, "Painting".

520.09.14 Bolted Connections

(1) Bolted connections in structural steel joints, unless otherwise shown on the Drawings shall be made with high-strength steel fastener assemblies. Fastener assemblies shall consist of either (1) a high-strength steel bolt, nut and hardened washer or (2) a tension control bolt, nut and hardened washer. A direct tension indicator may be used with the high-strength bolt, nut and hardened washer fastener assembly.

(2) Bolted connections using fastener assemblies shall conform to the requirements in "Specification for Structural Joints Using ASTM A325 or A490 Bolts" (RCSC Specification) approved by the Research Council on Structural Connections of the Engineering Foundation, and these specifications.

(3) When reference is made to the RCSC Specification, the "Allowable Stress Design" version shall be used when allowable stress design is shown on the Drawings and the "Load and Resistance Factor Design" version shall be used when load factor design or load and resistance factor design is shown on the Drawings.

(4) All connections made with fastener assemblies shall be tensioned as a slip critical connection, whether classified as a slip critical or bearing type connection, unless otherwise designated on the Drawings.

(5) The hardened washer shall be installed under the nut or bolt head, whichever element is turned in tightening. Nuts shall be located, wherever practicable, on the side of the member that will not be visible from the travelled way. Nuts for bolts that will be partially embedded in concrete shall be located on the side of the member that will be encased in concrete.

(6) When the bolt head is used as the turned element, all tension testing and tension verification, including determining job inspecting torque, shall be performed by turning the bolt head.

(7) Each length and diameter of fastener assemblies used in any one joint of a high-strength bolted connection shall be from the same rotational capacity lot. The Contractor shall keep a record of which rotational capacity lots are used in each joint.

(8) The Contractor shall provide, calibrate and maintain the equipment and tools necessary for the preliminary testing, installation and inspection of all fasteners.

(9) Bolt tension measuring devices and calibrated wrenches shall be calibrated within one year prior to first being used on the job, and a minimum of once each year thereafter. This calibration shall be done by a qualified independent laboratory or authorized warranty repair and calibration centre recognized by the tool manufacturer. Bolt tension measuring devices shall be calibrated, to within one percent of the actual tension value, with a minimum of 4 verification readings evenly spaced over a range of 20 to 80 percent of full scale. Calibrated wrenches shall be calibrated to within 2 percent of the actual torque value, with a minimum of 4 verification readings evenly spaced over a range of 20 to 100 percent of full scale. Test equipment used for certification and calibration standards shall be traceable to the National Institute of Standards and Technology.

(10) Prior to the use of bolt tension measuring devices or calibrated wrenches, the Contractor shall furnish to the Engineer certificates of calibration with plots of verification readings for each device or wrench.

(11) The Contractor shall furnish certified test reports in a format approved by the Engineer, including text, tables, digital photographs and sketches or drawings to scale of tests on fastener components and fastener assemblies performed prior to shipment to the jobsite. Information recorded shall include: names of inspectors; date; types of structural components; test methods and results; location, type, and any other information required by the Engineer. Photographs shall be taken of all aspects of the inspections and all components. Certified test reports for fastener components and fastener assemblies shall be furnished to the Engineer prior to use of the fastener assembly. The certified test reports shall include the rotational capacity lot numbers for fastener assemblies supplied and the test reports specified in the "Certification," "Report," "Number of Tests and Retests," and "Certification and Test Report" sections in the appropriate ASTM requirements for the fastener components. For ASTM A307, Grade B or Grade C anchor bolts, the chemical composition and calculated carbon equivalent of each batch of steel shall be furnished.

(12) The surfaces of all bolted connections shall be prepared before assembly in conformance with the requirements in the Particular Specifications.

520.10 BOLT HOLES

(1) Bolt holes shall be either punched full size, drilled full size, sub-punched and reamed, or sub-drilled and reamed.

(2) Attention is directed to the provisions in Section 520.20, "Assembly," and details shown on the Drawings for connections where drilling or reaming is required after the joint is assembled.

(3) The finished holes shall be cylindrical, perpendicular to the plane of the connection and shall be not more than 1.6 mm larger than the nominal diameter of the bolt. Holes shall be clean cut, without torn or ragged edges. All burrs, fins, sharp edges and hole irregularities which would prevent solid seating of the parts shall be removed.

(4) All holes punched full size, sub-punched or sub-drilled shall be located with sufficient accuracy so that after assembling (before any reaming is done) a cylindrical pin 3.2 mm smaller in diameter than the nominal size of the punched, sub-punched or sub-drilled hole may be passed through the hole without drifting, in at least 75 percent of the holes for each connection. All holes shall pass a pin 4.8 mm smaller in diameter than the nominal size of the hole.

(5) Mis-punched or mis-drilled holes shall not be corrected by welding, unless approved by the Engineer.

(6) Punching, drilling and reaming shall conform to the following:

520.11 PUNCHING

(1) Punching or sub-punching of structural steel conforming to the requirements in ASTM A345 where the material is thicker than 22 mm will not be permitted. Punching or sub-punching of high-strength structural steel where the material is thicker than 19 mm will not be permitted.

- (2) The diameter of the die for punching shall not exceed that of the punch by more than 2.4 mm.
- (3) Holes sub-punched for reaming shall be sub-punched 6 mm less in diameter than that of the finished hole.

520.12 DRILLING

- (1) Drilling full size shall be done with the parts assembled or to a steel template with hardened bushings or may be performed with gang drill equipment if approved by the Engineer. The Engineer may require a proof assembly to check the fit of major field connections.
- (2) Where bolt holes are sub-drilled for reaming, they shall be sub-drilled 6 mm less in diameter than that of the finished hole.
- (3) Drilling through templates shall be performed only after the templates have been accurately placed and firmly clamped or bolted.
- (4) If members are drilled while assembled, the parts shall be held securely together while drilling is being done.
- (5) Stack drilling of plate parts with precision gang drills will be permitted if all parts are firmly clamped during drilling and if the drill bits remain perpendicular to the work during drilling operations.

520.13 REAMING

- (1) Reaming shall be done after the pieces forming a built-up member are assembled and are firmly bolted together so that the surfaces are in close contact or after templates are securely located over the member. The pieces shall be taken apart before bolting, if necessary, and shavings removed. If it is necessary to take the members apart for shipping or handling, the pieces reamed together shall be so marked in order that they may be reassembled in the same position. Reamed parts shall not be interchanged.
- (2) Reaming templates shall have hardened steel bushings and holes accurately dimensioned. Templates shall have reference lines which will permit accurate location of the template on the member or members to be reamed. Templates used for reaming shall be properly located on the material and shall be firmly clamped or bolted in position. Templates used for the reaming of matching members, or the opposite faces of one member, shall be exact duplicates.
- (3) Holes through assembled material that are to be reamed shall not consist of sub-punched nor sub-drilled holes and holes punched or drilled full size.

520.14 INSTALLATION

- (1) If any components of fastener assemblies are furnished with water soluble lubricants, fastener installation will not be permitted when surface moisture is present at a high-strength bolted connection. If fastener assemblies are furnished with other than water soluble lubricants, the Engineer may require the Contractor to perform additional fastener testing if any fastener work or testing is performed when surface moisture is present.
- (2) Manual torque wrenches shall have either a dial gage or digital read out. Any electric, pneumatic or hydraulic calibrated wrench used to tension fasteners shall have an adjustable control unit that can be set to positively shut off at the desired torque.
- (3) Wrenches used for snugging tension control bolts in a connection prior to final tensioning shall not apply torsion to the splined end of the bolt.

(4) For all bolts, the threaded end projecting past the outer face of the nut (thread stickout), where first full formed thread is present, shall be at least flush with, but not more than 6 mm beyond, the outer face of the nut. In addition, a minimum of 3 full threads shall be located within the grip of the connection. A maximum of one hardened washer, in addition to the single washer required under the turned element, may be installed under the non-turning element.

(5) The thread stick-out of studs, rods and anchor bolts shall be at least flush with, but not more than 25 mm beyond, the outer face of the nut, unless otherwise approved in writing by the Engineer.

(6) Larger bolts, having diameters up to 6.4 mm greater than the diameter of the bolt shown on the plans, may be used if approved by the Engineer, provided that spacing and edge distance requirements for the larger bolt are met and the net section is adequate.

(7) When direct tension indicators are used, one direct tension indicator shall be installed under each bolt head with the direct tension indicator protrusions contacting the bearing surface of the bolt head. To tension the bolt, the bolt head shall be held stationary and the nut turned. Unless otherwise specified, manufacturer's installation procedures shall be followed. Each bolt shall be tensioned in at least 2 tightening stages until at least 50 percent of the gaps on each direct tension indicator are greater than zero and less than 0.127 mm. Complete crushing of all direct tension indicator protrusions (0 gaps) on any given direct tension indicator will be cause for rejection.

(8) The same head orientation shall be used within any one high-strength bolted connection.

520.15 ROTATIONAL CAPACITY TESTING PRIOR TO SHIPMENT TO JOBSITE

(1) Rotational capacity tests on fastener assemblies shall be performed.

520.16 INSTALLATION TENSION TESTING AND ROTATIONAL CAPACITY TESTING AFTER ARRIVAL TO JOBSITE

(1) Installation tension tests and rotational capacity tests on fastener assemblies shall be performed as specified in the Particular Specifications.

520.17 TENSION VERIFICATION OF FASTENER ASSEMBLIES

(1) Minimum fastener tension in all completed high-strength bolted connections shall be verified.

(2) For each type of fastener assembly, at least 10 percent, but no fewer than 2 assemblies used in each high-strength bolted connection shall be checked for minimum tension, by the Contractor, in conformance with the procedure described in Section 9(b), "Arbitration Inspection," of the RCSC Specification. For determining the job inspecting torque for short bolts, the procedure described in steps 1 through 9 of the "Arbitration of Disputes, Inspection Torque Method-Short Bolts," section of the "Structural Bolting Handbook," published by the Steel Structures Technology Centre, Incorporated shall replace Section 9(b)(2) of the RCSC Specification. A separate inspecting torque shall be determined and used for each different rotational capacity lot of fasteners.

(3) The verification for minimum tension shall be performed (1) no longer than 48 hours after all fasteners in the connection have been tensioned, (2) on fastener assemblies selected by the Engineer, (3) in the presence of the Engineer, and (4) in such a manner that the Engineer can read the torque wrench gage or access the direct tension indicator gaps during inspection.

520.18 PIN CONNECTIONS

(1) Pins shall be accurately turned to the dimensions shown on the plans and shall be straight, smooth and free from flaws. The final surface shall be produced by a finishing cut.

- (2) Pins and rollers shall be forged and heat treated in conformance with the designation shown on the plans or as specified in the Particular Specifications.
- (3) In pins larger than 225 mm in diameter, a hole not less than 48 mm in diameter shall be bored full length along the axis after the forging has been allowed to cool to a temperature below the critical range under suitable conditions to prevent injury by too rapid cooling, and before being annealed.
- (4) Holes for pins shall be bored true to the specified diameter, smooth and straight, at right angles to the axis of the member and parallel with each other unless otherwise required. The final surface shall be produced by a finishing cut.
- (5) Machined surfaces for pins and holes shall be coated with a rust inhibitor that can be easily removed.
- (6) The distance outside-to-outside of holes in tension members and inside-to-inside of holes in compression members shall not vary from that shown on the plans by more than 0.80-mm.
- (7) The diameter of the holes for pins shall not exceed that of the pin by more than 0.50-mm for pins 125 mm or less in diameter, or 0.80-mm for larger pins.
- (8) Holes for pins in built-up members shall be bored after assembly of the member, or may be bored prior to assembly, provided procedures approved in advance by the Engineer are followed which result in the holes being positioned to the same degree of accuracy as would be obtained if the holes were bored after assembly.
- (9) Pin-connected hanger plates shall be bored in pairs or in stacks firmly bolted or clamped together so that each pair of hanger plates is matched. Pilot and driving nuts shall be used in driving pins. Pins shall be so driven that the members will take full bearing on them. In field assembling, the pine nuts on pin connections shall be tightened and secured with a positive locking device.

520.19 ASSEMBLY

- (1) Contact surfaces of high strength bolted connections shall be cleaned and painted in conformance with the provisions in Section 520.11.14, "Bolted Connections". All other surfaces of metal in contact shall be thoroughly cleaned of rust, mill scale, dirt, grease, paint or other material foreign to the metal before assembly.
- (2) Completed sub-assemblies for structures or units of structures shall be pre-assembled prior to erection as necessary to verify the geometry of the complete structure or unit and to verify or prepare field connections as specified herein.
- (3) Bolted splice joints for plate girders shall be pre-assembled with the abutting sections adjusted for line and camber and holes for field connections shall be drilled or finish reamed while the sections are assembled.
- (4) Splice joints for welded girders shall be pre-assembled with abutting members adjusted for line and camber and prepared for welding.
- (5) All pre-assembly methods shall be compatible with the erection methods to be used, unless otherwise permitted in writing by the Engineer.
- (6) All machinery shall be completely pre-assembled. All bearings shall be fitted to the specified clearances and alignments. Gear reductions and all line gears shall have gear centre distances set and the gears properly match-marked.
- (7) The parts shall be accurately assembled in their final position, as shown on the plans, and all match-marks shall be followed. The material shall be carefully handled so that no parts will be bent, broken or otherwise damaged. Hammering which will injure or distort the members will not be permitted.

(8) Drifting done during assembly shall be only such as to bring the parts into position, and not sufficient to enlarge bolt holes or distort the metal.

520.20 WELDING

(1) Welder qualification and inspection of welding shall conform to the requirements in these specifications, ANSI/ AASHTO/ AWS D1.5 and the Particular Specifications.

(2) The minimum size of all fillet welds, except those to reinforce groove welds, shall be as shown in the following table:

Table 520.3 - Minimum Size of Fillet Welds

Base Metal Thickness of the Thicker part Joined, (mm)	*Minimum Size of Fillet Weld, (mm)
≤ 13	5
> 13 to 19	6
> 19 to 38	8
> 38 to 57	10
> 57 to 150	13
> 150	16

* Except that the weld size does not need to exceed the thickness of the thinner part joined.

(3) The flat side of all butt welded joints shall not deviate from flatness by more than 5 mm in a length of 600 mm centered over the weld joint.

(4) In addition to the non-destructive testing requirements in ANSI/AASHTO/AWS D1.5, 25 percent of all main member tension groove welds, in material in excess of 13 mm thickness, shall be ultrasonically tested.

(5) The location of all non-destructive testing shall be determined by the Engineer.

(6) All weld surfaces shall be ground smooth and flush when non-destructive testing is required.

(7) Brackets, clips, shipping devices or other material not required by the project plans or Particular Specifications shall not be welded or tacked to any part of the girders, unless shown on the working drawings specified in Section 520.02, "Drawings," and approved by the Engineer.

520.21 BEARINGS AND ANCHORAGES

(1) All bearing assemblies shall be set level. Adjustments in the horizontal positions of bearing assemblies shall be made for temperature as directed by the Engineer. Full bearing on the concrete shall be obtained under bearing assemblies regardless of tolerances otherwise permitted.

(2) In conformance with the details shown on the Drawings, masonry plates and the bearing plates of bearing assemblies shall be set on ground concrete surfaces, on preformed fabric pads, on elastomeric bearing pads or on mortar pads.

(3) Immediately before setting bearing assemblies or masonry plates directly on ground concrete surfaces, the Contractor shall thoroughly clean the surfaces of the concrete and the metal to be in contact and shall apply a coating of non-sag polysulfide or polyurethane caulking conforming to the requirements in Federal Specification TT-S-230, Type II, to contact areas to provide full bedding. Non-metallic bearing pads shall be protected from damage due to welding heat by means subject to approval by the Engineer.

(4) Mortar to be placed below masonry plates or bearing plates of the bearing assemblies and in anchor bolt sleeves or canisters shall conform to the provisions of Specifications with the proportion of cement to sand to be 1 to 3.

(5) The embedded end of anchor bolts shall be either headed or with a nut and washer. Anchor bolts shall be installed with or without either pipe sleeves or corrugated metal canisters as detailed on the plans. The anchor bolts shall be carefully installed to permit true positioning of the bearing assemblies.

(6) When anchor bolts are installed in pipe sleeves or metal canisters, the pipes or canisters shall be completely filled with mortar. Mortaring and the construction of mortar pads under masonry plates, if required, shall be done after erection of girders and before placing deck concrete.

520.22 MEASUREMENT

(1) Measurement shall be as follows:

Item no	Description	Unit
520-1	Furnish Bridge Structural Steel	Tonne
520-2	Erect Bridge Structural Steel	Lump Sum
520-3	Spherical Bearings, Fixed	Number
520-4	Spherical Bearings, Free	Number
520-5	Spherical Bearings, Guided	Number

(2) Quantities of each type of steel will be measured by the kilogram computed from the dimensions shown on the Drawings by the Engineer using the following rules and assumptions:

(3) The density of structural and cast steel shall be 7849 kg/m³.

(4) The mass of rolled shapes and of structural plates will be computed on the basis of their nominal mass and dimensions, without deductions for copes, cuts and holes.

(5) The mass of shop and field fillet welds will be assumed as follows:

Table 520.4 - Mass of Shop and Field Fillet Welds

Size of Fillet Weld (mm)	Mass (kg / linear meter)
5	0.098
6	0.141
8	0.251
10	0.392
13	0.663
16	1.005
19	1.417
22	1.899
25	2.453

(6) The computed mass of the completed members will be obtained by adding to the above mass the mass of all bolts, nuts and washers from both shop and field, on the basis of the following masses. The additional mass of oversize bolts and nuts will not be included in the computed mass.

Table 520.5 - Mass of Bolts

Nominal Bolt Diameter (mm)	Mass per 100 bolts (kg)
M16	11.831
M20	19.558
M22	30.009
M24	43.557

- (7) The mass of bolts, cap screws, anchor bolts, nuts, washers and anchor pipe sleeves remaining in the finished structure will be computed on the basis of their nominal mass and dimensions.
- (8) No allowance will be made for the mass of paint in computing the mass of metal to be paid for.
- (9) Whenever an alternative is shown or noted on the Drawings or permitted by these specifications, the quantity of structural steel to be paid for will be computed on the basis of the dimensions, details and types of structural steel shown on the Drawings and no increase or decrease in the quantity to be paid for will be made for any variation because of the use by the Contractor of the alternatives.

520.23 PAYMENT

- (1) Payment will be made at the rates entered in the Bill of Quantities.
- (2) Payment for Furnish Bridge Structural Steel shall include full compensation for furnishing all labour, materials, tools, equipment and incidentals, and for doing all the work involved in furnishing, fabricating and delivering structural steel to the job site, making ready for erection, furnishing all bolts, nuts and washers, stud connectors, welding materials, preformed fabric pads and elastomeric bearing pads, or other materials required for the erection and connection or splicing of the structural steel; and conforming to the qualification and testing requirements associated with member fabrication, as shown on the Drawings, as specified in these specifications and as directed by the Engineer.
- (3) Payment for Erect Bridge Structural Steel shall include full compensation for furnishing all labour, materials, tools, equipment and incidentals, and for doing all the work involved in erecting the structural steel complete in place, connecting and splicing the structural steel, installing stud connectors; placing preformed fabric pads and elastomeric bearing pads; furnishing and applying caulk; furnishing and placing mortar for masonry or bearing plates and anchor bolts; checking bolt tension; and conforming to qualification and testing requirements associated with member erection, connection or splicing; as shown on the Drawings, as specified in these specifications and as directed by the Engineer.
- (4) Payment for Spherical Bearings items shall include for bearing devices, sole plates, anchor bolts, nuts, washer plates and bearing pads.
- (5) Payment for steel reinforcement will be made under Section 506 - Steel Reinforcement.
- (6) Payment for cleaning and painting structural steel will be made under Section 521 – Painting.

SECTION 521

PAINTING

521.01 DESCRIPTION

(1) This work shall consist of the painting of metal and masonry surfaces shown on the plans or otherwise specified or instructed by the Engineer to be painted. The work includes, but is not limited to, the preparation of surfaces to be painted, application and curing of the paint, protection of the work, protection of existing facilities, vehicles, and the public from damage due to this work, and the furnishing of all labour, equipment and materials needed to perform the work.

521.02 MATERIALS

521.02.1 General

(1) The Contractor shall submit for the Engineer's approval the origin and characteristics of the paints which inter alia shall be used for protection of the metal structures against corrosion

(2) The selection of the paints to be used shall take into consideration:

- the guarantee requested against corrosion (6 years);
- the guarantee requested against blistering and peeling (5 years);
- the guarantee requested against degradation of colour (non uniform, 5 years);
- the guarantee requested against degradation of the paint film (non uniform, 3 years);
- the compatibility between the paint and the materials, as well as the compatibility of each coat of paint with the next one (prime coat and undercoat, undercoat and finish coat).

(3) All materials and works shall comply with "Steel Structures Painting Council, Surface Preparation Specification No. 10, SSPC-SP10 - Near-White Blast Cleaning"; ASTM Standards A6, -D1640, -D3363, -D4417, -D4752; AASHTO M 160 and AASHTO M 300, and any other applicable standard as advised by the Engineer.

(4) The Contractor shall select, preferably, paints that are approved by an independent quality control organisation.

(5) The Engineer will be entitled to order preliminary approval tests carried out on samples of the paints, in a laboratory of his own choice; sampling, transport and testing shall be at the Contractor's expense.

(6) All paints shall be supplied by the same manufacturer, unless otherwise authorised by the Engineer.

(7) The colour of the top or finish coat of paint shall be as directed or approved by the Engineer.

521.02.2 Coating Systems and Paints for Metal Surfaces

(1) The prime coat of paint for un-galvanized ferrous metal shall be either a shop coat of a two-pack, solvent based inorganic zinc silicate primer (for new steelwork); or a field coat of a two-pack, zinc-rich polyamide cured epoxy primer (organic primer for rehabilitation of existing steel structure). Either coating shall be applied to achieve a minimum dry film thickness of 75 microns.

(2) Galvanized surfaces shall not be coated unless specified otherwise in the Drawings.

(3) Aluminium or aluminium alloy surfaces shall not be coated unless specified otherwise in the Drawings.

- (4) Unless noted otherwise on the Drawings, the paint to be used for the finish coat shall consist of a two-pack micaceous iron oxide pigmented polyamide cured epoxy. It shall be applied in two coats to achieve a minimum dry film thickness of 250 microns.

521.02.3 Paints for Concrete Surfaces

- (1) Paint to be applied to concrete surfaces shall be acrylic emulsion and shall comply in all respects to US Federal Specification TT-P-19 (latest revision), Paint, Acrylic Emulsion, Exterior, or approved equal. This paint may be tinted by using "Universal" or "All Purpose" concentrates.

521.03 CONSTRUCTION REQUIREMENTS

521.03.1 Weather Conditions

- (1) Paint shall be applied only on thoroughly dry surfaces. Painting of metal surfaces will not be permitted when the atmospheric temperature, paint, or the surface to be painted is at or below 4.5 °C or above 37.8 °C, or when metal surfaces are less than 15 °C above the dew point, or when the humidity exceeds 85% at the site of the work, or when freshly painted surfaces may become damaged by rain, fog, or dust, or when it can be anticipated that the atmospheric temperature will drop below 4.5 °C during the drying period, except as provided herein for painting in enclosures.

- (2) Metal surfaces, which are hot enough to cause the paint to blister, to produce a porous paint film, or to cause the vehicle to separate from the pigment, shall not be painted.

- (3) Subject to approval of the Engineer, the Contractor may provide a suitable enclosure to permit painting during inclement weather. Provisions shall be made to artificially control atmospheric conditions inside the enclosure within limits suitable for painting throughout the painting operation. Surfaces painted under cover in damp or cold weather shall remain under cover until the paint dries or weather conditions permit open exposure. Full compensation for providing and maintaining such enclosures shall be deemed to be included in the prices paid for the various contract items of work involving painting and no additional compensation will be allowed therefore.

- (4) Application of acrylic emulsion paint on concrete surfaces shall be done only when the ambient temperature is 10 °C or above. Painting of this type will not be permitted when it can be anticipated that the ambient temperature will drop below 10 °C during the application and drying of the paint.

- (5) All blast cleaning, except that performed within closed buildings, and all painting shall be performed during daylight hours unless otherwise provided by the contract documents or approved by the Engineer.

521.03.2 Cleaning of Steel Surfaces

- (1) All exposed surfaces of structural steel, except galvanized or metalized surfaces, shall be thoroughly cleaned and painted.

- (2) Surfaces shall be removed of rust, loose mill scale, dirt, oil or grease and other foreign substances. Unless cleaning is to be done by sand blasting, all weld areas, before cleaning is begun, shall be neutralised with a proper chemical, after which it shall be thoroughly rinsed with water.

- (3) Three methods of cleaning are provided herein. The particular method to be used shall be specified by the Engineer. However, only the sandblasting method shall be used for cleaning the structural steel used for bridge decks.

521.03.2.1 Hand Cleaning

- (1) The removal of rust, scale and dirt shall be done by the use of metal brushes, scrapers, chisels, hammers or other effective means. Oil and grease shall be removed by the use of gasoline or benzine. Bristle or wood fibre brushes shall be used for removing loose dirt.

521.03.2.2 Sand Blasting

- (1) All structural steel used for the bridge decks shall be cleaned by sandblasting. The sandblasting shall remove all loose mill scale and other substances down to the bare metal and it shall leave all surfaces with a dense and uniform anchor pattern of not less than 1 mil (25 µm) nor more than 2 mils (50 µm) as measured with an approved surface profile comparator.
- (2) The steel surfaces shall be blasted to approval in accordance with the requirements of the “Steel Structures Painting Council, Surface Preparation Specification No. 10, SSPC-SP10 - Near-White Blast Cleaning”. Furthermore the steel surface shall meet the index of roughness specified, by the paint manufacturer, for the type of paint and the conditions of application.
- (3) When blast cleaning is being performed near machinery, all journals, bearings, motors, and moving parts shall be sealed against entry of abrasive dust before blast cleaning begins.
- (4) Oil and grease shall be removed by solvent cleaning before sand or grit blasting. Sand or steel grit blasting shall be carried out with compressed air-equipment. Compressed air shall be dry and without oil traces; for this purpose the equipment shall be fitted with separators and valves. Sand or grit blasting shall proceed only when the relative humidity is less than 80 %. Blast products shall be removed from the surface of blast cleaned steel by air pressure and vacuum cleaning; brush cleaning only shall not be considered as satisfactory.
- (5) Special attention shall be given to cleaning of corners and re-entrant angles. Before painting, sand adhering to the steel in corners and elsewhere shall be removed. The cleaning shall be approved by the Engineer prior to any painting, which shall be done as soon as possible before rust forms or the surface becomes contaminated with foreign material. If this occurs, the surface shall be re-blast cleaned by the Contactor at his own expense.

521.03.2.3 Flame Cleaning

- (1) Flame cleaning shall not be used on the inside surfaces of closed members unless approved respirators and other safety equipment specified by the Engineer are supplied and used.
- (2) Where approved by the Engineer, flame cleaning shall be carried out in accordance with the following:
 - i) Oil, grease and similar adherent matter shall be removed by washing with a suitable solvent. Excess solvent shall be wiped from the work before proceeding with subsequent operations.
 - ii) The surface to be painted shall be cleaned and dehydrated (free of occluded moisture) by the passage of oxyacetylene flames which have an oxygen to acetylene ratio of at least one. The inner cones of these flames shall have a ratio of length to port diameter of at least 8 and shall be not more than 3.7 mm centre to centre. The oxyacetylene flames shall be traversed over the surfaces of the steel in such manner and at such speed that the surfaces are dehydrated; and dirt, rust, loose scale in the form of blisters or scabs, and similar foreign matter are freed by the rapid, intense heating by the flames. The flames shall not be traversed so slowly that loose scale or other foreign matter is fused to the surface of the steel. The number, arrangement and manipulation of the flames shall be such that all parts of the surfaces to be painted are adequately cleaned and dehydrated.
 - iii) Promptly after the application of the flames, the surfaces of the steel shall be wire brushed, hand scraped wherever necessary, and then swept and dusted to remove all free materials and foreign particles. Compressed air shall not be used for this operation.
 - iv) Paint shall be applied promptly after the steel has been cleaned and while the temperature of the steel is still above that of the surrounding atmosphere, so that there will be no recondensation of moisture on the cleaned surfaces.

521.03.3 Cleaning of Concrete Surfaces

- (1) Prior to painting concrete surfaces, laitance and curing compounds shall be removed by abrasive blast cleaning, in accordance with the above. Concrete surfaces shall be thoroughly dry and free of dust at the times that the paint is to be applied. Any artificial drying procedures and methods shall be subject to the approval of the Engineer.

521.03.4 Number of Coats and Colour

(1) All steel shall be painted with one prime coat, and with not less than two other coats of finishing paint. The number of coats and the thickness of each coat shall be submitted by the Contractor to the Engineer's approval. The total dry film thickness of all applied coatings shall not be less than 325 µm.

(2) The colour of each coat shall be as specified or determined by the Engineer. The coats shall be sufficiently different in colour to permit detection of incomplete application.

521.03.5 Steelwork in Contact with Concrete

(1) Areas of steelwork in contact with concrete in the completed structure shall receive the surface preparation and applied coatings as that employed on adjacent exposed areas for a minimum distance of 50 mm from the exposed surface. Areas further than 50 mm from the exposed surface shall receive the same surface preparation and primer, but coatings applied after the primer may be reduced to give a total minimum dry film thickness for all coatings of 150 µm.

521.03.6 Shear Studs

(1) Shear studs shall receive the same surface preparation as adjacent areas of steelwork and primed to achieve a total dry film thickness of 50 µm.

521.03.7 Surfaces to be Bolted

(1) The faying surfaces of friction-type bolted connections shall be treated as follows:

- Abrasive blast clean to Class 2 ½;
- Surface profile 25 to 65 µm;
- Apply one coat of inorganic zinc primer with a minimum dry film thickness of 75 µm

(2) The faying surfaces of bearing-type bolted connections shall receive the same treatment as the adjacent steelwork.

521.03.8 Application

521.03.8.1 General Procedures

(1) The Contractor shall notify the Engineer, in writing, at least one week in advance of the date that cleaning and painting operations are to begin.

(2) The Contractor shall protect pedestrian, vehicular and other traffic upon or underneath the structure and also all other portions of the structure, against damage or disfigurement by spatters, splashes and smirches of paint or paint materials.

(3) Painting shall be done in a neat and workmanlike manner. Unless otherwise specified, paint shall be applied by brush, spray or roller, or any combination thereof corresponding to the paint being applied.

(4) Each application of paint shall be thoroughly cured and any skips, holidays, thin areas, or other deficiencies corrected before the succeeding application. The surface of the paint being covered shall be free from moisture, dust, grease, or any other deleterious materials that would prevent the bond of the succeeding applications. In spot painting, old paint, which lifts after the first application, shall be removed by scraping and the area repainted before the next application.

(5) Succeeding applications of paint shall be of such shade as to contrast with the paint being covered.

(6) Surfaces exposed to the atmosphere and which would be inaccessible for painting after erection shall be painted with the full number of applications prior to erection.

(7) On all surfaces that are inaccessible for painting by regular means, the paint shall be applied by sheepskin daubers, bottlebrushes, or by any other means approved by the Engineer.

521.03.8.2 Specific Procedures

(1) Paint shall be factory-mixed except as provided in this section. All paint shall also be field mixed before applying in order to keep the pigments in uniform suspension. Zinc rich paints shall be continually agitated in the pot by an approved method during application.

(2) The following provision shall apply to application of both undercoat and finish coat: To secure a maximum coating on edges of plates or shapes, bolt heads and other parts subjected to special wear and attack, the edges shall first be striped with a longitudinal motion and the bolt heads with a motion rotary of the brush, followed immediately by the general painting of the whole surface, including the edges and bolt heads.

(3) Field Painting:

- i) When the erection work is complete including all bolting and straightening of bent metal, all adhering rust, scale, dirt, grease or other foreign material shall be removed as specified under 521.03.2.
- ii) As soon as the Engineer has examined and approved all field bolts, the heads of such bolts, all welds and any surfaces from which the prime coat or the undercoat has become worn off or has otherwise become defective, shall be cleaned and thoroughly covered with one coat of prime coat paint.
- iii) The application of the finish coat shall be deferred until adjoining concrete work has been placed and finished. If concreting operations have damaged the paint, the surface shall be re-cleaned and repainted.

(4) When brushes are used, the paint shall be so manipulated under the brush as to produce a smooth uniform, even coating in close contact with the metal or with previously applied paint, and shall be worked into all corners and crevices.

(5) Rollers, when used, shall be of a type that does not leave a stippled texture in the paint film. Rollers shall be used only on flat, even surfaces to produce a paint film of even thickness with no skips, runs, sags, or thin areas.

(6) Spraying:

- i) Power spraying equipment shall apply the paint in a fine, even spray without the addition of any thinner. The Contractor shall follow the manufacturer's recommendations with regard to the adjustment of the painting equipment (nozzle orifice and pressure), the weather conditions required during application and the interval of time between the coats.
- ii) When necessary, paint applied with spray equipment shall be immediately followed by brushing to secure uniform coverage and to eliminate wrinkling, blistering and air holes.
- iii) Any spray method which produces excessive paint build-up, runs, sags, or thin areas in the paint film, or skips and holidays, will be considered unsatisfactory and the Engineer may require modification of the spray method or prohibit its use and require brushing instead.

(7) If the painting is unsatisfactory to the Engineer, the paint shall be removed and the metal thoroughly cleaned and repainted.

(8) Paint as delivered in containers when thoroughly mixed is ready for use. If it is necessary to thin the paint in order that it shall spread more freely, this shall be done only by heating in hot water or on steam radiators, and liquid shall not be added nor removed unless permitted by the Engineer.

(9) Painting of galvanised surfaces shall be as directed in writing by the Engineer.

(10) Shop Protective Treatment:

- i) Unless otherwise specified, steelwork shall be given one coat of approved primer paint after it has been accepted by the Engineer, either in shop before it is shipped from the plant (for new steelworks), or in the field (for rehabilitation of existing steel structures). The prime coat must be applied within maximum two (2) hours after the blasting and dust freeing. If the time elapsed since the start of blasting exceeds this limit, brushing and dust freeing must be repeated. Priming shall proceed only when the relative humidity is less than 80 %.
- ii) Structural steel that is to be welded shall not be painted before welding is complete. Steel that is to be field welded shall be given one coat of boiled linseed oil or other approved protective coating after shop welding and shop fabrication is completed.
- iii) Surfaces of iron and steel castings, either milled or finished, shall be given one coat of paint.
- iv) With the exception of abutting joints and base plates, machine-finished surfaces shall be coated as soon as practicable after being approved before removal from the shop.
- v) Erection marks for the field identification of members and weight marks shall be painted upon surfaces areas previously painted with the shop coat. Material shall not be loaded for shipment until it is thoroughly dry, and in any case not less than 24 hours after the paint has been applied.

(11) The control of the paint work shall include a verification of the quality of the blasting and surface roughness, the quality of the paint applied, and the thickness of the various paint coats. The dry film thickness shall be measured in place with a calibrated magnetic film thickness gauge according to "Steel Structures Painting Council SSPC-PA2".

(12) When painting concrete the application of acrylic emulsion paint to the surfaces shall be in not less than two coats to provide a uniform appearance.

521.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
521-1	Shop Protective Treatment of Metal Structures	Metre Square
521-2	Field Protective Treatment of Metal Structures	Metre Square
521-3	Field Protective Treatment of Concrete Structures	Metre Square

(2) The steel surface shall be calculated without reduction or addition for bolt holes, contact surfaces, welds, and cross-sectional ends.

521.05 PAYMENT

(1) Payment will be at the rate entered in the Bill of Quantities which shall include for work, materials, labour and equipment, including furnishing of paint material, cleaning of surfaces and application of paint.

SECTION 522

STRUCTURAL TIMBER

522.01 DESCRIPTION

(1) The work covered by this Section consists of fabricating, treating, erecting, and painting structural timber. This work also includes required timber which has been sawed into boards, planks, or other structural members of standard or specified length. Also required hardware is included in this work.

522.02 MATERIALS

(1) Timber may be of any species of timber which will withstand and support the loads imposed on the structure.

(2) Sawn timbers used shall conform to the dimensions shown on the approved drawings.

(3) Timber shall be of sound wood, straight grained, free from decay, unsound knots, splits, shakes or any other defects.

(4) The straightness of individual timber members shall conform to a straight line from the centre of one end to the centre of the other end entirely lying within the body of the timber member.

(5) All fastening shall be either wrought iron or medium steel and shall be galvanized in accordance with the requirements of ASTM A153.

(6) Paints shall be of a high quality and before use shall be tested by the Contractor and subject to the approval of the Engineer.

522.03 CONSTRUCTION REQUIREMENTS

522.03.1 General

(1) When lifting timber, slings or other devices shall be used to protect the corners of heavy timbers and banded packages of lighter timber.

(2) Timber shall be cut and formed so that joints have even bearing over their entire contact surface. All joints shall be closed and shims shall not be used in making joints. When used, nails and spikes will be driven heads flush with the wood surface.

(3) The same end, face, and edge of the timber member shall be used for all layout dimensions. Holes will be bored from mating faces.

522.03.2 Storing Material

(1) Material shall be stored in an area cleared of weeds, rubbish, or other objectionable material and the material shall be elevated at least 200 mm above the ground. Sufficient support shall be provided to prevent sagging.

(2) Open-stack untreated material to shed water. Free air circulation shall be allowed for by stacking material in layers on stickers that extend across the full width of the stack. Align stickers vertically and space them at regular intervals. Treated timber material shall be close-stacked, but shedding of water needs to be allowed.

(3) Material shall be protected from the elements by covering the timber with water-resistant paper or opaque polyethylene film. Impervious membranes (such as polyethylene film) shall not be used during dry weather. In order to permit water drainage, individual wrappings shall be slit or punctured the full length on the lower side.

(4) Glued laminated timber shall be stored and protected according to the AITC 111, *Recommended Practice for Protection of Structural Glued Laminated Timber During Transit, Storage, and Erection*.

522.03.3 Holes for Drift Pins, Dowels, Bolts, and Lag Screws

(1) Holes shall be bored before preservative treatment.

(2) Holes for round drift pins and dowels shall be bored to a diameter of 1.6 mm less than the diameter of the pin or dowel. Holes for square drift pins and dowels shall be bored to a diameter equal to the side dimension of the pin or dowel.

(3) Holes for galvanized bolts shall be bored to a diameter 1.6 mm larger than the diameter of the bolt.

(4) Holes for lag screws shall be bored according to Subsection 7.3.1 of the AITC, *Timber Construction Manual*.

522.03.4 Treating Timber

(1) When practical timbers shall be cut, framed and bored before treatment. In coastal waters timber shall not be cut or bored below the high-water mark.

(2) Treated timber shall be handled according to the AWPAs published Consumer Information Sheet. Extreme care has to be taken not to drip or spill preservative into the aquatic environment or onto the ground. Treated timber shall be handled without damaging their surfaces, and cant dogs, hooks, or pike poles shall not be used.

(3) Cuts or abrasions shall be treated with preservatives, by dipping, soaking, spraying, or applying three brush coats of the same preservative according to AWPAs M4, *Standard for the Care of Preservative-Treated Wood Products*.

(4) Holes bored after the initial treatment shall be impregnated with the same preservative using tools suitable for proper application. Unused holes will be plugged with the same treated timber.

522.03.5 Hardware

(1) Hardware and fasteners including nails, spikes, bolts, washers, and timber connectors shall be galvanized, but malleable iron or cast iron hardware shall not be galvanized.

(2) Malleable washers with a diameter approximately three times the bolt diameter shall be used under bolt heads and nuts in contact with wood. Cast iron washers shall be used when the timber is in contact with the ground. Square washers will be used only when specified.

(3) Bolt lengths in excess of more than 25 mm shall be cut off. To prevent loosening of the nuts after final tightening, bolts shall be checked or burred with a pointing tool.

522.03.6 Countersinking

(1) Screws, bolts, and nuts shall be countersunk where required. Before filling the recesses with approved filler, the countersunk recesses will be treated with an approved preservative, but railings will be excluded from the treatment. After bolts, screws and nuts have been put in place, the recesses will be filled with hot pitch or other approved filler.

522.03.7 Framing

(1) Treated piles shall not be slabbed or trimmed when fitting sway or sash braces. Braces shall be securely fastened to smaller piles using treated separate pieces of timber for filling the gaps.

522.03.8 Framing Bents

(1) Mud blocks shall be firmly and evenly be bedded to solid bearing by tamping.

(2) When concrete is cast together with structural timber works, dowels for anchoring sills and posts shall project at least 150 mm above the tops of the pedestals. Framed bents supporting concrete pedestals shall be finished so that sills or posts bear evenly on the pedestals.

(3) Sills shall be constructed to bear evenly and true on mud blocks, piles, or pedestals. Sills will be bolted into place with drift bolts that extend into the mud blocks or piles for at least 150 mm. To provide air circulation around the sills remove material in contact with sills, where possible.

522.03.9 Bent Caps

(1) Timber caps shall bear evenly and uniformly over the tops of aligned supporting posts or piles and the caps will be secured with drift bolts extending at least 230 mm into the approximate centre of each post or pile.

522.03.10 Bracing

(1) The ends of bracing shall be bolted through the pile, post, cap or sill. Intermediate intersections will be braced with posts or piles using bolts and spikes with wire, or boat spikes as required. Galvanized spikes shall be used in addition to bolts.

(2) Bracing shall bear firmly against the pile or cap to which it is bolted. If necessary provide and place shims to prevent bending of the bracing more than 25 mm out of the true line when bracing bolts are tightened.

(3) Where the space between the bracing and cap or pile is:

- i) Less than 25 mm, shims are not needed;
- ii) 38 ± 13 mm, two ogee washers shall be placed with their narrow faces together or other approved washers shall be placed on each bolt that passes through the space; or
- iii) Over 50 mm, wooden shims of the proper thickness shall be used.

(4) The wooden shims shall be fabricated from the same treated wood used in the structure. Built-up wooden shims shall not be used. Wooden shims shall be made from a single piece of timber with the width not less than 100 mm and the length not less than the width of the bracing measured along the cap or pile. Trimming, cutting or adzing of treated members shall not be done to avoid the use of shims.

522.03.11 Stringers

(1) Stringers shall be sized at bearings and shall be positioned so that knots near the edges are in the top portion of the stringer.

(2) Outside stringers may have butt joints with ends cut on a taper. Interior stringers shall be lapped so that both stringer ends have full length bearing on a floor beam or cap. When stringers are two panels in length the joints shall be staggered. In order to ensure air circulation, lapped ends of untreated stringers shall be separated by at least 13 mm.

(3) Cross-bridging shall be placed at the centre of each span and the cross-bridging members shall be cut to provide full bearing on the stringer sides at each end. The cross-bridging will be securely toenailed with at least two nails in each end. If separate pieces of timber (as a construction member or as a support) are used, these shall made to fit snugly and securely.

522.03.12 Plank Floors

- (1) Only planks that have been provided with finished surfaces on all four sides shall be used.
- (2) Single-ply timber floors consist of a single thickness of planks supported on stringers. Plank thickness shall be graded so no two adjacent planks vary in thickness by more than 3 mm. The planks shall be laid with the heart side down with 6 mm space between them for dry, seasoned material and with no joint space for unseasoned material. Each plank shall be spiked securely to each stringer.
- (3) Two-ply timber floors consist of two layers of flooring supported on stringers. The lower layer shall be treated according to Subsection 522.03.4. The top layer shall be laid either perpendicular or parallel to the roadway centreline.
- (4) Joints shall be staggered at least 900 mm. Each top layer member shall be securely fastened to the lower layer. Where the top layer is placed parallel to the centreline of the roadway, special care will be used to securely fasten the ends of the flooring. The ends of top layer members at each end of the structure shall be bevelled.

522.03.13 Wheel Guards and Railings

- (1) Wheel guards, rails, and posts which are used shall have been processed to finished surfaces on all four sides. Wheel guards shall be at least 3.7 m long. Square butt-joint shall be used when joining rails at posts.

522.03.14 Trusses

- (1) Irregularities in alignment shall be avoided. In horizontal projection, chords will be fabricated straight and true from end-to-end. In vertical projection, chords will be fabricated to a smooth, corded curve through panel points conforming to the correct camber. Bearing surfaces shall be made to fit accurately and uneven or rough cuts shall not be made at the points of bearing.

522.03.15 Painting

- (1) When required by the contract, painting shall be done conforming to subsection 522.02.

522.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
522-1	Untreated Structural Timber	Metre Cube
522-2	Treated Structural Timber	Metre Cube

- (1) The quantities shall be computed from nominal dimensions and actual lengths.

522.05 PAYMENT

- (1) Payment will be made at the rates entered in the Bill of Quantities, which rates shall include full compensation for furnishing all materials, placing and aligning, all equipment, labor, tools and incidentals necessary to complete the work.

SECTION 523

CONDUITS, FITTINGS AND BOXES

523.01 DESCRIPTION

(1) The work covered by this Section consists of furnishing and installation of all the conduits fittings, pull and junction boxes, conduit expansion joints and incidental parts necessary to provide for future lighting or operation of structures. The type, size and location of conduits, fittings and boxes will be as indicated on the Drawings.

523.02 MATERIALS

523.02.1 Metallic Conduit, Fittings and Boxes

(1) Conduit shall be formed of mild steel without laminations due to slag breaks, blisters or pockets, and without cinders or other foreign matter. Conduit shall have a circular cross- section, with uniform wall thickness to permit the cutting of clean, true threads. All seams shall be completely and thoroughly welded.

(2) The conduit shall be galvanised on the outside by one of the three methods of hot dip galvanising, sherardising or electro-galvanizing, and the inner surfaces shall be protected in a like manner by a thick coating of enamel. All mill scale shall be removed before pickling and conduit shall be thoroughly cleaned and dried after pickling is completed. Galvanising shall be done under controlled temperatures. The zinc coating and enamel coating, if used, shall have an even, smooth appearance and be of uniform quality. Conduits shall be capable of standing five dips in the Preece Copper Sulphate test for galvanised coating, according to ASTM A239-40.

(3) The conduct seam and coating shall withstand being bent cold at minimum temperature of 150 °C. under slowly applied pressure through 900 to a radius six times the outside diameter of the conduit with the seam on the outside of the bend, without developing cracks or opening the weld and without cracking or flaking the coating.

(4) All conduit fittings without exception shall be made from the same material and shall have the same coating as specified for conduit. The test for the continuity of coating shall be the same as specified for conduit. One coupling shall be furnished with each length of conduit or bend.

(5) Pull or junction boxes shall be made of sheet steel or cast iron in accordance with the Drawings and/or these Specifications. Sheet steel boxes shall have sharp, straight edges and continuous electric welded seams. A 10 mm flange, turned in, shall be used to take a rubber gasket and shall be drilled and tapped for an approved number of 5 mm brass machine screws. If box is to be encased in concrete, the cover shall extend 10 mm beyond dimensions of the box and shall be drilled to match tapped holes in flange of same. When boxes are completely exposed, the cover shall conform to the outside dimensions of the box. All holes for conduit entrances into sheet steel boxes shall be drilled. Sheet steel boxes shall be galvanised in the same manner as for conduit.

523.03 CONSTRUCTION REQUIREMENTS

523.03.1 General

(1) The size of each conduit shall be such that the sum of the areas of the cross-section of all conductors, including insulation and protective coverings, shall be not greater than 30 per cent of the inside area of conduit, except that no conduit encased in concrete or installed underground shall be less than 50 mm, inside diameter, and no conduit smaller than 20 mm inside diameter shall be used except for fixture hangers.

- (2) All conduit sizes and conduit layout shall be approved by the Engineer before installation, and the Contractor shall submit data on the layout for the exact makeup, overall diameter, and cross-sectional areas of the actual conductors he intends to use and the sum of the areas of the conductors in each conduit.
- (3) Bends shall be of long sweep, free from kinks and of such easy curvature as to permit the drawing in of conductors without injury. The radius of curvature of inner edge of bends shall not be less than ten times the inside diameter of the conduit except as may be otherwise noted on the Drawings or in these Specifications. Conduits shall be not flattened or distorted. The total angle of all bends between any two boxes or fittings shall not exceed 90 degrees.
- (4) All conduits used on a contract shall be the product of one manufacturer.
- (5) Exposed conduit runs shall be parallel to or at right angles to walls, slabs, girders and in locations giving greatest accessibility for painting and least accumulation of dirt. All exposed conduit runs shall be attached to steel, masonry, concrete or timber by galvanised malleable iron or galvanised steel straps, clamps or hangers of an approved type, held at not less than two points by galvanised steel bolts or lag screws. The runs shall be supported at not greater than 3 metre centres on horizontal runs, unless otherwise specified and not less than 50 mm clear of the supported members. Conduits mounted on structural steel members shall be securely clamped to prevent rattling and wear.
- (6) All ends of conduits installed during construction, or for future use, shall be closed against the introduction of foreign material by the use of standard pipe or bush caps. All conduits shall be installed so that they will drain and necessary holes for this purpose shall be made as directed.
- (7) All conduit risers in railing posts shall, unless otherwise shown on the Drawings terminate 20 mm below the top surface of the post. The risers shall be accurately placed so that they may be located for future use.
- (8) All conduits installed underground shall have a concrete envelope which shall afford a 70 mm cover beyond the maximum dimension of the conduit. Concrete grade 30 shall be used.
- (9) Excavation for the encasement shall be carefully done, sidewalls trimmed to line and bottom of trench graded, so that the envelope will be uniform, and there will be no pockets or low points in the conduit run. All backfill shall be carefully tamped to conform to the requirements of Section 207 of these Specifications, unless otherwise specified, and care shall be taken not to injure concrete envelope or conduit.
- (10) All conduits, boxes, etc., to be encased in concrete must be accurately placed and rigidly held in position so that no variation from line or grade occurs when concrete is placed.
- (11) Conduits, fittings and boxes shall be stored under cover and above ground.
- (12) Upon completion of the conduit installation, the system shall be cleared in the presence of the Engineer before any conductors are installed. Immediately prior to the installation of conductors in any run, the conduits comprising that run shall again be checked. Any and all obstructions shall be removed to the approval of the Engineer.
- (13) The Contractor shall install and leave in place a No.10 iron wire in all conduit runs installed for future use.
- (14) The Contractor shall furnish work drawings of A1 size (594 mm x 840 mm), in duplicate, for the Engineer's preliminary examination. After work drawings have been accepted by the Engineer and revisions made, the Contractor shall furnish additional copies as may be requested.

523.03.2 Metallic Conduits, Fittings and Boxes

- (1) Conduits runs shall be with as few couplings as standard lengths will permit. Screw couplings shall be used. All cuts shall be made with the hacksaw and reamed clear of fins or burrs with a reamer.

(2) Conduit shall have threaded ends coated with red or white lead and of sufficient length so that they will butt squarely and tightly in the coupling. Long running threads will not be permitted. Conduits shall be installed so as to be continuous and watertight between boxes and/or equipment.

(3) Where conduits have cross expansion joints in the structure, or where otherwise specified, they shall be provided with expansion fittings of an approved type. The electrical continuity of the conduit which runs across the expansion fittings shall be assured by approved fittings and bare No.8 copper wire.

(4) Pull boxes shall be used wherever necessary to facilitate the installation of the conductors. Conduits entering into cast iron pull boxes or enclosures shall be threaded into hubs on same. Conduits entering into sheet steel boxes or enclosures shall be secured with two lock nuts and the projecting ends shall be equipped with an approved insulating bushing.

(5) All surfaces of conduits, boxes, fittings, etc., in contact with concrete encasement shall be painted one coat of approved paint

523.04 MEASUREMENT

(1) Measurement will be as follows:

Item No.	Description	Unit
523-1	Furnishing and Installation of Conduits, Fittings and Boxes	Lump Sum

523.05 PAYMENT

(1) Payment will be made at the rate entered in the Bill of Quantities, which rate shall include for the furnishing and installation of conduits, fittings and boxes, complete in place, including all working drawings, conduits, fittings, pull and junction boxes, fixings, conduit expansion joints and incidentals, excavation, concrete encasement, backfill, tamping, galvanising, painting, tools labour, equipment and incidentals necessary to complete the work.

SERIES 600
MISCELLANEOUS

SECTION 601

BOX GABIONS / GABION MATTRESSES / GEOTEXTILE SHEETINGS

601.01 DESCRIPTION

(1) The work covered by this Section consists of the construction of wire-mesh box gabions, gabion mattresses and geotextile sheetings at the locations shown on the Drawings or ordered by the Engineer.

601.02 MATERIALS

601.02.1 Stones

(1) Stones for box gabions and gabion mattresses shall be hard, durable, quarried or natural stone with no obvious planes of weakness, weak laminations and cleavages, and shall not disintegrate when submerged in water or exposed to severe weathering.

(2) At least 30 days before delivery to the site, the contractor shall inform the engineer in writing of the source from which the rock will be obtained. The test data and other information by which the material was determined by the contractor to meet the specification are included. The contractor shall provide the engineer free access to the source for the purpose of obtaining samples for testing and source approval.

(3) The apparent specific gravity shall be not less than 2.5, and absorption shall be a maximum of 6% when tested in accordance with AASHTO T 85.

(4) Abrasion loss shall not be more than 45% when tested according to AASHTO T 96 (500 revolutions).

(5) Rock for box gabions shall have a dimension of between 100 mm and 250 mm. The minimum dimension shall not be less than half the maximum dimension.

(6) Gabion mattress rock shall have a maximum dimension of between 80 mm and 200 mm. The minimum dimension shall not be less than half the maximum dimension.

601.02.2 Mesh and Wire

(1) Gabions shall be constructed of wire mesh of galvanised steel wire of minimum diameter of 2.70 mm with a 0.5 mm thick PVC coating, capable of resisting effects of exposure and highly corrosive environment. Alternatively, if approved by the Engineer, galvanised steel wire of minimum diameter of 3.0 mm without a PVC coating can be used. The tensile strength of the wire shall be in the range of 400 to 600 MPa, determined in accordance with ASTM A392. The minimum zinc coating of the wire shall be 240 g/m² of uncoated wire surface in accordance with ASTM A90.

(2) The mesh shall be twisted to form hexagonal openings of uniform size. The linear dimension of the mesh opening shall not exceed 100 mm and the area of the mesh opening shall not exceed 8,000 mm². The mesh shall be fabricated in such a manner as to be non-ravelling, where non-ravelling is defined as the ability to resist pulling apart at any of the twists or connections forming the mesh when a single wire in a section is cut.

(3) Gabions shall be delivered folded flat to facilitate transport and handling, and shall be furnished in dimensions corresponding to the various basket lengths and heights required by the Drawings.

- (4) Gabions shall be fabricated in such a manner that the sides, ends, lid and diaphragms can be assembled at the construction site into rectangular baskets of the specified sizes. Gabions shall be of single unit construction, lids, ends and sides shall be either woven into a single unit or one edge of these members connected to the base section of the gabion in such a manner that the strength and flexibility at the point of connection is at least equal to that of the mesh.
- (5) The gabion shall be equally divided into cells by diaphragms of the same mesh and gauge as the body of the gabion. The cells shall be no more than 1.0 m x 1.0 m plan size.
- (6) The gabion shall be furnished with the necessary diaphragms secured in proper position on the base in such a manner that no additional tying at this junction will be necessary.
- (7) All perimeter edges of the mesh forming the gabion shall be securely selvaged so that the joints, by tying the selvages, have at least the same strength as the body of the mesh.
- (8) Selvage wire used through all the edges (perimeter wire) shall not be less than 3.40 mm diameter (0.134 inch) U.S. Wire Gauge No. 10 and shall meet the same specifications as the wire mesh.
- (9) Tie and connection wires shall be supplied in sufficient quantity to securely fasten all edges of the gabion and diaphragms and to provide for four cross-connecting wires in each cell whose height is 1/3 or 1/2 the width of the gabion, and 8 cross-connecting wires in each cell whose height equals the width of the gabion. The wire shall meet the same specifications as for wire used in the mesh.
- (10) Box gabions shall have the following dimensions: length 2.0 m or 3.0 m, width 1.5 m, 1.0 m or 0.5 m, and height 0.5 m or 1.0 m.
- (11) Gabion mattresses shall have the following dimensions: length 3 m or 6 m, width 2 m or 3 m, and height 0.25 m, 0.30 m, 0.35 m or 0.50 m.

601.02.3 Geotextile Sheeting

- (1) Fibres used in the manufacture of geotextiles, and the threads used in joining geotextiles by sewing, shall consist of long-chain synthetic polymers, composed of at least 85% by weight of polyolefins, polyesters, or polymids conforming to AASHTO M 288 Class A or B. The density shall be at least 200 g/ m² or as approved by the Engineer.
- (2) Geotextile sheeting rolls shall be furnished with a wrapping for protection against moisture and ultraviolet exposure before placement.

601.03 CONSTRUCTION REQUIREMENTS

601.03.1 Foundations

- (1) The foundations shall be excavated to a smooth surface and to the depth shown on the Drawings or ordered by the Engineer.
- (2) Soft, unstable material at foundation level shall be removed and replaced with suitable materials approved by the Engineer.
- (3) The foundation shall be firm and compacted to the Engineer's satisfaction. Geotextile sheeting shall be placed on the foundation where shown on the Drawings or ordered by the Engineer.

601.03.2 Positioning

- (1) Gabions shall be installed in a workmanlike manner.
- (2) The baskets shall be positioned in accordance with the Drawings and shall be held in place by tie-rods to prevent deformation. The tie-rods shall be bars with a minimum diameter of 12 mm.

(3) All perimeter edges of the gabion mesh shall be securely clip bound or selvaged. The baskets shall be lifted into a vertical position and attached together with binding wire. Binding shall be carried out in a continuous lacing operation. The wire shall be passed through each mesh and around the selvages.

(4) Tie wire shall be supplied to provide at least four cross connecting wires in each cell whose height is equal to the cell width, and at least two cross connecting wires in each cell whose height is one half of the cell width.

601.03.3 Filling Stones

(1) Before stones are placed in the baskets, each gabion unit shall be assembled and the empty gabion units set to line and grade as shown on the Drawings or as directed by the Engineer. Internal tie wires shall be uniformly spaced and securely fastened in each cell of the structure. A fence stretcher, chain fall, or iron rod may be used to stretch the wire baskets and hold alignment.

(2) The placing of stones shall be done by hand by skilled labour. The baskets shall be slightly over-filled to allow for subsequent settlement. Voids shall be minimised.

(3) Rounded stone shall not be used unless permitted by the Engineer, in which case the Contractor shall exercise the maximum care to obtain gabions with plane faces, sharp corners, and sides completely filled with stones.

(5) The cells in any row shall be filled in stages so that the depth of rock placed in any one cell does not exceed the depth of rock in any adjoining cell by more than 25 cm. Along the exposed faces, the outer layer of stone shall be carefully placed and arranged by hand to ensure a neat, compact placement with a uniform appearance.

(6) Gabions shall be levelled and aligned to the satisfaction of the Engineer. Where there is more than one course of gabions, the upper course shall be laced to the lower course.

(7) Vertical joints in the completed work shall be staggered at approximately 1/3 or 1/2 the length of the full baskets.

(8) After the gabion has been filled, the lid shall be bent over until it meets the sides and edges. If necessary only by the Engineer approved lid closing tools shall be used. The use of crowbars or other single point leverage bars for lid closing is prohibited as they may damage the baskets. The lid shall then be secured to the sides, ends and diaphragms, with spiral binders, approved alternate fasteners, or lacing wire wrapped with alternating single and double half-hitches in the mesh openings.

(9) Any damage to the wire or coatings during assembly, placement, and filling shall be repaired promptly in accordance with the manufacturer's recommendations or replaced with undamaged gabion baskets.

601.03.4 Repair

(1) When instructed to repair existing gabions, the Contractor shall remove the existing gabions to the extent instructed and replace them by gabions meeting the requirements of this Section of the Specifications. Existing gabion stones may be re-used provided they meet the requirements of Sub-clause 601.02.1 of the Specifications.

601.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
601-1	Box Gabions	Metre Cube
601-2	Gabion Mattresses	Metre Cube
601-3	Geotextile Sheeting	Metre Square
601-4	Repair of Box Gabions	Metre Cube
601-5	Repair of Gabion Mattresses	Metre Cube

(2) Measurement for geotextile sheeting shall exclude laps between the sheets.

601.05 PAYMENT

(1) Payment will be made at the rates entered in the Bill of Quantities.

(2) Payment for Items 601-1, 601-2, 601-4 and 601-5 shall include the production, supply and positioning of the gabions, excavation and preparation of the foundation, backfilling, compaction, and all wire and tie-bars.

(3) Payment for Item 601-3 shall include the supply and positioning of the geotextile sheeting, as well as any incidental work.

(4) Excavation and disposal of surplus material arising shall be deemed to be included in the rates.

SECTION 602

SLOPE PROTECTION and MASONRY STRUCTURES

602.01 DESCRIPTION

(1) The work covered by this Section consists of the construction of loose or grouted stone rip-rap, stone masonry, hand-laid rock embankment and/or reinforced concrete slope protection and other retaining structures in conformity with the lines, grades, and thickness shown on the Drawings or ordered by the Engineer.

602.02 MATERIALS

602.02.1 Stones

(1) Stones for rip-rap, and stone masonry and hand laid rock embankment shall be hard, sound, durable, angular field- or quarry stone and shall not disintegrate when submerged in water or exposed to severe weathering. Stones for the exposed faces shall be split to produce a reasonably planar finish.

(2) The apparent specific gravity shall be minimum 2.5, and the absorption shall be maximum 6% when tested according to AASHTO T 85.

(3) Abrasion loss shall not be more than 45% when tested according to AASHTO T 96 (500 revolutions).

(4) The stones for rip-rap work shall weigh between 2 and 50 kg, and at least 50% of the stones shall weigh more than 10 kg.

(5) The stones for stone masonry shall, unless otherwise shown on the Drawings, have a thickness of not less than 150 mm, and widths of not less than one and one-half times their respective thickness, and lengths of not less than one and one half times their respective widths. Each stone shall be of good shape and be free of depressions and projections that might weaken or prevent it from being properly bedded.

(6) Stones for stone masonry shall be dressed to remove any thin or weak portions. Face stones shall be dressed to provide bed and joint lines that do not vary more than 20 mm from the true lines and to ensure the meeting of bed and joint lines without the rounding of corners of the stones in excess of 30 mm in radius.

(7) The shape of the stones for rip-rap and stone masonry work shall be such as to allow for proper placing. Stones which are to be grouted or mortared shall be kept free from dirt or other deleterious material which may prevent proper adhesion of the mortar.

(8) Unless otherwise required by the Drawings, all stones for hand laid rock embankment work shall be more than 0.015 cubic metre in volume and not less than 75 % of the total volume of rock embankment and shall consist of stones not in excess of 0.03 cubic metre in volume. Stones obtained from excavation performed under the Contract may be used if approved.

602.02.2 Mortar

(1) Cement, sand and water shall conform to the requirements of Section 507 of the Specifications.

(2) Mortar for grouted rip-rap shall consist of one part Portland cement to three parts sand by volume, thoroughly mixed with the minimum quantity of water necessary to obtain a thick creamy consistency, and to avoid excess shrinkage.

(3) Mortar for stone masonry shall be composed of one part of Portland Cement and two parts of fine aggregate by volume and sufficient water to make the mortar of such consistency that it can be handled easily and spread with a trowel.

(4) Mortar shall be mixed only in those quantities required for immediate use. Unless an approved mortar mixing machine is used, the fine aggregate and cement shall be mixed dry in a tight box until the mixture assumes uniform colour, after which, water shall be added as the mixing continues until the mortar attains the required consistency. Mortar that is not used within 90 minutes after the water has been added shall be discarded. Retempering of mortar will not be permitted.

(5) The standard strength of the mortar shall be established by load tests on 100 mm cubes (or such other specimen size and shape chosen by the Engineer), and mortar production thereafter monitored by comparing the strength of tested specimens with the standard strength. Mortar shall be rejected if the site mix fails to reach 95 % of the standard strength, and work undertaken with such mortar shall be broken out and redone.

602.02.3 Reinforced Concrete

(1) Concrete shall be Grade 25 in accordance with Section 507 of the Specifications.

(2) Reinforcement shall conform to the requirements of Section 506 of the Specifications.

602.03 CONSTRUCTION REQUIREMENTS

602.03.1 General

(1) The bed upon which the slope protection is to be placed shall be excavated to the required grades and lines as shown on the Drawings or ordered by the Engineer. A footing trench shall be excavated along the toe of the slope as shown on the Drawings or ordered by the Engineer. All excavation, trenches and underlying surfaces shall be approved by the Engineer before stone or concrete is placed.

(2) Slopes shall be shaped to allow full thickness of the specified slope protection and any bedding or filter gravel, where required. Where the slopes cannot be excavated to undisturbed material, the underlying material shall be compacted to 95 % of maximum dry density determined according to AASHTO T 99.

602.03.2 Loose Rip-rap

(1) Larger stones shall be hand placed first with close joints in the footing trench. Stones shall be placed with their longitudinal axis normal to the embankment face and so arranged so each stone above foundation course has a three-point bearing on underlying stones.

(2) Loose rip-rap shall not be placed by dumping. Gaps shall be filled with smaller stones and spalls. Surface irregularities shall not vary by more than 100 mm from the intended line of slope.

(3) After approval of its placing, the surface voids in the rip-rap in the footing trench and on the lower portions of the slope shall be filled with hand rammed excavated suitable material and dressed to the satisfaction of the Engineer.

602.03.3 Grouted Rip-rap

(1) The surfaces of the stones shall be cleaned of adhering dirt and clay and shall be thoroughly moistened with water after placement. Stones shall be placed to the vertical height and thickness shown on the Drawings or ordered by the Engineer, and shall be carefully arranged by hand to interlock and have a three-point bearing on underlying stones with their longitudinal axis normal to the surface of the slope.

(2) Grout shall be applied while the stone is moist and shall be thoroughly worked into the gaps to fill the voids completely. Immediately after grouting, the grout shall be spaded and rodded into place with suitable spades, trowels or other approved tools, and broomed into the spaces until the voids are completely filled. No stone should touch another; all stones should be fully bedded into mortar. The exposed surface of the stones shall project not less than 50 mm and not more than 100 mm above the grout surface.

(3) The grouted rip-rap surface shall be cured by covering with wet hessian or curing blankets for a minimum period of 4 days after grout placement. Immediately after the curing medium is removed, the exposed surfaces shall be thoroughly cleaned.

602.03.4 Stone Masonry

(1) The foundation material and the width of the base of the wall shall be approved by the Engineer and shall then be blinded with Grade 15 concrete.

(2) The stone masonry shall be constructed to dimensions and lines matching the existing structure, or as otherwise approved by the Engineer.

(3) Care shall be taken to prevent the bunching of small stone or stones of the same size. Large stones shall be used in the corners.

(4) All stones shall be cleaned thoroughly and wetted immediately before being set, and the bed which is to receive them shall be cleaned and moistened before the mortar is spread. They shall be laid with their longest faces horizontal in full beds of mortar, and the joints shall be flushed with mortar.

(5) The exposed faces of individual stones shall be parallel to the faces of the walls in which the stones are set.

(6) The stones shall be so handled as not to jar or displace the stones already set. Suitable equipment shall be provided for setting stones larger than those that can be handled by two men. The rolling or turning of stones on the walls will not be permitted. If a stone is loosened after the mortar has taken initial set, it shall be removed, the mortar cleaned off, and the stone re-laid with fresh mortar.

(7) Mortar beds for face stones may vary from 20 mm to 50 mm in thickness. They shall not extend in an unbroken line through more than 5 stones. No stone should touch another; all stones should be fully bedded into mortar.

(8) Joints may vary from 20 mm to 50 mm in thickness. They shall not extend in an unbroken line through more than two stones. They may be at angles with the vertical from 0° to 45°. Face stone shall bond at least 150 mm longitudinally and 50 mm vertically. At no place shall corners of four stones be adjacent to each other.

(9) Cross beds for vertical faced walls shall be level, and for battered walls may vary from level to normal to the batter line of the face of the wall.

(10) Headers shall be distributed uniformly throughout the walls of the structures so as to form at least one-fifth of the exposed faces. They shall be of such lengths as to extend from the front face of the wall into the backing by at least 300 mm. When a wall is 450 mm or less in thickness, the headers shall extend entirely from front to back face.

(11) Backing shall be built chiefly of large stones and in a workmanlike manner. The individual stones composing the backing and hearting shall be well bonded with the stones in the face wall and with each other. All openings and gaps in the backing shall be filled completely with mortar or with spalls surrounded completely by mortar.

(12) Both bed and vertical joints shall be finished as shown on the Drawings or as directed by the Engineer. The top surface of stone masonry shall be crowned to provide drainage.

(13) Copings, if required, shall be as shown on the Drawings.

(14) Where copings are not required, the top of the wall shall be finished with stones wide enough to cover the top of the wall from 450 mm to 1000 mm in length, and of random heights, with a minimum height of 150 mm. Stone shall be laid in such a manner that the top course is an integral part of the wall. The tops of top course of stone shall be pitched to line, in both vertical and horizontal planes.

(15) All walls and abutments shall be provided with weep holes. Unless otherwise shown on the Drawings or directed by the Engineer, the weep holes shall be placed at the lowest points where free outlets for water can be ensured and shall be spaced at not more than 2 m centre to centre.

(16) Immediately after being laid, and while the mortar is fresh, all face stones shall be thoroughly cleaned of mortar stains and shall be kept clean until the work is completed.

(17) The stone masonry shall be satisfactory protected from the sun and shall be kept continuously wet by an approved method for a period of at least four (4) days after completion.

(18) The exposed surface of any stone shall not vary from the desired line by more than 50 mm.

602.03.5 Hand Laid Rock Embankment

(1) Sufficient excavation shall be made to expose a foundation bed that is satisfactory to the Engineer. The stone shall be founded on this bed and laid to the lines and dimensions required.

(2) Stone shall be laid flat and securely placed with broken joint lines. The larger stones shall generally be located in lower part of the structure and voids shall be eliminated to the extent possible. Spalls smaller than the minimum stone size specified in Sub-clause 602.02.1 paragraph (8) shall be used to lock the larger stones solidly in position and to substantially fill the voids between the major stones as laid in the embankment.

(3) The exposed face of the rock mass shall be reasonably uniform, with no projections of more than 150 mm, beyond the neat lines shown on the Drawings or as directed by the Engineer.

602.03.6 Reinforced Concrete

(1) Reinforced concrete shall be placed at the locations shown on the Drawings or ordered by the Engineer. Placing and finishing of concrete shall conform to the requirements of Section 507 of the Specifications, except that only hand-finishing methods will be required.

(2) Unless otherwise specified, concrete slabs shall not be greater than 4 metres by 4 metres and shall have plain vertical joints between slabs with no joint filler or sealant.

602.03.7 Repair

(1) When instructed to repair existing slope protection, the existing protection shall be removed and then replaced as specified for each type of protection above. Surplus material arising from the excavation shall be disposed of in spoil tips approved by the Engineer.

602.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
602-1	Loose Rip-rap Slope Protection	Metre Cube
602-2	Grouted Rip-rap Slope Protection	Metre Cube
602-3	Stone Masonry Slope Protection	Metre Cube
602-4	Hand Laid Rock Embankment	Metre Cube
602-5	Reinforced Concrete Walls and Slope Protection	Metre Cube
602-6	Repair of Loose Rip-rap Slope Protection	Metre Cube
602-7	Repair of Grouted Rip-rap Slope Protection	Metre Cube
602-8	Repair of Stone Masonry Slope Protection	Meter Cube
602-9	Repair of Rock Embankment	Meter Cube
602-10	Repair of Reinforced Concrete Slope Protection	Metre Cube
602-11	Masonry Retaining Wall (grouted)	Metre Cube
602-12	Masonry Retaining Wall (dry stone)	Metre Cube

(2) Loose rip-rap, grouted rip-rap, stone masonry and reinforced concrete slope protection shall be measured by the area of completed and accepted work times the designated thickness.

(3) No measurement will be made of unauthorised areas or for extra thickness.

(4) No deductions shall be made for weep holes, drain pipes or other openings of less than one (1) square metre in area.

602.05 PAYMENT

(1) Payment will be made at rates entered in the Bill of Quantities, which rates shall include excavation, backfilling, disposal of surplus materials and furnishing and placing of all materials including reinforcing steel and filter material (as relevant), as well as all incidentals.

SECTION 603

GUARDRAILS

603.01 DESCRIPTION

- (1) The work covered by this Section consists of furnishing and placing steel beam guardrails as shown on the Drawings or ordered by the Engineer.

603.02 MATERIALS

603.02.1 Posts

- (1) Posts and plates shall be of the dimensions and types shown on the Drawings and manufactured of structural steel conforming to the requirements of AASHTO M 183.
- (2) Posts and plates shall be galvanised, after fabrication and hole drilling, in accordance with the requirements of AASHTO M 111. Hardware shall be galvanised in accordance with the requirements of AASHTO M 232.

603.02.2 Beams

- (1) Beams shall conform to the requirements of AASHTO M 180, Class A, Type 1.
- (2) Slots and round holes shall be drilled, punched, burned or cut before the beams are galvanised. The same criteria shall apply for curved sections and splice plates.

603.03 CONSTRUCTION REQUIREMENTS

603.03.1 General

- (1) The Contractor shall submit to the Engineer for approval detailed shop and erection drawings, manufacturer's warranties, performance specifications, and other relevant data, and obtain approval thereto before he orders any materials for use in the Works.
- (2) Guardrails shall be located and erected as shown on the Drawings or ordered by the Engineer.
- (3) Posts on embankment shall be set plumb in excavated holes or driven if permitted by the Engineer. Driving shall not distort the posts.
- (4) If placed in excavated holes, the embedded post shall be encased in a minimum of 150 mm (depth) of Grade 15 concrete, and shall remain undisturbed for a minimum of 48 hours.
- (5) Rail elements shall be erected in a manner resulting in a smooth continuous installation with the elements overlapping in the direction of traffic flow. All bolts, except adjustment bolts, shall be drawn tight. Once the rail alignment and installations have been approved, the threads shall then be filed over or spot-welded to prevent removal of the nuts.
- (6) In the span of the rail crossing bridge joints, the rail splice shall have slots for the bolt holes and a nylon washer at the interface between rail and nut, rail and rail, and rail and bolt head to allow for movement.

(7) Minor damage to galvanising shall be repaired with two coats of an approved zinc-rich inorganic paint especially formulated for the repair of galvanised finishes. If in the opinion of the Engineer the damage to the galvanisation is not minor, then if so directed by the Engineer the damaged elements shall be removed and replaced at the Contractor's expense. Removed elements shall not be reused in the Works.

603.03.2 Existing Bridge Decks with Existing Steel Parapets

(1) Standard posts shall be bolted to the edge face of the deck slab and through a cleat plate onto the top of the deck with a total of 4 No. M16 bolts, or as otherwise approved by the Engineer. The rail shall be bolted to the web of the post with a suitable spacer to allow a nominal gap between the guardrail and the steel parapet. The Contractor shall submit proposals of the fixing and spacer for each bridge. Strong connection between the flexible guardrail and the rigid parapet shall be made, according to a standard drawing agreed with the Engineer. The connection between the guardrail and the parapet shall be strengthened by having sufficient number of guardrail posts near the parapet and embedding the posts in concrete foundation.

603.03.3 Existing Bridge Decks with Existing Concrete Parapets

(1) The guardrail shall be drilled with additional holes to allow it to be bolted onto the existing concrete posts. The bolt shall pass completely through the post. Strong connection between the flexible guardrail and the rigid parapet shall be made, according to a standard drawing agreed with the Engineer. The connection between the guardrail and the parapet shall be strengthened by having sufficient number of guardrail posts near the parapet and embedding the posts in concrete foundation.

(2) The standard height of rail shall be measured from the level of the footway.

603.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
603-1	Guardrail on Embankments / Culverts	Metre
603-2	Guardrail Fixed to Existing Bridge Decks	Metre
603-3	Guardrail Fixed to Concrete Parapet Posts	Metre

(2) Measurement shall be from centre to centre of end posts with rails laps excluded.

603.05 PAYMENT

(1) Payment will be made at the rates entered in the Bill of Quantities and shall include excavation and backfilling, rails, bolts, washers, concrete foundations (encasement) and repairs to galvanisation.

(2) Payment for the Guardrail Fixed to Existing Bridge Decks item shall include for the standard posts and cleat plates.

(3) Payment for the Guardrail Fixed to Concrete Parapet Posts item shall not include for the concrete parapet posts, but shall include for drilling a hole through the post if so required to allow fixing of the Guardrail.

SECTION 604

TRAFFIC MARKINGS

604.01 DESCRIPTION

(1) The work covered by this Section consists of the application of continuous or intermittent lines, letters or figures and the supply and installation of reflecting road studs, including any necessary excavation, grouting and finishing of the pavement, to the dimensions and at the locations shown in the Contract Documents or as directed by the Engineer, including the supplying of all labour, tools and equipment, materials, warning and traffic guidance signs as necessary for the safe and efficient completion of the entire work, and shall consist of hot applied thermoplastic or cold applied traffic marking paint (non-thermoplastic paint), reflectorized with glass beads, as directed.

604.02 MATERIALS

604.02.1 General

(1) The retroreflective traffic markings shall meet the performance requirements specified in ASTM D4280, Section 6.2, for luminous intensity, flexural strength, compressive strength, resistance to cracking, and thermal cycling, as modified herein

(2) For each lot or batch of paint and glass beads, a certificate of compliance, including the product name, lot or batch number, and manufacture date shall be submitted.

(3) All paints shall be free from all skins, dirt and foreign objects.

Colour

(1) White coloured materials will only be required to meet the initial daytime chromaticity requirements.

(2) White and yellow materials for pavement markings shall meet the performance requirements as shown in below table. The initial daytime chromaticity for white and yellow materials shall fall within the box created by the following coordinates:

Table 604.1 - Initial Daytime Chromaticity for White and Yellow Materials

Initial Daytime Chromaticity Coordinates (Corner Points)				
	1	2	3	4
x	0.530	0.510	0.455	0.472
y	0.456	0.485	0.444	0.400

(3) The night-time chromaticity for yellow materials shall fall within the box created by the following coordinates:

Table 604.2 - Night-time Chromaticity for Yellow Materials

Initial Daytime Chromaticity Coordinates (Corner Points)				
	1	2	3	4
x	0.575	0.508	0.473	0.510
y	0.425	0.415	0.453	0.490

604.02.2 Bituminous Adhesive for Traffic Markers

(1) Bituminous adhesive as recommended by the marker manufacturer shall be used for bonding the markers to the pavement.

- (2) The bituminous adhesive shall meet the properties of adhesives per ASTM D4280 Section A1, including filler-free and filler alone properties.
- (3) The performance of the adhesive shall be determined in accordance with the test methods listed in ASTM D4280.
- (4) Thermoplastic primers shall conform to current MONRE air pollution regulations, including those for the control of emissions (Volatile Organic Compounds, VOC).

604.02.3 Thermoplastic Materials

- (1) The laid material shall be one of three types detailed below as required by the Contract Documents or as directed by the Engineer, and in accordance with AASHTO T 250-05.

(a) Non-Reflectorized Thermoplastic

- (1) The thermoplastic material shall be factory mixed, from an approved manufacturer and shall be suitable for the type and location of application. The material shall possess adequate thermoplastic properties over the range of climatic conditions of the location, i.e. resistance to spreading under traffic at the highest road temperatures and retention of plasticity at the lowest road temperatures and shall give a marking which is effective for at least eighteen months under normal traffic conditions. The composition of the material with minimum and maximum proportions and grading of the constituents, the acid value of the binder, the temperature range of mixing and application, the setting time, the softening point (°C) and the open flash point (°C) shall be as stated.
- (2) The thermoplastic composition shall be specifically formulated for application at temperatures greater than 205 C. The components in the compositions shall show no significant break-down, or deterioration at 246 C.
- (3) The binder component shall be formulated as a hydrocarbon resin; or it shall be formulated as a mixture of high boiling point monohydric primary alcohol and modified maleic resin; or the manufacturer may submit an optional binder formulation for Engineer's approval. The pigment, beads and filler shall be uniformly dispersed in the binder resin.

Table 604.3 - Thermoplastic Composition

Component	Test Method	% by Weight	
		White	Yellow
Binder	AASHTO T 250, Section 5 ASTM D4797	min 20	min 20
Titanium Dioxide	AASHTO T 250, Section 9 ASTM D4764, - D4797	min 10	-
Calcium Carbonate & Inert Fillers (200 mesh sieve)		max 30	max 37.5
Yellow Pigments (Lead Free)		None	min per manufacturer

- (4) The physical properties of the composition shall be as follows

Table 604.4 - Thermoplastic Physical Properties

Component	Test Method	Min	Max
Water Absorption	ASTM D570		0.5% by weight
Softening Point	AASHTO T 250, Section 15 ASTM D36/ ASTM E28	90 °C	
Specific Gravity	Water Displacement	1.9	2.3
Flash Point	AASHTO T 250, Section 20 ASTM D92	246 °C	

Colour

- (1) White thermoplastic composition, as placed shall be white, free from dirt or tint.
- (2) Yellow thermoplastic composition, as placed, shall be yellow, free from dirt or tint.
- (3) The day-time and night-time colours of painted traffic markings shall comply with ASTM D6628.

Drying Time

- (1) When installed at 21 °C, and in thickness between 3 mm and 4 mm, the composition shall be completely solid and shall show no damaging effect from traffic after ten (10) minutes.

Yellowness Index (AASHTO T 250, Section 8)

- (1) White thermoplastic composition shall not exceed a yellowness index of 0.12 when tested and calculated in accordance with AASHTO T 250, respective ASTM E313.

Flowability (AASHTO T 250, Section 11)

- (1) After heating the thermoplastic for 240 ±5 minutes at 218 ±2 °C and testing for flowability, the white thermoplastic shall have a maximum percent residue of 18 and the yellow thermoplastic shall have a maximum residue of 21 %.

Low Temperature Stress Resistance (AASHTO T 250, Section 12)

- (1) Cracking resistance at low temperature shall be tested by heating the thermoplastic material for 240 ±5 min at 218 ±2 °C and then applying to concrete blocks, and cooling to 9.4 ±2 °C. If the material does not show any cracks, the material passes the test.

Impact resistance (AASHTO T 250, Section 14)

- (1) Impact resistance will be tested by heating the thermoplastic material for 240 ±5 min at 218 ±2 °C and making test specimens and testing per ASTM 256, Method A (un-notched). If the impact resistance is at least 1.0 J, the material shall be accepted.

Flowability with Extended Heating (AASHTO T 250, Section 17)

- (1) After heating the thermoplastic for 8.0 ±0.5 hrs at 218 ±2 °C, with stirring the last 6 hrs, and testing for flowability, the thermoplastic shall have a maximum residue of 28 %.

Skid Resistance

- (1) The surface of the pavement markings shall provide a minimum skid resistance value of 35 BPN (British Pendulum Number) when tested according to ASTM E303.

(b) Reflectorized Thermoplastic

(1) The material shall be in accordance with (a) above except that glass beads shall be incorporated in the mixture during the manufacture of the thermoplastic material. The quantity of glass beads included shall be 40 % by weight of the total mix, according to below table.

Table 604.5 – Glass Bead Requirements

Component	Test Method	% by Weight	
		White	Yellow
Glass Beads, AASHTO Type 1	AASHTO T 250, Section 6	min 20	min 20
Glass Beads, AASHTO Type 3	ASTM D4797	min 20	min 20

(2) The initial retro-reflectance of the applied traffic markings shall be a minimum of 450 mcd/ lx/ m² for white markings and 350 mcd/ lx/ m² for yellow markings when measured under ASTM E1710. The initial retro-reflectance shall be measured earliest 3 days after the application and latest 10 days after the application. After three years the retro-reflectance of the white and yellow traffic markings shall not be less than 250 mcd/lx·m².

(c) Reflectorized Thermoplastic with Glass Bead Surface

(1) The material shall be in accordance with (a) above except that a layer of glass beads shall be superimposed in the surface of the hot thermoplastic immediately after laying to give immediate reflectivity. The superimposed glass beads shall be of the same quality as that incorporated in the reflectorized thermoplastic mix, but may be smaller in size.

604.02.4 Glass Beads

(1) Glass beads shall be of a composition designed to be highly resistant to traffic wear and to the effects of weathering for the production of a reflective surface, without altering day visibility of the marking.

(2) Glass beads applied to molten thermoplastic material shall be 50% of Type 1 beads and 50% of Type 3 beads complying with AASHTO M 247 together with the requirements of this section.

(3) The glass beads must have an adhesion-promoting and water-repellent coating complying with the paint manufacturer's instructions.

(4) Glass beads shall have a spherical shape and at least 70 % of the glass beads shall be true spheres when tested in accordance with ASTM D1155. The glass beads shall be free of flaws and sharp angular particles, colourless, clean, transparent, free from milkiness and do not exhibit dark spots, air inclusions, or surface scratches or surface scarring when viewed under 20X magnification.

(5) Glass beads shall be resistant to chemicals and shall retain their brightness after soaking in the following solutions.

- Buffered acid solution;
- 1 N calcium chloride;
- Distilled water which is free from carbon dioxide gas. This water when titrated with 0.1 N hydrochloric acid at the amount of not more than 2.5 millilitres will reach a neutral point;
- The glass heads when soaked in sodium sulphide shall not turn black.

(6) Each lot of glass beads shall be tested for arsenic and lead by an independent testing laboratory. Each lot of glass beads used in pavement markings must contain less than 200 ppm by weight each of arsenic and lead. Any lot of glass beads not conforming to this requirement shall be discarded in an environmentally friendly manner, as directed by the Engineer.

(7) The silica content of the glass spheres shall not be less than 60 %.

- (8) All testing regarding the brightness of glass beads shall be in accordance to the requirements of Federal Specification TT-P-85 b.
- (9) The index of refraction of the glass beads shall be minimum 1.50 when tested by the liquid immersion method (Becke Line Method or equal) at a temperature of 25 ± 5 °C.
- (10) Glass beads shall meet the gradation requirements as specified below, when tested in accordance with ASTM D1214, except as otherwise directed.

Table 604.6 - Grading Requirements for Glass Beads

Sieve Designation	Percentage by Weight Passing	
	Type 1	Type 3
1.700 mm		100
1.400 mm		95 - 100
1.180 mm	100	80 - 95
1.000 mm		10 - 40
0.850 mm	95 - 100	0 - 5
0.710 mm		0 - 2
0.600 mm	75 - 95	
0.300 mm	15 - 35	
0.150 mm	0 - 5	

- (11) The crushing resistance of the spheres shall be as follows: A 18 kg dead weight, for 850 µm to 600 µm mesh spheres, shall be the average resistance when tested in accordance with ASTM D1213.
- (12) Glass spheres when superimposed in the surface of thermoplastic paint shall be treated with a moisture-proof coating.
- (13) Random samples of glass beads shall be taken from each sack for testing. The number of samples shall be one percent of the total sacks of the glass beads supplied. Each sample shall contain a minimum of two kilograms of beads.
- (14) If decided by the Engineer, he will perform a night-time, drive-through, making a visual inspection of the retro-reflectivity of the traffic markings and notify the Contractor of any locations with deficient retro-reflectivity. The measurement of the retro-reflectivity of deficient areas is done by using a retro-reflectometer under ASTM E1710 and the sampling protocol specified in ASTM D7585.
- (15) All tests, trials and documentation shall be at Contractor's own cost.

604.02.5 Reflectorized Durable Non-thermoplastic Paint

- (1) The paint shall be a cold-applied ready mixed paint suitable for application to cement concrete or bituminous pavements. The paint shall be durable and made reflectorized by superimposing glass beads on the surface of the paint. The paint shall also be suitable for applying by brush or mechanical means. The following particulars of the paint shall be supplied:
- i) composition (analysis by weight);
 - ii) application;
 - iii) type and maximum amount of reducer (thinner);
 - iv) drying time (to touch);
 - v) setting time (to recoat);
 - vi) recommended coverage (litres per square metre);
 - vii) heat resistance (max. road temperature);

viii) details of any primer, undercoat of tack coat required.

- (2) The paint shall be supplied fresh and ready for use in sealed containers which shall be stored in accordance with the manufacturer's instructions.
- (3) The paint colour shall be the type as detailed on the Drawings or as directed by the Engineer.
- (4) The composition of the paint shall be as shown in below table.

Table 604.7 - Composition of Reflectorized Durable Non-thermoplastic Paint

Component	Test Method	Criteria
Total Solids, by weight	ASTM D2369	min 75 %
Pigments, by weight	ASTM D3723	min 57 %
Vehicle Solids, % on Vehicle *		min 40 %
TiO ₂ , Type II Rutile (white paint only)	ASTM D476	max 18 kg/L
Volatile Organic Content (VOC)	ASTM D3960	max 150 g/L

* Vehicle Solids, % on Vehicle = % total solids - % pigment = 100% - % pigment
Vehicle Solids shall be 100% acrylic emulsion polymer

- (5) Laboratory samples shall meet below tabled physical requirements and shall be tested in accordance with ASTM E811 and ASTM E1349:

Table 604.8 - Physical Requirements on Reflectorized Durable Non-thermoplastic Paint

Property	Test Method	Minimum	Maximum
Density	ASTM D1475	1.62 ±0.168 kg/L	N/A
Viscosity at 25 °C	ASTM D562	80 KU	100 KU
Fineness of Grind	ASTM D1210	3 (HS)	
Dry Opacity at 5 mils (0.127 mm) WFT	ASTM D2805	0.92	
Bleed Ratio	ASTM D969	0.95	
Flexibility	ASTM D522, Method B	Pass	
Abrasion Resistance	ASTM D4060	Pass	

- (6) The paint shall set to bear traffic in not more than ten minutes.
- (7) The paint shall be tested for abrasion resistance, by testing four samples using a Taber Abrader. The paint shall be applied to specimen plates using a drawdown blade having a clearance of 0.5 mm. Air dry each sample until fully cured based on the manufacturers product recommendation. Clean with a soft brush and weigh each sample. Abrade samples for 1,000 cycles with a combined load of 500 g (arm plus auxiliary weight) on each arm and CS-10 wheels. Clean the samples with a soft brush and weigh again. The average weight loss for the four plates shall not exceed 75 mg per plate.
- (8) The white and yellow pavement markings shall attain an initial retro-reflectance of not less than 450 mcd/lx·m² and 300 mcd/lx·m², respectively. The retro-reflectance of the white and yellow pavement markings at the end of the 18 month period shall not be less than 150 mcd/lx·m².

604.02.6 Road Studs

- (1) All road studs, reflecting and non-reflecting, shall comply with the requirements of BS EN 1463-2. Only road studs which have been approved by the Engineer shall be incorporated in the Works. The Contractor shall submit details of the road studs he proposes to use in the Works to the Engineer for his approval.

(2) Reflecting road studs shall be of an approved design with self-cleansing reflecting units from a reputable manufacturer. Each stud shall be provided with at least two reflecting lenses for each traffic direction and the reflecting surface of each lens shall be at least 80 mm². The lenses shall be capable of withstanding impacts and no contact shall be possible between the lenses and vehicle tyres. The studs shall not project more than 20 mm above the level of the surrounding road surface and the lowest part of the lenses shall be more than 5 mm above the surrounding road surface. The reflecting units shall be interchangeable and capable of easy and quick replacement without disturbance of the road surface. The design shall be such as to ensure study attachment to the road pavement with adequate load distribution and such that it shall not be possible for heavy equipment such as road rollers and tracked vehicles travelling in the direction of the road axis to meet with any sharp edges whereby the stud might be removed.

604.02.6 Packaging and Shipping

(1) The thermoplastic and non- thermoplastic compositions shall be shipped to the job site in containers that are strong, sturdy and capable of being sealed in a manner approved by the Engineer. The containers shall protect the contents from contamination and shall be stored in accordance with the manufacturer's instructions.

(2) The containers shall be clearly marked with the manufacturer's name and address, description of the material, date of manufacture and batch number.

(3) The reflective glass spheres to be superimposed on the surface of the paint shall be shipped in moisture resistant bags. Each bag shall be marked with the name and address of the manufacturer and the name and net weight of the material.

(4) Thermoplastic primers shall be shipped in pails, drums, or other strong sturdy containers. Each container shall be clearly marked with the name of the product, the name and address of the manufacturer, the date of manufacture, the quantity of material, and the date of the expiration or shelf life. In addition, two-component primer containers shall be identified as "Part A" and "Part B". Primers shall be shipped to the job site accompanied with written instruction for use.

604.02.7 Basis of Acceptance

(1) Thermoplastic and non-thermoplastic material shall be accepted on the basis of sampling and inspection at the place of manufacture or in a warehouse as determined by the Engineer. Samples submitted shall be taken as directed by the Engineer. In addition, all samples shall be accompanied with the manufacturer's certified identification (originals to be submitted) of the binder formulation (e.g. "formulated as a hydrocarbon resin"). Any unauthorized tampering or breaking of seals on the containers between the time of sampling and delivery to the job site shall be cause for rejection of the material.

(2) Reflective glass beads shall be accepted on the basis of submission of glass beads to the Engineer for testing, together with original of the manufacturer's certification.

(3) Thermoplastic primers shall be accepted at the job site on the basis of the manufacturer's original certificate, which certifies that the primer conforms to the requirements of this specification.

604.03 CONSTRUCTION REQUIREMENTS

604.03.1 Thermoplastic Materials

(1) The material shall be applied only on a surface which is clean and dry during a period of favourable weather, when the pavement surface temperature is above 10 °C. It shall not be laid over loose detritus, mud or similar extraneous matter, or over an old paint marking, or over an old thermoplastic marking which is faulty.

(2) Mechanical wire shall be used to remove dirt, contaminants, and loose material from the pavement surface that is to receive the traffic marking. Abrasive blast cleaning shall be applied to remove laitance and curing compound from the surface of new concrete pavement that is to receive traffic marking.

(3) In the case of concrete surfaces and asphalt surfaces older than 6 months and/or where the Engineer directs, a tack coat or primer shall be applied as instructed by the manufacturer to the surface prior to the application of the material. The tack coat or primer shall be applied immediately before and concurrently with the application of the thermoplastic material. The type of tack coat/ primer and the rate of application shall be as the manufacturer of thermoplastic material recommends, with the approval of the Engineer.

(4) The material shall be melted in accordance with the manufacturer's instructions in a heater fitted with a mechanical stirrer to give a smooth consistency to the thermoplastic and such that local overheating shall be avoided. The temperature of the mass shall be within the range specified by the manufacturer and shall on no account be allowed to exceed the maximum temperature stated by the manufacturer. The molten material shall be used as expeditiously as possible and for thermoplastics which have natural resin binders or are otherwise sensitive to prolonged heating the material shall not be maintained in a molten condition for more than 4 hours.

(5) Centre lines, lane lines and edge lines shall be applied by approved mechanical means and shall be laid to a regular alignment. Other markings may be applied by hand-screed, hand-propelled machine or by self-propelled machine as approved or directed by the Engineer. After transfer to the laying apparatus the material shall be maintained within the temperature range specified by the manufacturer and stirred to maintain the right consistency for laying.

(6) In the case of screeded application the material shall be laid to a thickness of not less than 3 mm or more than 4 mm when measured above the pavement surface, unless specifically authorised by the Engineer when laid over an existing marking. In the case of sprayed application the material shall be laid to a thickness of not less than 1.5 mm, unless specifically authorised by the Engineer.

(7) The thermoplastic material shall be applied in a single uniform layer and the thermoplastic material shall completely coat and fill voids in the pavement surface. In all cases the surface produced shall be uniform and free from bubbles and streaks.

(8) Where the Contract Documents require or the Engineer directs that glass beads shall be applied to the surface of the markings, these shall be applied uniformly to the surface of the hot thermoplastic, immediately after laying such that the quantity of glass beads firmly embedded and retained in the surface after completion complies with the requirements of sub-clause 604.02.3, item (b) of these Specifications.

(9) Traffic marking of a repetitive nature, other than centre lines, lane lines, etc. shall, unless otherwise directed by the Engineer, be set out with stencils which comply with the size and spacing requirements shown on the Drawings.

(10) Glass beads shall be embedded in the freshly applied coat of thermoplastic paint to a depth of 1/2 their diameters, immediately after laying to give immediate reflectivity. Glass beads shall be applied at rate of 250- 450 grams per square metre such that the combined total of glass beads incorporated in and superimposed on the paint shall be as shown in Table 604.5, i.e. totally minimum 40% by weight of the material, unless otherwise directed by the Engineer.

(11) At the end of the day's work as much as possible of the material remaining in the heater and/or laying apparatus shall be removed. This may be broken and used again provided that the maximum heating temperature as specified in sub-clause 604.02.3 paragraph (2) has not been exceeded and that the total time during it has been in a molten condition does not exceed the allowable time.

604.03.2 Non-Thermoplastic Paint

(1) The paint shall be applied on a surface that is clean and dry during a period of favourable weather, when the pavement surface temperature is above 10 °C. It shall not be laid over loose detritus, mud or similar extraneous matter or over a traffic marking or over an old paint marking that is faulty or incompatible with the paint being applied. If a primer or undercoat is necessary to ensure proper adhesion of the marking paint to the road surface without bleeding or other discoloration the primer or undercoat shall be fully compatible with the marking paint and the road surface and shall be applied only if, and at the rate of application, approved by the Engineer.

(2) All cold-applied paint shall be thoroughly field mixed before applying in order to keep the pigments in uniform suspension. Hot-applied paints shall be heated in a properly designed heater, preferably thermostatically controlled, to the correct laying temperature at which it shall be maintained as required for the method of application. The paint shall on no account be allowed to exceed the maximum temperature specified by the paint manufacturer. The use of thinners or other additives shall not be permitted unless otherwise agreed by the Engineer.

(3) Centre lines, lane lines and edge lines shall be applied by approved mechanical means and shall be laid to a regular alignment. Other markings shall be applied by brush, spray, screed, hand-propelled or self-propelled machine according to the marking configuration and the type of paint approved for use or as directed by the Engineer. The rate of application of the paint for each coat shall be that recommended by the manufacturer unless otherwise directed by the Engineer.

(4) When more than one coat is used, the succeeding coat shall not be applied until the previous coat has fully set.

(5) Traffic markings of a repetitive nature, other than centre lines, lane lines etc. shall, unless otherwise directed by the Engineer, be set out with stencils that comply with the size and spacing requirements given in the Drawings.

604.03.3 Road Studs

(1) Road studs shall be installed in the locations shown on the Drawings. They shall be installed exactly as prescribed by the manufacturer. Road studs not installed in compliance with these instructions shall be rejected and removed from the Site.

(2) Excavation of the road pavement to form a cavity for each stud shall be carried out in accordance with the manufacturer's instructions. In the case of concrete surfaced roads cavities shall be at least 5 cm from an expansion joint and shall be clear of dowel bars at the joint. Care shall be taken to ensure a reasonably level floor and vertical sidewalls without projections into the cavity and that all loose material produced in excavating the cavity is cleaned out. A layer of approved stone (6.5 mm and smaller) shall be laid and compacted level on the cavity floor. The stud shall be prepared in accordance with the manufacturer's instructions and firmly bedded on the levelling layer such that the correct projection of the stud above the road surface is achieved. A template shall be used to check the line and level of the bedded stud. The cavity walls shall be brushed with asphaltic tack coat and the whole of the remaining cavity grouted with hot filled asphalt in accordance with the recommendations of the manufacturer until level with the road surface.

(3) Care shall be, taken to ensure that no asphalt is spilled on the projecting portion of the stud. Any asphalt inadvertently spilled shall be carefully removed so that a clean workmanlike job is presented with a fully effective reflector unit. Traffic shall not be permitted to pass over the stud until the grout has firmly set.

604.03.4 Trials

(1) Prior to the commencement of paint application operations and the operations for installing road studs, the Contractor shall paint a trial length of at least 15 m length, as well as install one road stud as directed and in the presence of the Engineer. The method, materials and equipment used shall be that which the Contractor intends use for the work proper. The purpose of the trials is to determine the adequacy of the Contractor's equipment and methods.

(2) The Contractor may proceed with his operations only after the equipment and methods in the trials have been accepted by the Engineer.

604.03.5 Defective Materials or Workmanship

(1) Materials which are defective or have been applied in an unsatisfactory manner or to incorrect dimensions or in a wrong location shall be removed, the road pavement made good and the materials replaced, reconstructed and/or properly located, all at the Contractor's expense and to the satisfaction of the Engineer.

604.03.6 Protection of Traffic and Existing/ New Traffic Markers

(1) The Contractor shall protect pedestrian, vehicular and other traffic adjacent to the working area, as well as protect existing traffic markers against damage or disfigurement by construction equipment, tools and materials or by spatter, splashes and smirches of paint or other construction materials and shall during the course of the work provide and maintain adequate signs and signals for the warning and guidance of traffic.

(2) All new markings shall be protected from traffic until they have dried sufficiently to show no pick-up of tyre marks. The Engineer in the field shall determine a time period in which traffic will not be allowed to pass over the particular traffic markings being used.

604.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
604-1	Reflectorized Markings, Yellow, Thermoplastic	Metre Square
604-2	Reflectorized Markings, White, Thermoplastic	Metre Square
604-3	Reflectorized Markings, Yellow, Non-Thermoplastic	Metre Square
604-4	Reflectorized Markings, White, Non-Thermoplastic	Metre Square
604-5	Reflectorized Road Studs	Number

(2) Where the width or length of laid marking proves to be greater than that specified and is accepted by the Engineer, the specified width or length shall be used when calculating areas for payment. Where the width or length of laid marking proves to be less than that specified and is accepted by the Engineer, the actual width or length of laid marking shall be used when calculating areas for payment.

604.05 PAYMENT

(1) Payment will be made at the rates entered in the Bill of Quantities, which rates shall include full compensation for all materials, preparation of surfaces, equipment, labour, tools, and incidentals necessary to the proper completion of the work.

(2) No partial payment for traffic markings shall be done.

SECTION 605

TRAFFIC SIGNS

605.01 DESCRIPTION

- (1) The work covered by this Section consists of furnishing, assembling and erecting posts, signs, sign frames and illuminated signs of a permanent nature as shown on the Drawings and as directed by the Engineer.
- (2) The work shall include all necessary foundations, excavation, backfill, anchorages, fixtures and fastenings, brackets, lighting units and electrical installations where required, application of paints, sheeting and finishes, testing and all the processes necessary to complete the work. Design of signs and associated electrical installations is included in the work.
- (3) This work shall also include the removal, cleaning, restoration and reinstalling of existing traffic signs and posts which are in good condition but not presently in the proper location for the finished road construction. This work will be directed and approved by the Engineer on an as-needed basis.

605.02 GENERAL REQUIREMENTS

605.02.1 Sizes, Colours, Types and Inscription

- (1) Signs shall be the sizes, colours and types shown on the Drawings or as directed by the Engineer. They shall be reflectorized and constructed in accordance with the requirements of this Section of these Specifications.
- (2) The inscription on traffic signs shall be in Lao and English with the Lao inscription above the English.
- (3) The Contractor shall provide the Engineer with following:
- shop drawings;
 - manufacturers' original certificates, certifying the origin of the main supplied items;
 - manufacturer's letter of authorized distributor for the supplied goods, including the reflective sheeting as well as the ASTM D4956 certification;
 - manufacturer's letter confirming that the Contractor is equipped and able to carry out maintenance, repair and provide spare parts.
- (5) The Contractor shall submit samples of each colour of the reflective sheeting attached to the sign plates, prior to ordering materials.
- (6) No sign plates shall be erected before being approved by the Engineer.
- (7) Signs delivered to the site shall be stored off the ground and under cover in a manner approved by the Engineer. Any sign damaged, discoloured or defaced during transportation, storage or erection shall be rejected.

605.02.2 Alternative Designs and Materials

- (1) The Contractor may submit or recommend alternative designs and construction materials to those specified in these Specifications or on the Drawings subject to the approval of the Engineer.

605.03 MATERIALS

605.03.1 Mounting Posts

- (1) Mounting posts shall be manufactured from one of the following materials:
- i) Reinforced Concrete Posts - Material shall conform to the requirements of Section 507 of these Specifications. Concrete shall be Grade 30 unless otherwise specified on the Drawings or in these Specifications.
 - ii) Prestressed Reinforced Concrete Posts - Materials shall conform to the requirements of Section 508 of these Specifications.
 - iii) Steel Posts - Steel posts shall be in the form of galvanised round tubes or pipes of not less than 75 mm outside diameter or other approved cross sections of adequate torsional rigidity and strength complying with the AASHTO M111.
 - iv) Aluminium Alloy Posts - Posts shall be manufactured from one of the following alloys:
 - 1) Alloy 6061-T6, 6062-T6 or 6063-T6 complying with the following ASTM specifications where appropriate:
 - B210 Drawn Seamless Tubes;
 - B221 Extruded Bars, Rods, Wire, Profiles, and Tubes;
 - B241 Seamless Pipes and Seamless Extruded Tubes;
 - B308 Structural Profiles.
 - or
 - 2) Approved alloy sections complying with other internationally recognised specifications acceptable to the Engineer.
- (2) Post Caps - Caps for hollow posts or other hollow sections used in construction may be approved cast or sheet metal or a suitable weather resisting plastics material.

605.03.2 Base Housings

- (1) Base housings for metal posts carrying illuminated signs shall be of fabricated steel or aluminium alloy not less than 4.5 mm thick or of cut iron or cast aluminium alloy having an average thickness of not less than 8 mm and a minimum thickness of 6.5 mm. Steel shall comply with the requirements of sub-clause 605.03.1, item iii) of these Specifications. Cast iron shall be ASTM A48, Class 30.
- (2) Fabricated aluminium alloy bases shall be of material complying with the requirements of sub-clause 605.03.1, item iv) of these Specifications. Cast aluminium alloy bases shall be either ASTM B26 or ASTM B108, Alloy SG 70A, Condition T6.

605.03.3 Sign Plates

- (1) Sign plates and panels shall be manufactured from one of the following materials:
- I. Aluminium Alloy
 - 1) Flat sheets and plates shall be one of the following alloys:
 - either Alloy 5052-H34, 6061-T6 or 3003-H18 complying with ASTM B209.
 - or
 - Approved alloy sheet or plate complying with such other internationally recognised specification as is acceptable to the Engineer.
 - 2) Extruded panels shall be one of the following alloys:
 - either Alloy 6063-T6 complying with ASTM B221
 - or
 - Approved alloy complying with such other internationally recognised specification as is acceptable to the Engineer.

II. Steel Plate, Sheet or Strip

The material shall be galvanised and shall comply with ASTM A245, Grade B, or such other internationally recognised specification as is acceptable to the Engineer.

605.03.4 Frames and Stiffening

(1) Except as otherwise provided in the Drawings or these Specifications, sign plates requiring frames or stiffening as specified under sub-clause 7.5.4.5 of these Specifications shall have adequate ribs or flanges as an integral part of the sign plate or shall have a metal frame or stiffening bars constructed of structural sections in steel or aluminium alloy complying with the appropriate specifications of sub-clauses 605.03.1 and 605.03.3 of these Specifications.

605.03.5 Fixtures and Fittings

(1) Brackets and clips shall be manufactured from approved cast metal, steel, stainless steel or aluminium alloy.

(2) Screws bolts, nuts and washers shall be of steel, aluminium alloy or of a high tensile non-corroding metal. All steel bolts, nuts and washers shall be galvanised in accordance with AASHTO M 232, Washers in contact with surfaces which may be damaged by over tightening of nuts or bolts shall be of a suitable soft and weather resisting material.

(3) Steel fixings and fittings which are in contact with aluminium shall be coated with zinc or cadmium. All steel fittings shall be rustproofed. Rivets shall be made from copper, brass aluminium alloy or pure aluminium. Brass, copper, lead or nickel shall not be used in contact with aluminium.

605.03.6 Electrical Components - General

(1) Electrical equipment and parts shall comply with the provisions of sub-clauses 611.01.2, 611.01.2 and 611.01.3 of these Specifications.

605.03.7 Wiring

(1) The provisions of sub-clause 611.02 of these Specifications shall apply except that for "lighting columns" and "columns" read "illuminated signs".

605.03.8 Switching

(1) The provisions of sub-clause 611.02.2 of these Specifications shall apply.

605.03.9 Preservatives, Paints and Finishes

(1) All coatings, paints, varnishes and enamels used in the preparation and finish of the signs, posts and fittings shall be of the best quality, specially made for the purpose they shall serve, and of brands and types acceptable to the Engineer. To ensure compatibility, primers, undercoats and finishing coats shall, wherever possible, be of the same manufacture. All materials shall be stored, and used within such time limits, as specified or recommended by the manufacturers or in accordance with the directions of the Engineer.

(2) Zinc coating (galvanising) on steel parts shall comply with ASTM A123 or ASTM A153 as appropriate.

(3) All paint used for steel parts, other than finishes on a sign face, shall be high zinc oxide content coating material of approved formulation containing a minimum of seven kilograms of zinc oxide (acicular type) per one hundred litres of coating material. The colour of the primer shall be different from succeeding coatings.

(4) Priming paints for aluminium alloys, when required, shall be pigmented with chromates or chromes (excluding lead chromes) except on sign faces where the specified finish is unsuitable for use with such primers.

(5) Plastics sheeting, film, and sprayed plastic finishes shall be of approved types and thicknesses, of durable colour and weather resistant, and shall be fully compatible with any materials with which they will come into contact. Such finishes shall be applied in accordance with the manufacturer's instructions.

(6) All aluminium plate and other members shall be anodised by a process approved by the Engineer.

(7) The whole of the face and edges of each finished sign plate shall have a full glossy coat of clear lacquer applied at the time of fabrication of the sign, and of a type specified or supplied by the manufacturer of the sheeting material.

(8) Back of aluminium sign plates shall not be painted. Galvanised steel frames, brackets, bolts and nuts shall not be painted.

605.03.10 Retroreflective Sheeting

(1) Sign plates shall be covered with "Scotchlite, Diamond Grade, Type IX" retroreflective sheeting or other colourfast reflective material of at least the same quality, conforming to ASTM D4956 and applied in accordance with the manufacturer's instructions. The sheeting shall cover the whole front surface, and the specified colours shall be applied.

(2) The retroreflective sheeting shall be manufactured as an unmetallized microprismatic retroreflective element material.

(3) A certificate of having the sheeting tested for coefficient of retroreflection, day time colour and luminance, shrinkage, flexibility, liner removal, adhesion, impact resistance, specular gloss and fungus resistance, 3 years outdoor weathering and the sheeting having passed these tests (described below) shall be obtained from a reputable international laboratory by the manufacturer of retroreflective sheeting, strictly as per ASTM D 4956

(4) The coefficient of retroreflection of the sheeting shall be measured according to ASTM D4956 and shall meet or exceed the minimum requirements for the Type IX Sheeting in the most current edition of ASTM D4956 at the specified 0.2°, 0.5° and 1.0° observation angles, as shown in the below table.

Table 605.1 - Required Retro-reflection Coefficients of Traffic Sign Sheeting, Type IX

Observation Angle	Entrance Angle	Minimum Coefficient of Retro-reflection (RA) (cd/ lx/ m ²)								
		White	Yellow	Orange	Green	Red	Blue	Fluorescent		
								Yellow-Green	Yellow	Orange
0.1°	-4°	660	500	250	66	130	30	530	400	200
	+30°	370	280	140	37	74	17	300	220	110
0.2°	-4°	380	285	145	38	76	17	300	230	115
	+30°	215	162	82	22	43	10	170	130	65
0.5°	-4°	240	180	90	24	48	11	190	145	72
	+30°	135	100	50	14	27	6	110	81	41
1.0°	-4°	80	60	30	8	16	3.6	64	48	24
	+30°	45	34	17	4.5	9	2	36	27	14

(5) None of the coefficients of retroreflection obtained on any of the samples shall be less than 80 % of the values required in above table.

(6) Sheeting shall have the same daytime and night-time colour when viewed by reflective light. The values shall be determined on a HunterLab ColorFlex Spectrocolorimeter. Computations shall be done in accordance with ASTM E308 for the 2.0° observer.

(7) After outdoor weathering the colour shall conform to the most current requirement of ASTM D4956, Tables 2 and 11, for daylight luminance factor respective colour specifications limits.

(8) The night-time colour values shall be determined on a Gamma Scientific RadOMA spectroradiometer. Night-time chromaticity shall be determined in accordance with ASTM E811 and evaluated using the CIE 1931 system in ASTM E308.9

- (8) The colours listed in below table are excluded from the night-time colour values.

Table 605.2 - Colours Excluded from Night-time Colour Values

Colour	Chromaticity Coordinates								Daytime Luminance Factor, Y %	
	1		2		3		4		Min	Max
Purple	0.302	0.064	0.310	0.210	0.380	0.255	0.468	0.140	2	10
Pink	0.600	0.340	0.450	0.322	0.430	0.275	0.536	0.230	25	None

- (9) All sheeting material shall have a minimum specular gloss of 40, as measured according ASTM D523 (Standard Method for Test for Specular Gloss).

Protective Liner

- (1) Protective liners shall be removable from the adhesive backing by peeling without soaking in water or other solvents and without breaking, tearing or removing any adhesive from the backing.

Adhesive Backing

- (1) The adhesive backing shall be either a pressure-sensitive (PS) or a positionable heat-activated (HA) adhesive, applied to the approved sign surface according to the instructions of the sheeting manufacturer without the necessity of additional adhesive coats on neither the reflective sheeting or application surface. After application the sheeting shall tightly adhere to the application surface, and show no discoloration, cracking, crazing, blistering, or dimensional change.

- (2) Pressure-Sensitive (PS) Adhesives shall be of an aggressive tack type requiring no heat, solvent or other pre-application preparation to the reflective sheeting for adhesion to clean, treated aluminium, painted plywood, or plywood with either a medium density overlay (MDO) or a high density overlay (HDO).

- (3) The adhesive shall form a durable bond to the clean surface.

- (4) The adhesive shall be in accordance with Section 6.9 of ASTM D4956.

- (5) Impact Resistance shall be in accordance with Section 6.10 of ASTM D4956.

Sheeting Film

- (1) The exterior film of the sheeting shall be transparent, flexible, smooth surfaced, moisture resisting material and shall have sufficient strength and flexibility to be easily handled, cut to shape, processed and applied without appreciable stretching, tearing or other damage.

- (2) Shrinkage shall be in accordance with Section 7.8 of ASTM D4956.

- (3) Flexibility shall be in accordance with Section 7.9 of ASTM D4956 and with the following addition. With the adhesive side of the sheeting against the mandrel, place a thumb and forefinger on the reflective side of the sheeting and within 1 second bend the sheeting around the mandrel to form a 180-degree bend.

- (4) The sheeting shall have adequate characteristics, not limited to tensile strength and flexibility, so that the sheeting can be handled processed, and applied in accordance with the manufacturer's recommended procedures without damage to the sheeting.

Outdoor Weathering

- (1) All sheeting shall be subject to outdoor weathering. At the end of the outdoor weathering exposure period the samples from the test shall show no appreciable discoloration, cracking, crazing, blistering, scaling, pitting, delamination, edge lifting, or curling, or dimensional change. The samples shall retain the specified "minimum coefficient of retroreflection, R_A" as included in Table 12 of ASTM D4956 as a percent of the referenced values in Table 605.1 of these specifications.

Satisfactory Performance Life

(1) Retroreflective sheeting shall have the following minimum satisfactory performance life and minimum percentage of the coefficient of retroreflection values specified in in table 605.1 at observation angle 0.2° and entrance angle -4°.

Table 605.3 – Minimum Satisfactory Performance Life of Sheeting Type IX (ASTM D4956)

Colour	Minimum Satisfactory Performance Life (Years)	Minimum Final Coefficient of Retroreflection (% of values in Table 605.1)
All, except orange and fluorescent orange	10	80
Orange and fluorescent orange	3	80

605.04 DESIGN AND CONSTRUCTION REQUIREMENTS

605.04.1 General

(1) The Contractor shall be responsible for the design of signs and all associated fittings and fixtures, including electrical equipment, in accordance with the Drawings and this Section of these Specifications. Full details of the Contractor's designs and proposed materials shall be submitted to the Engineer for approval before commencement of the work.

(2) Signs shall be mounted on posts, unless otherwise instructed by the Engineer in writing. Design and construction of signs shall be such that all sign plates, posts, fittings, lighting units, electrical equipment and conduit can be assembled and erected without site modification.

(3) The Engineer shall establish and mark the longitudinal location of each sign.

(4) All signs considered by the Engineer to be in the way of construction or rehabilitation works shall be carefully removed by the Contractor and shall be placed as directed by the Engineer. Signs removed shall be the property of the Government. Road signs removed, but in good condition and still necessary to the proper signing of the road shall be reinstalled in accordance with sub-clause 605.04.15 of these Specifications.

605.04.2 Mounting Posts

(1) Posts shall be adequate in number and size to support the signs and any lighting fittings attached to the frames or posts. Where apertures are cut in posts for cable entry etc. due allowance shall be made to ensure that the post will be of adequate strength.

(2) Post shall be such that, at a wind pressure of 150 kilograms per square metre, the maximum deflection at the centre of the sign is limited to one fortieth (1/40th) of the height measured from the ground for signs mounted on a single post and to one eightieth (1/80th) for signs mounted on more than one post.

(3) The lengths of posts shall be adequate for the requirements allowing for embedment in the ground and/or extensions for lighting fittings. All posts shall be effectively prevented from rotation in the ground and if necessary in the case of metal posts, suitable metal base plates shall be provided for this purpose. Unless otherwise shown on the Drawings base plates shall be not less than 4.5 mm thick and shall have an area of not less than five times the plan area of the post. Effective means for securing the base plate to the post shall be provided.

(4) Post lengths shown on the Drawings are indicative only. The Engineer will authorize the location of each sign, with the station and offset distance from the edge to the pavement. The Contractor shall determine the correct length of posts to obtain the vertical clearance shown on the Drawings. Field cutting of posts shall be performed by sawing.

- (5) Where a post has to be sited close to a wall either the top of the post shall be angled away from the wall to provide adequate clearance for the sign or an adequate bracket or brackets shall be provided from the post for this purpose. In either case the post shall be of adequate strength and rigidity to withstand the additional bending moments and torsion resulting from the arrangement.
- (6) All open ended posts, or other hollow sections used in construction shall be effectively capped to prevent the entry of water.
- (7) Construction of reinforced concrete and prestressed reinforced concrete posts shall be in accordance with Sections 507 and 508 of these Specifications, respectively, and as approved by the Engineer. All surfaces above ground shall receive a rubbed finish complying with sub-clause 507.11.3 of these Specifications.
- (8) Timber posts above ground shall be smooth planed.

605.04.3 Base Housings

- (1) Base housings for posts shall have ample accommodation for the electrical components to be fixed therein. Suitable means shall be provided for fastening the posts firmly to the base housings. Base plates shall have an area not less than two and a half times the plan area of the base housings and shall be not less than 4.5 mm thick in the case of steel and aluminium plate and not less than 6.5mm thick for cast housings.
- (2) A service door or panel of rigid construction shall be provided to give ready accessibility for maintenance purposes. The door or panel shall be weatherproof and shall be capable of being secured with key fastenings. Screws shall be of non-corrosive metal and captive. Screws of a self-tapping type shall not be used.
- (3) Ventilation and drainage, sufficient to prevent undue condensation, shall be provided and the bottom of the housing shall be sealed to prevent the upward seepage of water. Arrangements shall be made for the service cable or conduit to enter the base housing at any depth between 150 and 300 mm below ground level and it shall be possible to lift away the post and housing without breaking the service joint. Cable entry holes shall be sealed, with a suitable gland, against the entry of dirt or water. Adequate earthing arrangements shall be provided.

605.04.4 Sign Plates

- (1) Aluminium alloy plates and panels shall have a minimum thickness of 2 mm. Steel plates and steel panels shall be stainless and shall have a minimum thickness of 1.5 mm. Sign plates constructed of other materials shall be of adequate rigidity and strength and shall be suitable for the finishes which are to be applied to them. Where the Engineer so directs, tests shall be carried out to determine the suitability of a material and its finish for use as a sign plate.
- (2) Extruded plank type aluminium panels may be of either the interlocking or bolted type. Cold formed plank type steel sections bolted together through the flanges may also be used for panels. Where such panel sections are used the ends of the sections shall be covered to present a flanged appearance such that the edges of the sign present the same appearance all round.
- (3) Sign plates and panels shall be cut accurately to the shapes and sizes specified on the Drawings. All mounting holes shall be accurately located and, after drilling or punching, any burrs, rough spots and loose material shall be removed. All holes shall be drilled before painting.

605.04.5 Frames and Stiffening

- (1) Except where ribs or flanges are an integral part of the sign plate and provide the necessary stiffening, sheet metal sign plates exceeding one metre in any dimension shall be stiffened by the attachment of a frame or stiffening member (s) to the back of the sign plate.
- (2) The post or posts supporting a sign may be taken into consideration for stiffening purposes. A bracket may form the stiffening frame or part of it.

- (3) The frame for a sign plate or plates shall be simple in design and shall have the minimum number of members to give it the required stiffness.
- (4) The stiffening or frame for a sheet metal sign plate may take the form of flanges round the edges of a sign, welded ribs or steel or aluminium sections with a minimum thickness of 2 mm. Where flanges are provided they shall be uniform on all edges of the sign.
- (5) Where metal frame members join they may be welded or joined with suitable brackets and nuts and bolts but in all cases the joints shall be strong enough to withstand the stresses induced in them.

605.04.6 Fixture and Fittings

- (1) Where necessary or desirable signs shall be mounted on existing suitable highway furniture, buildings or structures by means of a properly designed bracket or brackets.
- (2) The method of fixing sign plates, frames and brackets to posts shall be such as will facilitate removal for replacement or maintenance purposes and permit adjustment in the position of a sign without detaching it from its post or posts, but the sign and any framing shall be held firmly enough to withstand the load to which it will be subjected. Signs mounted on single posts shall have fixing to prevent the forced rotation of the signs on the posts. Clips and brackets shall be shaped to secure a firm hold on the post without placing any bending strain on the sign plate.
- (3) Where materials with different coefficients of expansion are fixed together, allowance for this shall be made so that the sign will not fail by shearing or buckling of fixing bolts, rivets or welds.
- (4) Where dissimilar metals are joined together, precautions shall be taken to prevent electrolytic action, particularly in the case of screws and rivets. This may be accomplished by using paint, lacquer or other suitable means to eliminate metal to metal contact.
- (5) Brackets used in the construction of signs may be manufactured from sheet or strip aluminium alloy, extruded sections, cast aluminium alloy or may be fabricated from steel sections. The minimum thickness of material shall be 3 millimetres. Welded joints shall be sound and their surfaces smooth. Holes shall be drilled before painting and shall be accurately located.
- (6) Steel or aluminium strip used for clips shall not be less than 2 mm thick.
- (7) Screws and bolts shall not be less than 8 millimetres in diameter and of adequate length, but without excessive projection of the screwed ends. In any situation where, if a screw were removed, the assembly would be insecure, that screw shall have not less than four full threads engaged when it is tight and shall be fitted with a locknut or a spring washer.
- (8) Where hollow rivets are used to connect sign plates to frames or fixings the holes shall be effectively blocked to prevent light shining through. Screw bolt or rivet heads on the face of a sign shall be as unobtrusive as possible and each shall match the colour of the part of the sign where it is located.
- (9) Caps for posts of hollow section shall be shaped to shed rainwater to the outside of the posts and adequate means of securing the caps to the posts shall be provided.

605.04.7 External Lighting Lanterns (Electric)

- (1) Full details of lanterns, including dimensions, shall be submitted by the Contractor to the Engineer before commencement of the work.

Materials and Design

- (1) The body of the lantern and its fittings shall be of robust construction, of ample dimensions, and shall be made of cast or sheet metal, or of weather-resisting plastics material. Sheet metal shall have a thickness of not less than 1.5 mm.

- (2) Both the exterior and interior surfaces shall be reasonably smooth to prevent the accumulation of dirt and to facilitate cleaning. The upper surface shall be shaped to shed rainwater.
- (3) The lantern shall be of the enclosed type and access to the interior shall be by a hinged bowl or door, which shall seat closely when fastened. The fastenings shall be key operated.
- (4) If a gasket is used it shall be capable of withstanding the operation conditions without deformation or softening, and shall be attached in such a way that it will be retained in position when the bowl or door is repeatedly opened for maintenance purposes.
- (5) When closed the lantern shall be waterproof and means of ventilation shall be provided

Electrical Components

- (1) Two lamp-holders, wired in parallel, shall be provided, securely mounted and correctly located, for the lamps appropriate to the size of sign, as given below.
- (2) Lanterns shall be capable of accommodation tungsten filament pearl lamps of any of the ratings given below.

Table 605.4 - Required Ratings of Lamps for Lit Traffic Signs

Size of sign	No. of lamps and rating
Up to 0.6 x 0.6 metre	2 x 25 watt
Up to 1.25 x 1.25 metre	2 x 40 watt
Up to 1.8 x 1.8 metre	2 x 60 watt

- (3) Alternatively, the lantern may be arranged for approved tubular fluorescent lamps. All lanterns shall be supplied complete with the necessary lamps.
- (4) The electrical wiring shall be totally enclosed in conduit. A readily accessible terminal block so insulated or shrouded as to prevent the accidental contact of a person with the live terminal, and an earthing terminal shall be provided. A 3-pin socket may be used instead of the terminal block and earthing terminal. Conduit tubing shall not be visible from the front of the sign.

Optical Components

- (1) Separate reflectors shall be of anodised aluminium, vitreous enamelled steel or other suitable material. The surface of refractors not wholly within the lantern shall be protected by a hermetically sealed cover plate. Diffusers shall be of glass or plastics material and shall have smooth interior and exterior surfaces.

Finish

- (1) The surface of lanterns shall be finished with approved paint, enamel or vitreous enamel.

Photometric Performance

- (1) The light distribution of the lantern shall be such that when it is mounted with the appropriate sign the following conditions are satisfied in respect of the white portions of the sign:
 - i) The average luminance of the sign shall be between 40 and 110 cd/sq-m;
 - ii) The maximum luminance of the sign shall not exceed 325 cd/sq-m;
 - iii) The distribution of illumination shall be reasonably uniform and the illuminated sign shall not present a patchy appearance. The ratio between the maximum and minimum luminance shall not exceed the following values;

Table 605.5 – Maximum Allowable Ratio between Maximum and Minimum Luminance

Size of sign	Limiting ratio
0.6 x 0.6 metres	10 : 1
1.25 x 1.25 metres	30 : 1
1.3 x 1.8 metres	40 : 1

- iv) No light shall be emitted direct from the lantern towards oncoming traffic and light spill shall be kept to a minimum.

Lantern Brackets

- (1) The length of the conduit bracket supporting the lantern shall be such that the outside edge of the lantern does not project more than the following distance from the front surface of the sign.

Table 605.6 – Maximum Allowable Projection of Lantern from Front Surface of Traffic Sign

Depth of sign (metres)	0.75	1.20	1.80	2.70	3.60
Maximum outreach (metres)	0.45	0.60	0.90	1.10	1.35

- (2) The lantern shall be mounted so that:
- the main illumination is downwards
 - the lantern does not obscure part of the sign
- (3) Conduit brackets shall be of adequate dimensions to minimise relative movement between the lantern and the sign due to vibration. Means shall be provided to prevent the lantern turning on the bracket.

605.04.8 Internally Illuminated Signs

General

- (1) Full details of the signs and their fittings, including dimensions, shall be submitted by the Contractor to the Engineer before commencement of the work.
- (2) The exterior of the sign shall have no sharp edges or protuberances and the exterior and interior surfaces shall be reasonably smooth to prevent the accumulation of dirt and to facilitate cleaning. The upper surface shall be shaped to shed rainwater.

Sign Housing

- (1) Sign housings shall be of cast or sheet metal or of weather-resisting plastics material, of adequate rigidity and strength, and so designed and constructed that light sources and any electrical gear are readily accessible for cleaning and maintenance purposes.
- (2) The housing shall be such that the assembled sign is waterproof and means of ventilation shall be provided.
- (3) Access doors or panels shall be of rigid construction, designed to seat closely when fastened and fastenings shall be key operated. Screws used for securing access doors and panels shall be non-corrosive and captive. Screws of a self-tapping type shall not be used.
- (4) Gaskets shall be capable of withstanding the operating conditions without becoming permanently deformed, softened or hardened and any adhesive used for fixing them shall be chemically compatible with the gasket material and with the material to which the gasket is fastened.
- (5) Gaskets used to retain the face of a sign shall be so designed that the face is not easily removable by unauthorised persons and shall be positively held in position so as not to work loose during maintenance operations. Circular signs shall have means to prevent the sign face rotating.
- (6) Cable entry holes shall be sealed with a suitable gland against the entry of dirt or water.
- (7) The method of fixing the housing to the mounting post or posts shall allow easy removal for maintenance or replacement purposes and provision shall be made to prevent the forced rotation of a sign when it is mounted on a single post. Fixing holes and holes for reflectors shall be made before painting. The internal finish of metal housings shall be of approved white enamel.

Sign Face

- (1) The material used for the sign face shall be clear, opal or self-coloured acrylic sheet with a minimum thickness of 3 mm or toughened glass with a minimum thickness of 4 mm. Other materials may be used provided their optical properties and mechanical strength in resistance to bending and impact are at least equivalent to those of acrylic sheet or toughened glass.
- (2) The legend symbol or border appearing on the sign face may be of plastics material in the form of foil or sheeting, paint, ink or screening paste, or another material which is chemically compatible with the material used in the sign face and appropriate to the method of construction. Paints, inks or screening pastes used on acrylic sheet shall be acrylic based. Material used in bonding acrylic sheet and forming fillets shall be approved bonding acrylic cement and any adhesive or solvent used on acrylic sheet shall be chemically compatible with it. In all cases, colours and diffusing surface shall have a uniform appearance.
- (3) Due allowance shall be made for differential expansion between the sign face and any retaining material and holes for fixing purposes shall have adequate clearance. Holes drilled in acrylic sheet shall be positioned so that their edges are not less than their own diameter from the edge of the sheet.

Electrical Components

- (1) Lamp-holders shall be provided, securely mounted and correctly located, for two standard tubular fluorescent lamps wired in parallel or one such lamp normally alight plus a second lamp (which may be a tungsten filament pearl type) arranged to come into service when the first one fails. For small signs the alternative of two tungsten filament pearl lamps may be acceptable. The lamp-holders, ancillary gear and wiring shall be to a three pin plug and shall be mounted on a frame so that the whole assembly can be removed from the sign without the use of tools.
- (2) A readily accessible terminal block and fuses shall be provided in the base of a supporting post for each illuminated sign. The terminal block shall be so insulated or shrouded as to prevent the accidental contact of a person with the live terminal and an earthing terminal shall be connected to the lamp-holders and to the base housing.

Optical Performance

- (1) The following conditions shall be satisfied in respect of white portions of the sign face when in new and clean condition.
 - i) The average luminance of the illuminated portions shall be between 45 and 215 candelas per square metre;
 - ii) The variation of luminance when viewed normally to the surface shall not exceed a ratio of 15 of 1;
 - iii) The luminance at any point shall not exceed 540 candles per square metre.

605.04.9 Preparation and Painting

General

- (1) All painting and finishing shall be carried out in clean, dry surroundings using heat lamps for drying and ovens for baking as may be needed. All paints shall be applied with a pressure spray to form a smooth even film and all surfaces and edges shall be coated unless stated otherwise. Paint shall be applied only when the surface or previous coat is dry.
- (2) The following requirements shall, unless otherwise provided in the Particular Specifications or on the Drawings, apply to preparation and painting of sign components; but excludes the finish on sign faces, plastics signs and components with finishes of reflective and plastics sheeting, film, and other proprietary finishes.

Aluminium Alloys

- (1) Aluminium alloys, other than sign faces, shall not be treated or painted unless they are in contact with earth. Surfaces in contact with earth shall be prepared as described in the next paragraph and two coats of approved asphaltic paint shall be applied.
- (2) Before painting, the surfaces of aluminium alloy sign plates shall be thoroughly degreased and pre-treated by anodising or by an equivalent process or by using an etching primer.
- (3) The prime coat shall then be applied. The back and edges of the plate shall receive a finish coat of light grey enamel.

Steel Surface

- (1) All steel components shall be rustproofed by galvanising, cadmium plating or other approved treatment prior to painting. Where necessary the surface shall be cleaned and degreased before painting. All surface other than screws, bolts, nuts and washers, shall then receive one prime coat of high zinc oxide paint. All surfaces, other than sign faces shall receive a finish coat of high zinc oxide paint, tinted light grey.

Cast Iron

- (1) Cast iron surfaces shall be cleaned and painted with an organic zinc-rich primer.

605.04.10 Finish of Sign Faces

- (1) Recommendations by the manufacturers of paint, reflecting materials, plastics sheeting or other finishes, regarding the preparation of surfaces prior to the application of the finish and protection of the finish, shall be carefully followed.
- (2) The finish on the face of a sign shall present an even surface free from twists, cracks or faults or any other blemishes. When reflecting sheeting or film is used it shall, where possible, be in complete sheets. Joints shall be kept to a minimum, but where they are necessary they shall be constructed in accordance with the manufacturer's instructions. Care shall be taken to ensure a proper day and night colour match at joints.
- (3) Enamel surfaces shall consist of one undercoat and one top coat, applied and stoved, of uniform thickness, homogeneous and uniform in colour with an egg shell flat finish.
- (4) Legends shall be carefully coloured at their edges to ensure true proportions. On signs where light colours are applied over dark, at least two coats of light colour shall be applied.

605.04.11 Retroreflective Sheeting

- (1) Unacceptable Performance of the sheeting shall be cause for immediate material rejection and replacement. Unacceptable performance includes, but need not to be limited to, the display of:
 - a) Bubbles or wrinkles on the sign face greater than 7 cm in length (excluding minor defects around dents or mounting holes), or any cracks or breaks or stress cracks;
 - b) Bubbles or wrinkles within the legend message area (legend/message shall be defined as the entire area within the limits of the legend message template);
 - c) A total shrinkage of more than 0.3 cm in the sheeting in any direction;
 - d) Delamination of the sheeting between the outer surface, optical reflecting system or the adhesive backing;
 - e) Lack of durable adhesive bond between the sheeting and the sign blank;
 - f) Daytime luminance factor outside the ranges specified in Table 2 of ASTM D4956;
 - g) Loss in the coefficient of retroreflection for the sheeting.
- (2) The Engineer reserves the right to approve, reject, or cause to be replaced any or all the material failing to satisfactorily meet all the specifications herein.

(3) Any or all material, which has been documented by written notification from the Engineer, shall be removed and replaced in full quantity within 30 calendar days at no expense to the Employer.

(4) The Contractor shall be liable for the replacement of all sheeting furnished by the Contractor, which fails to meet the specifications. The Contractor shall also be liable to the Employer for all costs associated with sheeting failures as may be incurred in the manufacturing signs, sign processing, sign refurbishment, and field force removal and replacement of signs directly associated with the failure. The minimum satisfactory performance life as specified in Article "605.03.10 Satisfactory Performance Life" shall be compared to the actual life duration of the sheeting, to assess the performance of the sheeting.

(5) The Contractor shall arrange at no cost to the Employer so that the material manufacturer provide the services of a qualified technician to the Employer for the purpose of assisting the Employer's personnel in the proper application of material, storage, packaging and other practises as they pertain to the sheeting, supplied by the manufacturer.

(6) Sheeting as supplied shall be of good appearance, free from ragged edges, cracks, and extraneous materials, and shall be furnished in either rolls or sheets as specified. When furnished as cut retroreflective sheeting or sign faces, the sheeting shall be packaged flat between pressed composition boards or corrugated pads of the same dimensions in accordance with commercially accepted standards. Each carton shall clearly stipulate the classification, colour, and type of adhesive. Stored under normal conditions, the sheeting shall be suitable for use for a minimum of 12 months.

605.04.12 Excavation and Reinstatement

(1) The provisions of sub-clause 611.03.1 of these Specifications shall apply.

605.04.13 Concrete Embedment of Posts

(1) Where so indicated on the Drawings the bases of posts shall be embedded in concrete. Concrete shall be Grade 30, as defined in Section 507 and shall contain the minimum quantity of water necessary to produce a mix that can be tamped and rammed round the base of the post such that the post will be firmly held in position immediately after completion of placing and compaction.

(2) The minimum thickness of concrete embedment and its height shall be as shown on the Drawings.

(3) The post shall be carefully positioned and plumbed and struts and stays applied as necessary to hold it in position during embedment. The concrete shall then be placed round the post in uniform lifts not exceeding 200 mm and each lift thoroughly rammed. Care shall be taken to avoid contamination of the concrete from the surrounding surface and soils. Any contaminating material falling into the concrete shall be immediately removed.

(4) All the concrete embedment for a post shall be provided in one operation and where the surface of the concrete embedment is above the level of the surrounding surface the exposed portion shall be formed to present a neat and tidy appearance and sloped to shed water away from the post.

605.04.14 Conduits and Fittings

(1) The provisions of sub-clause 611.03.3 of these Specifications shall apply.

605.04.15 Pull Boxes

(1) The provisions of sub-clause 611.03.4 of these Specifications shall apply, except that inscriptions on covers shall be "Road Signs".

605.04.16 Relocation of Existing Traffic Signs

(1) Existing traffic signs and posts which, in the opinion of the Engineer, are still in good and usable condition and necessary to the proper signing of the completed road, shall be removed, cleaned thoroughly repainted if necessary and reinstalled nearby in the location designated by the Engineer. Traffic signs not designated to be reused or relocated shall, upon removal, be cleaned and transported to a location as directed by the Engineer.

605.04.17 Inspection and Testing

(1) Testing of electrical installations shall be in accordance with the provisions of sub-clause 611.03.5 of these Specifications.

(2) Before fabrication of signs the Contractor shall supply an example of each type of sign with information concerning equipment and procedures and state the location of the workshops manufacturing the signs. The Engineer will inspect the facilities and, if satisfactory, issue approval to fabricate the remaining signs.

(3) When so requested by the Engineer, samples of preservatives, paints, sheeting and finishes shall be supplied by the Contractor and shall be tested by him as directed by the Engineer for the appropriate conditions (exposure, compatibility of materials, bonding, reflectance etc.) Testing shall be carried out for sufficient time to ascertain the quality and/or suitability of the materials.

605.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
605-1	Sign Posts	Metre
605-2	Traffic Signs	Metre Square
605-3	Relocate Traffic Signs and Posts	Number
605-4	Overhead Signs	Metre Square
605-5	Steel Truss for Overhead Sign	Metre
605-6	Foundation & Steel Post for Overhead Sign	Number
605-7	Overhead Traffic Sign	Number

(2) Measurement as described in this section shall only apply to permanent signs erected or reinstalled. Signs used temporarily for traffic diversion on temporary detour facilities will not be measured for payment.

605.05 PAYMENT

(1) Payment will be made at the rates entered in the Bill of Quantities, which rates shall include full compensation for furnishing and erecting all materials including labour, tools, testing, frames, hardware (including bolts, nuts, washers, straps, temporary jigs and strutting, etc.) and incidentals necessary to complete the work.

(2) Payment for Relocate Traffic Sign and Post(s) shall include any necessary excavation, cleaning of post(s) and sign, painting of post and frame if necessary, all materials labour and equipment required to reinstall the sign and post(s) in a location satisfactory to the Engineer.

SECTION 606

KILOMETRE AND EDGE MARKER (GUIDE) POSTS

606.01 DESCRIPTION

(1) The work covered by this Section consists of furnishing and erecting reinforced concrete kilometre posts and edge marker posts as shown on the Drawings or as directed by the Engineer.

606.02 MATERIALS

(1) Reinforced concrete shall be in accordance with Section 507 of the Specifications. Reinforcing steel bars shall be in accordance with Section 506 of the Specifications.

606.03 MANUFACTURING REQUIREMENTS

606.03.1 Forms

(1) The forms used for precasting the concrete members shall conform to Section 505 of the Specifications with the following additional requirements as specified herein.

(2) All joints shall be carefully fitted.

(3) All exposed corners shall be chamfered 10 mm unless otherwise shown on the Drawings or directed by the Engineer.

(4) Forms for exposed surfaces less than 200 mm in width shall be either of single width boards or lines formed from approved suitable material. No form joints will be permitted in these surfaces.

(5) Letters and numbers of approved appearance shall be fixed in the forms before casting.

606.03.2 Dimensions

(1) Elements shall be manufactured to the dimensions shown on the Drawings and/or as otherwise specified by the Engineer. Manufacturing tolerances shall be ± 3 mm in any one dimension and end faces shall be truly perpendicular to the base.

606.03.3 Concrete Works

(1) Reinforcement shall be cut, bent, placed and fixed in the positions shown on the Drawings in accordance with the requirements of Section 506 of the Specifications.

(2) The operations of preparing, mixing, casting and curing concrete shall comply with the requirements of Section 507 of the Specifications.

(3) The class of concrete shall be as specified on the Drawings or, if not specified, Grade 25.

(4) The date of precasting shall be stamped on the element in a place which will not be visible in its final position.

606.03.4 Surface Finish

(1) The finished product shall be of sound appearance with clean plane faces, be free of segregation, honeycombing, pits, broken corners or other defects. External rendering to remedy effects will not be allowed. Any defects which the Engineer considers to be minor may be repaired with approved materials to the satisfaction of the Engineer.

606.03.5 Approval

- (1) Final approval will be given when the elements are installed in place, as shown on the Drawings to the full satisfaction of the Engineer.
- (2) Rejected elements shall be promptly removed and replaced at the Contractor's expense.

606.03.6 Age of Concrete

- (1) Precast elements shall not be placed until at least 2 months after manufacture.
- (2) The period may be reduced as permitted by the Engineer when rapid-hardening cement is used.

606.04 CONSTRUCTION REQUIREMENTS

606.04.1 Excavation and Backfill

- (1) Foundation trenches and pits shall be excavated to the required depth and compacted to form a level and solid surface. Unsuitable material below the base shall be removed to a minimum depth of 150 mm below the foundation elevation and backfilled with suitable material compacted to the requirements of the Specifications. Excavation, backfill and compaction shall conform to the relevant requirements of Section 207 of the Specifications.

606.04.2 Location

- (1) Edge marker posts shall be placed at the locations ordered by the Engineer.
- (2) Kilometre posts shall be placed at every kilometre alternatively on either side of the road.

606.04.3 Painting

- (1) Unless otherwise shown on the Drawings, the kilometre posts shall be painted white with an approved oil-based paint recommended for use on concrete by the manufacturer.
- (2) Numerical figures on kilometre posts shall be in Arabic numerals of equal width and the wording on kilometre posts shall be in solid Lao characters of equal width, all as shown on the Drawings or directed by the Engineer. The paint for numbers/characters shall be black and shall be an oil-based paint, recommended for use on concrete by the manufacturer and approved by the Engineer.

606.05 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
606-1	Kilometre Posts	Number
606-2	Edge Marker (Guide) Posts	Number

606.06 PAYMENT

- (1) Payment will be made at the rates entered in the Bill of Quantities, which shall include excavation, removal of unsuitable material and replacement with suitable material, compaction, formwork, reinforcement, foundations, backfill, painting and all other work as specified.

SECTION 607

CONCRETE KERBS (BARRIER AND MOUNTABLE) AND GUTTER

607.1 DESCRIPTION

(1) This work shall consist of providing concrete barrier kerb, mountable kerb, concrete kerb and gutter and concrete barrier kerb as shown on the drawings or as required at locations determined by the Engineer. The work covered by this Section consists also of the manufacture of and construction of pre-cast kerbs with concrete bed and backing. The work shall be constructed as shown in the standard details and in conformance with the requirements of Section 607 of these Specifications.

(2) This work shall also include barrier kerb and kerb markings of black and white paint where shown on the Drawings or designated by the Engineer.

607.2 MATERIALS

(1) Bedding material, where show on the Drawings, shall consist of Grade 15 concrete as defined in Section 507 of these Specifications or approved granular material as defined in Section 208 of these Specifications, or as otherwise instructed by the Engineer.

(2) Concrete for kerbs and gutters shall be Grade 25 as defined in Section 507 of these Specifications.

(3) Bedding mortar shall consist of one part Portland cement to 2 parts sand. Sufficient water shall be added to give a mix that will support the kerb without being squeezed out.

(4) Paint shall be of approved industrial quality and shall conform to an international standard acceptable to the Engineer.

607.3 CONSTRUCTION REQUIREMENTS

(1) Excavation shall be made to the required depth, and the base upon which the kerb, gutter, or combination kerb and gutter is to be set shall be compacted to a firm even surface. All soft and unsuitable material shall be removed and replaced with suitable material. If shown on the Drawings, bedding mortar shall be placed and compacted to form a bed of the required thickness, but not more than 15mm thick.

(2) As an alternative to the use of bedding mortar the Contractor may use a “dry concrete” for the bedding and bed the kerb directly on the concrete bed. The “dry concrete” shall have the same strength as the specified bedding concrete.

(3) Formwork for pre-cast kerbs shall be constructed entirely in steel.

(4) When a kerb is placed next to a concrete pavement, expansion joints in the kerb shall be located opposite expansion joints in the pavement. Expansion joints shall be formed at the intervals shown on the Drawings using preformed filler 10 mm in thickness in accordance with the requirements of Section 314 of these Specifications. Dummy joints with the concrete pavement shall not be measured and paid for separately but shall be considered incidental to the pay item for the kerb.

(5) Concreting shall be generally in accordance with the requirements of Section 507 of these Specifications. Forms shall be removed within 24 hours after concrete has been placed. Minor defects shall be repaired with mortar containing one part of Portland cement and two parts of fine aggregate. Repair will not be permitted on the faces and rejected portions shall be removed and replaced at the Contractor's expense. The exposed surfaces shall be finished while the concrete is still green, by wetting a soft brick or a wood block and rubbing the surfaces until they are smooth. The surfaces shall

be wet thoroughly either by 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 then be 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 covered with suitable materials and kept moist for a period of 3 days. The concrete shall be suitably protected from the weather until thoroughly hardened.

(6) After the concrete has set sufficiently, the spaces in front and back of the kerb and gutter shall be refilled to the required elevation with the proper material, which shall be tamped in layers of not more than 150 mm, until properly compacted.

(7) The finished kerb alignment shall have a tolerance of + or – 3 mm to the specified alignment in both horizontal and vertical directions and shall be laid to present smooth flowing alignments.

607.4 MEASUREMENT

(1) Measurement will be as follows:

Item No.	Description	Unit
607-1	Concrete Kerb	Metre
607-2	Mountable Kerb	Metre
607-3	Concrete Kerb and Gutter	Metre
607-4	Precast Concrete Kerb	Metre
607-5	Concrete Barrier Kerb, Type ____	Metre
607-6	Concrete Barrier Kerb, Type ____	Metre
607-7	Kerb Marking	Metre Square
607-8	Barrier Marking	Metre Square

(2) The quantity measured for payment shall be the number of linear metres of concrete of the several types and sizes of concrete gutter, kerb, and the combination kerb and gutter completed in place and accepted. Concrete kerb, gutter and combination kerb and gutter shall be measured in place along the centre of the gutter, or kerb. Deductions shall be made for flattening of kerbs for entrances or for kerb drainage inlets.

(3) Concrete Barrier Kerb will be measured by the linear metre along the longitudinal axis of the finished barrier, including the transitions at ends complete in place, as directed by the Engineer.

(4) Kerb Markings and Barrier Kerb Markings shall be measured on a two-dimensional basis by the square metre for the areas painted as directed by the Engineer.

607.5 PAYMENT

(1) Payment will be made at the rates entered in the Bill of Quantities

(2) Concrete Kerb, Mountable Kerb, Concrete Kerb and Gutter and Concrete Barrier Kerb as measured in Clause 607.4 of these Specifications shall be paid per linear metre, complete in place, which prices shall include all excavation backfilling, tamping, materials, formwork, equipment, tools, labour and all incidentals necessary to proper completion of the work.

(3) Kerb Markings will be paid per square metre, complete and accepted by the Engineer, which price shall include all paints of required colours and quality, labour, tools and incidentals necessary to the satisfactory completion of the work.

SECTION 608

FOUNDATION INVESTIGATIONS

608.01 GENERAL REQUIREMENTS

608.01.1 Preamble

(1) Foundation investigations shall be carried out by the Contractor at the location of each abutment and pier positions for all structures unless otherwise directed by the Engineer, in accordance with the following requirements.

608.01.2 Major Structures

(1) Major structures shall be defined as bridges with a total length more than a single 12 metre span. For such structures the investigations shall comprise a minimum of two boreholes at each foundation location. Boring shall be done by shell and auger equipment or rotary drilling equipment as appropriate. In case these boreholes show appreciable differences in geologic strata/levels then a third borehole shall be undertaken. At pier locations the initial (two) boreholes shall be about 5 metres apart, while the boreholes below abutments shall be located within the area of influence.

(2) The locations of all boreholes shall be subject to the approval of the Engineer.

608.01.3 Other Structures

(1) For bridge structures (including submersible bridges) not covered under Sub-clause 608.01.2 above and for box culvert structures, the investigations will comprise Dynamic Cone Penetration (DCP) testing to at least 2 metres below founding level or a Plate Loading Test at foundation level with auger boring to 2 metres below founding level to confirm material consistency.

(2) The number of tests to be undertaken will be determined by the Engineer depending on the length of the structure and the severity of the imposed loading (overburden).

608.01.4 Available Information

(1) Where sub-soil investigations have been undertaken as part of the design, data therefrom will be made available to the Contractor for information only and will not be construed as data provided under the Contract. Such data shall be for guidance only.

608.01.5 Confirmation of Design

(1) The data obtained from the sub-soil investigations undertaken under this Section of the Specifications will be used by the Engineer to confirm or amend the designs of the structures as given in the Drawings.

(2) No work shall commence on construction of a structure until the design has been confirmed or amended by the Engineer, and the Contractor shall incorporate these requirements into his construction programme.

608.02 BORING AND DRILLING

608.02.1 General

(1) Boring and Drilling shall be done according to ASTM D2113 - 14 "Standard Practice for Rock Core Drilling and Sampling of Rock for Site Exploration".

(2) The Contractor shall provide and use boring/drilling equipment capable of satisfying the following requirements:

- a) Equipment capable of taking 300 mm long and 100 mm diameter undisturbed samples in cohesive soil.
 - b) Equipment capable of taking cores of NX size (54 mm diameter) in rock. Double tube core barrels (swivel type) shall be used for recovery of cores.
- (3) The diameters specified shall be obtained at the maximum depths required.
- (4) The boreholes shall have a minimum diameter of 100 mm and shall be adequately supported (by lining or drilling mud) and unless otherwise specified elsewhere in the Contract Documents or instructed by the Engineer, shall be taken to 10 metres below the founding level shown on the Drawings or to a depth of 3 metres below the sound rock strata having a Rock Quality Designation (RQD) 75%, whichever is lesser.
- (5) The boreholes shall be sunk by shell and auger to hard rock strata and then rotary Tungsten-Carbide (TC) or diamond drilling, with coring, in rock with a water flush system. Double tube core barrels shall be used for drilling in rock.
- (6) Casing shall be used in all bore or drill holes down to rock level. The toe of the lining shall at no time be more than 1.0 metre above the level to which the soil has been removed from the borehole.
- (7) Casing shall not be driven below any level at which sampling or testing is to be conducted until the sampling or testing at that level has been completed. No borehole shall be backfilled nor the casing removed without the prior approval of the Engineer.
- (8) In addition to the details as listed in Clause 608.05 for all boreholes a record shall be kept of "Percentage of recovery", "Rock Quality Designation (RQD)" and "penetration times" for each core run.
- (9) Where the advance of a borehole using shell and auger technique is obstructed by cobbles, boulders or a layer of hard or other tough material, the use of a chisel or drill may be adopted to penetrate these materials where approved by the Engineer.
- (19) No water shall be added while boring through cohesive soils and cohesion-less soils above the water table. While boring through cohesion-less soil below water table, the water level in the casing shall always be maintained above the water table so that a positive head is maintained at the base of the borehole at all times.
- (11) After completion of the borehole, a bore-log shall be prepared by a qualified Geotechnical Engineer in an approved standard proforma and three (3) copies shall be submitted to the Engineer. Soils shall be logged in accordance with the Unified Soils Classification System (USCS) and rock will be logged in accordance with the United Kingdom Geological Working Party Report or approved equivalent.
- (12) After observing the position of the water table after 24 hours, backfilling of the borehole shall be carried out with approved materials in a manner as approved by the Engineer.

608.02.2 Rejection of Boreholes

- (1) If any borehole cannot be completed according to the Specifications because it has been drilled off line or caving in has occurred or because tools are jammed in the hole or for any other reason, the Engineer may order the boring to be discontinued, the hole backfilled and a replacement borehole drilled at a nearby location to be designated by the Engineer. No payment will be made for any rejected borehole.

608.02.3 Standard Penetration Test (SPT)

- (1) Standard Penetration Test shall be conducted inside each borehole as per Test 19 of BS 1377 at the following intervals or at every identifiable change of strata, whichever is earlier.

- 0 – 15.0 m @ 1.5 m interval
- 15 – 30.0 m @ 2.0 m interval

(2) The driving of split-spoon shall be recorded for every 75 mm of penetration till the total penetration is 450 mm.

(3) The driving of the split-spoon shall be terminated when $N > 50$ blows/ 15cms of penetration or when no advancement in penetration is recorded for 10 consecutive blows. The test shall be conducted after driving the casing to the bottom of the borehole and after cleaning out. N-values as observed in the field shall be reported in the bore-logs without any correction for overburden and water table. In soils containing a high percentage of coarse gravel, the normal split-spoon sampler may, at the discretion of the Engineer, be replaced by a solid 60° cone.

608.02.4 Sampling

a. Disturbed Soil Sampling

(1) Disturbed samples shall be taken from borehole cuttings and split-spoon of the Standard Penetration Test apparatus for visual classification and field identification tests at the site. The samples shall be taken at 1.5 m intervals or at every identifiable change of strata, whichever is more frequent, to give a reliable record of the variations in the condition of the soil. Disturbed samples shall be sent to the laboratory in air-tight plastic containers suitably and uniquely labelled for record purposes and laboratory soil classification testing.

b. Undisturbed Soil Sampling

(1) Undisturbed sampling of cohesive soils, i.e. clay (fine grained soil) or soil with a high clay content, shall be done according to ASTM D15787.

(4) All undisturbed samples shall be securely packed before transport to the laboratory. The packing and transport of the samples shall be by a method which will ensure the least possible disturbance to the samples.

(5) All undisturbed samples shall be clearly labelled with the borehole number, the sample number and the depth and date of sampling.

c. Rock Cores

(1) Sampling of rock cores shall be done according to ASTM D5079.

(2) Continuous NX size cores shall be recovered from rock strata for the full depth of the rock to be drilled.

(3) The cores are to be preserved in standard core boxes 1.5 m long and divided longitudinally by light battens to hold 5 rows of core. The core boxes are to be soundly constructed with fastenable lids fitted with strong locks and are to be to the approval of the Engineer. Each lock shall have three (3) keys which shall be given to the Engineer. Adequate core boxes shall be available before drilling commences. The core box shall be carefully marked to show the Contract number and title, the borehole number, chainage and depth, etc., and the core shall be laid in the boxes to produce a true record of the formation as drilled. Where required spacer blocks shall be inserted to indicate the end of a drill run and the start of the next run.

(4) There must be no movement of the cores when the box is closed. Spacer pieces of a length equal to any missing lengths of core shall be placed in box to fill any gaps. The boxes shall be marked similarly both inside and outside the lid, on top and at one end, showing the boreholes reference number and the depths of the borehole at which the core has been extracted with the date of coring.

(5) Representative samples of rock cuttings or sludge shall be retained where cores cannot be recovered, for example in weathered, shattered or jointed rock. These cuttings shall be treated as disturbed samples.

(6) The cores shall be laid out at a location to be designated by the Engineer, for the Engineer's examination. After this examination, the Contractor shall take a colour photograph of all parts of the core or samples, after longitudinal splitting, (if required) against a metric scale, colour chart and identification label, as instructed by the Engineer. The rock cores shall be suitably moistened before photography. Prints shall be supplied as directed by the Engineer, showing complete core boxes at not less than one-tenth natural scale, with selected larger scale details as directed by the Engineer.

(7) The cores shall then be replaced in the core box and kept in the store or despatched for laboratory tests as directed by the Engineer.

d. Water Sampling

(1) 5 litre samples of groundwater shall be taken as directed by the Engineer from the boreholes and placed in sealed jars and clearly labelled giving the site location, borehole number and depth and time at which the samples were taken.

e. Despatch of Samples

(1) All samples shall be despatched to the laboratory as soon as possible after being obtained and shall not accumulate at site. If it appears to the Engineer that there is a danger of samples deteriorating through further storage, the Contractor shall despatch such samples as soon as directed by the Engineer.

f. Core and Sample Storage

(1) A secure shed to the approval of the Engineer shall be erected at an approved location adjacent to the Engineer's main office. The shed shall be large enough to accommodate all core boxes and samples in a convenient manner for subsequent inspection.

(2) The filled core boxes and samples shall on completion of each hole be laid out as to provide rack storing of core boxes and samples allowing easy access to each. The layout of the store shall be to the Engineer's approval. The shed shall on completion of the Contract become the property of the Contractor (and shall be removed) but the core boxes, rock cores, samples and other contents shall become the property of the Engineer.

(3) Undisturbed and bulk samples despatched to the laboratory for testing shall be retained for at least 3 months after submission of test results or shall be returned to the Engineer as directed by the Engineer.

608.03 INVESTIGATIONS FOR MAJOR STRUCTURES AND CULVERTS

608.03.1 Dynamic Cone Probing

(1) Dynamic Cone Probing shall be conducted as per BS 5930:2015. A 50 mm diameter cone shall be attached to drill rods (whose diameter shall be slightly less than the cone) and shall be driven into the ground by a 63.5 kg monkey (hammer) falling freely through a height of 750 mm. The number of blows required for every 100 mm penetration shall be recorded. The probing shall be continued up to 10 m depth or where the number of blows exceeds 100 for 300 mm penetration.

(2) A graphical representation of the number of blows for every 300 mm of penetration shall be prepared and submitted to the Engineer.

608.03.2 Plate Load Tests

(1) Where Dynamic Cone probing is not possible due to presence of hard deposits or cobbles at shallow depth, a Plate Load Test shall be conducted as per ASTM D1194 at founding level by excavating a trial pits of suitable size.

(2) On completion of plate load test, a short borehole shall be made by a 100 mm diameter hand auger up to a depth of 2 m below plate load test level. Disturbed samples shall be collected at 0.5 metre intervals and shall be tested for natural moisture content, grain size analysis and liquid and plastic limit. The ground water level in the borehole, if encountered, shall be measured and reported.

608.03.3 Trial Pits

(1) Trial pits shall be made as per BS 5930:2015. The size of trial pit shall be 2 metres x 2 metres in plan and shall extend to the proposed founding level. Undisturbed samples shall be taken by driving a 100 mm diameter thin sampling tube into the bottom of the trial pit. In addition, 2-3 metre deep hand auger boring shall be carried out and disturbed samples collected for natural moisture content, grain size analysis and liquid and plastic limit tests. Ground water, if encountered shall be measured and reported. A bore-log along with description of stratum up to trial pit bottom shall be prepared and submitted. The trial pit shall be backfilled as and when directed by the Engineer.

608.04 LABORATORY TESTS

608.04.1 General

(1) Laboratory test shall be carried out as specified in Section 105. The results of all tests shall be submitted on an approved proformas. The following routine classification tests are required:

- (i) Natural Moisture Content
- (ii) Natural Bulk Density and Dry Density
- (iii) Grain size analysis including clay fraction
- (iv) Liquid and plastic limits
- (v) Specific Gravity
- (vi) Organic Content on selected soil samples

608.04.2 Preparation of Test Specimens

(1) Preparation of test specimens for the various tests shall be carried out as per the procedures laid down in the relevant AASHTO Standards.

(2) In case of soft to firm cohesive undisturbed soil samples, test samples for all types of strength tests shall be prepared strictly by hand trimming on a soil lathe. Care shall be taken to avoid bending of the soil samples ejected from the sampling tubes. Samples shall be ejected in the same direction of travel as the samples entered the tubes.

(3) Similarly, test specimens for consolidation tests shall be prepared to the required size by hand trimming only. The ring of the consolidation apparatus shall be inserted by pressing gently with the hands and carefully removing the material around the ring. In no case shall the ring be forced into the soil. Great care shall be taken during the trimming of the sample at the top and the bottom of the ring. The test specimen shall be prepared in the same orientation as that of the actual strata so that the laboratory test load compresses the soil in the same direction relative to the soil strata as the applied load in the field.

608.04.3 Unconfined Compression Tests

(1) Unconfined compression tests, shall be carried out as per AASHTO T 208 or ASTM D2166. The test shall be conducted both on intact and remoulded soil samples. Remoulded soil specimens shall be prepared by the dynamic method of compaction.

(2) Each unconfined compression test (intact or remoulded) shall comprise of tests on minimum of three soil specimens not less than 33 mm in diameter and a height to diameter ratio of 2 to 2.5. After testing, the natural moisture content and density of the sample shall be determined. The water content of the specimen shall be taken from the failure zone of the specimen. The test results shall be observed and reported as per standard practice.

608.04.4 Triaxial Tests

- (1) Triaxial tests shall be conducted on samples in unconsolidated and undrained condition, -i.e. on undisturbed samples-, selected by the Engineer and in accordance with ASTM D2850 (Standard Test Method for Unconsolidated-Undrained Triaxial Compression Test on Cohesive Soils).
- (2) If directed by the Engineer, the tests shall also be conducted in consolidated undrained condition with or without measurement of pore pressure.
- (3) The stress-strain diagrams as well as the Mohr circle envelopes for these tests shall be submitted to the Engineer.

608.04.5 Consolidation Tests

- (1) Consolidation tests on soil samples shall be done according to ASTM D2435 (Standard Test Methods for One-Dimensional Consolidation Properties of Soils Using Incremental Loading).

608.04.6 Rock Core Sample Tests

- (1) Rock samples shall be prepared and tested according to ASTM D7012 (Standard Test Methods for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens under Varying States of Stress and Temperatures).

608.04.7 Chemical Analysis

- (1) Chemical analysis of soil and water samples shall be carried out for ph value, sulphate content (SO₄), calcium content, chloride content and total dissolved solids.

608.05 REPORT AND RECORDS

- (1) On completion of each borehole, three copies of the bore-logs shall be submitted to the Engineer, along with one copy of the list of disturbed and undisturbed samples taken from the borehole.
- (2) The bore-logs shall show:
 - (i) Ground level referred to the reduced level;
 - (ii) The location of the borehole referenced by coordinates and by a sketch plan showing offsets to adjacent permanent or semi-permanent features;
 - (iii) A detailed description of each stratum;
 - (iv) The position, type and identification of each sample and SPT value;
 - (v) Any other field test results;
 - (vi) The levels at which each separate ground water level was first encountered and at which it came to rest (standing water level);
 - (vii) Any changes in the physical condition of rock cores after recovery and storage.
- (3) On completion of all field and laboratory testing, all the results shall be submitted to the Engineer in 3 (three) copies.

608.06 MEASUREMENT

- (1) Measurement will be as follows:

Item	Description	Unit
608-1	Mobilise Drilling Rigs to Site	Lump Sum
608-2	Shift Drilling Rigs to Next Structure Site	Number
608-3	Shell and Auger Boring:	
	0 – 10 metres	Metre
	10 – 20 metres	Metre
	20 – 30 metres	Metre
608-4	Drilling in Rock	Metre
608-5	Dynamic Cone Probing	Metre
608-6	Plate Load Tests	Number
608-7	Trial Pits	Number
609-8	Additional Testing	Provisional Sum

(2) Measurement for item 608-3 shall be from ground level at the top of the borehole to the depth order by the Engineer or to the base of the hole whichever is of lesser length.

608.07 PAYMENT

(1) Payment will be made at the rate entered in the Bill of Quantities.

(2) Payment for the Mobilise Drilling Rigs to Site item shall include for the establishment of all boring and rock drilling equipment at the first structure site to the investigated, and for eventual removal from Site of the drilling rigs on completion of the investigation work. One half of the lump sum will be payable on establishment of the equipment at the first site with the second half payable on demobilisation and removal of the equipment from Site or at such earlier date as may be approved by the Engineer.

(3) Payment for the Shift Drilling Rigs to Next Structure Site item shall be made on completion of the transfer of equipment to each succeeding structure site.

(4) Payment of the Shell and Auger Boring item shall include all boring, chiselling, sampling, conducting SPT, preparation, storing and transportation of samples to the laboratory as directed, in-situ and laboratory testing and the keeping and providing of boring records, including laboratory testing and reports.

(5) Payment for the Drilling in Rock item shall include for all drilling, sampling, core boxes, locks, keys, storage of core boxes, photographing cores and keeping and providing records, including laboratory testing and reports.

(6) Payment for the Dynamic Cone Probing item shall include mobilisation and demobilisation and shifting between locations and sites, driving of cone, recording, interpretation, and preparation of the report.

(7) Payment for the Plate Load Test item shall include mobilisation and demobilisation, shifting between sites, preparing trial pit, auger boring, conducting plate load test, sampling, laboratory testing of disturbed samples, recording and preparation of reports.

(8) Payment for the Trial Pits item shall include mobilisation and demobilisation, shifting between sites, preparation of the trial pits, conducting auger boring, collection of disturbed and undisturbed samples, laboratory testing and preparation of reports.

(9) No separate payment shall be made for the in 608.04.1 specified routine classification testing and the rates entered shall be deemed to cover these costs. However, the Engineer may order other tests, not necessarily restricted to those described herein, in which case such tests will be carried out at a commercial laboratory approved by the Engineer. For these special tests, reimbursement will be made under the Additional Testing item in the Bill of Quantities as the net approved test sum together with sample transportation costs, plus 10% to cover overheads and profit.

SECTION 609

SODDING

609.01 DESCRIPTION

(1) The work covered by this Section consists of furnishing and laying of live sod on the shoulders, slopes, ditches or other locations as designated construction of sod ditch checks or similar components preventing erosion of the materials in which it is planted, all as shown on the Drawings or as ordered by the Engineer.

609.02 MATERIALS

(1) The sod shall consist of healthy, dense, well-rooted growth of permanent and desirable grasses indigenous to the general locality where it is to be used. It shall be free from weeds or undesirable grasses. The sod shall be deep rooted and sufficiently rapid growing and spreading to give complete cover over the planted area within two years of planting.

(2) At the time the sod is cut, the grass on the sod shall have a length of approximately 50 mm (if longer, the grass shall be cut to approximately this length) and the sod shall have been raked free from debris.

(3) For block sodding, the sod shall be cut into uniform squares approximately 300 mm x 300 mm.

(4) For strip sodding, the sod shall be cut into uniform strips 300 mm wide and approximately 1.0 metre long, rolled for convenience of handling and transportation.

(5) The thickness of the sod shall be as uniform as possible, approximately 40 mm or more depending on the nature of the sod, so that practically all of the dense root system of the grasses will be retained, but exposed in the sod strip so and that the sod can be handled without undue tearing or breaking.

(6) In the event that the sod to be cut is in a dry condition so as to cause crumbling or breaking during cutting operations, the Contractor, at his own expense, shall apply water in sufficient quantities at least 12 hours before cutting to provide a well-moistened condition of the sod to the depth to which it is to be cut.

(7) All sods shall be subject to the approval of the Engineer.

(8) Fertiliser shall be approved lime or mixtures of plant nutrients or both.

609.03 CONSTRUCTION REQUIREMENTS

609.03.1 Scheduling of the Work

(1) Grass shall be planted at such a time and the work shall be done in such a way that at the time of the final construction inspection all areas to be grassed are substantially covered with healthy, well established, firmly rooted grass and the planted area is free from erosion channels.

609.03.2 Preparation of the Earth Bed

(1) The area to be sodded shall be constructed to the required cross-section and contour, and the tops and bottoms of the slopes shall be rounded as shown in the typical roadway section Drawings.

(2) The areas to be sodded shall be free from stones, roots or other undesirable foreign materials.

- (3) The soil on the area to be sodded shall be loosened and brought to a reasonably fine texture to a depth of not less than 30 cm by means of equipment or hand methods adapted for the purpose.

609.03.3 Placing the Sod

- (1) The earth bed upon which the sod is to be placed shall be moistened to the loosened depth, if not naturally sufficiently moist, and the sod shall be placed thereon within 24 hours after the sod has been cut.
- (2) Unless otherwise required, the sod on slopes shall be laid in horizontal strips beginning at the bottom of the slope and working upwards. When placing sod in ditches, or in the construction of sod ditch checks or similar appurtenances, the length of the strips shall be laid at right angles to the direction of the flow of the water.
- (3) Sod shall be laid so that the joints caused by abutting ends of sod strip are not continuous. Each sod strip shall be so laid as to abut snugly against strip previously laid.
- (4) As the sod is being laid it shall be lightly tamped with suitable wooden or metal tampers sufficiently to set or press the sod into the underlying soil.
- (5) At points where it is anticipated that water may flow over a sodded area, the upper edges of the sod strips shall be turned into the soil to be below the adjacent area and a layer of earth place over this juncture and thoroughly compacted. At the limits of sodded areas, the end strips shall be turned in and treated similarly.
- (6) Fertiliser shall be added at the time of planting if required in the Contract Documents or if it is necessary to ensure good ground cover within the required time.

609.03.4 Staking the Sod

- (1) On all slopes steeper than one vertical to four horizontal, sod shall be pegged with stakes 200-300 mm in length, spaced as required by the nature of the soil and steepness of slope. Stakes shall be driven into the sod at right angles to the slope until being in the same plane as the bottom of the grass blades.

609.03.5 Top Dressing

- (1) After staking has been complete, the surface shall be cleared of loose sod, excess soil or other foreign material, whereupon a thin layer of topsoil shall be scattered over the sod as a top dressing and the areas shall then be thoroughly moistened by sprinkling with water.

609.03.6 Watering and Maintenance

- (1) The Contractor shall regularly water and maintain sodded areas in a satisfactory condition for the duration of the Contract and until final acceptance of the Works by the Engineer. Such work shall include cutting the grass if so directed by the Engineer.

609.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
609-1	Sodding	Metre Square (Horizontal or Sloping)

609.05 PAYMENT

- (1) Payment will be made at the rate entered in the Bill of Quantities which rate shall include for preparing the bed, for furnishing, placing, staking, top dressing and watering and maintenance of the sod, and for all labour, equipment, tools and incidentals necessary to complete the Item.

SECTION 610

BIO-ENGINEERING: PLANTING AND SOWING

610.01 DESCRIPTION

(1) This item shall consist of furnishing and planting grasses, shrubs and trees as shown in the Drawing or as ordered by the Engineer, using vegetative cuttings, or nursery-raised seedlings.

610.02 MATERIALS

610.02.1 General

(1) All planting stock shall be of high quality and is vigorous enough to grow on the site to be planted.

(2) All planting stock must be of approved species in the lists produced from time to time by the Engineer, and will be either indigenous to Lao or of known vigorous pan-tropical characteristics. They must be appropriate for the precise site conditions in which they are to be planted and the Contractor must ensure that they apply to the specific altitude and other environmental characteristics of the site in question.

(3) The timing of many bio-engineering operations is of the utmost importance. Activities such as planting must be carried out within the critical few weeks when they will yield the desired results.

(4) All bio-engineering plant materials, planting schedule and constructed measures shall be subject to the approval of the Engineer.

610.02.2 Species of Plants

(1) The Contractor is to use only species drawn from the List of Approved Species for Bio-engineering in Annex A to this Section or as otherwise instructed by the Engineer.

610.02.3 Provision of Grass Slip Cuttings

(1) Slip cuttings, consisting of a section of the stem, the rhizome (the tubular underground section) and roots (the fibrous underground section) must be taken from grasses of approved species that are known to propagate easily by vegetative means. They should normally be collected in locations adjacent to the site. The size of cuttings to be made depends on the species and should be as described in this section or in lists of approved species, the Drawings or the Engineer's instruction.

(2) The Contractor is responsible for making all necessary arrangements with landowners, farmers and the local Forest Office, as applicable, before the excavation of plants to make cuttings.

(3) Cuttings must be made only from healthy plants that show vigorous growth and good form. Grass clumps with stunted growth should not be considered as sources. Since roots are required as part of the cuttings, grass clumps should be carefully dug up to avoid damage the material.

(6) Individual slip cuttings shall be made by separating the clumps carefully by hand, using a sharp knife or razor blade when necessary. There must be no tearing of the plant fabric. Slips shall be formed that consist of one large or two small stems, with the rhizomes and roots still attached. They must be trimmed down using a sharp knife or machete to give two or three nodes on the stem and rhizome, and, with at least two viable buds on the rhizome. The different sizes of grass plants are as follows:

- (i) Fully rhizomatous grasses such as nyar khaem or dok khaem (broom grass or *Thysanolaena latifolia*): slip cuttings with 100 to 150 mm of stem and 50 to 80 mm of rhizome.

- (ii) Semi-rhizomatous large grasses such as nyar kha (*Imperata cylindrica*): slip cuttings with 100 to 200 mm of stem and 50 to 80 mm of rhizome.
 - (iii) Semi-rhizomatous smaller grasses such as nyar phaek or nyar khaem Lao (*Themeda triandra*, *Vetiveria zizanioides* and *T. arundinacea*): slip cuttings with 100 to 150 mm of stem and 30 to 60 mm of rhizome and root.
- (7) All fibrous roots must be cut off 25 to 50 mm from the rhizome. The slips should be checked to ensure that they have enough rhizome and stem to be a viable plant.
- (8) Cuttings must be immediately wrapped in wet hessian jute and are to be kept moist and as cool as possible until planted. All cuttings must be planted the same day that they are made.

610.02.4 Provision of Standard Hardwood Cuttings

- (1) Hardwood cuttings must only be taken from shrubs and trees of approved species, which are known to propagate easily by vegetative means.
- (2) Cuttings must be made from as many healthy individual plants as possible. The plants from which the cuttings are taken must show vigorous growth and good form. Mis-shapen and stunted plants should not be considered as sources.
- (3) Apart from the branches from which cuttings are taken, the Contractor must under no circumstances damage plants while taking cuttings. The Contractor is responsible for making all necessary arrangements with landowners, farmers and the local Forest Office, as applicable, before the making of hardwood cuttings. In no event is more than 60 percent of the aerial parts of a single plant to be removed in the making of cuttings.
- (4) Hardwood cuttings must be made from stems which are between 6 and 18 months old. Materials outside this range are not normally vigorous or strong enough to survive as cuttings.
- (5) Hardwood cuttings must be made using sharp secateurs or a sharp saw. The top cut should be made at right-angles to the stem and the bottom cut should be made at 45° to the stem: this is to show the orientation of planting. Side branches are trimmed off close to the main stem, just outside the point where the woody material narrows down to the diameter of the branch. Under no circumstances must there be any tearing, bruising or other damage to the bark of the cutting.
- (6) Hardwood cuttings shall be 20 to 40 mm in diameter and of the following lengths, which sizes should not be exceeded unless specified by the Engineer.
- (i) 500 mm for use in palisades, vegetated stone-pitched walls and for pegging jute netting.
 - (ii) 450 to 600 mm for use in brush layers.
 - (iii) 1000 to 2000 mm for use in fascines.
 - (iv) 2000 mm for the horizontal elements in live check dams.
- (7) Once cuttings have been made, they shall be immediately wrapped in wet hessian jute and kept moist and as cool as possible at all times. All cuttings shall be planted the same day that they are made.

610.02.5 Provision of Large Truncheon Cuttings

- (1) A number of species can be propagated using large truncheon cuttings, and these are identified on lists of approved species. This form of cutting is for use in certain unstable debris slopes and to form the vertical elements in live check dams. Hardwood cuttings for truncheons shall be from material that is 18 to 30 months old, and is 30 to 80 mm in diameter. Cuttings shall be made to 2000 mm in length unless otherwise specified.
- (2) Apart from the age and size details, all other aspects of truncheon cuttings shall be as described in Sub-section 610.02.3.

610.02.6 Provision of Nursery-raised Seedlings

- (1) Nursery raised seedlings, shall be used in accordance with the Drawings or as instructed by the Engineer. Plants shall be of a suitable standard and of the approved species.
- (2) Nursery-raised seedlings shall be supplied in polythene pots of 75 × 180 or 100 × 180 mm or greater when laid flat. The pots should be of black, 200 gauge polythene. They must have adequate drainage holes at the bottom and be filled with fertile forest topsoil mixed with clean sand to a texture of sandy loam.
- (3) Plants should have been cultivated with suitable water and light conditions. Plants that have been shaded for too long become long and thin (etiolated), resulting in weak stems, are not acceptable. Roots protruding from the bottom of pots greater than 25mm in length should have been pruned during cultivation.
- (4) Trees and shrubs must be healthy, vigorous and showing no signs of damage, wilt, irregular growth, fungal or pest attack, or nutrient disorders. They must be between 300 and 600 mm in height above soil surface level and of good proportion and form, without any pruning of shoots and branches. The roots must be in good condition and there should be no signs of disturbance to the soil in the polythene pot, including after transport to site.

16.02.7 Provision of Large Bamboo culm-and-rhizome Planting Stock

- (1) Large bamboos shall be used in accordance with the Drawings or as instructed by the Engineer. The Contractor will obtain plants of a suitable standard and of the approved species.
- (2) Large bamboo culm-and-rhizome planting stock must be made only on the day that it will be replanted on site.
- (3) To provide the planting stock, a section of rooted rhizome and an entire culm is cut out of an established bamboo clump. For replanting the culm cut off about 2 metres above the ground, leaving branches emerging from one or two of the nodes.
- (4) Material must be selected that consists of one-year-old rhizomes and 2.0-2.5 metres of culm. A suitable culm is selected near the edge of the parent clump and the rhizome dug out and cut off carefully. It must be removed from the clump with minimal damage to the fibrous roots.
- (5) The culm must be cut off about 2 metres above ground level. The rhizome is cut off where it branches from the main plant, care should be taken not to damage the buds and small roots.
- (6) The root ball must be wrapped in damp hessian and the cutting transported to site for planting on the same day.

610.02.8 Mulch

- (1) Mulch is to be produced or procured so that it can be used on site to enhance planting works. If prepared on site, its preparation shall commence at least 4 months before the date of its use.
- (2) Mulch should be made from annual and perennial weeds of poor rooting characteristics, such as khao nyar dork, Lao harng nyar or meuang harng nyar (*Eupatorium odoratum*). The greenery should be collected when there is most material available but before it forms seeds. This is most often in August and September.
- (3) Collected material should be chopped finely and stored in a mound, walled bay or pit. The maximum size for chopped mulch is 150 mm.
- (4) Mulch should be kept moist but not waterlogged, and in an aerated condition. It should be completely turned once a month on a regular schedule. At higher altitudes it can have cow manure mixed in to assist the process of decomposition.

(5) Mulch should not be applied on site until it is fully rotted, blackish in colour and the parts of individual plants indistinguishable. Early application can lead to a nutrient loss in the soil if microbes extract nitrogen to decompose the added organic material.

610.03 CONSTRUCTION REQUIREMENTS

610.03.1 General

(1) The planting of all bio-engineering measures is intended to create a strengthened slope surface which is resistant to erosion.

(2) The planting of all bio-engineering measures is a delicate business and should be approached in the same way as for agricultural crops. The Contractor should employ experienced and skilled agricultural labourers for this work.

610.03.2 Preparation of the Earth Bed

(1) The area to be planted shall be constructed to the required cross-section and contour, and the tops and bottoms of the slopes shall be rounded as shown in the typical roadway section Drawings.

(2) The areas to be planted shall be free from stones, roots or other undesirable foreign materials.

(3) The soil on the area to be planted shall be loosened and brought to a reasonably fine texture to a depth of not less than 100 mm by means of equipment or hand methods adapted for the purpose.

610.03.3 Planting of Grass Slips (Stem and Root Cuttings)

(1) The configuration of grass slip planting will be determined according to individual site conditions and indicated in the Drawing or Engineer's order. It will be either random, contoured, diagonal or downslope.

(2) Using appropriate tools (such as tape measures and spirit levels), planting lines must be marked out with string as required.

(3) All diagonal grass lines should be planted at 45 degrees to the line of maximum slope. In certain situations, where the planting ordered is not on an even grade but on a slope with a micro-scale landscape of ridges and rills, this means that the rows will not necessarily be straight or parallel. In this situation it is important that the line of planting is always related to the slope angle, and not to the relationship between neighbouring rows.

(4) The plants supplied should be prepared for planting as described in Sub-section 610.02. The Contractor is to transport them from the source wrapped in hessian jute. At all times, plants are to be kept moist and as cool as possible and be planted the same day as cuttings are taken.

(5) Planting should be started at the top of the slope and under no circumstances should new plants be walked on or otherwise disturbed. By using a small bar, a hole should be made that is just big enough for the roots. The slip cutting is inserted; care must be taken that the roots are not tangled or bent back to the surface. Soil is then replaced around the roots and firmed with the fingers. The spacing of plants within rows should be 100 mm unless otherwise specified.

(6) If the soil is dry and there is no rain within 16 to 24 hours of planting, the site should be watered carefully with a fine spray. The Contractor is required to water for the first two weeks after planting in the event of inadequate rainfall.

610.03.4 Planting of Shrubs and Trees

- (1) The location and spacing of seedling plantation will be determined according to individual site conditions and indicated on the Drawings or as instructed by the Engineer. Seedlings should, unless otherwise instructed, be planted at 1500 mm centre-to-centre.
- (2) The Contractor is to transport the containerised plants to site with all due care. The polythene pots should not be removed until the moment of planting. Plants are to be lifted by the pots, and never by the stem or leaves. At all times they are to be kept as cool as possible and the soil around the roots not allowed to dry out. All plants must be planted within three days of removal from the nursery.
- (3) Planting should be started at the top of the slope and under no circumstances should new plants be walked on or otherwise disturbed.
- (4) A planting pit wide and deep enough for the roots to be buried in without bending, and wide enough for all the roots and surrounding soil ball, shall be made at the time of planting. The polythene pot must be removed from the seedling by cutting it away with a razor blade. The plant will then be carefully placed into the hole and the soil packed in around it by hand, ensuring that all gaps are filled and there are no air pockets. All surrounding soil is then firmed up using gentle foot pressure, taking care not to cause any damage to the plant or its roots. The surface over and around the pit should then be mulched using any appropriate, locally available material, such as dead leaves or cut herbage.

610.03.5 Brush Layering

- (1) Brush layering is a technique whereby woody (or hardwood) cuttings are laid in shallow trenches aligned across the slope, usually following the contour. These form a strong barrier, preventing erosion and the development of rills, and trap material moving down the slope. In the long term, a small terrace will develop. The main engineering functions are to catch debris, and to armour and reinforce the slope. In certain locations, brush layers can be angled to provide a drainage function.
- (2) The cuttings used for brush layering should be 20 to 40 mm in diameter and between 450 and 600 mm in length. They should be temporarily stored and transported wrapped in hessian jute. At all times, cuttings are to be kept moist and as cool as possible. All cuttings should be planted the same day that they are taken from the parent plant.
- (3) Brush layering should be constructed in accordance with this sub-section, unless otherwise instructed by the Engineer.
- (4) Starting at the bottom of the area to be treated, and using appropriate measuring equipment, exact lines shall be marked out. From 1 metre above the bottom of the slope, a precise contour line should be marked out every 2 metres up the slope.
- (5) Starting at the bottom, trenches approximately 450 mm wide on landslide debris or 350 mm on road embankments shall be excavated along the lines. The base of the trench should be laid back into the slope at approximately 10°.
- (6) Cuttings shall then be placed into each trench at 50 mm centre to centre, the correct way up and angled so that they are at right-angles to the maximum slope angle. All cuttings should be inserted to a depth such that three-quarters of their length is buried.
- (7) The trench should then be partially backfilled and another line of cuttings placed along the trench at 50 mm centre to centre and 100 mm behind the first line, and with the individual cuttings offset to coincide with the gaps between the cuttings in the first line. This results in cuttings at 25 mm centre to centre in each brush layer (i.e. 40 cuttings per running metre). The trench is then completely backfilled and gently compacted using careful foot pressure. Any loose or excess material is cleared down the slope before the next line is planted.

(8) In some cases it will be specified that cuttings should be placed in a criss-cross fashion. Where this is to be done, one layer of cuttings is laid in the trench at 30° to one side of the line of maximum fall of slope. A second layer of cuttings is laid on top of this, at 30° to the other side of the line of maximum fall of slope. Backfilling and compaction are then completed.

610.03.6 Live Check Dams

(1) A live check dam is a structure used specially to control erosion in small gullies. It uses a matrix of inter-woven live hardwood cuttings to catch debris and control runoff water.

(2) The cuttings used for live check dams are two types.

- (i) Those for vertical elements shall be truncheon cuttings or established plants 30 to 80 mm in diameter and 2000 mm long.
- (ii) Those for horizontal elements shall be 20 to 40 mm in diameter and 2000 mm in length.

(3) All cuttings or plants should be temporarily stored and transported wrapped in hessian jute and kept moist and as cool as possible. All cuttings must be planted the same day that they are taken from the parent plant.

(4) Live check dams should be constructed in accordance with this sub-section, unless otherwise instructed by the Engineer.

(5) The spacing of check dams shall be as show on the Drawings or at locations instructed by the Engineer. The locations will be selected so as to achieve the greatest effects of controlling the water flow and stabilising the gully floor.

(6) At each check dam location, two lines shall be marked out across the gully. These will form the lines for a series of vertical posts placed at intervals of 300-500 mm. A foundation trench is then excavated to a depth 100 mm deeper than the gully bed, and extending 300 mm into the gully sides.

(7) Holes are to be large enough to insert vertical truncheon cuttings or established plants to a depth of 1000 mm. To do this, a large crowbar is used to make a hole 10 to 20 mm bigger in diameter than the truncheon cutting. The cutting/plant is to be inserted carefully, making sure that the bark is not scratched or torn. Soil or whatever fine material is available is then replaced around the cutting/plant and firmed from the top with gentle foot pressure. The holes shall be spaced at 500 mm centre to centre in two horizontal lines 500 mm apart across the gully.

(8) Long hardwood cuttings shall then be woven in and out between the vertical posts, separately for each line. This is started at the bottom and worked up, with the weaving alternating on opposite sides of the vertical posts.

(9) The horizontal members shall be keyed right into the end of the trench in the wall of the gully, and cut to length as necessary. In the centre, one vertical post and two or three horizontal members are cut to form a central spillway.

(10) A backfill of stone and soil is then carefully placed by hand around and between the two live walls of the check dam, and compacted with gentle foot pressure.

610.03.7 Truncheon Cuttings

(1) Large hardwood cuttings, known as truncheon cuttings for specific areas shall be planted as shown on the Drawings or as instructed by the Engineer. Only approved species may be used for this purpose.

(2) Truncheon cuttings/plants will be 30 to 80 mm in diameter and 2000 mm long. They should be temporarily stored and transported wrapped in hessian jute and kept moist and as cool as possible at all times. All cuttings must be planted the same day that they are taken from the parent plant.

(3) Planting should be started at the top of the slope and under no circumstances should new cuttings be disturbed.

(4) The planting hole will be dug of sufficient diameter for the truncheon cutting, and at least 1000 mm deep. The cutting should be inserted carefully, making sure that the bark is not scratched or torn. Soil or whatever fine material is available is then replaced around the cutting and firmed from the top with gentle foot pressure.

(5) Under no circumstances should cuttings be hammered into the ground.

(6) Truncheon cuttings should be spaced at 1000 mm centre to centre in horizontal lines, unless otherwise instructed by the Engineer depending on the site conditions. The cuttings should be successively offset to occupy the gaps in the adjacent lines.

610.03.8 Large Bamboo Planting (Culm-and-Rhizome Method)

(1) Large bamboos using the culm-and-rhizome method will be planted in specific areas as shown on the Drawings or as directed by the Engineer. Only approved species may be used for this purpose.

(2) Cuttings for large bamboo planting must include a section of rooted rhizome and about 2 metres of culm that has been cut out of an established bamboo clump. They should be temporarily stored and transported wrapped in hessian jute and kept moist and as cool as possible. All cuttings must be planted the same day that they are taken from the parent plant.

(3) All loose debris must be removed from the site and the surface prepared in accordance with 610.03.2.

(4) Holes must be dug, at least five times the size of the cutting's rhizome. The rhizome is planted either upright or at right angles to the slope. The hole must then be backfilled carefully and the soil firmed around the plant.

(5) The disturbed and surrounding soil must be mulched well.

(6) A depression must be formed around the roots to act as a water collection area. It should be watered thoroughly immediately after planting and every two days for the next month if there is not a significant level of rainfall.

(7) Unless otherwise instructed, large bamboo plants should be spaced at 3000 mm centre to centre in horizontal lines.

610.04 MEASUREMENT

(1) Measurement for bio-engineering works shall be as follows:

Item No.	Description	Unit
610-1	Grass Slip Planting	Metre Square
610-2	Planting of Polyplot Seedlings of Trees and Shrubs	Nos of Seedlings
610-3	Brush Layering	Metre
610-4	Live Check Dams	Metre
610-5	Truncheon Cuttings/ Established Plants	Cutting/Plant
610-6	Large Bamboo Planting (Culm-and-Rhizome Method)	Cutting

(2) Where grass lines are planted on slope surfaces that have a complex surface topography, measurement will be based on the average number of slips planted over an area of 10 m².

(3) No measurement will be made of unauthorised areas or for works exceeding the specifications.

610.05 PAYMENT

(1) Payment will be made at rates entered in the Bill of Quantities, which rates shall include slope preparation (incl. final slope preparation), trimming, filling, disposal of surplus materials and furnishing and placing of all materials (incl. live plants), labour, tools, equipment and incidentals including plant and material provision.

LIST OF APPROVED SPECIES FOR BIO-ENGINEERING

Lao name	Other name	Botanical name	Comments
Grasses			
Nyar khaem, dok khaem	Broom grass	<i>Thysanolaena maxima</i> or <i>T. latifolia</i>	The most widely used NTFP, hence valuable to farmers
Nyar kha		<i>Imperata cylindrica</i>	A tough, invasive grass, very common but seen as a troublesome weed in shifting cultivation
Nyar phaek		<i>Themeda triandra</i>	Clumping grass, not as big as Imperata
Nyar khaem lao		<i>Themeda arundinacea</i>	
Nyar khaem lao		<i>Saccharum spontaneum</i>	Listed as common weed in shifting cultivation, but South Asian <i>S. spontaneum</i> not seen in northern Lao. (may not be suitable for widespread colonisation)
Nyar phaek, fek hom	Vetiver	<i>Vetiveria zizanioides</i>	Available from the Huayson Huaysua Agriculture Development and Service Centre. Use only on fill material, not on cut slopes.
Shrubs and trees for hardwood cuttings			
Mak koh	Chestnut	<i>Castanopsis</i> sp.	Grows only above 700 metres elevation
Korbai leuam	Chestnut	<i>Castanopsis</i> sp.	
Posa	Paper mulberry	<i>Broussonetia papyrifera</i>	Fibres collected from bark for paper etc
	"Diesel nut"	<i>Jatropha curcas</i>	Large shrub; grows in hot, sunny locations; grows slowly on rocky sites
Peuak meuak, toutiang		<i>Boehmeria malabarica</i>	Straggly shrub; valued for its bark, which is used to make paper
Khee nok, khee hen, ngen	Simali	<i>Vitex</i> spp.	Seedlings preferable as common Lao <i>Vitex</i> spp. As may not propagate from cuttings like the South Asian <i>V. negundo</i>
Mai mook		<i>Euphorbia hirta</i>	Seedlings preferable as may not propagate from cuttings.
Thorng		<i>Erythrina</i>	Medium-sized tree. Good for truncheon cuttings.
Shrubs and trees as established seedlings			
Khileckdong		<i>Cassia garrettiana</i>	
Koun	Amaltas	<i>Cassia fistula</i>	Showy yellow flowers; grows in hot, sunny sites
Khathin		<i>Leucaena leucocephala</i>	Widely planted, fast-growing, small leguminous tree from Central America Seems to perform well in Lao
Tiou dam		<i>Cratogeomys prunifolium</i>	
		<i>Crotalaria anagyroides</i>	Legume; performed well in agricultural trials in northern Lao.
Pohou		<i>Trema orientalis</i>	Seed difficult to collect; grows well on hot, rocky sites
		<i>Flemingia congesta</i>	Legume; considered by NAFRI to be suited to Lao conditions and to be of strong potential
		<i>Calliandra calothyrsus</i>	Legume
Hookatai		<i>Tephrosia vogelii</i>	Legume; small shrub that allows natural regeneration under its canopy.
		<i>Acacias</i>	
		<i>Samanea saman</i>	

Trees for planting as nursery-raised container seedlings			
Mai nhom hin		<i>Chukrasia tabularis</i>	Timber tree
Mai dou		<i>Pterocarpus macrocarpus</i>	Timber tree; light canopy
Mai ham ngoua	Mahogany	<i>Swietenia spp.</i>	Timber tree; light canopy
Mai champa pa		<i>Paramichelia baillonia</i>	Timber tree; shade tolerant
Mai te kha		<i>Azela xylocarpa</i>	Veneer timber tree
Mai sako		<i>Anthocephalus chinensis</i>	Light canopy; shade tolerant
Mai kadao sang		<i>Melia azedarach</i>	Light canopy; grows on bare, hot sites
Mai khilek ban		<i>Senna siamea</i>	Firewood tree; light canopy
Magdua	Milky sap	<i>Ficus neriifolia</i>	Small edible figs and animal fodder
		<i>Ficus semicordata</i>	Small edible figs and animal fodder; natural coloniser of rocky slopes
Large bamboos for planting by the culm-and-rhizome method			
Bong	Bamboo	<i>Bambusa spp.</i>	A large number of large species of this genus are available in Lao
Hok	Bamboo	<i>Dendrocalamus spp.</i>	A large number of large species of this genus are available in Lao

SPECIES NOT SUITABLE FOR USE IN BIO-ENGINEERING

Lao name	Other name	Botanical name	Comments
	Teak	<i>Tectona grandis</i>	Provides too much shade and excludes other plants
	Ban mara	<i>Eupatorium adenophorum/ Chromolaena odorata</i>	Very invasive, weedy herbaceous plant with weak roots but shading out other more vigorous plants
Thua hae	Pigeon pea	<i>Cajanus cajan</i>	Not robust enough for hard slopes, or in multi variety planting
		<i>Sesbania sesban</i>	Appears to fail when planted in combination with other species
Mai vick		<i>Eucalyptus spp.</i>	Excludes other plants
Mai pek song bai		<i>Pinus merkusii</i>	Provides too much shade and excludes other plants
Mai pek sam bai		<i>Pinus kesiya</i>	Provides too much shade and excludes other plants

SECTION 611

STREET LIGHTING

611.01 DESCRIPTION

The work covered by this Section consists of the supply of all lanterns complete, brackets, columns and other supporting devices, bases, cables, switchgear and all necessary ancillary equipment together with the transportation, storage, assembly, erection, connection and testing of the same in order to supply a complete street lighting system in accordance with the details shown on the plans and as specified herein. Design of the system may be included.

611.01.1 General

(1) If shown in the Contract Drawings and designated in the Tender documents, this work shall consist of modifying and/or adding to an existing street lighting system or constructing a new street lighting system, as the case may be. To the greatest extent possible all materials, above ground and underground, used in existing lighting system in accordance with the following articles of these Specifications shall be prepared by the Contractor and submitted in three copies including design calculations, drawings, Wiring diagrams and requirement and materials list to the Engineer within three (3) months after the commencement date of the Contract.

(2) All underground utilities are not necessarily shown on the Drawings and locations of underground utilities as shown on the Drawings are approximate only.

(3) The Contractor shall search for and take special precautions to protect any existing utility services such as power lines, telephone lines, gas and oil pipelines, sewers and water works affected by his operations at his own cost, and shall minimize and be responsible for any damage caused thereby. He shall at all times and at his own expense conduct his operations in accordance with the requirements of the Utility Authorities having jurisdiction.

(4) The following data shall be furnished by the Contractor to the Engineer and shall be included in the design documents:

- a) Catalogues of electrical components; Lanterns, ballast, etc.;
- b) Plans and circuit diagrams, ground road connection diagram;
- c) Photometric data;
 - i) Utilization Curve;
 - ii) Isocandela Diagram;
 - iii) Horizontal Iso Foot Candle Diagram;
 - iv) Polar Light Distribution Curve.
- d) Details of columns, brackets, base plates.

611.01.2 Responsibility for Design and Materials

(1) Items of equipment and parts shall have maker's specifications agreeing with those of the American National Standards Institute (ANSI), the American Society for Testing Materials (ASTM), the American Association of State Highway and Transportation Officials (AASHTO), the National Institute of Standards and Technology (NIST), the British Standards Institute (BSI), the Institution of Engineering and Technology (IET) regulations or other similar internationally recognised body. All works shall be done, and all goods shall be made in strict accordance with the requirements of the Electrical Code of the Lao PDR and of the regulations of the Électricité du Laos (EDL).

(2) The Contractor shall be solely responsible for the adequate design and the co-ordinated functioning of all goods and construction furnished under this contract. All the component parts shall be designed so as to ensure their proper co-ordinated functioning and operation. All equipment shall be of the maker's standard models and shall include all recent improvements in design and materials.

(3) All materials used in manufacture and construction shall be of high quality and fully in accordance with the best modern practice.

(4) The equipment offered and the work done shall be suitable for continued trouble-free operation under adverse climatic conditions of heavy rain, high humidity and intense sunlight. The equipment must be able to withstand over long periods ambient air temperatures varying from 0 °C to a maximum of 50 °C.

611.01.3 Compliance with Manufacturer's Specifications

(1) The Contractor shall ensure that the equipment and parts used will be entirely suitable for the work to be performed and that they will be manufactured to proper clearances and fit. He shall further ensure that the loading of equipment under all normal circumstances will not exceed the maximum laid down or agreed in writing by the manufacturer.

(2) The Contractor shall be responsible for the inspection of all equipment and parts before their incorporation in the works to ensure that they comply with the conditions of the Contract and that they are not defective in any way as regards materials or workmanship. Should any such non-compliance or defects be found during the inspection, the Contractor shall correct or cause to be corrected such non-compliance and defects, all at the Contractor's expense and to the satisfaction of the Engineer.

611.01.4 Defects Liability Period

(1) All repairs and replacements required during the Defects Liability Period shall be carried out without delay and an adequate supply of spares shall be available for this purpose.

611.01.5 Electricity Supply

(1) The Contractor shall carry out negotiations with the Electricity Supply Authority concerned with the electricity supply to the installation, and any costs associated with obtaining this supply shall be included in the Contract rates. The Contractor must ensure that the equipment supplied will function correctly at the supply, voltage, and must allow for normal variations and surges.

611.01.6 Definitions

(1) Unless specifically defined herein, definitions shall be as given in British Standard BS 6100-4:2008 "Building and civil engineering. Vocabulary. Transport".

Lantern: A housing for one or more lamps comprising the body and any refractor, reflector, diffuser or enclosure associated with the lamp or lamps.

Outreach: The distance measured horizontally between the centre of a lantern mounted on a bracket and the centre of the column or wall face.

Overhang: The distance measured horizontally between the centre of a lantern and the adjacent edge of the pavement.

Mounting Height: The vertical distance between the centre of lantern and the surface of the pavement.

Spacing: The distance measured parallel to the centre line of a road, between successive lanterns. In a staggered arrangement, this distance is measured parallel to the centre line from the centre of a lantern on one side of the road to the centre of the next lantern on the opposite side.

Beam: That portion of the light output of the lantern contained by the solid angle subtended at the effective light centre of the lantern containing the maximum intensity but no intensity less than 90% of the maximum intensity.

Luminous flux: The light given by a light source of lantern or received by a surface, irrespective of the direction in which it is distributed. The unit of luminous flux is the lumen.

Lower hemispherical flux or Downward Flux: The luminous flux emitted by a lantern in all directions below the horizontal.

Peak Intensity Ratio: The ratio of the maximum intensity to the mean hemispherical intensity of the light emitted below the horizontal.

Mean Hemispherical intensity: The downward flux divided by 6.28. (This is the average intensity in the lower hemisphere).

Intensity Ratio: The ratio of actual intensity in any direction of lantern to the mean hemispherical intensity.

Luminous Intensity: The light giving power of a lantern in any particular direction. The unit of luminous intensity is the candela (cd).

Lux: The SI unit of illuminance and luminous emittance, measuring Luminous Flux per unit area. It is equal to one Lumen per Metre Square. In photometry, this is used as a measure of the intensity, as perceived by the human eye, of light that hits or passes through a surface.

Beam Centre: A direction midway between the directions for which the intensity is 90 percent of the maximum in a vertical plane through the maximum and on a conical surface through the maximum.

Isocandela Curve: A curve traced on an imaginary sphere with the source at its centre and joining all the points corresponding to those directions in which the luminous intensity is the same, or a plane projection of this curve.

Isocandela Diagram: An array of isocandela curves.

Polar Curve: Curve of light distribution using polar coordinates.

611.02 MATERIALS AND EQUIPMENT

611.02.1 Lanterns

- (1) Lanterns shall be of the cut-off or the semi-cut-off type as shown on the Drawings or as specified in the Special Provisions. Non-cut-off lanterns shall not be used.
- (2) Unless otherwise specified, the mounting height shall be not less than 7.6 meters nor more than 12.2 meters. At junctions, or where high mast lighting is specified, this maximum height may be exceeded, but in such case, means must be provided to lower the lanterns for repair and cleaning.
- (3) Where there is no speed limit on the road or where there is a speed limit of more than 60 km/hr the minimum clearance between columns and the edge of the pavement shall be 1.5 meters but where this is not reasonably attainable, the minimum clearance may with the permission of the engineer be reduced to 1.0 meter.
- (4) Where there is a speed limit of less than 60 km/hr the minimum clearance between columns and the edge of the pavement should be 1.5 meters but this may be reduced to:
 - 0.50 meter for crossfalls of not more than 1 in 40 towards the curb
 - 0.60 meter for crossfalls of between 1 in 40 and in 24 towards the curb
 - 0.75 meter for crossfalls of more than 1 in 24 towards the curb with the previous permission of the Engineer.
- (5) Each lantern should normally direct two beams along the length of the road. The polar curves of the lanterns in both horizontal and vertical planes should be smooth and free from any abrupt variations so that the luminous intensity diminishes smoothly and progressively from its maximum. For centrally mounted lanterns the beams should be approximately axial; for lanterns mounted at the sides of the roadway, the maximum toe-in of the beam will be 15°. Adequate but not excessive light should be directed towards the curbs and outer edge of the road. Where area illumination is required using high mast lighting, these provisions shall not necessarily apply.

(6) For cut-off lanterns, the beam should be in a direction about 65° from the downward vertical. The peak intensity ratio shall be between 2.0 and 4.0; the intensity in the zone 0° to 30° below a horizontal plane through the lantern shall be between 0.3 and 2.0. An intensity ratio of 1.2 shall lie between elevations of 72° and 78° from the downward vertical in the vertical plane parallel to the axis of the roadway and the horizontal intensity ratio in the same plane shall be not greater than 0.15.

(7) In the case of semi-cut-off lanterns, the beam should lie in a direction about 75° from the downward vertical. The peak intensity ratio shall be between 1.8 and 4.0. The intensity ratio in the 0° to 30° zone below a horizontal plane through the lantern shall be between 0.3 and 1.7. An intensity ratio of 1.2 shall lie between elevations of 78° and 84° from the downward vertical in the vertical plane parallel to the axis of the roadway and the horizontal intensity ratio in the same plane shall be not greater than 0.6 except that in the case of sodium lamps, the intensity ratio of 1.2 shall lie similarly between 80° and 86° and the horizontal intensity ratio in the same plane shall not exceed 0.7.

(8) The siting of lanterns shall be in accordance with the following table which gives minimum required illumination. Particular care shall be taken with the siting of lanterns on bends and summit vertical curves. At junctions and roundabouts, lantern spacing shall be designed so as to give at least the minimum illumination required by the following tables and also lanterns shall be spaced and sited, where possible, so as to delineate the course of the roadway plainly to road users approaching from any normal direction without any possible misleading impressions. The level of illumination provided at road junctions and roundabouts shall be at least as high as that on any of the approach roads and in the case of roundabouts, a minimum level of illumination at any curb line of 10 lumens per square meter shall be provided.

(9) The required minimum average horizontal illumination in Lux (Lumens per Square Meter) is shown in below table.

Table 611.1 - Required Minimum Average Horizontal Illumination (Lux)

	Central Urban Areas	Sub-Urban Areas	Rural Areas
High Grade Motorways	21.5	15.0	10.75
At Junctions	21.5	21.5	15.0
Main Route	21.5	13.0	9.7
Secondary Routes	13.0	9.7	6.5
Local Roads	9.7	6.5	2.1
			(Residential areas only)

(10) The Contractor shall certify that the design of the installation has been done in accordance with "American National Standard Practice for Roadway Lighting, ANSI / IESNA RP-8-00, 2000" published by the Illuminating Engineering Society, except when these have been varied by these specifications or any particular specifications.

(11) All lanterns shall be new, totally enclosed, side entry, dustproof, insect-proof and water-tight and tested for these requirements. All lanterns shall be supplied complete with all the necessary control gear fully wired and fixed and ready for erection. The gear shall be integral with the lanterns. The lantern wiring shall be of a size and insulated with materials that will effectively withstand the current, voltage and temperatures expected within the lantern during both the starting and operating modes in the ambient temperatures of the site. The lamp compartment of the lantern shall be accessible via a hinged bowl which shall, in the closed position, be firmly upon a soft resilient gasket which shall be firmly secured to the lantern by means of stainless steel clips and large pins. In the lowered position the bowl shall be restrained from becoming detached or blown against the other parts of the lantern or column arm or bracket. Reflector, if used, shall be mirror type and made of anodised aluminium sheet. The bowl (refractor), if made of transparent acrylic, shall not display any drop in output due to colour changes within the first five (5) years of service.

(13) A sample lantern of the type proposed for use in this Contract is to be supplied to the Engineer for his approval, together with a certificate of approval by the Electricity Authority concerned before any installation is made. Transverse and longitudinal cross-section drawings of the lantern at 1:10 scale shall also be furnished to the Engineer.

611.02.2 Switching

(1) The switching supplied for control of lanterns shall be of a type approved by and agreed with the Electricity Supply Authority. If approved by the Electricity Supply Authority, photoelectric relay switching will be permitted, each device controlling a group of lanterns.

(2) Switching shall be by photo-electric relay.

611.02.3 Columns and Brackets

(1) Columns shall be of steel construction and shall consist of tapered round hollow shafts with anchor bases. Each column shall be provided with a suitable cable slot and a weatherproof service door fitted with a tamperproof lock. All locks shall be of the same pattern, and six keys shall be provided for them.

(2) A non-hygroscopic mounting board composed of electrically insulating material shall be fitted in an easily accessible position inside the column, and shall be of suitable size to take all necessary electrical equipment. Adjacent to this mounting board, there shall be provided on the inside of the column two stainless steel studs, not less than 4 cm long nor less than 8 mm diameter and complete with stainless steel lock nuts and washers, for use as earthing connections.

(3) Brackets to provide the required outreach shall be of sufficiently strong construction to support the lantern under all normal conditions without significant movement, and shall be provided with suitable fittings to take the lanterns. When in position, brackets shall be inclined upwards at an angle of approximately 15° to the horizontal, and shall be fixed to their supports by suitable welding, fastenings or wall plates.

(4) Columns and brackets shall be structural steel having the following mechanical properties:

-	Thickness of sheet steel (min)	4	mm.
-	Ultimate Tensile Strength (min)	4,000	kg/cm ²
-	Yield point (min)	2,500	kg/cm ²
-	Elongation (min)	21	%

(5) Straightness. That part of the column above the ground shall not deviate from straightness by more than 2 mm per meter of column length.

611.02.4 High Mast Lighting

(1) Columns carrying high mast lighting shall be designed to permit the whole of the lantern carriage to be easily, safely and quickly lowered to ground level for maintenance works. The columns shall be designed in accordance with BS EN 1993-1-1:2005+A1:2014 or other internationally accepted standard for design of structural steelwork in buildings, except that the temporary horizontal deflection of the top of the column may be up to 7 ½ % of the height above ground. In calculating the bending moment at ground level due to wind load, it shall be assumed that the wind speed at a point ten meters above ground level is 60 kilometres per hour, and the design of the column shall be such that, wind excited oscillations are damped as much as possible. Adequate allowance shall be made for the stresses produced by such oscillations. Details shall be given of the vertical and horizontal load and the bending moment at the foundations.

(2) The base plate shall be free from laminations and all dimensions of the base plate shall be provided, including details of the holding down bolts. A cable entry hole of not less than 30 cm diameter shall be provided centrally in each base plate, and the bottom of the mast shall pass through the base plate and be welded on both sides. An alternative construction of equal strength may be accepted by the Engineer, but a butt weld on to the base plate will not be accepted.

(3) Each holding-down bolt shall be tensioned to the design value, and within the defects liability period, the bolts shall be checked and retightened as necessary, after which the nuts shall be repainted.

(4) The columns shall be delivered to the site in the minimum practicable number of lengths. Any joints necessary shall be positioned as near the top of the columns as possible.

(5) The lantern carriage shall support the designed number of lanterns without significant sway or movement, and shall be capable of supporting these lanterns and a cradle with two men for maintenance work. The lantern carriage shall be protected to prevent damage to the painted surface of the columns, rotation of the carriage during raising and lowering shall be prevented and correct location when raised shall be ensured by some positive means. It shall be possible to remove the lantern carriage without lowering the column.

(6) The lantern carriage shall be raised and lowered by a self-sustaining winch capable of being operated either by hand or by a portable electrically operated tool. It shall be possible to lock the winch in any position by a simple, robust and easily operated mechanism. The worm gear shall have a ratio of at least 20:1

(7) The winch shall have removable handles, and it shall be mounted within the base compartment at a convenient working height. The opening in the column shall be of sufficient size to allow proper operation and maintenance of the winch mechanism. A weatherproof label shall be fixed in an obvious position within the column base, giving a full list of all lubricating points on the winch and other mechanism, and details of recommended lubricants. Winches fixed inside the column shall be provided with a substantial cover to fully protect them from falling dirt and dust.

(8) A sufficient number of turns of the hoisting cable shall be left on the winch drum when the carriage is fully lowered to ensure that the cable anchorage on the drum does not take the full load of the carriage at any time.

(9) The last 30 cm of travel to the fully raised position of the carriage shall be by hand operation, and for this purpose either a limit switch shall be provided to cut off the power supply to the portable electric tool at the appropriate time, or else some form of indication shall be provided to indicate when the carriage is 30 cm from the fully raised position

(10) The winch cable shall be of stranded stainless steel wires and shall have sufficient capacity to carry safely the lantern carriage complete with lanterns and a cradle with two men attached thereto. Great care shall be taken during installation to ensure that the hoisting cables do not twist or kink, and any set twist or kink shall be sufficient reason for the rejection of that cable.

(11) All parts of the raising and lowering mechanism which are inaccessible after erection of the columns shall be adequately protected against moisture, dirt and corrosion. Where necessary, pulleys shall be fitted with shields to prevent the winch cable becoming displaced. Pulleys for electrical cables shall be of sufficient diameter that the cable will not be bent to a smaller radius than that permitted by local regulations or those of the British Institution of Electrical Engineers, 14th Edition. Where necessary for continued trouble free operation, metal parts shall be of stainless steel or other approved non-corrodible material.

(12) When power tool operation is used, a suitable power outlet shall be provided and the operator shall be adequately safeguarded against any electrical shocks. The power tool shall preferably be designed to work on a reduced voltage and in this case, a suitable approved type of transformer shall be provided. The power tool shall be designed so that continuous operation will cause no harmful effects on either the winch or the tool, and in the event of power failure the winch shall be self-locking. Conversion from power to hand operation and vice versa shall be quick and easy and shall not require special tools. Full information on the type of power tool proposed shall be given with the tender.

611.02.5 Protection against Corrosion

(1) Unless otherwise specified, columns, bracket arms, and brackets shall be protected against corrosion either by painting or galvanizing as follows:

a) Painting:

i) Columns and masts shall be treated internally with hot asphalt under high pressure so as to give a complete and unbroken asphaltic covering or other approved anticorrosion treatment shall be applied to give at least equally good protection. Base shall be similarly treated up to a level of 215 cm above ground level;

- ii) Before delivery to the site, columns, masts, steel brackets, and external fittings shall have all external welds ground down and all external surfaces cleaned by shot blasting or other approved method to a white metal finish free of all signs of rust. Immediately following this treatment the items shall be painted with two coats of tropical red lead undercoat followed by two coats aluminium paint or they shall be treated in a similar and not less effective manner acceptable to the Engineer to prevent subsequent corrosion. After erection, all imperfections and damages shall be made good to the Engineer's satisfaction and the items shall be given a final coat of aluminium paint.
- b) Galvanizing:
 - i) Before delivery to the site, columns, masts, steel brackets, and external fittings shall have all external welds ground down. Poles and other ferrous materials shall be galvanized both inside and outside by the hot dip process in accordance with ASTM A653M - 17. Weight of zinc coating shall not be less than 550 grams per square meter;
 - ii) Bases of columns, both inside and outside shall be coated with bituminous paint up to a level of 25 cm above the base plate.

611.03 CONSTRUCTION REQUIREMENTS

611.03.1 Excavation and Reinstatement

- (1) Excavation for cable or conduit laying or for foundations and reinstatement shall be carried out in accordance with the provisions of Section 207 of these Specifications. Reinstatements shall be such that the surface is restored to at least its original standard.

611.03.2 Concrete Work

- (1) All necessary foundations and footings or other concrete work shall be carried out in accordance with Section 507 of these Specifications. Unless otherwise specified on the Drawings or in the Special Provisions, concrete shall be Grade 30. Foundations shall be placed in one operation except that the top 5 cm may be placed after the superimposed structure is in position. The exposed portions of foundations shall be formed to present a neat and tidy appearance and sloped to shed water away from the structure supported. Where existing obstructions prevent the construction of foundations as shown on the plans, then an effective alternative may be provided subject to the prior approval of the Engineer.

611.03.3 Conduits, Fittings and boxes

- (1) Conduits, fittings and boxes shall be provided and installed in accordance with the provisions of Section 523 of these Specifications, except that chemically stable tough plastic conduits, fittings and boxes, according to samples previously approved by the Engineer, will be permitted providing that they do not soften when exposed to high ambient temperature.
- (2) The Contractor may use a larger size of conduit than that specified, at no extra charge, if he wishes, but in this case the entire run shall be of the same size. No reducing couplings will be permitted.
- (3) When metal conduits are used, cuts shall be made square and true and all couplings shall be screwed up until the ends of the conduits are brought together in order to provide a good electrical contact throughout. The threads on all ferrous metal conduits shall be painted with a rust preventing paint before couplings are made up. Where the coating on ferrous metal conduit has been damaged in handling, such damaged places shall be painted with rust preventing paint before installation.
- (4) All conduit ends shall be threaded and capped until wiring is started. When caps are removed, the threaded ends shall be provided with approved conduit bushings.

(5) Conduits shall be laid to a depth of not less than 50 cm below paved foot-walks and medians and not less than 75 cm below the roadway surface. The location of all conduits at curb lines shall be marked by means of a "Y" at least 10 cm high incised in the face of the curb directly above the conduit. Conduit terminating in standards, cabinets or pedestals shall extend at least 5 cm vertically above the bottom of the box. Such conduit shall be sloped towards the top of the box to facilitate pulling. Conduit entering the bottom of the box shall enter in the direction of the run.

611.03.4 Pull Boxes

(1) Pull boxes shall be installed as shown on the plans and in any case at not more than 60 meters intervals. The Contractor may install additional pull boxes without extra charge if he wishes. Pull boxes shall be of reinforced concrete not less than 10 cm thick and may be of approved pre-cast design. Reinforced concrete covers, secured by two recessed brass bolts shall be used on foot-walks, the covers being inscribed in both Lao and English "Street Lighting" on the outside. Under the roadway, covers shall be of steel or cast iron, inscribed as specified above, and laid in a suitable concrete footing to withstand traffic loads. Metal covers shall be effectively earthed to an earthing rod inside the box. Tops of pull boxes shall be effectively level with the surrounding paved areas, whether foot-walk or roadway, but in unpaved areas the tops of pull boxes shall be buried 30 cm below ground level. The bottom of pull boxes shall be bedded in sand and cement or crushed rock. Permanent markers shall be provided and erected to show the position of all pull boxes.

611.03.5 Testing

(1) A functional test shall be made on completion of 'the work in order to demonstrate that every part of the equipment and installation functions as intended and specified. This test shall consist of not less than five nights continuous and satisfactory operation. If any defects or unsatisfactory operation are revealed, this, condition shall be corrected and the test continued until the required five nights of satisfactory operation have been performed.

(2) Prior to the functional test, the Contractor shall carry out the following tests to the entire satisfaction of the Engineer.

- i. Each circuit shall be tested for continuity;
- ii. Each circuit shall be tested for earthing;
- iii. A 'megger' test shall be made between each circuit and earth. The insulation resistance shall be shown to be at least that specified within the relevant Codes.
The distribution horizontal illumination value of specified spacing in each code item, in rate of lux measured between two luminaries every two meters along longitudinal and transverse roadway lines, are essentially measured to show maximum, mean and minimum illumination and also uniformity ratios.

Uniformity ratio = $\frac{\text{minimum illumination}}{\text{average illumination}}$ = not less than 0.40

and = $\frac{\text{maximum illumination}}{\text{minimum illumination}}$ = not less than 6.0

- iv. Rainproof Test

The lantern under test shall be mounted in its normal orientation on an adjustable support as shown in BS 1788, so that the fitting is near the centre of the area described by the oscillating tube.

After being switched on for one hour, the lantern shall be subjected to a spray of water at a temperature not exceeding 20 °C and at a pressure of approximately 0.4 kg/cm², the tube being oscillated so as to describe an angle of 60 degrees from the vertical and in both directions from it. This treatment shall be continued for 20 minutes, the fitting being switched off after 10 minutes.

At the end of this test, there shall be no damage to the lamp or enclosure and no visible evidence of water having accumulated in the fitting.

(3) On the completion of testing, the Contractor shall supply to the Engineer three copies of 'as built' plans and circuit diagrams, which shall clearly indicate any modifications which have been made to the original design.

611.04 MEASUREMENT

(1) Prior to the preparation of the design drawing referred to in these Specifications, the Contractor together with the Engineer shall inspect the entire existing electrical lighting system (if any) to determine the condition of any present installations and the ability of its components to be re-used. Tapered steel lighting poles and column high mast mountings, with height and single or double bracket requirements specified on the drawings and/or in the Tender documents and fitted with high pressure sodium lamps, will be measured as sets complete including all connecting cable and ancillary items required for the operation of the street lighting system.

(2) Measurement shall be as follows:

Item No.	Description	Unit
611-1	Tapered Steel Pole, Single Bracket, with one High Pressure Sodium Lamp _____ Watts cut off	Set
611-2	Tapered Steel Pole, Double Bracket, with two High Pressure Sodium Lamps _____ Watts cut-off	Set
611-3	High Mast Complete with Lanterns, Spare Parts, Foundation Draw Pits, Trenches, Cables, Ground & Accessories	Set
611-4	Soffit Complete with Lanterns, Spare Parts, Draw Pits, Trenches, Cables, Ground & Accessories	Set
611-5	Supply Pillars Complete with Foundation, Fence, Draw Pits, Trenches, Cables, Ground & Accessories	Set
611-6	Relocated Tapered Steel Pole, Single Bracket	Set
611-7	Relocated Tapered Steel Pole, Double Brackets	Set

611.05 PAYMENT

(1) The work measured shall be paid at the Contract unit price for each item, such price and payment constituting full compensation for all materials, labour, equipment, tools and incidentals needed to complete the work. All materials and work necessary for satisfactory completion of the installation which are not specifically mentioned in the Bill of Quantities shall be deemed to be included in the items shown.

(2) Tapered steel poles, single or double brackets, and column high mast mounting, with high pressure sodium lamps, will be paid for at the Contract unit prices per set, complete and accepted in place, which prices shall be all inclusive of junction boxes, poles, bracket arms, luminaries, painting, retro-reflective sheets, ballast, pole foundations, transformers (where necessary or as specified), transformer bases, cable, conduit, trenching, pull wires, cable and conduit markers, labor, equipment and incidentals necessary to the complete operation of the lighting system.

SECTION 612

SOLAR POWERED STREET LIGHTING

612.01 DESCRIPTION

(1) This work shall consist of the supply of solar panels, all lanterns complete, bracket arms, columns and other supporting devices, battery, battery box, battery management system, system controller, cables, switchgear and all necessary ancillary equipment together with the transportation, storage, assembly, erection, connection and testing of the same in order to supply a complete solar powered street lighting system in accordance with the details shown on the drawings and as specified herein. Design of the system may be included.

(2) If not covered by this Section 612, applicable parts of “Section 611 Street Lighting” shall apply.

612.02 MATERIALS AND EQUIPMENT

612.02.1 General

(1) Arrangements shall be provided countering theft of all components of the solar powered street lighting, i.e. the battery, solar panels etc.

(2) Applicable parts of the International Electrotechnical Commission (IEC) standards shall be complied with.

612.02.2 Solar Panels

(1) Solar panels shall utilize multi-crystalline or mono-crystalline silicon solar cells that provides high watts output.

(2) The photoelectric conversion efficiency shall be at least 18.5%.

(3) The frames of the panels shall be of aluminium (light weight, strong and corrosion resistant) and shall be able to resist winds up to 209 km/hr (130 mph). Stainless steel screw shall be used as fasteners of the frames. Panels shall be effectively isolated against humidity, dust, heat and insect invasion.

612.02.3 Lanterns

(1) Lanterns supplied shall be LED luminous flux lamps, 80 W, 7200 lm or more.

(2) LED street lamps shall be with transparent acrylic cover, which is totally enclosed, dust proof, water tight and insect proof.

(3) All lanterns shall be supplied with all the necessary control gear, fully wired and ready for erection.

(4) A reflector shall be provided in the LED street light to increase and spread the light uniformly.

(5) A sample of the proposed lantern to be used shall be supplied to the Engineer for his approval before any installation is made, together with the manufacturing certificate.

612.02.4 Battery, Battery Box and Electronics

- (1) The battery module shall have 2 environmentally friendly Lithium-ion batteries, which comes together with a battery management system allowing the 2 batteries to discharge alternately and thereby extending the cycling lifespan of the whole battery module. The discharge depth of a battery shall be maximum 90% and once it reaches 90%, the battery shall stop discharging and switches to the other battery. The battery management system shall also protect the battery from over charge.
- (2) The system shall be provided with 2 LED indicators: a green light indicating charging in progress and a red LED indicating deep discharge condition of the battery.
- (3) The minimum operational life span of the battery shall be 6 years.
- (4) An easily operated charging controller for the battery shall be provided, which maximises the energy harvest, and which has protection for over-current, over voltage and over-heating.
- (5) Adequate protection shall be incorporated under no load conditions e.g. when the lamp is removed and the system is switched on.
- (6) Fuses shall be provided to protect against short circuit conditions.
- (7) Protection for reverse flow of current through the system shall be provided.
- (8) Electronics shall have temperature compensation for proper charging of the battery throughout the year.
- (9) The battery shall be installed in an insulated, ventilated, thief-proof underground battery box, which shall withstand at least 5 tons loads. The battery box shall have a service life of minimum 20 years.

612.02.5 System Controller

- (1) The Solar powered LED street lighting shall have a control devise that automatically switches ON at dusk, operates throughout the night and automatically switches OFF at dawn. The control device shall also allow adjustment of the dusk to dawn lighting settings with adaptive lighting features (for example setting dusk +6 hours at full 80 Watt lighting intensity...dimming to 40 Watt intensity...returning to full 80 Watt intensity 1 hour predawn. Note: This is just an example).
- (2) Provide "Smart Off-Grid" monitoring, control, load and battery management system for the solar powered LED street lighting. The "Smart Off-Grid" system shall utilise wireless networking, data collection and streaming and cloud software for remote control and monitoring of the solar powered system, over the Internet from a PC or smartphone. The "Smart Off-Grid" system shall enable 24 x 7 system health monitoring and proactive maintenance of the system, while reducing maintenance costs and providing capabilities such as dimming, motion sensing, and the ability to add and control security cameras.

612.02.6 Columns and Brackets

- (1) Columns and brackets shall be strong enough to carry the full weight of the installed solar panels respective the lanterns, without significant movement, and shall be provided with suitable fittings for the solar panels and the lanterns.

612.02.7 Technical Data Requirements

- (1) The following tables list the minimum technical requirements of the solar powered street lighting system:

Table 612.1 - Minimum Technical Requirements of Solar Powered Street Lighting System

Physical Parameters	
Power of Solar Panel Module (W)	min 130 W
Lithium Battery Capacity (Wh)	min 656 Wh
Environmental Requirements	
Charge Temperature (°C)	0°C - 60°C
Discharge Temperature (°C)	-20°C - 60°C
Storage Temperature (°C)	0°C - 45°C
Mounting Requirements	
Wind Load Rate (km/h)	209 km/h (130 mph)
Top of Pole Outside Diameter (mm)	80 – 85 mm

Table 612.2 - Minimum Technical Requirements of LED Street Lights

Light Parameters	
Light Output (W)	min 80 W
Typical Luminous Flux (lm)	min 9600 lm
Optical Distribution	Bat Wing
Visual Angle (°)	140° x 70°
Color Temperature (K)	5000 K
Light Photosensitivity (lx)	30 lx
Environmental Requirements	
Working Temperature (°C)	-40°C - 60°C
Storage Temperature (°C)	-20°C - 45°C
Mounting Requirements	
Wind Load Rate (km/h)	209 km/h (130 mph)
Bracket Arm/ Tenon Outside Dia. (mm)	60 ± 2 mm
Recommended Installation Height (m)	6 – 12 m
Recommended Installation Distance between Poles (m)	25 – 40 m

612.03 CONSTRUCTION REQUIREMENTS

612.03.1 Solar Panels

(1) The solar panels shall be fixed firmly on top of the pole with suitable tilt and inclination so as to receive maximum sunlight throughout the day.

612.03.2 Battery, Battery Box and Electronics

(1) The solar battery shall be housed inside a battery box, which shall be located underground for easy maintenance and replacement.

612.03.3 Other Requirements

- (1) There shall be a Name Plate on the system, which will give: (i) Name of the Manufacturer or Distinctive Logo. (ii) Serial Number.
- (2) The solar panel modules will be warranted for a minimum period of twenty five (25) years from the date of supply and the other components of the street lighting system (including the battery) will be warranted for a period of six (6) years from the date of supply.
- (3) Solar panel modules used in Solar Street Lighting System must be warranted for their output peak watt capacity, which should not be less than 90% at the end of twelve (12) years and 85% at the end of twenty (20) years.
- (4) The Warranty Card to be supplied with the system must contain the full details of the system. The manufacturers can also provide additional information about the system and conditions of warranty as necessary.
- (5) Necessary lengths of wires/cables and fuses should be provided.
- (6) An Operation, Instruction and Maintenance Manual, in English and the Lao language, shall be provided with the Solar Street Lighting System. The following minimum details shall be provided in the Manual:
 - Basic principles of solar power;
 - A small write-up, with a block diagram, on Solar Street Lighting System - its components, solar panels, battery, battery management system, system controller, electronics and lanterns and expected performance;
 - Charging and significance of indicators;
 - Instructions about erection of pole and mounting of solar panels and lanterns on the pole.

612.04 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
612-1	Tapered Steel Pole Complete with Lantern, Dual Solar Panels of Mono-Crystalline- or Multi-Crystalline Silicon Solar Cells, Battery with Underground Battery Box, Battery Management System, System Controller, Foundation, Cables, Ground & Accessories	Set

612.05 PAYMENT

- (1) Payment will be made at the rates entered in the Bill of Quantities, which rates shall include full compensation for all materials, labour, equipment, tools and incidentals needed to complete the work.

SECTION 613

ROAD TRAFFIC SIGNALS

613.01 DESCRIPTION

(1) The work covered by this Section consists of the supply of all signal heads, supports, controllers, detectors, cables, switchgear with all necessary ancillary equipment together with the transportation, storage, erection, connection and testing of the same in order to supply a complete traffic signal installation in accordance with the Drawings and as specified herein.

613.01.1 General Requirements

(1) Designs shall be prepared by the Contractor in accordance with the principles set out in Clause 613.4 of these Specifications. Signals shall be designed to operate by the combination of time switch and vehicle activated controller fitted with speed measuring equipment including primary and secondary detectors. Designs shall take into account the mix of traffic, in particular the high proportion of two-wheeled vehicles. Complete details of the design of the signals for each junction, in three copies, including design calculations, drawings, wiring diagrams and requirement and materials list and specification, shall be submitted to the Engineer for approval within three months after the commencement of the Contract.

(2) On "Responsibility for Design and Materials" the provisions of sub-clause 611.02.2 of these Specifications shall apply.

(3) On "Compliance with Manufacturer's Specifications" the provisions of sub-clause 611.01.3 of these Specifications shall apply.

(4) On "Defects Liability Period" the provisions of sub-clause 611.01.45 of these Specifications shall apply.

(5) On "Electricity Supply" the provisions of sub-clause 611.01.5 of these Specifications shall apply.

(6) On "Definitions" the provisions of sub-clause 611.01.6 of these Specifications shall apply.

613.02 MATERIALS

613.02.1 Signal Face

(1) Each signal face shall consist of three electrically operated and controlled optical units arranged vertically. The top unit shall show red, the centre amber and the lowest green. Additional optical units may be added if required for special facilities. Suitable visors will be fitted to all optical units. Louvres and sighting screens shall be supplied if required to give the most efficient operations under all conditions. Each signal face shall conform to a sample supplied to and approved by the Engineer.

613.02.2 Optical Units

(1) Optical Units shall consist of a lens, a reflector, a lamp-holder and a clear traffic signal lamp visible to the traffic to be controlled. Optical Units shall be housed in a non-ferrous corrosion resistant casing that shall be weather tight and capable of being securely fixed in direction and elevation. Access shall be provided by hinged doors which when shut shall be forced against a neoprene gasket on the body and fastened by a simple, corrosion resistant, non-detachable fastening device which does not require special tools for operation.

613.02.3 Lenses

(1) Lenses shall be made from best quality glass, free from imperfections, and shall conform to the requirements of BS EN 12368: 2015 for colour and transmittance. All lenses will be unlettered and shall be mounted so as to display a circular area 200 mm in diameter towards the traffic to be controlled. The lens shall be so designed and finished that when it is installed in an optical unit as herein described, that unit shall, when the lamp is illuminated, display a uniformly bright area to traffic without any shadows or dark areas. The polar curve shall be reasonably smooth and free from sudden changes or secondary maxima. The mounting of the lens shall ensure that there will be no escape of light from the lamp, apart from that passing through the lens itself.

613.02.4 Reflectors

(1) Reflectors may be of silvered glass or metal. Silvered glass reflectors shall conform to Clause 8.02 of the Institute of Traffic Engineers Technical Report No. 1 “Adjustable Face Vehicle Traffic Control Signal Head Standard” as approved by the American National Standards Institute (ANSI). Metal reflectors shall be of non-ferrous metal not less than 0.55 mm thick plated with nickel and then chromium plated, or other suitable construction that is not less effective. Metal reflectors shall be stiffened and supported to prevent distortion.

613.02.5 Lamp-holder

(1) Each lamp-holder shall be suitable for an Edison screw lamp or other type approved by the Engineer and the dielectric shall be of a tough incombustible insulating material which will not be affected by prolonged heating to 200 °C nor by prolonged immersion in water. The lamp-holder shall be permanently positioned in such a way that the lamp filament shall be at focal centre of the reflector. A means shall be provided to rotate either the lamp-holder or the reflector so that the lamp lead-in wires will be at the top, and there shall be a suitable clamp to ensure that the lamp will not unscrew due to vibration. The lamp-holder shall be provided with two insulated wires of sufficient length to reach the specified terminal block at all times. The metal parts of the lamp-holder shall be electrochemically compatible with other contiguous metals

613.02.6 Lamps

(1) The lamps shall be Edison screw type, or such other type as approved by the Engineer, having an output of 665 lumens minimum.

613.02.7 Wiring

(1) All lamp-holders shall be wired to a suitable terminal block mounted in the housing, and shall be ventilated to avoid condensation. Wires shall be PVC insulated and free of all joints except in terminal blocks and shall be permanently colour coded to facilitate maintenance and repair. At each signal location unless shown otherwise on the Drawings there shall be a terminal compartment provided on the mounting which shall be provided with a terminal block containing 12 poles each with two screw type terminals of suitable size.

(2) A weathertight cover shall be provided to the terminal compartment which will give ready access to the terminal block, and the terminal compartment and cover shall be of sufficient strength to remain intact if the mounting pole is knocked down. Ventilation or other suitable means shall be provided in the terminal compartment to avoid excessive condensation.

(3) Connections from the signal face to the terminal compartment, where external, shall be protected by approved metallic tubing. Buried cables from the controller to signals and detectors shall be suitably armoured or laid in approved conduit and free of all joints except at terminal blocks of junction boxes. Wiring to signal will not be run to a terminal block on a signal pedestal unless it is to be connected to a signal that is mounted thereon.

(4) Sufficient conductors shall be provided to perform the functional operation of the signal system throughout and in addition between the controller and the signals three spare conductors shall be provided of size equal to the largest conductor in the run except neutral. Wires subject to bending due to opening and closing of doors shall be stranded.

(5) All metallic parts not carrying current shall form an electrically continuous system which shall be earthed, or they shall be separately earthed, using bare copper conductors with a minimum cross-sectional area of 4 square mm. All items below ground level shall be so designed and installed that they will continue to operate without fault if immersed in ground water.

613.02.8 Pedestals

(1) Pedestals shall consist of solid drawn or longitudinally butt welded mild steel tube, 115 mm outside diameter and not less than 4.5 mm wall thickness. The length of the pedestal shall be sufficient so that the centre of the lowest signal aspect will be at least 2.15 metres above ground when the foot of the pedestal is buried at least 600 mm below ground. A suitable base plate and finial shall be provided for each pedestal.

(2) Where necessary or desirable, signal heads may be mounted on existing suitable street furniture or buildings by means of a properly designed bracket or brackets, and where mounting has to be done close to a wall, the signal head may be attached to the pedestal via a bracket, but in this case the pedestal shall be at least 127 mm outside diameter and at least 165 mm outside diameter for one metre above ground level and of sufficient length so that the base of the signal head will be at least 2.4 metres above ground. Brackets shall be so designed that they will allow full adjustment of the signal heads and will support the signal heads rigidly under all normal conditions.

(3) Pedestals shall be provided with cable slots near the base and with the required cable bush holes in correct position. All cable slots and holes shall be free of burrs and rough edges. Suitable means shall be provided to fasten base plates, brackets and signal heads firmly to pedestals and to allow adjustment where required.

(4) All nuts, bolts, fastenings, hinges and adjusting brackets on pedestals, finial, terminal compartment and signal heads shall be cadmium plated or of stainless steel or made corrosion resistant in a not less effective manner.

613.02.9 Painting

(1) Paint and painting shall be in accordance with Section 521 of these Specifications with the following additions and modifications.

(2) Pedestals and brackets shall be provided with a prime coat and two coats of undercoat before delivery and sufficient finishing coat shall be provided for final painting after erection. The signal heads, terminal compartments, visors, louvres, and sighting screens shall be delivered primed-and with two undercoats and a finishing coat. Controller and other cases shall be finished with two coats of an approved aluminium paint on the outside and shall have priming, two undercoats and one finishing coat of paint on the interior. A coating of sprayed molten zinc will be accepted as an alternative to painting of cabinets.

613.02.10 Detectors

(1) Detectors for vehicle activated signals are required, and they shall be either inductive loops or pneumatic one way or pneumatic two way.

Inductive loops

(1) Inductive loops shall consist of a loop or loops of insulated conductor, a sensor unit relay and a power source. The loop detector shall operate on the principle that a vehicle standing or crossing over the loop will cause a change in inductance which will be detected by the sensor unit, so-operating the detector relay in the signal controller. The loop shall be installed in slots cut in the highway surface or laid under the wearing course and the depth, orientation and dimensions of the loop shall be as recommended by the manufacturer. The sensor unit shall be a solid state electronic device capable of sensing changes in the inductance of one or more loops and mounted in a waterproof container that will be located and suitably housed under the roadway or sidewalk close to the loop or loops.

(2) The detector shall be so designed constructed and adjusted that:

- i) It shall respond only to a vehicle passing over or standing over any portion of the loop.
- ii) It shall detect vehicles passing over it at speeds up to 100 kph.
- iii) The detector relay shall be de-energised immediately after a vehicle passes over it.
- iv) It shall re-balance to ignore parked vehicles and shall thereafter detect subsequent vehicles passing over it.
- v) It shall operate normally under any range of weather, temperature and humidity conditions and it shall not be affected by normal variations of line voltages.
- vi) Where operating as a speed detector which will influence the operation of the controller, the detector shall be fully capable of detecting differences of speed which are consistent with the capabilities of the controller.

(3) Inductive loop detectors shall detect over the entire width of the approach road leaving no gaps of more than 400 mm. Where required for separate detection, individual detectors will be provided for each traffic lane, and these shall be so designed and installed that there will be no mutual interference between them.

Pneumatic Detectors

(1) Pneumatic detectors shall be designed to be bolted securely into a metal frame set flush in the roadway so that the detector may be replaced without disturbing the roadway surface. The detector frame shall be designed to take the full live loading to be expected on the road. The detector shall extend the full width of the approach with no gaps of more than 400 mm, and where required separate detectors shall be with no gaps of more than 400 mm, and where required separate detectors shall be provided for each traffic lane.

(2) Operation shall be by pressure sensitive electrical switch that relays a demand to the controller. The pressure sensitive switch shall be waterproof and located in a waterproof container located under the roadway or the sidewalk in such a way that the switch will be readily available for inspection and checking after installation. Means shall be provided to ensure that arcing in operation is reduced to a minimum so that the switch will not require frequent cleaning or adjustment.

(3) The detector tread rubber shall extend over approximately the whole length of the detector and shall have the following properties when new:

Table 613.1 - Required Properties of Detector Tread Rubber

Test	Tensile Strength at break, kg / cm ²	Elongation at break %
Shore Durometer Type 'A' Hardness - 62 to 70	min 175	min 500
After ageing in a Geer Oven for 120 hours – at minimum 70 °C and 140 kg / cm ² pressure	min 120	min 400
After ageing in oxygen bomb for 120 hours - at 70 °C and 21.2 kg / cm ² pressure	min 105	min 350

(4) The Contractor shall provide certified test sheets from an approved laboratory for each batch for tread rubber, or other satisfactory evidence that the tread rubber is of approved type. The number of joints between the rubber tread and the pressure sensitive switch shall not exceed two. The tube connecting the tread and the pressure switch shall be readily replaceable and laid within a protective conduit which shall be kept free of water. A separate pressure switch shall be provided for each tread.

(5) Pressure sensitive detectors shall be capable of being operated by wheels having a wheel load of 25 kilograms or more. Detectors shall activate at speeds up to 100 kilometres per hour under normal conditions. When provided with suitable relay equipment, directional detectors shall operate to make a demand on the controller when a vehicle crosses in one direction but not when it crosses in the opposite direction. When a detector is required to operate as a speed detector, the treads shall be spaced sufficiently far apart that differences of speed will be detected which are consistent with the capabilities of the controller.

(6) For each detector, whether inductive or pressure sensitive, a button shall be provided at the controller which can simulate a demand on that detector. An ON/OFF switch shall also be provided at the controller for each detector to allow that detector to be switched out of circuit independently of any other detector. Both buttons and switches shall be clearly and permanently labelled to indicate which detector is controlled and switches shall have the ON and OFF positions labelled. The detector shall be in the circuit when the switch is in the ON position.

613.02.12 Controller

General

(1) The controller shall be a complete electrical mechanism for controlling the operations of the traffic control signals, including the timing mechanism and all necessary auxiliary equipment, securely mounted in a cabinet. Preference will be given to solid state circuitry and to designs having replaceable units for ease of maintenance. Interval timing shall be by electronic and not by mechanical means. The colour sequence of signal indications shall be as given in sub-clause 613.03.1 of these Specifications and there shall be control to ensure that green will not be shown at the same time on opposing phases under any circumstances. Operation shall be either by fixed time sequences, (variable by time switch) or shall be by vehicle activation or by combination of both, as specified in the Special Provisions or as directed by the Engineer, and as herein described.

(2) The operating voltage shall be as given in the Special Provisions, or as directed by the Engineer, and the controller shall be designed to operate satisfactorily with voltage variations up to +17.5 % or -20.0% from that specified. The timing of the controller shall be within ± 7.5 % of correct at the rated voltage and shall not be affected by more than ± 10 % for a ± 10 % change in voltage or a ± 4 % change in frequency of the supply.

(3) The controller shall be so designed that temperature variations between 10 °C and 70 °C shall not change the timing by more than 5% or otherwise the cabinet shall be artificially ventilated to keep the internal temperature within satisfactory limits. In the event of power failure, the controller shall shut down and re-commence operations without the necessity for manual re-setting.

(4) The controller shall be provided with suitable mechanism for closing and opening signal circuits, which shall be positive and without any dark intervals, flickering or conflicting signal indications. All contact points which carry, make or break current shall be of fine silver, silver alloy or an alternative better material and shall be capable of carrying, making or breaking a current of 150 % of maximum demand load through one million operations without electrical or mechanical trouble.

(5) Every current interrupting device shall be equipped with a suitable radio interference suppressor installed at the input power point. Interference suppressors shall be of a design which will minimise interference on both broadcast and aircraft frequencies.

(6) The controller shall provide for the proper phase intervals and sequences as herein specified or as may be required by traffic conditions. The setting of time intervals shall be by means of a positive method against a scale calibrated in seconds. This timing scale shall be easily accessible and identifiable within the controller and it shall not be necessary to remove or change wires or contacts to adjust the time intervals.

Manual Operation

- (1) Manual operation shall be possible by means of an approved key or by external buttons on the controller housing. If push buttons are used, they shall be inoperative until the controller has been switched to manual operation by means of a switch mounted under a lockable cover. The automatic operation of the controller shall not be upset by manual operation, and automatic control shall resume without the need for any manual adjustment at the end of manual operation.
- (2) Provision shall be made for the following manual operations:
 - i) substitution of flashing signals in place of the normal cycle (where flashing signals have been specified)
 - ii) allocating right of way to approaches independently of the pre-set timing of the controller
 - iii) switching signals to "OFF"
- (3) Provision shall be made that under no circumstances will an approach lose its right of way without having at least the appropriate minimum green time plus amber time.

Time Switch

- (1) Where a time switch is required this shall be capable of two 'ON-OFF' periods per day of a minimum length of sixty minutes each and with a minimum period of sixty minutes between successive 'ON-OFF' positions. The setting dial shall clearly distinguish between day and night, and the switching mechanism shall be fitted with a selective device enabling all switching to be eliminated on any one day in the week or early or late switching on two selected days. The week dial shall be clearly marked with the days. The time mechanism shall be fitted with a first quality mechanical movement that shall be electrically wound and shall have a minimum spring reserve of twelve hours.

Flashing Signals

- (1) Where flashing operation is called for, this shall permit either amber or red flashing on any or all approaches. The flashing unit shall generate signal indications at the rate of not more than 60 nor less than 50 per minute, and the rapidity of flashes shall remain constant. The illuminated period of each flash shall be approximately equal to the non-illuminated period. A switch or fuse shall be provided which will allow the controller to be shut down when the flashing signals are in operation.

Switches and Fuses

- (1) The controller shall be provided with a main switch and fuse which will isolate the complete installation. There shall also be provided one general purpose outlet and fuse. All fuses and switches shall be adequately and permanently labelled.

Controller Housing

- (1) The Controller shall be housed in a weatherproof cabinet of aluminium, sheet metal, glass fibre or other approved material having sufficient strength and rigidity to protect the contents from the effects of water, dust and accidental blows. Sheet metal shall be at least 2 millimetres thick at all points and reinforced where necessary. Ferrous metal shall not be buried and it shall be rust-proofed by galvanising or some other equally effective means. If aluminium or aluminium alloy is used, it shall be suitably protected against electrolytic or chemical corrosion and in the base of the housing it shall contain at least 8% of silicon.
- (2) The housing shall be securely fixed to a concrete base through which connections shall be made to detectors and signals. All doors shall be hinged with concealed hinges, and provided with locks, the door hinges and pins being of non-corrodible metal which shall require lubrication not more often than once per year. Doors shall open and shut freely without binding on the frame or the base. Otherwise, doors may consist of a stiff removable panel having self-positioning interlock joints provided with suitable gaskets. Such panels shall be provided with at least two locks. All locks shall be captive, flush-fitting and non-corrodible and shall operate by a standard key which will fit all housings.

(3) The controller shall be sited in such a way that it will not cause an obstruction or hazard to traffic or pedestrians, and where it will not be subject to accidental damage from traffic.

(4) The cables running to signals and detectors shall be terminated in a convenient and readily accessible position on blocks having the required number of terminals and provided with non-hygroscopic non-inflammable insulating bases. Sufficient space shall be left between terminals and between blocks to enable external cables to enter and be formed in a neat manner without obstructing individual terminal points. Electrical connections between controller and the terminals shall be by approved plug and socket connections.

(5) Each terminal point and connection shall be clearly marked by colour coding or by a numbering system. Ends of all spare conductors shall be shielded, covered or insulated so that no live parts will be exposed.

Identification

(1) All equipment and replaceable assemblies shall be marked with an item number and any other identification which is required for re-ordering.

Records

(1) The following records shall be provided and kept within the housing, either fixed to the inside of the main door or placed within a metal pocket provided thereon.

- i) a wiring diagram of the system showing the colour coding or number of the conductors;
- ii) a layout plan of the road intersection showing the detectors, the signals controlled by each phase and the cycle details; and
- iii) a suitable record card shall be fixed within the controller upon which space is provided to record maintenance undertaken, the date of visit and the name of the person doing the maintenance.

(2) The signal serial number shall be stencilled in two noticeable locations on the outside of the housing in letters not less than 25 mm high.

Fixed Time Signal Controller

(1) In addition to the foregoing requirements, where fixed time signals are required, the controller shall be capable of carrying out the following operations, although it shall not necessarily be limited to these:

- i) allocation of right of way by suitable timed green aspects to the various approaches in accordance with the timings previously set on the controller;
- ii) changing from one phase to another by means of the correct sequence of signal phases as given in sub-clause 613.03.1 of these Specifications and maintaining the correct pre-set amber periods throughout. It shall be possible to vary the length of inter- green period without use of special tools;
- iii) allowing a late start or early cut off on one or more phases as may be specified;
- iv) displaying left or right filter arrows as may be specified.

(2) By means of a time switching device it shall be possible to alter the phase and cycle lengths to allow for varying traffic conditions. It shall be possible to operate at least three such programmes during a period of 24 hours.

(3) It shall be possible to integrate the controller into a linked system working under a master controller if required, and to add a facility for vehicle counting. The sequence of phases shall be capable of alteration without any modification to the controller. When specified, it shall be possible automatically to dim the traffic signal lights during the hours of darkness.

Vehicle - Activated Signal Controller

- (1) In addition to the foregoing requirements where vehicle activation is called for, the controller shall be capable of, but not necessarily limited to the following operations.
- i) In the absence of detector activation, the right of way shall remain on the phase on which the last demand was made. However, a recall switch shall be incorporated into each phase which, when closed, will result in the right of way automatically returning to that phase without further demand. (Automatic Reversion);
 - ii) When the right of way is transferred to a phase in response to a demand, this right of way shall continue for at least a pre-set and adjustable minimum period (Minimum Green Time);
 - iii) Continued demands beyond a predetermined number on a phase having the right of way shall cause the initial minimum right of way period to be extended, the extension being proportional to the additional demands (Vehicle Extension Periods);
 - iv) In the absence of demands from other phases, continued demands on the phase having the right of way shall hold that right of way. When a demand is made from another phase, the phase holding the right of way shall lose it, even in the event of continuing demands, after a pre-set adjustable maximum period (Maximum Green Period). The timing of the maximum green period shall commence from the first receipt of a demand from another phase;
 - v) Should there be outstanding demands on the phase losing the right of way or should further demands be made on a phase during the clearance period, then right of way shall revert automatically to the phase losing it, once demands of other phases have been satisfied;
 - vi) The transfer of right of way shall take place only after an adjustable clearance period, which may differ between different phases (Inter-green Period);
 - vii) Provision shall be made for green filter arrows and late-start or early cut-off facilities on any phase. If these are not required at the outset, there shall be provision for their inclusion at a later stage if required;
 - viii) It shall be possible to incorporate the controller into a linked system under a master controller if required, and there shall be facilities for resumed independent operation either on a time basis or as a result of altered traffic conditions;
 - ix) Traffic counting and queue detection, if not specified, may be required at a later stage and facilities for these should be incorporated or it should be possible to add them easily when required.

Vehicle - Activated Controller with Speed Measuring Equipment

- (1) When the controller is to be used with speed measuring detector, the following additional facilities will be required on the controller, as well as items (i) to (ix) above:
- i) The minimum green time referred to in sub-clause 613.3.11 *Vehicle-activated Signal Controller (ii)* above of these Specifications shall be reduced according to the number of demands that have been made below the predetermined number from sub-clause 613.3.11 *Vehicle - activated Signal Controller (iii)* of these Specifications so that if there are less than the pre-determined number of vehicles waiting for the right of way, only sufficient time will be given for that number to clear the junction before right of way is given to another phase that has made a demand (Variable Minimum Green Time);
 - ii) The vehicle extension period given in sub-clause 613.3.11 *Vehicle - activated Signal Controller (iii)* above of these Specifications shall be variable in length and not fixed, the length of each vehicle extension period being inversely proportional to the speed of the vehicle making the demand at the detector pad (Variable Vehicle Extension Period);
 - iii) If a demand is made on a phase not having the right of way and all demands have been met on the phase having the right of way, then the right of way shall be given to the phase making the demand after a minimum inter-green period. However, if at the expiration of the maximum green period on the phase having the right of way there are still vehicle extension periods outstanding, the inter- green period shall be lengthened by the introduction of an all-red period if required to ensure that the right of way is not given to an opposing phase before fast traffic has cleared the junction on the phase losing the right of way (Variable Inter-green Period).

613.03 DESIGN REQUIREMENTS

(1) This clause gives general guidance in the design principles when the Contractor is required to make the design.

613.03.1 Sequence

(1) The colour sequence of signal phases shall be:

- Red
- Red and Amber
- Green
- Amber

(2) During any signal phase, there shall be no visual flicker of the signal illumination.

613.03.2 Siting of Signals

(1) Siting of signals will be carried out in detail at the junction and shall be agreed by the Engineer. Each approach road shall be served by a minimum of two signal faces as follows:

- i) The Primary Signal which will be located not less than 1.0 metre beyond the Stop Line on the nearside of the road. Where there is a central median, a second primary signal shall be provided similarly on the offside of the approach; and
- ii) The Secondary Signal which will be on the diagonally opposite side of the junction facing the approach, that is, on the back of the primary signal serving the opposite approach in the case of a four arm junction. The secondary signal may be opposite the offside of the approach where there is a central median, but in any case should not be outside an angle of 30° extended from the centre line of the approach at the Stop Line to the offside. Where the distance from the Stop Line to the secondary signal is more than 50 metres, additional secondary signals should be provided.

(2) No part of any signal or pedestal shall be within 500 mm of the kerb line, and the height of the centre of the green light shall be not less than 2.15 metres nor more than 3.0 metres from the ground.

(3) The axes of the beams from the optical systems shall be directed at a point 45 metres away from the primary signal face at a point approximately 1.5 metres above the centre line of the approach, unless sharp gradient changes make this undesirable.

613.03.3 Stop Lines

(1) Stop Lines shall be located as shown on the site layout plan.

613.03.4 Detectors

(1) Detectors, where vehicle activation is specified, shall be not more than 45 metres nor less than 30 metres from the stop line on each approach, although on difficult approaches carrying only slow traffic, this minimum may be reduced to 20 metre. On high speed roads, where secondary detectors are called for, these shall be placed at not more than 165 metres from the stop line.

613.03.5 Phases

(1) The number of phases at the intersection shall be kept to the minimum required to avoid dangerous conflict of traffic. Where additional phases are called for by unusual traffic conditions at certain times, these additional phases shall be suppressed when not required. In designing the number of phases and the details of the cycle, the principle shall be to arrive at the arrangement which will at all times give minimum average delays to traffic with adequate capacity and maximum safety to both vehicles and to pedestrian.

613.03.6 Filter Signals

(1) Filter Signals mounted at the side of the main signal may be used to allow a movement in one direction. A green filter arrow indication shall always be followed by an amber and red colour, and if this cannot be done on the main signal, separate amber and red aspects must be provided for the filter signal. Particular care shall be taken to ensure that filtering traffic does not form an undue hazard to pedestrians crossing; guard rails, slip roads, islands or relocating of the stop line may be required to avoid this. Filtering traffic will not be permitted when it will have to merge with through traffic. Where an early cut-off is used for left turning traffic, a left-side filter arrow will be provided to indicate to turning traffic that it is safe to proceed.

613.03.7 Clearance Period

(1) Clearance periods shall be at least four seconds. Where required for safety or to allow turning traffic to clear, a longer clearance period may be introduced but this should be kept to the shortest period that is consistent with the demands of traffic and safety at any time.

613.03.8 Linked Systems

(1) When a linked system is called for, or where linking with nearby signals is desirable, this system shall be designed to give progression of green periods in both directions along the routes involved and at speeds that will give high capacity. The speeds through the system shall be as uniform as possible and the demands of cross traffic shall be fully met. With fixed time signals, there shall be the facility to change automatically the programme of linking, if necessary, so as to give preference to the heavier flows at different times of the day. With vehicle activated signals, local controllers shall be free to revert to independent operation when there ceases to be a continuous demand, providing that this will not interfere with the overall progression through the system. All calculations done for linked systems will be submitted for checking by the Engineer.

613.03.9 Signal Timing

(1) Signal Timing will be done on the basis of traffic demands as estimated from the traffic flows. Verification and adjustment will be required on site after the system is in operation, but the contractor must show by calculations to the Engineer that the system proposed is capable of handling the estimated maximum and normal flows in an efficient manner and with minimal delays. With fixed time signals, he will submit details of phases and cycles for each approach throughout the day. In the case of vehicle activated signals, he will give similar details of maximum cycle time, maximum and minimum green times, vehicle extension periods and inter-green periods.

613.04 CONSTRUCTION REQUIREMENTS

613.04.1 Excavation and Reinstatement

(1) The provisions of sub-clause 611.03.1 of these Specifications shall apply.

613.04.2 Concrete Work

(1) The provisions of sub-clause 611.03.2 of these Specifications shall apply.

613.04.3 Conduits, Fittings and Boxes

(1) Conduits, fittings and boxes shall be provided and installed in accordance with the provisions of Section 523 of these Specifications, except that chemically stable, tough plastic conduits, fittings and boxes, according to samples previously approved by the Engineer, will be permitted providing that they do not soften when exposed to high ambient temperature.

(2) The Contractor may use a larger size of conduit than that specified, at no extra charge, if he wishes, but in this case the entire run shall be of the same size. No reducing couplings will be permitted.

(3) When metal conduits are used, cuts shall be made square and true and all couplings shall be screwed up until the ends of the conduits are brought together in order to provide a good electrical contact throughout. The threads on all ferrous metal conduits shall be painted with a rust preventing paint before couplings are made up. Where the coating on ferrous metal conduit has been damaged in handling, such damaged places shall be painted with rust preventing paint before installation.

(4) All conduit ends shall be threaded and capped until wiring is started. When caps are removed, the threaded ends shall be provided with approved conduit bushings.

(5) Conduit shall be laid to a depth of not less than 500 mm below paved sidewalks and medians and not less than 750 mm below the roadway surface. The location of all conduits at curb lines shall be marked by means of a 'Y' at least 100 mm high incised in the face of the curb directly above the conduit. Conduit terminating in standards, cabinets or pedestals shall extend at least 50 mm vertically above the foundations and shall be sloped towards the opening. Conduit entering pull boxes shall terminate at least 50 mm inside the box wall and at least 50 mm vertically above the bottom of the box. Such conduit shall be sloped towards the top of the box to facilitate pulling. Conduit entering the bottom of the box shall enter near the sides or end to leave the centre clear. All conduit shall enter in the direction of the run.

613.04.4 Pull Boxes

(1) Pull boxes shall be installed as shown on the plans and in any case at not more than 60 metre intervals. The Contractor may install additional pull boxes without extra charge if he wishes. Pull boxes shall be of reinforced concrete not less than 100 mm thick and may be of approved precast design. Reinforced concrete covers, secured by two recessed brass bolts shall be used on sidewalks, the covers being inscribed 'Traffic Signals' on the outside. Under the roadway, covers shall be of steel or cast iron, inscribed as specified above and laid in a suitable concrete footing to withstand traffic loads. Metal covers shall be effectively earthed to an earthing rod inside the box. Tops of pull boxes shall be effectively level with the surrounding paved areas, whether sidewalk or roadway, but in unpaved areas, the tops of pull boxes shall be buried 300 mm below ground level. The bottom of pull boxes shall be bedded in sand and cement or crushed rock. Permanent markers shall be provided and erected to show the position of all pull boxes.

613.04.4 Testing

(1) A functional test shall be made on completion of the work in order to demonstrate that every part of the equipment and installation functions as intended and specified. This test shall consist of not less than five days continuous and satisfactory operation. If any defects or unsatisfactory operation are revealed, this condition shall be corrected at the cost of the Engineer and the test continued until the required five days of satisfactory operation have been fulfilled.

(2) Prior to the functional test, the Contractor shall carry out the following tests to the entire satisfaction of the Engineer:

- i) Each circuit shall be tested for continuity;
- ii) Each circuit shall be tested for earthing;
- iii) A 'megger' test shall be made between each circuit and earth. The insulation resistance shall be shown to be at least that specified within the relevant Codes.

(3) On the completion of testing, the Contractor shall supply to the Engineer three copies of "as built" plans and circuit diagrams, which shall clearly indicate any modifications made to the original design.

613.05 MEASUREMENT

- (1) Measurement shall be as follows:

Item No.	Description	Unit
613-1	Traffic Signals	Lump Sum

- (2) The details of the work to be included in the lump sum measurement shall be as shown on the Contract Drawings and as specified in these Specifications.

613.05 PAYMENT

- (1) Payment will be made at the rate entered in the Bill of Quantities which shall be full compensation for furnishing all labour, materials, tools equipment, supervision and incidentals and for doing all the work involved in furnishing and installing the system shown on the Drawings and as specified herein and in the Particular Specifications, and as directed by the Engineer, including any necessary backfill, concrete foundations, restoration of foot-walk, roadway, curbing and appurtenances damaged or destroyed during construction and in making all tests. It shall also cover the costs of design.

- (2) The lump sum payment shall be deemed to include full compensation for all additional materials and work not shown on the Drawings or specified which are necessary to complete the installation.

- (3) The location of traffic signals are to be stated in the Bill of Quantities and in the drawings.

SECTION 614

PERMANENT TIMBER BARRICADES

614.01 DESCRIPTION

(1) The work covered by this Section consists of furnishing materials and erecting permanent timber barricades according to these Specifications, at the specified locations and in conformity with the dimensions and design shown on the Drawings or as directed by the Engineer.

614.02 MATERIALS

(1) Concrete shall conform to the requirements of Section 5.7 of these Specifications. Reinforcement, where required, shall conform to the requirements of Section 5.6 of these Specifications.

(2) Posts and railing for the barricades shall be timber of the Mai Teng, Rung or Takhien types. Timber posts shall be treated as specified in AASHTO M 122 73. Timber railings shall receive three coats of paint as specified on the Drawings.

(3) With the approval of the Engineer, the Contractor may substitute reinforced concrete posts with hardwood posts with no change in unit price. Reinforced concrete post shall be constructed with Grade 20 Concrete, according to Section 507 of these Specifications.

(4) All fastening shall be either wrought iron or medium steel and shall be galvanized in accordance with the requirements of ASTM A153.

(5) Paints shall be of a high quality and before use shall be tested by the Contractor and subject to the approval of the Engineer. White paint used in the painting shall possess a highly reflective quality.

(6) Concrete footings used for the post shall conform to the requirements of Grade 20 Concrete, according to Section 507 of these Specifications.

614.03 CONSTRUCTION REQUIREMENTS

(1) Barricades shall be constructed to conform to the sizes and dimensions shown on the Drawings and in accordance with these Specifications.

614.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
614-1	Permanent Timber Barricades	Metre

(1) Permanent Timber Barricades shall be measured by the number of linear meters from centre to centre of the end posts completed and accepted in place.

614.05 PAYMENT

(1) Payment will be made at the rates entered in the Bill of Quantities, which rates shall include full compensation for furnishing all materials, excavations, placing and aligning, backfilling and all equipment, labor, tools and incidentals necessary to complete the work.

SECTION 615**FENCING****615.01 DESCRIPTION**

(1) The work covered by this Section consists of furnishing and installing fences and gates of the type indicated, constructed in accordance with this Specification at the locations and in accordance with the lines, grades, levels, designs and dimensions shown on the Drawings.

615.02 MATERIALS

(1) Concrete shall conform to the requirements of Section 5.7 of these Specifications. Reinforcement, where required, shall conform to the requirements of Section 5.6 of these Specifications.

(2) Timber shall be sound timber free from shakes, splits, wavy edges and heart wood. The timber shall be well seasoned, treated in accordance with the requirements indicated on the Drawings and of the dimensions indicated. The species of timber shall be as stated in the Drawings or in these Specifications. Cable, chain link and barbed wire shall be of the gauge, weight, size and type indicated on the Drawings or in these Specifications and shall be galvanised. Hinges and fittings shall be of the size and type indicated in the Drawings or in these Specifications.

615.03 CONSTRUCTION REQUIREMENTS

(1) Posts shall be set vertically to the depth shown on the Drawings and maintained in accurate alignment while fencing is erected and backfilling is done. Backfilling shall be done with suitable material, not necessarily the material excavated, and shall be well tamped into compacted layers not exceeding 100 mm thickness. On completion of erection the fence shall be firm with no loose or movable parts and true to lines grades and levels to within 100 mm.

(2) Gate anchors shall be securely buried and backfilled as for posts and shall show no signs of movement when wires are strained tight.

(3) Painting shall be in conformity with the requirements stated on the Drawings or in Section 521 of these Specifications.

615.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
615-1	Fencing (description to be added)	Metre
615-2	Gates (description to be added)	Number

(2) If more than one type is used, successive serial numbers may be used in brackets to define new items.

615.05 PAYMENT

(1) Payment will be made at the rates entered in the Bill of Quantities, which rates shall include full compensation for furnishing all materials and for all labour, equipment, tools and incidentals necessary to complete the work.

SECTION 616

LANDSCAPING AND BEAUTIFICATION WORKS

616.01 DESCRIPTION

(1) The work covered by this Section consists of furnishing, delivering and planting ground cover, turf, sods and grass seeding including topsoil, fertiliser and other items involved in landscaping and beautification work, all as shown on the Drawings or as ordered by the Engineer.

616.02 MATERIALS

616.02.1 Top Soil for Landscaping Area

(1) Top soil shall be natural loam from the local area, free from large stones, roots, sticks, clay, weeds and shall be obtained from rice fields, gardens, foothills or other approved source. It shall be soil having a pH ranging from 6.5 to 7.5 and having more than 3% of organic matter without any toxic materials harmful to plant growth.

616.02.2 Fertilizer

(1) Fertilizer shall be urea, containing not less than 46% of nitrogen (N) or other fertilizers in 15-15-15 (N-P-K) grade or organic fertilizer as directed by the Engineer. Fertilizer shall be delivered to the site in the original unopened containers, showing the manufacturer's guarantee and analysis. It shall be stored in a dry and ventilated area before use.

616.02.3 Plants and Sods

(1) Plants shall be of the type, size and dimensions as shown on the Drawings. All plants shall be of complete form and free from any sickness and shall, as much as possible, be delivered from a single plant nursery as approved by the Engineer. The plants shall, at time of delivery, be clearly marked with a name plate tied to the trunk. Shrubs and ground covers shall be of complete form and fine grown in standard flower pots.

(2) Sod sheets shall be 50 x 100 cm, obtained from the local area, free from noxious weeds and burned spots and shall have a complete mat with healthy root systems. Sod stored more than 3 days before use shall be rejected.

616.03 CONSTRUCTION REQUIREMENTS

616.03.1 Clearing

(1) All planting areas shall be cleared of existing vegetation not specified to remain and all other debris and foreign material considered a hindrance to planting operations and/or unsightly in appearance. All weeds shall be chemically eradicated or manually removed.

(2) The previously established grades shall be maintained (Finish graded areas only).

(3) The Contractor shall be responsible for cleaning existing plants made dirty by him during his construction works. Plants which have been removed from their original locations and are suitable for re-planting, shall be re-planted at locations as instructed by the Engineer.

616.03.2 Planting

(1) Tree and shrub pits shall be 60 cm greater in diameter than the ball earth or spread of roots of the tree and sufficiently deep to allow for a 30 cm thick layer of loam (topsoil) beneath the ball or roots.

- (2) The depth of planting beds and pits shall be adjusted as necessary to permit a minimum of 10 cm of topsoil over the balls or roots of all plants.
- (3) Plant pits shall not be backfilled with topsoil until they have been approved by the Engineer.
- (4) If pits are prepared and backfilled with topsoil on grade prior to planting, their location shall be marked and recorded on the Drawings so that when planting proceeds they can be easily be found. Plants shall be planted at the densities noted in the schedule.
- (5) After the plants are set in the centre of pits plumb and straight, topsoil shall be compacted around bases of balls to fill all voids. All burlap, ropes or wires shall be removed from the balls. After planting, trees and shrubs shall be secured by stakes or wires as long as necessary to ensure a satisfactory growth.
- (6) Topsoil around roots or balls shall be thoroughly compacted and watered. Immediately after the plant pit is backfilled, a shallow basin slightly larger than the pit shall be formed with a ridge of soil to facilitate watering and to preserve water.
- (7) After planting, ground cover shall be covered with approved covered materials to protect against the sun for as long as necessary to promote growth.
- (8) Fertilizer shall be added at the time of planting if necessary to acquire a healthy growth. The type of fertilizer shall be appropriate for each type of plant (conforming to the principles of Botany) as recommended by the nursery and as approved by the Engineer.

616.03.3 Sodding

- (1) The subgrade of areas to be sodded shall be raked and all rubbish, sticks and lumps of soil shall be removed. Topsoil, conforming to Clause 616.02.1 of this section shall be spread and lightly compacted to a depth of 10 cm. Over areas to be planted, with fertilizer applied as recommended. Sods shall be placed in a solid strip laid edge to edge with staggered joints. The combined thickness of the sod and topsoil shall be at least 13 cm. Careful handling of the sods and maintenance of the sodded area as mentioned in Section 609 of these Specifications shall be followed.

616.03.4 Grading

- (1) Finish grading shall be adjusted with topsoil as necessary. Grades shall be smooth and even on a uniform plane with no abrupt changes or pockets, and shall slope away from all buildings. Surface drainage of all planting areas shall be ensured.
- (2) The Engineer shall be informed of any discrepancies, obstructions, or other conditions considered detrimental to proper execution of the work.
- (3) Landscaping work shall be tied to existing conditions and controls such as existing trees and landscape features, utility lines, pavement, curbs, and other adjacent objects. Finished grades shall bear proper relationship to such controls. All new work shall be adjusted as necessary to meet the conditions and fulfil the intentions of the Drawings.
- (4) After initial settlement the finish grade shall be lower than the top of adjacent walks, curbs and headers.
- (5) Immediately prior to planting operations, all planting areas shall be cleaned of weeds, debris, stones over 25 mm in diameter, and clumps of earth that will not break up.

616.03.5 Maintenance

- (1) The Contractor shall maintain the plants at his expense until the end of the Defects Liability Period. Maintenance shall consist of preserving, trimming, and protecting plants as well as replacing dead plants. The Contractor shall water and fertilize the plants at such intervals as may deemed necessary for the healthy growth of the plants during the Defects Liability Period. Dead plants shall be replaced by the Contractor as soon as possible.

616.04 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
616-1	Ground Cover, Complete, incl. Maintenance	Provisional Sum
616-2	Flower Beds, Complete, incl. Maintenance	Provisional Sum
616-3	Other Landscaping and Beautification Work	Provisional Sum

616.05 PAYMENT

(1) Payment will be made at the rates entered in the Bill of Quantities (Provisional Sums are estimates of the construction costs) which rates shall include full compensation for all the specified requirements of these specifications and all requirements not shown on the drawings or specified which are necessary to complete the work, covering the furnishing and placing of all materials shown on the drawings including all labour, equipment, tools and incidentals.

(2) Payment will be made on the basis of the degree of completion of the work, as determined by the Engineer in the field based on break down of costs of the above mentioned items of work, as accepted by the Engineer.

(3) Sodding of the road embankment shall be paid for separately in Section 609.

SECTION 617

TRAFFIC CALMING DEVICES

617.01 DESCRIPTION

- (1) The work covered by this Section consists of furnishing and installing speed bumps, speed humps, speed tables and rumble strips as shown on the Drawings or as directed by the Engineer.
- (2) Speed humps and speed tables are mostly used on streets and roads, while speed bumps are used more in parking lots. While speed bumps generally slow cars to 8–16 km/h, speed humps slow cars to 24–32 km/h.
- (3) The rumble strips may be transverse rumble strips that extend across the travel lanes alerting drivers to unexpected changes in alignment and to conditions requiring a stop, or longitudinal rumble strips along the shoulder or centre line alerting road users that they are leaving the travel lanes.

617.02 SUBMITTALS

617.02.1 Drawings

- (1) The Contractor shall provide detailed working drawings, including locations plans, to be reviewed by the Engineer prior to start of the works.
- (2) The Contractor shall not start the construction of any work for which working drawings are required until the drawings have been approved by the Engineer.

617.02.2 Product Data

- (1) For all products to be used, descriptions of physical characteristics, sizes, patterns and method of installation shall be submitted.

617.02.3 Test Reports

- (1) Certified test reports, prepared by an independent testing laboratory, showing conformance to specified quality standards shall be provided. Test results shall represent average results for produced goods and shall not be older than two (2) years.
- (2) Certified test reports shall be submitted to the Engineer indicating that the materials meet all requirements specified.

617.02.4 Maintenance

- (1) Manufacturer's recommended cleaning and maintenance data shall be provided, including maintenance procedures, recommended maintenance materials and suggested schedule for cleaning.

617.03 MATERIALS

617.03.1 Speed Bumps, Speed Humps and Speed Tables

- (1) Material options for speed bumps shall be partly or 100 % recycled material (e.g. rubber from tires, synthetic and natural rubber composites) blended with polyurethane pre-polymer, bonded polymer, high strength PVC.
- (2) Rubber composite material shall be compression moulded and it shall be resistant to UV, moisture and oil. The material shall be tested as shown below.

Table 617.1 - Tests Required on Rubber Composite Materials

Characteristics	Requirements	Test Method
Coefficient of thermal expansion	Min $14.4 \times 10^{-6} \text{ K}^{-1}$	ASTM C531: Test Method for Linear Shrinkage and Coefficient of Thermal Expansion of Chemical-resistant Mortars, Grouts and Monolithic Surfacing
Density	Min 0.085 g / cm^3	ASTM C642: Test Method for Density, Absorption and Voids in Hardened Concrete
Tensile strength	Min 3.5 MPa (500 psi)	ASTM D412: Test Methods for Rubber Properties in Tension
Weathering for a minimum of 70 hours at 70 °C	Hardness retained: 100% ($\pm 5\%$) Compressive strength: 100% ($\pm 5\%$) Tensile strength: 100% ($\pm 5\%$) Elongation retained: 100% ($\pm 5\%$) Hardness retained: 100% ($\pm 5\%$)	ASTM D573: Test Method for Rubber – Deterioration in an Air Oven
Compression deformation	Minimum compression deformation of 10% at 0.5 Mpa and 20 °C	ASTM D395: Standard Test Methods for Rubber Property – Compression Set
Brittleness	Low temperature brittleness of -40 °C	ASTM D746: Test Method for Brittleness Temperature of Plastics and Elastomers by Impact
Hardness	Minimum Durometer hardness of 65 A	ASTM D2240: Test Method for Rubber Property – Durometer Hardness
Thermally embedded Reflective Material		
Tensile strength	Min 6.9 Mpa	ASTM D2370: Test Method for Tensile Properties of Organic Coatings
Elongation	Min 200%	
Abrasion	Max 20 mg loss	ASTM D4060: Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser

(3) Adhesive shall be urethane adhesive, non-toxic, non-flammable, waterproof; complying with the following:

Viscosity:	Tensile strength, minimum 6.9 Mpa when tested to ASTM D2370
Solids:	95% $\pm 2\%$
Working or Open Time:	Up to one hour
Weight per Litre:	1.258 kg
Flash Point:	121 °C
Storage Stability:	One year
Shrinkage:	None
Maximum VOC:	100 grams per litre

(4) Speed bumps shall be resistant to warping, cracking, chipping and rotting and they shall be flexible and capable of conforming to irregularities in paving surface. The material shall not suffer from colour fading and neither shall the colour and strength be affected by weed killers. When cleaned with hot soapy water the properties of the material shall not be affected.

(5) Speed humps and speed tables shall be made from asphalt, concrete, brick, recycled plastic, metal, vulcanized rubber, concrete pavers or other by the Engineer approved material.

617.03.2 Raised Rumble Strips

- (1) Thermoplastic material shall be used for rumble strips, which upon cooling to normal pavement temperature shall produce and adherent, reflective pavement marking capable of resisting deformation by traffic.
- (2) The thermoplastic material shall be free from all skins, dirt and foreign objects.
- (3) Laboratory samples shall be prepared in accordance with ASTM D5960 and shall meet the following criteria.

Table 617.2 - Required Properties of Raised Rumble Strips Material (Thermoplastic)

Property	Test Method	Minimum	Maximum
Water Absorption	ASTM D570	-	0.5%
Softening Point	ASTM D36	99 °C	-
Low Temperature Stress Resistance	AASHTO T 250	Pass	-
Specific Gravity	Water displacement	1.9	2.3
Indentation Resistance	ASTM D2240* Shore Durometer, A2	65	-
Impact Resistance	ASTM D256, Method A	1.0 Nm	-
Flash Point	ASTM D92	246 °C	-

* The durometer and panel shall be at 27 °C, but not exceeding 32 °C with a 2 kg load applied. Instrument measurement shall be taken after 15 seconds.

- (4) The colour, either white or yellow, of raised rumble strips shall differ from the colour of the pavement.
- (5) The white and yellow pavement marking shall attain an initial retro-reflectance of not less than 300 mcd/lx·m² and not less than 250 mcd/lx·m², respectively. The retro-reflectance of the white and yellow pavement marking at the end of the three year service life shall not be less than 150 mcd/lx·m².
- (6) Durability is the measured percent of thermoplastic material completely removed from the pavement. The thermoplastic material line loss must not exceed 5.0 % at the end of the three year service life. Durability also includes flattening of the profile or raised portions of the line. The flattening of the profile or raised portion of the line shall not exceed 25 % at the end of the three year service life

617.03.3 Rumble Strips for Shoulders and Centre-lines

- (1) The colour of the slightly raised or depressed longitudinal rumble strip shall be the same colour as the longitudinal pavement marking line the rumble strip supplements, which shall differ from the colour of the pavement.

617.04 DELIVERY, STORAGE AND HANDLING

- (1) If materials are factory made, they shall be delivered to the installation site in the manufacturer's original packaging. Packaging shall contain manufacturer's name, product colour, identification number and other related information.

617.05 DESIGN REQUIREMENTS

617.05.1 Speed Bumps, Speed Humps and Speed Tables

- (1) Speed humps and speed tables shall not be installed on streets with more than two travel lanes.

- (2) Speed humps and speed tables shall be installed only on streets where the speed limit is 50 km/h or less.
- (3) Speed humps shall be placed in a series 100–170 m apart, thus reducing 85th percentile speeds by 13–15 km/h.
- (4) The pavement where speed humps and speed tables are going to be installed shall have good surface and drainage qualities and the speed humps shall not be installed in such locations that road drainage is compromised.
- (5) Speed humps and speed tables shall not be installed over manholes, water valves, fire hydrants, less than 3 m from driveways, on sharp horizontal curves (due to vehicles stability problems), survey monuments, etc.
- (6) Speed humps (and other traffic calming devices) shall not be installed on streets with vertical grade greater than 5 %, unless approved by the Engineer.
- (7) Speed Bumps, Speed Humps and Speed Tables shall be implemented with a height of 76 to 100 mm.
- (8) Speed Bumps shall have a traverse distance less than but near 30 cm.
- (9) Speed Humps shall have a traverse distance of 3.0 to 4.3 m.
- (10) The speed table consists of the flat plateau with approaches on either side that can be straight, parabolic or sinusoidal in profile, with the dimensions according to the drawings and as agreed with the Engineer. On straight ramps, slopes shall be no steeper than 1:10, nor less than 1:25.
- (11) Speed tables may be used and marked as a pedestrian crossing (then referred to as “raised crosswalks” or “raised crossings”). When a speed table is used as a “raised crosswalk”, inlay tape and thermoplastic markings shall be applied, thus ensuring the speed table being visible to motorists, especially at night time.
- (12) Speed humps and speed tables shall have a side gradient of 1:3.
- (13) All speed calming devices shall be provided with reflectors, e.g. recessed cat-eye reflectors, as approved by the Engineer.

617.05.2 Rumble Strips

- (1) Transverse rumble strips shall consist of intermittent, narrow, transverse areas of rough-textured, slightly raised or depressed road surface that extend across the travel lanes.
- (2) Longitudinal rumble strips consist of a series of rough-textured, slightly raised or depressed road surfaces located along the shoulder.
- (3) Intervals between transverse rumble strips may be reduced, as decided by the Engineer, as the distance to the approached conditions is diminished in order to convey an impression that an approach speed is too fast and/or that an imminent action is required, e.g. slow down or stop the vehicle.
- (4) Transverse rumble strips shall be placed transverse to vehicular traffic movement and they shall not adversely affect overall pavement skid resistance under wet or dry conditions.
- (5) Transverse rumble strips shall be designed in a manner that does not promote unnecessary braking or erratic steering manoeuvres by road users.
- (6) Transverse rumble strips shall not be placed on sharp horizontal or vertical curves.
- (7) Rumble strips shall not be placed through pedestrian crossings or on bicycle routes.

(8) Transverse rumble strips shall not be placed on roadways used by bicyclists unless a minimum clear path of 1.2 m is provided at each edge of the roadway or on each paved shoulder as described in AASHTO's "Guide to the Development of Bicycle Facilities".

(9) Sufficient depth and centre to centre spacing of the longitudinal rumble strips shall be ensured.

(10) Longitudinal rumble strips shall not be placed on the shoulder of a roadway that is used by bicyclist unless a minimum clear path of 1.2 m is also provided on the shoulder.

617.06 CONSTRUCTION REQUIREMENTS

617.06.1 General

(1) Installation site and installation of the traffic calming devices need prior approval of the Engineer.

(2) Before installation, debris and dust from pavement surface and surrounding area shall be cleaned and removed and the pavement shall be washed with water and allowed to dry.

(3) Speed humps, speed tables and rumble strips shall be properly marked and shall be visible from the distance of minimum 30 m.

(4) Warning signs shall be placed sufficiently in advance warning on each speed hump, speed table and transverse rumble strip, and shall be placed in such a manner that the signs are clearly visible by approaching motorists.

617.06.2 Speed Bumps

(1) Loose speed bumps shall be attached to concrete pavement with lag bolts. Holes shall be drilled through indicated marks on the bumper, penetrating bumper to reach substrate material. Lag bolt with washer shall be driven through bumper holes and into substrate until flush with top of speed bump.

(2) Loose speed bumps shall be attached to asphalt pavement with lag bolts. Holes shall be drilled through indicated marks on the bumper and the holes shall be drilled 1 inch longer than length of shield, which shall be made of lead. Lag bolts shall be tightened until securely fastened into substrate and being flush with top of speed bump. Utmost caution shall be exercised so that bolts are not overtightened.

617.06.3 Speed Humps/ Speed Tables

(1) Speed humps and speed tables may be constructed on existing roadways (i.e., retrofit); or on new roadways or during resurfacing projects.

(2) When speed humps are constructed at site, profile template shall be used to ensure that the speed hump dimensions and profile are accurate within reasonable tolerances.

(3) When asphalt material is used to construct the speed humps or speed tables, the Contractor shall ensure that the works are performed in suitable temperature and by applying tack coat ensuring that the bond between the new asphalt and the existing street is sufficient, thus securing the durability of the speed humps and speed tables.

(4) Speed humps and speed tables shall be installed across the entire width of the pavement surface, except for leaving a 30 cm gap between the speed hump/ speed table and the pavement kerb to facilitate drainage.

Examination, Preparation and Installation of Speed Bumps/ Humps/ Tables

- (1) Before commencing the works the Contractor shall ensure that the pavement is smooth and flat and that the pavement and ambient air temperature are within temperature range recommended for proper curing of adhesive.
- (2) Installation with adhesive shall not be done when the pavement is wet or rain is anticipated.
- (3) As adhesive allows repositioning within the first hour after application; immediately after placement, bumpers shall be adjusted and repositioned in correct positions.
- (4) Excessive adhesive shall be removed immediately after placement and adjustment
- (5) Pre-fabricated speed humps and speed tables shall be installed with appropriate zinc plated steel lag bolts, zinc plated steel washers and shields, as approved by the Engineer.

617.06.4 Raised Rumble Strips

- (1) Before applying raised rumble strips, any material that would adversely affect the bond of the raised rumble strips shall be removed by a method approved by the Engineer.
- (2) Raised rumble strips shall be applied only to dry surfaces, and only when the ambient air and surface temperature is at least 13 °C and rising.
- (3) Before applying thermoplastic materials on concrete surfaces, a primer sealer shall be applied as recommended by the manufacturer.
- (4) Transverse rumble strips shall be formed by placing two pieces or more of pavement marking material on top of each other to obtain the desired thickness as specified or as directed by the Engineer.
- (5) Applied raised rumble strips shall have well defined edges.

617.06.5 Ground-in Rumble Strips for Shoulders and Centre-lines

- (1) Before the construction of any ground-in rumble strips, the Contractor shall demonstrate to the Engineer that the equipment to be used can achieve a depression having well defined edges and a smooth interior finish without snagging or tearing the finished pavement.
- (2) When milling into crowned pavements, the milling machine shall be equipped with a vertical alignment guide to orient the rumbles on the horizontal, rather than tilted level with the crown on one side of the joint or the other.
- (3) Where there are deterioration concerns due to that ground-in rumble strips provide reservoir to hold water, an asphalt fog seal shall be placed over ground-in strips to reduce oxidation and moisture penetration, as decided by the Engineer.
- (4) When constructing ground-in rumble strips on existing concrete shoulders, no rumble strips shall be located closer than 15 cm from any pavement joint.
- (5) Before opening the adjacent lane to traffic, the Contractor shall ensure that all debris generated by the grinding process is removed and disposed of daily by vacuum or a method approved by the Engineer. Debris shall not disposed of within the right of way.
- (6) Debris generated by the grinding process shall not be used in recycled asphalt.
- (7) When ground-in rumble strips do not meet the requirements of the Contract, the pavement shall be restored to the satisfaction of the Engineer at no additional cost to the Employer.
- (8) Pavement markings shall be applied over the ground-in rumble strips.

(9) On locations where centre line rumble strips have been constructed, warning signs specifically for motorcyclists shall be installed.

617.06.6 Defective Materials or Workmanship

(1) Materials which are defective or have been applied in an unsatisfactory manner or to incorrect dimensions or in a wrong location shall be removed, the road pavement made good and the materials replaced, reconstructed and/or properly located, all at the Contractor's expense and to the satisfaction of the Engineer.

617.06.7 Warranty

(1) A two (2) year warranty shall be provided on all factory made components of speed bumps, speed humps and speed tables, which have been installed as per the manufacturer's installation instructions.

617.06.8 Protection of Traffic

(1) The Contractor shall protect pedestrian, vehicular and other traffic adjacent to the working area against damage by construction equipment, tools and materials and shall during the course of the work provide and maintain adequate signs and signals for the warning and guidance of traffic.

617.07 MEASUREMENT

(1) Measurement shall be as follows:

Item No.	Description	Unit
617-01	Speed Bumps	Number
617-02	Speed Humps	Number
617-03	Speed Tables	Number
617-04	Rumble Strips	Metre Square

(2) Where the area of laid rumble or ground-in strips proves to be greater than that specified and is accepted by the Engineer, the specified area shall be used when calculating payment. Where the area of laid or ground-in rumble strips proves to be less than that specified and is accepted by the Engineer, the actual area of laid rumble or ground-in strips shall be used when calculating payment.

617.08 PAYMENT

(1) Payment will be made at the rates entered in the Bill of Quantities, which rates shall include full compensation for all cleaning and preparing of surfaces, disposal of all debris, furnishing of all materials, application, curing and protection of all items, protection of traffic, furnishing of all tools, machines and equipment, and all incidentals necessary to complete the work. Final payment will be withheld until all deficiencies are corrected.

(2) No partial payment for traffic calming devices shall be done.

SECTION 618

DAYWORK

618.01 DESCRIPTION

(1) The work covered by this Section consists of furnishing of labour, materials and equipment to carry out specific activities as instructed by the Engineer, in accordance with the provisions of the Conditions of Contract on a daywork basis.

618.02 GENERAL REQUIREMENTS

(1) In accordance with the provisions of the Conditions of Contract, the Engineer may instruct that varied work be undertaken on a daywork basis.

(2) Work shall not be executed on a daywork basis except by written order of the Engineer.

(3) The rates entered against the various items of the daywork bill shall apply to any quantity of work ordered by the Engineer. Quantities of work indicated against items of the daywork bill are nominal, and the extended total of the daywork bill, carried forward to the summary, is Provisional and may be expended as a whole, in part, or not at all, at the decision of the Engineer. Payments for daywork shall be subject to the price adjustment in accordance with the provisions of the Conditions of Contract.

618.03 MEASUREMENT

618.03.1 Labour

(1) Measurement for labour shall be as follows.

Item No.	Description	Unit
618-1	Foreman	Hours
618-2	Skilled Labourer	Hours
618-3	Unskilled Labourer	Hours
618-4	Mason	Hours
618-5	Carpenter	Hours
618-6	Steel Fixer	Hours
618-7	Driver - Vehicle up to 10 t	Hours
618-8	Driver - Vehicle above 10 t	Hours
618-9	Equipment Operator for Crane	Hours
618-10	Equipment Operator for Tractor, Loader, Excavator, Grader, etc.	Hours

(2) The hours for labour will be reckoned from the time of the arrival of the labour at the job site to execute the particular item of daywork, to the time of departure from the job site, but excluding meal breaks and non-working periods.

(3) Only the time spent working by those classes of labour directly engaged in the daywork ordered by the Engineer, and who are considered competent, by the Engineer, to perform such work, will be measured. The time spent by foremen or other supervision personnel will not be measured.

618.03.2 Materials

(1) Measurement for materials shall be as follows.

Item No.	Description	Unit
618-100	Cement, ordinary Portland or equivalent in bags	Tonne
618-101	Steel reinforcement grade ____ plain round	Tonne
618-102	Steel reinforcement grade ____ deformed	Tonne
618-103	Coarse concrete aggregate (nominal 19 mm)	Metre Cube
618-104	Fine concrete aggregate	Metre Cube
618-105	Sand	Metre Cube
618-106	Crushed Rock Base Course	Metre Cube
618-107	Laterite	Metre Cube
618-108	Lime	Tonne
618-109	Bitumen, Pen grade 60 - 70	Litre
618-110	Bitumen, Pen grade 80 - 100	Litre
618-111	Bitumen Emulsion	Litre
618-112	Sealing Aggregate, 19 mm	Metre Cube
618-113	Sealing Aggregate, 12.5 mm	Metre Cube
618-114	Crusher dust	Metre Cube
618-115	Rock Riprap	Metre Cube
618-116	RC Pipes, 600 mm dia	Metre
618-117	RC Pipes, 750/800 mm dia	Metre
618-118	RC Pipes, 900 mm dia	Metre
618-119	RC Pipes, 1000 mm dia	Metre
618-120	RC Pipes, 1200/1250 mm dia	Metre
618-121	RC Pipes, 1500/1550 mm dia	Metre

618.03.3 Construction Equipment

(1) Measurement for construction equipment shall be as follows.

Item No.	Description	Unit
618-200	Dozer with Blade and Ripper, Min 55 Kw	Hours
618-201	Dozer with Blade and Ripper, Min 100 Kw	Hours
618-202	Motor Grader, Min 100 Kw	Hours
618-203	Wheeled Loader, Min 2 Cu-m Capacity Bucket	Hours
618-204	Excavator, up to 1 Cu-m Capacity Bucket	Hours
618-205	Roller, Vibratory, Smooth Drum, Min 10 Tonnes	Hours
618-206	Roller, Vibratory, Pad-Foot, Min 10 Tonnes	Hours
618-207	Roller, Vibratory, Smooth Drum, Min 1.5 Tonnes	Hours
618-208	Roller, Pneumatic Tyred, Min 15 Tonnes	Hours
618-209	Backhoe/ Loader, Min 0.5 Cu-m Loader Bucket	Hours
618-210	Dump Truck, Min 6 Cu-m Capacity	Hours
618-211	Flat-Bed Truck, Min 10 Tonnes Capacity	Hours
618-212	Low Loader Truck and Trailer, Min 40 Tonnes	Hours
618-213	Water Tanker with Spray-bar, Min 6,000 L Capacity	Hours
618-214	Bitumen Distributor, with Spray-bar, Min 6,000 L	Hours
618-215	Mechanical Road Broom	Hours
618-216	Chip Spreader (Self-Propelled or Lorry-Mounted), Min Spread Width 3 m	Hours
618-217	Water Pump, Min 100 mm Dia	Hours
618-218	Mobile Crane, Min 25 Tonnes Capacity	Hours
618-219	Concrete Mixer, Min 1 Cu-m Capacity	Hours

(3) Only the actual number of working hours will be measured, except that, where applicable and agreed with the Engineer, the travelling time from the part of the site where the construction equipment was located when ordered by the Engineer to be employed on daywork and the time for return journey thereto shall be measured.

618.05 PAYMENT

(1) Payment for labour will be made at the rates entered in the Bill of Quantities, which rates shall include full compensation for (but not limited to) the amount of wages paid to labour, transportation time, overtime, subsistence allowances, and any sums paid to or on behalf of labour for social benefits in accordance with local law, as well as Contractor's profit, overheads, superintendence, liabilities and insurance and allowance to labour, timekeeping and clerical and office work, the use of consumable stores, water, lighting and power; the use and repair of staging, scaffolding, workshops and stores, portable power tools, manual equipment and tools; supervision by the Contractor's staff, foremen and other supervisory personnel; and charges incidental to the foregoing.

(2) Payment for material will be made at the rates entered in the Bill of Quantities, which rates shall include full compensation for, providing freight, insurance, handling expenses, damage, losses, etc., and delivery to store for stockpiling at the site; the cost of hauling materials for use on work ordered to be carried out as daywork from the store or stockpile on the site to the place where it is to be used, which will be paid in accordance with the terms for labour and constructional equipment.

(3) The materials for which the cost is included in the percentage addition to labour costs as detailed above, will be paid from the daywork item for labour.

(4) The Contractor shall be entitled to payments in respect of constructional equipment already on site and employed on daywork at the basic rental rates entered in the daywork bill in respect of constructional equipment.

(5) The equipment rates shall be deemed to include due and complete allowance for depreciation, interest, indemnity and insurance, repairs, maintenance, supplies, fuel, lubricants, and other consumables, and all overhead profit and administrative costs related to the use of such equipment. The cost of drivers, operators and assistants will be deemed to be included in the rates entered for constructional equipment.

(6) Payments will be made in the currencies and portions as defined in the Conditions of Contract.

MEASUREMENT AND PAY ITEMS (BoQ)

Item No.	Description	Unit
SECTION 101 - Preamble to General Provisions		
101-1	Performance Security	Lump Sum
101-2	Bank Guarantee for Advance Payment	Lump Sum
101-3	Insurance of the Works	Lump Sum
101-4	Insurance of Contractor's Equipment	Lump Sum
101-5	Third Party Insurance	Lump Sum
SECTION 102 - General Obligations		
102-1	Maintenance of Roads, Bridges and Culverts	Month
102-2	Contract Sign Board	Number
SECTION 103 - Contractor's Establishments		
103-1	Provision of Contractor's Establishments	Lump Sum
103-2	Maintenance of Contractor's Establishments	Month
SECTION 104 - Facilities for the Engineer		
104-1	Provision of Main Office and Facilities	Lump Sum
104-2	Maintenance of Main Office and Facilities	Month
104-3	Provision of Mobile Office	Month
104-4	Maintenance of Mobile Office	Office-Month
104-5	Field Equipment	Lump Sum
104-6	Provision of Housing Unit - Type A	Number
104-7	Provision of Housing Unit - Type B	Number
104-8	Provision of Single Persons Quarters	Number
104-9	Provision of Mess Hall	Number
104-10	Maintenance of Housing Units	Unit-Month
104-11	Maintenance of Single Persons Quarters and Mess Hall	Month
104-12	Provision of Vehicle - Type A	Number
104-13	Provision of Vehicle - Type B	Number
104-14	Provision of Vehicle - Type C	Number
104-15	Maintenance of Vehicles	Vehicle Month
104-16	Provision of Motorcycle	Number
104-17	Maintenance of Motorcycle	Cycle Month
104-18	Other Services for the Engineer	Lump Sum
SECTION 105 - Testing and Control		
105-1	Provision of Main Laboratory	Lump Sum
105-2	Maintenance of Main Laboratory	Month
105-3	Provision of Mobile Laboratory	Number
105-4	Maintenance of Mobile Laboratory	Lab-month
105-5	Provision of Audit Laboratory	Number
105-6	Maintenance of Audit Laboratory	Lab-month
105-7	Acceptance Testing	Month
105-8	Providing Full Time Laboratory Technician	Month
105-9	Providing Full Time Laboratory Assistant	Month
SECTION 109 - Clearance of Unexploded Ordnance		
109-1	Non-Technical Survey	Lump Sum
109-2	Technical Survey/ UXO Clearance	Provisional Sum

Item No.	Description	Unit
SECTION 201 - Clearing and Grubbing/ Tree Removal		
201-1	Clearing and Grubbing	Metre Square
201-2	Preparation for Reforestation	Metre Square
201-3	Removal of Trees	Number
SECTION 202 - Demolition Work		
202-1	Removal of Structures	Metre Cube
202-2	Removal of Bailey Bridges	Metre
202-3	Removal of Metal Pipe Culverts, < 600 mm	Metre
202-4	Removal of Metal Pipe Culverts, 600 - 1000 mm	Metre
202-5	Removal of Metal Pipe Culverts, > 1000 mm	Metre
202-6	Removal of Concrete Pipe Culverts, < 600 mm	Metre
202-7	Removal of Concrete Pipe Culverts, 600 - 1000 mm	Metre
202-8	Removal of Concrete Pipe Culverts, > 1000 mm	Metre
202-9	Removal of Timber Structures > 6 m ²	Metre Square
SECTION 203 - Roadway Excavation		
203-1	Common Excavation	Metre Cube
203-2	Rock Excavation	Metre Cube
203-3	Unsuitable Excavation and Backfilling	Metre Cube
203-4	Backfilling with rock	Metre Cube
203-5	Removal of Landslides	Metre Cube
SECTION 204 - Construction of Embankments		
204-1	Embankment from Excavated Materials	Metre Cube
204-2	Embankment from Borrow Materials	Metre Cube
204-3	Selected Fill Material in Flooded Areas	Metre Cube
SECTION 207 - Structural Excavation		
207-1	Structural Excavation (Common)	Metre Cube
207-2	Structural Excavation (Rock)	Metre Cube
207-3	Structural Excavation for Pipe Culverts, Inlet & Outlet	Metre Cube
207-4	Structures on Pipe Culverts (Rock)	Metre Cube
207-4	Structural Excavation under Water	Metre Cube
SECTION 209 - Reconditioning of Existing Pavement		
209-1	Preparing existing pavement for overlay	Metre Square
209-2	Reconditioning of pavement surface	Metre Square
SECTION 301 - Aggregate Sub-base		
301-1	Sub-base Type A	Metre Cube
301-2	Sub-base Type B	Metre Cube
301-3	Sub-base Type C	Metre Cube
301-4	Capping Layer	Metre Cube
SECTION 302 - Crushed Aggregate Base Course		
302-1	Base Course Type A	Metre Cube
302-2	Base Course Type B	Metre Cube
302-3	Base Course Type C	Metre Cube
SECTION 303 - Prime Coat		
303-1	Prime Coat	Litre

Item No.	Description	Unit
SECTION 304 - Surface Dressing		
304-1	First Seal Coat	Litre
304-2	Cover Material (19 mm nominal size)	Metre Cube
304-3	Second Seal Coat	Litre
304-4	Cover Material (12.5 mm nominal size)	Metre Cube
304-5	Cover Material (16 mm nominal size)	Metre Cube
304-6	Cover Material (10 mm nominal size)	Metre Cube
SECTION 305 - Bituminous Pavement Courses (Asphaltic Concrete)		
305-1	Bituminous Concrete Surface Course, Hot-laid _____ mm thick Binder Course	Metre Square
305-2	Bituminous Concrete Surface Course, Hot-laid _____ mm thick Binder Course	Metre Square
305-3	Bituminous Concrete Surface Course, Hot-laid _____ mm thick Wearing Course	Metre Square
305-4	Bituminous Concrete Surface Course, Hot-laid _____ mm thick Wearing Course	Metre Square
SECTION 306 - Tack Coat		
306-1	Tack Coat	litre
SECTION 308 - Cement Stabilised Base and Sub-Base		
308-1	Cement Stabilised Base	Metre Cube
308-2	Cement Stabilised Sub-Base	Metre Cube
308-3	Cement for stabilising Base or Sub-Base	Tonne
SECTION 309 - Lime Stabilised Base and Sub-Base		
309-1	Mix in Lime	Metre Cube
309-2	Lime	Tonne
SECTION 310 - Cold Mixed Asphalt		
310-1	Cold Asphalt (fluxed)	Metre Cube
310-2	Cold Asphalt (cutback)	Metre Cube
310-3	Cold Asphalt (emulsion)	Metre Cube
310-4	Bitumen Additive: Specify Type (provisional)	Litre
SECTION 311 - Slurry Seal		
311-1	Slurry Seal	Metre Square
SECTION 312 - Gravel Wearing Course		
312-1	Gravel Wearing Course	Metre Cube
SECTION 313 - Sand Layer under Concrete Pavement		
313-1	Sand Layer	Metre Cube
SECTION 314 - Rigid Pavements / Concrete Pavements		
314-1	Plain Concrete Pavement, _____ mm thick	Metre Square
314-2	Reinforced Concrete Pavement, _____ mm thick	Metre Square

Item No.	Description	Unit
SECTION 401 - Box Culverts		
401-1	Concrete for Box Culverts	Metre Cube
401-2	Steel Reinforcement for Box Culverts	Tonne
401-3	Masonry for Headwalls, Wing-walls and Aprons	Metre Cube
SECTION 402 - Pipe Culverts		
402-1	Pipe Culvert, 600 mm diameter	Metre
402-2	Pipe Culvert, 750/800 mm diameter	Metre
402-3	Pipe Culvert, 900 mm diameter	Metre
402-4	Pipe Culvert, 1000 mm diameter	Metre
402-5	Pipe Culvert, 1200/1250 mm diameter	Metre
402-6	Pipe Culvert, 1500/1550 mm diameter	Metre
402-7	Concrete (Grade 25) for Headwalls, Wing-walls and Aprons	Metre Cube
402-8	Reinforcing Steel in Headwalls, Wing-walls and Aprons	Tonne
402-9	Reseal Mortar Joints	Metre
402-10	Reseal Bituminous Joints	Metre
402-11	Masonry for Headwalls, Wing-walls and Aprons	Metre Cube
SECTION 403 - Sub-Surface Drains		
403-1	Perforated PVC Pipe, ____ mm diameter	Metre
SECTION 404 - Ditch, Apron Protection, Inlet and Outlet Structures		
404-1	Concrete (Grade 25)	Metre Cube
404-2	Reinforcement Steel	Tonne
404-3	Grouted Rip-rap	Metre Cube
404-4	Stone Masonry	Metre Cube
404-5	Loose Rip-rap	Metre Cube
404-6	Box Gabions	Metre Cube
404-7	Gabion Mattresses	Metre Cube
404-8	Geotextile Sheeting	Metre Square
404-9	Concrete Kerbs	Metre
SECTION 405 - Minor Drainage Structures		
405-1	Precast U-Drain and Cover Slab	Metre
405-2	Side Drain Access Slab including Foundation	Metre
405-3	Manhole, Type _____	Metre Cube
405-4	Manhole, Type _____	Metre Cube
405-5	Manhole, Type _____	Metre Cube
405-6	Catch Basin, Type _____	Number
405-7	Drop Inlet	Metre Cube
405-8	RC Side Ditch, Type _____	Metre
405-9	RC Side Ditch, Type _____	Metre
405-10	RC Side Ditch, Type _____	Metre
405-11	(additional items as necessary)	
SECTION 406 - Bridge Drainage		
406-1	Gully	Number
406-2	Grating (Sizes and Types shall be stated)	Number
SECTION 501 - General Requirements		
501-1	Re-survey for Bridge Structure	Number

Item No.	Description	Unit
SECTION 503 - Precast Concrete Piles		
503-1	Precast Concrete Piles (_____ mm x _____ mm)	Metre
503-2	Pile Splices	Number
503-3	Dynamic Load Testing (Precast Concrete Piles [_____ mm x _____ mm])	Number
503-4	Static Load Testing (Precast Concrete Piles [_____ mm x _____ mm])	Number
SECTION 504 - Bored Piles		
504-1	Bored Pile, _____ mm diameter	Metre
504-2	Casing (remaining and not reused)	Metre Square
504-3	Bored Pile Integrity Test	Number
504-4	Bored Pile Sonic Test	Number
504-5	Bored Pile High-Strain Dynamic Load Test	Number
SECTION 506 - Steel Reinforcement		
506-1	Steel Reinforcement	Tonne
SECTION 507 - Structural Concrete		
507-1	Concrete Grade 15 (for minor unreinforced concrete works)	Metre Cube
507-2	Concrete Grade 20 (for mass concrete)	Metre Cube
507-3	Concrete Grade 25 (for piers, abutments, retaining walls and approach slabs, etc.)	Metre Cube
507-4	Concrete Grade 30	Metre Cube
507-5	Concrete Grade 40 (for precast post-tensioned girders)	Metre Cube
507-6	Concrete Grade 40 (for diaphragms and decks)	Metre Cube
507-7	Concrete Grade 40 (for precast deck panels)	Metre Cube
SECTION 508 - Prestressing of Concrete		
508-1	Prestressing Steel	Tonne
SECTION 509 - Bearings		
509-1	Elastomeric Bridge Bearings, Type _____	Number
509-2	Pot Bearings	Number
509-2	Spherical Bearing Assembly, Fixed	Number
509-3	Spherical Bearing Assembly, Free	Number
509-4	Spherical Bearing Assembly, Guided	Number
SECTION 510 - Bridge Railings		
510-1	Bridge Railing	Metre
SECTION 513 - Expansion Joint System		
513-1	Compression Seals	Metre
513-2	Rapid-Cure Silicone Sealants	Metre
513-3	Strip Seal Joints	Metre
513-4	Steel Finger Joints	Number
513-5	Modular Expansion Joints	Number
513-6	Header (Polyester- or Elastomeric Concrete)	Metre Cube
SECTION 514 - Bridge Load Testing		
514-1	Bridge Loading Tests	Number

Item No.	Description	Unit
SECTION 520 - Steel structures		
520-1	Furnish Bridge Structural Steel	Tonne
520-2	Erect Bridge Structural Steel	Lump Sum
520-3	Spherical Bearings, Fixed	Number
520-4	Spherical Bearings, Free	Number
520-5	Spherical Bearings, Guided	Number
SECTION 521 - Painting		
521-1	Shop Protective Treatment of Metal Structures	Metre Square
521-2	Field Protective Treatment of Metal Structures	Metre Square
521-3	Field Protective Treatment of Concrete Structures	Metre Square
SECTION 522 - Structural Timber		
522-1	Untreated Structural Timber	Metre Cube
522-2	Treated Structural Timber	Metre Cube
SECTION 523 - Conduits, Fittings and Boxes		
523-1	Furnishing and Installation of Conduits, Fittings and Boxes	Lump Sum
SECTION 601 - Box Gabions / Gabion Mattresses / Geotextile Sheetings		
601-1	Box Gabions	Metre Cube
601-2	Gabion Mattresses	Metre Cube
601-3	Geotextile Sheeting	Metre Square
601-4	Repair of Box Gabions	Metre Cube
601-5	Repair of Gabion Mattresses	Metre Cube
SECTION 602 - Slope Protection and Masonry Structures		
602-1	Loose Rip-rap Slope Protection	Metre Cube
602-2	Grouted Rip-rap Slope Protection	Metre Cube
602-3	Stone Masonry Slope Protection	Metre Cube
602-4	Hand Laid Rock Embankment	Metre Cube
602-5	Reinforced Concrete Walls and Slope Protection	Metre Cube
602-6	Repair of Loose Rip-rap Slope Protection	Metre Cube
602-7	Repair of Grouted Rip-rap Slope Protection	Metre Cube
602-8	Repair of Stone Masonry Slope Protection	Metre Cube
602-9	Repair of Rock Embankment	Metre Cube
602-10	Repair of Reinforced Concrete Slope Protection	Metre Cube
602-11	Masonry Retaining Wall (grouted)	Metre Cube
602-12	Masonry Retaining Wall (dry stone)	Metre Cube
SECTION 603 - Guardrails		
603-1	Guardrail on Embankments / Culverts	Metre
603-2	Guardrail Fixed to Existing Bridge Decks	Metre
603-3	Guardrail Fixed to Concrete Parapet Posts	Metre
SECTION 604 - Traffic Markings		
604-1	Reflectorized Markings, Yellow, Thermoplastic	Metre Square
604-2	Reflectorized Markings, White, Thermoplastic	Metre Square
604-3	Reflectorized Markings, Yellow, Non-Thermoplastic	Metre Square
604-4	Reflectorized Markings, White, Non-Thermoplastic	Metre Square
604-5	Reflectorized Road Studs	Number

Item No.	Description	Unit
SECTION 605 - Traffic Signs		
605-1	Sign Posts	Metre
605-2	Traffic Signs	Metre Square
605-3	Relocate Traffic Signs and Posts	Number
605-4	Overhead Signs	Metre Square
605-5	Steel Truss for Overhead Sign	Metre
605-6	Foundation & Steel Post for Overhead Sign	Number
605-7	Overhead Traffic Sign	Number
SECTION 606 - Kilometre and Edge Marker (Guide) Posts		
606-1	Kilometre Posts	Number
606-2	Edge Marker (Guide) Posts	Number
SECTION 607 - Concrete Kerbs (Barrier and Mountable) and Gutter		
607-1	Concrete Kerb	Metre
607-2	Mountable Kerb	Metre
607-3	Concrete Kerb and Gutter	Metre
607-4	Precast Concrete Kerb	Metre
607-5	Concrete Barrier Kerb, Type ____	Metre
607-6	Concrete Barrier Kerb, Type ____	Metre
607-7	Kerb Marking	Metre Square
607-8	Barrier Marking	Metre Square
SECTION 608 - Foundation Investigations		
608-1	Mobilise Drilling Rigs to Site	Lump Sum
608-2	Shift Drilling Rigs to Next Structure Site	Number
608-3	Shell and Auger Boring:	
	0 – 10 metres	Metre
	10 – 20 metres	Metre
	20 – 30 metres	Metre
608-4	Drilling in Rock	Metre
608-5	Dynamic Cone Probing	Metre
608-6	Plate Load Tests	Number
608-7	Trial Pits	Number
608-8	Additional Testing	Provisional Sum
SECTION 609 - Sodding		
609-1	Sodding	Metre Square (Horizontal or Sloping)
SECTION 610 - Bio-Engineering: Planting and Sowing		
610-1	Grass Slip Planting	Metre Square
610-2	Planting of Polyplot Seedlings of Trees and Shrubs	Nos of Seedlings
610-3	Brush Layering	Metre
610-4	Live Check Dams	Metre
610-5	Truncheon Cuttings/ Established Plants	Cutting/Plant
610-6	Large Bamboo Planting (Culm-and-Rhizome Method)	Cutting

Item No.	Description	Unit
SECTION 611 - Street Lighting		
611-1	Tapered Steel Pole, Single Bracket, with one High Pressure Sodium Lamp _____ Watts cut off	Set
611-2	Tapered Steel Pole, Double Bracket, with two High Pressure Sodium Lamps _____ Watts cut-off	Set
611-3	High Mast Complete with Lanterns, Spare Parts, Foundation Draw Pits, Trenches, Cables, Ground & Accessories	Set
611-4	Soffit Complete with Lanterns, Spare Parts, Draw Pits, Trenches, Cables, Ground & Accessories	Set
611-5	Supply Pillars Complete with Foundation, Fence, Draw Pits, Trenches, Cables, Ground & Accessories	Set
611-6	Relocated Tapered Steel Pole, Single Bracket	Set
611-7	Relocated Tapered Steel Pole, Double Brackets	Set
SECTION 612 - Solar Powered Street Lighting		
612-1	Tapered Steel Pole Complete with Lantern, Dual Solar Panels of Mono-Crystalline- or Multi-Crystalline Silicon Solar Cells, Battery with Underground Battery Box, Battery Management System, System Controller, Foundation, Cables, Ground & Accessories	Set
SECTION 613 - Road Traffic Signals		
613-1	Traffic Signals	Lump Sum
SECTION 614 - Permanent Timber Barricades		
614-1	Permanent Timber Barricades	Metre
SECTION 615 - Fencing		
615-1	Fencing (description to be added)	Metre
615-2	Gates (description to be added)	Number
SECTION 616 - Landscaping and Beautification Works		
616-1	Ground Cover, Complete, incl. Maintenance	Provisional Sum
616-2	Flower Beds, Complete, incl. Maintenance	Provisional Sum
616-3	Other Landscaping and Beautification Work	Provisional Sum
SECTION 617 - Traffic Calming Devices		
617-01	Speed Bumps	Number
617-02	Speed Humps	Number
617-03	Speed Tables	Number
617-04	Rumble Strips	Metre Square

Item No.	Description	Unit
SECTION 618 - DAYWORK		
618-1	Foreman	Hours
618-2	Skilled Labourer	Hours
618-3	Unskilled Labourer	Hours
618-4	Mason	Hours
618-5	Carpenter	Hours
618-6	Steel Fixer	Hours
618-7	Driver - Vehicle up to 10 t	Hours
618-8	Driver - Vehicle above 10 t	Hours
618-9	Equipment Operator for Crane	Hours
618-10	Equipment Operator for Tractor, Loader, Excavator, Grader, etc.	Hours
618-100	Cement, ordinary Portland or equivalent in bags	Tonne
618-101	Steel reinforcement grade ____ plain round	Tonne
618-102	Steel reinforcement grade ____ deformed	Tonne
618-103	Coarse concrete aggregate (nominal 19 mm)	Metre Cube
618-104	Fine concrete aggregate	Metre Cube
618-105	Sand	Metre Cube
618-106	Crushed Rock Base Course	Metre Cube
618-107	Laterite	Metre Cube
618-108	Lime	Tonne
618-109	Bitumen, Pen grade 60 - 70	Litre
618-110	Bitumen, Pen grade 80 - 100	Litre
618-111	Bitumen Emulsion	Litre
618-112	Sealing Aggregate, 19 mm	Metre Cube
618-113	Sealing Aggregate, 12.5 mm	Metre Cube
618-114	Crusher dust	Metre Cube
618-115	Rock Riprap	Metre Cube
618-116	RC Pipes, 600 mm dia	Metre
618-117	RC Pipes, 750/800 mm dia	Metre
618-118	RC Pipes, 900 mm dia	Metre
618-119	RC Pipes, 1000 mm dia	Metre
618-120	RC Pipes, 1200/1250 mm dia	Metre
618-121	RC Pipes, 1500/1550 mm dia	Metre
618-200	Dozer with Blade and Ripper, Min 55 Kw	Hours
618-201	Dozer with Blade and Ripper, Min 100 Kw	Hours
618-202	Motor Grader, Min 100 Kw	Hours
618-203	Wheeled Loader, Min 2 Cu-m Capacity Bucket	Hours
618-204	Excavator, up to 1 Cu-m Capacity Bucket	Hours
618-205	Roller, Vibratory, Smooth Drum, Min 10 Tonnes	Hours
618-206	Roller, Vibratory, Pad-Foot, Min 10 Tonnes	Hours
618-207	Roller, Vibratory, Smooth Drum, Min 1.5 Tonnes	Hours
618-208	Roller, Pneumatic Tyred, Min 15 Tonnes	Hours
618-209	Backhoe/ Loader, Min 0.5 Cu-m Loader Bucket	Hours
618-210	Dump Truck, Min 6 Cu-m Capacity	Hours
618-211	Flat-Bed Truck, Min 10 Tonnes Capacity	Hours
618-212	Low Loader Truck and Trailer, Min 40 Tonnes	Hours
618-213	Water Tanker with Spray-bar, Min 6,000 L Capacity	Hours
618-214	Bitumen Distributor, with Spray-bar, Min 6,000 L	Hours
618-215	Mechanical Road Broom	Hours
618-216	Chip Spreader (Self-Propelled or Lorry-Mounted), Min Spread Width 3 m	Hours
618-217	Water Pump, Min 100 mm Dia	Hours
618-218	Mobile Crane, Min 25 Tonnes Capacity	Hours
618-219	Concrete Mixer, Min 1 Cu-m Capacity	Hours