TECHNICAL SPECIFICATION

Version for
Date

Table of content

SERIES-1000
PRELIMINARY AND SITE FACILITIES

Version for ____ *1*

Date ____ *1*

Section 1100: General Requirements and Provisions ____ *1*

1101 Scope ____ **1**

1102 Program of Work ____ **1**

1103 Workmanship and Quality Control ____ **1**

1104 Measurement and Payment ____ **2**

1105 Substantial Completion of the Works ____ **3**

1106 Protection of the Works and Requirements to be met before Construction of New Work on top of Completed Work is Commenced ____ **3**

1107 Remedial Work ____ **4**

1108 Sign Boards ____ **4**

1109 Measurement and Payment for sign boards ____ **4**

1110 Photographic Records ____ **4**

1111 Access to Site ____ **4**

1112 Security of the Works ____ **5**

1113 Suppression of Noise ____ **5**

1114 Safety ____ **5**

1115 Work Methodology ____ **5**

1116 Temporary Works ____ **6**

1117 Provision for Traffic ____ **6**

1118 Testing of Materials ____ **6**

1119 Materials Testing by Independent Laboratories ____ **8**

1120 Special and Additional Testing ____ **8**

1121 Staff for Materials Testing ____ **8**

1122 Test Results and Records ____ **8**

1123 Measurement and Payment ____ **8**

1124 Approval of Sources of Materials ____ **8**

1125 Stockpiling of Materials ____ **9**

1126 Control Tests on Material Stockpiles ____ **9**

1127 Compaction Equipment ____ **9**

1128 Compaction ____ **9**

1129 Compaction Trials ____ **10**

1130 Compaction Control ____ **10**

1131 Mixing and Control of Moisture Content ____ **10**

1132 Drainage during Construction 10
1133 Protection to Existing Embankment/Pavement Layers 10
1134 Disposal of Hauling Equipment 10
1135 Plying of Traffic 11
1136 Drawings 11
1137 Typical Cross Section 11
SECTION 1200: CONTRACTOR'S ESTABLISHMENT 11
1201 Scope 11
1202 Locating construction camps 11
1203 Provision of facilities, plant and equipment 11
1204 Compliance with the Conditions of Contract 11
1205 Contractor Office Equipment 11
1206 Survey Equipment 12
1207 Levels and Levelling Staffs 12
1208 Total station 12
1209 Mobilization 12
1210 Demobilization 14
1211 As –Built Drawings 14
SECTION 1600: Setting Out Horizontal and Vertical Alignment 14
1601 Scope 14
1602 Construction Method 14
1603 Measurement and Payment 15

SERIES-2000
CLEARING AND EARTHWORKS

2000 GENERAL 15
2001 General Requirements for Earthworks 15
2002 Compaction Control of Embankment Construction 15
2100 CLEARING AND GRUBBING 16
2101 Scope 16
2102 Description 16
2103 Requirements 16
2104 Clearing and Grubbing 16
2105 Debris Disposal 17
2106 Individual Trees 17
2107 Measurement and Payment 17
2200 DEMOLITION OF STRUCTURES 17
2201 Description 17
2202 Methods 18

2203 Safety Precautions 18
2204 Ownership of Material 18
2205 Method of Measurement 19
2206 Basis of Payment 19
2300 REMOVAL OF EXISTING PAVEMENTS 19
2301 Description 19
2302 Removal Methods 20
2303 Disposal of Materials 20
2304 Methods of Measurement 20
2305 Basis of Payment 20
2400 Roadway Excavation 20
2401 Description 20
2402 Spoil Material 21
2403 Removal of Topsoil 21
2404 Construction Methods 21
Soft Excavation in hilly area or along the road 21
Excavation/cutting hard material with machines 21
Excavation of Hard materials (rock) that required blasting 22
2405 Measurement and Payment 22
2500 Structure and Channel Excavation 23
2501 Description 23
2502 Construction Methods 23
2503 Excavation within enclosures for foundations 23
2504 Foundation Compaction and Extra Depth of Excavation 24
2505 Inspection of Excavations 25
2506 Backfilling and filling 25
2507 Preservation and Diversion of Channels 25
2508 Excavation Limits 26
2509 Measurement 26
2510 Basis of Payment 27
2600 Borrow Excavation 27
2601 Description 27
2602 Method of Measurement 28
2603 Basis of Payment 28
2700 ROADWAY EMBANKMENT 28
2701 Description 28
2702 Embankment Material 28
2702.1 Embankment construction with material from Borrow 30
2702.2 Embankment construction with material Cut to fill 30

2703 Construction Method 30
a) Preparation for Embankment 30
b) Incorporation of Existing Embankment in the Works 31
c) Embankment Formation 31
a) Controlling Moisture control 33
e) Compaction Trials 33
f) Standard of Compaction 33
2704 Maintenance and Stability of Embankments 34
a) Embankments to be free draining and maintained in shape. 34
b) General Construction Procedures 34
2705 Construction Requirements for Finishing of Slopes 35
(a) Equipment 35
(b) General 35
(c) Cutting Slopes 35
(d) Embankment Slopes 35
2706 Measurement 35
2707 Basis of Payment 36
2800 SUB-GRADE PREPARATION 36
2801. Description 36
2802 Construction Requirements 36
2803 Proof Rolling 37
2804 METHOD OF MEASUREMENT AND PAYMENT 38

SERIES-3000
SOIL/AGGREGATE PAVEMENT

PART 3000 - SOIL/AGGREGATE PAVEMENT *Error! Bookmark not defined.*
3000 GENERAL 38
3001 Description 38
3100 IMPROVED SUB GRADE 38
3101 Description 38
3102 Material 39
3103 Construction Method 39
3104 Testing 39
3105 Measurement and Basis of Payment 39
3200 Aggregate Sub-Base (Gravel Sub-Base) for Pavements and Shoulders 40
3201 Description 40
3202 Materials 40
Blended material Table 3-1 40
Alternative Grading for Sub Base, Table 3-2 41
3203 Construction Methods 41
3204 Testing 42
3205 Measurement and Payment 42
3300: AGGREGATE BASE COURSE 43

3301 Description 43
3302 Materials 43
Table 3-3 43
3303 Construction Method 44
3304 Testing 45
3305 Measurement and Payment 46
3400 PREPARATION OF EXISTING PAVEMENT *Error! Bookmark not defined.*
3401 Description Error! Bookmark not defined.
3203 Construction Method Error! Bookmark not defined.
3403 Measurement and Payment Error! Bookmark not defined.

SERIES-4000
BITUMINOUS PAVEMENT

4000 GENERAL ***46***
4001 Materials 46
4002 Bituminous Materials 46
4003 Application temperatures of bituminous binder materials 48
4004 Measurement 49
4100 Asphalt Mix Types 50
4101 Asphalt Wearing Course (Surface Course) 50
4102 Asphalt Intermediate (Binder) Course 50
4103 Asphalt Base Course 50
4104 ASPHALT layer Thickness and Surface Tolerances 50
4200 BITUMINOUS PRIME COAT AND TACK COAT ***51***
4201 Description 51
4202 Materials 51
4203 Construction Methods 52
4204 Method of Measurement 53
4205 Basis of Payment 53
4300 BITUMINOUS PREMIX SURFACE COURSE (HOT ROLLED ASPHALT) ***53***
4301 Description 53
4302 Materials 53
4303 Job Mix Formula 55
4304 Mix Design 55
4305 Plant 57
4306 General Requirements 58
4307 Construction Methods 59
4308 Mix Quality Control Testing 63

4309 Method of measurement 63

4310 Basis of Payment 63

SERIES-5000
MISCELLANEOUS WORKS

5000 Miscellaneous Work 64

5100 Pitching and Stonework 64

5102 Materials 64

Table 5.1- Maximum amount of deleterious substances 65

5103 STONE PITCHING 65

a) Plain stone pitching 65
b) Grouted stone pitching 65

5104 Riprap 66

5105 Stone Masonry Walls 66

Plain stone masonry walls 66
Cement mortared stone masonry walls 66

5106 MEASUREMENT AND PAYMENT 66

5200 KERBS AND FOOTWAYS 67

5203 Measurement and Payment 69

5300: Road Signs and Road Appurtenance 71

5301 Sizes and Colours 71

5302 Fabrication of Signs 71

Table 5.1 Minimum Coefficient of Retro reflection 71

5303 Erection of signs 72

5304 Method of Measurement and Payment 72

5305 Kilometre Posts 72

5306 Letters and Figure 72

5307 Erection 72

5308 Method of Measurement and Payment 72

5309 Concrete Guard Posts 73

5310 Materials 73

5311 Construction Methods 73

5312 Measurements and payment 73

5400 PAVEMENT MARKINGS Error! Bookmark not defined.

5401 General Error! Bookmark not defined.

5402 Materials Error! Bookmark not defined.

5403 Longitudinal Lines Error! Bookmark not defined.

5404 Transverse Line Error! Bookmark not defined.

5405 Pavement Lettering and Symbols Error! Bookmark not defined.

5406 Method of Measurement and Basis of Payment Error! Bookmark not defined.

5500 BRICK AND BRICKWORK 75
5502 Sampling 75
5503 Dimension 75
5504 Appearance 75
5505 Unit Weight 76
5506 Crushing Strength 76
5507 Water Absorption 76
5508 Bricks for Brick Masonry construction 76
5509 Brick Face work Fixed to Concrete 77
5600: GABIONS 77
5602 MATERIALS 77
5603 FORMING THE GABION CAGES 78
5604 CONSTRUCTION OF GABIONS 79
5605 MEASUREMENT AND PAYMENT 80
5700: SUBGRADE DRAINS 80
5702 Materials 80
5703 CONSTRUCTION METHODS 81
5704 MEASUREMENT AND PAYMENT 81
5800: TREE PLANTING 81
5802 CONSTRUCTION METHODS 81
5803 MEASUREMENT AND PAYMENT 82
5900: Lined Road Side Drainages- 82
5902 Materials for Stone Masonry 82
5903 Preparation of Sand Bedding 82
5904 Plastering Side Drain in Cement Mortar 82
5905 Net Cement Finishing 82
5906 Backfilling 82
5907 Pre-Cast Concrete and cast in-situ Side Drains 82
5908 Placing Side Drains 82
5909 Measurement and Payment 83

SERIES-6000
CONCRETE PRODUTION

6100: Contractor's Plant, Equipment and Construction Facilities 83
6101 General 83
Mixing of Concrete: 83
6102 Handling and Placing of Concrete: 83
6103 Payment 84

6200 Composition of Concrete 84
6201 General 84
6202 Maximum Size Aggregate 84
6203 Responsibility for Mix Design 84
6204 Criteria for Designing Mixes 84
a) General 84
b) Use of Standard Deviation 85
c) Average Strength of Trial Mixes 85
6205 Approval of Mix Design 85
6300: Properties of Concrete 85
6301 Required Properties of Concrete 85
Table 6-1 - part A - Standard Classes of Concrete 85
Table 6-1 Part B - Type of Mix to be used in Structure Error! Bookmark not defined.
6302 Water 86
6303 Regulation of Water Content 86
6400: CEMENT 86
6401 Type of Cement 86
6402 Testing Cement 87
6403 Maximum Storage period 87
6404 Delivery of Cement 87
6405 Delivery of Bulk Cement 87
6406 Delivery of Bagged Cement 87
6407 Storage and Handling of Cement 87
6408 Temperature of Cement 88
6409 Rejection 88
6410 Payment 88
6500 ADMIXTURES 88
6501 General 88
6502 Rapid setting agent 88
6503 Water-Reducing, Set-Retarding Agent 88
6504 Non-permissible Admixture 88
6505 Sulphate Resistant 89
6506 Payment 89
6600 AGGREGATES 89
6601 General 89
6602 Tests 89
6603 Deleterious Substances 89
Table 6-2 Maximum amount of deleterious substances 89
6604 Particle Shape 89

6605 Grading of Fine Aggregate 89
Table 6-3 Grading of Fine Aggregate 90
6606 Normal size and Grading of Coarse Aggregate 90
Table 6-4 - Nominal size and grading of coarse aggregate 90
6607 Other Properties 90
Table 6-5 required properties of aggregate 90
6608 Processing 91
6609 Measurement and Payment 91
6700 Batching and Mixing 91
6701 Plant 91
6702 Measuring and Tolerances 91
6703 Calibration 92
6704 Batching and Weighing Equipment 92
6705 Vibrating Screens 93
6706 Records 93
6707 Mixing Equipment 93
6708 Batch Mixer 93
6709 Truck- Mounted Mixer and Agitation Units 93
6710 Mixing Time 94
Table 6-6 Min time requirement for mixing 94
6711 Charging Sequence 94
6712 Mixing and Transporting 94
6713 Discharging Period 95
6714 Mixer performance 95
6715 Delivery Docket 95
6716 Measurement and Payment 95
6800: Temperature of Concrete 95
6801 Placing Temperature 95
6802 Cooling Plastic Concrete 95
6803 Measurement and Payment 96
6900: Sampling and Testing 96
6901 Testing Facilities 96
6902 Standards 96
Table 6-7- Part 1 - Standards for testing concrete 96
Table 6-7 - Part 2 - Relationship between imperial and metric sieves 96
Table 6-8 - Part 3- Standards for testing aggregate 97
6903 Testing Cement at Source 97
6904 Testing Cement Elsewhere 97

6905 Testing Aggregate 98
6906 Sampling and Testing Plastic Concrete 98
Table 6. 9 (4) - Frequency of sampling concrete 98
6907 Rejection of Concrete 98
6908 Testing Cylinders 99
6909 Testing Hardened Concrete in Structures 99
6910 Measurement and Payment 99
6010: Concrete Construction *99*
I. General 99
II. Accessories 99
III. Changes to Dimension 100
IV. Changes in Colour 100
V. Application of Loads 100
VI. Joint Fillers and sealants 100
6011: CONSTRUCTION AND CONTRACTION JOINTS *100*
I. Construction Joints 100
II. Measurement and Payment 101
6012: Bituminous Fibre Sheet for Contraction Joints *101*
I. General 101
II. Materials 101
III. Installation 101
IV. Measurement and Payment 101
6013: Waterproof Sealant for Joints *101*
I. General 101
II. Materials 101
III. Construction 101
IV. Measurement and Payment 101
6014: FORMWORK *101*
I. General 102
II. Architectural Requirements 102
III. Shop Drawings 102
IV. Form-Ties 102
V. Treatment of Forms 103
VI. Removal of Forms 103
VII. Measurement and Payment 103
6015 TOLERANCE FOR CONCRETE CONSTRUCTION 103
I. General 103
II. In-situ Concrete 103

IV. Embedded Metalwork 104
6016: REINFORCEMENT 104
I. General 104
II. Material 104
III. Drawings 105
IV. Reinforcement Schedules 105
V. Placing Reinforcement 105
VI. Joining and Splicing Reinforcement 106
VII. Measurement and Payment 106
6017: PREPARATION FOR PLACING CONCRETE, FINISHING, CURING 106
I. General 106
II. Cleaning Foundations 107
III. Excavation for foundations 107
IV. Blinding Concrete 108
V. Cleaning Previously Placed Concrete Surfaces 108
6018: PLACING CONCRETE 108
II. Concreting During Hot Weather 108
III. Depositing Concrete 109
IV. Concrete Placed in Horizontal Layers 109
V. Compaction 109
6019: FINISHES AND FINISHING 110
II. Class of Finish for Formed Concrete 110
III. Class of Finish for Unformed Concrete 111
6020: CURING OF CONCRETE 111
II. Water Curing 111
III. Membrane Curing 112
IV. Steam Curing 112
6021: REPAIR OF CONCRETE 113
II. Dry-Pack 113
III. Concrete 113
IV. Epoxy Resin 114
V. Plugging form-tie holes 114
VI. Measurement and Payment 114
6022: Weep Holes 114
II. Payment 114
6023: RAIN WATER DOWN PIPE 115
II. Payment 115
6024: CONSTRUCTION OF STRUCTURES 115

I. Requirement 115
II. Materials 115
III. Clearing and Grubbing 115
IV. Excavation 115
Construction sequence 115
V. Backfilling 116
VI. Traffic Diversion 116
VII. Measurement and payment 116
6025: CONCRETE IN MAJOR STRUCTURES ***116***
I. Concrete in Pile Caps 116
II. Concrete in Bridge Girder 116
III. Concrete in Bridge Decks 116
IV. Concrete in Parapets and Barrier Wall 116
V. Measurement 117
VI. Payment 117

SERIES-7000
CONCRETE CONSTRUCTION

7000: Concrete Construction ***116***
7001 General 116
7002 Accessories 116
7003 Changes to Dimension 116
7004 Changes in Colour 117
7005 Application of Loads 117
7006 Joint Fillers and sealants 117
7020: CONSTRUCTION AND CONTRACTION JOINTS ***117***
7021 Construction Joints 117
7022 Measurement and Payment 117
7030: Bituminous Fibre Sheet for Contraction Joints ***1018***
7031 General 101
7032 Materials 101
7033 Installation 101
7034 Measurement and Payment 101
7040: Waterproof Sealant for Joints ***101***
7041 General 101
7042 Materials 101
7043 Construction 101
7044 Measurement and Payment 101

7050: FORMWORK ____ 101
7051 General ____ 102
7052 Architectural Requirements ____ 120
7053 Shop Drawings ____ 120
7054 Form-Ties ____ 102
7055 Treatment of Forms ____ 103
7056 Removal of Forms ____ 103
7057 Measurement and Payment ____ 103
7100 TOLERANCE FOR CONCRETE CONSTRUCTION ____ 103
7101 General ____ 103
7102 In-situ Concrete ____ 103
7104 Embedded Metalwork ____ 104
7200: REINFORCEMENT ____ 104
7201 General ____ 104
7202 Material ____ 104
7203 Drawings ____ 105
7204 Reinforcement Schedules ____ 105
7205 Placing Reinforcement ____ 105
7206 Joining and Splicing Reinforcement ____ 106
7207 Measurement and Payment ____ 106
7300: PREPARATION FOR PLACING CONCRETE, FINISHING, CURING ____ 106
7301 General ____ 106
7302 Cleaning Foundations ____ 107
7303 Excavation for foundations ____ 107
7304 Blinding Concrete ____ 108
7305 Cleaning Previously Placed Concrete Surfaces ____ 108
7306: PLACING CONCRETE ____ 108
7307 Concreting During Hot Weather ____ 108
7308 Depositing Concrete ____ 109
7309 Concrete Placed in Horizontal Layers ____ 109
7310 Compaction ____ 109
7311: FINISHES AND FINISHING ____ 110
7312 Class of Finish for Formed Concrete ____ 110
7313 Class of Finish for Unformed Concrete ____ 111
7314: CURING OF CONCRETE ____ 111
7316 Water Curing ____ 111
7317 Membrane Curing ____ 112
7318 Steam Curing ____ 112

7400: REPAIR OF CONCRETE 113
7401 Dry-Pack 113
7402 Concrete 113
7403 Epoxy Resin 114
7404 Plugging form-tie holes 114
7405 Measurement and Payment 114
7500: CONSTRUCTION OF BOX CULVERTS 115
7501 Requirement 115
7502 Materials 115
7503 Clearing and Grubbing 115
7504 Excavation 115
7505 Construction sequence 115
7506 Backfilling 116
7507 Traffic Diversion 116
7508 Measurement and payment 116
7600: Construction of Pipe Culverts/ Prefabricated Culverts 133
7601 Materials 133
7602 Excavation 134
7603 Installation 134
7604 Jointing 134
7605 Backfilling 134
7606 Construction equipment 134
7607 Measurement and payment 134
7700: Concrete in Major structures 116
7701 Concrete in Pile Caps 116
7702 Concrete in Abutments 116
7703 Concrete in Piers 135
7704 Concrete in Bridge Girder 135
7705 Concrete in Bridge Decks 116
7706 Concrete in Parapets and Barrier Wall 116
7707 Measurement 117
7708 Payment 117
7800: RAIN WATER DOWN PIPE 115
7802 Payment 115
7900: Weep Holes 114
7902 Payment 114

SERIES-8000
PRECAST CONCRETE

PART 8000 - PRECAST CONCRETE _____ Error! Bookmark not defined.
8000: precast concrete construction _____ Error! Bookmark not defined.
8102 Approval of Methods _____ *Error! Bookmark not defined.*
8103 Construction _____ *Error! Bookmark not defined.*
8104 Marking _____ *Error! Bookmark not defined.*
8105 Handling _____ *Error! Bookmark not defined.*
8106 Tolerances _____ **138**
Table 8-1-Allowable tolerances _____ **138**
8200: Precast Concrete Pipes _____ **138**
8202 Materials _____ **138**
Table 8-3 minimum required strengths and classes _____ **138**
8203 Joints _____ **138**
8204 Payment _____ **138**
8300: Precast Concrete Beams _____ ***139***
8302 Dimensions and Tolerances _____ **139**
8303 Payment _____ **139**
8400: Precast Prestressed Concrete Beams _____ ***139***
8402 Approval of Methods _____ **139**
8403 Handling of Beams _____ **139**
8404 Dimensions and Tolerance _____ **139**
8405 Construction _____ **140**
8406 Payment _____ **141**

SERIES-9000
PRESTRESSING

9.0 GENERAL **141**

1. Pay Items **141**

9.1 PRESTRESSING - GENERAL **142**

1. General **142**
2. Approval of Methods **142**
3. Materials for Tendons **142**
4. Anchorage Devices and Couplings **143**

5. Ducts **144**

6. Handling and Storage for Tendons and Accessories **145**

9.2 PRESTRESSING OPERATIONS 146

1. General **146**

2. Tensioning Equipment **146**

3. Required strength and age of concrete for prestressing **146**

4. Tensioning force required **146**

5. Placing and tensioning of tendons **146**

6. Data to be recorded **147**

7. Grouping of prestress tendons **148**

8. Cutting and anchorage protection 150

9.3 PAYMENT FOR PRESTRESSING 150

SERIES-10000
PILING WORKS

10000 Board Cast in Place Piles 10-4

10001 Description 10-4
10100 Materials 10-4
10101 Steel Classing 10-4
10102 Concrete 10-5
10103 Reinforcement 10-5
10104 Drilling Fluid 10-5

10200 Construction Methods 10-5

10201 General 10-5
10202 Setting out Piles 10-6
10203 Diameter of Piles 10-7
10204 Tolerance 10-7
10205 Boring 10-7
10206 Placing Reinforcement 10-9
10207 Placing Concrete 10-9
10208 Extraction of Temporary Casing 10-10
10209 Temporary Support 10-10
10210 Records 10-12
10210 Measures in Case of Rejected Casing 10-12

10212 Measurement 10-12
10213 Payment 10-12

10300 Precast Concrete Units for River Training and Retaining Structures 10-13
10301 Description 10-13
10302 Materials 10-13
10303 Construction Methods 10-13
10304 King Post & Anchor Piles 10-14
10305 Precast Planks 10-14
10306 Tolerance 10-14
10307 Measurement 10-14
10308 Payment 10-14

10400 Pile Test Loading 10-15
10401 General 10-15
10402 Definitions 10-15
10403 Supervision 10-15

10500 Safety Precautions 10-16
10501 General 10-16
10502 Kentledge 10-16
10503 Tension Piles and Ground Anchors 10-16
10504 Testing Equipment 10-16
10600 Construction of a Pilot Pile to be Test Loaded 10-**17**

10601 Notice of Construction 10-17
10602 Method of Constructions 10-17
10603 Boring or Driving Record 10-17
10604 Cut-Off Level 10-17
10605 Pile Head for Compression Test 10-17
10606 Preparation of a Working Pile to be Tested 10-17
10607 Reaction Systems 10-18
10608 Compression Tests 10-18
10609 Working Piles 10-18
10610 Spacing 10-18
10610 Adequate Reaction 10-18
10612 Care of Piles 10-18
10613 Loading Arrangement 10-18
10614 Equipment for Applying Load 10-18
10615 Measurement of Load 10-18
10616 Adjustability of Loading Equipment 10-19

10700 Measuring Movement of Pile Heads 10-19

10701 General 10-19
10702 Levelling Method 10-19
10703 Independent Reference Frame 10-19
10704 Others Methods 10-20
10705 Protection from Weather 10-20
10706 Prevention of Disturbance 10-20
10707 Notice of Test 10-20
10708 Records 10-20

10800 Test Procedure **10-20**

10801 Proof Test by Maintained Load Test 10-20
10802 Presentation of Results 10-20
10803 Schedule of Records Data 10-20
10804 Completion of a Test 10-21
10805 Measuring Equipment 10-21
10806 Kentledge 10-22
10807 Temporary Piles 10-22
10808 Pile Integrity Test 10-22
10809 Measurement and Payment 10-23

10900 Bitumen Slip Layer for Piles **10-23**

10901 Description 10-23
10902 Materials 10-23
10903 Primer 10-23
10904 Bitumen 10-24
10905 Field Storage and Installation 10-24
10906 Measurement 10-24
10907 Payment 10-24

SERIES-11000
METAL WORK AND STRUCTURAL STEEL

11000 METALWORK - GENERAL **11-2**

11100 General 11-2
11101 Standards 11-2
11102 Embedded Metal Work 11-2
11103 Grout and Dry Pack for Metalwork 11-2

11200 CORROSION PROTECTION 11-2

11201 General 11-2
11202 Coating System 11-3
11203 Surface Preparation 11-3
11204 Application of Coating Materials - General 11-4
11205 Application of Zinc Metallised Coating 11-5
11206 Galvanising 11-5
11207 Inspection 11-6

11300 MISCELLANEOUS METALWORK 11-6

11301 General 11-6
11302 Payment 11-6

11400 SRUCTURAL STEEL 11-6

11301 General 11-7

11302 Material 11-7

11403 Delivery of Structural steel 11-7

11404 Fabrication of Structural Steel 11-7

SERIES-12000
BRIDGE BEARINGS AND DECK JOINTS/GI PIPE RAILING

12.1 Bridge Bearings - General 12 - 2

12.2 Bearing Performance Characteristics 12 - 2

12.3 Bearing Manufacture 12 - 2

1. Materials and Manufacturing Tolerances 12 - 2
2. Manufacture 12 - 2
3. Testing 12 - 3

12.3 Installation of Bearings 12 - 3

1. Installation Tolerances 12 - 3
2. Cement Mortar Bearing Pads 12 - 4
3. Installation of Bearings 12 - 4
4. Care of Bearings 12 - 5

12.4 Bridge Deck Joints 12 - 5

1. General 12 - 5
2. Joint Performance Requirements 12 - 5
3. Joints Installation 12 - 5

12.4 Measurement and Payment 12 - 6

1. Measurement 12 - 6
2. Payment 12 - 6

12.5 GI Pipe as Railing 12 - 6

1. General

12.501 Measurement and Payment 12 - 6

1. Measurement 12 - 6
2. Payment 12 - 6

SERIES-13000
BRIDGE/PAVEMENT REPAIRS

14.1 GENERAL 14 - 2

14.2 REQUIREMENTS 14 - 2

14.3 CONSTRUCTION 14 - 2

14.4 MEASUREMENT AND PAYMENT 14 - 2

SERIES-14000
HDPE DUCTS FOR OPTICLA FIBER CABLES

SERIES-15000
CHAIN LENK FENCE

Section 1100: General Requirements and Provisions

1101 Scope

This Section covers matters which relate to the construction work as a whole.

1102 Program of Work

The program of work required in terms of the General Conditions of Contract shall be submitted to the Engineer not later than 14 days after the Contractor has been issued with the order to commence.

The Program shall be prepared showing clearly the anticipated activities and sequence and quantities of work to be performed each week/month,(Construction Planning) the resources to be applied to each activity, as well as the anticipated earnings for the various sections of work. It shall clearly show the critical path of the program. If, during the progress of the work, the quantities of work performed per week/month fall below those shown in the program, or if the sequence of operations is altered, or if the program is deviated from in any other way, the Contractor shall, within one week after being notified by the Engineer, submit a revised program.

If the program is to be revised by reason of the Contractor falling behind his program, he shall produce a revised program showing the modifications to the original program necessary to ensure completion of the works or any part thereof within the time for completion or any extended time granted as per the Conditions of Contract. Any proposal to increase the tempo of the work must be accompanied by positive steps to increase production by providing more labour and plant on Site, or by using the available labour and plant in a more efficient manner.

Failure on the part of the Contractor to work according to the program or revised program shall be sufficient reason for the Employer to take steps as provided for in the Conditions of Contract clause 27"Programs" and shall be construed as not executing the Works in accordance with the Contract.

The approval by the Engineer of any program shall have no contractual significance other than that the Engineer would be satisfied if the work is carried out according to such program and that the Contractor undertakes to carry out the work in accordance with the program, nor shall it limit the right of the Engineer to instruct the Contractor to vary the program should circumstances make this necessary. The above shall not be taken to limit the right of the Contractor to claim for damages or extension of time to which he may be fairly entitled to in terms of the General Conditions of Contract for delay or disruption of his activities.

1103 Workmanship and Quality Control

The onus is on the Contractor to produce work which conforms in quality and accuracy of detail to the requirements of the Specifications and/or Drawings, and the Contractor must, at his own expense, institute a quality control system and provide experienced engineers, foremen, surveyors, materials technicians, other technicians and other technical staff, together with all transport, instruments and equipment, to ensure adequate supervision and positive control of the Works at all times.

The cost of all supervision and process control, including testing, so carried out by the Contractor, shall be deemed to be included in the rates tendered for the related items of work except that the cost of certain tests and the provision of certain items of testing and sampling equipment will be paid for separately as provided for in those Sections of the Specifications where this applies.

Unless otherwise instructed by the Engineer, the Contractor shall obtain approval for each layer of the works, in embankments, sub-grade, or any gravel or pavement layers and shall not proceed with subsequent layers until each approval is granted. The Contractor shall be required to give reasonable notice to the Engineer to allow any inspection to be carried out. If any test is required to verify compliance with these specifications, then the Contractor shall plan his Works so as to allow the Engineer sufficient time to carry out such tests. Unless instructed otherwise, the Contractor may proceed with the Works even though the results of tests may not yet be available. However, the Contractor shall be required to re-execute work if tests indicate non-compliance with these Specifications. Any approval given by the Engineer shall not relieve the Contractor of any of his obligations under the Contract.

1104 Measurement and Payment

Bill of Quantities

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

Contract Rates

In computing the final contract amount, payments shall be based on actual quantities only of authorized work done in accordance with the Specifications and/or Drawings. The tendered rates shall apply, subject to the provisions of the General Conditions of Contract, irrespective of whether the actual quantities are more or less than the billed quantities.

The Contractor shall accept the payment provided in the Contract and represented by the prices tendered by him in the Bill of Quantities, as payment in full for executing and completing the work as specified, for procuring and furnishing all materials, labour, supervision, plant, tools and equipment, for wastage, transport, loading and offloading, handling, maintenance, temporary work, testing, quality control including process control, overheads, profit, risk and other obligations and for all other incidentals necessary for the completion of the work and maintenance during the Period of Maintenance.

Pay items

The descriptions under the pay items in the various Sections of the Specifications, indicating the work to be allowed for in the tendered prices for such pay items, are for the guidance of the Contractor and do not necessarily repeat all the details of work and materials required by and described in the Specifications.

These descriptions shall be read in conjunction with the relevant Specifications and/or Drawings and the Contractor shall, when tendering, allow for his prices to be inclusive as indicated above.

Materials on Site

No Payment will be made for materials stocked at site, as it will complicate the payment system as they are clubbed into works and not itemized separately. The payment will be made once it tallies with the specification.

Provisional Sums

The Bill of Quantities may contain certain Provisional Sums so designated and entered as a preliminary allowance to cover the cost of work, materials, goods or services to be provided by the Contractor and which have not been fully specified or measured or to cover the cost of unforeseen items of work or contingent expenditure. Work done under a Provisional Sum shall only be executed upon a written order by the Engineer which order shall also specify the method of payment.

The Contractor shall furnish to the Engineer such receipts or other vouchers as may be necessary to prove the amounts paid and, before ordering materials, shall submit to the Engineer quotations for the same for his approval. In respect of such of the works executed on a day works basis, the Contractor shall, during the continuance of such work, deliver each day to the Engineer an exact list of the names, occupation and time of all workmen employed on such work and a statement showing the description and quantity of all materials and equipment used other than the Contractors equipment which is included in the percentage addition in accordance with such day work schedule.

The Contractor shall not be entitled to any payment unless such lists and statements have been fully and punctually provided. Where the Engineer considers that for any reason the provision of such lists was impracticable he shall nevertheless be entitled to authorize payment for such work provided that, such work or value thereof shall, in his opinion, is fair and reasonable.

1105 Substantial Completion of the Works

The Contractor shall note that the Engineer reserves the right not to certify the Works to be "substantially completed" as required by the General Conditions of the Contract, unless the following portions of the Works are completed according to the Specifications:

(a) All bituminous seal works or, where a seal is not included, the uppermost gravel layer.
(b) All drains and drainage structures, for the construction of which timeous instructions were given by the Engineer.
(c) Finishing of all support or retaining structures.

Opening of individual sections or lots shall not entitle the Contractor to receive a Completion Certificate.

1106 Protection of the Works and Requirements to be met before Construction of New Work on top of Completed Work is Commenced

The Contractor is to provide temporary drainage works such as drains, open channels, banks, etc. and furnish and operate temporary pumps and such other equipment as may be necessary to adequately protect, drain and dewater the works and temporary works. This will be in addition to any permanent drainage works specifically paid for separately. Care shall be exercised to keep all completed layers properly drained, not to cause dumps of material on completed layer work to inhibit surface drainage or to form wet spots under and around dumps, and to protect all parts of the work against erosion by floods and rain.

Material shall not be spread on a layer that is so wet such as to damage underlying layers or prevent adequate compaction of overlying layers. Such wet layers shall be dried and re-compacted or removed. Excavations for pipe drains, culverts, sewer drains, water mains, manholes, service ducts and similar structures shall be adequately protected against the possible ingress of water during rainstorms.

All completed layer work shall be protected and maintained until the following layer is applied. Maintenance shall include immediate repairs to any damage or defects which may occur and shall be repeated as often as is necessary to keep the layer continuously intact and in a good

condition. Before any completed layer is primed or a succeeding layer constructed thereon, any damage to the existing layer shall be repaired so that after repair or reconstruction if necessary, it will conform in all respects to the requirements specified for that layer. All repair work other than minor surface damage repairs shall be submitted to the Engineer before covering up.

Work performed as part of the above obligations shall not be measured and paid for separately and the cost thereof is to be included in the prices tendered for the various items of work requiring protection and for the Contractor's establishment on Site as specified in Section 1200.

1107 Remedial Work

When any part of the Works or any equipment or material is found upon examination by the Engineer not to conform to the requirements or is at any stage before final acceptance damaged so that it no longer conforms to the requirements of the Specifications, the Engineer may order its complete removal and replacement, at the Contractor's expense, with satisfactory work, equipment or material or he may permit the Contractor to apply remedial measures in order to make good any such defects or damage. The actual remedial measures taken shall at all times be entirely at the Contractor's own initiative, risk and cost, but subject to the Engineer's approval regarding the details thereof.

In particular, remedial measures shall ensure full compliance with the Specifications of the final product, shall not endanger or damage any other part of the Works and shall be carefully controlled.

1108 Sign Boards

The Contractor shall provide identification sign boards. A signboard is to be erected at each end of the works and maintain them in good condition. All information on the signboards will be written in English and Dari/Pashto. The signboards will be positioned as directed by the Engineer. The Contractor shall submit proposals for the materials of the signboards, the text layout and installation of the signboards on Site to the Engineer for approval. Each sign shall show:

Name and Number of Contract
Name of Employer and Employer's Agent
Length of Works
Cost of Works
Date of Commencement and Completion.

1109 Measurement and Payment for sign boards

No separate payment will be made for these sign boards, its cost should be considered to be included in the Mobilization.

1110 Photographic Records

The Engineer shall make photographs and other records to be agreed with the Contractor of the condition of the surfaces of the site immediately before entering upon them for the purpose of constructing the Works. Each month, the Contractor shall make a set of up to 100 digital colour photographs illustrating progress of the Works, or any other photograph that he may deem necessary for record purposes, and provide these to the Engineer for his records. The copyright of all photographs shall be vested in the Employer and the Contractor shall not use any photograph for any purpose whatsoever without the Engineer's approval.

1111 Access to Site

The Contractor shall make his own arrangements for access to the various parts of the Site where works are to be constructed but all such accesses shall be subject to the approval of the Engineer.

Where the access to the Site proposed to be used by the Contractor lies across the land of any third party the Contractor shall produce to the Engineer the written consent of the owner and the occupier of the land over which the access lies before making use of the same.

The Contractor shall also make a record to be agreed by the Engineer of the conditions of the surfaces of any land (and of any crops on such land) over which access lies before he uses it for access purposes and he shall keep all such surfaces in a reasonable state of repair during the executing of the Works. On the termination of the Contractor's use of such access he shall restore any lands, roads or other property to a condition at least equal to that existing before his first entry upon them.

1112 Security of the Works

Generally, the site is located in Kabul province, and may not have serious security problem, however, the contractor is responsible for the security of its personnel, Engineers, and client while on project sites, plant machinery, campsites, etc. during the execution of the work. The contractor shall provide 24 hours security to the Engineer's site offices and residential accommodations including during any shutdown periods.

Measurement and Payment

The contractor is responsible for the cost of the site security, and this cost will not be paid as a separate item. Therefore the contractor shall include all costs associated with providing adequate site security in the payable items of works in the contract.

1113 Suppression of Noise

The Contractor shall make every reasonable endeavor both by means of temporary works and by the use of appropriate plant or silencing devices to ensure that the level of noise resulting from the execution of the Works does not constitute a nuisance.

1114 Safety

The Contractor shall immediately notified the Engineer any accident occurs whether on Site or off Site in which the Contractor is directly involved which results in any injury to any person whether directly concerned with the Site or whether a third party. Such initial notification may be verbal and shall be followed by a written comprehensive report within 24 hours of the accident.

Transportation of any material by the Contractor shall be in suitable vehicles which when loaded do not cause spillage and all loads shall be suitably secured. Any vehicle which does not comply with this requirement or any of the local traffic regulations and laws shall be removed from the Site.

1115 Work Methodology

The Contractor shall submit work methodology for his whole work for the prior approval from the Engineer and adopt a method of working such as to permit the satisfactory and timely completion of the Works and to limit disturbance and damage to a minimum.

The Contractor shall only open up sections of the Works for which his resources are sufficient to maintain continuous and methodical progress. If in the opinion of the Engineer, the Contractor has not complied with the foregoing, he shall be entitled to suspend sections of the works as per the General Conditions of Contract until other sections have been completed to a stage where risk of damage through exposure to traffic and the elements and inconvenience to public traffic has been minimized.

Constructional Plant used in the execution of the Works shall be of a design and used in a manner approved by the Engineer. The Engineer may at any time withdraw his approval for any method of working proposed by the Contractor and the Contractor shall immediately adopt another method of Working. If such change shall be required to achieve satisfactory progress or workmanship, the Contractor shall have no claim against the Employer for costs incurred by him in changing the method of working or in the provision and use of other plant.

1116 Temporary Works

The Contractor shall provide, maintain and remove on completion of the Works all temporary works necessary for the construction of this permanent works. All temporary works shall be properly designed and constructed to carry such loads as may be imposed upon them and shall be safe and suitable in every respect for providing access or carrying plant or for the construction of the Works or other purposes.

1117 Provision for Traffic

The Contractor shall at all times provide for traffic flow along existing roads, rivers and canals. The Contractor shall provide and maintain all detours, temporary roads, temporary bridges, necessary barricades, warning lights and guide signs as well as other equipment at all hours during the day or night.
The Contractor shall submit the plan and section drawings of proposed detours, temporary roads and temporary bridges to the Engineer for approval prior to commence of works.

The width of the pavement diversion shall be 5.0m with 1.0 m shoulders on each side on a compacted soil of 95% of MDD AASHTO T 180 laboratory compaction covered with a minimum of 300 mm of gravel sub-base with gravel surfacing laid and well edged. The Contractor shall provide drainage facilities through the diversions.

The Contractor shall in due time and at least one month before any diversion of traffic, submit a detailed stage program for the Engineer's approval. The program shall show all arrangements necessary to ensure a smooth traffic flow. Upon completion of the Works, all temporary roads, temporary bridges, barricades, signs and other equipment shall be completely removed, unless otherwise approved in writing by the Engineer.

The Contractor shall so plan his operation so as to maintain the flow of traffic through the Works without disruption or delay. Road closures may be permitted by the Engineer in exceptional circumstances. The Contractor shall give at least 7 days' notice of any proposed road closure.

Upon completion of a day's work, or if the Works are to be left unattended, the Contractor shall leave the Works in such a condition so as to allow the safe passage of traffic. The Contractor shall be responsible for complying with all regulations relating to the temporary closure of roads in Afghanistan.

Should the road width be restricted or should there be any form of obstruction or danger to traffic, the Contractor shall supply adequate flagmen, signs, barriers, lights, communications and staff to ensure that the traffic is safely conducted through the Works.

1118 Testing of Materials

Contractor's Site Laboratory

The Contractor shall assign a third party independent laboratory, whom shall provide and maintain minimum facilities of a site laboratory for the use of the Contractor and the Engineer including furniture, testing equipment and consumable stores necessary to carry out all the routine tests of the project which are listed below, and may contain tests which are not listed but is feasible and is part of the routine tests in Afghanistan. The laboratory shall be constructed with

a concrete floor and brick walls, shall be watertight and provided with electricity, potable running water and sewerage.

The list of the test furnished below may include but not be limited to those required for.

List of minimum site tests

Soil	Classification (Grading, Atterberg limits), Compaction, (AASHTO T180), density, moisture contents, dry density, DCP, CBR, Hydrometer, FDT
Aggregate (Coarse & fine)	Grading (Fineness modulus), Flakiness, density, moisture content, Specific gravity
Cement	Setting time, mortar cube strength
Concrete	Slump, Compressive Strength, Unit Weight, Air Content, Curing, Temperature
Bitumen	Penetration, Softening Point, Ductility, Flash Point, Sp. gravity
Bricks	Absorption, Unit weight
Bituminous mixture	Temperature, combined gradation, Extraction, Gmb, GMM, Stability, flow, Marshal Tests
Pavement Layers	surface tolerance and thickness checking
Pavement Surface	Roughness

A minimum list of lab equipment shall be provided by the Engineer during the period for mobilization, the other equipment which are not listed in here should be available on site lab, one month in advance before the related activities get starts. A preliminary list given but not to be limited to those required for.

List of Minimum site Lab equipment

SI No.	Description of Items	Unit	Qty
1	Scientific Calculator	no.	1
2	Hammer 1 kg	no.	2
3	Slides callipers	no.	1
4	Particle size analysis of soils Set consisting of 200mm dia. sieves (11 nos.).	Set	1
5	a) Liquid limit device with counter (Casagrade)	no.	1
	b) Spatula 200 mm. blade	no.	1
6	a) for plastic limit tests Glass plate 30 x 30 x 5 mm. = 1 no.	no.	1
	b) Moisture can	no	30
	c) Spatula 100 and 200 mm. = 2 nos.	no.	1
7	c)small Gas burner with 2 cylinders	no.	1
	c) Balance 311g x 0.01g	no.	1
8	a) Sand cone, base plate & plastic bottle	no.	2
	b) Field balance 15 to 20kg capacity	no.	1
9	Plastic graduated cylinder 1000ml	no.	2
10	a) 0.75x0.75x0.05 m Galvanize trays	no.	2
	b) 0.25x0.25x.0.03 m Galvanize trays	no.	2
11	Soil mortar	no.	1
12	Rubber mallet	no.	1
13	Soil Pestle	no.	1
14	Washing sieve 300mm dia and 0.075mm sieve for washing Materials	no.	1
16	Sieve analysis of fine & coarse aggregates as per ASTM	set	1
17	a) Flakiness gauge	no.	1

	b) Flakiness sieves (set of 7 pcs)	set	1
	c) Elongation gauge	no.	1
18	l) Dial thermometer 259°C	no.	1
19	Concrete cylinder mould 150mm dia x 300mm high	no.	18
20	Digital Concrete Compressive Strength Machine	no.	2
21	Pressure Type Concrete Aire Meter	no.	2
22	Measure for unit weight and density of concrete	set	2
23	CBR Molds with all its accessaries	no.	6
24	Modified Proctor Molds (6 inches) with all its accessories	Set	2
25	Soaking Tank of CBR Molds	no.	1
26	Tamping rod, 16mm plain bar 600mm length with round edges	no.	2
21	Slump test device a(slump cone) and tamping rod, base plate	no.	2
	Straight edge/ steel ruler	no.	2

1119 Materials Testing by Independent Laboratories

In addition to the Site testing facilities described in Specification Section 1118, the Contractor shall be responsible for arranging for the field and off-Site laboratory tests listed and all other tests indicated as the responsibility of the Contractor in Sections of Divisions 2 to 5 of the Specifications, to be performed by testing laboratories approved by the Engineer. The Contractor shall be responsible for all attendance on staff from these approved testing laboratories, including if necessary the provision of transport for personnel, equipment and test specimens.

1120 Special and Additional Testing

In addition to the testing described in Specifications here, the Engineer may require further testing to be carried out. Such special and additional testing shall be arranged by the Contractor at approved laboratory at Afghanistan or out-side abroad under the direction of the Engineer.

1121 Staff for Materials Testing

The Contractor shall provide qualified laboratory engineers, technicians, assistants, labours, etc. to carry out sampling and testing of materials.

1122 Test Results and Records

The Contractor shall maintain complete records of test results which may be inspected by the Engineer at any time. All test results shall be recorded on standard forms approved by the Engineer and shall be signed by the Contractor's engineer or technician in charge of the laboratory. Completed forms shall clearly show the locations of samples, sampling dates and testing dates. Samples shall be numbered serially at the time of sampling. The Engineer may witness any sampling or testing carried out in the laboratory and will have the right to use the facilities and equipment to make his own tests. The Contractor shall have the right to witness any sampling or testing carried out by the Engineer. On completion of the contract the original copies of all tests results shall be handed over the Employer, via the Engineer. All tests results should be submitted to the Engineer immediately after the test.

1123 Measurement and Payment

The provision of the laboratory, Materials Engineers office, furniture, equipment and services detailed in Specification Section 1118 and the removal from Site of the laboratory, Materials Engineers office, furniture and equipment at the end of the Contract shall be covered by other rates of the BOQ.

1124 Approval of Sources of Materials

The sources of the materials shall be selected by the Contractor, but approved by the Engineer prior to their incorporation in the Works. For this purpose, the Contractor shall furnish all

relevant test data for representative samples from each source area as desired by the Engineer and also afford opportunities for the Engineer to visit the source areas. The number of representative samples to be tested shall not be less than two for each type of material in each source area. Notwithstanding approval of sources of materials, materials as brought to the work site for use in the work shall be subject to acceptance or rejection by the Engineer based on quality control tests to be performed before use in construction.

1125 Stockpiling of Materials

All materials brought to the site shall be stockpiled and stored in a systematic manner so as to prevent deterioration or mixing of materials or intrusion of foreign matter. Preparation and storage of materials along the alignment will not be allowed. The Contractor shall make all arrangements and bear all costs associated with the provision of these storage areas.

The site of stockpile shall be cleared of vegetation and debris, graded and drained. The bottom 50mm layer of aggregate or any contaminated aggregate shall not be used in the work. Materials which have suffered intrusion and deterioration due to improper storage shall not be used in the works.

1126 Control Tests on Material Stockpiles

The Contractor shall use only such materials in construction as conform to the requirements regarding composition, grading, and physical properties and engineering characteristics specified for different kinds of material. For this purpose pre-construction control tests shall be carried out on representative samples collected at random from material brought to the site or at stockpiles. Any stockpile or any material brought to the site found not conforming to the Specification requirements shall be removed promptly.

1127 Compaction Equipment

Mechanical equipment shall be used for compacting materials by rolling, tamping and watering, spreading, mixing and shaping. The choice of equipment and the procedure for their use shall be subject to the approval of the Engineer upon his being satisfied about their effectiveness on the basis of trial compaction.

It shall be understood by the Contractor that different types of material are likely to require different kinds of compaction equipment, including successive applications thereof, to achieve the specified degrees of compaction, and the Contractor shall keep available compaction equipment of the requisite kind, size and number.

For compacting narrow strips and for compaction in restricted areas smaller sized compacting equipment may be required and if so, the same shall be provided for by the Contractor.

1128 Compaction

Compaction of materials shall be done in layers of uniform thickness using approved compaction equipment including combinations thereof if desired by the Engineer.

Compaction with rollers shall commence at the edges and progress towards the center except in super-elevated and other stretches of unidirectional cross fall, where the rolling shall commence at the lower edge and progress towards the upper edge. When commencing rolling from an edge, rollers shall run forward and backward along the edge several times till the edge strip becomes firm to provide lateral support. The roller shall then move inwards parallel to the center line of the road in successive passes with the tracks made by successive passes overlapping. Rolling shall continue till the specified degree of compaction is achieved throughout. When rolling is terminated at an edge, the procedure similar to that for commencing rolling at an edge shall be adopted. During rolling, the top of the layer being rolled shall be checked for levels and cross fall and any irregularities in these regards corrected by loosening the material in the affected area and

by removing or adding materials and continuing with the rolling until the entire area being rolled has been brought to a state of uniform and desired compaction.

1129 Compaction Trials

To demonstrate the efficiency of mixing and compaction equipment and the working methods proposed to be used by the Contractor for different kinds of materials, the Contractor may be required to carry out compaction trials before starting full-scale construction on the road. Based on results of compaction trials and construction observations, the Engineer may direct the use of particular mixing and compaction equipment and methods and disallow the use of others.

1130 Compaction Control

After the compaction of each layer of material, field density tests shall be done on the compacted material. For locating test points, successive compaction panels covering the entire area of work shall be designated in advance of compaction. The frequency of the tests (in terms of square meters of compacted area of each layer for which minimum one test is to be done) shall be separately specified for different kinds of material. The test locations shall be chosen through random sampling techniques.

For material other than bituminous mixes, the compaction panels in which the compaction work is found as non-acceptable shall be given re-compaction accompanied with scarifying and wetting/drying for the entire thickness of the compacted layer to achieve the specified degree of compaction. In case of bituminous mixes, the compaction panels in which the compaction work is found as non-acceptable shall be stripped off and re-laid with fresh bituminous mix and re-compacted.

1131 Mixing and Control of Moisture Content

Before compaction is taken up (other than for bituminous mixes), each layer of material shall be brought to a state of uniform composition, texture and moisture content by thorough mixing and addition of water or drying as required. The Contractor shall be deemed to have taken account of the fact that the materials encountered may vary widely with respect to their in-situ moisture content and the moisture content at which the materials are to be compacted.

1132 Drainage during Construction

All embankment, sub-grade, shoulder and pavement layers under construction shall be protected from any accumulation of water due to rains or other causes and from erosion. All such layers under construction shall be provided with cross-fall to facilitate surface run-off and, if necessary, the cross-fall shall be supplemented with temporary drains or pumping arrangements to prevent accumulation of water.

1133 Protection to Existing Embankment/Pavement Layers

Excavation for new construction, and placement of materials and their in-situ processing and compaction shall be done in such a manner and with such precautions as not to cause any damage to embankments, sub-grade layers, shoulders and pavement layers in position including those pre-existing and intended to form part of the improved road.

1134 Disposal of Hauling Equipment

Hauling equipment bringing materials to the site of work shall be dispersed uniformly over the surface of the previously constructed layers in order to avoid rutting and uneven compaction. The materials from hauling equipment shall not be dumped in concentrated heaps but deposited as evenly distributed layers.

1135 Plying of Traffic

Layers of embankment, sub-grade, pavement and shoulder during construction shall be protected against the plying of any kind of traffic other than construction equipment, till the new construction has been finally opened to traffic.

1136 Drawings

The drawings referred to in the contract document are the standard cross sections of the road.

1137 Typical Cross Section

The "Standard Cross Sections" given in the drawings are provided as a guide only. The locations and extent of works to be undertaken will be ordered by the Engineer on site.

SECTION 1200: CONTRACTOR'S ESTABLISHMENT

1201 Scope

This Section covers the setting up of the Contractor's establishment on the site, maintenance of the site establishment and the removal thereof after completion, and compliance with the provisions of the contract.

1202 Locating construction camps

The Contractor shall establish his principal construction camp at or near to the site at a location of his choice, subject to the approval of the Engineer. The principal construction camp shall accommodate the Contractor's administrative offices and testing facilities but the Contractor may establish other camps as he may require accommodating stores, plant workshops, casting yards, concrete batching facilities, crushing plant etc. The Contractor shall be solely responsible for the provision of land for construction camps, the cost of which shall be deemed to be included in his tender.

1203 Provision of facilities, plant and equipment

The Contractor shall provide all facilities, personnel, equipment, plant and all other things whether of a permanent or temporary nature required for the execution and maintenance of the work.

1204 Compliance with the Conditions of Contract

The Contractor shall be deemed to have examined the documents comprising the contract and to have included in his tender for the cost of complying with the provisions thereof whether itemized in the Bill of Quantities or not.

1205 Contractor Office Equipment

The Contractor shall procure and maintain the office equipment such as photocopy machines, desktop computers, printer, UPS, Internet facilities, and Mobile Telephone for their field office.

Equipment List

Sl. No.	Description of equipment	Quantity
1	Latest Model Desk Top Computer with associated soft ware	1
2	Latest model new laser printer to take A4size sheets..	1
3	Photo copier(A4 size) with operator	1
4	Heavy duty Stapler	4
5	Heavy duty puncher	1
6	Desk set of office equipment of each desk (stapler, staple remover, calendar desk tidy, pair of scissors etc	1

7	Steel and fiber tapes 100m, 30m and 5m	2
8	Electrical wall clocks 250mm dia.	2
9	Note book	24
10	Survey Equipment	2

1206 Survey Equipment

The Contractor will be required to provide survey equipment for the use of the Contractor's and Engineer's staff as required for the project.

In addition to the survey equipment, the Contractor will procure miscellaneous tools and minor items of survey equipment such as 30 m and 3 m long steel tapes, ranging rods, spirit levels, plumb bobs, umbrellas, hammers, knives, wooden stakes, steel pins, string lines, paint, marking crayons etc. to the Site. These shall be available in reasonable quantities at all times for use by the Contractor's and Engineer's staff. Ranging rods shall be 1.8 m long with alternate red and white painting.

The Contractor shall supply approved chainmen and other artisans to the Engineer to assist with survey and setting out works, as and when required.

1207 Levels and Levelling Staffs

Levels shall be auto set in carrying cases, complete with centering tripods with extension legs, and to the following minimum specifications:

Magnification 32 times	Stadia 1:100
Aperture 40 mm minimum	Resolving power 3" (sec)
Angular field of view 1° 20'	Range of sensitivity ± 15 minutes or less Short Focusing
Distance 1 m	Horizontal circle diameter 75 mm
Addition constant 0	Graduation 10 min Accuracy ± 1 mm for 1 km double run

Staffs shall be telescopic, aluminums with graduations in Metric units.

1208 Theodolites

Theodolites shall be double circle Triangulation with optical Micrometers. The instruments shall be in airtight metal/wooden carrying cases with tool compartments and eyepiece filters complete with centering tripods and extension legs, to the following minimum specifications. One or more Theodolites suitable for the attachment of an EDM may be required.

Objective aperture 45 mm	Addition constant 0
Shortest focusing distance 1.7 m	Sensitivity of collimation of level 20"/2 mm
Multiplication constant 100	Graduations 360°

1209 Mobilization

Measurement and Payment

Supplying materials for and construction/hire/rental of the site camp/field office for the Engineer, including all furniture and fittings, access roads etc., and the provision of water electricity and sewerage facilities, and the removal of the field office for the use of Contractor and Engineers staff, providing of sign boards, as described in this specification series 1200 shall be paid for at a lump sum price for site mobilization and site facilities.

Item		Unit
12.01	Mobilization	Lump Sum

Payment for mobilization shall be compensation in full for the cost of establishing plant equipment facilities and personnel upon the site and shall include (but not necessarily be limited to).

(i) Transport of plant, buildings, temporary facilities to the site.
(ii) Provision and erection of contractor temporary buildings, office facilities on the site.
(iii) Provision of access roads, hard standings etc. within construction camps.
(iv) Airfares, temporary accommodation during the mobilization phase, permits, bonds etc. necessary to establish expatriate supervisory personnel upon the site.
(v) Establishment of testing and process control facilities on the site.
(vi) Provision of transportation facilities for supervisory, administrative and technical personnel.

50% of mobilization cost shall be made initially once contractor demonstrates that all required machines and equipment at the site and work is progressing and when the Contractor has established himself upon the site to the satisfaction of the Engineer.

2nd payment for mobilization will be made once the contractor mobilizes at the end of winter period If the site to be closed during the winter time. Otherwise rest of the 50% will be paid on monthly basis at Engineer's discretion.

Payment for maintenance of the Contractor's establishment on the site shall be compensation in full for the costs of maintaining offices, supervisory, technical and administrative personnel and facilities both on and off the site and shall include (but not necessarily be limited to).
(i) Salaries leave fares, gratuities and miscellaneous entitlements of supervisory personnel, technical personnel, surveyors, administrative personnel, security personnel, store men etc.
(ii) Maintenance of offices, buildings, laboratories and transportation facilities for administrative, supervisory and technical personnel.
(iii) Communications.
(iv) Maintenance of housing for administrative, supervisory and technical personnel.
(v) Overheads off site.
(vi) Financing charges.
(vii) Compliance with the provisions of the contract whether specified or implied.
This item shall not include for maintenance or depreciation of plant, the cost of which shall be deemed to be included in the relevant work item.

Payment shall be made at a lump sum rate per week/month in respect of the period commencing from the Engineer's order to commence until the date for completion of the whole of the Works subject to the Contractor having provided an acceptable Performance Bond in accordance with the Conditions of Contract.

Notwithstanding equal monthly payments as aforesaid, in the event that the Contractor shall fail to complete to Works, total payment under this item shall be limited to the sum of all items pertaining to maintenance of the Contractors establishment multiplied by the value of works completed (excluding General and Preliminary items, Day works and Provisional Sums) divided by the total value of the Works (excluding General and Preliminary items, Day works and Provisional Sums) and any over payment shall be recoverable as a debt by the Employer.

In the event that the Contractor shall complete the Works before the date for completion, then the whole of the sum under this item shall become due and payable with the first interim certificate after completion has been certified. Subject to the above provisions relating to failure to

complete the whole of the Works, this provision shall apply equally to Sections of the Works defined in the contract.

1210 Demobilization

In the event of an extension of the Contract period being granted by the Engineer (excluding any extension for which the Contractor is not entitled to costs) then payment shall be due at the lump sum rate per week/month for an extension not exceeding three months. Thereafter, costs associated with time extension shall be determined as provided for by the contract.

Item		Unit
12.02	Demobilization	Lump Sum

Payment for demobilization shall be compensation in full for the costs of removing plant, equipment, facilities and personnel from the site and shall include (but not necessarily be limited to).

(i) Transport of plant, buildings, and temporary facilities from the site and export if required.
(ii) Dismantling and removal of all temporary facilities on the site.
(iii) Airfares for repatriation of expatriate personnel.
(iv) Removal of contract sign boards.
(v) Restoration of all construction camp areas to a satisfactory condition.

Payment shall be made upon completion of demobilization to the satisfaction of the Engineer. This item shall be payable only in respect of the whole of the Works and shall not apply in cases of sectional completion.

1211 As –Built Drawings

The Contractor shall furnish sets of as-built Drawings of the Works to the Engineer, showing the permanent works as actually constructed, within 14 days of completion of the Works. Included in the sets of as-built Drawings will be revisions of Tender Drawings and Drawings supplied to the Contractor during the Contract as well as revisions of drawings supplied by the Contractor during the Contract. The as-built drawings submitted by the Contractor will be subject to the approval of the Engineer.

SECTION 1600: SETTING OUT HORIZONTAL AND VERTICAL ALIGNMENT

1601 Scope

Setting out the horizontal alignment and elevation levels shall consist of the provision and placement of ranging rods and profile boards to determine the exact alignment of the road. The ranging rods and profile boards shall be of good quality metal and their finish of such a standard that they can be used for good and correct setting out. The setting out shall include vertical as well as horizontal alignment. The contractor shall ensure that the setting out is maintained for the entire period required to achieve the dimensions of the road according to the drawings.

1602 Construction Method

Setting out of alignment shall be carried out following the instructions of the Engineer. The setting out shall ensure that the dimensions of the road are according to the drawings and shall be maintained by the contractor for the time required to complete the works.

Both alignments shall follow as closely as appropriate to the existing terrain and road lines and they shall be established by pegging the center line, edge of carriageway and ditch lines.

Reference pegs shall be provided at intervals outside the roadway to allow for the reestablishment of the alignment during construction. Chainage shall be clearly marked on pegs at not less than 100 meter intervals.

The Contractor shall set out, using pegs and string lines, the various construction operations in sufficient detail to ensure that the required standards and tolerances are achieved, and in such a way that any task work system adopted may be easily checked by the Engineer.

The limits of the embankments shall be marked by fixing out wooden pegs (at least 50mm dia and 500mm long) at 20m intervals or closer if desired by the Engineer. The pegs shall be fixed at about 0.5m beyond the actual limits of the fill and painted in a distinctive color

1603 Measurement and Payment

Item		Unit
16/1	Setting out alignments	meter

The unit of measurement for setting out is meter (m). The quantity shall be measured as the length of the road section where setting out has been carried out for center line and other edges of the road.
No extra payment shall be made for the re-placement of pegs, profile boards or any other setting out materials which are removed from the site prior to instructions of the Engineer.

2000 GENERAL

2001 General Requirements for Earthworks

The Contractor is required to take particular note of the specifications for the compaction of earthworks. Details of compaction control are discussed in paragraph below and the testing of embankment earthworks will require particular care.

The Contractor shall programme the works so that existing embankment materials are re-used to the maximum extent possible under the Specifications. Any action need to be taken to improve the properties of the embankment material shall be incidental to the tendered rates.

The earthworks quantities given in the Bills-of-Quantities are approximate only and the Contractor shall be paid according to the relevant items of the Bills-of-Quantities for the actual quantities of work performed in accordance with the Specifications.

2002 Compaction Control of Embankment Construction

This paragraph outlines the field and laboratory tests on soil samples that are necessary to ascertain the quality and the degree of compaction of the embankment to be constructed as roadway embankment.

a) Materials

Samples of embankment and sub-grade materials shall be obtained from the newly formed embankment or from those borrow pits alongside the existing road, or other borrow pits provided by the Contractor where required, from which materials to be used as embankment construction materials are to be obtained.

b) Testing of Materials

The following tests shall be performed on the soil samples which shall be obtained as required by the Standard Test Procedures, or as stated herein or as directed by the Engineer.

i. Maximum Density and optimum Moisture Tests
ii. Gradation tests
iii. Atterberg Limits (liquid limit)
iv. Plastic limit and Plastic Index
v. CBR Test

All the tests specified herein shall conform to the latest AASHTO standards unless otherwise advised by the Engineer. Tests shall be conducted by the Contractor in the laboratory under the supervision of the Engineer.

The Contractor shall employ at least one Civil Engineer qualified by a recognized degree and having at least 5 years experience in soil and materials investigation and testing. The Contractor's Engineer shall be supported by at least two experienced laboratory technicians familiar with soil laboratory test procedures plus labour as required. These staff of the Contractor shall work under the supervision of the Engineers representative.

c) Method of Measurement and Basis of Payment

There will be no additional payment for testing. All costs associated with testing including the maintain laboratory shall be incidental to earth work rates of the contract.

2100 CLEARING AND GRUBBING

2101 Scope

This Section covers general clearing activities of the road alignment, including the roadside drains and ditches, borrow areas.

2102 Description

This work shall consist of clearing, grubbing, removing, and disposing of vegetation and debris located within the limits shown on the plans or designated by the Engineer, except such objects as are designated to remain in place or are to be removed in accordance with other sections of these specifications. This work shall also include the preservation from injury or defacement of all vegetation and objects designated to remain.

2103 Requirements

The Contractor shall do minimum vegetation clearing to minimise the damages to surrounding environment. Unless otherwise advises any vegetation contiguous to streams, ponds, or lakes shall be preserved and kept safe from injury. Any unauthorised vegetation removal or any accidental damages shall be replaced or removed by the contractor at his cost as directed by the Engineer.

2104 Clearing and Grubbing

All surface objects and all trees, stumps, roots, and other protruding obstructions, not designated to remain, shall be cleared and/or grubbed as required, except as provided below:

(a) On the slope of an embankment, unless the area is to be benched, undisturbed stumps and roots that do not appear to extend beneath the pavement may remain provided they do not extend more than 150 mm above the ground.

(b) Grubbing of pits, relocated channels and ditches will be required only to the depth necessitated by the proposed excavation within such areas.

Except in areas to be excavated, stump holes and other holes from which obstructions are removed shall be backfilled with suitable material and compacted.

All areas, where clearing and grubbing is in progress or has been completed, shall be kept well drained. Any standing or ponding of water will not be permitted.

2105 Debris Disposal

Materials and debris may be disposed of by methods and at locations approved by the Engineer, on or off the project.

When burning perishable material is permitted, it shall be burned with extreme care not to damage surrounding environment including adjacent properties, or anything designated to remain on the right-of-way. Burning shall be done in accordance with applicable laws, ordinance, and regulations.

If disposal is by burying, the debris shall be placed in layers with the material so distributed as to avoid formation of cavities. Each layer shall be covered or mixed with earth material to fill all voids. The top layer of material buried shall be covered with at least 300 mm of earth or other approved material and shall be graded, shaped, and compacted to present a pleasing appearance. Materials shall not be buried beneath drainage ditches or in any areas that will be subject to flowing water.

If the disposal location is off the project, the Contractor shall make all necessary arrangements in writing with property owners for obtaining suitable disposal locations that are outside the limits of the project. The cost involved shall be included in the contract unit price. A copy of such agreements shall be furnished to the Engineer.

2106 Individual Trees

Where individual trees are designated for removal, such trees shall be clearly marked with paint. If the Contractor wishes to remove trees for his own convenience, he shall clearly mark the trees and obtain the Engineer's approval before proceeding with removal. Only such trees as are clearly marked shall be removed and all others will remain undisturbed.

2107 Measurement and Payment

Item 21/1 Clearing and grubbing .....sq.m

The unit of measurement for clearing and grubbing is square meter. The quantity shall be taken as the plan area in square meters designated by the Engineer and cleared and grubbed in accordance with these Specifications. The clearing and grubbing of borrows will not be measured.

The measurement for clearing and grubbing shall be the plan area of the permanent works. No deductions shall be made for buildings or structures. Existing carriageways shall not be measured.

The item coverage for the tendered rate for clearing and grubbing shall include the requirements of Division 2000 and the following:

a. Demolition, breaking up and removal of all walls and superficial obstructions affected by the Works down to existing ground level except as otherwise stated in the Contract;
b. Felling of trees, grubbing up and blasting stumps and roots;
c. Filling stump and root holes with suitable material from any source and compaction;
d. Uprooting of bushes, small trees and vegetation;
e. Disposal of surplus material;
f. Making good to severed ends of existing fences and walls;
g. Preservation from injury or defacement of all vegetation and objects designated to remain;
h. Re-clearing.

2200 DEMOLITION OF STRUCTURES

2201 Description

This item shall include demolition of bridges, culverts and other structures, buildings and septic tanks and septic wells, within the right-of-way required to complete the works. Demolition, unless otherwise specifically directed by the Engineer, shall be complete including foundations. No demolition work shall be carried out without the prior written approval of the Engineer.

For this project the main item would be the demolition of buildings rather than other concrete structures, The buildings consist of brick masonry as well as of concrete, and comprise of single story to multistorey to three story buildings, as well as septic wells and septic tanks.

This item shall consist of performing the following operations in accordance with provisions of the Contract and the requirements hereinafter set forth: excavating all materials which must be removed to permit removing the structures and buildings; removing, cleaning, transporting and storing the pipe, steel beams or other reusable components; breaking, removing and disposing of bricks, concrete, masonry and other materials in structures and buildings, all as approved by the Engineer. This items shall also include the
This item shall not include payment for demolition and disposal of site accommodation specified in Part-I of the specifications, payment for which is otherwise provided.

The depressed areas, and holes which remains after demolition of buildings, shall be backfilled with suitable material and compacted.

This item also shall not include payments for demolition and disposal of temporary bridges and access roads separately specified in these specifications, payment for which is otherwise provided.

2202 Methods

Demolition and disposal shall be performed according to standard practices approved by the Engineer.

Buildings and appurtenances shall be removed, including removal of foundations and concrete slabs or other types of floors resting upon the ground. The Engineer shall review the Contractor's proposals and appropriately approve or disapprove the Contractor's proposed methods for each building or structure which is to be removed. The Employer reserves the right to eliminate from the work to be done by the Contractor, the removal of any or all of the buildings, structures, etc. from the area, if deemed advisable by the Engineer. Such elimination shall not affect the price bid on the remaining buildings, structures, etc. to be removed and the Contractor will not be entitled to any compensation due to such elimination.

Where the Engineer's instructions call for pipe or other structures to be removed for reuse or storage, there shall be removed a section of pipeline or other structure sufficient in length to permit determining the quality of pipe or other structure and the possibility of removing it without damage. If the Engineer determines that the pipe or other structure is worth salvaging and can be salvaged the Contractor shall perform the remainder of the excavation in a manner that will not damage the pipe. Where caving occurs, the caved material shall be excavated before the trench created by the excavation is backfilled.

Pipes, steel beams, or other reusable or salvageable structural components shall be removed in such manner that they will not be damaged. After removal the pipe shall be cleaned and hauled to the location where it will be reused, or to storage. Where pipe is to be stored, storage shall be on the Right-of-Way at locations approved by the Engineer.

The trench resulting from the removal of pipe shall be backfilled in accordance with the provisions for embankment except when the trench lines within the limits of subsequent excavation.

2203 Safety Precautions

The Contractor shall comply with all laws, ordinances and building code regulations. Unless otherwise permitted by the Engineer, the Contractor shall furnish, erect and maintain suitable barricades to prevent personal injury or property damage.

2204 Ownership of Material

All material, except that belonging to public or private utility company, or unless otherwise specified such a bailey bridge, steel bridge, including joist, screw pile, trough plat, steel etc. or shown on the Drawings shall become the property of the Client.

2205 Method of Measurement

Demolition and removal of structures shall be measured on a lump sum basis for the total project and the price Bid therefore shall be shown in Bill 1 of the Bill of Quantities. Such price will cover all of the work required under this Section.

Demolition of multi-story buildings, houses, shops etc., will not be measured separately but will be included in the bid under Item 22/1 for the work in general.

2206 Basis of Payment

Since there is a large quantity of houses, shops, and buildings, hence the Structures demolishing will be measured in square meter. It should also include the cost of its transportation, and safely deposing, and filling the cavities and holes which results from the demolition of the Structures.

Pay Item		Unit
Item 22/1	Demolition of Structures	sq.m.

2300 REMOVAL OF EXISTING PAVEMENTS

2301 Description

This item shall consist of the removal of existing pavement (flexible or rigid) including base course, sub-base and shoulders as applicable and the satisfactory disposal of materials removed.

Since the works to be carried out under the Contract are for the overlay/betterment of the existing road the work under this item shall normally involve only the removal of bituminous wearing/levelling courses and concrete pavement slabs. Removal of other types of pavement and shoulder materials will be required at structures and may be required in areas elsewhere as shown in the Drawings or at the direction of the Engineer.

The existing pavement and shoulders may consist of layers of varying thickness of the following materials:

- blended and natural sands and soil
- brick soling, broken brick and sand aggregate, herring-bone brick
- broken stone aggregate, water bound or bitumen penetrated
- broken stone aggregate/sand bitumen premix
- seal coats with river pebble chipping stone or stone chipping
- normal or reinforced Portland cement concrete 125 m thick
- other combinations of bricks, stone, sand and bitumen are also possible

The total thickness of the layers will rarely exceed 600 mm and will normally exceed 300 mm.

In some instances levelling courses or wearing surfaces of hand-mixed and hand-placed bituminous concrete will be found on top of rigid pavement. Rigid pavement usually consists of two layers of Portland cement concrete approximately 125 millimetres in total thickness, in which the coarse aggregate may be brick chips or stone and there may be some reinforcement and dowel bars. Concrete slabs which may have been broken under traffic loads are generally about 3 metres by 6 metres between joints.

Prior to the removal of any existing road pavement the Contractor shall excavate trial pits and trenches as required by the Engineer to ascertain in detail the depth and composition of the pavement and this cost shall be included in the Contractor's rates generally.

All bituminous seal coats, wearing courses and levelling courses shall be removed and if not suitable for use elsewhere shall be disposed of by the Contractor.

All Portland cement concrete slabs, 125 mm thick, whether reinforced or not, shall be removed and the material processed for re-use where approved by the Engineer. Areas of existing pavement at the sites of new structures and at other locations as directed by the Engineer, for instance where the depth of the pavement in strips or localized areas is insufficient to form the sub-base to the new pavement structures or where bitumen has adversely contaminated granular base materials, shall be removed and if unsuitable for re-use shall be disposed of by the Contractor.

All suitable materials for re-use as sub base or other material for the works as approved by the Engineer shall be brought to the Contractor's materials preparation areas for stockpiling and re-use on the works.

The laboratories to establish quality and usage will test the materials.

2302 Removal Methods

The pavement and base course may be removed by either hand or machine provided the methods used do not cause an undue wastage of material. Bituminous concrete overlays on rigid pavement shall be separated from the Portland cement concrete slabs and removed before removal of the rigid pavement slabs.

2303 Disposal of Materials

All recovered pavement material suitable of re-use shall be handled as per the Conditions of Contract. The unsuitable materials shall be disposed of as spoil as instructed by the engineer.

2304 Methods of Measurement

The unit of measurement for the removal of existing pavement materials shall be the Square meter of bituminous wearing / levelling courses, concrete slab, HBB/BFS or full pavement structure removed, as the case may be. Where the full pavement structure is to be removed the measurement shall be of the volume in cubic metres and will not be made of individual pavement layers regardless of the composition and depth of the pavement section removed.

2305 Basis of Payment

These volume measured as provided herein above shall be paid for at the contract unit price for the items shown below which are listed in the Bill of Quantities; which prices and payment shall provide full compensation for removing, separating, loading, transporting and stock-piling or otherwise disposing of all materials, and for all labour, equipment, tools and incidentals necessary to complete this item of the works.

Pay Item	Unit
23/1 - Removal of Bituminous Surfacing	Sq.m
23/2 - Removal of Concrete Pavement	Sq.m
23/3 - Removal of Existing Pavement Structure	Sq.m

2400 Roadway Excavation

2401 Description

This work shall consist of the excavation, and satisfactory disposal of all material excluding materials measured and paid for under Item 2.3 - Excavation of Existing Pavements, encountered within the grade lines shown on the Drawings or approved by the Engineer below the existing ground or surface elevation and above the final sub-grade elevation or final slope line, and the removal and disposal of all unsuitable materials encountered below the final sub-grade elevation, provided that such unsuitable material is deemed by the Engineer to be unsuitable through no fault of the Contractor.

This item shall include all necessary stripping, shaping of the sub-grade, excavation for slopes and ditches, and the formation of berms, inlet, outlet and lateral drainage ditches shown on the Drawings or established by the Engineer.

After completion of clearing and grubbing and the removal of existing pavement as specified and after the slope stakes have been set and approved the Contractor shall excavate materials at such locations and in such sequence as the Engineer may approve.

All suitable material removed from road way excavation shall be used as far a practical in the formation of embankment, sub-grade, shoulders, slopes, bedding, and backfill for structures, and for other purposes shown on the plans or as directed by the Engineer. Unsuitable material shall be disposed of as spoil.

Unsuitable materials encountered below the final sub grade elevation shall be removed to such a depth as the Engineer may stipulate.

All material excavated, whether hard or soft, should be tested in contractor's laboratory to determine whether the material is suitable to be used in embankment construction, or is unsuitable to be spoiled.

Roadway excavation that has become unsuitable attributable to carelessness of the Contractor will be removed and disposed of at the expense of the Contractor.

2402 Spoil Material

Cut to spoil shall be measured as the net difference between the total volume of cut and the net volume of fill. The net volume of fill shall include any fill, sub-base or any other material used elsewhere on the Works, which is measured and paid for as per these specifications under a separate pay item and originated from a cut.

The net volume of fill shall exclude the net volume in place in a fill of material arising from a borrow pit, or excavated from the pavement of the existing road, if such excavation is not within the road prism. No account shall be taken of variations in actual quantities due to bulking.

The tendered rates for cut to spoil shall include full compensation for testing and disposal of surplus materials, including the cost of preparation of surface for embankment filling, providing disposal sites outside of the site, shaping compacting, landscaping and draining such sites.

2403 Removal of Topsoil

All topsoil encountered during required excavation shall be removed and stored in stockpiles at locations approved by the Engineer for later use in accordance with the requirements of these specifications. The Engineer may direct that topsoil is not to be removed where he considers that this operation may result in a reduction in shear strength in foundation for embankment.

Where required, the quantities of Top soil removal and preservation measured as specified above will be paid for at the Contract unit price per cubic metre shown in the Bill of Quantities for Item 24/1.

Pay Item		Unit
24/1	Top Soil Removal and Preservation	Cum

2404 Construction Methods

After completion of clearing and grubbing or hard/soft cutting of embankment and removal of existing pavement if necessary as specified and after slope stakes have been set and approved, the Contractor shall excavate material at such locations and in such sequence as the Engineer may approve. All suitable material required to be removed to make way for the Works shall be used in the formation of Roadway Embankment, Bunds, Spur Dikes or otherwise utilised for the works as approved by the Engineer. Unsuitable material shall be disposed of as spoil.

Soft Excavation in hilly area or along the road

Soft material excavation refer to the excavation of material either manually or using earth moving equipment such as excavator, bull dozer.

Excavation/cutting hard material with machines

Excavation of road side material or along the road refers to the excavation of laterite or weathered rock mass with machines by jackhammering ripping, chiselling, wedging, line drilling or using hard tooth of buckets. Under this definition those material are categorized which require up to 375 kW (500 hp) heavy duty track-type tractors or back-hoes with a single tine, rear mounted ripper. This kind of material should be further defined as the material having a headcut erodibility index (kh) or rippability index (kn) of 100 to 10000, or having a siesmic velocity (ASTM D5777) of 2150 m/s to more than 2450 m/s

Excavation of Hard materials (rock) that required blasting

Refer to hard rock material that required blasting to remove from the road way or road sides including trimming and levelling. This kind of material should be identified as those with headcut erodbility index (kh) or rippability index (kn) of >10000, or having sesicmic velocity (ASTM D5777) of >3045 m/s. Blasting shall be controlled.
The use of explosive will, itself, not be a sufficient reason for classification of materials as hard materials (rock) that require blasting.

It should be noted that all types of the excavation described above (Soft, hard, rock) is payable under one item, and no separate measurement will be made for each item.

All unsuitable materials (as determined by the Engineer) encountered below final sub-grade elevation shall be removed to such depth as the Engineer may stipulate. After removal of these unsuitable materials and cross-sectioning of the area, the Contractor shall bring the roadway to final sub-grade elevation in accordance with the specifications for the formation of Roadway Embankment.

Excavation of preloaded embankment material where placed shall not commence without the written approval of the Engineer. The pre-load material may be used in embankment and berm construction where this is approved by the Engineer. If not approved as embankment or berm material, it shall be hauled to disposal areas outside the right-of-way. Removal of the material shall be to average ground level in the area or as otherwise directed or approved by the Engineer.

The final trimmed surface level of the sub-grade at any point shall be within 25 mm of the design level as approved by the Engineer. For any section of finished sub-grade measuring 100 metres along the alignment, the differences between actual and design levels at points checked by the Engineer shall show no departure trend in either direction and areas consistently above the design level shall be trimmed to level.

2405 Measurement and Payment

Roadway Excavation to spoil as specified herein shall be measured for direct payment. All required and accepted roadway excavation to spoil shall be measured in its original position and the volume determined in cubic metres by the average end area method as computed from the original and final cross sections of required and completed work.

The volume of suitable material placed in accordance with the requirements of these specifications to replace unsuitable materials (except waste material) ordered by the Engineer to be removed below final sub-grade elevation will be measured by cross-sectioning and computed in cubic metres by the average-end-area method and shall be paid for as embankment material.

The quantities of roadway excavation to spoil measured as specified above will be paid for at the Contract unit price per cubic metre shown in the Bill of Quantities for Item 24 - Roadway Excavation to Spoil. Payment shall include for excavation, removal, haulage and satisfactory disposal of all roadway excavation, for shaping, dressing and completion of all surfaces and for furnishing all labour, materials, tools and equipment.

Materials removed in roadway excavation and incorporated in embankment or elsewhere in the works shall be paid for at the contract price for the relevant pay item for that part of the works but shall not be paid for under item 2400.

A separate payment will not be made for sub-grade preparation after roadway excavation. All costs involved with removal of excavated material and preparation of sub –grade afterwards shall be considered as incidental to the excavation and shall be included to the respective tendered rates.

Pay Item		Unit
24/2	Road way excavation	Cum

2500 Structure and Channel Excavation

2501 Description

This item shall consist of the necessary excavation for water channels and for the foundation of bridges, retaining walls, culverts and any other structure not otherwise prescribed.

Excavation for structures and channels shall include the removal of all material from within the excavation limits as shown on the Drawings or hereinafter prescribed or otherwise approved by the Engineer; all clearing and grubbing of the site of the proposed work except as otherwise provided for, the construction, and subsequent removal of all necessary bracing, shoring, sheeting, cribbing, and cofferdams; all pumping, bailing, draining, and disposal of surplus or unsuitable material.
Excavation shall be classified as follows:

a) Unclassified Structure Excavation
This classification shall include all excavation made within the horizontal limits hereinafter prescribed and between the existing ground or embankment surface and the elevation of the bottom of structure as shown on the Drawings or approved by the Engineer.

b) Extra Depth Structure Excavation
This classification shall include all excavation within the horizontal limits and between the elevation of the bottom of structure as defined in (a) and the actual bottom of excavation that becomes necessary by reason of the removal of any unsuitable material below a footing as directed by the Engineer.

c) Unclassified Channel Excavation
This classification shall include all excavation of existing stream channels made within the limits hereinafter prescribed.

2502 Construction Methods

All equipment necessary and required for structure excavation shall be in first-class working condition and approved by the Engineer before excavation will be permitted to begin.

If structure or channel excavation is shown in the Bill of Quantities as a separate bid item, the Contractor shall notify the Engineer a sufficient time in advance of the beginning of the excavation so that the Engineer and the Contractor can jointly agree on a system of survey of the ground before excavation and the necessary cross-sectional elevations and measurements may be taken of the undisturbed ground. Any materials removed or excavated before the measurements have been taken will not be paid for. The ground at the structures site shall not be disturbed without the permission of the Engineer.

The area required for a structure or channel shall be cleared and grubbed as provided in Section 2100.

2503 Excavation within enclosures for foundations

All foundations, where practicable, and in particular all culvert foundations shall be constructed by open excavation. The foundation openings shall be shored, braced or be protected by cofferdams if necessary in accordance with approved methods. Foundation excavation shall be made and piles, where required, driven or drilled in such sequence that no portion of the structures shall be endangered by reason of subsequent operations. No foundation excavation shall be commenced without the prior approval of the Engineer.

a. Cofferdams

Cofferdams shall be dewatered and foundations placed in the dry except as specified below. When conditions are encountered which, in the Engineer's judgement, render it impracticable to dewater the cofferdams below the level for placing foundations, he may require the placing of underwater concrete of such dimensions or quantities as may be necessary. The cofferdam shall be pumped out and the balance of the foundation placed in the dry. During the placing of underwater concrete the elevation of the water inside the cofferdam shall be controlled and if the cofferdam is to remain in place it shall be vented or ported at low water level.

After each excavation is completed the Contractor shall notify the Engineer, and no further construction work shall be started until the Engineer has approved the depth of the excavation and the character of the foundation material.

i) Construction

Cofferdams, cribs or sheeting for foundation construction shall in general be carried well below the bottom of the footings and shall be such as to give sufficient clearance for the construction of forms and the inspection of their exteriors, and to permit pumping outside of the forms if required. Cofferdams or cribs which are tilted or sinking shall be righted and this work shall be at the sole expense of the Contractor.

Cofferdams shall be constructed so as to protect green concrete against damage from a sudden rising of the stream and to prevent damage by erosion. No timber or bracing shall be left in cofferdams or cribs in such a way as to extend into the substructure.

For all foundation work, the Contractor shall submit Drawings showing his proposed method of cofferdam, support, dewatering and other details. The type and clearance of supports and cofferdams, insofar as such details affect the character of the finished work, will be subject to the approval of the Engineer, but other details of design will be left to the Contractor, who is responsible for the successful construction of the work.

ii) Removal

Unless otherwise shown on the Drawings or approved by the Engineer, cofferdams, trench support or cribs with all sheeting and bracing shall be removed by the Contractor after the completion of the substructure and after approval by the Engineer for such removal to be effected. The removal shall be effected in such a manner as not to disturb or mar the finished work. In lieu of the entire removal of the cofferdams or cribs the Engineer may require the Contractor to remove any portion of the same or to leave them entirely in place.

Cofferdams, cribs, sheeting and bracing left in place by written order of the Engineer shall be paid for in the amount of the actual delivered cost of the material left in place, and no allowance will be made for labour or any other item required for this work.

b) Pumping

Pumping from the interior of any foundation enclosure shall be done in such a manner as to preclude the possibility of any portion of the concrete materials being carried away. No pumping will be permitted during the placing of concrete, or for a period of at least 24 hours thereafter, unless it be done from a suitable sump separated from the concrete work by a water-tight wall.

Pumping to dewater a sealed cofferdam shall not commence until the seal has set sufficiently to withstand the hydrostatic pressure and in no case less than 7 days or such additional length of time after the sealing of the cofferdams as the Engineer may direct.

2504 Foundation Compaction and Extra Depth of Excavation

The foundations shall be excavated to permit the placing of the full widths and lengths of footings shown on the Drawings with full horizontal or slightly graded beds as specified herein. Special care shall be taken at the bottom of the excavations for foundations for structures to ensure that the foundation material is not disturbed. The foundation excavation shall be completed to within 50 mm of the required underside of the structure, including blinding concrete and improved sub-grade material, and the excavation shall be inspected before any further action is taken. Beneath structures the compaction of the base of foundation shall be to 95% of maximum dry density as determined using AASHTO T180. The final trim of the

foundation shall remove the base of the excavation to the underside of the blinding concrete, which shall be immediately placed thereon.

If the bottom of the excavation is not considered by the Engineer suitable as a foundation, Extra Depth Structure Excavation shall be removed until the material is considered suitable or until the depth is 2 metres below the underside of the concrete foundation. The bottom of the excavation where suitable shall be compacted as above defined. The void excavated for Extra Depth Structure Excavation shall be refilled with river sand suitable for improved sub-grade material as herein defined or by sand embankment material and shall be compacted as specified for Roadway Embankment to 95% of AASHTO T180 maximum dry density. Density tests in accordance with AASHTO T191 shall be made at a rate of one per compacted layer for each discrete excavation or per 100 square metres of compacted surface within an excavation, whichever gives the greater number of tests.

2505 Inspection of Excavations

After each excavation is completed and before the foundation is covered, the Contractor shall notify the Engineer and no material shall be placed until the Engineer has approved the condition of the foundation and its depth and has given permission to proceed.

2506 Backfilling and filling

All material used for backfill shall comply with 2.5.4 or 2.7.2 as applicable and shall be of the type specified or shown on the Drawing or acceptable to the Engineer. All spaces excavated for and not occupied by structures and other permanent work shall be refilled with embankment material, or other specified material, as shown on the Drawings up to the ground surface existing before excavation was made.

Special precautions shall be taken to prevent any wedging action against structures. Fill around culverts, and bridges shall be placed on both sides to approximately the same elevation at the same time. Fill shall be placed simultaneously at both ends of arches and frames in such a manner as to load the structures uniformly and symmetrically.

Adequate provision shall be made for the drainage of all backfilling weep holes, which shall be formed in abutments and retaining walls where specified in these specifications or where shown on the Drawings. Their outlet ends shall be placed where shown on the Drawings or specified herein or approved by the Engineer. The fill side ends of weep holes shall be covered by geo-textile and aggregate seepage drain material as specified in 2.7.2.

Pipe drains shall be provided when called for on the Drawings.

In order to prevent the collection of water in spaces around footings, backfill shall be placed up to existing ground line around abutments, wing walls, retaining walls, end bents and piers as soon as possible after vertical forms have been removed. Backfill around arches and rigid frames shall be placed up to existing ground line as soon as possible after the forms have been removed.

All excavated material used in roadway embankments shall be placed and compacted in accordance with the requirements for embankment.

2507 Preservation and Diversion of Channels

Unless otherwise specified, no excavation shall be made outside the area required for construction of the foundation as shown on the Drawings and the natural stream bed adjacent to the structure shall not be disturbed unless shown on the Drawings. If any excavation or dredging is made at the site of the structure before cribs or cofferdams are sunk or in place, the Contractor shall, without extra charge, after the foundation base is in place, backfill all such excavations to the original ground surface or river bed with material satisfactory to the Engineer as specified for roadway embankment.

Materials deposited within the stream area from foundation excavation or from filling of cofferdams shall be removed, and the stream left in its original or planned condition.

The Contractor during excavation of embankment from channel diversions shall maintain channels, or borrow pits in a well drained condition and shall not excavate below the final stream bed level and shall not open the borrow pit or the diversion channel to water flow from the existing stream nor allow flow from an existing stream to enter a diversion channel until the Engineer has approved the Contractor's written proposal to open the excavation to running water.

The Contractor shall make every endeavour to incorporate in the works all material excavated for channels, and shall not commence excavation from borrow pits located in such areas as require channels until he has submitted to the Engineer a detailed written proposal as to his mode of operation for the excavation and the Engineer has approved the proposal.

All such material excavated and incorporated in embankment and approved by the Engineer shall be paid for as embankment material and all such material excavated and ordered by the Engineer to be disposed shall be paid for as spoil material.

2508 Excavation Limits

General

For any class of excavation, only the actual volume of the material excavated to the limits defined shall be measured for payment.

Unclassified Structure Excavation

For purposes of payment, the horizontal limits shall be the neat lines of the footings and to the limit of the free draining backfill (assumed 0.5m on each side of foundation concrete), the vertical limits shall include all excavation made between the existing ground surface and the original plan elevation of the bottom of the footing, including blinding concrete and to the limit of free draining backfill.

Extra Depth Structure Excavation

Shall include all excavation directed by the Engineer below the original plan elevation of the underside of the blinding layer.

The horizontal limits of Extra Depth Structure Excavation shall be to the neat lines of footings and to the limit of free draining backfill.

Unclassified Channel Excavation

When shown on the Drawings or specified, channels shall be excavated to the elevation and dimensions called for. The excavated material shall be used to form embankments where suitable and where required, otherwise it shall be disposed of in borrow pits or be used to flatten embankment slopes.

All channels shall be excavated and materials disposed of in a manner satisfactory to the Engineer.

2509 Measurement

If a separate bid item for unclassified structure excavation or other particular classification of excavation is given in the Bill-of-Quantities, the quantity to be paid for under this section shall be the number of cubic metres of all material measured in its original position, which has been excavated in accordance with the requirements of these Specifications from within the limits prescribed herein. The method of average end areas shall be used in computing the volume of excavation except as agreed between the Engineer and the Contractor.

Measurement for Structural Excavation shall include the cost of inspection and compaction of the bed of the structures.

Excavation above original plan elevation of bottom of footing made necessary by increasing the horizontal dimensions of footings over those originally shown on the Drawings or for any other reason, shall be measured as herein before prescribed per cubic metre for Unclassified Structure Excavation.

Measurement for Extra Depth Structure Excavation for the area measured above shall include the cost of any over break, dewatering (if required), shoring and supports and the cost of backfilling as specified

including the provision of the backfill materials and for any difficulty of working and compacting in excavations.

Material excavated before the Engineer has made the necessary measurements either at the beginning or during the progress of the work; excavation outside the prescribed limits; material in over breaks and slides, and excavation made necessary by the heaving of a foundation due to the driving of piles, shall not be measured as excavation, nor shall unauthorised voids be measured for roadway embankment.

Rehandled material shall not be measured as excavation, except where a structure, the excavation for which is a pay item, is required to be constructed subsequent to the placing of the roadway fill at the structure site. The excavation (measured in place in the compacted fill) necessary for the construction of the structure in this case shall be included in the measurement for payment.

2510 Basis of Payment

Payment will be made at the Contract Unit Price for the Items listed below which are shown in the Bill of Quantities. Such price will include full compensation for all labour, tools, equipment, supplies, required tests and all other things necessary for the work. Where excavations require shoring, cofferdams or dewatering or the enlargement of existing shorting, cofferdams or dewatering facilities, these shall also be included.

Where a pay item is not included in a Bill of Quantities for a particular structure or group of structures, for example a large bridge or minor structures in general, the work shall be considered as included in the price bid in Bill No. 2 for the works in general and will not be paid separately.

Pay Item		Unit
25/1	Unclassified Structural Excavation (Soft, Hard, Rock)	cum
25/2	Unclassified Channel Excavation	cum

Backfilling around structures above the elevation of the ground line existing before excavation was made shall, unless otherwise specified on the Drawings or in the special Provisions, be done by the Contractor and the entire cost of same shall be included in the contract unit prices bid per cubic metre for Embankment as specified herein.

2600 Borrow Excavation

2601 Description

This item shall include excavation of borrow pits provided by the Contractor outside the right-of-way and placing in the embankment according to embankment specifications. The right-of-way for this project is 100m, 50m on each side. The borrows located within the limits of the right-of-way will be paid on prices of fill from roadway cutting.

Construction Methods

During the time that any borrow pit is in use as a source of embankment material for any portion of the works:

a) It shall be kept drained, if necessary by the excavation of a sump or sumps as well points and the installation and maintenance of mechanical pumping equipment;

b) Development of the excavation of any borrow pit shall have the approval of the Engineer. Borrow pits shall not be developed any closer to the roadway than as shown on the Drawings or as instructed by the Engineer, and under no circumstances shall any longitudinal edge of any borrow pit be within 5 metres of the toe of any roadway embankment or private land.

c) Where a variety of materials are available on any land to be the site of a borrow pit, the Contractor shall adopt excavation methods designed to mix the different material from the pit so as to yield a consistent product when delivered to the embankment.

The overburden in the borrow pits shall be stripped and be disposed of if it contains materials not suitable for embankment construction. Disposal shall consist of burning and/or spreading the unsuitable materials in sections of the borrow pits where excavation has been completed as approved by the Engineer.

Excavated material which is not suitable for embankment construction shall be wasted or stockpiled for use in flattening of slopes or in backfilling ditches or for other use, as directed by the Engineer.

Any method of excavation may be used that will leave the borrow pits in a neat, smooth condition after excavation is completed.

If slopes at the edge of borrow pits are shown on the Drawings, the actual slopes may by flatter than shown on the Drawings, but in no case shall they be steeper or steeper than roadway embankment. Except as limited in regard to having the edges of borrow pits the required minimum distance from toe to embankment or right-of-way lines, borrow pits shall be excavated to cover the entire borrow pit area, with the depth being varied if approved to provide the required orphan amount of embankment.

When any borrow pit is no longer required as a source of embankment material, as certified by the Engineer, the lines of the excavation shall be trimmed to neat, regular faces as directed by the Engineer, prior to the carrying out of soil conservation measures if required by the Contract.

2602 Method of Measurement

Borrow shall not be measured separately for the payment.

2603 Basis of Payment

The work in this item will be paid for payment under the contract unit price bid for Roadway Embankment or Miscellaneous Embankment or other pay items as specified herein.

2700 ROADWAY EMBANKMENT

2701 Description

This work covered by this item shall consist of the construction of embankment, including preloaded embankment, and berms and backfill not specified elsewhere, by furnishing, placing, compacting and shaping material or materials as specified herein below, obtained from approved sources, to the lines, levels, grades, dimensions and cross-sections shown on the Drawings or as directed by the Engineer.

This item shall consist of placing in roadway embankments, suitable material (soft or hard suitable) excavated as roadway excavation, structure excavation or borrow excavation, all in accordance with these Specifications and in conformity with the lines, grades and typical cross-sections shown on the Drawings or established by the Engineer.

Embankment construction shall include the preparation of the areas upon which the embankment is to be constructed; the selection and preparation of materials; the formation, compaction and stabilisation of the embankment; and the disposal of surplus and unsuitable material.

2702 Embankment Material

Only suitable materials free of vegetation, roots, rubbish, sods, weeds, logs, stumps, other organic or deleterious material, shall be used in the construction of roadway embankment and backfills. Disregard to the material source (cut to fill or borrow) the filling material shall comply with the following properties

a) Unsuitable Material

Unsuitable material shall be material not acceptable for embankment construction and shall include:

- material with an organic content greater than 2% when tested accordance with AASHTO 267,
- material from swamps, peat, logs, stumps or perishable material and topsoil,
- material with a swell of more than 2.5%,
- material containing clays with a Liquid Limit exceeding 45% or Plasticity Index exceeding 15%, unless otherwise permitted by the Engineer,

- materials susceptible to spontaneous combustion,
- frozen material which may otherwise be suitable when unfrozen,
- Material with a CBR of less than 7 % measured after a 4-day soak on a laboratory mix compacted to a dry density of 95 % MDD (AASHTO T180).

b) Suitable Material

Suitable material shall be material acceptable for embankment construction and is defined as material other than that classified as unsuitable. Suitable material will comprise "soft suitable" and "hard suitable".

Soft suitable material are those which couldn't categorized as Unsuitable material as described above in bullet a.

c) Hard Suitable Material

Hard suitable material used for fill shall have a maximum dimension of 350mm and shall be well graded. Rock shall be placed, manipulated and compacted in uniform layers not exceeding 400mm loose depth and shall extend over the full width of the embankment. Rock shall not be end dumped over the edge of the previous layer but dumped on the toper of the previous layer and worked into places. The material shall be spread and levelled by a crawler tractor weighing not less than 15 ton. After compaction each layer shall, if voids remain, be blinded with smaller rock spall, rock fines and granular material so as to fill as many of the voids as possible. The top of the layer shall blinded with a fine graded material to seal the surface.
Moisture shall be added for the purpose of controlling dust. It should be noted that the rockfill is not allowed to be placed within 1.0m of the top of the embankment.

In addition to above, the subgrade (Top 300mm of Embakment) material shall also meet the following criteria.

d) Material for Subgrade (Top 300mm of Embankment)

- Material within the top 300mm top of embankment or natural subgrade in cut sections, should not contain any material larger than 75mm,
- Liquid Limit of less than 40, and Plasticity index of less than 6%.
- Fine particles passing 0.075mm sieve should not be more than 20%.
- Minimum CBR value of 10% at 95% compaction of the Maximum dry density from AASHTO (Test Method T 180 Method D) after soaking for four days.

e) Structural Backfill

Provide free draining structural backfill at least 0.5m behind each structure, conforming to the following requirements:

➢ Maximum particle size	75mm
➢ Material Passing No.200 Seive	10% max
➢ Plasticity Index	Non-plastic

f) Bedding Material

Pipe bedding material shall be well graded granular material with a maximum stone size of 20 mm and a maximum of 10% by weight passing the 75mm sieve.
Pipe bedding shall be compacted to 95% MDD (AASHTO T180).
Voids shall be formed under the sockets to allow pipe jointing. When the pipe joint has been completed, the void shall be rammed with pipe bedding material

All suitable material that are product of Grading and excavating operations in Roadway, Structure and Channel Excavation shall be re-used where required for the formation of embankments, sub grade, shoulders, approaches, intersections and for backfilling around structures.

Preloaded embankment and berms shall be constructed of materials which meet the requirements for embankments, and when compacted shall have a unit mass (in situ moist density) of at least 1.75 t/cum.

At least 20 (twenty) days prior to the scheduled commencement of any embankment placement, the Contractor shall submit to the Engineer samples of any material or materials intended for use. The samples shall be accompanied by a written description stating the source of the material and if it is sand, whether it is natural sand or includes blended fractions. The description shall also indicate the section of embankment wherein it is proposed to use the sampled material.

No material shall be incorporated in the works prior to the written approval of the Engineer.

2702.1 Embankment construction with material from Borrow

Where sufficient quantities of suitable material are not available from roadway excavation as planned, additional materials that have a density of less than 95% of the maximum dry density determined in accordance with AASHTO T-180 shall be excavated from borrow pits as directed in clause 2600 above, supplied and compacted.

Material use form Borrow to fill the embankment shall be paid as Material from Borrow under the Pay Item 27/1.

2702.2 Embankment construction with material Cut to fill

The material, excavated from the road way excavation, classified as suitable material if it has a density of less than 95% of the maximum dry density determined in accordance with AASHTO T-180.
Such material could be used as embankment filling material and will be paid as “cut to fill” in pay item 27/2.

If there is any excess suitable material from cut after filling where necessary on the road way as per the design, such excess material shall be considered as wasted or shall be used in flattening of slopes or in backfilling ditches or for other use, as directed by the Engineer. Such volumes will be paid under the pay item rate 24/1.

2703 Construction Method

a) Preparation for Embankment

Prior to placing any embankment upon any area, all clearing and grubbing operations shall have been completed in accordance with Section 2100 hereof.

The height of an embankment at any point is measured from the finished centreline of pavement or shoulder level (whichever is the lower) to the level of the natural surface.

In areas where embankment 2 metres or more in height is to be placed the surface of the ground shall be broken so that the embankment will bind with the original ground.

In areas where roadway embankment less than 2 metres is to be placed, the exposed surface shall be ploughed or otherwise loosened to a depth of at least 200 mm and compacted according to the density requirements hereinafter specified. The top 150 mm of the residual mineral soil shall be processed as necessary and compacted to 95% of the maximum dry density as determined by AASHTO test method T-180 Method D.

The Engineer may notify the Contractor of areas where top soil may not be removed prior to his inspection of the operation. The Contractor will take care to grade and drain the embankment foundation at all time during the preparation for fill placement.

No payment will be made for foundation excavation or backfill when, in the opinion of the Engineer the requirement for these operations results from the Contractor's neglect of grading and drainage.

In sections of the road embankment so designated or so shown on the Engineering Drawings, sand embankment material shall be placed as a filter layer or zone of minimum thickness 500 mm compacted on the cleared and grubbed in-situ soil before roadway embankment itself is placed. Where the embankment height does not provide sufficient space for 500 mm of sand embankment free draining improved sub-grade may be used instead of sand embankment material.

b) Incorporation of Existing Embankment in the Works

Where existing embankments, road, or parts thereof, after recovery of the pavement materials as specified, are to be modified to form the embankment, the top, to the extent to be reconstructed, and one or both slopes of the old embankment shall be stripped of vegetation and roots and the embankment shall be removed to proposed finished sub-grade elevation. Steps with horizontal and vertical faces shall be cut in the existing slopes to provide a key between the old and the new embankment.

The top of the embankment after removal of existing pavement layers if it is to be raised shall be treated as the foundation of a new embankment as specified herein.

The top of the embankment where it is not to be raised more than 300 mm shall be compacted as sub-grade otherwise it shall be compacted as embankment. The embankment material immediately (down to 300 mm) below sub-grade level is not suitable for sub-grade material if its soaked CBR is less than 10%, in which case the unsuitable sub-grade shall be excavated and used for embankment below sub-grade and suitable sub-grade material shall be filled thereon as specified. The excavated volume shall only be measured for payment if the material is unsuitable for use in the embankment and it is spoiled with the Engineer's written approval.

A widened embankment shall be constructed as for new embankment.

Where embankments are to be constructed on or placed against existing embankment the slopes of which are 1 on 3 or steeper, the slope shall be benched as the fill is constructed. The width and depth of the benches shall be as shown on the Drawings or as directed by the Engineer. Suitable materials from the benches shall be re-compacted in the new fill. The volume of the benches shall not be measured and no extra payment will be allowed for this excavation or embankment.

When embankment are made on hillsides or slopes flatter than 1 on 3, the slopes of the original ground shall be loosened or ploughed to a minimum depth of 150 mm. No extra payment will be allowed for this excavation.

When the widened embankment has been filled to the underside of sub-grade, the sub-grade on the existing embankment and the new sub-grade shall be filled and compacted at the same time.

After the existing embankment has been lowered the amount sufficient to provide for the widening or other incorporation described above, the exposed surface shall be compacted as specified herein for embankment material in the sub-grade zone.

The soil removed, if suitable, shall be used as roadway embankment for widening or for new embankment. After completion of these preparatory works, borrowed or transported embankment material may be placed if required and compacted to final elevation as directed by the Engineer.

c) Embankment Formation

In embankment construction, the materials shall be deposited and spread in successive uniform layers shaped to drain. Each layer of the embankment, before starting the next, shall be thoroughly compacted by approved mechanical compaction equipment. Hauling shall be distributed over the width of the embankment being filled and in no case will deep ruts be allowed to form during the construction of the embankment.

Where embankments are to be constructed across ground which will not support the weight of trucks or other hauling equipment, the first layer of the fill may be constructed by dumping successive loads in a uniformly distributed layer of a thickness not greater than that necessary to support the trucks or hauling equipment while placing subsequent layers. The remainder of such fills shall then be constructed in layers as above specified.

The Contractor shall make suitable allowance for consolidation of the material in the construction of embankments.

Embankments over and around pipes, culverts, arches, bridges and other structures shall be structural fill material shown on the Drawings placed and thoroughly tamped in a manner that will avoid unbalanced loading and will not cause movement or place undue strain on any structure. Embankments placed against or adjacent to bridge abutments, retaining wing walls open end bents, culverts and around pipes, shall be placed in horizontal layers not exceeding 150 mm compacted and must be thoroughly compacted by means of an approved vibrating or mechanical tamper capable of achieving the specified density throughout the layer. Each layer shall be compacted to the condition as specified in the specification before the next layer is placed thereon. The volume of embankment around structures that cannot be rolled with a power vibrating roller or a tamping roller shall be mechanically tamped to the same density as the adjacent portion of the embankment. Filling and tamping around structures shall be carried on simultaneously on both sides to prevent undue strain to the structure. Weep holes shall be constructed as per the design progressively. No embankment shall be placed against any structure or culvert until permission has been given by the Engineer and in no case until the concrete has been in place and has reached a strength at which it is capable of withstanding the loads of the backfill.

At sections along the alignment where the toe of the new embankment is in water and, in the opinion of the Engineer, it is impracticable to drain the water prior to placement of the fill, and where construction equipment like bulldozers with low contact pressure cannot in the opinion of the Engineer be used the Contractor may place a sand working platform provided that:

i. Prior to any placement of sand, the foundation shall be cleared of water logged vegetable matter and organic soil;
ii. The total compacted depth of the sand shall not exceed 1 metre unless otherwise approved by the Engineer.

Except as otherwise directed by the Engineer, the embankment shall be constructed in layers of uniform thickness approximately parallel to the finished grade of the road bed with compaction by approved mechanical compaction equipment proceeding in the direction of the alignment and gradually covering the width of the embankment or part embankment by overlapping passes. Successive layers of the embankment shall be graded with power graders or by other means in conjunction with the compaction operation. All the time during compaction of any section of embankment, a smooth surface grade having an adequate crown slope or cross-fall shall be maintained to provide for rainfall runoff. The Contractor shall take particular care to drain that portion of any new embankment where it abuts an existing road embankment. Surface water must on no account be permitted to concentrate at the joint between an existing and a new embankment.

The Contractor shall ensure that the compaction effort is uniformly spread over the layer. Concentrated compaction by construction traffic will not be permitted.

Materials approved for use in the embankment from whatever source, shall be uniform when run out in loads on the road bed. If, in the opinion of the Engineer, unacceptable non-uniformity exists in the delivered materials either within individual loads or between successive loads, the Contractor may be directed to suspend the compaction whilst the non-uniform material is blended on the road bed with power graders or by approved labour methods. The Contractor may also be directed to suspend the delivery of further material whilst blending of non-uniform material is proceeding. If, in the opinion of the Engineer, a uniform embankment material will not result from blending by power grader on the road bed, the non-uniform material shall be rejected and must thereupon be removed from the works to approved disposal. The Contractor shall be entitled to no additional compensation for:

i. blending of non-uniform material on the road bed as directed by the Engineer;
ii. down time in the event of the suspension of the compaction as directed by the Engineer;
iii. down time in the event of the suspension of the delivery of material as directed by the Engineer;
iv. Removal of any rejected material to disposal in pursuance of the foregoing.

a) Controlling Moisture control

The Contractor will make his own arrangements for watering of the soil when required for effective compaction and shall do so by providing sufficient water tankers or tanker trucks and shall provide sufficient water pumps on site for filling trucks and for dewatering the works as necessary.

The Contractor shall provide on site for the cutting, moving, dewatering, transporting, spreading, mixing, drying and watering and compaction of soil, least equipment required completing the work.

The type of compaction plant in use on embankment sections shall be of sufficient capacity to produce the specified standard of compaction within a reasonable number of passes so as not to delay production.

Prior to the commencement of the compaction of any layer of embankment on the road the material shall be worked to distribute moisture evenly. Compaction shall be undertaken at moisture content close to the optimum moisture content (+/- 2%) determined for the material in accordance with AASHTO T-180 Method D for the degree of compaction required.

The Contractor shall at all times have on the embankment works, a sufficient number of mobile water tankers to water the embankment material at the required rate and to control dust loss to the satisfaction of the Engineer.

The number of items of compaction plant in use on any embankment section shall at all times be compatible with the rate of delivery of materials to the road bed. The Engineer may direct a decrease in the delivery rate or a total suspension of deliveries, if in his opinion, the compaction or watering or mixing operations cannot handle the volume of material. The Contractor will have no right to additional compensation or extension of time in such circumstances.

e) Compaction Trials

If requested by the Contractor, and at his expense, the Contractor shall perform a field compaction test of his compaction plant on any material approved for use as embankment fill. The Engineer will supervise and test the results of such full scale field test and might, depending upon his interpretation of the result, and without waiving any requirement of the Contract:

i. approve a standard thickness of uncompacted layers placed in the embankment for a given type of compaction equipment, and
ii. Approve compaction of material in the embankment within a range of moisture contents different from that specified.

f) Standard of Compaction

The standard of compaction achieved on all embankments shall be as follows:

All tests shall achieve 95% or more of the maximum dry density as determined by AASHTO test method T-180 Method D for all layers of the embankment constructed of approved materials, except as prescribed otherwise hereinafter or in the proceeding passages or in the Drawings.

The moisture content of the sample material will be at the optimum estimated by the Engineer for proper compaction. The in-place density determination will be made according to standard procedures approved by the Engineer.

Unless the material at the time of compaction has the proper moisture content, it shall be allowed to dry if too wet; or mixed with water if too dry, until the material contains the proper amount of moisture for compaction.

The embankment material shall be tested by the Contractor under the supervision of the Engineer at every change in the observable characteristics of the material or at least at each 2000 cubic metres placed, to determine its classification, compaction characteristics and CBR value.

The laboratory CBR is to be tested in the soaked condition at optimum or at any moisture content which the Engineer may deem relevant to the long term characteristics of the embankments.

The Contractor shall make a field density test under the supervision of the Engineer on the compacted embankment layers by AASHTO Test Method T-191 or other approved test for at least each 500 sq.m of each layer of embankment compacted. If the results of the tests made at representative locations in any layer, when interpreted by the Engineer, shown that the specified density has not been obtained, reworking of the layer will be directed. Reworking includes but is not necessarily limited to, scarification of the full depth of layer; windrowing by power grader of the loosened material; drying out or watering of the material, whichever is appropriate; and re-compaction. Further field tests will follow the reworking of any layer.

Other types of field density test or penetrometer test may be used for rapid assessment or measurement of field compacting during placement, after a correlation with the results of AASHTO test method T191 or other approved test has been established to the satisfaction of the Engineer.

2704 Maintenance and Stability of Embankments

a) Embankments to be free draining and maintained in shape.

The top of the embankment shall be maintained with adequate compaction, camber and shape at all times to withstand rain and flood waters.

Following damage by traffic, weather or flood the Contractor shall strip and re-compact the top 300 mm of the embankment over the full length unprotected by a seal in order to achieve satisfactory compaction of the surface to the approval of the Engineer. No extra payment shall be made therefore.

The Contractor shall be responsible until final acceptance for the stability of all embankments made under the Contract and shall replace at his own expense any portion which, in the opinion of the Engineer, has become displaced or damaged prior to final acceptance of the Project.

Embankments shall be maintained to the grade and cross-section shown on the Drawings, or established by the Engineer, until the completion and acceptance of the works.

b) General Construction Procedures

When there is difficulty in the movement of hauling equipment over a constructed or partly constructed embankment, the Contractor may be permitted to place a blinding layer consisting of dense graded sand to a maximum depth of 100 mm, over any layer in the embankment. The blinding material must be approved by the Engineer. Payment for the blinding layer will not be made separately, but the material shall be included and measured as part of the embankment material in place.

Embankment shall be constructed to the required grade and completed embankment shall correspond to the shape of the typical sections shown on the Drawings. The final trimmed surface of the embankment at sub-grade level shall be, at any point, within 25 mm of the design level. For any section of finished embankment measuring 100 metres along the alignment, the differences between actual and design levels at points checked by the Engineer shall show no trend in either direction.

The Contractor shall programme his embankment construction so that any constructed embankment will not be overtopped by floodwaters during the construction period.

When constructing on soft ground the Engineer may direct the actual rate of raising the height of embankment to minimise possible soil failure. If soil failure does occur, or is expected during construction, the Engineer shall suspend embankment construction in the area of failure, until corrective measures can be determined.

An extension in the Contract time caused by a delay due to soil failure may be granted in accordance with the Conditions of Contract.

2705 CONSTRUCTION REQUIREMENTS FOR FINISHING OF SLOPES

(a) Equipment

Equipment used for the finishing of slopes shall be suitable for use on the surface to be finished.

(b) General

The slopes of cuttings and embankments shall be trimmed by hand or by approved mechanical means to remove loose material and to provide uniform slopes as described in the Contract or as instructed by the Engineer. Such trimming shall be completed prior to construction of the pavement.
Slopes of cuttings and embankments shall be finished to a uniform appearance. Except in solid rock, the tops and bottoms of all slopes shall be rounded unless otherwise directed by the Engineer. Slopes at transitions between cuttings and embankments shall be landscaped to merge one with the other. Slopes shall be adjusted, if required by the Engineer, to avoid unnecessary injury or destruction to standing trees and to harmonise with the existing landscape features. The transition to such adjusted slopes shall be gradual.
Slopes of cuttings and embankments which are flatter than 1 in 4 shall have a standard of finish that can be obtained by a motor grader.

(c) Cutting Slopes

The slopes of cuttings shall be trimmed to neat lines and to a standard that is generally attainable with proper care and workmanship in the type of material concerned. All loose rocks, stones, and other material shall be removed from the slopes. The final surface of slopes shall have a rough surface suitable for subsequent grassing or which will allow the natural vegetation to grow as described in the Contract.

(d) Embankment Slopes

Embankment slopes shall be finished as described in the Contract. All loose rock and uncompacted material shall be removed. The final surface of the slope shall depend on the nature of the embankment material but shall be as smooth as is consistent with the material used.
In the case of rock fill soft material shall be used to fill the interstices of the rock up to the surface of the slope.

2706 Measurement

At sections where a new embankment abuts upon an existing road embankment or natural slope, the area of the cross section used in the quantity computation will be based on the joint between the new embankment and existing soil cross section surveyed after grubbing as shown on the Drawings or directed by the Engineer.

The units of measurement shall be the volume in cubic metres of Roadway Embankment and Miscellaneous Embankment completed and accepted and the volume in cubic metres of soils excavated and spoiled where they are unsuitable for use in embankment or they are surplus to the requirement for the construction of Roadway Embankment or Miscellaneous Embankments.

The volume shall be measured by surveyed cross sections measured before clearing and grubbing and the design cross section to sub-grade elevation as accepted by the Engineer.

The average area of added embankment in two adjacent cross sections shall be multiplied by the distance between them to obtain the volume of Roadway Embankment. The horizontal distance between cross sections shall be mutually agreed between the Engineer and the Contractor and may be varied according to the variability of the cross sections. No allowance will be made for settlement.
If the volume of roadway excavation as measured by the cross sections above, less the volume of recovered pavement materials measured separately, less the volume of Miscellaneous Embankment, less the volume classified by the Engineer as unsuitable after testing for the whole of the Works exceed the

volume of Roadway Embankment as measured above then the additional excavation shall be paid as Roadway Excavation to Spoil.

Where the Contractor is required to excavate unsuitable material from below the ground level, the volume of replacement material will be measured for payment by the Engineer using a method, in his opinion, suitable to the conditions. Where the Contractor excavates material from below ground level under the embankment or anywhere beneath the finished sub-grade level and, in the opinion of the Engineer, the need to excavate such material results from careless working of the embankment foundation, the volume of backfill will not be measured for payment.

Performance of work prescribed in section 2705.a thru 2705.d is not payable directly but shall be considered as a subsidiary obligation of the contractor, covered under the contract unit prices for performance of work under the other Earthwork payment items.

2707 Basis of Payment

This work measured as provided above shall be paid for at the Contract unit rates as agreed at the tender.

Payment shall be full compensation for performing the work, furnishing the specified materials from whatever approved source, disposing of waste and spoil, construction of slope as specified.

The payment shall be full compensation for excavation (except if otherwise paid for as specified herein above) and hauling; formation and compaction of embankments; testing, refilling around structures; removal and disposal of all roots, stumps, logs and other debris; clearing and grubbing; preparation of sub-grade surface, shoulders and slopes; and the furnishing of all labour, equipment, tools and incidentals necessary to complete the work.

Payment for Roadway Embankment will be at the price for pay Item 2.7/1 and 27/2 as per the source of the material.

Unless otherwise approved in specific cases by the Engineer, Payment for material used to replace unsuitable material that has been excavated will be made at the price for Roadway Embankment.

Pay Item		Unit
27/1	Roadway Embankment filling from Borrow	cum
27/2	road way Embankment filling from cut to fill	cum
27/3	Structural Backfill	cum
27/4	Bedding Material	cum

2800 Sub-Grade Preparation

2801. Description

This work will consist of the preparation of the top surface of the embankment to accommodate the placement of the pavement structure, shoulders and other cross-section features in accordance with these Specifications and in conformity to the lines, grades, and width shown on the Drawings and cross sections or as directed by the Engineer.

2802 Construction Requirements

The existing embankment shall be scarified (at least 150 mm), bladed, and shaped to conform to the line, grade, and cross-section shown on the Drawings or as established by the Engineer. Any high place in the embankment shall be cut to grade and scarified; the resulting material hauled and deposited on low areas or on fill slopes as directed by the Engineer. All depressions shall be filled with approved material so as to bring the surface of the sub-grade to the elevation shown on the Drawings or approved by the Engineer.

All soft and yielding material, other than material that would be satisfactory but for its high moisture content, boulders and loose stones, or any other objectionable materials in the sub-grade, shall be removed and replaced with suitable material, which shall be thoroughly compacted. Large rocks, stones,

boulders or soil lumps greater than 75 mm shall be removed for a depth of 300 mm below sub-grade elevation. All buried roots, stumps, or other perishable matter encountered in the preparation of the sub-grade shall be removed to a depth of not less than 600 mm below sub-grade elevation.

The sub-grade for all pavements shall be compacted at close to optimum moisture content for AASHTO Test T 180 Method D and shall be compacted to not less than 95% of maximum dry density. At least one density test shall be performed for each 500 square metres of finished sub-grade surface. Any portion of the sub-grade inaccessible to the roller shall be thoroughly compacted in thin layers with approved mechanical tampers. The sub-grade for pavement widening shall be compacted by rolling with an approved heavy vibrating compactor or tamper.

Should the sub-grade become baked and hardened before laying a sub-base it shall be scarified, moistened and thoroughly compacted.

The sub-grade shall be in a final condition for receiving sub-base, base course or surface course material for a distance of at least 200 metres in advance of placing of such materials, forms, etc. No materials, forms, etc., shall be placed until the sub-grade has been approved.

No vehicle, the gross mass of which exceeds 10 kilograms per millimetre width of tyre shall be permitted on the sub-grade. If the sub-grade is in such condition that vehicles cause excessive rutting, either lighter vehicles shall be used or suitable runways provided.

2803 Proof Rolling

Prior to the placement of the pavement if directed by the Engineer, the Contractor shall furnish and operate at the direction of the Engineer heavy pneumatic-tyred compaction or other approved equipment for compacting and for testing for stability of the sub-grade.

The sub-grade and base course shall be prepared and compacted in accordance with their respective Specification requirements and shall be further compacted and tested with a heavy pneumatic-tyred roller if required by the Engineer.

The sub-grade, prior to proof-rolling with a heavy pneumatic-tyred roller, shall be prepared and compacted in accordance with the requirements for Roadway Embankment in these Specifications. The sub-grade shall then be compacted and tested with two or more coverage's as directed by the Engineer, of a proof roller meeting the requirements of the Engineer. Coverage is considered to be that stage in the rolling procedure when the entire width of the section designated has been in contract with the pneumatic tyres of the roller at least once.

The roller shall be operated in a systematic manner at a speed no greater than six kilo meters per hour so that the number of coverage over all areas designated can be readily determined and recorded.

Where the operation of the proof roller shows the sub-grade to be unstable or to have non-uniform stability, the Contractor shall correct the unstable areas by one of the following methods:

i. If the quality of the soil is acceptable and the instability of the sub-grade is due to high moisture content, the soil shall be dried by aeration or other means, and then compacted and tested with the heavy pneumatic-tyred roller. No payment will be made for drying the soil.

ii. If the Contractor has not incorporated unsuitable material, as defined herein above, in the sub-grade and the soil is inherently incapable of being stable, the unsuitable material shall be removed to a depth not exceeding 600 mm below the top of sub-grade levels, and it shall be replaced with material that is satisfactory and workable. The corrected sub-grade shall be then be compacted and tested with the proof roller. The material removed will be paid for under Roadway Excavation, if confirmed as unsuitable, or as otherwise approved by the Engineer and the material used for replacement will be paid for as Embankment material or as otherwise approved by the Engineer. The sub-grade shall then be checked for line and grade and any deviations corrected. All materials authorized for removal due to unsatisfactory conditions or high moisture contents shall be reused

for embankments after drying and there shall be no payment for excavation to spoil unless the Engineer confirms the materials as unsuitable after laboratory verifications.

In a manner similar to that described above for the sub-grade, and as directed by the Engineer, the sub-base and base course shall in turn be compacted and tested by proof roller, and areas found deficient in stability shall be corrected to a condition of uniform and satisfactory stability, and shaped to plan line and grade.

Proof-rolling shall be done only in the presence of the Engineer, who will approve or disapprove the stability of the sub-grade, sub-base and base course and supervise the correction of the unstable areas.

Proof-rolling done in the absence of the Engineer or Engineer's Representative will not be accepted.

2804 Method of Measurement and Payment

The work in this item performed on roadway embankment or roadway excavation and sub-grades will not be paid as a separate item. Any cost involved with Sub-grade preparation deemed to be incidental to Road Embankment works of above pay items 27/1, 27/2 and Road way excavation to spoil materials 24/1

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No payment shall be made for additional material required to make the sub grade evenly smooth or to compensate for loss of volume due to re-compaction.

Unsuitable or unsatisfactory embankment removed and replaced shall be measured by cross-sectioning prior to and subsequent to removal of unsatisfactory or unsuitable material and subsequent to the replacement of satisfactory material. The average end area method of computation shall be used. The material measured as unsuitable shall be paid as spoil.

Unsatisfactory material dried and reused in embankment shall be paid under pay item 27/2 as embankment material from cut to fill.

The replacement material shall be paid for as embankment material from borrow under pay item 27/1.

3000GENERAL

3001 Description

Improved sub-grade shall be placed beneath roadway pavement or other structures in accordance with the Engineering Drawings and the Specifications therefore or as directed by the Engineer.

Where the Contract involves widening of the existing pavement materials, including improved subgrade, subbase and base course will have to be placed and compacted in narrow widths.

Aggregate base course material will be placed in a variable thickness layer to provide a levelling course for the pavement in addition to the function as a base course.

3100 IMPROVED SUB GRADE

3101 Description

This is to improve the existing subgrade condition by importing appropriate soil. Item consists of the removal of unsuitable layer if required, supplying approved soil from outside the right of way if required, placing, shaping, compacting and testing. Improved Sub Grade Layer shall be above the compacted subgrade to form the working Platform for the pavement in accordance with these specifications and to the lines, grades and thickness and in the locations shown on the Drawings.

3102 Material

Improved sub-grade shall be any natural soil or sand or any blend or mixture of soils, sands (natural or manufactured), broken brick or aggregate having a maximum particle size of 37 mm, a plasticity index of less than 6%, a minimum of 12% and maximum of 25% finer than 0.075 mm sieve and must have a minimum CBR value of 10% when compacted to 95% of the maximum dry density from AASHTO (Test Method T 180 Method D) and soaked for four days.

3103 Construction Method

The improved sub-grade shall be placed in uniform layers on the top of compacted subgrade shaped as required to camber or cross-falls. Blends of materials preferably shall be mixed off site by approved methods but if sufficient labour or equipment capable of mixing materials in place are provided then the materials may be laid loose in uniform layers of thickness appropriate to the required final proportions and the layers shall be thoroughly and evenly mixed together to a uniform colour and texture in a dry state. Prior to compaction the materials shall be remixed with water to near the optimum (+/- 2%) moisture content and only then shall be compacted to a density of not less than 95% of the maximum dry density AASHTO (Test Method T-180 Method D).

Whichever method is adopted prior to placing any materials, the Contractor shall demonstrate by providing samples to the Engineer and by laboratory test results that the proposed material or materials meet the requirements, and if mixing is required shall have determined appropriate mix proportions and mixing procedure.

The materials in place shall be compacted to the specified density at moisture content close to the optimum. The compacted layer shall be of the thickness shown on the Drawings within a tolerance of -15 mm to +10 mm. the average of at least 2 depths measured over any 100 meter length shall be within a 5 mm variation from the required depth.

Any deficiencies in material shall be made up by scarifying the material and adding and mixing in new material as required and re-compacting as specified, except that deficiencies may be made up with material of the next layer above but at the Contractor's expense.

Excess material shall be trimmed off and disposed of in the borrow pits and shall not be paid for.

3104 Testing

The density shall be tested at last for every 500 sq.m of completed work. Samples shall be removed from the pavement and shall be tested for grading, compaction and CBR once for each one kilometer. Where the material does not meet the requirements of the Specification at the conclusion of two additional tests, the material shall be removed and replaced as specified or the faults shall be corrected by methods approved by the Engineer at the Contractor's expense.

3105 Measurement and Basis of Payment

Measurement shall be the volume in cubic meters computed from plan lines or field measurements of widths and depths provided that the maximum depth to be paid for shall be the compacted depth of material required or instructed by the Engineer.

The price shall be full compensation for providing soils, mixing, watering, trimming to shape, compacting, testing, trimming and re-compacting and removing if necessary.

Item		Unit
31/1	Improved Sub-grade	Cum

3200 AGGREGATE SUB-BASE (GRAVEL SUB-BASE) FOR PAVEMENTS AND SHOULDERS

3201 Description

This item shall consist of a compacted aggregate sub-base and shoulder material constructed in accordance with the requirements hereinafter set forth and in conformity with the lines, grades and cross sections shown on the Drawings. This item shall be compensation for aggregate subbase constructed with materials from outside the ROW provided by the Contractor and with materials recovered from structures and the old pavement in the right-of-way.

3202 Materials

a) Aggregate Components

Materials for this course shall be sound, durable crushed rock, slag, natural gravel, river gravel, concrete, or fused clay aggregate as specified herein below. The characteristics of these materials shall be such that they will compact to the density and stability established as satisfactory by the Engineer. Materials shall be processed from recovered structures and pavement materials or shall be provided by the Contractor as necessary.

The material shall be clean, sound, and durable, of uniform quality, and free from thin, elongated, flaky or brittle pieces.

The % of deleterious substances shall not exceed the following values:

Deleterious Material	Precent by weight
Coal	1.0
Clay Lumps	0.25
Soft Fragments	3.0
Shale and other deleterious substances (such as mica, laminate pieces, concrete, Cementitious material readily disintegrating)	2.5

The abrasion resistance of coarse aggregates passing 37.5 mm shall be measured by the Los Angeles Abrasion Test (AASHTO Test Method T-96). In the case of aggregate having a bulk specific gravity, saturated surface dry condition (SSD) less than 2.55 the standard test procedure shall be modified by decreasing the weight of material charged into the L. A. Abrasion machine. The weight of material charged shall be a fraction of the standard weight which fraction shall be the bulk specific gravity saturated surface dry condition of the material to be tested divided by 2.65.

These aggregates shall have a Los Angeles Abrasion loss of not more than 40%.

Properties of Aggregate

The aggregate shall be well graded evenly within the following grading distribution limits. Material meeting the following requirements may be obtained by blending if approved by the Engineer.

Blended material Table 3-1

	Total Per cent Passing					
Sieve Size	50 mm	25 mm	19 mm	4.75 mm	0.600 mm	0.075 mm
% passing	100	70-100	50-90	30-60	9-33	0-10

Alternatively the grading of Table 3-2 maybe used for sub base. The fraction passing #200 sieve shall not be greater than two thirds of the fraction passing the 0.425 mm sieve. In addition particles having diameter less than 0.02mm shall not be more than 3 percent by weight of total sample tested as determined by AASHTO T88.

Alternative Grading for Sub Base, Table 3-2

	Total Percent passing				
Sieve Size	63 mm	25 mm	4.75 mm	0.425 mm	0.075 m
% passing	100	70-100	25-100	5-50	0-10

The material shall have 4 days soaked CBR value of not less than 30% when tested at the density and moisture conditions approved by the Engineer to best simulate service conditions.

The fraction of the material passing a 0.425 mm (No. 40) sieve shall have a liquid limit not greater than 30 and a plasticity index of not more than 6. The sand equivalent value of fine aggregate shall be no lower than 35.

3203 Construction Methods

Any defects such as ruts, holes, or soft yielding places which occur in the subgrade or other under-laying course by reason of any improper drainage conditions, traffic or hauling over the same, or for any other causes, shall be corrected and compacted to required density and stability and shall comply with the smoothness requirement of the Specifications before aggregate sub-base is placed thereon.

Stockpiling and loading methods shall be already identified as the materials to be used and approved by the Engineer. Sites for stockpiles shall be clean prior to storing materials. The stock piles shall be built up in layers not to exceed 1 meter height, and each layer shall be completely in place before the next layer is started. Aggregates shall not be removed from stockpiles within 200 mm of the ground until final clean-up of the site of the work and no material which has become mixed with foreign matter or other sizes or grades of aggregates shall be used.

Coarse aggregates shall be placed in stockpiles in units of not less than 200 cubic meters at least seven days prior to their anticipated use in the work. The Engineer will sample each stockpile or each 200 cubic meters of stockpile to determine the quality of the material and assess it for approval for use in the various types of construction.

Aggregate sub-base materials shall be evenly spread on the subgrade, or other under-laying course, by the use of approved, self-propelled spreading machines capable of placing the materials true to line and grade without damage to the subgrade or other course. Aggregate sub-base materials shall be at or near optimum moisture content at the time of loading for transportation to the site, during and on completion of compaction.

The aggregate subbase materials shall be spread in courses of not less than 75 mm compact thickness or of a greater depth up to that depth capable of being compacted as specified by the available equipment. It is expected that smooth wheel vibrating rollers of a minimum mass of 10 tonnes will be required to achieve the compaction standard.

Compaction of the layer shall immediately follow the spreading operation and rolling or compacting shall begin at one edge of the course (the low edge on superelevated sections). Water in the amount that is necessary for compaction shall be added before and during rolling.

Any irregularities that develop in the surface of the aggregate subbase course during compaction shall be corrected by loosening the surface, adding or removing material and re-compacting unit the surface presents a smooth regular appearance. The finished surface of the course shall conform so nearly to that indicated on the Drawings that it will nowhere vary more than 10 mm from a straight edge, 3 meters long, applied to the surface parallel to the centreline of the pavement, nor more than 12 mm from a template conforming with the cross sections shown on the Drawings. The Contractor shall furnish all the straight edges, full width templates and other devices necessary to control construction of aggregate subbase course to these surface tolerances. The finished subbase course shall not be used for the carriage of through traffic but may be used for the carriage of local traffic only. Any damage which is done to the finished aggregate subbase course by traffic shall be repaired by loosening, reshaping, re-compacting, watering as necessary and placing more aggregate sub-base course material if necessary at the expense of the Contractor.

The surface of the finished layer shall be within +10 mm or -15 mm of the elevation shown on the Drawings. The depth over each 100 meters shall be measured in at least 2 places and the mean depth shall not be less than the required depth. Deficiency in depth shall be corrected or made up in the next layer above at the Contractor's expense.

In the case where the course is allowed to stand more than 24 hours before the application of a prime coat or the placing of a subsequent course, the Contractor shall regularly sprinkle the surface of the course with water, at his own expense, so that the course is prevented from drying out through its depth.

3204 Testing

Before commencing the work, the Contractor shall furnish to the Engineer, a sufficient quantity of the materials intended for use in order that the Engineer can determine the maximum dry density in accordance with AASHTO T-180 (Method D). The density requirement for the project shall be at least 100% of the maximum dry density. During the construction, the grading including sizes small than 0.02mm and atterberg limits shall be checked on samples from each 500 cubic meters of stockpiled aggregate and/or mixed material and if there is an appreciable change in grading or shape of the aggregate, or a change of source of aggregate, the Contractor shall furnish sufficient samples to the Engineer in order to establish a new value for the density requirements. All of the remaining quality tests should be checked at a frequency of not more than 1000 cu.m of the material placed. Field test for moisture content and dry density shall be in accordance with AASHTO T-191. At least one test shall be carried out for each 400 square meters of completed subbase course.

3205 Measurement and Payment

The quantity of aggregate subbase course to be paid for under this item shall be the number of cubic meters computed from plan lines of approved aggregate subbase course and shoulder surface material compacted in conformity with the lines, grades and cross sections shown on the Drawings and agreed field measurements of width and depth.

The payment shall constitute full compensation for providing aggregates and water for the subbase, hauling, placing, mixing, compaction, manipulating and re-compaction where necessary, proof-rolling if required and for furnishing all labour, equipment tools and incidentals necessary to complete this item.

Aggregates source may be from material salvaged from the existing road or structures and payment will be considered full compensation for the aggregate regardless of source.

Pay Item		Unit
32/1	Aggregate Sub-Base	Cum

3300: AGGREGATE BASE COURSE

3301 Description

This item shall consist of a compacted aggregate base course constructed in accordance with the requirements hereinafter set forth and in conformity with the lines, grades and cross sections shown on the Drawings.

Finished base course levels shall be determined following the choice of horizontal and vertical alignments for the new road pavement. The base course shall be constructed, with variable thickness where necessary, to the lines and levels directed by the Engineer.

3302 Materials

Materials for this course shall be sound, durable crushed rock, crushed slag, crushed boulder, as specified in Section 3200 for aggregate sub-base, except as otherwise specified herein below. The characteristics of these materials shall be such that they will compact to the density and stability established as satisfactory by the Engineer.

Coarse and fine aggregate materials may be mixed to obtain the required specifications as set out below. Fine aggregate material passing the 4.75 mm sieve shall normally consist of crushed stone screenings.

The materials shall be uniformly blended by mixing predetermined quantities of coarse and fine aggregate and at the time of compaction the moisture content shall be plus or minus two % of the optimum moisture content. The aggregate shall meet the grading limits of Table 3-3 of this specification. The fraction passing the 0.075 mm sieve shall be not more than two thirds of the fraction passing the 0.425 mm sieve.

The fraction of the material passing a 0.425 mm sieve shall have a liquid limit not greater than 25 and a plasticity index of not more than 4. The sand equivalent value of fine aggregate shall be no lower than 35.

Table 3-3

	Total Per cent Passing					
Sieve Size	50 mm	25 mm	19 mm	4.75 mm	0.600 mm	0.075 mm
% passing	100	70-100	50-90	30-60	9-33	0-10

Coarse aggregate sizes shall have at least 90 % by weight of pieces with two fractured faces and at least 98 % by weight shall have at least one fractured faces. Thin flat flaky or oversized aggregate detrimental to compaction and effective choking shall not be used. The amount of flat and elongated particles in coarse aggregate shall not exceed 20%. A flat particle is one having a ratio of width to thickness greater than 3; an elongated particle is one having a ratio of length to width greater than 3, tested according to ASTM D4791.

When tested in accordance with the Method of Test of Soundness of Aggregates by use of Sodium Sulphate, AASHTO Test Method T-104, and the weighted average loss in five cycles shall not exceed 15% by weight. The aggregates shall have a Los Angeles Abrasion loss of not more than 30 %.

The California Bearing Ratio (CBR) value of this material compacted and tested at the approved density and moisture content shall be not less than 80%.

3303 Construction Method

Any ruts, holes, defects or soft yielding places which occur in the subbase by reason of any improper drainage condition, traffic or hauling over the same, or for any other cause, shall be corrected and compacted to required density and stability and shall comply with the smoothness requirements of the Specification before aggregate base course is placed thereon.

Plant:

The processing and mixing plant and its operation shall be approved prior to the start of the work. The coarse and fine materials shall be measured separately and accurately by either volume or weight and shall be fed to the pug mill or other approved type of mixer in their proper proportions and at a rate to ensure correct blending in the mixer. Added water shall be measured accurately by weight, volume, or an approved metering device, and shall be uniformly distributed in the mix.

All mixing plants shall be equipped with automatic cut-off devices which will stop the feed to the mixer if the delivery of any component of the mix should fail.

Means shall be provided for checking and verifying the accuracy of all proportioning and measuring devices.

Stockpiling aggregates for proportioning by any method approved by the Engineer shall be accomplished in a manner that will ensure separation of different sized aggregates and prevent segregation and degradation of the aggregates.

Delivery:

The mixture shall be handled and transported without segregation or loss of moisture. The vehicles used for hauling shall be clean and free of all harmful material. To prevent loss of moisture during transportation, the mixture shall be covered with tarpaulins or other suitable covers, if necessary, until it is deposited in the spreader. Frequent moisture control tests will be made at the point of delivery on the project, as directed by the Engineer. Aggregate base materials shall be at or near optimum moisture content at the time of loading for transportation to the Project site.

Aggregate base materials shall be evenly spread on the subbase or lower base course by the use of approved, self-propelled spreading machines capable of placing the materials true to line and grade without damage to the subbase or lower base course.

The aggregate base materials shall be spread in courses of not under 75 mm compacted thickness. Compaction shall be carried out using heavy vibrating power rollers, heavy rubber tyred rollers or plate compactors for small widths.

Base course shall be compacted to the full width shown on the Drawings. Either shoulder material or extra base material shall be placed and compacted with the base to provide edge support and to allow full compaction. Base course material only will be paid for to the limits of the lines shown on the Drawings.

Compaction of the course shall immediately follow the spreading operation and compaction shall begin at the edges of the course. When the shoulder backing is firmly compacted, the rolling shall proceed inward until the crown part is reached. In the case of superelevated curves the compaction shall be from the low side to the high side, in the manner described above, until the shoulder backing at the high side is firmly compacted. Water in the amount that is necessary for compaction shall be added during rolling.

In narrow base widening, inaccessible to the main compaction equipment, the compaction may be performed with approved reciprocating or vibratory tampers. Unless the excavation is performed accurately by cutting to neat lines, the requirement for backing up the edge as stated above will apply for each course. The same density requirement as stated herein shall be followed.

Any irregularities that develop in the surface of the aggregate base course during compaction shall be corrected by loosening the surface, adding or removing material and re-compacting until the surface presents a smooth regular appearance. The finished surface of the course shall conform closely to that indicated on the Drawings so that it will nowhere vary more than 10 mm from a straight edge 3 meters long applied to the surface parallel to the centreline of the pavement, nor more than 12 mm from a template conforming with the cross sections shown on the Drawings. The Contractor shall furnish all the straight edges, full width templates and other devices necessary to control construction of aggregate base course to these surface tolerances.

The upper surface of the base course in no place shall be more than 6 mm above the planned elevation nor more than 10 mm below the planned elevation and the mean of five measurements of thickness taken in any 200 meter long section by digging holes shall be at least equal to the required base course thickness.

For construction of wide roads, the finished base course shall not be used for the maintenance of through traffic but may be used for the maintenance of local traffic only. Any damage which is done to the finished aggregate base course by traffic shall be repaired by loosening, reshaping, re-compacting watering as required and the addition of more aggregate base course material, if necessary. Repair operations shall be done at the expense of the Contractor. When a section has been completed as described above it shall be allowed to surface dry before the application of a bituminous prime coat. If a prime coat is not provided, a base course of another type may be placed immediately. In case the application of a prime coat or the placing of subsequent course, the Contractor shall sprinkle the surface of the course with water, at his own expense, so that the course is prevented from drying out through its depth.

3304 Testing

Before commencing the work, the Contractor shall furnish to the Engineer a sufficient quantity of the materials intended for use in order that the Engineer can determine the density requirements in accordance with AASHTO T-180 (Method D) and the CBR of the material. Course aggregate shall be placed in stockpiles in units of not less than 200 cubic meters at least seven days prior to their anticipated use in the work. The density requirements for the project shall be at least 100 % of the dry density. During construction, grading shall be checked on samples from each 500 cubic meters of stockpile. If there is an appreciable change in grading of the aggregate from stockpiled samples or from samples in place and compacted on the roadbed, as determined by the Engineer, or a change of source of aggregate, the Contractor shall furnish sufficient samples to the Engineer in order to establish a new density for the density requirements. The remaining properties (Atterberg Limits, MDD, CBR, Fracture Face, Flat & Elongated particles, Soundness, and Los Angeles Abrasion) should be checked at each 1000 cubic meters of the placed material.

Field test for density shall be in accordance with AASHTO T-191 and shall be carried out by the Contractor at a rate of at least one per 300 sq. meters of compacted base course.

3305 Measurement and Payment

The quantity of Aggregate Base Course to be paid for shall be the number of cubic meters, computed from plan lines, of approved aggregate base course material compacted in conformity with the lines, grades and cross sections shown on the Drawings or agreed field measurements of width and depth.

The quantity measured as provided above shall be paid for at the contract unit price per cubic meter bid for "Item 33/1 Aggregate Base Course which price and payment shall constitute full compensation for providing aggregate and water for the base, crushing, screening, stockpiling, testing, hauling, placing, compacting, manipulating and preparation and re-compaction where necessary, providing all labour, equipment, tools, and incidentals necessary to complete this item.

The unit price shall cover all operations defined above whether the base material has been provided by the Contractor from outside the right of way or from materials recovered from structures and existing pavement as provided for in TS2000.

Item		Unit
33/1	Aggregate Base-Course	Cum

BITUMINOUS PAVEMENT

4000 GENERAL

4001 Materials

All materials shall be tested by the Contractor in the presence of the Engineer's representative at the Site except where manufacturer's test certificates are supplied and accepted.

Unless otherwise specified, all tests shall be carried out in accordance with the AASHTO & ASTM Standards.

If the quality of the sample from any stockpile or consignment after test is found to be inferior to that required by the specifications the material of that consignment will not be accepted and the Contractor shall remove such rejected materials from site.

The Contractor may arrange for testing to be carried out at his own cost prior to delivery of materials to site but this shall in no way affect the Engineer's right to carry out tests and reject defective materials at the Works.

4002 Bituminous Materials

a) Penetration Grade Bitumen

Sampling: Bitumen shall be sampled in accordance with AASHTO T40. Samples thus sampled will be tested for penetration, specific gravity, softening point, Ductility, loss on heating, flash point and solubility.

Packing: Bitumen shall be supplied in bulk in appropriate road tankers or be packed in securely sealed brand new steel drums.

- Penetration: The penetration shall be not less than 60 and not more than 70, or as otherwise directed by the Engineer. Penetration shall be determined in accordance with AASHTO T49 at 25°C.

- Specific Gravity: Specific gravity shall be determined in accordance with AASHTO T228.
- Specific gravity at 25°C shall be not less than 1.00 and not more than 1.05.
- Softening Point: Softening point shall be determined in accordance with AASHTO T53.
- The softening point shall be not less than 43°C and not more than 54°C.
- Ductility: Ductility shall be determined in accordance with AASHTO T51.
- The ductility shall be not less than 100cm, tested at 25°C and at a rate of 5cm/min.
- Loss on Heating: Loss on heating shall be determined in accordance with AASHTO T47.
- Loss on heating shall not exceed 0.8%.
- Penetration of residue: Minimum 54% of the original penetration value, using the same condition
- Ductility of residue: Minimum 50% of the original value, using the same condition
- Flash Point: Flash point shall be determined in accordance with Cleveland Open Cup method AASHTO T48.
- The flash point shall be not less than 232°C.
- Solubility: Solubility shall be determined in accordance with AASHTO T44.
- The solubility shall be not less than 99.0%.
- General Requirements: The bitumen shall be homogeneous, free from water and shall not foam when heated to 180°C.

b) Bitumen Emulsion

General: Bitumen emulsion shall be a mixture of penetration grade bitumen, water and an emulsifying agent. Bitumen emulsion deteriorates on storage and always should be used as soon as possible after manufacture. Drums should be rolled for several minutes before use to remove any sediment. Testing generally should be in accordance with AASHTO T59.

Sampling: Bitumen emulsion shall be sampled shortly before use, sampling shall be in accordance with AASHTO T40. Samples thus sampled shall be tested for bitumen content, viscosity, residue on sieving etc.

Packing: Bitumen emulsion shall be packed in clean steel drums of the type and quality used for fuel oil deliveries. Drums shall be fitted with a watertight screwed stopper.
Bitumen Content: The percentage of bitumen by weight retained after distillation in accordance with BS434 Appendix-E shall be not less than 57%.

Viscosity: The viscosity of the bitumen emulsion shall be between 6 and 9 degrees Engler at 20°C as determined in accordance with BS434 Appendix-F.

Residue: The percentage of residue by weight as determined in accordance with BS434 Appendix-C shall not be greater than 0.05% on the 0.710 mm sieve or 0.15% on the 0.150 mm sieve.

Coagulation: There shall be no coagulation of the emulsion at low temperature as determined in accordance with BS434 Appendix-G.

c) Cut-back Bitumen

General: Cut-back bitumen is a mixture of penetration grade bitumen and kerosene. The Engineer will direct the mix proportions to be adopted for a particular application but the following will indicate the range of likely mixtures.

(i) Grades

(a) Fluid - 85/100 bitumen mixed with 20% - 40% kerosene by volume.
(b) Medium - 85/100 bitumen mixed with 10% kerosene by volume. (Suitable for use in penetration grouting etc.)
(c) Viscous - 85/100 bitumen mixed with 5% kerosene by volume. (Suitable for surface dressing work etc.)

(ii) Constituents:

The 80/100 bitumen used for making cut-back bitumen must conform in all respects to the relevant Specification. The cutting oil shall be normal commercially available kerosene free from any dirt or other impurities.

(iii) Mixing:

The bituminous binder shall be penetration grade 85/100 bitumen cut-back with kerosene so that the total diluent content of the binder is in accordance with Table 4.1. Binder which is sprayed while the shade air temperature of the site is rising shall be blended in accordance with the maximum expected temperature on the day. The maximum temperature shall be estimated by the Contractor and approved by the Engineer. Binder sprayed while the shade air temperature is falling shall be blended in accordance with the shade air temperature measured at the time of spraying. Interpolation may be used to obtain intermediate values from Table 4.1. The formulations may be used over a range of ± 3°C from the specified temperatures except that where no kerosene is required the upper temperature limit shall not apply. Binder not complying with this specification shall not be used without re-blending.

Total dilatants (diesel, kerosene) for 80/100 penetration grade bitumen - Table 4-1

Shade air Temperature ^{O}C	Parts per hundred parts of bitumen binder at $15^{O}C$
12.5	16
15.0	14
17.5	12
20.0	10
22.5	8
25.0	6
27.5	4
30.0	2
32.5 and above	0

(iv) Blending:

The total quantity of each component incorporated into the bituminous binder shall be accurately measured by a volume metering or weighing device. The binder shall be thoroughly mixed before use. The minimum acceptable degree of mixing shall be such that the concentration of any component in any part shall not differ by more than 15% from the concentration calculated assuming that the binder is perfectly mixed. All plant and methods used to be blend the binder shall be approved by the Engineer.
The Engineer may by specific direction require that cutback and/or flux oil to be blended either at a central blending plant or on site. When blending is done in a central blending plant, the Contractor shall provide a blending certificate with each load of binder. The certificate shall list the following:

- Time and date of blending,
- Temperature of bitumen when blended,
- Grade of bitumen,
- Number of parts of diesel per 100 of bitumen,
- Number of parts of kerosene per 100 parts of bitumen,
- Type and quantity of other additives (in parts per 100 parts of bitumen) as well as the quantity in either kilograms or litres at 15°C.

If the Contractor fails to provide the specified blend or to provide accurate delivery certificates, the Engineer will require the Contractor to blend only in the presence of and at times and locations previously approved by the Engineer.

4003 Application temperatures of bituminous binder materials

Where the binder, or its bitumen component, is to be stored for a period exceeding one week, it shall be stored at a temperature not exceeding 150°C. The quantity of bituminous binder or bitumen raised above this temperature in any one day should not exceed that which is to be sprayed on that day.

Where binder which has been heated to spraying temperatures must be stored for more than one day, thermostatic heaters shall be used to maintain the binder temperature not higher than 50°C below the appropriate spraying temperature listed in Table 4-2, except with the specific approval of the Engineer.

Any binder which has been heated to a temperature in excess of 30°C above that specified in Table 4.2 for any period, or which has been held in storage at temperatures above those permitted in this specification, shall not be used until it has been re-tested for compliance with these specifications.

a) Penetration Grades

Penetration grade bitumen will be sprayed at the highest temperature possible to gain time for spreading and rolling of chips. However, in no case may the temperature at any time exceed 180°C.

b) Bituminous Emulsions

Emulsified bitumen shall not be reheated above a temperature of 90°C nor stored in such as to allow deterioration of its properties. Emulsified bitumen shall be continuously circulated to ensure a uniform temperature throughout. Any emulsified bitumen showing lack of uniformity will be condemned and shall immediately be removed from the site of the works.

The emulsified bitumen may be sprayed at the temperature at which it is received from the manufacturing plant except that no emulsified bitumen shall be sprayed at a temperature in excess of 90°C or below 20°C.

c) Cut-back bitumen

The binder, according to its composition, shall be sprayed at a spraying temperature within the limits defined in Table 4-2.

Spraying temperatures for cut-back bitumen of 80/100 grade bitumen - Table 4-2

Total Diluent	Temperature ^{O}C	Total Diluent	Temperature ^{O}C
0	185	11	157
1	182	12	154
2	180	13	151
3	177	14	148
4	175	15	146
5	172	16	144
6	170	17	141
7	167	18	139
8	164	19	136
9	162	20	133
10	150	--	--

Notes:

1. Total diluent refers to the total quantity of diluents expressed as parts per hundred parts of bitumen (measurement by volume at 15°C).
2. Binder may be sprayed at temperatures varying not more than 10°C from these tabulated values.
3. This table does not apply to binders containing diluents other than those listed in note 1.

4004 Measurement

Bituminous materials shall be measured by volume at 15°C for payment. The following table shall be used for computing volumes of materials stored or used at other temperatures:

(Multipliers for reducing the volume of hot bitumen to the equivalent volume at 15°C)

Volume Correction Table 4-3

Observed Temperature					
(°C)	Multiplier	(°C)	Multiplier	(°C)	Multiplier
15	1.000	81	0.959	147	0.920

18	0.998	84	0.957	150	0.918
21	0.996	87	0.056	153	0.916
24	0.994	90	0.954	156	0.914
27	0.993	93	0.952	159	0.913
30	0.991	96	0.950	162	0.911
33	0.989	99	0.948	165	0.909
36	0.987	102	0.946	168	0.907
39	0.985	105	0.945	171	0.905
42	0.983	108	0.943	174	0.904
45	0.981	111	0.941	177	0.902
48	0.979	114	0.939	180	0.900
51	0.978	117	0.937	183	0.899
54	0.976	120	0.936	186	0.897
57	0.974	123	0.934	189	0.895
60	0.972	126	0.932	192	0.893
63	0.970	129	0.930	195	0.892
66	0.968	132	0.928	198	0.890
69	0.967	135	0.927	201	0.888
72	0.965	138	0.925	204	0.886
75	0.963	141	0.923		
78	0.961	144	0.921		

4100 Asphalt Mix Types

The type of hot (or cold for patches) asphalt mixes shall be as indicated on the Drawings.

4101 Asphalt Wearing Course (Surface Course)

Asphalt Concrete Surface Course is intended as the top layer of pavement that is exposed to the traffic. It is placed on a binder or leveling course, or existing asphalt surface, the surface of which has been prepared with a Tack coat.

4102 Asphalt Intermediate (Binder) Course

Asphalt Concrete Intermediate (Binder) Course, when required by drawings, is intended as the layer of pavement immediately below the Asphalt Wearing Course. It is intended to be placed directly on a prepared sub-base material in substitution for unbound base and sub-base materials or placed upon Asphalt Base Course Layer.

4103 Asphalt Base Course

Asphalt Base Course, when required by drawings, is intended as the layer of pavement immediately below the Asphalt Binder Course. It is placed under the Asphalt Intermediate (Binder) course and on a prepared sub-base or base course material, the surface of which has to be prepared with a Prime Coat.

4104 ASPHALT layer Thickness and Surface Tolerances

The thickness of asphalt concrete laid shall be monitored by pavement cores taken by the Contractor under the supervision of the Engineer. 100mm cores shall be taken for both compaction and thickness checked at 100m intervals on alternate sides of each paved area, 0.5 m from the edges. Repeat cores shall be taken 1m on either side of failure cores, until the extent of the affected area is known.

The actual thickness of asphalt concrete placed over any given section of the Works shall be defined per lot in accordance with requirements and procedures noted in this specification.

The pavement must conform to the designed finished grade shown on the Drawings. The finished surface levels of the asphalt surfacing shall conform to the design finish grade at all points.

The variation of the finished surface of asphalt mixes used as binder courses from a 3 m straightedge shall not exceed 15mm at any point and 7mm for asphalt base courses.

The variation of the finished surface of asphalt wearing courses from a 3 m-straightedge shall not exceed 5 mm at any point.

The wearing course tolerance from the specified design levels shall be on– 0mm, + 5 mm.

4200BITUMINOUS PRIME COAT AND TACK COAT

4201 Description

This item shall consist of the careful cleaning of a base, wearing course or an existing road surface and the application of a prime coat or tack coat of bituminous material as described in these Specifications.

4202 Materials

a) Prime Coat

The primer seal or prime coat shall be 80/100 bitumen mixed with 30%-35% kerosene by volume or alternative primer of a grade approved by the Engineer.

The primer application rate shall nominally be 1.0 litres per sq.m (residual bitumen) but shall be within the range 0.80 - 1.40 litres per sq.m as directed by the Engineer.

b) Tack Coat

A tack coat shall be applied where directed to bond a new bituminous surface to an older bituminous surface. A tack coat shall comprise a light application of bituminous material in a similar manner to the prime coat. The tack coat shall be bitumen emulsion or equivalent subject to approval of the engineer.

A dilute bitumen emulsion applied at a sufficient time before laying the bituminous layer to allow the emulsion to break and the water to run off or evaporate, spread to give note less than 0.2 litres per sq. metre residual bitumen, but shall be in the range 0.25 to 0.7 litres per sq. metre as required for the existing surface and ordered by the Engineer.

Where a tack coat is required in the Engineers opinion only to overcome a delay or damage to a bitumen surface, which could have been reasonably prevented by the Contractor, then the tack coat shall be applied at the Contractor's expense and shall not be measured for payment.

c) Primer seal Aggregate

Sand for primer seal aggregate shall meet the requirements of binders aggregate Type C.

The application rate for the aggregate shall be within the range 0.007 - 0.012 cum per sq. metre to the approval of the Engineer.

Gradation of the aggregate Table 4-4

Sieve Size mm	Total Percent Passing by Mass		
	Type A	Type B	Type C
19 12.5 9.5 6.3 4.75 2.36 1.18	100 90 - 100 40 - 70 0 - 15 0 - 5	100 90 - 100 10 - 35 0 - 5	 100 95 - 100 60 - 90 0 - 10 0 - 5

4203 Construction Methods

a) Cleaning Surface

Surface to be tacked or primed shall be thoroughly cleaned to remove all mud, earth, dust, animal droppings and other foreign material.

The sweeping on a water bound surface shall be just sufficient to expose the pattern of the coarse aggregate.

Special care shall be taken to clean the edges of the road to be primed in order to ensure uniform application of the bituminous material directly on the existing base or pavement material.

Material cleared from the surface shall be removed and disposed of as directed by the Engineer.

b) Protection of Structures from Bituminous Material

When bituminous material is being applied, the surfaces of all structures shall be protected by a satisfactory method or device to prevent their surface from being marred or defaced by the operation.

c) Applying Bituminous Material

i. After the surface has been cleaned as described above and when in a dry condition, the bituminous material, except as noted below, shall be uniformly applied by means of heating and distributing equipment conforming to the requirements of Section 4300.

ii. Prior to commencing bitumen application for the Works, the Contractor at his own cost shall demonstrate to the Engineer by means of trial sections the method he proposes to use for bitumen application. This method must be approved by the Engineer before the Contractor shall be permitted to commence bitumen application.

iii. In irregular areas, such as driveways and intersections, the method of application shall be that approved by the Engineer. Dry spots shall be retreated and excess pools of bituminous material shall be removed from the surface.

iv. The temperature of the cut back bitumen at the time of application shall be within the range 110°C - 135°C, unless the Engineer approves or directs that application be carried out at a lower temperature.

Tack coats shall not be applied when the shade air temperature is under 5°C. Prime coats shall not be applied when the shade air temperature is below 0°C nor when the air temperature within the proceeding 24 hours has been 5°C or lower. .

d) Tack Coat

Tack coats shall be provided only where directed by the Engineer. When a tack coat is to be provided it shall not precede the work of placing the subsequent course to such an extent that the treated surface may be damaged.

e) Prime Coat

Primer shall be applied in one or more applications if directed by the Engineer except that the Engineer may vary the rate of application depending upon the condition of the surface being primed. A prime coat shall not be applied when the surface of the course is wet or if it is dusty. The bituminous material shall not be applied at such a rate as will cause it to flow off the course or road surface. The area primed shall be closed to traffic for a period sufficient to allow for proper penetration and curing. Any primed area shall be allowed to fully cure for not less than 24 hours before placing of subsequent layers unless otherwise directed by the Engineer.

f) Primer sealing

For Bituminous Surface Course primer seal shall be applied in the same manner of Prime Coat and after which primer seal aggregate shall be applied at the rate given in Section 4200. After primer sealing area shall be closed to traffic for a period sufficient to allow penetration and curing. Then traffic to be allowed to run on the primer sealing surface for a minimum period of 2 weeks before the surface dressing is applied in accordance with Section 4.4 of these specifications.

4204 Method of Measurement

The quantity of primer seal, prime or tack coat used as directed shall be measured in accordance with Section 4.0.5. The volume measured shall exclude kerosene where cut back bitumen is used.

4205 Basis of Payment

The quantities measured as above provided shall be paid for at the contract unit price bid per sqm.

The Rates, price and payment shall constitute full compensation for cleaning of the surface, furnishing and applying all materials, including sand or aggregate for primer seal where called for by the Engineer and for all labour, equipment, tools and incidentals necessary to complete this item.

Item No.	Unit
42/1 -Bituminous Prime Coat	Sq.m
42/2 - Bituminous Tack Coat	Sq.m
42/3 - Bituminous Primer sealing	Sq.m

4300BITUMINOUS PREMIX SURFACE COURSE (HOT ROLLED ASPHALT)

4301 Description

This item shall consist of one or more courses of compacted bituminous premix constructed on the prepared base, or existing pavement, in accordance with these Specifications and in conformity with the lines, grades, designed thickness, typical cross sections and other details shown on the Drawings.

The bituminous premix shall be composed of a mixture of coarse and fine aggregate, approved mineral filler and bitumen.

4302 Materials

a) Binder

Unless otherwise noted on the Drawings or in the Special Provisions the binder used shall have penetration grade bitumen meeting the requirements of Section 4002a. It shall not be cut back.

b) Coarse Aggregate

Coarse aggregate (material retained on the 2.36 mm Sieve), shall be crushed stone, crushed slag or crushed gravel. The sodium sulphate soundness loss shall not exceed 9 percent and the magnesium sulphate loss shall not exceed 12 percent when tested in accordance with AASHTO T104.

The abrasion resistance of coarse aggregates shall be measured by the Los Angeles Abrasion Test (AASHO Designation T-96). The maximum allowable abrasion loss for bituminous premix coarse aggregate shall be 30% by weight.

When crushed gravel is used not less than 95 % by weight of the particles retained on the 4.75 mm sieve shall have less than two fractured faces, and 100% by weight for one fractured face.

The coarse aggregates (material retained on 4.75mm sieve) should not have flat and elongated particles that have a maximum to minimum ratio of greater than 5:1, of more than 10%, when tested according to ASTM D4791.

The coarse aggregate shall be of such gradation that when combined with the other aggregate fractions in proper proportion the resultant mixture will meet the gradation required under the composition of the mixture for the specific type under contract.

When subjected to Coating and Stripping Tests, AASHTO T 182, the aggregate shall have a coated area of not less than 95%.

c) Fine Aggregate

The fine aggregate shall be defined as material passing the 2.36 mm sieve and shall be either a natural or manufactured product, the surface of which shall be clean and free from clay and any deleterious coatings. The Plasticity Index of the material passing the 0.425 mm sieve shall not exceed 4 and shall have a sand equivalent not less than 45 as determined by the Sand Equivalent Test AASHTO T176.

The fine aggregate should have an angularity value or uncompacted void content of not less than 45% as determined according to AASHTO T304, method A.

The material shall be graded uniformly from coarse to fine and may be supplied as two or more components capable of being combined with the coarse aggregates to produce a satisfactory overall combined grading.

d) Mineral Filler

Mineral filler shall consist of rock dust, hydrated lime or Portland cement. It shall be dry and free from lumps and shall meet the following grading requirements:

Grading for mineral filler Table 4-5

Particle Size	Percentage by Mass Passing (AASHTO T-11 and T-27)
0.6 mm 0.18 mm 0.075 mm	100 95 - 100 65 - 100

e) Sampling, Testing and Approval of Materials

Prior to the delivery of any mineral aggregate or mineral filler, the Contractor shall furnish and test samples under the supervision of the Engineer. At the completion of the tests the Engineer will inform the Contractor if such materials as represented by the samples conform to the requirements of the Specifications. Permission to use a material shall not be construed as an approval of the source of supply of this material.

Upon the initial delivery or manufacture of the materials and during subsequent deliveries and manufacture, samples will be taken and tested to determine that the materials being furnished conform to the original samples and also to the requirements of these Specifications. For each day of production the Contractor shall test at least two samples of all materials entering into uncompacted pavement. All tests will be performed by the Contractor under the supervision of the Engineer unless the Engineer chooses to separately test the samples.

The test procedures to be used are as listed below although the Engineer may specify other tests should these be required.

Testing procedures for Asphalt works Table 4-6

Characteristic	Method of Test	
	AASHTO	ASTM
Materials Finer than 0.075 mm sieve	T 11	C 117
Unit Weight of Aggregate	T 19	C 29
Sieve analysis of Fine and Coarse Aggregates	T 27	C 136
Sieve Analysis of Mineral filler	T 37	C 546
L.L.A Test (Resistance to Abrasion of Coarse Aggregate)	T 96	C 131
Soundness of Aggregates by use of Sodium Sulphate	T 104	C 88
Plastic Fines in Graded Aggregates and Soil by use of the Sand Equivalent Test	T 176	-
Asphalt Content by Quantities Extraction	T164	D2172
Mechanical Analysis of Extracted Aggregate	T30	-

4303 Job Mix Formula

The table following gives the composition limits within which the Job Mix Formula will be set by the Engineer. After examination of the materials that the Contractor proposes to use, and following tests of trial mixes by the Contractor, the Engineer shall establish the Job Mix Formula. Should the Contractor at any time propose to change the source or processing of the materials, sufficient notice shall be given the Engineer before such change is made. Samples shall be provided and tested by the Contractor supervised by the Engineer so that the mix design may be checked and the Job Mix Formula amended as necessary.

The Engineer may vary the Job Mix Formula to suit changing materials or to improve workability but no change shall be made unless authorised by the Engineer.

Aggregate Gradation for Hot Asphalt mixes, Table 4-7

Sieve Size mm	% Passing by Weight of Total Aggregate in mix		
	Asphalt Base Course	Asphalt Intermediate Course (19 mm)	Asphalt Surface Course (12.5 mm)
37.5	100		
25	90 – 100	100	
19	-	90 - 100	100
12.5	56 – 80	-	90-100
9.5	-	56 - 80	-
4.75	29 – 59	35- 65	44-74
2.36	19 – 45	23 - 49	28-58
1.18	-	-	-
0.300	5 – 17	05 - 19	5-21
0.075	1 – 7	2 – 8	2-8
Asphaltic Cement by weight of total mix %	3.0 - 5.0	4.0 - 5.5	4.5 - 6.0

4304 Mix Design

The mix design shall comply with the following tables which show the composition limits within which the mixes will be approved by the Engineer. After examination of the materials that the Contractor proposes to use, the Contractor, supervised by the Engineer will establish a mix that will produce the required density and stability which shall be determined by conducting Marshall Test on trial mixes. Should the Contractor at any time propose to change the source for processing of material, sufficient notice shall be given to the Engineer before such change is made. Samples shall be provided by the Contractor so that the mix design may be checked by the Contractor supervised by the Engineer. In no instance shall coarse aggregates of widely different absorption characteristics be blended.

The agreed Job Mix Formula shall not be changed without Engineer's consent if changing materials or to improve workability.

The Engineer shall require trial mix designs to be prepared and tested in the laboratory not less than 30 days prior to the scheduled commencement of paving. The trials shall be performed by the Contractor under the supervision of the Engineer. The cost of such tests shall be included in the rates for bituminous premix course.

The laboratory trials will be directed toward determining the optimum mix design for the material samples submitted. Should the materials actually used in construction deviate from the samples submitted further laboratory trials may be required at the discretion of the Engineer.

The optimum mix design will be selected according to the stability, flexibility and flow desired and achievable with the available materials while maintaining bitumen and void contents at the level indicated herein.

Marshall Test procedures shall be followed, and the following parameters shall be adopted:

Mix property requirement- Table- 4-8

Mix Properties	Asphalt Concrete Base Course	Asphalt Concrete Binder Course	Asphalt Surface Course
Specimen compaction, number of blows each end of specimen	75	75	75
Stability, N (minimum)	8000	8000	8000
Flow, 0.25mm	8 - 14	8 - 14	8 - 14
Air voids %	3 – 5	3 – 5	3 – 5
Voids in mineral aggregate % (minimum)	12	13	14
Voids filled with Asphalt (VFA), %	65 – 75	65 – 75	65 – 75
Air Voids at Refusal Compaction, min %	2	2	2
Retained Marshall Stability %(minimum)	70%	70%	70%

Once the Job Mix Formula is set by the Engineer, field quality control shall be achieved by control of the aggregate content and grading, bitumen content and the compacted density. The Engineer shall also require checks on mix properties by means of Marshall Tests on two samples from each day's production.

The limits, relative to the Job Mix Formula, within which aggregate gradation and bitumen contents, determined by the field quality control and checks on mix properties, shall lie within the following, provided the aggregate grading is within the gradation envelope specified in Section 4303.

Aggregate grading Table 4-9

Passing Sieve	Percent
4.75 mm and larger 0.150 mm - 2.36 mm 0.075 mm	± 5 ± 4 ± 2
Bitumen	± 0.3[1]

Note 1: this variation should not result outside of the limits of narrow range of asphalt contents that pass all of the guidelines as shown in Asphalt Institute Manual (MS-2).

Any variation from these tolerances shall be sufficient cause for the Engineer to discontinue production until the cause of the variation has been corrected. The Contractor shall take and analyse pavement samples of the materials in question either before or after incorporation in the pavement and if laboratory analysis of those samples confirms the Engineer's analysis the Engineer may require the Contractor to

remove and replace the material exceeding these variations in composition. No compensation shall be paid to the Contractor for samples taken by himself or by the Engineer and the material removed shall not be measured for payment.

4305 Plant

The mixing plant should be a weigh-batching type and the use of a continuous drummixing plant is not allowed on this project. The Contractor shall submit at the time of tender details of the plant he proposes to use for the production of bituminous premix. The Contractor shall demonstrate that the plant proposed is capable of supplying premix materials at a rate which is adequate to meet the requirements of the Contractual Programme.

The Contractor shall further submit to the Engineer at least 60 days before paving is scheduled to commence full details of the plant.

On the basis of the details submitted and the outcome of the field inspection where held the Engineer shall either accept or reject the equipment. Acceptance however shall not relieve the Contractor of his responsibility to produce, transport and pave material conforming in all respects to the requirements of this Specification.
For the Engineer to provide this initial acceptance the various plant items must have the following minimum attributes.

a) Batch Plant

i) Mixing plants shall be of sufficient capacity to adequately handle the proposed bituminous construction in a smooth continuous operation.

ii) Cold Feed System. The plant shall have not less than 4 cold feed bins of a width sufficient to ensure that, with the loading equipment proposed by the Contractor, each bin can be charged without spill or overflow into adjacent bins. The cold feed bins shall be fitted with an adjustable feed mechanism which shall be in good working order.

iii) Dryer. The dryer shall be of a capacity suitable for the rated output of the plant. Its burner or burners shall be oil fired and controlled automatically by sensors to ensure the aggregate temperature remains reasonably uniform. The burners shall be in good condition and capable of producing a clean flame without leaving a residue of soot or unburnt fuel on the surface of the aggregate.

iv) Dust extractor. The plant shall be fitted with an efficient dust extractor with water sprinkler, automatic damper control, adjustable venturi and centrifugal separator and fan which shall remove the maximum possible amount of fine material from the exhaust gases. The extractor system shall have the capability of returning some or all of the extracted fine material to the hot elevator or to spoil as required.

v) Hot elevator. The hot elevator shall be enclosed and fitted with an accurate temperature sensing device, the output from which shall be displayed in the plant's control room.

vi) Screens. The vibrating screens shall be in good condition and of mesh sizes suitable for producing the specified mix. The screens shall be replaced if openings are larger than the nominal size due to wear. They shall have an operating efficiency such that the aggregate deposited in any bin shall not contain more than 1.0% of oversize or undersize material.

vii) Hot aggregate bins. There shall minimum of four hot bins, each of sufficient capacity to allow continuous operation of the plant at its rated capacity. Each bin is to be fitted with a contents indicator and a temperature sensing device, each displaying its output in the plant control cabin. A suitable sampling gate shall be provided at the base of each bin. The hot bin gates shall be mechanically operated, quick acting and tight fitting.

viii) Filler feed. The plant shall be fitted with separate filler feed and weighing arrangement which feeds directly into the pugmill.

ix) Weigh box. The weigh box shall have a capacity greater than the rated batch size and shall be capable of being calibrated by the sequential addition of standard weights. The Contractor shall make available at all times at the plant site a range of such weights, of sizes directed by the Engineer, to enable the calibration to be checked. The output from weigh box scales shall be displayed in the control cabin.

x) Binder proportioning device. Binder shall be fed into the mix by means of a spray bar fed from the plant's binder metering device. This device shall be capable of adding binder to an accuracy of within 1 kg of the required amount. It shall be capable of being calibrated and shall display its output in the control cabin. A temperature sensor shall be fitted in the binder feed line adjacent to the metering device and its output shall also be displayed in the control cabin.

xi) Pug mill: The pug mill shall have a minimum rated capacity of 1000 kg of mix. It shall be of the double shaft type and its paddles, paddle tips and liners shall not be significantly worn. The clear gap between paddle tip and liner at any point shall not be more than half the maximum aggregate size in the mix. Where this limit is exceeded the paddle tips and pug mill liners shall be replaced. The discharge gates shall be mechanically operated, quick acting and not subject to leaks.
A batch counter shall be provided which displays its output in the control cabin.

xii) Controls. The plant shall be fitted with fully functional automatic mixing controls. As a minimum the process from discharge of aggregates into the weigh hopper and subsequent discharge of the mix into a truck shall be controlled to pre-set requirements, which shall include mix proportions and mixing time. Manual operation for other than plant checking or start up shall not be permitted.
Control cabin. The control cabin shall be an air-conditioned room separate from but having a full view of the plant. It shall contain all necessary devices to monitor all aspects of the plant from cold feed bin contents through to discharge of the mix into the truck. Where the Contractor provides his own weigh bridge to weigh trucks it shall be installed adjacent to this control cabin.

b) Bituminous Pavers.

Bituminous pavers shall be self-contained, power-propelled units, provided with an adjustable activated screeder strike-off assembly, heated and capable of spreading and finishing courses of bituminous plant mix material in lane widths applicable to the specified typical section and thicknesses shown on the plans.

Pavers shall be equipped with a control system capable of automatically maintaining the screed elevation as specified herein. The control system shall be automatically actuated from either a reference line or surface through a system of mechanical sensors or sensor directed mechanisms or devices which will maintain the paver screed at a predetermined transverse slope and at the proper elevation to obtain the required surface. When directed, the transverse slope control system shall be made inoperative and the screed shall be controlled by sensor directed automatic mechanisms which independently control the elevation of each end of the screed from reference lines or surfaces.

The controls shall be capable of working in conjunction with any of the following attachments:

i) Ski-type device of not less than 9 m in length or as directed by the Engineer.
ii) Taut stringline (wire) set to grade.
iii) Short ski or shoe.

The Contractor shall furnish the long ski, the short ski or shoe and furnish and install all required stakes and wire for a taut stringline.

Should the automatic control system become inoperative during the day's work, the Contractor will be permitted to finish the day's work using manual controls, however, work shall not be resumed thereafter until the automatic control system has been made operative.

The Contractor shall provide and have ready for use at all times enough tarpaulins or covers, as may be necessary, for use in any emergency such as rain, chilling wind, or unavoidable delay, for the purpose of covering or protecting any material that may have been dumped and not spread.

4306 General Requirements

a) Field Laboratory

The Contractor shall provide a suitable field laboratory meeting the requirements as set forth in this Specification and required by the Engineer to perform the specified tests on aggregates, mixes and cores.

b) Preparation of Mixtures

The exact proportions, within the limits specified for each type of mix, shall be regulated so as to produce a satisfactory mixture with all particles coated with bitumen. To ensure this is achieved the Contractor shall calibrate the aggregate and binder proportioning devices in the presence of the Engineer prior to the commencement of mixing and at such other times as the Engineer may require.

The aggregates shall be mixed dry for a minimum of 15 seconds; the binder shall then be added in an evenly spread sheet over the full length of the mixer. The mixing shall be continued for a minimum of 30 seconds. The total time of mixing shall be the interval of time between the opening of the weigh box gate and the opening of the mixer gate. The Engineer may vary the length of the dry and wet mixing periods, but under no circumstances shall the total mixing time be less than neither 45 seconds nor more than 60 seconds.

Continuous mixing is not allowed on this project. The mixture shall be loaded into the trucks in such a manner that segregation will not occur.

c) Temperature Control

Temperature shall be controlled within the following limits.

Binder	135 - 160°C
Aggregate (ex-dryer)	150 - 180°C
Mix (pugmill)	135 - 170°C
Delivery (paver)	130°C minimum
Rolling (initial)	110°C minimum

4307 Construction Methods

a) Cleaning of Base of Old Pavement

Immediately prior to the arrival of the mix at the paving site, the base, levelling course or old pavement to be surfaced shall have been thoroughly cleaned of all soil or foreign materials. Unstable or fatty patches of surplus bituminous material shall be removed from the old pavement and be replaced where necessary with suitable material, before spreading of any of the bituminous mixtures.

The cost of such cleaning and preparation shall be included in the price bid for bituminous premix.

b) Transportation and Placing of Mixtures

Mixtures shall be transported to the work in trucks having tight, clean and smooth metal beds that have been sprayed or painted with a minimum amount of soapy water to prevent mixture from adhering to the beds. No load shall leave the plant that is not thoroughly protected by a waterproof canvas cover. Any truck causing excessive segregation of materials by its spring suspension or other contributing factors, or that shows oil leaks of any magnitude, or that causes undue delays, shall upon the direction of the Engineer be discharged from the work until such conditions are corrected.

Recording of Truck Weights - A digital recorder shall be installed as part of the platform truck scales. The recorder shall produce a printed digital record on a ticket of the gross and tare weights of the delivery trucks along with a time and date print for each ticket. Provisions shall be made so that scales may not be manually manipulated during the printing process. In addition, the system shall be so interlocked as to allow printing only when the scale has come to rest. The scales and recorder shall be of sufficient capacity and size to accurately weigh the heaviest loaded trucks or tractor trailers that are used for the delivery of the bituminous concrete from that plant.

When any mixtures are being transported at shade air temperatures below 10°C or when the length of haul exceeds 10 kilometres, all truck beds shall be insulated to maintain workable temperature of the mixture. The maximum distance mixtures may be transported from mixing plant to paving site shall not exceed 30 kilometres except by specific permission of the Engineer.

Mix shall be dumped into the hoppers of the spreading and finishing machines hereinafter described in Section 4307.

Alternative labour - intensive spreading and finishing methods will require the prior approval of the Engineer, and will only be permitted for small irregular areas of work.

Except as specified below, no loads of mix shall be despatched from the plant so late in the day that they cannot be spread, compacted and completed in daylight. The Engineer may permit the surface course to be constructed after daylight hours, provided sufficient artificial illumination is available and that the work performed complies in every respect to this Specification.
No mix shall be spread when the base or supporting course is wet or when other conditions prevent proper spreading, finishing or compacting.

c) Spreading and Finishing

Bituminous premix shall be spread by self-powered pavers, which shall be capable of spreading and finishing the mixtures true to the line, grade and crown shown on the Drawings or set by the Engineer, without the use of forms or side supports.

No mix shall be placed when weather conditions are such that proper spreading, finishing, compaction and bonding may not be obtained.

A longitudinal joint when adjoining lane is not placed the same day or has become distorted by traffic or other means, shall be carefully trimmed to line and shall have a near vertical face. The face shall be coated with a thin layer of seal coat before placing the abutting material.

Transverse joint shall be constructed and compacted to provide a smooth riding surface. The joints should be straight and be trimmed to a near vertical face and coated with a thin layer of seal coat prior to the placing of fresh material adjacent to the joint.

Faces of castings, kerbs, gutters, concrete pavement etc. against which the mix is to be placed shall be painted or sealed with bituminous material as specified in Section 4203. The cost of the painting or sealing shall be included in the price bid for bituminous premix and no separate payment shall be made therefore.

Immediately after any course is screeded and before compaction has commenced, the surface shall be checked, any irregularities adjusted, all foreign material removed by a rake or hoe and all fat spots in any course removed and replaced with satisfactory material. Irregularities in alignment and grade along the outside edge shall also be corrected by the addition or removal of mixture before the rolling of the edge is performed.

The Contractor shall provide competent workmen who are capable of performing the work incidental to the correction of all pavement irregularities. Special attention shall be given to the straight edging of each course immediately following the initial rolling.

Any areas such as intersections, turnouts or driveways that are impracticable to be constructed by machine intensive methods shall be spread and finished by acceptable hand methods.

d) Compaction

After spreading, the mixture shall be thoroughly and uniformly compacted. The density of the completed pavement shall be in accordance with the requirements specified below.

Steel wheel rollers shall be tandem static/vibratory rollers unless otherwise approved by the Engineer. Pneumatic tyred rollers shall have a minimum of 7 wheels and be capable of adjusting tyre pressure while moving.

Rolling shall be carried out in three sequences:

- Breakdown rolling by steel wheel roller at a temperature not less than 110^{o}C
- Secondary rolling by pneumatic tyred roller
- Finish rolling, by smooth wheel vibrating or static rollers at a temperature not less than 80^{o}C.

The number of rollers used shall be sufficient to compact at a rate not less than the rate of paving, making due allowance for rapid cooling at low temperature. At all times, the motion of the rollers shall be slow

enough to avoid displacement of the mix. Rolling shall commence as close behind the paver as is practicable and shall be continued until all roller marks are eliminated and no further compaction is possible. The initial pass of the roller over the uncompacted surface shall be with the powered drive wheel towards the paver.

To prevent the adhesion of mix the roller drums and tyres shall be kept moist for their full width, but an excess of water will not be permitted.

In general, rolling shall begin at the sides and shall progress toward the centre, parallel to the centreline of the roadway. Successive passes of the roller shall uniformly lap the previous passes. On superelevated curves, rolling shall start at the low side and progress to the high side as above described. Where a longitudinal joint is being made, the joint shall be thoroughly rolled before starting at the edge to roll inward. Alternate passes of the roller shall be terminated in steps at least 1 metre distant from any preceding stop, and such stops shall be so regulated as to preclude the trapping of any water on the rolled surface. Other rolling procedures may be approved or directed by the Engineer as conditions require.

In areas adjacent to kerbs, compaction shall be performed with a reciprocating tamper or trench roller, or other method, to the approval of the Engineer. In other areas inaccessible to any roller the required density shall be secured by the use of tampers or other compaction equipment meeting the approval of the Engineer.

The Contractor shall employ only bituminous surfacing skilled operators, supervisors and drivers who are capable of adjusting their operations to the observed conditions.

Where the paving and rolling of the surfacing is not carried out in a workmanlike manner the Engineer may suspend surfacing operations until suitably skilled workmen and operators are provided by the Contractor.

e) Small Tools and Portable Equipment

The Contractor shall provide all necessary tools and keep them in first-class condition. Sufficient number of standard 3000 mm straight edges or surface testers for bituminous pavements and standard templates constructed to the true cross section of the road shall be provided by the Contractor and shall be available at all times at all individual work sites where they may be required to be used. This provision shall be complied with before work is started.

f) Surface Tolerances

The finished surface shall not vary more than 3 mm from a template cut to the cross section of the course, nor more than 3 mm from a 3000 mm edge applied parallel to the centreline of the pavement nor shall any portion be more than 3 mm below or above the finished level shown on the Drawings or instructed by the Engineer.

Portions of the completed pavement that do not comply with the requirements of the Specifications shall be taken up, removed and replaced or otherwise corrected in a manner satisfactory to the Engineer. These corrections shall be made at the Contractor's cost.

g) Protection of Wearing Course

After the completion of the wearing course, no vehicular traffic shall be allowed on the pavement until it has so cooled that its surface will not glaze or flush. Upon completion of the final rolling, suitable barricades shall be placed on the surface of the course at such intervals as will keep vehicular traffic off the course. The minimum period of protection shall be 6 hours after placing and when the shade air temperature is above 30^{o}C the protection shall be lengthened by the Engineer as required but in no case shall this exceed 10 hours.

h) Plant Tickets

When batch mixers are used, the number of batches and total net weight of all loads of mix shall be recorded in triplicate upon Engineer's Plant Ticket forms by an authorised representative of the Engineer. The Contractor shall install and regularly calibrate an acceptable weigh bridge to weigh the mix

transporting vehicles and shall provide suitable plant tickets to the Engineer's requirements. Installation of a weigh bridge is a mandatory requirement for this contract.

With each load delivered to the Work, the driver shall present one copy of the plant ticket to the Engineer's representative and another to the authorised representative of the Contractor. The plant inspector shall keep the third copy until the completion of the Work and then forward it to the Engineer. Any changes in the amounts set forth on the tickets, necessitated by the rejection of any material or in the designation as to where material is used, shall be noted by the Engineer's representative upon all copies, and a reason stated for such rejection. At any time during the delivery of material for the purpose of checking the operation and weighing equipment of the plant, the Engineer may direct the Contractor to weigh or cause to be weighed, on tested and approved scales at the Contractor's expense, any truck either full or empty engaged in delivery of mix to the Works.

i) Sampling Pavement

For the determination of thickness and density of the compacted mix, the Contractor under the supervision of the Engineer will take core samples of the pavement. These cores shall be a minimum 100 mm diameter and taken at intervals of not more than 200 lane metres or 2 per day whichever gives the greater number of samples.

If the bulk density of the compacted mix determined from these cores is less than 96% of the design density of the mix, such additional rolling or modification of rolling shall be initiated at once as will secure this result. This rolling shall be carried out when the ambient temperature is high and shall employ pneumatic tyred rollers at maximum tyre pressure. Steel wheeled rollers shall not be used. Upon completion of rolling, further cores will be taken and tested as above. If the results remain less than the required value, the Engineer may direct that the mix represented by this core be removed from the works and replaced at the Contractor’s expense.

j) Thickness

The total thickness of bituminous premix courses determined as herein specified, shall be not less than the design thickness, and shall not be more than 6 mm greater. When the total thickness is less than the minimum specified, the deficient area shall be corrected at the Contractor's expense either by an overlay course, or by removal and replacement of the unsatisfactory thickness. The corrective measures will be subject to the approval of the Engineer.

k) Acceptance Sampling and Testing of Bituminous Mixture

The mean and range of the density of the pavement will be calculated from the results of all tests run on randomly selected sites each two production days. Regardless of the quantity of pavement placed, no less than ten tests will be run. The compaction of the lot will be considered acceptable when the average of all test results for two production days is equal to or greater than 96% of the target density plus 0.35 times the range (the difference between the largest and smallest test result).

In additional to the tests which are run on randomly selected sites, the Engineer reserves the right to test any area which appears defective and to require further compaction of areas that do not have at least 96% of target density.

The in-situ and target densities shall be measured in terms of "Bulk Specific Gravity" as determined by AASHTO T166. The target density test specimen shall be determined using the procedure for test specimen preparation including mixing, moulding and curing described in AASHTO T167. (Compressive Strength of Bituminous Mixtures')

When the thickness of a sample is found to be less than the minimum permissible pavement thickness, two additional samples shall be cut at locations 2 m longitudinally in both directions from the location of the deficient sample. If both of these samples give thicknesses more than the design thickness, the represented shall be considered satisfactory and no correction shall be required. If either or both of these samples are deficient in thickness, additional samples shall be taken in the direction or directions of deficiency indicated, at intervals of 30 metres measured longitudinally from the location of the first deficient sample, until a pavement thickness within the specified tolerance limits is found.

If an overlay is used for correction it shall be placed for the full width of the pavement over the entire area of deficiency and shall have butt joints at the ends. A tack coat meeting the requirements of the Contract Specification shall be applied at the expense of the Contractor.

The overlay course shall be not less than a 20 mm thickness of 10 mm mix or 40 mm of 20 mm mix and it shall not be measured for payment.

If the deficient area in a lane is removed and replaced, the courses shall be stepped into adjoining pavement for a distance of 500 mm at the ends and 300 mm at the edges. The area of deficiency in this case need not extend to the limiting sample locations described above, but shall extend to the point where the thickness of the exposed edge of bituminous premix remaining is found to be of satisfactory thickness. The supporting base course shall be regarded and re-compacted if necessary, and the various courses replaced. The overall thickness of the replaced courses shall be within the tolerances specified.

4308 Mix Quality Control Testing

The Contractor shall keep daily records of all his tests and these records shall be sent to the Engineer the following day. The Contractor shall provide the Engineer with the following 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.

a) Temperature of mix when sampled at the mixing plant and on the road (each truck load).

b) Laboratory Density of three compacted specimens fabricated following AI MS-2 6th Ed. Chapter 4, from each sample, and each type of mixture destined to the paving operation.

c) Density of finished in-place mix, and percentage compaction (following AAHTO T 166, and AI MS-2 6th Ed. Chapter 4), of the mix relative to that day's Laboratory Density of the same mix type, of at least two randomly selected core samples, but not more than 200m apart, which shall be a minimum of 10 cm in diameter. The thickness of these same core samples shall be reported.

d) Marshall Stability and Flow as defined in this Specification section for each set of the three specimens prepared for the determination of Laboratory Density for each type mix.

e) Asphalt content and aggregate grading of mix as determined by bitumen extraction testing for at least two samples, one for the morning production and one for the afternoon production. The centrifuge method according to AASHTO T 164 will only be used as an indication of the bitumen content, the batch weight of bitumen taking precedence as a measure of actual bitumen percentage in the mix. The gradation of the extracted aggregate shall be accomplished in accordance with AASHTO T 30.

f) Air voids in laboratory compacted specimens as calculated based on the Maximum Specific Gravity of Bituminous Paving Mixtures (AASHTO T 209) performed on the same sample of mix used for the laboratory compacted specimens.

g) Voids in the Mineral Aggregate (VMA) calculated as per AI MS-2 6th Ed., Chapter 4.

h) Control charts showing a moving average of 5 sample results for extracted bitumen content, the 4.75 mm, 2.36 mm, 0.30 mm and 0.075 mm sieve sizes, as well as % air voids, shall be updated daily and posted at the plant site in clear view. The Engineer may request copies of these charts at any time.

4309 Method of measurement

Measurement for bituminous premix surface course of the various thicknesses specified shall be made in cubic meter accepted.

No price adjustment shall be made in case the quantity of bitumen used becomes more or less because of change in job mix formula during the process of the works.

4310 Basis of Payment

The quantities measured as provided above shall be paid for at the Contract unit price per Sqm bid for:

Item		Unit
43/1 -	Bituminous Premix Surface Course 38 mm.	Cu.m
43/2 -	Bituminous Premix Binder Course 57 mm	Cu.m
43/3 -	Bituminous Premix Base Course 130 mm	Cu.m
43/4 -	Bituminous Premix Surface Course 50 mm.	Cu.m

Which prices and payment shall constitute full compensation for the Bituminous Premix Surface Course complete in place and includes the furnishing of all materials, labour, equipment, tools, sampling, field trials testing and incidentals necessary to complete this item.'

5000 MISCELLANEOUS WORK

5100 Pitching and Stonework

General

This section covers the furnishing of materials and construction of a protective covering in stone pitching, or cast in situ concrete pitching on exposed surfaces such as earth slopes, drains and stream beds, as well as heavier protection in the form of riprap and stone masonry retaining walls all as shown on the Drawings.

5102 Materials

Stone

Stone for pitching rip raps and masonry shall be hard to very hard field or quarry stone and shall be of no less than 2.24 gr/cm^3 density, and a compressive strength of no less than 50MPa. They shall be, irregular, tough and durable. Minimum size of the stone used shall not be less than 200 mm in minimum dimension. Any stones less that 200mm shall be used only with cement/sand mortar to fill the gaps and spaces between the larger stones. Rocks or stone shall be of such a shape as to form a stable protection structure of the required section. Rounded boulders or cobbles shall not be used on slopes steeper than 2:1 unless grouted. All stone intended for use on any particular pitching or masonry job shall receive the prior approval of the Engineer.

Stone for riprap and Gabion works shall be hard field or quarry stone not susceptible to disintegration or excessive weathering on exposure to the atmosphere or water. It shall be free from soft material such as sand, clay, shale or organic material and shall not contain an excessive amount of elongated stone. The critical mass for Rip raps and Gabion works are 10kg.

The required size of stone will be determined by the "critical mass" specified. At least 50% of the material comprising the riprap shall consist of stones having a mass heavier than the critical mass and not more than 10% by mass of the material shall consist of stone having a mass of less than 10% of the critical mass or more than 5 times the critical mass.

Cement

Cement for concrete, mortar and grout shall be from an approved source and shall conform to the requirements of AASHTO M85 for Type I cement. Cement shall have low alkali content with a sodium oxide equivalent of less than 0.6%.

Sand

Fine aggregates (sand) shall contain maximum size of particles is 4.75 mm and shall conform to AASHTO M6 and M80 respectively, and to the requirements of this Specification. The quality of sand shall be highest and shall not have any impurities beyond the limits of below table;

Table 5.1- Maximum amount of deleterious substances

Item	Maximum % by Mass	
	Fine Aggregate	Coarse Aggregate
- Material passing 0.075 mm sieve	2.0	1.0
- Lightweight material	2.0	3.0
- Clay lumps	1.0	0.5
- Other deleterious substances Such as shale, alkali, mica, soft and flaky particles	3.0	3.0

Concrete

Concrete works shall be carried out in accordance with the provisions of Section 7300.

5103 STONE PITCHING

a) Plain stone pitching

The area shall be excavated shaped, compacted and trimmed to accommodate the stone work. A trench shall be excavated as directed by the Engineer along the toe of any slope to be pitched or along the unprotected edge of the pitching in the beds of stream.

Commencing at the bottom of the trench, the stone shall be laid and firmly bedded into the slope and against adjoining stones. The stones shall be laid with their longitudinal axes at right angles to the slope and with their surfaces in contact so as to break joint. The stones shall be well rammed into the bank or surface to be protected and the spaces between the larger stones shall be filled with fragments of approved pitching stone securely rammed into place. Placing of rock by dumping shall not be allowed.

The finished surface of the pitching shall present an even, tight and neat appearance with no stones varying by more than 25 mm from specified surface grades or lines. The thickness of the pitching, measured at right angles to the surface, shall not be less than 200 mm, or as indicated on the drawings.

b) Grouted stone pitching

This work shall be similar to plain stone patching except that the spaces between the stones shall be filled with cement mortar composed of 1:3 cement to sand. Before the mortar is applied the surfaces of the stones shall be thoroughly cleaned of adhering dirt and clay then moistened.

The mortar shall be placed in a continuous operation for any day's run at any one location and shall be worked into the pitching to ensure that all spaces or voids between the stones are completely filled to the depth of stone pitching. After the grout has been placed, the stones shall be thoroughly brushed so that their top surfaces are exposed. The grouted pitching shall be cured for minimum four days after grouting with wet sacking or other approved wet cover, and shall not be subjected to loading until adequate strength has been developed. Where required, weep holes shall be formed in the pitching.

The Mortar shall have a compressive strength of at least 14MPa, besides being mixed on predefined proportion, if the mortar would results in less than 14MPa, the contractor has to take remedy actions toward correction of the issue, it may be necessary to decrease the sand proportion in the mix in order to attain the specified strength, such alteration should be made by the contractor without any extra charge than those quoted in Bill of Quantity. The contractor shall take at least one set of six cubes of mortar from each production point, and at least one per day.

5104 Riprap

Riprap shall consist of a course or courses of large rock placed on bank slopes and toes, river and stream beds and other localities where protection of this type may be required. Two types of riprap are specified,

1. Packed riprap Rocks are individually packed,
2. Dumped riprap. Rocks are dumped and then spread by machines,

The surface of areas to receive riprap shall be neatly trimmed to line, leveled and compacted of any loose material. The perimeters of riprap shall be protected by the construction of either rock-filled trenches, walls or other structures as may be required. Perimeter trenches shall normally be backfilled with rock of the same size and quality as used in the construction of the riprap it adjoins but any cavities shall be filled with smaller material and the whole backfill well consolidated.

5105 STONE MASONRY WALLS

General

Stone masonry walls may be plain with dry joints or cement mortar joints as indicated on the Drawings. The Stones used for masonry wall shall comply with the conditions specified in the Clause 5102 “Materials” of this specification.

Plain stone masonry walls

A foundation trench shall be excavated down to rock, or to material of adequate bearing capacity at a minimum depth of 300 mm below ground level. Large selected stones shall be laid with the largest dimension in the horizontal plane. Stones shall be individually placed to break joints and to provide a minimum of voids, and shall be firmly bedded against adjoining stones. The spaces between the larger stones shall be filled with spalls securely rammed into place. The larger stones shall not bear on the spalls used to fill the voids. The top and ends of the wall shall be neatly finished with selected coping stones. The resulting appearance of the wall shall present an even, tight surface.

Cement mortared stone masonry walls

The construction shall be as for plain walls above, with the exception that the stones shall be wetted and set in 3:1 sand: cement mortar. Exposed stones on the wall faces shall be cleaned of mortar by washing or wire brushing. The mortar shall be flush pointed to the approval of the Engineer who may require a capping and end treatment in the same mortar. Weep holes shall be provided as ordered and shall be cleaned of mortar and any other clogging material that may have entered during construction. The wall shall be protected and kept moist for a minimum period of four days after completion.

5106 MEASUREMENT AND PAYMENT

Stone Pitching

The tendered rate for each type of stone pitching shall include full compensation for furnishing all materials, compaction and trimming of excavated areas, testing, placing of stones, grouting where applicable; and for all other work necessary to complete the pitching as specified.

Excavations for foundation and the construction trenches and edge beams will be paid for separately.

Pay Item		Unit
51/1	Plain pitching	Sq.m
51/2 (a)	Grouted pitching (200 mm thick)	Sq.m
51/2 (b)	Grouted pitching (250 mm thick)	Sq.m

Riprap

The rates tendered shall include full compensation for the preparation of surfaces, including excavation but excluding excavation for trenches and bulk excavations and for the furnishing, transporting, testing, handling and placing of riprap. Collectively the rates shall also include full compensation for all other incidentals necessary for completing the work as specified.

Pay Item		Unit
51/3	Packed riprap (Critical mass of stone indicated)	Cum
51/4	Dumped riprap (critical mass of stone indicated)	Cum

Stone masonry walls:

The tendered rate for each type shall include full compensation for furnishing all materials, trimming of areas, placing of stones and cement-mortar where necessary, testing and all other work necessary to complete the walls as specified. Forming of weep holes will not be paid separately and its price should be considered to be incorporated in stone masonry, however the excavation of foundation paid separately.

Pay Item		Unit
51/5	Plain	Cum
51/6	Cement-mortared.....	Cum

5200KERBS AND FOOTWAYS

General

This item shall consist of concrete cast-in-place or precast kerb, combination of kerb and gutter, header kerb and/or footway composed of Portland cement concrete or other approved material constructed in accordance with these Specifications at the location and to the dimensions, lines and grades shown on the Drawings. The concrete shall be composed of coarse aggregate, fine aggregate, Portland cement, water, and any admixture in accordance with the Specifications for concrete 6000 series.

5202 Concrete Kerbs and Footway

a) Description

This item shall consist of concrete kerb or kerb and gutter as specified herein and shown on the Drawings. Kerbs may be precast or in-situ concrete.

b) Precast Concrete Sections

Unless otherwise described in the Contract, or approved by the Engineer, precast concrete slabs or precast concrete flags shall be hydraulically pressed or cast in such other manner as is approved by the Engineer.

Precast concrete sections shall be constructed of Class C structural concrete as provided in Section 6.02.

Precast concrete kerbs, edging and quadrants shall comply with and shall be laid and bedded in a layer of mortar not less than 12 mm and not more than 40 mm thick laid on 150 mm Class E concrete foundation or alternatively on pavement base course at least 150 thick. Kerbs shall be backed with Class E concrete.

Any unit of kerb, channel edging and quadrant deviating more than 4 mm in 2 m from line and level shall be made good by lifting and relaying.

c) In-situ Concrete Kerbs

In-situ concrete kerbs shall be laid by approved methods. The kerbs shall be dense with regular sides, arises and chamfers finished to a fine surface free from blow holes and dragging and to dimensions described in the Contract. The kerbs shall be formed in concrete Class C structural concrete as specified in Section 6.02.

Kerbs shall be cut whilst the concrete is green to form expansion joints and contraction joints at not more than 3 m centres and the cut shall be grooved with a 3 mm radius grooving tool.

Expansion joints shall be filled and sealed with materials complying with the requirements of the Engineer for expansion joint filler in such cases.

The vertical alignment of the finished kerb shall not depart from the true level more than ±6 mm and, at any point; the maximum deviation of the top of the kerb under a straight edge shall 4 mm in 2 m.

The horizontal alignment shall not depart from that shown in the drawing.

d) Footways (Concrete Paved)

Precast concrete flags (slabs) for footway sidewalks or footpaths shall comply with the requirements given above for precast sections.

Flags shall be laid to the required cross falls, unless otherwise specified, with a 3% downgrade in the direction away from the road centreline, and bedded using 3 parts of cement mortar not less than 150 mm in diameter for each slab. The flags shall be laid to a 150 mm minimum bond or as described in the Contract with joints at right angles to the kerb.

On circular work where the radius is 12 metres or less all flags shall be radially cut on both edges to the required line.

Concrete or concrete footway and steps shall be Class C in accordance with the Specifications.

Forms for concrete footway cast in place shall be of wood not less than 50 mm nominal thickness or of steel of equal rigidity. Flexible strips shall be used on curves. The form shall be securely held to line and grade and shall at no time deviate more than 6 mm from an accurate template 30 m in length. Forms shall be cleaned and oiled after each use.

Transverse expansion joints shall be 6 mm to 10 mm wide and shall be placed in such manner that the joint will be filled to within 12 mm of the surface of the walk and shall be constructed at intervals of not more than 8 metres, unless otherwise ordered by the Engineer. They shall be placed at the grooved division line and shall be truly normal to the grade. Wherever concrete footway abuts other walks, steps, kerbs, manholes, catch basins, or adjacent building foundations, expansion joins 12 mm thick or joint composed of two thicknesses of 6 mm material shall be provided. At the expansion end of a bridge, an approach walk shall be effectively separated. All concrete shall be cleaned from the top of the pre-moulded joints.

Footway and steps shall be placed and finished by the following methods.

The base course shall be adequately moistened just before the concrete is placed. The concrete shall be deposited and compacted in a single layer to the thickness indicated on the Drawings and the minimum layer thickness shall be 75 mm. It shall be struck off with a template and smoothed with a float to produce a sandy texture. The edge shall be rounded to 6 mm radius.

The surfaces of footway shall be divided into blocks by the use of a grooving tool. The grooves shall be spaced equally at approximately 2 metre intervals to form rectangular blocks, unless otherwise ordered by the Engineer. Grooves in the surface of footway reinforced for beam action shall not be placed where the full thickness of concrete is required for strength. During the setting and before the removal of forms, no loading shall be paced upon the concrete. Footway forms shall not be removed within 72 hours after the concrete is placed. Immediately after the forms are removed any concrete that is unsatisfactory in appearance or density shall be replaced or repaired.
Treads of steps shall be finished to produce a sandy texture. The forms on faces of steps or integral walls which will be exposed to view shall be removed as soon as the concrete is hardened sufficiently that it will not be injured, in order to facilitate surface finishing. Any small cavities or openings in the surface shall be neatly painted with cement mortar of the same proportions as used in the original mixture. All exposed surfaces of integral walls and steps, except treads, shall be rubbed with a float until all projections and form marks are removed. The material which, in the above process, is being ground to paste, shall then be brushed "thinly and uniformly over the entire surface and allowed to reset.

Within 15 days from this time, the final finish shall be attained by a thorough rubbing with a fine silicon carbide or other equally good abrasive. The rubbing, using clear water, shall continue until the entire surface is of a smooth texture and uniform colour.

No heavy loads shall be permitted on the footway or steps at any time. Concrete footway and steps shall be protected, cured and opened for use as specified herein under Part 7, Concrete Construction.

5203 Measurement and Payment

Measurements for the kerb shall be made for the volume of the concrete placed according to specification, and drawings, completed and accepted by the Engineer. The quantity measured as provided above shall be paid for at the contract unit price per cubic meter.

Measurements for the footway to be paid shall be the actual volume of the concrete placed of footway according to specification, and drawings, completed and accepted by the Engineer. The quantity measured as provided above shall be paid for at the contract unit price per cubic meter

The Payment shall constitute full compensation for necessary excavation and backfill, the removal and disposal of all surplus excavation and discarded material, furnishing, preparing and placing all material, including expansion joints, cement, reinforcing steel, sub grade material, drainage outlet for sub grade material, and for all labor, equipment, tools and incidentals necessary to complete this item.

Where kerb or combination kerb and gutter is used to form medians or islands, the cost of backfilling of earth inside the medians or island with falls to the top of the kerb and the furnishing and placing of drainage pipe through the kerb and median is included in the price per metre bid under the respective bid items above.

Pay Item		**Unit**
52/1	Pre-cast Concrete Footway, 25MPa	cu.m
52/2	In-situ Concrete Footway, 25MPa	cu.m
52/3	Concrete Kerb, 25MPa	cu.m
52/4	Concrete kerb and Gutter, 25 MPa	cu.m

5300: ROAD SIGNS AND ROAD APPURTENANCE

General Description
This item shall consist of the provision and installation of road signs to the dimensions and lines that are in accordance with these Specifications and Engineering Drawings.

The item shall not include project signs, temporary signs and barricades installed in accordance with General Specification 1000 for Provision for Traffic.

5301 Sizes and Colours

All signs shall be the sizes, colours and shapes shown on the Drawings and as per the AASHTO standards.

5302 Fabrication of Signs

Sign supports shall be fabricated of Galvanised mild steel and the posts shall be retained in the ground with concrete Class E, using steel and concrete as specified in these Specifications, and as shown on the Drawings. Signboards shall be fabricated from aluminium sheet of thickness not less than 10 gauges.

Tubular steel supports shall be a minimum of 70 mm outside diameter or as required to resist wind loads of 2.5 kPa with only minor deflections and shall be galvanized.

Cleaning and finishing shall conform generally to BS 7079. The top two coats of paint shall be horizontal black and white strips commencing with black at ground level.

Sign faces shall be braced with aluminium sections affixed to sign with suitable rivets as necessary and shall be firmly fixed to the support and prevented from rotating.

The Contractor shall provide detailed Drawings, load and stress calculations of the signs to be provided showing the fabrication of the sign faces and their connection to the supports. The sign face material shall be of "Plastic Sheeting". Plastic sheeting shall be Scotch lite High Intensity Grade Reflective Sheeting or equivalent. Reflective sheeting shall be fixed to the sign plate with heat activated adhesive using a heat vacuum applicator. The High Intensity Reflective Sheeting materials shall be applied on treated aluminium by heat vacuum treatment. The surface of the sheeting shall be smooth and flexible. Reflective materials shall have high durability under all weather conditions, heat and moisture.

The minimum retro reflective values will remain effective for its intended use and the stated minimum retro reflective value.

Table 5.1 Minimum Coefficient of Retro reflection

Candle/Sq.Ft. (.2^0 observation and -4^0 entrance)

Sheeting Colour	Coefficient of Retro reflection	Initial Minimum after (7 Years)
White	250	200
Yellow	170	136
Red	45	36
Green	45	36
Blue	20	16

The expected service life of plastic sheeting should not be less than 7 years. With his tender the Contractor shall indicate his proposed road sign, its manufacture, sign facing and Specifications.

At least sixty days before the erection of any sign the Contractor shall supply detailed Drawings and Specifications and a sample sign for the Engineers approval. The signs supplied and erected

shall be equal to or better than the approved sample and shall conform to the drawing and Specification.

5303 Erection of signs

Signs shall be erected in the manner and at the locations and be of the types shown on the Drawings or as directed by the Engineer. Where the indicated position of a sign is obstructed, the sign shall be located as directed by the Engineer. The Contractor and the Engineer shall inspect all sign locations prior to erection. No payment will be made for relocating a sign erected without the Engineer's prior approval.

5304 Method of Measurement and Payment

Signs shall only be measured for payment after they are completed in place and accepted by the Engineer. Payment shall be full compensation for excavating foundations, supplying and placing concrete backfill, manufacture, design, supply and erection of signs including all labor, equipment and tools required to complete the work.

Signs, shall be measured by the number of signs supplied, erected and accepted.

Payment shall be at the contract unit price for the items listed below which are shown in the bill of quantities.

Pay Item		Unit
53/1	Road Signs	each

5305 Kilometre Posts

General

This item shall consist of the supply and erection of reinforced concrete kilometre posts as shown on the Drawings. The concrete and reinforcement shall be as specified for precast concrete.

5306 Letters and Figure

Letter and figures as directed shall be inset 5 mm deep in the face of the concrete pillar during casting or, for kilometre posts, in a plaster coating applied to the roughened surface of the precast concrete tablet, or as shown on the Drawings. For kilometre posts the letters and figures shall be painted black and the background shall be yellow, all in approved paint supplied in new sealed drums and from a reputable manufacturer.

5307 Erection

Posts shall be erected truly vertical to the depth shown and at the position marked on the Drawings and as directed.

Kilometre posts shall be erected in such a manner that, as the post is approached, the letters and figures seen on the visible face of the post will be those referring to the name of, and the distance to the town towards which the traveller is proceeding. No part of the post or foundation shall be closer to the edge of the pavement than 2.5 m.

5308 Method of Measurement and Payment

Payment shall constitute full compensation for excavation and backfill, the removal and disposal of all surplus excavation material and discard material, furnishing preparing and placing all material including all concrete, mortar, paint, reinforcement, and for all labour, equipment, tools and incidentals necessary to complete the item.

For kilometre posts the number of posts to be paid for shall be the actual number of posts installed, completed and accepted.

Pay Item		Unit
53/2	Kilometre Posts	each

5309 Concrete Guard Posts

General

This work shall consist of furnishing and installation of concrete guard posts as detailed on the drawings and at locations indicated on the drawings or as directed by the Engineer.

5310 Materials

Concrete guard posts shall be pre cast using concrete and reinforcement. Paint, if not indicated on the drawings, shall be of the appropriate type and colours and approval of the Engineer.

5311 Construction Methods

Construction, fabrication and installation of concrete guard posts shall be as shown on the drawings.

5312 Measurements and payment

The price and payment shall be full compensation for the furnishing and placing, painting, including all materials, labour, equipment, tools and incidental necessary to complete the work.The quantity measured for payment shall be the actual number of concrete guard posts placed and accepted.

Pay Item		Unit
53/4	Concrete guard post	each

5400PAVEMENT MARKINGS

5401 General

Road marking paint shall be specially manufactured for that purpose and comply with AASHTO M 248, Ready-Mixed White and Yellow Traffic Paints.

Thermoplastic material for road marking shall comply with AASHTO M249, White and Yellow Reflective Thermoplastic Striping Material (Solid Form). Road markings shall be reflectorised with glass beads that comply with AASHTO M247, Glass Beads Used in Traffic Paint.

The Contractor shall submit, for each consignment of thermoplastic material delivered to Site, a Manufacturer's certificate to show that the materials comply with the Construction Specification. Paint will be cheaper and thermo will last longer

5402 Equipment

Line marking and the surface application of glass beads shall be carried out only by mechanical means.

Equipment shall be capable of mechanically extruding hot thermoplastic material to produce a line thickness of between 4 and 6 mm. The Contractor shall conduct Site trials to demonstrate the satisfactory performance of his equipment to the Engineer.

Letters, figures and symbols shall be marked on the road by means of stencils.

5403 Application of Road Markings

Traffic markings shall be applied to bituminous surfaces only after sufficient time has elapsed to allow for the evaporation of volatile substances from the bitumen.
Before road marking commences, the road surface shall be clean and dry and completely free from soil, dust, grease, petroleum products or other deleterious material.

Thermoplastic material shall be applied mechanically in a single layer. Rates of application of thermoplastic materials shall be checked and adjusted if necessary on a daily basis.

The Contractor shall apply retro reflective beads to road markings by means of a spraying device, forming an integral part of the road marking machine, immediately after the application of the road marking material and in one continuous operation. Machines that apply beads by means of gravity only shall not be used.

The rate of application of glass beads to thermoplastic material shall be 0.35 kg/m2 or such other rate as may be instructed by the Engineer.

5404 Retroreflective Studs

Retro reflective road studs shall not be placed over longitudinal or transverse pavement joints.

Dowel holes shall be drilled in accordance with the manufacturer's instructions. The dowel hole and the adjacent portion of the pavement surface to which the marker is to be bonded by adhesive shall be thoroughly cleaned by blasting.

The adhesive shall be placed uniformly inside the dowel hole and on the adjacent pavement surface, or alternatively, directly to the dowel and on the underside of the marker in a quantity to ensure complete coverage of the contact area with no voids present and with a slight excess after the marker has been pressed into place. The marker shall be placed in position and uniform pressure applied until firm contact is established. Excess adhesive around the marker shall be immediately removed. Soft rags moistened with an approved solvent complying with the manufacturer's recommendations may be used, if necessary, to remove adhesive from exposed faces of pavement markers. Only approved solvents may be used for this purpose.

Mixing and use of adhesive shall be in strict accordance with the manufacturer's instructions to ensure that materials are used within the permissible limits. Any adhesive which becomes too viscous shall not be used.

Retro reflective markers shall be placed so that the reflective face of the marker faces the oncoming traffic.

Retro reflective road studs shall be within ± 20 mm of the required longitudinal position and within ± 5 mm of the required lateral position.

5405 Tolerances for Thermoplastic Road Markings

The width of lines and other markings shall not deviate from the specified width by more than 5%.
The position of letters, figures, symbols or lines shall not deviate from that shown in the Drawings or Construction Documents by more than 20 mm in any direction.
The alignment of any edge of a line parallel to the road centreline shall not deviate from that shown in the Drawings or Construction Documents by more than 10 mm in 15 m.

The length of segments of any broken line parallel to the road centreline shall not deviate from that shown in the Drawings or Construction Documents by more than 150 mm.

Both broken and unbroken lines on horizontal curves shall not be marked as chords but shall follow the correct arc, not deviating from it by more than 20 mm.

5406 Method of Measurement and Basis of Payment

The length of a pavement marking to be paid for shall be that length, being the product of the specified width of each line and the specified centre line length thereof, actually installed in accordance with these Specifications and the Drawings and as directed, finished in place, completed and accepted. The measurement of irregular areas shall be as directed by the Engineer.

The number of Reflective studs to be paid shall that which have been actually installed and have been accepted by Engineer as per these specification and drawings as directed, finished in place, completed and accepted.

Payment shall be at the contract unit price for the items listed below which are shown in the bill of quantities.

Pay Item	Unit
54/1 - Road Marking, Edge Line	L.m.
54/2 - Road Marking, centre Line (Intermittent)	L.m.
54/3 - Retroreflective Studs	Each.

Payment shall be full compensation for furnishing all labour, materials, equipment and incidentals and for doing all work necessary to prepare the road surface and to paint pavement marking onto the roads at the locations shown on the Drawings and as specified herein or directed by the Engineer and including making good or repainting those areas where the surfacing peels or loses balloting and is deficient in appearance

5500BRICK AND BRICKWORK

General

This section specifies whole bricks for use in the Works and specifies brickwork construction using whole bricks and mortar.

5502 Sampling

Whole bricks shall be sampled in accordance with standard test procedures. Samples thus collected will be tested for crushing strength, unit weight and water absorption. Samples shall be collected from each batch of 10,000 bricks supplied.

5503 Dimension

First Class Bricks should have the following dimensions after burning: 250 mm x 120 mm x 70 mm.

5504 Appearance

Bricks shall be uniform in size and colour and shall have a clear metallic sound when struck. They should have an even surface without cracks. When scratched by steel nails these should leave no permanent mark on the surface.

5505 Unit Weight

Bricks shall be broken by hand or machine to the sizes shown below in order to determine the unit weight.

Sieve Sizes (mm)		Percentage of Sample	Min. Weight Reqd. Grams
Passing	Retained		
38	25	25	1500
25	19	25	1500
19	12.5	25	1500
12.5	9.5	25	1500

The unit mass shall determined in accordance with Standard Test Procedures Test 7.3 (Compacted).

The unit mass of First Class bricks shall be not less than 1100 kg/cu.m.

5506 Crushing Strength

The crushing strength of bricks shall be tested in accordance with Standard Test Procedures Test 7.9.

The average crushing strength of First Class bricks shall be not less than 17 MPa.

5507 Water Absorption

Bricks shall be broken by hand or machine to the sizes shown below in order to determine the water absorption.

Table 5-1

Sieve Sizes (mm)		Percentage of sample	Min. Weight Reqd. Grams
Passing	Retained		
38	25	25	750
25	19	25	750
19	12.5	25	750
12.5	9.5	25	750

The water absorption shall be determined in accordance with Standard Test Procedures Test 7.2 for Material between 38 mm and 10 mm.

The water absorption as a percentage of the dry weight shall not exceed 20% for First Class bricks.

5508 Bricks for Brick Masonry construction

Only First Class bricks shall be used in brick masonry construction.

Bricks shall be laid to the specified bond or as directed on a full bed of the mortar described in the contract and single frogged bricks shall be laid with the frog uppermost. Perpends between bricks shall be filled with mortar before the next mortar bed is laid. Whole bricks shall be used except where necessary for closers or where expressly authorized. Exposed joints shall be treated as specified herein below. Brickwork shall be built uniformly; corners and other advanced work shall be racked back and not raised above the general level more than one metre. Courses shall be kept horizontal and matching perpends shall be in vertical alignment.

Unless agreed by the Engineer, overhead work shall not be permitted.

Immediately after laying and for 3 days thereafter, brick work shall be protected against harmful effects of weather. The upper surface of newly laid brickwork shall continue to be protected

against rain as the work proceeds by covering with approved waterproof sheets until such time as the brickwork is completed and the upper damp course, coping or other finishing feature is laid.

All visible brickwork and any surface below the brickwork which is visible at the completion of the Works shall be clean and free from damage. All purpose made open joints shall be free from debris of any description.

Fabric reinforcement shall be completely embedded in the mortar joint if specified.

Brick reinforcement shall be completely embedded in the mortar joints, shall be sufficiently thick to prevent stone-to-stone or brick contact and shall be completely filled with mortar.

The joints shall be raked out to a depth of 12 mm and after the completion of the entire face work, pointed in weather struck cement mortar as described in the Contract. All joints shall be pointed except where otherwise specified or approved.

The mortar for joints which are not to be pointed, shall extend slightly beyond the full width of the beds and shall then be struck off flush as the work proceeds.

5509 Brick Face work Fixed to Concrete

Any loose material shall be removed from the concrete, and its surface washed with clean water before any bricks are laid.

The proportion of fixing ties projecting from the concrete shall be completely embedded in the mortar of the face work and shall be kept back a minimum of 30 mm from the face of the brickwork.

The cavity between brick face work and concrete shall be completely filled as the work proceeds with mortar of the same mix as that specified for the face work.

5600: GABIONS

General

This section covers the construction of gabion walls and aprons for the construction of retaining walls, lining of channels, revetments and other anti-erosion structures.

5602 MATERIALS

Rocks used as filling for cages shall be clean, hard, sound, durable and unweathered boulders or rock fragments. No rock particles shall exceed the maximum size given below and at least 85% of the rocks shall have a size equal to or above minimum size given below:

Tale 5-2

	Rock size according to largest dimension of the rock	
Depth of cage (m)	Minimum (mm)	Maximum (mm)
0.2	75*	125
0.3	95**	125
0.5	100	250
1.0	100	300

* Using 60 x 80 mm mesh ** Using 80 x 100 mm mesh

All wire used in the fabrication of the gabions and in the wire operations during construction shall be to BS 1052, having a tensile strength of not less than 350 MPa. All wire used in the fabrication of gabions shall be galvanized in accordance with the provisions of BS 729 for Class

A heavy galvanized mild steel wire. The minimum mass of the zinc-coating shall be according to the figures shown in the table below:

Table 5-3

Nominal diameter of coated wire (mm)	Mass of coating (g/m²) surface area)
3.7 - 4.0	290
3.0 - 3.6	275
2.2 - 2.9	260
Below 2.2	245

The adhesion of the zinc coating to the wire shall be such that when the wire is wrapped six turns round a mandrel of four times the diameter of the wire, it shall not flake nor crack to such an extent that any zinc can be removed by rubbing with the bare fingers.

Wire mesh shall be hexagonal-woven mesh wherein the joints are formed by twisting each pair of wires through the three half turns. The tightness of the twisted joints shall be such that a force of not less than 1, 7 kN is required when pulling on one wire in order to separate it from the other wire provided each wire is prevented from turning and the applied forces and the wire are all kept in the same plane. The diameter of the wire and the size of mesh used shall be as follows:

Table 5-4

Depth of gabion	Mesh size (mm)	Wire diameter (mm)
0.5m and over	80 x 100	2.5
	100 x 120	2.7
0.2m - 0.3m	80 x 100	2.2
	60 x 80	2.0

The shorter dimensions of the mesh shall be taken from centre to centre of the twisted joints, and the larger dimensions shall be between the inside ends of twisted joints.

Where indicated on the drawings or ordered by the Engineer, one layer of geo-textile filter fabric shall be paced on the prepared surface prior to the placing of gabions. The material shall be placed as directed in vertical strips with a minimum overlap of 300 mm, and shall be properly fastened to prevent any movement or slipping during the placing of gabions.

5603 FORMING THE GABION CAGES

Gabion cages shall be fabricated of wire mesh of the size and type and selvedge as specified below. The cages shall be sub-divided into cells by wire mesh diaphragms and will be of two types:

Boxes *:* which are generally used for the construction of gabion walls. Boxes are sub-divided into cells by diaphragms spaced at 1.0 interval.

Mattresses : which are generally used as single layer aprons only in revetments, channel linings, etc., and in which the maximum width shall be 2.0 m, the maximum depth shall be 0.5m. Mattresses shall be sub-divided by diaphragms into cells having a width of 600 mm or 1.0 m as specified in the Bill of Quantities.

Standard sizes of boxes and mattresses as follows:

Boxes:	Lengths:	1, 2, 3 and 4 metres
	Width:	1 m
	Depths	0.3 m, 0.5 m and 1.0 m
	Diaphragm spacing:	1.0 metre
Mattresses:	Lengths:	6 m
	Widths:	2 m
	Depths:	0.2 m, 0.3 m and 0.5 m
	Diaphragm spacing:	600 mm or 1.0 m as directed.

Other gabions may be supplied, provided the Engineer's approval is obtained beforehand.

The cut edges of all mesh used in the construction of gabions, except the bottom edge of diaphragms and end panels, shall be selvedge with wire of at least twice the diameter of the mesh wire diameter. Where the selvedge is not woven integrally with the mesh but has to be fastened to the cut ends of the mesh, it must be attached by finding the cut ends of the mesh, about it so that a force of not less than 8.5 KN applied in the same panel as the mesh, at a point on the selvedge of a mesh sample 1 m long, is required to separate it from the mesh.

The diaphragms and end-panels shall be selvedge on the top and vertical sides only. The end-panels shall be attached by twisting the cut ends of the mesh wires at the bottom of the panel about the selvedge on the base of gabions. Similarly, the diaphragms shall be attached by twisting the cut ends of the mesh to the twisted joints of the mesh of the base of the gabion. In each case the force required to separate the panels from the base should not be less than that required to break the mesh over the same length.

Sufficient binding and connecting wire must be supplied with the gabion cages to perform all the wiring operations to be carried out in the construction of the gabion work specified in section 6204 below. The diameter of wire shall be 2.0 mm. A tolerance on the specified diameters of all wire of $\pm$ 2% shall be permitted. The length of the cages is subject to a tolerance of $\pm$ 3% and the width of cages is subject to a tolerance of $\pm$ 3% up to a maximum of 25 mm.

5604 CONSTRUCTION OF GABIONS

The bed, on which the gabion cages are to be laid prior to filling, has to be levelled to a depth as shown on the drawings or as directed by the Engineer so as to present an even surface. If necessary, cavities between rock protrusions shall be filled with material similar to that specified in Sub-section 6202. Where required, a foundation trench along the toe of the revetment or wall shall be excavated to the dimensions shown on the drawings or indicated by the Engineer.

The methods of erection, stretching, aligning, wiring and filling the gabions shall generally be in accordance with the manufacturer's instructions as approved by the Engineer but, nevertheless, sufficient connecting wire braces shall be provided and tensioned between the vertical sides of each of the outer visible cells to prevent the deformation of boxes as they are being filled with stone.

It is essential that the corners of gabion cages be securely wired together to provide a uniform surface and ensure that the structure does not appear as a series of posts or panels. Consecutive courses of boxes should preferably be `bonded' as in brickwork to avoid the coincidence of vertical joints.

Particular care shall be exercised in filling visible faces of gabion boxes where only selected stone of adequate size shall be used and pre-packed to obtain a fair faced finish. The filling of boxes shall be done in stages in order to prevent deformation and bulging. Boxes shall be filled

to just below the level of the wire braces after which the braces shall be twisted to provide tension. Care must be taken to ensure that consecutive layers of cages being filled are filled evenly to a level surface ready to receive the next course.

The filling of the 0.3 m and 0.5 m gabion mattresses forming aprons and revetments has to be carried out by spreading random stones on the first layer and using selected stones for the top layer so as to present a dry stone-pitched surface.

5605 MEASUREMENT AND PAYMENT

Any excavation is needed will be paid as per the pay item 2000 for structural excavation. The unit of measurement for the levelling and preparation of areas to receive gabions shall be the square metre to the neat dimensions of wall foundations, revetments or aprons.

The tendered rate shall include full compensation for the excavation, filling cavities with rock; for levelling the ground surface ready to receive gabion cages in retaining walls, aprons and revetments.

The unit of measurement shall be the cubic metre of the rock-filled cages and the quantity shall be calculated from the dimensions of the gabions indicated on the drawings or ordered by the Engineer, irrespective of any deformation or bulging of gabions as constructed.

The tendered rate shall include full compensation for the supply of all materials including rock fill, wire mesh cages, binders, connectors; for loading, transporting and offloading; for the assembly and filling of the cages and for any other work necessary for the construction of the gabions.
The unit of measurement shall be the square metre area covered with filter fabric placed in position.

The tendered rate shall include full compensation for the supply of the filter fabric, cutting, waste, placing, joining, overlapping, and fastening the material in position.

Pay Item		Unit
56/3	Surface preparation for gabions	square metre (sq m)
56/4	Gabion boxes (size of box and mesh indicated).	Cum
56/5	Gabion mattresses (depth of mattresses, mesh size an diaphragm spacing indicated).	Cum
56/6	Filter fabric	square metre (sq m)

5700: SUBGRADE DRAINS

General

This work shall consist of excavating, furnishing materials, backfilling and finishing drains in accordance these Specifications and the dimensions and cross sections shown or Drawings or instructed by the Engineer.

5702 Materials

The material for backfilling of sub grade drains shall be clean, free draining gravel, free from any vegetable matter, soft particles, silt or clay. The grading of the material shall conform to the grading shown in Table 5.13

Grading requirements of Drain Backfill Materials

Table 5-13

Sieve	**% Passing by Weight**
10 mm	10
4.8 mm	80 – 100

2.4 mm	65 – 95
1.2 mm	50 –80
600 micron	25 –50
300 micron	10 –20
150 micron	0 – 10
75 micron	0 – 2

5703 CONSTRUCTION METHODS

Sub grade drains shall be excavated neatly in the prepared sub grade to the dimensions and grades shown on the Drawings or as directed by the Engineer.

Drains shall be constructed at the intervals shown on the Drawings. Drains on opposite sides of the road shall be staggered. Geo-textile material shall be placed in the excavation and wrapped around the backfill in accordance to the drawing.

The backfill shall be compacted by hand and struck off level with, or slightly above, the finished sub grade level.

Shoulder and pavement materials over the drains and geofabric shall be placed carefully by hand for a depth of not less than 100mm prior to placing and rolling of the general shoulder and pavement materials.

5704 MEASUREMENT AND PAYMENT

Sub-grade drains shall be measured in linear meters of drain completed and accepted. Drains shall extend from a point vertically below the outer edge of the carriageway surfacing layer to the finished face of the embankment, or side ditch, side slope. In the event that the Contractor constructs the embankment to dimensions in excess as those shown on the plans and sections the Contractor shall extend the sub-grade drains to the embankment face at his own expense.

The work measured as provided above shall be paid at the Contract unit rate per linear meter. Payment shall be full compensation for performing the work including excavation, filling and providing all labour, equipment, materials, tools and incidentals necessary to complete the works.

Pay item:	Unit
57/1 Sub-grade drains	Linear Meter.

5800: TREE PLANTING

General

This work shall consist of planting tree seedlings at the base of embankment and side slope fills to prevent erosion of the material in which it is planted.

5802 CONSTRUCTION METHODS

The planting shall be carried out at intervals and locations as directed by the Engineer. The tree seedlings shall be planted with their root system substantially undamaged, well buried in firm material, and packed around with moist earth in which they have grown.

Tree seedlings 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 seedlings are well established, firmly rooted and the planted area is free from erosion channels.

The Contractor shall maintain the seedlings at his expense until the issuance of the Practical Completion Certificate. Maintenance shall consist of preserving, protecting, watering and replacing seedlings and such other work as may be necessary to keep them in a healthy condition.

The unit of measurement shall be the Number of planted trees and accepted.

The tendered rate shall include full compensation for the supply of all materials including trees, watering regularly, and cage protecting the trees from animals.

5803 MEASUREMENT AND PAYMENT

Pay Item		Unit
58/1	Tree planting	Number

5900: LINED ROAD SIDE DRAINAGES-

General
As shown on the drawing, side drains should be constructed of grouted stone pitching, with cement mortar and Reinforced Concrete as shown on drawings. The Specification of cement and sand should comply with the specification 6000 series sections.

5902 Materials for Stone Masonry
The materials shall be dressed stone comply with the specifications in section 5700 and 6200

5903 Preparation of Sand Bedding
A layer of sand as shown in the drawing should be placed over the excavated side drain prior construction of lined drain. Sand should be spread in uniform thickness, brought up to the optimum moisture content and compacted with proper equipment such as vibrating plate compactor.

5904 Plastering Side Drain in Cement Mortar
All brick works should plaster in cement mortar (1:3). The plaster should be even and smooth. No cracking is allowed.

5905 Net Cement Finishing
The internal sides of the drains shall be plastered with net cement finishing. The layer should be even and smooth.

5906 Backfilling
All spaces which have been excavated shall be backfilled and compacted with material as shown in the drawing. The layers shall not be more than 250mm in depth and shall be compacted to a density comparable with the adjacent undisturbed material.

5907 Pre-Cast Concrete and cast in-situ Side Drains
This work consists of supply and installation of pre-cast or in-situ concrete side drains as per series 8000.

5908 Placing Side Drains
The pre-cast concrete drains shall be placed according to the drawings or as instructed by the engineer. Care has to taken to maintain the alignment specified in the drawings.

The drains shall be connected by both mechanical and plaster joints.

5909 Measurement and Payment

The tendered rate shall include full compensation for the supply of all materials including excavation, backfilling, loading, transporting and offloading, plastering, neat cement finishing, sand cushions, lean concrete, tools, local haulage etc complete. No extra item shall be measured.

Pay Item		Unit
59/1	Masonry lined concrete drain	linear meter
59/2	Masonry lined Pre-cast or in-situ road side drain	linear meter

6100: CONTRACTOR'S PLANT, EQUIPMENT AND CONSTRUCTION FACILITIES

6101 General

Mixing of Concrete:

Concrete shall be thoroughly mixed in a central batching plant and/or batch mixer of an approved size and type which will ensure a uniform distribution of the materials throughout the mass. No mixer shall be charged in excess of its rated capacity.

The first batch of concrete materials placed in the mixer shall contain a sufficient excess of cement, sand and water to coat the inside of the drum without reducing the required mortar content of the mix. Upon cessation of mixing for a considerable period, the mixer shall be thoroughly cleaned.

Digital scales accurate to one percent throughout the range of use shall be used for measuring aggregates, sand, water and cement shall be approved by the Engineer.

The sequence of feeding to the machine shall be as coarse aggregates, fine aggregate and cement. These materials shall be mixed dry before water is added.

Mixing and delivery of concrete shall be in accordance with the appropriate requirements of ASTM C-94 except as modified in the following paragraphs

All concrete shall be mixed for not less than 2 minutes after all materials, including water, are in the mixer. Every batch shall be mixed until a uniform consistency of the mixture is obtained. The entire contents of the mixer shall be removed from the drum before mixing of the next batch commences.

All concrete should be batched by weight, batching by volume is not allowed on this project.

Concrete shall be placed and compacted within 45 minutes of batching. Concrete which has experienced initial set shall not be used. Remixing of concrete is not permitted.

6102 Handling and Placing of Concrete:

Concrete shall not be placed until the reinforcement and the forms have been inspected and approved by the Engineer.

Before placing of concrete all sawdust, wood chips and other construction debris and extraneous matter shall be removed from the interior of the forms, the reinforcement shall be thoroughly cleaned; and the forms and reinforcement shall be thoroughly wetted.

Concrete shall be placed so as to avoid segregation of the materials and the displacement of the reinforcement. The use of long troughs and chutes requires the permission of the Engineer. The chutes or troughs shall be kept clean and free from hardened concrete.

Concrete to be placed from a height of more than 1.5m shall be poured through troughs, chute, or Tromie pipes unless directed by the Engineer.

All Struts, stays and braces that hold the forms in position of concrete shall be removed when the concrete has reached the strength and an elevation rendering their service unnecessary. They shall not be buried in the concrete.

Concrete shall be laid in layers of 150mm to 300mm in thickness and each layer shall be properly vibrated before laying the next one.

6103 Payment

The Contractor shall not be entitled to any additional payment over the rates and lump sums tendered in the priced Bill-of-Quantities for concrete by reason of any limitations in the batching, mixing, transporting and placing of concrete required under the provisions of this Specification.

6200 COMPOSITION OF CONCRETE

6201 General

a) Concrete shall be composed of Portland cement, fine aggregate, coarse aggregate, water and admixtures as specified, all well mixed and brought to the proper consistency.

b) The source and type of ingredients used in the concrete shall not be varied without approval.

c) All concrete, constituent materials, mixing methods and procedures shall conform to standard approved by the Engineer. Standards of the American Association of State Highways and Transportation Officials hereinafter referred to as AASHTO, and the American Society for Testing of Materials (ASTM) have been quoted herein.

d) All sieve sizes referred to in this Section refer to the aperture dimensions in millimetres to sieves conforming to ASTM E11, ASTM E323 and AASHTO M92.

6202 Maximum Size Aggregate

a) Unless otherwise approve or directed, the nominal maximum size aggregate used in concrete shall be in accordance with Table 6.1 - Part A.

b) In heavily reinforced sections and in walls less than 275 mm in thickness, the Engineer may direct the use of a smaller maximum size aggregate.

6203 Responsibility for Mix Design

The Contractor shall be responsible for the design of concrete mixes, and for ensuring that all concrete placed in the works meets the requirements of the Specification.

The Contractor shall obtain permission from the Engineer to employ volume batching.

6204 Criteria for Designing Mixes

a) General

i. All mixes shall be designed so that the amount of cement and fine aggregate are the minimum necessary to obtain concrete having approved workability, density, permeability, resistance to abrasion, durability, low shrinkage and meeting the requirements as mentioned in this specification.

ii. Concrete mix proportions, including water-cement ratio, shall be established on the basis of field experience and/or trial mixes with the proposed concrete materials.

iii. Make trail mixtures having proportions, consistencies and air content suitable for the work based on methodology described in ACI 211.1, using at least three different water/cement (w/c) ratios for each type and class of mixture, which will produce a range of strength encompassing those required for each class and type of concrete required on the project.

iv. Strengths of concrete shall be determined by testing cylinders at 28 days made and tested in accordance with the standard testing procedure.

v. Concrete for Pile Caps should be designed as mass concrete.

vi. Concrete for pipe culverts should be designed as no slump concrete as per ACI 211.3R

b) Use of Standard Deviation

Where a concrete production facility has test records, a standard deviation for concrete strength shall be established. Test records from which a standard deviation is calculated:

- shall represent materials, quality control procedures, and conditions similar to those expected and changes in materials and proportions within the test records shall not have been more restricted than those for the proposed works.
- shall represent concrete produced to meet the same 28 day strength.
- shall consist of at least 30 consecutive tests that span a period of not less than 45 days.

c) Average Strength of Trial Mixes

i. Where a standard deviation has been established, the required average 28 day compressive strength of trial mixes shall be not less than the strength specified in Table 6.02 (6) - Part A plus the following factor times the standard deviation, depending on the method of measuring concrete batch ingredients, adopted by the Contractor.

Batch Measurement	Factor
by weight	1.65

ii. When no or insufficient test records are available for a standard deviation to be established, the required average 28 day compressive strengths of trial mixes should be determined as follow:

a) If the specified compressive strength f'c is less than 20 MPa
f'cr = f'c + 6.9 MPa

b) If the specified compressive strength f'c is 20 to 35 MPa
f'cr = f'c + 8.3 MPa

c) If the specified compressive strength f'c is over 35 MPa
f'cr = 1.10f'c + 5 MPa

6205 Approval of Mix Design

a) The Contractor shall submit details of his proposed mixes for required classes, at least 60 days before placing any concrete in the Works for approval of Engineer.

b) When test records are used to demonstrate that proposed concrete mixes will produce the required average strengths, such records shall represent materials and conditions similar to those expected. Changes in materials, conditions, and proportions within the test records shall not have been more restricted than those for the proposed works.

c) Before approving the proposed mixes, the Engineer may require the Contractor to prepare, in the Engineer's presence, trial mixes of the proposed mixes to be sampled and tested in accordance with test procedure to verify their compliance with the Specification.

d) During the course of the contract, the Engineer may approve variations to the mix design to take account of the standard deviation achieved in the tested samples.

6300: PROPERTIES OF CONCRETE

6301 Required Properties of Concrete

a) The class of concrete and properties applicable to the concrete in various structures shall be as specified in Table 6.1 - part A. The Contractor shall design mixes to satisfy the properties specified in this table. The mix design shall be subject to approval in accordance with this specification.

Table 6-1 - part A - Standard Classes of Concrete

Class of concrete	Maximum size of aggregate	Maximum Water-cement ratio by mass	Minimum Cement content	Maximum Slump	Target Air Content,	28 day cylinder strength (MPa)

	(mm)		(Kg/cm)	(mm)	%	
A1[1]	20	0.40	450	50	5	40
A	20	0.40	400	75	5	35
B[2]	20	0.45	400	75	5	30
C	10	0.50	410	60	5.5	25
D	20	0.50	360	75	5	25
E	20	0.55	290	75	-	15
F	20	0.70	220	75	-	15

Notes:
1 - The 40 MPa concrete for prestressed concrete bridges should contain plasticizer, and the maximum slump value is before adding HRWR admixture.
2 – The 30MPa concrete which would be used in pile foundations should contain HRWR admixture in order to attain a flowable concrete mixture, also the concrete for pipe culverts should be no slump concrete, the maximum slump range for these types of concrete is not applicable.

6302 Water

The water used in concrete, grout and mortar, for washing aggregate and for curing concrete, shall be subject to approval and shall be free from objectionable quantities of suspended material, organic matter, acid, alkali, salts, sugar and other impurities.

Surface and groundwater in the vicinity of the works may not meet the above requirements without prior treatment.

a) Water used for concrete work will be tested by the Contractor prior to use in concrete and in the presence of the Engineer in accordance with the requirements of AASHTO T26. The water shall meet the following requirements:
   i. The total percentage of solids by mass shall not exceed 2.25%.
   ii. For reinforced concrete the concentration of chloride ions shall not exceed 1000 ppm.
   iii. For prestressed concrete the concentration of chloride ions shall not exceed 200 ppm.

b) When water fails to meet the requirements it shall not be used until treated the water to conform to the Specification or use water from another source.

6303 Regulation of Water Content

a) During batching, the Contractor shall regularly measure the moisture content of aggregates by moisture metre or other appropriate and approved procedure in accordance with AASHTO T217, T255 or T265.
b) The amount of water used in the concrete shall be regulated to adjust for any variation of the moisture content or grading of the aggregates as they enter the mixer as follows:

   i. Weight Batching
   Direct adjustment shall be made to weighed quantities of aggregates of aggregates and the volume of water added shall be corrected for the water in aggregates.

c) To expedite the adjustment of the damp fine aggregate volume in sub-section 7.b. ii a "bulking curve" showing the relation between moisture content and increase over dry volume shall be prepared in advance by tests on the fine aggregate to be used.
d) Addition of water to overcome stiffening of the concrete before placing will not be permitted.
e) Concrete shall have uniform consistency from batch to batch.
f) Aggregate shall not be batched for concrete or mortar when free water is dripping from the aggregate.

6400: CEMENT

6401 Type of Cement

i. Cement for concrete, mortar and grout shall be from an approved source and shall conform to the requirements of AASHTO M85 for Type I or any other type of cement as indicated on drawings. Cement shall have low alkali content with a sodium oxide equivalent of less than 0.6%.

ii. For surfaces exposed to public view, where colour of the finished concrete is important, all cement shall be of the same type and colour and from one source.

6402 Testing Cement

Cement shall be tested in accordance with section 6.9.

6403 Maximum Storage period

Cement that has not been used within 6 months from its date of initial testing at its source in accordance with section 6.9, or has been stored on site throughout a monsoon period, shall not be used in the Works unless it has been retested and approved. Such retesting shall be at the expense of the Contractor.

6404 Delivery of Cement

The Contractor shall deliver cement to the Works in bulk or bags.

6405 Delivery of Bulk Cement

Where cement is supplied in bulk containers, the following requirements shall apply:

a) All containers shall be completely weatherproof and maintained in good order and condition.

b) All apertures in the containers shall be fitted with completely watertight closures and shall be sealed after filling. Depending on the transportation methods adopted, the Engineer may require to be present at any subsequent transfer or delivery point when these seals are to be broken.

c) All containers shall be filled as completely as possible.

d) All containers shall be completely cleaned out at each transfer or delivery point after each and every use and before being returned for refilling.

e) Each and every container dispatched from the manufacturer's works or any intermediate transfer point shall be accompanied by a delivery docket signed by a responsible person which shall clearly show the brand and type of cement, and identification number of numbers relating to the testing and certification of the cement, the date of the testing and certification of the cement, the date of filling the container and the net mass of the cement in the container. This docket shall be carried in a suitable fashion inside the sealed container and shall be handed over to the Engineer at any subsequent transfer or delivery point.

f) Cement supplied in bulk shall not be re-bagged for use in the works without approval.

6406 Delivery of Bagged Cement

Where cement is supplied in bags the following requirements shall apply:

a) Cement shall be delivered in sound undamaged bags uncontaminated by moisture, oil or any other substance.

b) The nominal mass of a bag of cement shall be 50 kg. Where cement is batched by bag, individual bags which vary by more than 5% from the nominal mass shall be rejected. The consignment shall be rejected, if the average mass of 50 bags taken at random from any one consignment is less than the nominal mass.

c) Every bag shall be marked with the manufacturer's brand, the type of cement, identification number or numbers and the date the bag were filled.

d) The contents of broken or damaged bags shall not be re-bagged.

6407 Storage and Handling of Cement

The storage and handling of cement at site, at any intermediate transfer or storage point shall be as follows:

a) All methods for transporting, handling and storing bulk/bagged cement shall be designed, constructed and arranged to ensure the use or transfer of cement in the approximate chronological order of manufacture.

b) All storage bins and cement handling equipment shall be completely weatherproof and substantially dust-free to the satisfaction of the Engineer and shall be designed and constructed to ensure that there will be no dead storage of cement.

c) Batches of cement procured at different times shall be stored separately and shall not be mixed.

d) All loading and unloading facilities for cement shall be under cover and weatherproof to the satisfaction of the Engineer.

e) All storage bins and silos shall be drawn down to be substantially empty at least once every 3 months.

f) Where cement is handled by pneumatic means which involve contact of compressed air with the cement, the temperature of air in contact with the cement shall not at any time exceed 38C^0. When after-coolers or other means provided to cool the compressed air, all compressed air supplies, if the air may come in contact with the cement, filters shall be used for the removal of moisture, oil or any other contaminating substances. Such filters shall be regularly inspected and maintained by the Contractor.

g) All bagged cement shall be stored at all times up to its use in the Works in completely weatherproof structures which shall include a timber floor raised not less than 300 mm above the surrounding ground and be adequately ventilated to prevent the accumulation of moisture.

h) All storage of bagged cement shall be arranged to permit easy access for inspection and definite identification of all cement in the storage.

6408 Temperature of Cement

The temperature of the cement at any time shall not exceed 60C^0.

6409 Rejection

Cement not conforming to the requirements of this specification shall not be used in the Works.

6410 Payment

a) Direct payment will not be made for cement used in concrete, mortar, dry-pack or grout.

b) The cost for cement shall be included in the rates tendered in the priced Bill of Quantities for the various items of concrete construction in which the cement is used.

6500 ADMIXTURES

6501 General

Only approved admixtures shall be used in the concrete, grout or mortar for the works. When more than one admixture is to be used, each admixture shall be batched in its own batcher and added to the mixing water separately before discharge into the mixer. Admixtures shall be delivered in suitably labelled containers to enable identification. All admixtures shall be prevented, by an approved method, from segregating before batching.

The use of such an admixture may not be approved to overcome problems associated with inadequate concrete plant capacity or improperly planned placing operations. It shall only be approved as an aid to extend the finishing time of concrete, or to overcome unusual circumstances and placing conditions. All aspects of the use of admixture, including, but not limited to, the quantity of admixture, the method of introducing the admixture into the concrete , the transporting, handling, forming, finishing and curing of such concrete, shall at all times be subject to approval.

6502 Rapid setting agent

Rapid setting agents are allowed add to concrete mix with the approval of Engineer to accelerate the setting process to facilitate the structure to be open for function it is designed.

6503 Water-Reducing, Set-Retarding Agent

a) The Engineer may approve the use of a water-reducing or set-retarding admixture to the concrete.

b) The water-reducing or set-retarding admixture shall be an approved admixture conforming to the requirements of Type D admixture as defined in AASHTO M194 and shall be compatible with the other ingredients of the mix as demonstrated by tests carried out on site by the Contractor in the presence of the Engineer at least 30 days before it is proposed to use the agent.

c) The specified limits in respect of maximum slump, slump loss during transit and the time allowed for concrete to remain in the mixer may be changed by the Engineer when approval to use the agent is given.

6504 Non-permissible Admixture

Any Admix that might affect the strength of the concrete shall not be used in any concrete, mortar or grout.

6505 Sulphate Resistant

In the event the sub-soil investigation report reveals that soil contents sulphate, then the contractor shall arrange sulphate resistant admixture or use cement that is resistant to sulphate at no extra cost.

6506 Payment

The cost of testing, supply and adding admixtures shall be incidental to their use and shall be included in the tendered rates of Bill of Quantities for the various items of concrete construction. No separate payment will be entertained if the adding of admix was requested by the contractor.

6600 AGGREGATES

6601 General

a) Fine and coarse aggregates shall conform to AASHTO M6 and M80 respectively, and to the requirements of this Specification.

b) The term '**fine aggregate**' is used to designate aggregate in which the maximum size of particles is 4.75 mm. Fine aggregate for concrete, mortar and grout shall be blend of natural sands or manufactured sands.
The term '**Coarse aggregate'** is used to designate aggregate in which the minimum nominal size is 4.75 mm and which is reasonably well graded from 4.75 mm to the largest size required in the work in which the material is being used. Coarse aggregate for concrete shall be consisted of crushed gravel, crushed stone or manufactured aggregate.

c) At least 90 days before placing any concrete the Contractor shall submit, for approval, representative samples of the proposed aggregates from the source proposed by the Contractor in his Tender and approved in the Letter of Acceptance.

6602 Tests

Aggregate will be tested in accordance with section 6.9.

6603 Deleterious Substances

a) Aggregates shall consist of hard, dense, durable, uncoated crushed stone or gravel particles, and shall be free from organic matter and the amounts of dust, clay lumps, soft or flaky particles, shale, salt, mica, alkali, loam and other substances considered deleterious by the Engineer shall not exceed the values given in AASHTO M80 and AASHTO M6 and Table 6.2.

Table 6-2 Maximum amount of deleterious substances

Item	Maximum % by Mass	
	Fine Aggregate	Coarse Aggregate
- Material passing 0.075 mm sieve	2.0	1.0
- Lightweight material	2.0	3.0
- Clay lumps	1.0	0.5
- Other deleterious substances Such as shale, alkali, mica, soft and flaky particles	3.0	3.0

b) The sum of the percentage of all deleterious substances in aggregate as delivered to the mixer shall not exceed 3% for fine aggregate and 3% for coarse aggregate.

6604 Particle Shape

The aggregate shall consist substantially of particles of satisfactory shape having a maximum dimension not greater than 1.8 times the sieve size of the particle and a minimum dimension not less than 0.6 times the sieve size of the particle.

6605 Grading of Fine Aggregate

a. The fine aggregate as batched shall be well graded and when tested shall conform to the limits specified in Table 6-3.

b. The fineness modulus of the fine aggregate is defined as the sum of the cumulative percentages retained on the sieves 4.75 mm to 0.15 mm inclusive and divided by 100 and shall be as shown in Table 6.5.

c. The grading of the fine aggregate shall be so controlled that at any time the fineness module of at least 9 out of 10 consecutive test samples of finished fine aggregate will not vary more than 0.20 from the average fineness modulus of the 10 test samples.

Where fine aggregates from different sources are being used at the one batching plant, or mixing site at the same time, they shall be so blended to ensure uniform grading and colour in successive batches.

Table 6-3 Grading of Fine Aggregate

Sieve size(mm)	% of total mass passing sieve
9.5	100
4.75	95-100
2.3	85-100
1.19	50-85
0.600	25-60
0.300	10-30
0.150	2-10
pan	2-5

6606 Normal size and Grading of Coarse Aggregate

The coarse aggregate as batched shall be separated into normal sizes in accordance with AASHTO T27 and shall be well graded conforming to Table 6.-6, or according to ASTM C33.

Table 6-4 - Nominal size and grading of coarse aggregate

Nominal size (mm)	% of total mass passing sieve	
	Normal size 10 mm	Normal size 20 mm
25	-	100
19	100	90 - 100
12.5	90 - 100	
9.5	40 - 70	20 - 55
4.75	0 - 15	0 - 10
2.36	0 – 5	0 - 5

6607 Other Properties

Aggregate which does not comply with Table 6-7 may be rejected.

Table 6-5 required properties of aggregate

Type	Fine Aggregate	Coarse Aggregate
i. Min specific gravity (dry basis).(AASHTO T84, T85)	2.56	2.56
ii. Max weight loss of portion retained on a 0.300 mm sieve in 5 cycles of sodium sulphate test. (AASHTO T104)	8% by mass	10% by mass
iii. Max loss in Los Angeles Abrasion Test at 500 revolutions. (AASHTO T96)	Not Applicable	30%
iv. Max sum of flakiness and elongation indices. (BS 812)	Not Applicable	60%

v. Min Fineness modulus.	2.10	Not Applicable
vi. Max fineness modulus		
• natural sand	3.10	Not Applicable
• manufactured fine aggregate	2.80	Not Applicable
• Mixture of natural sand and manufactured fine aggregate	a proportional value between 3.10 and 2.80	Not Applicable

6608 Processing

a) Aggregates shall be screened and washed. Processing of the raw materials may include crushing, milling and blending to produce fine and coarse aggregates meeting the requirements of this specification and shall be done at an approved location and in an approved manner.

b) Water used for washing aggregate shall comply with section 6.5.

c) After washing, fine aggregate shall be stored in stockpiles for at least 72 hours and shall be subsequently handled to ensure that sand delivered to the batching plant has uniform and stable moisture content.

d) Where the surface of stockpiles from which fine aggregate is being delivered directly to the batching plant is substantially drier or wetter than the bulk of fine aggregate in the pile, handling shall be such as to exclude this surface material from the batching plant.

e) The mixing of different kinds or sizes of aggregate, or aggregate from different sources in one stockpile will not be permitted.

f) Different kinds or sizes of aggregates shall be measured separately and kept clean.

g) Stockpiles shall be placed on concrete, sheet metal, wood planks or other approved foundation.

6609 Measurement and Payment

a) Direct payment will not be made for fine and coarse aggregate used in concrete, mortar or grout.

b) The cost of producing or furnishing aggregates required under this Specification shall be included in the rates tendered in the priced Bill of Quantities for the various items of concrete construction in which the aggregate is used. Such rates shall also include all expenses of the Contractor in testing, winning, handling, processing, transporting and storing the materials.

c) The Contractor will not be entitled to any additional payment for materials wasted from deposits, including crusher fines, excess material of any of the sizes into which the aggregates are required to be separated by the Contractor, and materials which have been discarded by reasons of being above the maximum sizes specified for use.

6700 Batching and Mixing

6701 Plant

a) If the Contractor installs at an approved central location a batch plant, it shall be constructed and operate in accordance with AASHTO M157 and this Specification. The batch plant shall be an approved, efficient and dependable, automatically or semi-automatically controlled batching plant.

b) The equipment shall be capable of controlling the delivery of each size of aggregate to the mixer within the tolerances specified herein.

6702 Measuring and Tolerances

a) Cement, fine aggregate and each size of coarse aggregate shall all be weighed separately on an individual scale. Water shall be weighed separately on an individual scale or may be measured by volume. Liquid admixtures may be measured by mass or volume. If water is measured by volume, two (2) flow meters shall be installed in parallel so that no delay shall result from faulty operation of one of the metres.

b) The equipment shall be capable of controlling the delivery of each size of aggregate to the mixer within the tolerances specified herein.

c) Volume measurement may be used as approved by the Engineer in accordance with AASHTO M241 and the requirements of this specification.

6703 Calibration

a) The construction and accuracy of the weighing and measuring equipment shall be such that the equipment will maintain accuracy within 0.4% of the scale capacity. The equipment shall be capable of ready adjustment for compensating for the varying weight of any moisture contained in the aggregates and for effecting changes in concrete mix proportions. The accuracy of all weighing devices shall be such that successive quantities can be measured to within 1.0% of the desired amount.

b) The Contractor shall provide standard certified test weights and any other auxiliary equipment required for checking the accuracy of each measuring device.

c) The Contractor shall calibrate each measuring device in the presence of the Engineer when and as directed. Such tests shall be made at least once every 4 week in the case of equipment for measuring aggregates and at least once every week in the case of equipment for measuring cement, water and admixtures.

d) The Contractor shall furnish copies of the complete results of all calibrations to the Engineer and shall adjust, repair or replace any measuring device which does not meet the requirements for accuracy

6704 Batching and Weighing Equipment

a) Where bagged cement is used, the quantities of aggregates for each batch shall be exactly sufficient for one or more complete bags. No batch requiring part bags of cement will be permitted.

b) Materials shall be weighed individually and each weighing device shall be equipped with a visible springless dial which shall register the scale load at any stage of the weighing operation.

c) The Contractor shall provide all necessary facilities for obtaining representative samples of aggregates and cement from the discharge streams between the bins and weigh-hoppers or between weigh-hoppers and the mixers.

d) All closing devices shall be positive in action and shall prevent leakage of materials when closed.

e) Batching equipment shall be interlocked so that:

i. A new weighing cycle cannot be started until all weigh-hoppers are completely emptied and the discharge gates closed;

ii. The discharge-gates of the weigh-hoppers cannot be opened until the correct masses of materials are in and the scales in balance;

iii. The discharge-gates cannot be closed until all materials are entirely discharged and the scales are back in balance;

iv. The discharge-valve of the water-measuring device cannot be opened until the filling-valve is closed; and

v. Accidental over batching of admixtures is prevented.

f) The batch bins shall be constructed to be self-cleaning during draw-down and the bins shall be drawn down until they are practically empty at least once per week. Materials shall be deposited in the batch bins directly over the discharge gates. The coarse aggregate shall be deposited in the batch bins through effective rock ladders when the distance through which the aggregate would fall is greater than 1.0 m. Equipment for conveying batched materials from the batchers or hoppers to and into the mixer shall be so constructed, maintained and operated that there will be no spillage or contamination of the batched materials or overlap of batches. Equipment that fails to conform to this requirement shall be effectively repaired, modified or replaced to the satisfaction of the Engineer.

g) When cement and aggregates are hauled from a central batching plant to the mixer, the cement for each batch shall be placed in an individual converted watertight compartment which, during transit, will prevent the cement from intermixing with the aggregates and will prevent loss or contamination of cement. Aggregates shall be covered to prevent changes in moisture content during transit. Each batch compartment shall be of sufficient capacity to prevent loss in transit

and to prevent spilling and intermingling of batches as compartments are being emptied. Surface haulage of batched aggregates from a central batching plant to mixers will not be permitted, if when so hauled, the change in moisture content of the fine aggregate between batching plant and mixer exceeds 1%.

6705 Vibrating Screens

a) Coarse aggregate shall be finish-screened over vibrating screens mounted on the batching plant or, at the option of the Contractor; the screens may be mounted on the ground adjacent to the batching plant. The finish-screens shall be so mounted that the vibrations of the screens will not affect the accuracy of the batching scales. The finished products shall pass directly to the batching plant bins.

b) Separation of the coarse aggregate into the specified sizes after finish-screening shall be such that the aggregate shall meet the requirements of section 6.6, and in particular Table 6.6.

6706 Records

Where a batch plant is set up by the Contractor, records shall be made by the Contractor for each batch, of the measurement of each separate concrete ingredient, including all water and admixtures. The records shall be available for inspection by the Engineer at all times and copies of the records shall be furnished to the Engineer at the completion of each day's production.

6707 Mixing Equipment

a) In addition to the requirements of sub-section 1 of this section, the mixing equipment shall be as specified herein.

b) A metal plate shall be attached to all mixing equipment, including agitators, on which is plainly marked the capacity in terms of volume of mixed concrete, and the manufacturer's recommendations for speed of rotation for mixing and for agitation.

c) When loaded to their rated capacity, mixers shall be capable of combining the ingredients within the time specified in sub-section 10 of this section and of discharging the concrete with a degree of uniformity such that, when samples taken at the one-quarter and three-quarter points of the batch volume are tested for slump, the difference between the two slumps shall not exceed 0.5 of the average of the two slumps.

d) All equipment shall be in sound mechanical condition and the interior of the drum or pan and mixing blades shall be kept thoroughly clean and free of hardened concrete or mortar by cleaning at frequent intervals as directed by the Engineer, and, in any case, before the commencement of or after a break in mixing operations.

6708 Batch Mixer

a) The concrete ingredients shall be mixed thoroughly in stationary mechanically operated batch-mixers of the type and size specified in this section, which is so designed as to ensure uniform distribution of all the component materials throughout the mass at the end of the mixing period.

b) The size of the mixer required shall be determined from the amount of concrete to be placed in a continuous operation. For each 25 cubic metres to be so placed in an 8-hour period the mixer or mixers to be used shall have a capacity of a least a one bag batch. The mixer shall be equipped with suitable devices, accurate to within 1 per cent, for automatically measuring the proper amount of water and for automatically timing each batch of concrete, so that all the ingredients will be mixed together for at least the minimum time required. Such devices shall be easily regulated and controlled to meet the variable conditions encountered.

c) The drum of the mixer shall revolve at a speed not less than 14 nor more than 20 rpm.

6709 Truck- Mounted Mixer and Agitation Units

a) Where the use of truck-mounted mixer and agitator units is approved, the Contractor shall maintain at the Site an up-to-date list of the approved truck-mounted mixer and agitator units and shall ensure that only approved units are allowed to be used for the Works.

b) Truck-mounted mixer and agitator units and the mixing and transporting of concrete in such units shall be in accordance with the requirements of an internationally recognised standard Specification and applicable to tropical conditions and as specified in this section. Each unit shall

be fitted with an approved mixer drum revolution recording counter which can be manually reset to zero, but shall not be capable of being advanced.

c) Truck-mounted mixer and agitator units will be approved for use only when the units and their operations are such that they conform to the requirements of this section over the full range of slumps and aggregate sizes of concrete for which they are used.

6710 Mixing Time

a) Unless otherwise directed or approved, the mixing of each batch shall continue for not less that the number of minutes stated in the following table after all materials are in the mixer.

Table 6-6 Min time requirement for mixing

Capacity of mixer (Cubic metre)	Minimum time of mixing (minutes)
1	1.5
2	2.0
3	2.5
4	2.75
5	3.0

b) The minimum mixing periods specified are conditional on the materials being fed into the mixer in a manner which will facilitate efficient mixing and on operation of the mixer at its designed speed.

6711 Charging Sequence

a) The Engineer reserves the right to vary the mixing time or to limit the batch size when the charging and mixing operations fail to produce a batch of concrete that conforms with the foregoing requirements with respect to adequacy of mixing. The concrete of a given composition, as discharged from the mixer, shall be uniform in composition and consistency within batches and from batch to batch.

b) The first batch of concrete materials placed in the mixer shall contain a sufficient excess of cement, sand, and water to coat the inside of the drum without reducing the required mortar content of the mix.

c) Water shall be added before, during and following the mixer-charging operations. Excessive over-mixing, requiring addition of water to preserve the required concrete consistency, will not be permitted.

6712 Mixing and Transporting

a) Notwithstanding other requirements of this , mixing and transporting of batched concrete shall be in accordance with any of the following methods:

i. Method 1 - Transit mixing

The concrete shall be mixed in a truck mixer. In general the water and cement shall be charged into the truck mixer at the batch plant with the fine and coarse aggregate. If proper control of the air content, consistency or mixing is not obtained, the time of charging the cement and water shall be as directed by the Engineer.

Immediately after all ingredients are in the mixer, mixing shall be started and continued until discharged. In the case of a truck mixer loaded to its maximum capacity not less than 70 revolutions of the drum or blades at mixing speed shall be required after all of the ingredients including water are in the mixer. If the batch is at least 0.5 cubic metres less than the maximum capacity, the minimum number of revolutions shall be 50 instead of 70. Not more than 100 revolutions of the drum or blades shall be at the rate of rotation stated by the manufacture as mixing speed. Additional mixing, if any, shall be at a slow speed stated by the manufacture as agitation speed.

ii. Method 2 - Stage (Shrink) mixing

All materials including water shall be partially mixed in a stationary mixer for at least 30 seconds and the mixing completed in truck mixer with not less than 50 revolutions or more than 100 revolutions of the drum or blades at mixing speed. Additional mixing, if any, shall be at agitation speed.

iii. Method 3- Central mixing and agitation hauling
The concrete shall be mixed in a stationary mixer for not less than 1.5 minutes after all materials are in the drum. The concrete shall be discharged into truck mixers or truck agitators and the mixing continued at agitation speed until it is discharged at the work.

iv. Method 4- Central mixing and truck hauling
The concrete shall be mixed in a stationary mixer for not less than 1.5 minutes after all materials are in the drum. The concrete shall be discharged into trucks equipped with special bodies and hauled by these trucks to the works where it is to be discharged.

b) Watertight covers shall be used to protect the concrete being hauled when it is raining or when the shade air temperature is 30^0C or higher.

6713 Discharging Period
Unless otherwise approved, concrete shall be completely discharged from the mixers or agitator drums within 40 minutes after the mixing water has been added to the dry ingredients. During weather not conducive to quick stiffening of concrete, this period may, if approved by the Engineer, be extended to not more than 90 minutes. Any concrete which requires additional water to be added to permit satisfactory discharge or placing will not be accepted regardless of the time which has elapsed since the mixing water has been added. Such rejected concrete shall be removed from the Works with the least possible delay.

6714 Mixer performance
a) Any mixer that at any time does not meet the requirements shall be repaired promptly and effectively or shall be replaced. Mixers shall be loaded to their rated capacity except where mixing mortar or concrete is for the concluding phase of concrete placement. Mixers shall not be loaded in excess of their rated capacity. Each stationary mixer shall be equipped with a mechanically operated timing and signalling device which will indicate and ensure the completion of the required mixing period and will count the batches.

b) The Contractor shall check, once each month, for each mixer in use, the actual volume of concrete mixed in each batch against the theoretical volume of concrete mixed in each batch. Such checks shall be carried out in the presence of the Engineer.

6715 Delivery Docket
At the point of delivery or placing, the Contractor shall furnish the Engineer with a delivery docket stating the batch number, the time of batching, class of concrete and volume of concrete delivered.

6716 Measurement and Payment
Separate payment will not be made for complying with the requirements of mixing. All costs shall be deemed to be included in the rates tendered in the Bill of Quantities for the various items of concrete construction.

6800: TEMPERATURE OF CONCRETE

6801 Placing Temperature
The temperature of all concrete when it is placed shall not exceed 30^0C nor shall concreting be commenced where it appears likely than the temperature of the concrete may exceed 30^0C.

6802 Cooling Plastic Concrete
The Contractor shall, where necessary, employ effective means such as precooling the aggregates, refrigerating the mixing water, adding chipped or flaked ice to the mixing water, placing at night or a combination of these or other approved methods to ensure than the concrete does not exceed the temperatures specified. The method of cooling shall be in accordance with methods approved by the Engineer.

6803 Measurement and Payment

Separate payment will not be made for complying with the requirements of controlling the temperature of concrete. All costs shall be deemed to be included in the rates tendered in the Bill of Quantities for the various items of concrete construction.

6900: SAMPLING AND TESTING

6901 Testing Facilities

a) The Contractor will provide, in accordance with general Specification clause 1.3, a laboratory and all equipment required for testing concrete and materials for concrete in accordance with this.

b) At any centrally located batch plants, the Contractor shall provide and maintain a lock-up weatherproof dustproof soundproof room for use by the Engineer. The room shall have a minimum area of 7 square metres with a 2.8 m high ceiling and shall be located immediately adjacent to and on the same level as the operations console of the plant. Each room shall be furnished with a bench 3 m long by 0.6 m wide, fitted with a sink connected to drainage, an overhead water supply, electricity power points and fluorescent lights. The design, layout and location of each room shall be submitted for approval, and all costs associated with the provision of these rooms shall be included in the rates for concrete.

6902 Standards

a) Unless otherwise approved, sampling and testing of concrete materials, plastic concrete and hardened concrete will be in accordance with the testing methods and recommended practices of the American Association of State Highway and Transportation Officials, (AASHTO). Where an AASHTO Standard is not available, testing will be in accordance with the relevant standard of the American Society for Testing and Materials, (ASTM).

Tests on materials for concrete, plastic concrete and hardened concrete will include, but not necessarily be restricted to, those listed in the various parts of Table 6. 7.

Table 6-7- Part 1 - Standards for testing concrete

Test	Standard
- Sampling	AASHTO T141
-Compressive strength	AASHTO T22, T23 and T126
- Slump	AASHTO T119
- Air content	AASHTO T152
- Unit weight	AASHTO T121

b) All sieve sieves referred to in this Section refer to the aperture dimensions in millimetres of sieves conforming to AASHTO M92. At least 90 days before placing any concrete, the Contractor shall submit, for approval, representative samples of the proposed aggregates.

c) In checking the grading of aggregate and other materials, imperial size sieves shall be related to specified metric sizes in accordance with Table 6.7 - Part 2.

Table 6-7 - Part 2 - Relationship between imperial and metric sieves

Specified metric size (mm)	Imperial Sieve Size
150	6 inch
100	4 inch
75	3 inch
37.5	1.5 inch
25	1 inch
19	3/4 inch
9.5	3/8 inch
4.75	No. 4
2.36	No. 8
1.18	No. 16
0.600	No. 30

0.300 0.150 0.075	No. 50 No. 100 No. 200

Table 6-8 - Part 3- Standards for testing aggregate

Test	Designation No.	Sampling/Testing FrequencyPer Cum
Sampling	ASTM Manual of concrete testing	500 cu.m.
Clay and friable particles	AASHTO T112	1 per source but no less than 1 per 1000 cu.m.
Material finer than 0. 075 mm	AASHTO T11	1 per 500 cu.m.
Light weight particles	AASHTO T113	All of the remaining tests, 1 per source but no less than 1 per 1000 cu.m. excpect moisture content test.
Organic impurities	AASHTO T71	
Soundness	AASHTO T104	
Sieve analysis	AASHTO T27	
Los Angeles abrasion	AASHTO T96	
Unit Weight	AASHTO T19	
Specific gravity and absorption	AASHTO T84, T85	
Moisture content	AASHTO T255	One per day

* As recommended by AASHTO or ASTM.

6903 Testing Cement at Source

a) Cement shall be sampled at the source and tested by the manufacturer and certified as conforming to the requirements of this Specification before being dispatched from the factory of the cement manufacturer. The date of any testing shall be noted in any certification of the cement.

b) Bulk or bagged cement used for concrete, mortar or grout shall be sampled by taking one grab sample representing not more than 100 tonnes of cement manufactured in an uninterrupted process and stored in one silo, and at least one sample for each brand. The sample shall be tested for all the requirements given in AASHTO M85 by the methods given in that standard.

c) Cement used for prestressed concrete grouting shall be additionally sampled by taking one grab sample (usually one integral bag), representing not more than 100 bags filled with cement manufactured in an uninterrupted process and delivered to the Site in one consignment. This sample shall be tested for fineness (Specific surface) in accordance with AASHTO M85, 100% of the cement shall pass a 0.150 mm sieve and not less than 90% shall pass a 0.075 mm sieve.

d) Test results shall be forwarded to the Engineer, within a specified time following testing, as determined by the Engineer.

6904 Testing Cement Elsewhere

a) The Contractor in the presence of the Engineer, shall take from any bulk or bagged storage, transfer point or cement usage point, samples of cement which appear to have deteriorated through age, damage to containers, improper storage or for any other reason and arrange for testing. The Contractor shall provide all facilities, labour and materials, including the actual cement, necessary to obtain and test these samples at no cost to the Employer.

b) In the event of any sample being found not to comply with this Specification, the whole consignment from which the sample comes shall be rejected and removed from the site immediately notwithstanding any previous acceptance on the basis of the manufacturer's certificate. The Engineer may require the removal of any concrete, mortar or concrete produced with cement not complying with the requirements of this Specification.

6905 Testing Aggregate

The Contractor, in the presence of the Engineer, will sample and test aggregate at the frequency shown in Table 6.9 Part 3, or as directed by the Engineer.

6906 Sampling and Testing Plastic Concrete

a) i. The Contractor in the presence of the Engineer will sample concrete for testing, in accordance with sub 2 of this, from the batching and mixing plant, delivery trucks, at the forms or elsewhere where concrete is being handled or placed. Samples will be obtained at uniform intervals throughout the production or delivery of concrete for a given placement.

ii. Where the concrete is deposited into the forms directly from an agitator truck chute, sampling shall be from the discharge chute and the sampling procedure will be as in AASHTO T141.

iii. A placement shall be considered as an operation involving the continuous placing of concrete as follows for:

· In- situ concrete between construction joints
· Precast concrete each unit or batch of units.

iv. In general, the frequency of sampling of a class of concrete in any one placement will be in accordance with Table 6.9 (4).

Table 6. 9 (4) - Frequency of sampling concrete

Size of Placement	Number of Samples
Up to 10 cubic metres	1
Up to 20 cubic metres	2
Up to 40 cubic metres	3
Each additional 20 cubic metres,	1 additional

iv. The slump, temperature of concrete and air, air-content, and unit weight should be performed on each sample of truck mixer.

v. In general, three specimen cylinders for testing at 28 days, plus as many specimens as required for other testing, will be made from every sample. For precast units, a third specimen cylinder shall be taken from every sample, for testing prior to removal of the forms.

vi. The Contractor shall provide the required quantity of concrete for sampling and testing and shall include the cost of this concrete and any concrete required separately by the Engineer for his own tests, and the necessary tests in the rates bid therefore in the priced Bill of Quantities for the various items of concrete construction.

vii. The Contractor has the right to be present at any sampling or testing conducted by the Engineer but such right shall not operate to restrict in any way the right of the Engineer to take samples or make tests at any time.

viii. The number and frequency of the sampling and tests on plastic concrete will be in accordance with Table 6.9(4) but in general shall not be less than four samples for each eight hours of concrete production.

xi. More frequent testing of plastic concrete will be directed under certain circumstances, such as, but not limited to times when the fine aggregate moisture content is fluctuating, and the Contractor shall not be entitled to any additional compensation because of any additional sampling or testing of plastic concrete at any location directed by the Engineer.

6907 Rejection of Concrete

a) Concrete shall be liable to rejection if:

i. after the concrete has been discharged at the placing point and before it has been consolidated the slump, measured to the nearest 5 mm, is not within ±10 mm of the slump specified in Table 6.1 Part A or the slump directed in accordance with paragraph c of 6.2.

ii. The water/cement ratio is not as specified in Table 6.1 part A of this Section.

iii. The amounts of admixtures, if used, are not within approved limits.

b) Plastic concrete which has been rejected shall be removed from the Works with the least possible delay.

6908 Testing Cylinders

The compressive strength of the concrete will be determined by tests on 150 mm diameter by 300 mm long cylinders. Concrete containing aggregate coarser than 37.5 mm shall be sieved to remove all larger particles before the cylinders are made.

Required properties of hardened concrete

a) The test strength of a sample will be the average strength of the three cylinders made from a sample and tested at 28 days.

b) Hardened concrete shall be liable to rejection if:

   i. the average compressive strength of any 3 consecutive samples representing each class of concrete is less than the specified 28 day cylinder strength for that class of concrete; or

   ii. the strength of a sample is more than 3.4 MPa below the specified 28 day cylinder strength.

6909 Testing Hardened Concrete in Structures

a) If approved by the Engineer on each specific occasion, and at the Contractor's expense, hardened concrete liable to rejection may be tested for compressive strength in accordance with AASHTO T24. Unless otherwise directed, core specimens shall be 150 mm in diameter. At least 3 specimens shall be tested and the points from which the specimens are obtained shall be as directed by the Engineer.

b) If the average compressive strength of the core specimens so obtained is equal to or greater than the 85% of the specified 28 day cylinder strength for that section of the Works, then the concrete represented by the core specimens shall be considered to be structurally satisfactory.

c) If the concrete is considered to be structurally satisfactory then the holes left by the removal of the test cores shall be repaired as specified. Unless otherwise directed, concrete which fails to meet the requirements of this shall be removed and replaced in an approved manner.

6910 Measurement and Payment

a) Payment for the items of concrete (of the various classes of concrete and the various locations as indicated on the Drawings, as described in the Bill of Quantities) shall be paid for in accordance with applicable Unit Prices as indicated on the Bill of Quantities

b) The entire cost of all sampling and testing shall be included in the rates bid therefore in the Bill of Quantities for the various items of concrete construction in the works.

c) The entire cost of securing and testing core specimens of hardened concrete and of removing and replacing rejected concrete shall be borne by the Contractor.

d) Payment for a laboratory and all equipment required for testing concrete is provided under Bill No. 1 of the Bill of Quantities.

6010: CONCRETE CONSTRUCTION

I. General

All concrete construction shall conform to the requirements of this section and the detailed requirements of section 6.11 to 7.12 inclusive. All structures shall be built to the lines, grades and dimensions shown on the drawing.

II. Accessories

The Contractor shall place and attach to each structure all timber, metal or other accessories necessary for its completion, as shown on the Drawings or directed. The cost of such work, for which specific Items are

not provided in the Bill of Quantities, shall be deemed to be included in the rates tendered in the priced Bill of Quantities for the work to which they are appurtenant.

III. Changes to Dimension

The dimensions of each structure shown on the Drawings will be subject to such changes as may be found necessary by the Engineer to adapt the structures to the conditions disclosed by the excavation.

IV. Changes in Colour

Abrupt changes in colour of external concrete surfaces exposed to public view will not be permitted. The Contractor shall ensure that as far as possible this surface shall be of uniform or well graded colour and shall use a consistent approved mix.

V. Application of Loads

Loads shall not be applied to concrete placed in the permanent works before 21 days of casting and without prior approval of the Engineer.

VI. Joint Fillers and sealants

At least 60 days before their proposed use, the Contractor shall submit, for approval, samples of the proposed joint fillers and sealants specified in sections 7300 and 7400 together with the manufacturer's technical data and the details of the recommended method of application.

6011: CONSTRUCTION AND CONTRACTION JOINTS

I. Construction Joints

a) Concrete surfaces, upon or against which concrete is to be placed and to which new concrete is to adhere, that have become so rigid that the new concrete cannot be incorporated integrally with that previously placed, are defined as construction joints.

b). The location of and details of required shapes for construction joints are shown on the Drawings and the reinforcement schedules shall be detailed on this basis.

c) Subject to approval, and excepting joints placed for architectural or other purposes which shall not be changed, the Contractor may vary the location of construction joints and sequence of concrete placements, provided that the Contractor shall make all necessary adjustments to the reinforcement to the satisfaction of the Engineer and without cost to the Employer.

d) Unless otherwise shown in the Drawings or approved the maximum spacing between construction joints measured along the structure or element of the structure shall be 10 metres.

e) The Contractor shall submit, for approval, Drawings showing his proposed location of construction joints and sequence of concrete pours not less than 30 days before placing concrete in each structure.

f) Joints shown on the Drawings as compulsory construction joints shall not be altered and no concrete shall be placed adjacent to the joint for at least 7 days for features up to 1 m in thickness and for at least 14 days where the thickness exceeds 1 m.

g) Construction joints shall be horizontal or vertical unless otherwise shown on the Drawings or directed and shall be given the prescribed shape by the use of forms, where required, or by other approved means that will ensure suitable jointing with subsequent work. Unless shown on the Drawings, keyways will not be required at construction joints. All intersections of construction joints with concrete surfaces which will be exposed to view shall be made straight and level or plumb and leak proof by the use of 25 mm by 18 mm timber or approved inserts in the corner of the formwork.

h) Contraction joints shall be located and constructed as shown on the Drawings. The joints shall be made by forming the concrete on one side of the joint and allowing it to set before concrete is placed on the other side of the joint. Unless otherwise shown or specified, the surface of the concrete first placed at contraction joints shall be coated with a colourless grease to break the bond before the concrete on the other side of the joint is placed.

II. Measurement and Payment

The cost of construction and contraction joints shall be included in the rates tendered in the Bill of Quantities for the concrete in which the joints are required.

6012: BITUMINOUS FIBRE SHEET FOR CONTRACTION JOINTS

I. General

The Contractor shall furnish and install bituminous fibre sheet in contraction joints in box culverts, or any other structure where shown or noted on the Drawing or directed.

II. Materials

The bituminous fibre sheet shall be about 12 mm thick sheet specifically manufactured for concrete joints complying with AASHTO M33 and conforming to samples and Specification submitted by the Contractor and approved by the Engineer.

III. Installation

a) Exposed edges of the bituminous fibre sheet shall be installed flush with either the back of the recess formed by chamfers on the corners of the concrete or the finished concrete surface as shown on the Drawings or as directed.

b) Joints in the bituminous fibre sheets shall be scarfed as recommended by the manufacturer and to the approval of the Engineer. The number of field joints shall be kept to a minimum and where possible joints shall be factory produced.

IV. Measurement and Payment

Separate payment will not be made for bituminous fibre sheet joint filler and all costs associated shall be included in the rates bid in the priced bill of quantities for the concrete between which the joints are installed.

6013: WATERPROOF SEALANT FOR JOINTS

I. General

The Contractor shall construct waterproof seals in butt joints as shown on the Drawings or as directed.

II. Materials

a) Waterproof joint seals shall be bitumen or rubber-bitumen or other compounds manufactured specifically for filling and waterproofing horizontal and vertical joints in concrete meeting the requirements of an appropriate international standard.

b) The Contractor shall submit to the Engineer not less than 45 days prior to the filling of any joint, samples, Specifications and manufacturer's instructions of the materials he proposes to use.

III. Construction

a) Bituminous or other waterproofing seals shall be prepared and formed in accordance with the manufacturer’s instructions.

b) Seals shall be placed after curing of mortar in joints. The joint shall be raked with an approved tool to a depth of 10 mm and the joint cleared of all loose material and thoroughly dried by compressed air jet or other approved means.

c) The seal shall then be placed to completely fill the prepared joint as shown on the Drawings.

IV. Measurement and Payment

Separate payment will not be made for waterproof seals for joints and all costs associated with meeting the requirements of this section shall be included in the rates bid in the Bill of Quantities for installing the precast concrete units between which the seals are installed.

6014: FORMWORK

I. General

Concrete shall not be placed until the reinforcement and the forms have been inspected and approved by the Engineer.

Before placing of concrete all sawdust, wood chips and other construction debris and extraneous matter shall be removed from the interior of the forms, the reinforcement shall be thoroughly cleaned; and the forms and reinforcement shall be thoroughly wetted.

Plastic cone snap ties are preferred with the formwork for wing walls, abutments and other vertical members. Metal ties or anchorages within the forms shall be constructed as to permit their removal to a depth of at least 25mm from the face without injury to the concrete. Ordinary wire ties may be used only when the concrete will not be exposed to view and sulfates. Upon removal of the forms, shall be cut back at least 7mm from the face of concrete with chisels or nippers. Fittings for metal ties shall be such design that upon their removal, the cavities that are left will be of the smallest possible size. The cavities shall be filled with cement mortar and surface left sound smooth, even and uniform color.

a) Forms shall be used to confine the concrete and shape it to the required lines.
b) Unless otherwise approved, forms shall be designed and constructed by the Contractor and shall have sufficient strength to withstand the pressure resulting from placement and vibration of the concrete without excessive deflection of any part of surface and shall be maintained rigidly in position.
c) Forms shall be of wood, metal or other approved material. Forms for exposed surfaces shall be lined with metal or plywood, or other approved material.
d) Forms shall be sufficiently tight to prevent loss of mortar from the concrete.
e) Unless otherwise shown on the Drawings, moulding strips shall be placed in the corners of forms to produce bevelled edges on permanently exposed concrete surfaces. Interior angles on such surfaces and edges at formed joints will not require bevelling unless the requirement for bevelling is shown on the Drawings.
f) The Engineer shall be informed before the Contractor strips any formwork.
g) The Contractor shall remain fully responsible for the safety of structures from which he removes formwork.

II. Architectural Requirements

a) Form-lining shall be continuous for the full height of the form.
b) Vertical joints in form-lining shall be equally spaced along the length of the form for exposed concrete surfaces. The spacing shall be identical in succeeding wall placements.
c) All edges of lining shall be straight plumb and true to level.
d) Form-ties shall have a regular set - out in relation to the whole form and to each piece of form-lining.

III. Shop Drawings

a) The Contractor shall submit, for approval, Drawings showing details of the formwork and its supports, including adjustments provided and provisions for stripping. The Drawings shall be accompanied by design calculations sufficiently detailed to allow easy checking showing the stresses and deflections in the form surfaces, members and supports. The Drawings and calculations shall be certified by the qualified civil engineer. Approval of these Drawings by the Engineer shall not relieve the Contractor of any of his responsibilities under the contract.
b) The Drawings shall show the proposed locations of joints in the form lining and the positions of any form ties.

IV. Form-Ties

a) Embedded ties for holding forms shall remain embedded not less than two diameters or twice the minimum dimension of the tie or 1 mm, whichever is the greater, from the formed faces of the concrete.
b) The ties shall be constructed so that the ends or end fasteners can be removed without causing appreciable spalling at the faces of the concrete.
c) Recesses resulting from removal of form-ties shall be repaired in accordance with section 7.13.

V. Treatment of Forms

Before formworks are erected the surface of the forms shall be coated with an approved lubrication to prevent sticking and will not stain the concrete surface. The Contractor shall summit for approval at least 2 litres of the proposed lubricant at least 30 days before its use is required. When concrete is placed, the surfaces of the forms shall be free from encrustation of mortar, grout, or other foreign material.

VI. Removal of Forms

a) Forms shall be removed carefully minimum after 14 days of placing the concrete.

b) Concrete shall be cured continually even the forms have been removed and curing only temporarily stopped in the actual locations if any repairs are being carried out.

c) In order to avoid excessive stresses in the concrete that might result from swelling of the forms, timber forms for wall openings shall be loosened as soon as this can be accomplished without damage to the concrete. Forms for the openings shall be constructed so as to facilitate such loosening.

e) Immediately after stripping, the concrete forms to be reused shall be cleaned, their surface shall be repaired as necessary and oiled with form-oil and the form shall be carefully stored in its true shape.

VII. Measurement and Payment

Separate payment will not be made for Form work, and all costs associated with meeting the requirements of this section shall be included in the rates bid in the Bill of Quantities for the concrete for which the formworks will be used.

6015 TOLERANCE FOR CONCRETE CONSTRUCTION

I. General

a) Allowable deviations from plumb or level and from the alignment, profile, grades and dimensions shown on the Drawings are defined as 'tolerances'. Tolerances shall be inclusive of surface irregularities as defined in section 7.11. The intent of this section is to establish tolerances that are consistent with modern construction practice, yet governed by the effect that permissible deviations will have upon the structural action or operational function of the structure. Deviations from the established lines, grades and dimensions will be permitted to the extent set forth in this section; provided that the Engineer may reduce the tolerance set forth in this section if such tolerances impair the structural action or operational function of a structure or item.

b) Where tolerances are not stated in the Specification or shown on the Drawings for any individual structure or feature thereof, permissible deviations will be interpreted in conformity with the provisions of this section. Notations on the Drawings or included in this Specification of specific tolerance in connection with any dimensions, shall be considered as supplementary to the tolerances specified in this section.

c) The Contractor shall be responsible for setting and maintaining concrete forms sufficiently within the tolerance limits and shall ensure that the work is completed within the tolerances specified in this section. Concrete work that exceeds the tolerance limits specified in this section shall be remedied or removed and replaced by and at the expense of the Contractor.

II. In-situ Concrete

Tolerances for reinforced concrete structures shall be in accordance with the requirements as specified below, except where such tolerances are reduced by the Engineer.

i. **Variation from the plumb:**

In the lines and surfaces of	In 3 m	5 mm
columns, piers, walls,	In 6 m	8 mm
railing posts	In 12 m or more	16 mm

ii. **Variations from the level or from the grades indicated on the Drawings**:

Concrete railings		6 mm
In slab and beam soffits	In 3 m	5 mm
In any bay		8 mm

		In 6 m	8 mm
		In 12 m or more	16 mm
	Other		12 mm
iii.	Variation from indicated position in plan		12 mm
iv.	Variation in bridge deck slab thickness between		+5 mm - 3 mm
v.	Variation in cross-sectional dimensions of columns, beams and in the thickness of slabs (other than in iv) and walls		+12 mm - 5 mm
vi.	Footings; (the following apply to concrete only, not to reinforcing bars) variations in dimensions in plan		+50 mm - 12 mm
	Misplacement or eccentricity 2% of the footing width in the direction of misplacement no more than 50 mm.		

III. Tolerance in Reinforcement

Tolerances for reinforcing steel:

i.	Length of splice	- 25 mm
ii.	Variation of protective cover	±5 mm
iii.	Variation in indicated position of reinforcement:	
	Starter bars	one bar diameter
	Slabs and walls	0.25 times the
	Indicated spacing Beams and columns	±5 mm
iv.	Dimensions of bent bars:	
	Stirrups and ties	±5 mm
	Other bars	±10 mm

Provided the number of bars required by the specified spacing is not varied and provided the specified minimum cover to reinforcement is maintained.

IV. Embedded Metalwork

Tolerances for placing embedded metalwork ±5 mm

6016: REINFORCEMENT

I. General

The Contractor shall furnish and install all steel reinforcing bar, wire, fabric and cover blocks, hereinafter referred to as reinforcement, required for execution of the works as specified herein, or as shown on the Drawings.

II. Material

High yield reinforcing steel bars shall be deformed bars with a yield stress not less than 425 Mpa and shall complying with ASTM A 615 or the latest such equivalent standard or specification in force that is considered by the Engineer to apply.

Reinforcing wire or fabric shall comply with AASHTO M32, M55, M225 or M221 as appropriate.

The Contractor shall state in his Tender his proposed source, and grades of reinforcement and shall furnish Certificates of Compliance from the manufacturer of the reinforcing bars, wire or fabric that the proposed materials comply with this Specification.

Al least 45 days before using any reinforcement in the Works, the Contractor shall submit, for approval, representative samples of the proposed reinforcement to the Engineer.

The Engineer may test, from time to time throughout the execution of the Works, further samples of the reinforcement for testing to check compliance with this Specification.

The Contractor shall not change his source of supply of reinforcement without prior written approval by the Engineer.

III. Drawings

Steel reinforcing bars shall be placed in concrete where shown in the Drawings or as directed.

IV. Reinforcement Schedules

The Contractor shall prepare detailed and complete bar lists and bending diagrams hereinafter referred to reinforcement schedules, from the reinforcement details shown on the Drawings. The schedules shall use the standard bar shapes and reinforcement schedule pro-forma as shown on the Drawings included with this Specification.

The Contractor shall submit to the Engineer for approval, at least 30 days before placing reinforcement, 2 copies and 1 transparency of the reinforcement schedules, together with 2 copies and 1 transparency of the reinforcement Drawings marked up with his proposed location of any construction joints additional to those shown on the Drawings. The approval of reinforcement schedules shall in no way relieve the Contractor of responsibility for the correctness of such schedules.

V. Placing Reinforcement

a) The Contractor shall be responsible for the accuracy of the cutting, bending and placing of the reinforcement. Reinforcement will be inspected for compliance with the requirements as to grade, size, shape, length, slicing locations, position and amount after it has been placed.

b) Before the reinforcement is placed, the surfaces of the bars or fabric and the surfaces of any metal bar supports shall be cleaned of heavy rust, loose mill scale, dirt, grease and other objectionable foreign substances. Heavy flaky rust which can be removed by firm rubbing with rough cloth or equivalent treatment is considered objectionable. After being placed, the reinforcing bars or fabric shall be maintained in a clean condition until they are completely embedded in the concrete.

c) Reinforcement shall be accurately placed in the position shown on the Drawings and shall be securely held by blocking from the forms, by supporting on concrete or on approved bar benches or plastic chairs and by wiring together at intersections using annealed wire of diameter not less than 1.2 mm with the ends turned into the main body of concrete. Bars shall be tied at all intersections except where the spacing in any direction is less than 300 mm when alternate intersections shall be tied.

d) Reinforcement supports shall be strong enough to withstand the imposed loads without movement of the reinforcement. They shall be positively attached to the reinforcement and of such size and number as to maintain the specified cover.

e) There shall be a clear distance of at least 25 mm between the bars and any adjacent embedded metalwork. The Contractor shall ensure that there is no disturbance of the reinforcing bars or fabric in concrete that has already been placed.

f) Chairs, hangers, spacers and other approved metal, plastic or concrete supports may be furnished and used by the Contractor for supporting reinforcing bars. Concrete supports where used shall be made for the same materials and of the same proportions of sand and cement as that of the

concrete in which they are to be used. They shall be cast and cured for at least 7 days before used and shall have wire or other approved device cast into each support for the purpose of attaching them positively to the reinforcement. If metal supports are used, the portion which extends to the surface of the concrete shall be galvanized or plastic coated and shall be of such shape that they will be easily enveloped by the concrete.

VI. Joining and Splicing Reinforcement

a) Joints or splices in reinforcing bars shall generally be made at the positions shown on the Drawings, but the Contractor will be permitted to make joints or splices at positions other than those shown on the Drawings, provided that such positions are approved by the Engineer and that the joints and splices in adjacent bars are staggered as directed by the Engineer. Approval of such additional splices will generally be restricted to splices not closer than 8 m in horizontal bars, or 4 m in vertical bars measured between the mid points of laps. The number of splices shall be kept to a minimum.

b) If cold worked reinforcing bars are used, welding will the permitted only if and when approval has been given by the Engineer for that particular case or application.

c) Welded splices of mild steel reinforcement shall only be permitted at those locations shown on the Drawings or directed by the Engineer.

d) All welding of reinforcement for splices shall generally be in accordance with the latest edition of the American Welding Society (AWS) publication "Structural Welding Code-Reinforcing Steel".

e) Only approved and experienced welders shall be permitted to make welded splices. Each welder shall make, for testing and approval purposes, in the presence of the Engineer, and using the equipment and welding materials proposed for use in the works, 3 welded splices using bar sizes and welding positions as direct by the Engineer.

f) A full welded splice shall have bars lapped or butted, and welded to develop in tension at least 125% of the specified minimum yield strength of the bar.

g) Splices in reinforcement in concrete piles where unavoidable shall only be made by butt welding. Lap splices in concrete piles shall not be permitted.

h) If the Contractor proposes to use mechanical couplings for reinforcing bars, he shall submit, for approval, samples of the proposed coupling not less than 60 days before their proposed use.

VII. Measurement and Payment

Separate payment will not be made for Reinforcement work, and all costs associated with meeting the requirements of this section (Reinforcement) shall be included in the rates bid in the Bill of Quantities for the concrete for which the reinforcement will be used.

6017: PREPARATION FOR PLACING CONCRETE, FINISHING, CURING

I. General

a) Concrete shall not be placed until all construction of formwork, installation of reinforcement and parts to be embedded, preparation of surfaces, methods and equipment for transporting, handling, placing and finishing concrete, the number of vibrators and method of consolidating the concrete and the method of curing the concrete have been approved for concrete in a nominated section of work.

b) Concrete shall not be placed in water unless permitted by the Engineer. Concrete placed in the water shall have extra cement quantity to substitute dissolving.

c) All surfaces of forms and embedded materials that have become encrusted with dried mortar or grout from concrete previously placed, shall be cleaned of all such mortar or grout before the surrounding or adjacent concrete is placed.

d) The Contractor shall notify the Engineer verbally and in writing, at least 48 hours in advance of the Contractor's intention to place concrete.

e) The Contractor shall have adequate and operable, as determined by the Engineer, mixers, vibrators, scales, measuring devices, materials and tools, prior to the Engineer approving starting of a concreting operation.

f) In order that concrete can be properly finished, when the amount of concrete to be placed continuously is such that it cannot be finished before the end of the regular working day, the time of starting the concreting operations shall be subject to the approval of the Engineer.

g) The Contractor shall furnish assurance to the Engineer of an adequate and uniform source of supply of concrete to permit proper placing and finishing before work will be permitted to start.

a) The Engineer under certain conditions will permit night work if requested and if an adequate system of lighting is provided by the Contractor and approved by the Engineer.

II. Cleaning Foundations

a) Immediately before placing concrete, all surfaces of foundations upon or against which the concrete is to be placed shall be free from standing water, mud, debris, oil, objectionable coatings and loose, semi-detached or unsound fragments. Where directed surfaces of foundations shall be cleaned with air-water jets.

b) The surfaces of absorptive a foundation against which concrete is to be placed shall be moistened thoroughly so that moisture will not be drawn from the freshly placed concrete.

III. Excavation for foundations

The Contractor shall notify the Engineer before commencing excavation of foundations so that the cross-section, elevations and measurements of the undisturbed ground may taken.

Foundations for structures shall be excavated to the lines, grades and elevations shown on the Drawings or as directed by the Engineer. The elevations of the bottom of the foundations shown on the Drawings are approximate only, and the Engineer may order such changes as are deemed necessary to provide a secure foundation.
Special care shall be taken not to disturb the bottom of the excavation, and final removal of the foundation material to grade shall not be made until just before the footing is to be placed.

Where the material below the bottom of footings not supported by piles has been disturbed, it shall be removed and the entire space filled with concrete not less than 15 MPa at the contractor’s expense. Under footings supported on piles, the over-excavation on disturbed volumes shall be replaced and compacted as directed by engineer.

The excavation shall be sufficiently large to provide for the necessary working space, shuttering and any other Temporary Works.

Boulders, roots and any other objectionable material encountered in excavation shall be removed. The excavated foundation shall be cleared of all loose material and cut to a firm surface.

The final 100mm of excavation under footings or abutments shall be deferred so that the foundation bottom is not exposed until just before concrete work begins.

The Contractor shall be solely responsible for the safety and stability of the excavation and shall provide all protective supports, bracing and shoring as required.

Excavated material classified as suitable for fill shall be stockpiled. Waste material, and suitable fill material in excess of requirements, shall be disposed by the Contractor outside the limits of the Site.

No footings, bedding material or structure shall be placed in any foundation until the Engineer has inspected and approved the depth of excavation and the foundation material.

IV. Blinding Concrete

a) Unless otherwise shown on the Drawings, or approved in each specific case, all foundation surfaces against which concrete is to be placed shall be covered with a layer of blinding concrete approximately 50 mm thick.

b) The class of concrete used for blinding concrete shall be as specified in Table 6.1 - Part B.

c) The blinding concrete shall be spread and shall be worked thoroughly into all irregularities of the surface.

d) Concrete shall not be placed upon blinding concrete which has become contaminated by water, debris or other deleterious material. Blinding concrete which has been so contaminated shall be removed from the surface of the foundation, the surface shall be re-cleaned and a fresh layer of blinding concrete deposited on the surface before concrete is placed against the surface.

V. Cleaning Previously Placed Concrete Surfaces

a) The surface of construction joints, as defined in section 7.2 shall be clean and damp then covered with fresh cement grout. Cleaning shall consist of the removal of all latency, loose or defective concrete, coatings, sand, curing compound if used, and other foreign material to the satisfaction of the Engineer.

b) The surface of block outs against which concrete is to be placed shall be roughened by scrabbling.

c) The surface of all construction joints, including surfaces of block outs, shall be washed thoroughly with air-water jets immediately before placing adjoining concrete. All pools of water shall be removed from the surfaces of construction joints before new concrete is placed.

d) The surface of all contraction joint as defined in section 7.2 shall be cleaned thoroughly of accretions of concrete or other foreign material by scraping, chipping, or by other approved means.

6018: PLACING CONCRETE

I. General

The Contractor shall advise the Engineer when concrete will be placed and concrete shall only be placed in the presence of the Engineer. All of the concrete related works (Form work, mixing, placing, curing, transporting, etc.) should meet the latest editions of applicable ACI Manuals. Special precaution should be taken during concrete placement of Hot and Cold weathers as defined in ACI 305R, and ACI 306R manuals respectively, and specific methodology should be prepared according to the aforementioned ACI manuals for concreting during cold and hot weather conditions.

II. Concreting During Hot Weather

a) No concrete shall be place when the shade air temperature is above 38^0C, unless adequate provision has been taken for the hot weather, a hot weather concrete methodology should be submitted in these cases, following the requirement of ACI 305R. Under no circumstances will concrete be accepted if the temperature of the concrete as deposited into the formwork exceeds 32^0C. It may be necessary for the Contractor to provide for the cooling of mixing water and for the efficient insulation of any storage tanks and pipe lines for mixing water to achieve the placing temperature specified in paragraph (a) above.

b) Aggregate bins, batching and mixing equipment shall be painted white and, if directed stock piles shall be sprinkled with water.

c) Appropriate measures shall be taken with respect to transporting and placing the concrete to control the temperature of concrete. Stockpiles, mixers and transported fresh concrete shall be kept shaded. Pipe lines for conveying concrete shall be shaded and insulated or painted white; the elapsed time from mixing to placing shall be minimized. Concrete shall be placed promptly when delivered and finishing operation shall not be delayed; concrete surfaces shall be protected from wind and sun if directed during placing, finishing or curing operations.

d) The cost of all materials, labour and equipment required as specified in this section shall be included in the rates tendered in the Bill of Quantities for concrete.

III. Depositing Concrete

a) Whenever practicable, concrete shall be deposited directly in its final position and shall not be dropped, chute or caused to flow in a manner to permit or cause segregation. Methods and equipment employed in depositing concrete in forms shall be such as will not result in clusters or group of coarse aggregate being separated from the mass. The movement of concrete within the forms by use of vibrators will not be permitted.

b) Unless otherwise agreed by the Engineer, concrete shall not be dropped into place from a height exceeding 1.5 metres.

c) The Contractor shall provide approved chutes and baffles to confine and control falling concrete. Open troughs, chutes or pipes shall be metal or metal lined and shall be kept clean and free from coatings of hardened concrete. Water used for flushing shall be discharged clear of the structure.

d) In the event of continuous placing being interrupted for any reason, the Contractor shall thoroughly consolidate the concrete at such joints to a reasonable uniform and stable slope while the concrete is plastic and any concrete which is un-compacted and no longer plastic shall be removed by the Contractor at his own expense. The concrete at the surface of such cold joints shall be clean and damp when covered with fresh concrete.

IV. Concrete Placed in Horizontal Layers

Except as intercepted by joints, all formed concrete shall be placed in continuous approximately horizontal layers, the depths of which generally shall not exceed 300 mm. The Engineer may direct thinner layers where concrete in 300 mm layers cannot be placed in accordance with the requirements of this Specification.

V. Compaction

a) Concrete shall be compacted to the maximum practicable density in such a manner that it is free from pockets of coarse aggregate and closes snugly against all surfaces of forms and embedded materials.

b) Whenever practicable, concrete shall be compacted by approved immersion type vibrators operated in accordance with the manufacturer's recommendations. Form vibrators, or impact hammers applied to the forms, shall be used wherever internal vibration is not possible or would be inadequate. Where the use of mechanical vibration is not possible or would be inadequate, concrete shall be compacted thoroughly by hand.

c) In compacting each layer of concrete, the immersion type vibrator shall be operated in near vertical position and the vibrating head shall be allowed to penetrate and revibrate the concrete in the upper portion of the underlying layer. In the area where newly placed concrete in each layer joins previously placed concrete in the same layer, more than usual vibration shall be performed, the vibrator penetrating deeply at close intervals over the areas of contact of these layers. Layers of concrete shall not be placed until layers previously placed have been vibrated thoroughly as specified. Contact of the vibrating head with surfaces of the forms shall be avoided. Direct vibration of the reinforcement will not be permitted.

d) The total compacted capacity in cubic metres of concrete per hour of all vibrators in effective operating condition, and employed on concrete compaction in the Works, shall be based on a rated capacity of 70% of the manufacturer's recommendation of each type of vibrator in operation

and the total compacting capacity so computed shall be not less than the maximum rate at which concrete is placed in the Works. For every 3 vibrators in use on a concrete placement, the Contractor shall provide one additional standby vibrator of similar compacting capacity in good working order.

6019: FINISHES AND FINISHING

I. General

a) Irregularities to finish as described herein are to be distinguished from tolerances as specified in section 7.6.

b) Finishing of concrete surfaces shall be performed by skilled workmen.

c). The Contractor shall inform the Engineer when concrete will be finished.

d) Unless inspection is waived by the Engineer in each specific case, finishing of concrete shall be performed only in the presence of the Engineer.

e) Concrete surfaces will be tested by the Engineer where necessary to determine whether surface irregularities are within the specified limits.

i. Surface irregularities are classified as ‘abrupt’ or ‘gradual’.

ii. Offsets caused by displaced or misplaced form sheathing or lining or form sections, or by loose knots or otherwise defective form timber will be considered as ‘abrupt’ irregularities, and will be tested by direct measurements.

iii. All other irregularities will be considered as 'gradual' irregularities, and will be tested by use of a template, consisting of a straight edge or the equivalent thereof for curved surfaces. The length of the template will be 1.5 m for testing of formed surfaces, and 3 m for testing of unformed surfaces.

d) Grinding and bush-hammering will not be required on formed surfaces, but, unless waived by the Engineer in each specific case, grinding will be required for the repair of surface imperfections or for the removal of concrete which is outside specified tolerances.

II. Class of Finish for Formed Concrete

a) All formed concrete surfaces shall be given Class 1, Ordinary Surface Finish, and in addition, if further finishing is required, shall be given a Class 2, Rubbed Finish.

b) Exposed surfaces of all formed concrete surfaces including precast concrete shall generally be given Class 2, Rubbed Finish except in the following specific locations, or as directed by the Engineer:

i. Tops and bottoms of bridge deck slabs.

ii. Class 2 finish shall be continued not less than 300 mm below the level of any subsequent backfilling.

iii. When forms lined with metal or plywood are used, the requirement for a Class 2, Rubbed Finish may be waived by the Engineer except for the surfaces of posts and railings on bridges.

c)

i. Ordinary Surface Finish (Class 1)

Immediately following the removal of forms, all fins and irregular projections shall be removed from all surfaces except from those which are not to be exposed. On all surfaces, the cavities produced by form ties and all other holes, honeycombs, broken corners or edges and other defects shall be repaired in accordance with section 7.13.

The concrete shall then be rubbed if required or cured in accordance 7.12.

The resulting surfaces shall be true and uniform. Surface irregularities shall not exceed 10mm. All surfaces which cannot be repaired to the satisfaction of the Engineer shall be "rubbed" as specified for Class 2, Rubbed Finish.

ii. Rubbed Finish (Class 2)

After removal of forms, rubbing of concrete shall start as soon as its condition will permit. Immediately before starting this work, the concrete shall be kept thoroughly saturated with water for a minimum period of three hours. Sufficient time shall have elapsed before the wetting down to allow the material used in any concrete repairs, in accordance with section 7.13 to thoroughly set.

Surfaces to be finished shall be rubbed with a medium coarse carborundum stone, using a small amount of mortar on the faces. The mortar shall be composed of cement and fine aggregate mixed in the proportions used in the concrete being finished. Rubbing shall be continued until all form marks, projections and excessive surface irregularities have been removed, all voids filled and a uniform surface has been obtained. Surface irregularities shall not exceed 5 mm. The paste produced by this rubbing shall be left in place at this time.

After all concrete above the surface being treated has been cast the final finish shall be obtained by rubbing with a fine carborundum stone and water. The rubbing shall continue until the entire surface is of a smooth texture and uniform colour.

After the final rubbing is completed and the surface has dried, it shall be rubbed with burlap to remove loose powder and shall be left free from all unsound patches, paste, powder and objectionable marks.

III. Class of Finish for Unformed Concrete

a) The classes of finish for unformed concrete surfaces are designated by the symbols U1 and U2. Interior surfaces shall be sloped for drainage where shown on the Drawings. Surfaces which will be exposed to the weather and which are nominally level shall be sloped for drainage at approximately two% unless the use of other slopes or level surfaces are shown on the Drawings.

These classes of finish shall apply as follows:

i. U1 - Finish U1 (screeded finish) applies to unformed surfaces that will be covered by fill material or by concrete. Finish U1 is also used as the first stage of finish U2. The surfaces shall be levelled and screeded sufficiently to produce even, uniform surfaces. Surface irregularities shall not exceed 10 mm.

ii. U2 - Finish U2 (floated finish) applies to unformed surfaces not permanently concealed by fill material or concrete, or not required to receive finish U1. Floating may be performed by use of hand or power-driven equipment. Floating shall be delayed until the screeded surface has stiffened sufficiently to prevent the formation of latency, and shall be the minimum necessary to produce a surface that is free from screed marks and is uniform in texture. Surface irregularities shall not exceed 5 mm. Joints and edges shall be tooled down where shown on the Drawings or directed.

b) Unformed surfaces of bridge parapet posts and railings shall be given a Class 2, Rubbed Finish.

6020: CURING OF CONCRETE

I. General

a) All concrete shall be cured using water or using curing compound, except for surfaces which do not require a rubbed finish in accordance with section 7.11 for which membrane curing may be approved. Membrane curing will not be approved for construction joints.

b) Curing of concrete shall start immediately with the removal of form work or after 24hours of completing the surface finishing.

c) The surfaces of construction joints shall be moistened by covering with water-saturated material or by other approved means as soon as the concrete has hardened sufficiently to prevent damage by water. The surfaces shall be kept completely and continuously moist, before and after form work removal, by water applied on these surfaces.

d) Water used for curing shall meet the requirements of this Specification for water used in concrete, but with the additional requirement that the water shall not contain any chemicals or other substances that will cause staining of concrete surfaces.

II. Water Curing

a) At least 14 days before placing concrete in any structure to be water cured, the Contractor shall submit, for approval, details of the equipment and methods he proposes to use for water curing. After the initial placement of concrete in any structure, subsequent placements will not be permitted until equipment for curing has been satisfactorily installed and is operating on all previous placements in the structure.

b) All unformed surfaces shall be protected with two thicknesses of wet coarse heavy fabric which have been spot stitched, wet jute cotton mats or by other approved effective means, as soon as the concrete has hardened sufficiently to prevent damage by water. These surfaces shall be kept completely and continuously moist, prior to and during form removal. This procedure shall be followed by the specified water curing or membrane curing.

c) Concrete to be water cured shall be cured for at least 14 days immediately following placement of the concrete, or until covered with fresh concrete, by keeping all surfaces continuously wet and avoiding cycles of being wet and then dry.

d) Water curing shall be accomplished by one or more of the following methods or any approved or directed by the Engineer.
   i. maintaining the formwork in position in a wet condition.
   ii. Ponding of water on the surface.
   iii. Covering with coarse heavy fabric, Hessian, jute felt cotton mats, cotton mats, burlap or similar approved material maintained in a damp condition.
   iv. Covering with at least 25 mm thickness of sand maintained in a damp condition.
   v. Continuously sprinkling with water.
   vi. Impervious burlap backed paper or plastic coverings placed and kept in contact with a thoroughly wetted surface.

e) Sheet materials for curing concrete and burlap shall comply with AASHTO M171 and M182 respectively.

III. Membrane Curing

a) Membrane curing, if approved, shall be by application of an approved type of curing compound complying with AASHTO M148 which forms a water retaining membrane on the surface of the concrete surface by spraying on one coat or, where approved, by brushing or rolling on two coats, to provide a continuous uniform membrane over all areas, with a maximum coverage per litre, as directed, according to the roughness of the surface to be covered

b) When curing compound is to be used on unformed concrete surfaces, application of the compound shall commence immediately after the finishing operations are completed.

c) The curing compound shall be applied while the surface is dump. There shall be ample coverage with the compound at edges, corners and blow-holes of formed surfaces. After application of the curing compound has been completed and the coating is dry to touch, any required repair of concrete surfaces shall be performed. Each repair, after being finished, shall be moistened and coated with curing compound in accordance with the foregoing requirements.

d) Equipment for applying curing compound and the method of application shall comply with the American Concrete Institute (ACI) Manual of Concrete Practice.

e) Traffic and other operations by the Contractor shall be such as to avoid damage to coatings of curing compound for a period of not less than 28 days after application of the curing compound. Where it is impossible because of construction operations to avoid traffic over surfaces coated with curing compound, the membrane shall be protected by a covering of sand not less than 50 mm in thickness or by other effective means. The protective covering shall not be placed until the sealing membrane is completely dry. The Contractor shall remove all sand covering after completion of the curing period.

f) The Contractor shall submit, for approval, details of the proposed compound before 30 days of usage with details accompanied by test certificates to show that the compound will give satisfactory results for the proposed application.

g) Curing compound shall be delivered to the site in suitable labelled containers to enable identification of the batch number and date of manufacture.

IV. Steam Curing

a) Concrete may be steam cured for the purpose of obtaining high early strength. Steam curing operations shall not commence without the written approval of the Engineer. Once approved, no alteration shall be made in the curing method without the written consent of the Engineer. No admixtures shall be used in conjunction with steam cured concrete without prior approval from the Engineer.

b) At least 14 days before the Contractor proposes to commence steam curing, he shall submit to the Engineer the following details:

i. The duration of the pre-setting period (i.e., the interval between placing the last concrete batched and the commencement of steam curing). If a retarding admixture is used in the concrete mix this period shall not be less than 4 hours, otherwise this period shall not be less than two hours.

ii. The rate at which the temperature of the air space surrounding the units will be raised or lowered. (This rate shall not exceed 15^0C per hour).

iii. The maximum temperature of the surrounding air space during the application of the steam. (At no time will a temperature exceeding 75^0C be permitted).

iv Method of measuring the temperature at any point on the concrete.

c) The Contractor shall record the maximum temperature at points as directed and shall keep a continuous record of the temperature by an approved thermograph located to the approval of the Engineer. Temperature variations throughout the steam chamber at any time shall not be more than 5ºC. Steam shall not be applied to the member in any way which will cause uneven heating.

e) On completion of the curing, the steam supply shall be cut off and the member shall be allowed to cool gradually and evenly. Rain shall be prevented from falling on the concrete during the cooling period. Steam covers shall not be removed or disturbed in any way until the temperature at the surface of the concrete mass has fallen to within 20ºC of the ambient temperature.

6021: REPAIR OF CONCRETE

I. General

a) Repair of concrete shall be performed by skilled workmen. The Contractor shall inform the Engineer when concrete will be repaired. Unless inspection is waived by the Engineer, in each specific case repair of concrete shall be performed only in the presence of the Engineer.

b) The Contractor shall correct all imperfections or the concrete surfaces as necessary to produce surfaces that conform to section 7.11. For formed concrete, where the forms are removed within three days and repair of imperfections completed within 24 hours after removal of forms, or for unformed concrete where repairs are completed within 24 hours after the placing of the concrete, repairs shall be dry-pack, mortar or concrete repairs, Otherwise repairs shall be epoxy resin repairs.

c) Concrete that is damaged from any cause and concrete that is honeycombed, fractured or otherwise defective, and concrete which is rejected because of excessive surface depressions, shall be removed and built up with dry-pack, mortar, or concrete, as hereinafter specified, to bring the surface to the prescribed lines. Where bulges and abrupt irregularities protrude outside the limits specified in section 7.11 on which Class 2, Rubbed Finish is required, the protrusions shall be reduced by bush hammering and grinding so that the surfaces are within the specified limits. After the dressing, the irregularities shall not exceed the limits specified in section 7.11.

II. Dry-Pack

a) Dry-pack that composed of a mix of 1 part of cement, by volume, to 2.5 parts, by volume, of fine aggregate passing a 1.18 mm sieve, together with enough water to produce a mortar which will just stick together could be used for filling holes having a depth greater than the least surface dimension; for narrow slots cut for repair of cracks; and for tie-rod fastener recesses as specified. Dry-pack shall not be used for filling behind reinforcement or for filling holes that extend completely through a concrete section.

b) Dry-pack shall be placed and packed into under-cut holes in layers each having a thickness of approximately 10 mm. Packing shall be carried out with a hardwood stick struck with a hammer to compress the dry-pack thoroughly into contact with the surfaces of the hole.

III. Concrete

a) Concrete-filling shall be used for holes extending entirely through concrete sections, for holes which are greater in area than 0.10 square metres and deeper than 80 mm, and for holes in reinforced concrete which are greater in area than 0.05 square metres and which extend beyond the reinforcement that is nearest the surface.

b) Concrete used for repairs shall be of the same class as the concrete in the location at which the repair is being made.

IV. Epoxy Resin

a) Epoxy resin repairs shall not be made until 28 days after the concrete has been placed, unless earlier repairs are approved, and shall be completed within 60 days after the concrete has been placed. All materials used for epoxy resin repairs shall be subject to approval and the repairs shall use an unfilled epoxy resin as the bonding medium between old concrete and the repair material, which can be dry-pack, mortar or concrete.

b) Epoxy resin repairs shall be carried out as follows:

i. All imperfections to be repaired with epoxy resin shall be chipped back to sound concrete and the edges of the holes trimmed square for a minimum depth of 3 mm.

ii. Immediately before performing a repair, the surface of the concrete to be repaired shall be free of all contaminants by grit blasting or scabbing, and shall present a clean, sound, dry, roughened and dust-free surface with the surface temperature not less than 15□C and not more than the temperature of the surrounding concrete.

c) After preparation, the surface of the area to be repaired shall be covered with a thick coat of an approved unfilled, solvent less epoxy resin, prepared, batched and mixed in accordance with the manufacturer's instructions and thoroughly brushed into the surface. Immediately and before the resin becomes 'tacky' the repair material shall be placed and finished to the required standard. Curing of the repair shall be performed in accordance with section 7.12 with the additional requirement that the repair is to be maintained at a temperature not less than 20^0C for a period of 24 hours, without allowing heat to be directed onto the repair and cause excessive drying of the repair material. Epoxy resin which has become 'tacky' before the repair material has been placed against it, shall be removed and the surface again prepared to the satisfaction of the Engineer.

d) Unused epoxy resin, shall be wasted when it loses its plastic condition. Excess or spilled resin on surfaces for which a Class 2, Rubbed Finish is specified shall be cleaned immediately and while the resin is in a plastic state.

e) Should it be necessary to form an epoxy filled repair, either the forms shall be incompatible with the resin or the form shall be coated with a special release agent.

f) The finished surface of the epoxy resin repairs shall comply with Section 7.11. Any grinding required on epoxy filled repairs shall be performed using a silicon-carbide or other suitable abrasive and preferably under water.

V. Plugging form-tie holes

In formed concrete, surface holes remaining after dismantling form-ties shall be cleaned out and neatly plugged with dry pack as previously specified. The dry-pack shall be colour matched with surrounding concrete.

VI. Measurement and Payment

All materials, labour and equipment required for the repair of concrete or removal of stains shall be provided at the expense of the Contractor.

6022: WEEP HOLES

I. General

Facilitation for removal of moisture behind earth fill of structures are called weep Holes. It comprises a small openings left in the outer wall of retaining walls or abutment walls as an outlet for water/moistures from inside to move outside the wall. Weep Holes shall be installed as per the drawing or the instruction of the Engineer. For the details of the weep Holes refer to the design. The weep hole consists of two pats. The pipe that cross the wall as the median for water flow and the filter at the mouth of the upper opening of the pipe. A PVC Pipe of 50mm dia to 100mm dia shall be used, as shown on drawings.

The filter pack should be as show on the drawings.

II. Payment

The payment will be made for forming the weep hole on the process of wall construction and back fill, facilitation of pipe through the wall, and construction of the filter at the mouth of the pipe. All such costs shall be measured and paid in the rates bid in the priced Bill of Quantities as each.

Separate payment will not be made for forming weep holes according to this section, , and all costs associated with meeting the requirements of this section (Weep Holes) including furnishing all filter and other associated materials shall be included in the rates bid in the Bill of Quantities for the relevant work for which the weep holes will be used.

6023: RAIN WATER DOWN PIPE

I. General

a) The Contractor shall form rain water down pipes made of steel and conforming to AASHTO standards, having a minimum diameter of 100 mm through box culvert top slab, bridges, or any other structure where and as shown on the Drawings or directed.

b) Rain water down pipes which become obstructed shall be cleaned out to their full depth in an approved manner or shall be replaced by and at the expense of the Contractor.

II. Payment

Separate payment will not be made for rain water down pipes work, and all costs associated with meeting the requirements of this section (Rain Water Down Pipe) shall be included in the rates bid in the Bill of Quantities for the concrete for which it will be used.

6024: CONSTRUCTION OF STRUCTURES

I. Requirement

The Contractor shall construct structures where shown on the Drawings or directed. Construction of each structures includes the followings:

i. demolition and disposal of existing structures where shown on the Drawings;
ii. provide cofferdams and remove, dewatering if required;
iii. Clearing and grubbing of the sites and excavation for foundation, and grading of the finished surface, for culverts it includes the area adjacent to apron slab;
iv. construction of cast in-situ or precast concrete structures and its parts which differ for each structure but may contain such as walls, apron slabs, wing walls and headwalls; and any other structures as show on the drawings
v. Backfilling and construction of structural fill around the structures; and
vi. Construction of brick pitching, slope and scour protection, where shown on drawings.

II. Materials

a) Materials and construction shall be in accordance with their respective parts of the Specification as follows:

	Section
Clearing and grubbing	2.1
Excavation for structures	2.5
Structural fill material	2.7
Aggregate drain	2.7
Form work	6.14
Concrete	Part 6

b) Foundation material for culverts shall consist of sound natural soil or road base material.

III. Clearing and Grubbing

Clearing and grubbing shall be carried out within 5 m of any structure.

IV. Excavation

Excavation and preparation of foundations shall be in accordance with the dimensions shown on the Drawings.

Construction sequence

The construction of the structures shall be carried out in a standard manner, according to the internatl standards such AASHTO, & ACI.

V. Backfilling

a) Backfilling and compaction shall be carried out in accordance with specification 2000 series with the particular requirements of this subsection.
b) All bracing, formwork etc. shall be removed prior to backfilling.
c) Prior to any construction plant or diverted traffic being permitted on the culverts and after all construction is approved by the Engineer a minimum of 300 mm of fill shall be placed over the culvert.

VI. Traffic Diversion

This project may not have the problem of traffic provision, but if in some location it would be needed, to allow the earliest possible diversion of traffic onto the culverts, the Contractor may construct the culverts to approximately half width and divert traffic prior to completing the remainder of the works but only with the prior approval of the Engineer. All provisions for traffic and temporary traffic diversion works shall be in accordance with Section 1.1 of the Specification 1000, however no payment will be made for provision of traffic, if required at some locations.

VII. Measurement and payment

a) Unless otherwise specified, payment will be made in accordance with the following sections:

Section	
Excavation for structures	2.5
Compaction of foundations	2.5
Free-draining backfill	2.7
Concrete in structures	6

Pay items	**unit**
6024/1 R.C.C Concrete in Structures, 30MPa	Cum
6024/2 RCC Concrete in Prestressed Bridge Girders, 40MPa	Cum
6024/3 RCC Concrete for production of precast concrete pipe culverts, 30MPa	Cum
6024/4 Lean or Blinding Cocnrete, 15MPa	Cum
6024/5 P.C.C Concrete for Manholes filling in rock area, 30 MPa	Cum

6025: CONCRETE IN MAJOR STRUCTURES

I. Concrete in Pile Caps

1. The item in the Bill of Quantities for Concrete in Pile Caps includes all required concrete in the pile caps for abutments and piers for bridges as shown on the Drawings or directed by the Engineer, but excluding concrete in piles, the concrete in abutments and piers are also included under this item.

2. The concrete for pile caps shall be deemed to be mass concrete.

II. Concrete in Bridge Girder

The Item in the Bill of Quantities for Concrete in girders, cross-beams includes all required concrete in above the pile caps, as shown on the Drawings or directed by the Engineer. This item also include concrete in diaphragams.

III. Concrete in Bridge Decks

The item in the Bill of Quantities for Concrete in Bridge Decks includes all required concrete in bridge decks for bridges including, kerbs, approach slabs and edge beams as shown on the Drawings or directed by the Engineer, but excluding concrete in parapets.

IV. Concrete in Parapets and Barrier Wall

The item in the Bill of Quantities for Concrete in Parapets and Barrier walls, includes all required concrete in parapets, including parapet posts and rails and end posts, above wing walls of abutments and

above edge beams of bridge decks, as shown on the Drawings or directed by the Engineer. It also include concrete of sidewalks as shown in the drawings.

V. Measurement

1. General

Measurement, for payment, for concrete in structures shall be made to the neat lines of the structures unless otherwise specified.

2. Deductions

In measuring concrete for payment, deductions shall be made for:

a) The volume of all ducts, embedded pipes and metalwork, and other block outs having a cross-sectional area larger than 0.10 sq.m as measured at right angles to their longitudinal axis; and

b) All openings, recesses and block outs with cross sectional areas less than 0.10 square metres but which have an individual volume larger than 0.5 cubic metres.

3. Over-breakage

Measurement will not be made for concrete required to be placed outside specified or approved excavation pay lines, excess excavation or wasted concrete, or for any other reason.

VI. Payment

1. Concrete in Structures

Payment for concrete in the various parts of the Works will be made at the applicable price per cubic metre tendered in the priced Bill of Quantities for the following items:

Pay Item		Unit
6025/1	Concrete in Pile Caps, Abutments, Piers	cubic meter
6025/2	Concrete in Bridge Girder & Diaphragm	cubic meter
6025/3	Concrete in Bridge Decks, Kerb, Approach Slab	cubic meter
6025/4	Concrete in Parapets, Crash Barriers, Sidewalks	cubic meter

7000: CONCRETE CONSTRUCTION

7001 General

All concrete construction shall conform to the requirements of this section and the detailed requirements of section 7.2 to 7.12 inclusive. All structures shall be built to the lines, grades and dimensions shown on the drawing.

7002 Accessories

The Contractor shall place and attach to each structure all timber, metal or other accessories necessary for its completion, as shown on the Drawings or directed. The cost of such work, for which specific Items are not provided in the Bill of Quantities, shall be deemed to be included in the rates tendered in the priced Bill of Quantities for the work to which they are appurtenant.

7003 Changes to Dimension

The dimensions of each structure shown on the Drawings will be subject to such changes as may be found necessary by the Engineer to adapt the structures to the conditions disclosed by the excavation.

7004 Changes in Colour

Abrupt changes in colour of external concrete surfaces exposed to public view will not be permitted. The Contractor shall ensure that as far as possible this surface shall be of uniform or well graded colour and shall use a consistent approved mix.

7005 Application of Loads

Loads shall not be applied to concrete placed in the permanent works before 21 days of casting and without prior approval of the Engineer.

7006 Joint Fillers and sealants

At least 60 days before their proposed use, the Contractor shall submit, for approval, samples of the proposed joint fillers and sealants specified in sections 7300 and 7400 together with the manufacturer's technical data and the details of the recommended method of application.

7020: CONSTRUCTION AND CONTRACTION JOINTS

7021 Construction Joints

a) Concrete surfaces, upon or against which concrete is to be placed and to which new concrete is to adhere, that have become so rigid that the new concrete cannot be incorporated integrally with that previously placed, are defined as construction joints.

b). The location of and details of required shapes for construction joints are shown on the Drawings and the reinforcement schedules shall be detailed on this basis.

c) Subject to approval, and excepting joints placed for architectural or other purposes which shall not be changed, the Contractor may vary the location of construction joints and sequence of concrete placements, provided that the Contractor shall make all necessary adjustments to the reinforcement to the satisfaction of the Engineer and without cost to the Employer.

d) Unless otherwise shown in the Drawings or approved the maximum spacing between construction joints measured along the structure or element of the structure shall be 10 metres.

e) The Contractor shall submit, for approval, Drawings showing his proposed location of construction joints and sequence of concrete pours not less than 30 days before placing concrete in each structure.

f) Joints shown on the Drawings as compulsory construction joints shall not be altered and no concrete shall be placed adjacent to the joint for at least 7 days for features up to 1 m in thickness and for at least 14 days where the thickness exceeds 1 m.

g) Construction joints shall be horizontal or vertical unless otherwise shown on the Drawings or directed and shall be given the prescribed shape by the use of forms, where required, or by other approved means that will ensure suitable jointing with subsequent work. Unless shown on the Drawings, keyways will not be required at construction joints. All intersections of construction joints with concrete surfaces which will be exposed to view shall be made straight and level or plumb and leak proof by the use of 25 mm by 18 mm timber or approved inserts in the corner of the formwork.

h) Contraction joints shall be located and constructed as shown on the Drawings. The joints shall be made by forming the concrete on one side of the joint and allowing it to set before concrete is placed on the other side of the joint. Unless otherwise shown or specified, the surface of the concrete first placed at contraction joints shall be coated with a colourless grease to break the bond before the concrete on the other side of the joint is placed.

7022 Measurement and Payment

The cost of construction and contraction joints shall be included in the rates tendered in the Bill of Quantities for the concrete in which the joints are required.

7030: BITUMINOUS FIBRE SHEET FOR CONTRACTION JOINTS

7031 General

The Contractor shall furnish and install bituminous fibre sheet in contraction joints in box culverts as shown on the Drawing or directed.

7032 Materials

The bituminous fibre sheet shall be about 12 mm thick sheet specifically manufactured for concrete joints complying with AASHTO M33 and conforming to samples and Specification submitted by the Contractor and approved by the Engineer.

7033 Installation

a) Exposed edges of the bituminous fibre sheet shall be installed flush with either the back of the recess formed by chamfers on the corners of the concrete or the finished concrete surface as shown on the Drawings or as directed.

b) Joints in the bituminous fibre sheets shall be scarfed as recommended by the manufacturer and to the approval of the Engineer. The number of field joints shall be kept to a minimum and where possible joints shall be factory produced.

7034 Measurement and Payment

Separate payment will not be made for bituminous fibre sheet joint filler and all costs associated shall be included in the rates bid in the priced bill of quantities for the concrete between which the joints are installed.

7040: WATERPROOF SEALANT FOR JOINTS

7041 General

The Contractor shall construct waterproof seals in butt joints as shown on the Drawings or as directed.

7042 Materials

a) Waterproof joint seals shall be bitumen or rubber-bitumen or other compounds manufactured specifically for filling and waterproofing horizontal and vertical joints in concrete meeting the requirements of an appropriate international standard.

b) The Contractor shall submit to the Engineer not less than 45 days prior to the filling of any joint, samples, Specifications and manufacturer's instructions of the materials he proposes to use.

7043 Construction

a) Bituminous or other waterproofing seals shall be prepared and formed in accordance with the manufacturer’s instructions.

b) Seals shall be placed after curing of mortar in joints. The joint shall be raked with an approved tool to a depth of 10 mm and the joint cleared of all loose material and thoroughly dried by compressed air jet or other approved means.

c) The seal shall then be placed to completely fill the prepared joint as shown on the Drawings.

7044 Measurement and Payment

Separate payment will not be made for waterproof seals for joints and all costs associated with meeting the requirements of this section shall be included in the rates bid in the Bill of Quantities for installing the precast concrete units between which the seals are installed.

7050: FORMWORK

7051 General

Concrete shall not be placed until the reinforcement and the forms have been inspected and approved by the Engineer.

Before placing of concrete all sawdust, wood chips and other construction debris and extraneous matter shall be removed from the interior of the forms, the reinforcement shall be thoroughly cleaned; and the forms and reinforcement shall be thoroughly wetted.

Plastic cone snap ties are preferred with the formwork for wing walls, abutments and other vertical members. Metal ties or anchorages within the forms shall be constructed as to permit their removal to a depth of at least 25mm from the face without injury to the concrete. Ordinary wire ties may be used only when the concrete will not be exposed to view and sulfates. Upon removal of the forms, shall be cut back at least 7mm from the face of concrete with chisels or nippers. Fittings for metal ties shall be such design that upon their removal, the cavities that are left will be of the smallest possible size. The cavities shall be filled with cement mortar and surface left sound smooth, even and uniform color.

a) Forms shall be used to confine the concrete and shape it to the required lines.

b) Unless otherwise approved, forms shall be designed and constructed by the Contractor and shall have sufficient strength to withstand the pressure resulting from placement and vibration of the concrete without excessive deflection of any part of surface and shall be maintained rigidly in position.
c) Forms shall be of wood, metal or other approved material. Forms for exposed surfaces shall be lined with metal or plywood, or other approved material.
d) Forms shall be sufficiently tight to prevent loss of mortar from the concrete.
e) Unless otherwise shown on the Drawings, moulding strips shall be placed in the corners of forms to produce bevelled edges on permanently exposed concrete surfaces. Interior angles on such surfaces and edges at formed joints will not require bevelling unless the requirement for bevelling is shown on the Drawings.
f) The Engineer shall be informed before the Contractor strips any formwork.
g) The Contractor shall remain fully responsible for the safety of structures from which he removes formwork.

7052 Architectural Requirements

a) Form-lining shall be continuous for the full height of the form.
b) Vertical joints in form-lining shall be equally spaced along the length of the form for exposed concrete surfaces. The spacing shall be identical in succeeding wall placements.
c) All edges of lining shall be straight plumb and true to level.
d) Form-ties shall have a regular set - out in relation to the whole form and to each piece of form-lining.

7053 Shop Drawings

a) The Contractor shall submit, for approval, Drawings showing details of the formwork and its supports, including adjustments provided and provisions for stripping. The Drawings shall be accompanied by design calculations sufficiently detailed to allow easy checking showing the stresses and deflections in the form surfaces, members and supports. The Drawings and calculations shall be certified by the qualified civil engineer. Approval of these Drawings by the Engineer shall not relieve the Contractor of any of his responsibilities under the contract.
b) The Drawings shall show the proposed locations of joints in the form lining and the positions of any form ties.

7054 Form-Ties

a) Embedded ties for holding forms shall remain embedded not less than two diameters or twice the minimum dimension of the tie or 1 mm, whichever is the greater, from the formed faces of the concrete.
b) The ties shall be constructed so that the ends or end fasteners can be removed without causing appreciable spalling at the faces of the concrete.
c) Recesses resulting from removal of form-ties shall be repaired in accordance with section 7.13.

7055 Treatment of Forms

Before formworks are erected the surface of the forms shall be coated with an approved lubrication to prevent sticking and will not stain the concrete surface. The Contractor shall summit for approval at least 2 litres of the proposed lubricant at least 30 days before its use is required. When concrete is placed, the surfaces of the forms shall be free from encrustation of mortar, grout, or other foreign material.

7056 Removal of Forms

a) Forms shall be removed carefully minimum after 14 days of placing the concrete.
b) Concrete shall be cured continually even the forms have been removed and curing only temporarily stopped in the actual locations if any repairs are being carried out.
c) In order to avoid excessive stresses in the concrete that might result from swelling of the forms, timber forms for wall openings shall be loosened as soon as this can be accomplished without damage to the concrete. Forms for the openings shall be constructed so as to facilitate such loosening.
e) Immediately after stripping, the concrete forms to be reused shall be cleaned, their surface shall be repaired as necessary and oiled with form-oil and the form shall be carefully stored in its true shape.

7057 Measurement and Payment

Separate payment will not be made for Form work, and all costs associated with meeting the requirements of this section shall be included in the rates bid in the Bill of Quantities for the concrete for which the formworks will be used.

7100 TOLERANCE FOR CONCRETE CONSTRUCTION

7101 General

a) Allowable deviations from plumb or level and from the alignment, profile, grades and dimensions shown on the Drawings are defined as 'tolerances'. Tolerances shall be inclusive of surface irregularities as defined in section 7.11. The intent of this section is to establish tolerances that are consistent with modern construction practice, yet governed by the effect that permissible deviations will have upon the structural action or operational function of the structure. Deviations from the established lines, grades and dimensions will be permitted to the extent set forth in this section; provided that the Engineer may reduce the tolerance set forth in this section if such tolerances impair the structural action or operational function of a structure or item.

b) Where tolerances are not stated in the Specification or shown on the Drawings for any individual structure or feature thereof, permissible deviations will be interpreted in conformity with the provisions of this section. Notations on the Drawings or included in this Specification of specific tolerance in connection with any dimensions, shall be considered as supplementary to the tolerances specified in this section.

c) The Contractor shall be responsible for setting and maintaining concrete forms sufficiently within the tolerance limits and shall ensure that the work is completed within the tolerances specified in this section. Concrete work that exceeds the tolerance limits specified in this section shall be remedied or removed and replaced by and at the expense of the Contractor.

7102 In-situ Concrete

Tolerances for reinforced concrete structures shall be in accordance with the requirements as specified below, except where such tolerances are reduced by the Engineer.

i. **Variation from the plumb:**

In the lines and surfaces of	In 3 m	5 mm
columns, piers, walls,	In 6 m	8 mm
railing posts	In 12 m or more	16 mm

ii. **Variations from the level or from the grades indicated on the Drawings**:

Concrete railings		6 mm
In slab and beam soffits	In 3 m	5 mm
In any bay		8 mm
	In 6 m	8 mm
	In 12 m or more	16 mm
Other		12 mm

iii. Variation from indicated position in plan 12 mm

iv. Variation in bridge deck slab thickness between +5 mm - 3 mm

v. Variation in cross-sectional dimensions of columns, beams and in the thickness of slabs (other than in iv) and walls +12 mm - 5 mm

vi. Footings;
(the following apply to concrete only, not to reinforcing bars)
variations in dimensions in plan +50 mm - 12 mm

Misplacement or eccentricity 2% of the footing width in the direction of misplacement no more than 50 mm.

7103 Tolerance in Reinforcement

Tolerances for reinforcing steel:

i.	Length of splice	- 25 mm
ii.	Variation of protective cover	±5 mm
iii.	Variation in indicated position of reinforcement:	
Starter bars		one bar diameter
Slabs and walls		0.25 times the
Indicated spacing Beams and columns		±5 mm
iv.	Dimensions of bent bars:	
Stirrups and ties		±5 mm
Other bars		±10 mm

Provided the number of bars required by the specified spacing is not varied and provided the specified minimum cover to reinforcement is maintained.

7104 Embedded Metalwork

Tolerances for placing embedded metalwork ±5 mm

7200: REINFORCEMENT

7201 General

The Contractor shall furnish and install all steel reinforcing bar, wire, fabric and cover blocks, hereinafter referred to as reinforcement, required for execution of the works as specified herein, or as shown on the Drawings.

7202 Material

Mild steel Reinforcing bars shall be Plain round bars and confine within the requirement of AASHTO M42/M 42M-92 and or approved equivalent, and having minimum yield strength not less than 275 MPa.

High yield reinforcing steel bars shall be deformed bars with a yield stress not less than 425 Mpa and shall complying with ASTM A 615 or the latest such equivalent standard or specification in force that is considered by the Engineer to apply.

Reinforcing wire or fabric shall comply with AASHTO M32, M55, M225 or M221 as appropriate.

The Contractor shall state in his Tender his proposed source, and grades of reinforcement and shall furnish Certificates of Compliance from the manufacturer of the reinforcing bars, wire or fabric that the proposed materials comply with this Specification.

Al least 45 days before using any reinforcement in the Works, the Contractor shall submit, for approval, representative samples of the proposed reinforcement to the Engineer.

The Engineer may test, from time to time throughout the execution of the Works, further samples of the reinforcement for testing to check compliance with this Specification.

The Contractor shall not change his source of supply of reinforcement without prior written approval by the Engineer.

7203 Drawings

Steel reinforcing bars shall be placed in concrete where shown in the Drawings or as directed.

7204 Reinforcement Schedules

The Contractor shall prepare detailed and complete bar lists and bending diagrams hereinafter referred to reinforcement schedules, from the reinforcement details shown on the Drawings. The schedules shall use the standard bar shapes and reinforcement schedule pro-forma as shown on the Drawings included with this Specification.

The Contractor shall submit to the Engineer for approval, at least 30 days before placing reinforcement, 2 copies and 1 transparency of the reinforcement schedules, together with 2 copies and 1 transparency of the reinforcement Drawings marked up with his proposed location of any construction joints additional to those shown on the Drawings. The approval of reinforcement schedules shall in no way relieve the Contractor of responsibility for the correctness of such schedules.

7205 Placing Reinforcement

a) The Contractor shall be responsible for the accuracy of the cutting, bending and placing of the reinforcement. Reinforcement will be inspected for compliance with the requirements as to grade, size, shape, length, slicing locations, position and amount after it has been placed.

b) Before the reinforcement is placed, the surfaces of the bars or fabric and the surfaces of any metal bar supports shall be cleaned of heavy rust, loose mill scale, dirt, grease and other objectionable foreign substances. Heavy flaky rust which can be removed by firm rubbing with rough cloth or equivalent treatment is considered objectionable. After being placed, the reinforcing bars or fabric shall be maintained in a clean condition until they are completely embedded in the concrete.

c) Reinforcement shall be accurately placed in the position shown on the Drawings and shall be securely held by blocking from the forms, by supporting on concrete or on approved bar benches or plastic chairs and by wiring together at intersections using annealed wire of diameter not less than 1.2 mm with the ends turned into the main body of concrete. Bars shall be tied at all intersections except where the spacing in any direction is less than 300 mm when alternate intersections shall be tied.

d) Reinforcement supports shall be strong enough to withstand the imposed loads without movement of the reinforcement. They shall be positively attached to the reinforcement and of such size and number as to maintain the specified cover.

e) There shall be a clear distance of at least 25 mm between the bars and any adjacent embedded metalwork. The Contractor shall ensure that there is no disturbance of the reinforcing bars or fabric in concrete that has already been placed.

f) Chairs, hangers, spacers and other approved metal, plastic or concrete supports may be furnished and used by the Contractor for supporting reinforcing bars. Concrete supports where used shall be made for the same materials and of the same proportions of sand and cement as that of the concrete in which they are to be used. They shall be cast and cured for at least 7 days before used and shall have wire or other approved device cast into each support for the purpose of attaching them positively to the reinforcement. If metal supports are used, the portion which extends to the surface of the concrete shall be galvanized or plastic coated and shall be of such shape that they will be easily enveloped by the concrete.

7206 Joining and Splicing Reinforcement

a) Joints or splices in reinforcing bars shall generally be made at the positions shown on the Drawings, but the Contractor will be permitted to make joints or splices at positions other than those shown on the Drawings, provided that such positions are approved by the Engineer and that the joints and splices in adjacent bars are staggered as directed by the Engineer. Approval of such additional splices will generally be restricted to splices not closer than 8 m in horizontal bars, or 4 m in vertical bars measured between the mid points of laps. The number of splices shall be kept to a minimum.

b) If cold worked reinforcing bars are used, welding will the permitted only if and when approval has been given by the Engineer for that particular case or application.

c) Welded splices of mild steel reinforcement shall only be permitted at those locations shown on the Drawings or directed by the Engineer.

d) All welding of reinforcement for splices shall generally be in accordance with the latest edition of the American Welding Society (AWS) publication "Structural Welding Code-Reinforcing Steel".

e) Only approved and experienced welders shall be permitted to make welded splices. Each welder shall make, for testing and approval purposes, in the presence of the Engineer, and using the equipment and welding materials proposed for use in the works, 3 welded splices using bar sizes and welding positions as direct by the Engineer.

f) A full welded splice shall have bars lapped or butted, and welded to develop in tension at least 125% of the specified minimum yield strength of the bar.

g) Splices in reinforcement in concrete piles where unavoidable shall only be made by butt welding. Lap splices in concrete piles shall not be permitted.

h) If the Contractor proposes to use mechanical couplings for reinforcing bars, he shall submit, for approval, samples of the proposed coupling not less than 60 days before their proposed use.

7207 Measurement and Payment

Separate payment will not be made for Reinforcement work, and all costs associated with meeting the requirements of this section (Reinforcement) shall be included in the rates bid in the Bill of Quantities for the concrete for which the reinforcement will be used.

7300: PREPARATION FOR PLACING CONCRETE, FINISHING, CURING

7301 General

a) Concrete shall not be placed until all construction of formwork, installation of reinforcement and parts to be embedded, preparation of surfaces, methods and equipment for transporting, handling, placing and finishing concrete, the number of vibrators and method of consolidating the concrete and the method of curing the concrete have been approved for concrete in a nominated section of work.

b) Concrete shall not be placed in water unless permitted by the Engineer. Concrete placed in the water shall have extra cement quantity to substitute dissolving.

c) All surfaces of forms and embedded materials that have become encrusted with dried mortar or grout from concrete previously placed, shall be cleaned of all such mortar or grout before the surrounding or adjacent concrete is placed.

d) The Contractor shall notify the Engineer verbally and in writing, at least 48 hours in advance of the Contractor's intention to place concrete.

e) The Contractor shall have adequate and operable, as determined by the Engineer, mixers, vibrators, scales, measuring devices, materials and tools, prior to the Engineer approving starting of a concreting operation.

f) In order that concrete can be properly finished, when the amount of concrete to be placed continuously is such that it cannot be finished before the end of the regular working day, the time of starting the concreting operations shall be subject to the approval of the Engineer.

g) The Contractor shall furnish assurance to the Engineer of an adequate and uniform source of supply of concrete to permit proper placing and finishing before work will be permitted to start.

b) The Engineer under certain conditions will permit night work if requested and if an adequate system of lighting is provided by the Contractor and approved by the Engineer.

7302 Cleaning Foundations

a) Immediately before placing concrete, all surfaces of foundations upon or against which the concrete is to be placed shall be free from standing water, mud, debris, oil, objectionable coatings and loose, semi-detached or unsound fragments. Where directed surfaces of foundations shall be cleaned with air-water jets.

d) The surfaces of absorptive a foundation against which concrete is to be placed shall be moistened thoroughly so that moisture will not be drawn from the freshly placed concrete.

7303 Excavation for foundations

The Contractor shall notify the Engineer before commencing excavation of foundations so that the cross-section, elevations and measurements of the undisturbed ground may taken.

Foundations for structures shall be excavated to the lines, grades and elevations shown on the Drawings or as directed by the Engineer. The elevations of the bottom of the foundations shown on the Drawings are approximate only, and the Engineer may order such changes as are deemed necessary to provide a secure foundation.
Special care shall be taken not to disturb the bottom of the excavation, and final removal of the foundation material to grade shall not be made until just before the footing is to be placed.

Where the material below the bottom of footings not supported by piles has been disturbed, it shall be removed and the entire space filled with concrete not less than 15 MPa at the contractor's expense. Under footings supported on piles, the over-excavation on disturbed volumes shall be replaced and compacted as directed by engineer.

The excavation shall be sufficiently large to provide for the necessary working space, shuttering and any other Temporary Works.

Boulders, roots and any other objectionable material encountered in excavation shall be removed. The excavated foundation shall be cleared of all loose material and cut to a firm surface.

The final 100mm of excavation under footings or abutments shall be deferred so that the foundation bottom is not exposed until just before concrete work begins.

The Contractor shall be solely responsible for the safety and stability of the excavation and shall provide all protective supports, bracing and shoring as required.

Excavated material classified as suitable for fill shall be stockpiled. Waste material, and suitable fill material in excess of requirements, shall be disposed by the Contractor outside the limits of the Site.

No footings, bedding material or structure shall be placed in any foundation until the Engineer has inspected and approved the depth of excavation and the foundation material.

7304 Blinding Concrete

a) Unless otherwise shown on the Drawings, or approved in each specific case, all foundation surfaces against which concrete is to be placed shall be covered with a layer of blinding concrete approximately 50 mm thick.

b) The class of concrete used for blinding concrete shall be as specified in Table 6.1 - Part B.

c) The blinding concrete shall be spread and shall be worked thoroughly into all irregularities of the surface.

d) Concrete shall not be placed upon blinding concrete which has become contaminated by water, debris or other deleterious material. Blinding concrete which has been so contaminated shall be removed from the surface of the foundation, the surface shall be re-cleaned and a fresh layer of blinding concrete deposited on the surface before concrete is placed against the surface.

7305 Cleaning Previously Placed Concrete Surfaces

a) The surface of construction joints, as defined in section 7.2 shall be clean and damp then covered with fresh cement grout. Cleaning shall consist of the removal of all latency, loose or defective concrete, coatings, sand, curing compound if used, and other foreign material to the satisfaction of the Engineer.

b) The surface of block outs against which concrete is to be placed shall be roughened by scrabbling.

c) The surface of all construction joints, including surfaces of block outs, shall be washed thoroughly with air-water jets immediately before placing adjoining concrete. All pools of water shall be removed from the surfaces of construction joints before new concrete is placed.

d) The surface of all contraction joint as defined in section 7.2 shall be cleaned thoroughly of accretions of concrete or other foreign material by scraping, chipping, or by other approved means.

7306: PLACING CONCRETE

General

The Contractor shall advise the Engineer when concrete will be placed and concrete shall only be placed in the presence of the Engineer. All of the concrete related works (Form work, mixing, placing, curing, transporting, etc.) should meet the latest editions of applicable ACI Manuals. Special precaution should be taken during concrete placement of Hot and Cold weathers as defined in ACI 305R, and ACI 306R manuals respectively, and specific methodology should be prepared according to the aforementioned ACI manuals for concreting during cold and hot weather conditions.

7307 Concreting During Hot Weather

a) No concrete shall be place when the shade air temperature is above 35^0C. Under no circumstances will concrete be accepted if the temperature of the concrete as deposited into the formwork exceeds 35^0C. It may be necessary for the Contractor to provide for the cooling of mixing water and for the efficient insulation of any storage tanks and pipe lines for mixing water to achieve the placing temperature specified in paragraph (a) above.

b) Aggregate bins, batching and mixing equipment shall be painted white and, if directed stock piles shall be sprinkled with water.

e) Appropriate measures shall be taken with respect to transporting and placing the concrete to control the temperature of concrete. Stockpiles, mixers and transported fresh concrete shall be kept shaded. Pipe lines for conveying concrete shall be shaded and insulated or painted white; the elapsed time from mixing to placing shall be minimized. Concrete shall be placed promptly when delivered and finishing operation shall not be delayed; concrete surfaces shall be protected from wind and sun if directed during placing, finishing or curing operations.

d) The cost of all materials, labour and equipment required as specified in this section shall be included in the rates tendered in the Bill of Quantities for concrete.

7308 Depositing Concrete

e) Whenever practicable, concrete shall be deposited directly in its final position and shall not be dropped, chute or caused to flow in a manner to permit or cause segregation. Methods and equipment employed in depositing concrete in forms shall be such as will not result in clusters or group of coarse aggregate being separated from the mass. The movement of concrete within the forms by use of vibrators will not be permitted.

f) Unless otherwise agreed by the Engineer, concrete shall not be dropped into place from a height exceeding 1.5 metres.

g) The Contractor shall provide approved chutes and baffles to confine and control falling concrete.

Open troughs, chutes or pipes shall be metal or metal lined and shall be kept clean and free from coatings of hardened concrete. Water used for flushing shall be discharged clear of the structure.

h) In the event of continuous placing being interrupted for any reason, the Contractor shall thoroughly consolidate the concrete at such joints to a reasonable uniform and stable slope while the concrete is plastic and any concrete which is un-compacted and no longer plastic shall be removed by the Contractor at his own expense. The concrete at the surface of such cold joints shall be clean and damp when covered with fresh concrete.

7309 Concrete Placed in Horizontal Layers

Except as intercepted by joints, all formed concrete shall be placed in continuous approximately horizontal layers, the depths of which generally shall not exceed 300 mm. The Engineer may direct thinner layers where concrete in 300 mm layers cannot be placed in accordance with the requirements of this Specification.

7310 Compaction

a) Concrete shall be compacted to the maximum practicable density in such a manner that it is free from pockets of coarse aggregate and closes snugly against all surfaces of forms and embedded materials.

b) Whenever practicable, concrete shall be compacted by approved immersion type vibrators operated in accordance with the manufacturer's recommendations. Form vibrators, or impact hammers applied to the forms, shall be used wherever internal vibration is not possible or would be inadequate. Where the use of mechanical vibration is not possible or would be inadequate, concrete shall be compacted thoroughly by hand.

c) In compacting each layer of concrete, the immersion type vibrator shall be operated in near vertical position and the vibrating head shall be allowed to penetrate and revibrate the concrete in the upper portion of the underlying layer. In the area where newly placed concrete in each layer joins previously placed concrete in the same layer, more than usual vibration shall be performed, the vibrator penetrating deeply at close intervals over the areas of contact of these layers. Layers of concrete shall not be placed until layers previously placed have been vibrated thoroughly as specified. Contact of the vibrating head with surfaces of the forms shall be avoided. Direct vibration of the reinforcement will not be permitted.

d) The total compacted capacity in cubic metres of concrete per hour of all vibrators in effective operating condition, and employed on concrete compaction in the Works, shall be based on a rated capacity of 70% of the manufacturer's recommendation of each type of vibrator in operation and the total compacting capacity so computed shall be not less than the maximum rate at which concrete is placed in the Works. For every 3 vibrators in use on a concrete placement, the Contractor shall provide one additional standby vibrator of similar compacting capacity in good working order.

7311: FINISHES AND FINISHING

General

a) Irregularities to finish as described herein are to be distinguished from tolerances as specified in section 7.6.

b) Finishing of concrete surfaces shall be performed by skilled workmen.

c). The Contractor shall inform the Engineer when concrete will be finished.

d) Unless inspection is waived by the Engineer in each specific case, finishing of concrete shall be performed only in the presence of the Engineer.

e) Concrete surfaces will be tested by the Engineer where necessary to determine whether surface irregularities are within the specified limits.

i. Surface irregularities are classified as ‘abrupt’ or ‘gradual’.

ii. Offsets caused by displaced or misplaced form sheathing or lining or form sections, or by loose knots or otherwise defective form timber will be considered as ‘abrupt’ irregularities, and will be tested by direct measurements.

iii. All other irregularities will be considered as 'gradual' irregularities, and will be tested by use of a template, consisting of a straight edge or the equivalent thereof for curved

surfaces. The length of the template will be 1.5 m for testing of formed surfaces, and 3 m for testing of unformed surfaces.

d) Grinding and bush-hammering will not be required on formed surfaces, but, unless waived by the Engineer in each specific case, grinding will be required for the repair of surface imperfections or for the removal of concrete which is outside specified tolerances.

7312 Class of Finish for Formed Concrete

a) All formed concrete surfaces shall be given Class 1, Ordinary Surface Finish, and in addition, if further finishing is required, shall be given a Class 2, Rubbed Finish.

b) Exposed surfaces of all formed concrete surfaces including precast concrete shall generally be given Class 2, Rubbed Finish except in the following specific locations, or as directed by the Engineer:

ii. Tops and bottoms of bridge deck slabs.

ii. Class 2 finish shall be continued not less than 300 mm below the level of any subsequent backfilling.

iii. When forms lined with metal or plywood are used, the requirement for a Class 2, Rubbed Finish may be waived by the Engineer except for the surfaces of posts and railings on bridges.

c)

i. Ordinary Surface Finish (Class 1)

Immediately following the removal of forms, all fins and irregular projections shall be removed from all surfaces except from those which are not to be exposed. On all surfaces, the cavities produced by form ties and all other holes, honeycombs, broken corners or edges and other defects shall be repaired in accordance with section 7.13.

The concrete shall then be rubbed if required or cured in accordance 7.12.

The resulting surfaces shall be true and uniform. Surface irregularities shall not exceed 10mm. All surfaces which cannot be repaired to the satisfaction of the Engineer shall be "rubbed" as specified for Class 2, Rubbed Finish.

ii. Rubbed Finish (Class 2)

After removal of forms, rubbing of concrete shall start as soon as its condition will permit. Immediately before starting this work, the concrete shall be kept thoroughly saturated with water for a minimum period of three hours. Sufficient time shall have elapsed before the wetting down to allow the material used in any concrete repairs, in accordance with section 7.13 to thoroughly set.

Surfaces to be finished shall be rubbed with a medium coarse carborundum stone, using a small amount of mortar on the faces. The mortar shall be composed of cement and fine aggregate mixed in the proportions used in the concrete being finished. Rubbing shall be continued until all form marks, projections and excessive surface irregularities have been removed, all voids filled and a uniform surface has been obtained. Surface irregularities shall not exceed 5 mm. The paste produced by this rubbing shall be left in place at this time.

After all concrete above the surface being treated has been cast the final finish shall be obtained by rubbing with a fine carborundum stone and water. The rubbing shall continue until the entire surface is of a smooth texture and uniform colour.

After the final rubbing is completed and the surface has dried, it shall be rubbed with burlap to remove loose powder and shall be left free from all unsound patches, paste, powder and objectionable marks.

7313 Class of Finish for Unformed Concrete

a) The classes of finish for unformed concrete surfaces are designated by the symbols U1 and U2. Interior surfaces shall be sloped for drainage where shown on the Drawings. Surfaces which will be exposed to the weather and which are nominally level shall be sloped for drainage at approximately two% unless the use of other slopes or level surfaces are shown on the Drawings.

These classes of finish shall apply as follows:

ii. U1 - Finish U1 (screeded finish) applies to unformed surfaces that will be covered by fill material or by concrete. Finish U1 is also used as the first stage of finish U2. The surfaces shall be levelled and screeded sufficiently to produce even, uniform surfaces. Surface irregularities shall not exceed 10 mm.

ii. U2 - Finish U2 (floated finish) applies to unformed surfaces not permanently concealed by fill material or concrete, or not required to receive finish U1. Floating may be performed by use of hand or power-driven equipment. Floating shall be delayed until the screeded surface has stiffened sufficiently to prevent the formation of latency, and shall be the minimum necessary to produce a surface that is free from screed marks and is uniform in texture. Surface irregularities shall not exceed 5 mm. Joints and edges shall be tooled down where shown on the Drawings or directed.

b) Unformed surfaces of bridge parapet posts and railings shall be given a Class 2, Rubbed Finish.

7314: CURING OF CONCRETE

General

a) All concrete shall be cured using water or using curing compound, except for surfaces which do not require a rubbed finish in accordance with section 7.11 for which membrane curing may be approved. Membrane curing will not be approved for construction joints.

b) Curing of concrete shall start immediately with the removal of form work or after 24hours of completing the surface finishing.

c) The surfaces of construction joints shall be moistened by covering with water-saturated material or by other approved means as soon as the concrete has hardened sufficiently to prevent damage by water. The surfaces shall be kept completely and continuously moist, before and after form work removal, by water applied on these surfaces.

d) Water used for curing shall meet the requirements of this Specification for water used in concrete, but with the additional requirement that the water shall not contain any chemicals or other substances that will cause staining of concrete surfaces.

7316 Water Curing

a) At least 14 days before placing concrete in any structure to be water cured, the Contractor shall submit, for approval, details of the equipment and methods he proposes to use for water curing. After the initial placement of concrete in any structure, subsequent placements will not be permitted until equipment for curing has been satisfactorily installed and is operating on all previous placements in the structure.

b) All unformed surfaces shall be protected with two thicknesses of wet coarse heavy fabric which have been spot stitched, wet jute cotton mats or by other approved effective means, as soon as the concrete has hardened sufficiently to prevent damage by water. These surfaces shall be kept completely and continuously moist, prior to and during form removal. This procedure shall be followed by the specified water curing or membrane curing.

c) Concrete to be water cured shall be cured for at least 14 days immediately following placement of the concrete, or until covered with fresh concrete, by keeping all surfaces continuously wet and avoiding cycles of being wet and then dry.

d) Water curing shall be accomplished by one or more of the following methods or any approved or directed by the Engineer.

   i. maintaining the formwork in position in a wet condition.
   ii. Ponding of water on the surface.
   iii. Covering with coarse heavy fabric, Hessian, jute felt cotton mats, cotton mats, burlap or similar approved material maintained in a damp condition.
   iv. Covering with at least 25 mm thickness of sand maintained in a damp condition.
   v. Continuously sprinkling with water.
   vi. Impervious burlap backed paper or plastic coverings placed and kept in contact with a thoroughly wetted surface.

e) Sheet materials for curing concrete and burlap shall comply with AASHTO M171 and M182 respectively.

7317 Membrane Curing

a) Membrane curing, if approved, shall be by application of an approved type of curing compound complying with AASHTO M148 which forms a water retaining membrane on the surface of the concrete surface by spraying on one coat or, where approved, by brushing or rolling on two coats, to provide a continuous uniform membrane over all areas, with a maximum coverage per litre, as directed, according to the roughness of the surface to be covered

b) When curing compound is to be used on unformed concrete surfaces, application of the compound shall commence immediately after the finishing operations are completed.

c) The curing compound shall be applied while the surface is dump. There shall be ample coverage with the compound at edges, corners and blow-holes of formed surfaces. After application of the curing compound has been completed and the coating is dry to touch, any required repair of concrete surfaces shall be performed. Each repair, after being finished, shall be moistened and coated with curing compound in accordance with the foregoing requirements.

d) Equipment for applying curing compound and the method of application shall comply with the American Concrete Institute (ACI) Manual of Concrete Practice.

e) Traffic and other operations by the Contractor shall be such as to avoid damage to coatings of curing compound for a period of not less than 28 days after application of the curing compound. Where it is impossible because of construction operations to avoid traffic over surfaces coated with curing compound, the membrane shall be protected by a covering of sand not less than 50 mm in thickness or by other effective means. The protective covering shall not be placed until the sealing membrane is completely dry. The Contractor shall remove all sand covering after completion of the curing period.

g) The Contractor shall submit, for approval, details of the proposed compound before 30 days of usage with details accompanied by test certificates to show that the compound will give satisfactory results for the proposed application.

g) Curing compound shall be delivered to the site in suitable labelled containers to enable identification of the batch number and date of manufacture.

7318 Steam Curing

a) Concrete may be steam cured for the purpose of obtaining high early strength. Steam curing operations shall not commence without the written approval of the Engineer. Once approved, no alteration shall be made in the curing method without the written consent of the Engineer. No admixtures shall be used in conjunction with steam cured concrete without prior approval from the Engineer.

b) At least 14 days before the Contractor proposes to commence steam curing, he shall submit to the Engineer the following details:

i. The duration of the pre-setting period (i.e., the interval between placing the last concrete batched and the commencement of steam curing). If a retarding admixture is used in the concrete mix this period shall not be less than 4 hours, otherwise this period shall not be less than two hours.

ii. The rate at which the temperature of the air space surrounding the units will be raised or lowered. (This rate shall not exceed 15^0C per hour).

iii. The maximum temperature of the surrounding air space during the application of the steam. (At no time will a temperature exceeding 75^0C be permitted).

iv Method of measuring the temperature at any point on the concrete.

c) The Contractor shall record the maximum temperature at points as directed and shall keep a continuous record of the temperature by an approved thermograph located to the approval of the Engineer. Temperature variations throughout the steam chamber at any time shall not be more than 5ºC. Steam shall not be applied to the member in any way which will cause uneven heating.

e) On completion of the curing, the steam supply shall be cut off and the member shall be allowed to cool gradually and evenly. Rain shall be prevented from falling on the concrete during the cooling period. Steam covers shall not be removed or disturbed in any way until the temperature at the surface of the concrete mass has fallen to within 20ºC of the ambient temperature.

7400: REPAIR OF CONCRETE

General

a) Repair of concrete shall be performed by skilled workmen. The Contractor shall inform the Engineer when concrete will be repaired. Unless inspection is waived by the Engineer, in each specific case repair of concrete shall be performed only in the presence of the Engineer.

b) The Contractor shall correct all imperfections or the concrete surfaces as necessary to produce surfaces that conform to section 7.11. For formed concrete, where the forms are removed within three days and repair of imperfections completed within 24 hours after removal of forms, or for unformed concrete where repairs are completed within 24 hours after the placing of the concrete, repairs shall be dry-pack, mortar or concrete repairs, Otherwise repairs shall be epoxy resin repairs.

c) Concrete that is damaged from any cause and concrete that is honeycombed, fractured or otherwise defective, and concrete which is rejected because of excessive surface depressions, shall be removed and built up with dry-pack, mortar, or concrete, as hereinafter specified, to bring the surface to the prescribed lines. Where bulges and abrupt irregularities protrude outside the limits specified in section 7.11 on which Class 2, Rubbed Finish is required, the protrusions shall be reduced by bush hammering and grinding so that the surfaces are within the specified limits. After the dressing, the irregularities shall not exceed the limits specified in section 7.11.

7401 Dry-Pack

a) Dry-pack that composed of a mix of 1 part of cement, by volume, to 2.5 parts, by volume, of fine aggregate passing a 1.18 mm sieve, together with enough water to produce a mortar which will just stick together could be used for filling holes having a depth greater than the least surface dimension; for narrow slots cut for repair of cracks; and for tie-rod fastener recesses as specified. Dry-pack shall not be used for filling behind reinforcement or for filling holes that extend completely through a concrete section.

b) Dry-pack shall be placed and packed into under-cut holes in layers each having a thickness of approximately 10 mm. Packing shall be carried out with a hardwood stick struck with a hammer to compress the dry-pack thoroughly into contact with the surfaces of the hole.

7402 Concrete

a) Concrete-filling shall be used for holes extending entirely through concrete sections, for holes which are greater in area than 0.10 square metres and deeper than 80 mm, and for holes in reinforced concrete which are greater in area than 0.05 square metres and which extend beyond the reinforcement that is nearest the surface.

b) Concrete used for repairs shall be of the same class as the concrete in the location at which the repair is being made.

7403 Epoxy Resin

a) Epoxy resin repairs shall not be made until 28 days after the concrete has been placed, unless earlier repairs are approved, and shall be completed within 60 days after the concrete has been placed. All materials used for epoxy resin repairs shall be subject to approval and the repairs shall use an unfilled epoxy resin as the bonding medium between old concrete and the repair material, which can be dry-pack, mortar or concrete.

b) Epoxy resin repairs shall be carried out as follows:

   i. All imperfections to be repaired with epoxy resin shall be chipped back to sound concrete and the edges of the holes trimmed square for a minimum depth of 3 mm.

   ii. Immediately before performing a repair, the surface of the concrete to be repaired shall be free of all contaminants by grit blasting or scabbing, and shall present a clean, sound, dry, roughened and dust-free surface with the surface temperature not less than 15 ^{0}C and not more than the temperature of the surrounding concrete.

c) After preparation, the surface of the area to be repaired shall be covered with a thick coat of an approved unfilled, solvent less epoxy resin, prepared, batched and mixed in accordance with the manufacturer's instructions and thoroughly brushed into the surface. Immediately and before the resin becomes 'tacky' the repair material shall be placed and finished to the required standard. Curing of the repair shall be performed in accordance with section 7.12 with the additional requirement that the repair is to be maintained at a temperature not less than 20^{0}C for a period of 24 hours, without allowing heat to be directed onto the repair and cause excessive drying of the repair material. Epoxy resin which has become 'tacky' before the repair material has been placed against it, shall be removed and the surface again prepared to the satisfaction of the Engineer.

d) Unused epoxy resin, shall be wasted when it loses its plastic condition. Excess or spilled resin on surfaces for which a Class 2, Rubbed Finish is specified shall be cleaned immediately and while the resin is in a plastic state.

e) Should it be necessary to form an epoxy filled repair, either the forms shall be incompatible with the resin or the form shall be coated with a special release agent.

f) The finished surface of the epoxy resin repairs shall comply with Section 7.11. Any grinding required on epoxy filled repairs shall be performed using a silicon-carbide or other suitable abrasive and preferably under water.

7404 Plugging form-tie holes

In formed concrete, surface holes remaining after dismantling form-ties shall be cleaned out and neatly plugged with dry pack as previously specified. The dry-pack shall be colour matched with surrounding concrete.

7405 Measurement and Payment

All materials, labour and equipment required for the repair of concrete or removal of stains shall be provided at the expense of the Contractor.

7500: CONSTRUCTION OF BOX CULVERTS

7501 Requirement

The Contractor shall construct box culverts where shown on the Drawings or directed. Construction of each box culvert includes the followings:

i. demolition and disposal of existing structures where shown on the Drawings;

ii. provide cofferdams and remove, dewatering if required;

iii. Temporary diversion of traffic;

iv. Clearing and grubbing of the sites and excavation for foundation, and grading of the finished surface adjacent to apron slab;

v. construction of cast in-situ or precast concrete slabs, walls, apron slabs, wing walls and headwalls;

vi. Backfilling and construction of road embankment around and above the culverts; and

vii. Construction of brick pitching, slope and scour protection.

7502 Materials

a) Materials and construction shall be in accordance with their respective parts of the Specification as follows:

	Section
Clearing and grubbing	2.1
Excavation for structures	2.5
Improved sub-grade material	2.9
Aggregate drain	2.7
Free draining backfill	2.7
Form work	7.05
Concrete	Part 6 and Part 7

b) Foundation material for culverts shall consist of sound natural soil or road base material.

7503 Clearing and Grubbing

Clearing and grubbing shall be carried out within 5 m of any structure.

7504 Excavation

Excavation and preparation of foundations shall be in accordance with the dimensions shown on the Drawings.

7505 Construction sequence

The construction of the box culverts shall be carried out in the following sequence:

i. Wing walls shall be constructed and back-filled to at least the level of the wall construction joint as shown on the Drawings, before any construction of the culvert Base Slabs or Apron Slabs in the vicinity of a wing wall shall be permitted.

ii. The Cut-off wall part of the Apron slab shall then be constructed and backfilled.
iii. The order of construction of the remainder of the works shall be as determined by the Contractor.

7506 Backfilling

a) Backfilling and compaction shall be carried out in accordance with specification 2000 series with the particular requirements of this subsection.
b) All bracing, formwork etc. shall be removed prior to backfilling.
c) Prior to any construction plant or diverted traffic being permitted on the culverts and after all construction is approved by the Engineer a minimum of 300 mm of fill shall be placed over the culvert.

7507 Traffic Diversion

This project may not have the problem of traffic provision, but if in some location it would be needed, to allow the earliest possible diversion of traffic onto the culverts, the Contractor may construct the culverts to approximately half width and divert traffic prior to completing the remainder of the works but only with the prior approval of the Engineer. All provisions for traffic and temporary traffic diversion works shall be in accordance with Section 1.1 of the Specification 1000, however no payment will be made for provision of traffic, if required at some locations.

7508 Measurement and payment

a) Unless otherwise specified, payment will be made in accordance with the following sections:

Section	
Clearing and grubbing	2.1
Demolition of Box Culverts	2.2
Excavation for structures	2.5
Compaction of foundations	2.5
Free-draining backfill	2.7
Form work installation and removal	7.05
Reinforcement in structures	7.7
Concrete in structures	7

Pay items		**unit**	
75/3	Demolition of existing structures		Each
75/4	Unclassified Structure Excavation	Cum	
75/5	Extra Depth Excavation	Cum	
75/6	Unclassified channel Excavation		Cum
75/10	Concrete in Culvert base slab/apron slab	Cum	
75/11	Concrete in culverts walls, roof slab and wing walls	Cum	

7600: CONSTRUCTION OF PIPE CULVERTS/ PREFABRICATED CULVERTS

General

The Contractor shall construct pipe culverts comprising jointed precast concrete pipes and in-situ concrete head walls to the lines grades and dimensions shown on the Drawings.

7601 Materials

Materials for and manufacture of pipe culverts shall comply with Parts 6 & 7 of this Specification and the requirements of the following:

i.	Precast concrete pipe	Section 9.3
ii.	Sand bedding	Section 2.7.2
iii.	Improved sub grade material	Section 3.1

7602 Excavation

a) After preparation of the embankment foundation in accordance with Section 2.2 is complete, further local excavation for trenches may be required and shall be in accordance with Section 2.5 and the particular requirements of this Section. Compressible and other unsatisfactory material on the bottom of trenches shall be removed as directed before laying the pipes. Rock, boulders or other unsuitable material shall be removed to not less than 150 mm below the pipe.

b) Trenches shall have vertical walls, or be as near to vertical as is practicable.

7603 Installation

a) The pipes shall be bedded on sand bedding complying with Section 2.7.2 to provide class B type bedding complying with the AASHTO Standard Specifications for Highway Bridges; and shall be installed in accordance with the Drawings.

b) Pipes shall be bedded on a 100 mm thick layer of sand bedding compacted by hand held mechanical compaction equipment to provide a firm and uniform bed for the pipe.

c) Culvert length shall be no less length than will conform to the cross sections shown on the Drawings, provided that culverts may be extended to use whole pipe lengths. Any adjustment of earthworks required to ensure burial of the pipe shall not be measured for payment but the cost shall be included in the Contractors rates generally.

d) The pipes shall be laid starting at the lowest end with the bell end laid upgrade, and with the invert of the pipes conforming to the grade line all as shown on the Drawings or directed by the Engineer. The minimum grade of a culvert shall be 0.5%, or as shown on the drawing.

7604 Jointing

a) Joints in pipes shall be of the bell and spigot type unless otherwise directed or approved by the Engineer.

b) All joints shall be sealed and made waterproof.

c) Rubber ring joints should be used and fitted in accordance with the manufacturer's instructions.

d) If rubber ring joint is not used the joints shall be totally filled with mortar made of 3:1 fine sand/ cement.

e) The faces of the pipes to be joined shall be thoroughly wetted, then butted as tightly as possible against each other. The space between the abutting ends of the pipes shall not exceed 0.5% of the diameter of the pipe. The joint shall be completely filled with mortar, both on the inside and outside of the pipe, to give neat and smooth surfaces uniform with the inside and outside surfaces of the pipe, respectively.

f) In all cases care shall be taken that the interior of the pipe is cleaned of any excess mortar after jointing.

g) Mortar joints shall be protected from the sun, and if necessary covered with sand or wet bags to prevent rapid drying of the mortar for at least 48 hours after placing.

7605 Backfilling

a) Once the pipes have been laid, jointed and approved, backfill material shall be placed about the pipes.

b) The backfill shall be selected sand bedding and improved sub grade material, conforming to the requirements of section 3.1. The fill material shall be brought up evenly and simultaneously on both sides of the pipe, ensuring it is in contact with the underside of the pipe. Minimum Height above pipe outer invert shall be equivalent to the diameter or to the design road surface level.

7606 Construction equipment

Heavy earth-moving and compaction equipment shall not be operated closer than 1.2 m to the pipe until a cover of 0.3 m has been placed and compacted over the top of the pipe.

7607 Measurement and payment

a) Measurement, for payment, for furnishing and installing of concrete pipes shall be made of the length of pipe measured along the centreline of the pipes in place, with no allowance for lap at joints.

b) Payment will be made at the Contract Unit Price for each of the items listed below which is shown in the Bill of Quantities. Such payment shall include furnishing, placement, joint sealing

materials and reinforcement in the pipes, back filling and all other tools, materials and tests necessary for the works except as noted below.

Pay Item	Unit
76/1 - Furnish and Install Concrete Pipe 300 mm, Class-I	m

c) Payment for excavation of trenches will make in accordance with Section 2.5.
d) Payment for blinding concrete, concrete in pipe culvert headwalls will be made in accordance with relevant section.
e) Payment for improved sub-grade material bedding and back filling up required level above the pipe will be made under Item 27/1.

7700: CONCRETE IN MAJOR STRUCTURES

7701 Concrete in Pile Caps

1. The item in the Bill of Quantities for Concrete in Pile Caps includes all required concrete in the pile caps for abutments and piers for bridges as shown on the Drawings or directed by the Engineer, but excluding concrete in piles.
2. The concrete for pile caps shall be deemed to be mass concrete and the requirements of sub-section 5 of Section 7.09 shall apply.

7702 Concrete in Abutments

The item in the Bill of Quantities for Concrete in Abutments (Item 81/6) includes all required concrete in the curtain walls and wing walls above the pile caps for bridges including run-on slabs, but excluding concrete in parapets as shown on the Drawings of directed by the Engineer.

7703 Concrete in Piers

The Item in the Bill of Quantities for Concrete in Piers includes all required concrete in the bridge piers above the pile caps, including columns and crossheads, as shown on the Drawings or directed by the Engineer.

7704 Concrete in Bridge Girder

The Item in the Bill of Quantities for Concrete in girders, cross-beams includes all required concrete in above the pile caps, as shown on the Drawings or directed by the Engineer.

7705 Concrete in Bridge Decks

The item in the Bill of Quantities for Concrete in Bridge Decks (Item 8.12) includes all required concrete in bridge decks for bridges including diaphragms, kerbs and edge beams as shown on the Drawings or directed by the Engineer, but excluding concrete in parapets.

7706 Concrete in Parapets and Barrier Wall

The item in the Bill of Quantities for Concrete in Parapets and Barrier walls (Item 8.13) includes all required concrete in parapets, including parapet posts and rails and end posts, above wing walls of abutments and above edge beams of bridge decks, as shown on the Drawings or directed by the Engineer.

7707 Measurement

1. **General**

Measurement, for payment, for concrete in structures shall be made to the neat lines of the structures unless otherwise specified.

2. **Deductions**

In measuring concrete for payment, deductions shall be made for:

a) The volume of all ducts, embedded pipes and metalwork, and other block outs having a cross-sectional area larger than 0.10 sq.m as measured at right angles to their longitudinal axis; and
b) All openings, recesses and block outs with cross sectional areas less than 0.10 square metres but which have an individual volume larger than 0.5 cubic metres.

3. **Over-breakage**

Measurement will not be made for concrete required to be placed outside specified or approved excavation pay lines, excess excavation or wasted concrete, or for any other reason.

7708 Payment

1. **Concrete in Structures**

Payment for concrete in the various parts of the Works will be made at the applicable price per cubic metre tendered in the priced Bill of Quantities for the following items:

Pay Item		Unit
77/1	Concrete in Pile Caps	cubic meter
77/2	Concrete in Abutments	cubic meter
77/3	Concrete in Piers	cubic meter
77/4	Concrete in Bridge Girder & Diaphragm	cubic meter
77/5	Concrete in Bridge Decks	cubic meter
77/6	Concrete in Parapets	cubic meter
77/7	Concrete wearing Course	cubic meter.

7800: RAIN WATER DOWN PIPE

General

c) The Contractor shall form rain water down pipes having a minimum diameter of 50 mm through box culvert top slab where and as shown on the Drawings or directed.

d) Rain water down pipes which become obstructed shall be cleaned out to their full depth in an approved manner or shall be replaced by and at the expense of the Contractor.

7802 Payment

a) The payment will be made for forming rain water down pipes and all such costs shall be measured and paid in the rates bid in the priced Bill of Quantities as linear meter

Pay Item		Unit
78/1	Supply and Installation of rain water down pipes	linear meter

7900: WEEP HOLES

General

Facilitation for removal of moisture behind earth fill of structures are called weep Holes. It comprises a small openings left in the outer wall of retaining walls or abutment walls as an outlet for water/moistures from inside to move outside the wall. Weep Holes shall be installed as per the drawing or the instruction of the Engineer. For the details of the weep Holes refer to the design. The weep hole consists of two pats. The pipe that cross the wall as the median for water flow and the filter at the mouth of the upper opening of the pipe. A PVC Pipe of 50mm dia or 75mm dia shall be used.

The filter should be as show on the drawings, if not shown on drawings, than the filter may comprise of three type of aggregate. 100mm stone at the mouth of the pipe followed by 100mm of 25mm open grade crushed stone. Another 100mm layer of sand or quarry dust layer shall be placed over the 25mm aggregate layer. The Filter shall have spherical shape.

7902 Payment

The payment will be made for forming the weep hole on the process of wall construction and back fill, facilitation of pipe through the wall, and construction of the filter at the mouth of the pipe. All such costs shall be measured and paid in the rates bid in the priced Bill of Quantities as each.

Separate payment will not be made for forming weep holes according to this section, , and all costs associated with meeting the requirements of this section (Weep Holes) including furnishing all filter and other associated materials shall be included in the rates bid in the Bill of Quantities for the relevant work for which the weep holes will be used.

8000: PRECAST CONCRETE CONSTRUCTION

General

a) The Contractor shall construct and erect precast concrete units, in accordance with this Part where and as shown on the Drawings or directed.

b) The units may be supplied by a manufacturer or may be manufactured by the Contractor at an approved location. For units, such as precast concrete pipes, which are not detailed on the Drawings, the Contractor shall also submit for approval all details of the individual units, including proposed reinforcement and location of lifting points as hereinafter specified.

c) Repairing of damaged units will not be approved except where such damage and repair will not impair the strength or the appearance of the units after installation.

8102 Approval of Methods

Thirty (30) days before commencing manufacture of all precast concrete units the Contractor shall submit for approval all details of the methods to be used in manufacture, handling, transport, storage and erection of the units.

8103 Construction

a) Except as otherwise provided in this Part, all units shall be constructed and created in accordance with the applicable requirements of series 6000.

b) The maximum size of aggregate for all precast concrete shall generally be 20 mm, except for concrete pipes where the maximum size of aggregate shall be 10 mm.

c) The classes of concrete used to manufacture precast concrete units shall be in accordance with Clause 6300 of Specification 6000

d) All units shall be cast in individual forms and may be cured in accordance with Clause 6020.

e) Where the use of immersion type vibrators is not practicable the Contractor shall consolidate thin precast concrete slabs and units on a vibrating table or by another approved method.

8104 Marking

a) Immediately on removal of forms, each unit shall be clearly marked with the date of casting, the estimated mass and the identification number directed by the Engineer. Temporary identification and date of casting markings shall be scratched into the top surface of beams near an end immediately after screeding off.

b) The marking shall be made by an approved indelible marking material using letters approximately 75 mm high.

c) Care shall be taken to ensure the marking on outside facing bridge beams is made on the inner face.

8105 Handling

a) At all times, especially during transportation, all precast concrete units shall be supported as in their final positions. Other methods of support may be approved if the Engineer considers that the units will not be damaged in any way by the proposed method of support.

b) All units shall be lifted only at the lifting points shown on the Drawings. Where lifting devices have not been detailed the Contractor shall submit, for approval, complete calculations and details of his proposed lifting devices.

c) All units shall be adequately braced and supported during erection to ensure proper alignment and safety. Such bracing or support shall be maintained until adequate permanent connections have been made. Special care shall be taken not to damage the flanges of beams.

d) Temporary supports for members shall be timber bearers at least 150 mm wide and 100 mm thick, placed on a firm foundation and supporting the members over their full width. The ground or space between the bearers supporting the members shall be carefully cleared and levelled to prevent the member being accidentally supported other than on the bearers.

e) No precast unit manufactured away from the site shall be delivered to the site without the approval of the Engineer, nor shall a unit be transported from the place of manufacture prior to the completion of the specified curing.

8106 Tolerances

For the purposes of this Clause the following definitions or interpretations apply:

i. Tolerance means the permitted variation from a stated dimension or shape, excluding any deliberate shortening of dimension to provide clearance.

ii. Length and Width refer, as the case requires to :
- the longer and shorter sides of a rectangular precast unit;
- any side of a unit which is not rectangular;
- the overall length and width at any location of any unit.

iii. Straightness and Flatness mean the tolerance distance of any part of an edge or surface from the nearest point of a straight line joining the ends of the edge or of the surface in any direction.

iv. Twist means the rotation of one end relative to the other end.

v. Warp means the maximum permissible tolerance distance of any point on a surface from any of the four planes through three of the four corners of a rectangular surface. These corners, if the surface is not rectangular, being those points on the surface which are the corners of a rectangle having the greatest possible area and generally, but not necessarily wholly, within the actual surface of the unit.

vi. Squareness means the maximum permissible tolerance distance by which a shorter side may deviate from a straight line through the corner and perpendicular to the longer side.

- any error in the straightness of the adjacent sides being ignored for the purposes of this definition; and
- where the included angle between the surfaces or sides is intended to be other than a right angle, the check line being varied accordingly.

The dimensions of all finished precast concrete units shall be within the following limits at the time of placement of the units in the structure, unless otherwise specified herein or shown on the Drawings:

Table 8-1-Allowable tolerances

	Dimensions	Tolerances
I.	Members others than flat panels:	
	Cross-section, overall dimensions-	
a)	Less than 600 mm,	±3 mm
b)	More than 600mm but less than 1600mm	±6 mm
c)	More than 1600 but less than 1500 mm,	+10 mm, - 6 mm
2.	Cross-section, dimension of parts such as webs, ribs and flanges	±6 mm
a)	less than 1500 mm,	+10 mm,- 6 mm
b)	more than 1500 mm.	+0, - 6 mm
3	Length, critical dimensions of abutting members.	±length/1000
	Length, non-critical –	
a)	less than 6 m;	±6 mm
b)	more than 6 m.	10 mm/m width per
3.	Twist.	3 m of length
II.	All units:	
a)	Straightness of edges and flatness of surfaces.	Length/1000
b)	Warp	
	less than 5 m diagonal	6 mm
	not less than 5 m diagonal	10 mm
c)	Squareness of corners -	
	less than 2 m, on shorter side;	3 mm
	not less than 2 m, less than 4 m,	5 mm
	not less than 4 m.	6 mm

d) Holes or openings and the like, diameter or side dimensions.	±3 mm ±7 mm
e) Location of holes or openings	2 mm
f) Grooves, width and depth.	Within 3 mm of their true positions in the group in which they are cast.
g) Position of individual connecting bolts, both holes, projecting metal or other devices in any associated group (e.g. the joint of two precast units).	Within 6 mm of its true position in the unit in which it is cast, if the tolerance does not adversely affect the proper assembly of the whole structure.
h) Longitudinal locations of any such groups (mentioned in item (g)	

8200: Precast Concrete Pipes

General

a) The Contractor shall manufacture precast concrete pipes for pipe culverts in accordance with this Clause and the applicable provisions of specification 6000 and 7000.

b) Concrete pipe shall be constructed in accordance with Clause 7015.

8202 Materials

a) Concrete pipes shall be of diameter as shown, and shall conform to the requirements of AASHTO M242M.

b) For each diameter of pipe, classes shall differentiate between pipes of different strength designation.

c) The strength designation of the pipe shall be the D-load to produce a 0.30 mm crack when tested by the three-edge bearing method of loading all in accordance with AASHTO T280M. The D-load strength is quoted as (KN/m). , and are.

Table 8-3 minimum required strengths and classes

Diameter mm	Class	D-load kN/m
300	II	15
600	I	24
	II	30
815	I	37
	II	46
	III	58
1700	I	68

d) Pipes to be tested for strength shall be selected at random by the Engineer. At least one pipe for each diameter and class of pipe shall be tested to failure by the Contractor in the presence of the Engineer, and the material cost of this pipe shall be paid for by the Employer. Otherwise, the cost of all equipment and labour required to carry all testing of pipes shall be included in the rates for construction of pipe culvert in Clause 7015.

e) Minimum clear cover to reinforcement shall be 30 mm.

f) Reinforcement shall comply with clause 7700.

8203 Joints

a) In general, concrete pipes shall be manufactured with male and female ends. Joints in concrete pipes shall be of the bell and spigot type.

b) All joints shall be capable of transferring the required shear across the joint. The Contractor shall furnish to the Engineer a certificate of compliance that the pipes conform to this requirement.

c) pipes shall be interchangeable, except for special end sections.

8204 Payment

Payment for precast concrete pipes will be made in accordance with Clause 7600.

8300: PRECAST CONCRETE BEAMS

General

The Contractor shall furnish and erect precast reinforced concrete beams for bridges to the lines, grades and dimensions shown on the Drawings or directed by the Engineer.

8302 Dimensions and Tolerances

a) The dimensions and shape of precast concrete beams shown on the Drawings shall apply to the beams as close as practicable to 28 days after casting and the beams shall be supported at the positions specified for stacking.

b) The dimensions and profile of the forms shall be so constructed to include the upward deviation in the vertical plane, or camber, required as shown on the Drawings. The Contractor shall submit, for approval, details of how he proposes to introduce the camber, and construction of the forms shall not commence without such approval by the Engineer.

c) Except where otherwise required by Clause 8500, tolerances for precast concrete beams shall be in accordance with Clause 8100.

8303 Payment

a) Payment for furnishing and erecting precast reinforced concrete beams will be made at the rate per cubic metre of concrete in the finished beam bid therefore in the priced Bill of Quantities.

b) The rate shall include the entire cost of all labour, equipment and materials required to manufacture and erect the precast beams in their final positions.

8400: PRECAST PRE STRESSED CONCRETE BEAMS

General

a) The Contractor shall cast, furnish and erect precast prestressed concrete beams for bridges to the lines, grades and dimensions shown on the Drawings.

b) Prestressing of precast beams shall be in accordance with series10000.

8402 Approval of Methods

The Contractor shall, at least 30 days before commencement of manufacture of the precast beams:

i. Submit to the Engineer for approval full details of his method of forming, placing and curing of the beams and his handling, transporting, stressing, grouting and erection methods. Once approved, the Contractor shall not vary his methods without the written approval or direction of the Engineer; and

ii. Submit to the Engineer for approval shop Drawings and details of all metalwork, prestressing tendon anchorages to be embedded in the beams, schedules of locations of material and marks by which individual items can be identified.

8403 Handling of Beams

a) Prestressed concrete beams shall be fully stressed or stressed to the extent shown on the Drawings and all stressed tendons shall have been grouted for 7 days before lifting or handling of the beam unless the moving of the beams off their casting beds before grouting stressed tendons is approved. If such approval is given each un-grouted tendon shall be adequately marked for possible slip and should any slip or damage occur, the tendon shall be replaced and/or re-stressed as directed.

b) Completed beams shall not be stacked on top of each other and no superimposed load shall be placed on a member without prior approval.

8404 Dimensions and Tolerance

a) The dimensions and shape of prestressed concrete beams shown on the Drawings shall apply to the beams at the time of their completion when under self weight alone.

b) Except where shown otherwise on the Drawings or approved, the dimensions and profile of the forms shall compensate for deformations caused by prestressing so that the dimensions and profile of the completed members shall conform to the Drawings. The Contractor shall submit, for approval, details of the magnitude of these deformations and how he proposes to allow for them. Construction of the forms shall not commence without such approval.

c) Except where otherwise required by this subclause, tolerances for prestressed concrete beams shall be in accordance with Clause 8.1.

d) Variation in the overall length and length centre to centre of bearings shall be accurate to within 7 mm or ±0.05 per cent of the length, whichever is the greater.

e) Sagging profiles in a vertical plane will generally not be permitted but upward deviation (hog) from the required profile of up to 0.1 per cent of the span length will be approved.

f) The deviation of a member from straightness in a horizontal plane (bow) shall not exceed 7 mm or ±0.05 per cent of the length of the member, whichever is greater.

g) Location of ducts and sheathing shall be accurate to ±4 mm.

h) Cover to ducts and sheathing shall be not less than 50 mm.

8405 Construction

a) Sheathing for all ducts shall be placed accurately in the formwork in the position shown on the Drawings and shall be adequately tied and held against movement during concreting. The sheathing shall be fixed so as to ensure the alignment as well as the position of ducts at joints is accurate. All joints in the sheathing shall be mortar tight. Sheathing shall be stiffened during concreting by means of an internal stiffener of equal or greater diameter than the final tendons. Immediately after the whole of the concrete has been placed in a precast concrete beam, all duct internal stiffeners shall be pulled back and forth for about 300 mm to ensure they are perfectly free inside the sheathing.

b) All anchorage plates for prestressing tendons shall be accurately positioned square to the line of action of the tendons and held firmly during concreting. Should any mortar adhere to the exposed faces of the anchorages, it shall be removed.

c) Concrete shall not be placed until all formwork, block outs, installations of sheathing, grout points or vents, anchorage plates for prestressing tendons, reinforcement, embedded metalwork and any other fittings shown on the Drawings or required by the Specification have been approved by the Engineer. Placing of concrete shall be performed only in the presence of the Engineer.

d) The parts of the top surface upon which the concrete deck is to be placed shall be suitably roughened to the extent shown on the Drawings by compressed air nail hammering or other approved means. Care shall be taken to protect corners from damage or disfiguration.

8406 Payment

a) Payment for furnishing, erecting, steel work, concrete work, prestressing precast prestressed concrete beams will be made at the rate per cu.m. bid therefore in the priced Bill of Quantities.

b) The rates shall include the entire cost of all labour, equipment and material required to manufacture the precast beams and to erect the prestressed concrete beams in their final positions, It also include supplying and installation of prestressing materials and prestressing, reinforcement and miscellaneous metalwork in the beams, in accordance with relevant sections, no separate payment will be made for any work related to prestressing beam till its final positioning and installation.

Pay Item		Unit
84/1	prestressed concrete beams	Cum

9000: GENERAL

9001 Pay Items

This item will not be paid as separate item, all of its associated cost should be considered to be included in the rates tendered for the prestressed concrete for which prestressing will be used.

9100 PRESTRESSING - GENERAL

9101 General

a) The Contractor shall furnish and install all prestressing materials and accessories, and carry out all prestressing operations required for the precast prestressed concrete bridge beams as shown on the Drawings or directed by the Engineer.

b) Precast prestressed concrete bridge beams shall be constructed in accordance with Part 9 and the particular requirements of this part.

c) The prestressing force in each member shall be applied by tendons of high tensile steel wires or strand.

e) Prestressed concrete design shall conform to the AASHTO Standard Specifications for Highway Bridges.

9102 Approval of Methods

a) The method of prestressing shall be as shown on the Drawings unless otherwise approved.

b) The Tenderer may propose in his Tender an alternative system to that specified herein and shown on the Drawings. The proposed alternative system shall provide means of:

i. Prestressing in stages, and de-stressing at any stage before grouting; and

ii. measuring the load in and elongation of the tendons.

c) All beams have been designed for the prestress forces and eccentricities shown on the Drawings. Reinforcement behind prestressing anchor plates has been designed for the prestressing shown on the Drawings.

d) Any alternative prestressing design or systems proposed by the Contractor shall be such that the general arrangement, depth and outward shape of the beams remain unaltered.

e) The Tenderer shall submit for approval with his tender full details of anchorages, anchorage reinforcement, sheathing and relevant particulars of the proposed tendons, together with complete Drawings of those parts of the structure affected by the change, complete with design calculations including calculated tendon elongations. All Drawings submitted shall be to the same scale as the relevant views on the Drawings.

f) Where no alternative prestressing system or design has been approved, the Contractor shall submit for approval at least 45 days before constructing any beams full details of anchorages and sheathing.

g) The Contractor shall precast the prestressed beams in accordance with Part 9, in segments as shown on the Drawings at an approved location.

9103 Materials for Tendons

a) Tendons shall comprise low relaxation type wire or strand complying with AASHTO M204 or M203 respectively unless otherwise approved in accordance with subclause 2 of this Clause.

b) The Contractor shall state the secant modulus of the tendon material proposed at the average tensioning stress shown on the Drawings together with the guaranteed limits of its variation. Values shall be substantiated by test results.

c) i. Three (3) test pieces selected by the Engineer shall be tested by the Contractor and manufacture. Placing of tendons shall not commence until satisfactory results have been received from these tests and the Engineer has approved the use of the material in tendons. Further test pieces, approximately one for each tonne of tendons used in the construction, will be taken during the progress of the work and shall be tested by the Contractor in the presence of the Engineer for conformity with the requirements of this Specification.

ii. The ratio of length to diameter of test pieces shall exceed 100:1. Test pieces shall not be taken from the end 1.5 m of a coil of wire or strand.

iii. Should any test piece fail to satisfy the specified properties of the steel, the quantity of material represented by that specimen shall not be used in the works and shall be replaced in accordance with the Conditions of Contract.

d) All testing shall be carried out in an approved laboratory.

9104 Anchorage Devices and Couplings

a) All anchorages for tendons shall be in accordance with the approved stressing systems. All anchorages shall be provided with a positive centring device so that the anchorage heads can not move during tensioning.

b) All couplings for tendons shall be in accordance with the approved stressing systems.

c) Anchorages and coupling devices shall be capable of withstanding a force of not less than 95 per cent of the specified minimum ultimate tensile strength of the tendon without damage or excessive deformation or draw-in.

d) Swaging of strand and button-heading of wire shall be carried out only by approved methods and the swages / button-heads shall develop not less than 95 per cent of the specified minimum ultimate tensile strength of the strand or wire.

e) At least 30 days before the start of concreting operations, the Contractor shall supply, to the Engineer, details and results of tests carried out on the following:

i. 2 complete anchorages and couplings for each type of tendon to be used in the works; and

ii. 2 sample lengths of tendon with ends treated for anchorages and couplings.

f) Anchorages and couplings shall be tested during the progress of the work at the rate of one anchorage of each size and one coupling for each type of the tendon for each consignment delivered to the works. Sufficient length of the appropriate made-up tendon shall be tested
with each anchorage or coupling for the strand prestressed tendons to suit testing arrangements.

g) Anchorages and tendons shall not be installed until testing of the anchorages has been approved.

h) Should any anchorage or coupling fail to comply with paragraph c) of this subclause, the quantity of anchorages or couplings represented by the specimen shall be replaced. The Engineer will not approve the use of further similar anchorages or couplings until he is satisfied that they will be able to meet the above requirements.

i) No damaged anchorage or coupling devices shall be used. All steel in the anchorages shall be protected from corrosion at all times. All threaded parts shall be protected by greased wrapping and all tapped holes shall be protected by suitable plugs until used. The devices shall be kept free from mortar, loose rust, grease, tar, paint, oil, mud or any other coating. The Engineer may direct the use of a suitable coating to protect the exposed faces of anchorages and anchorage plates after embedment in the precast beam segments but all such coating shall be removed immediately before the tendons are installed.

9105 Ducts

a) Ducts for the insertion of prestressing tendons shall be formed in the concrete beams by means of flexible galvanised steel or bright metal sheathing or by other approved means.

b) The ducts shall be strong enough to withstand the placing and the vibration of the concrete without suffering any damage or deformation. Internal and external diameters of the ducts shall be within the limits approved or directed by the Engineer.

c) The ducts and any joints shall be mortar tight and the ducts shall be in one piece between the ends of each segment or placement. Curved pieces of duct shall be pre-bent to the dimensions shown on the Drawings and shall be checked with lengths of tendon for flattening and other distortions which might obstruct the free movement of the tendons.

d) Before the ducts are embedded in the concrete, they shall be accurately aligned and securely fixed in position by means of rigid supports spaced at intervals of not more than 1 m.

e) Ducts shall be grouted from the centre of each beam and grout vents shall be provided at both ends of ducts. Grout holes and vents shall be equipped with a plug, valve or similar device capable of withstanding a grout pressure of 500 kPa without loss of water or air.

9106 Handling and Storage of Tendon and Accessories

a) The Contractor shall receive all materials at the site and store the materials under cover on suitable supports above the ground. High-tensile steel wire and strand shall be supplied in coils, which shall be supported so that they are free to rotate before lengths of tendons are drawn from them. Materials shall be kept free from loose or thick rust, oil, grease, tar, paint, mud, or any other deleterious substance but shall not be brought to a smooth polished condition. A slight film of rust will not be regarded as harmful, but the steel shall not be visibly pitted by rust.

b) The Contractor shall be responsible for checking that all dimensions and quantities shown on the manufactured schedules are correct and shall obtain copies of these schedules from the manufacturers for this purpose.

c) Before being assembled or worked in any way, the prestressing materials shall be clean and free from kinks or damage. All damaged materials shall be removed from the Site and replaced.

9200: PRESTRESSING OPERATIONS

9201 General

a) Care shall be taken during all prestressing operations and during tensioning in particular to ensure the safety of all personnel engaged on the work and of other persons in the vicinity.

b) Jacks shall be secured in such a manner that they will be restrained should they lose their grip on the tendons. No person shall be allowed to stand behind the jacks or close to the line of action in front while tensioning is in progress. The operation of the jacks, the measurement of the elongation and associated operations shall be carried out in such a manner and from such positions that the safety of all concerned is ensured.

c) Heavy stoppers, made either of hardwood or sheet metal, shall be provided and placed in such a manner as to prevent any tendon which might become loose from recoiling unchecked. During actual stressing operations, warning signs in adequately large letters shall be displayed at both ends of the member being tensioned.

d) All anchorage plates for prestressing tendons shall be accurately positioned square to the line of action of the tendons and held firmly during concreting. Any mortar adhering to the exposed faces of the anchorages shall be removed.

e) Concrete shall not be placed until all formwork, blockouts, installations of sheathing, grout points or vents, anchorage plates for prestressing tendons, reinforcement, embedded metalwork, lifting devices and any other fittings shown on the Drawings or directed by the Engineer have been approved. Placing of concrete shall be performed only in the presence of the Engineer.

9202 Tensioning Equipment

a) All tensioning equipment shall preferably be power driven and subject to approval before use. The power unit shall be so adjusted that the rate of extension of the tendon is within recommended limits or as directed.

b) Dynamometers and each set of equipment comprising pump, jack and pressure gauges shall be calibrated as directed and the true force determined from the calibration curve. Dynamometers and scales shall permit force and elongation respectively, to be determined within an accuracy of 2 per cent.

c) Pressure gauges shall be concentric scale gauges accurate to within 1 per cent of their full capacity; they shall be selected so as to be used between 50 and 90 per cent of their full capacity and shall be not less than 200 mm in diameter. Where pressure gauges are used, a device shall be fitted to protect the gauge against sudden release of pressure. Provision also shall be made, by such means as a Tee connection, for the attachment of a second gauge to be used as a check when directed:

9203 Required strength and Age of Concrete for Prestressing.

a) The prestressing force shall not be applied to a beam until all the concrete in the beam has attained the compressive strength stated on the Drawings, nor shall it be applied at an earlier age than 14 days after casting (or repair) if moist cured, or 2 days after casting (or repair) when steam cured, provided that when steam cured the temperature of the concrete has returned to the ambient temperature. The use of excess cement to obtain high early strength will not be permitted.

b) The age at which the prestressing force is to be applied will be directed or approved and shall take into consideration the modulus of elasticity of the concrete. Variations in atmospheric temperature and humidity may make it desirable to vary the age at which individual beams are prestressed so that the modulus of elasticity, and hence the resulting deformations and hogging of beams are as alike as possible.

9204 Tensioning Force Required.

a) The tensioning force applied to any tendon shall be measured both directly by measurement of the force or jacking pressure and indirectly by measurement of the elongation of the tendon. Where not stated on the Drawings, the Engineer will direct which of these methods is to be regarded as determining the tensioning force and which is to be regarded as checking it.

b) The values for elongation of the tendons due to the applied tensioning force shall be determined by the Engineer. Allowance shall be made for the anticipated draw-in at the anchorage devices on release of the jacks.

c) Determination of the tensioning force by means of elongation will only be approved when the limits of variation of the secant modulus, at the tensioning stress guaranteed by the Contractor, are approved. Should the secant modulus of batches of tendons differ by more than 3 per cent, the required elongation shall be adjusted accordingly.

d) Every endeavour shall be made to obtain the force shown on the Drawings or directed. A tolerance of 5 per cent will be permitted for individual tendons provided that the total prestress load being applied at that time is within 2 percent of the required value.

e) If, on completion of tensioning of a tendon, the requirements of this Clause are not completely satisfied, the Engineer may direct the Contractor to adopt special methods of overcoming friction loss, such as lubricating the tendon with water soluble oil, and may direct the tendon to be stressed simultaneously from both ends in the restressing operation.

9205 Placing and Tensioning of Tendons.

a) Prestressing tendons shall be placed in the sheathing in accordance with the recommendations of the prestressing system supplier and this Clause.

b) The method of placement shall be such as to ensure that neither the tendon nor the sheathing shall be damaged during the operation.

c) Immediately before placing each tendon, the Contractor shall ensure that all water is driven out of the duct and that the tendon, once placed, shall be completely protected against weather, in the period between placing in the duct and grouting, by covering and sealing openings in the duct as directed. In the period between placing in the duct and grouting of the tendon, ends exposed to weather shall be provided with approved weatherproof coverings. The Engineer may direct the Contractor to dry any tendon in a duct or to fill the duct with a saturated lime solution before fitting weatherproof covers and seals.

d) Tensioning shall be performed only in the presence of the Engineer and only by technicians trained for and experienced in this type of work. Special care shall be taken to apply the tensioning force smoothly and at an even rate and to release the jack smoothly. Members shall be prestressed in accordance with the best practice applicable to the particular prestressing method.

e) The process of prestressing shall be continuous, the tendons being stressed in the sequence to the loads shown on the Drawings and the operation completed without interruption in as short a time as possible, unless otherwise specified or directed.

f)

i. The protruding ends of tendons shall be cleaned of any contamination, which may have accumulated since placing. Tendons shall be checked before tensioning to ensure that they are free to move inside the duct, and anchorages shall be thoroughly cleaned before commencement of tensioning. Special care shall be taken to set the jack or jacks accurately in the line of the tendon. The force which is applied initially to take up the slack of the tendon shall be chosen so as to seat the jack firmly but shall not exceed the force normally associated with the particular method of prestressing.

ii. During the tensioning of each tendon, after taking up the slack, the jack force (or l be read and an elongation reading made. Subsequent similar readings of force and elongation shall be made at intervals directed by the Engineer and plotted to determine the total tendon elongation. The draw-in on anchoring shall also be measured.

g) If a tendon breaks or slips during or after tensioning, so that the allowable tolerances are exceeded, the tendon shall be released, replaced if necessary and restressed. the cost of such work shall be at the expense of the Contractor.

h)

i. Unless otherwise shown on the Drawings or directed, tendons shall be stressed from one end only.

ii. When stressing a tendon from both ends is directed, the jacking forces shall not differ by more than 10 per cent throughout the tensioning operation. The tensioning operation shall continue until the required force in the tendon at each jack is reached.

iii. Where tendons are shown on the Drawings to be stressed simultaneously, the force shall be increased in each tendon so that the maximum jacking force for each tendon is reached and tendons are anchored at approximately the same time.

i) Under no circumstances shall the jacking force exceed 80 per cent of the specified minimum breaking load of the tendon, or the rated capacity of the jacking equipment used whichever is the lesser.

9206 Data to be recorded

a) The following data, where applicable, shall be recorded on approved forms:

i. Identification number of dynamometers, gauges, pumps and jacks.

ii. Identification particulars of tendons.

iii. Initial force (or pressure) when tendons are marked for measurement of elongation.

iv. Final force (or pressure) and elongation obtained on completion of tensioning.

v. Elongations remaining after release of jacks.

vi. Ramming pressures.

vii. Elongation obtained at suitable intervals during tensioning together with corresponding force (or pressure)

b) All forms shall be forwarded to the Engineer on completion.

9207 Grouping of prestress Tendons.

a) The Contractor shall completely fill with grout each prestressed tendon duct in accordance with AASHTO Standard Specifications for Highway Bridges and this Clause.

b) Tendons shall be grouted as soon as practicable after stressing and in any case within 72 hours of tensioning unless otherwise directed.

c) All cement used in the grouting of the prestressing tendons shall comply with Clause 6.03.

d) The ratio of water to cement by weight in the cement grout shall not be more than 0.45 and the compressive strength on 150 mm by 75 mm diameter cylinders of cement grout, cured for 28 days at 20^0C $\pm 2^0$C and 97 to 100 per cent relative humidity, shall be at least 27.5 MPa. Before injection the grout mixture shall be mixed for a minimum of three minutes by means of a high speed mechanical stirrer and sieved through a 1.4 mm sieve and, unless otherwise directed, the flow time through a standard flow cone shall be not greater than 30 seconds.

e) i. The grout shall be prepared using a mixture and additives which prevent shrinkage and bleeding. Admixtures containing chlorides in excess of 0.5 percent by weight, fluorides, sulphate or nitrates shall not be used.

ii. Expanding agents may be used to obtain 5 to 10 percent unrestrained expansion of the grout. If aluminium powder is used as an expanding agent, the proportion shall be 50 parts per million of the cement by weight and the powder shall be mixed with ground pumice stone and /or dry cement prior to mixing with the grout cement. The proportion and colour

of the pumice or cement used shall be as approved by the Engineer and the Contractor shall ensure that accurate and uniform mixing with the cement is obtained.

iii. A methylcellulose additive may be used to improve fluidity and control bleeding.

iv. Water used in the grout mixture shall be substantially free of either chloride or sulphate compounds.

f) At least 45 days before grouting any prestressing tendons, the Contractor shall prepare in the presence of the Engineer a trial mix of his proposed grout mixture, including admixtures, which shall then be sampled and tested by the Contractor to verify its compliance with this Clause.

g) As the work progresses, the Contractor shall take further samples for testing when directed. The Engineer may direct grout mixtures to be varied so as to achieve the specified properties.

h) Unless otherwise approved, the grout shall be used within one hour of commencing to mix the ingredients.

i) Grout mixtures, use of admixtures, methods of mixing, shall be subject to approval.

j) The grouting equipment shall be arranged to provide a supply line and return line from the grout pump to the grout connection. Provision shall be made to permit accurate control of grouting pressures and of grout flow at the grout connection, and continuous circulation of grout within the grouting system.

k) The duct to be grouted shall first be filled with water under pressure of 500 kPa for at least one hour before grouting. All leaks detected shall be rectified and the duct retested before grouting. All ducts shall be flushed with clean water followed by compressed air immediately before grouting until all loose particles are removed. Grout shall then be injected by means of the grout pump of either the piston displacement type or screw or impeller type. An even slow continuous flow of grout shall be maintained until the duct is completely filled and pure grout of the consistency being injected issues from all vents and until all entrapped air has been expelled. The vents shall be progressively closed until the duct is completely filled. The grout shall then be held at 500 kPa pressure for at least one minute after which the grouting end shall be plugged. All care shall be taken to prevent loss of grout immediately after grouting. The grouting tubes shall be topped up with grout if a wastage or subsidence of grout occurs when disconnecting the pump. Unless otherwise directed, all vents and other opening shall be kept closed until regrouting commences.

l) Sufficient grout shall be available for immediate use to enable the grouting of a whole duct without interruption, refilling of the grout tank or the necessity of mixing further quantities.

m) Re-grouting of prestress tendons, in accordance with this subclause, shall be carried out by the Contractor during the second hour after the first grouting of the tendon has been competed but in any case before the grout begins to set. Grout shall be injected in such a way as to prevent air being introduced into the duct with the grout. The Engineer will direct the locations at which grout is to be injected into any duct. The Engineer may

direct the use of a mineral pigment in the grout to help determine when grout from the second grouting operation is beginning to flow through vent openings.

9208 Cutting and Anchorage Protection

a) After the grout in any tendon duct has set and when approved by the Engineer, the wire or strand ends shall be cut to the prestressing system supplier's requirements with a cutting disc.

b) All anchor heads for strand tendons shall be protected by grout or concrete with a minimum clear cover of 25 mm.

9300: Payment for Prestressing

a) No separate payment will be made for furnishing and installing, prestressing materials and accessories, and carrying out prestressing operations including the entire cost of furnishing and installation of the tendon duct seating and fittings, anchorages and prestressing tendons, all labour, materials and equipment required to complete the work described in this Part, for precast bridge beams. All of its associated cost should be considered to be included in the rates tendered for the prestressed concrete for which prestressing will be used.

b) It should also be noted that no separate payment will be made for furnishing of all test pieces of tendons, all anchorages and couplings for testing, all prestressing operations, including de-stressing, restressing and replacement of tendons as required and grouting of all prestressed tendons. All of its associated cost should be considered to be included in the rates tendered for the prestressed concrete for which prestressing will be used.

10000: Bored Cast In Place Piles

10001 Description

This work comprises the construction of bored cast in place piles for bridges, including the provision of all material and structures in accordance with these Specifications and in conformity with the requirements of the Drawings or other parts of the Contract Documents.

Piles through water and soft upper soil layers shall be provided with a permanent steel casing if shown on the Drawings.

The pile boring shall be carried out using a temporary steel casing bored to the pile toe or to a level approved by the Engineer. The temporary casing shall be withdrawn.

Under certain circumstances the Contractor may be permitted to bore all or part of the pile without casing under water or using drilling fluid to stabilise the borehole as referred to in Section 10.1.2.4.

The piles shall be concreted and reinforced to resist pile loads and horizontal forces on the pile caps according to the Drawings and these Specifications.

10100 Materials

10101 Steel Casing

This part of the Specifications only deals with the permanent steel casing. For steel casing used during boring of the pile see Section 10.1.3, Construction Methods.

When permanent steel casing is shown on the Drawings, the steel shall conform to the AASHTO Standard Specification M 183-79 (ASTM A36) or equivalent.

The minimum thickness of the permanent steel casing shall be 10 mm. The minimum length shall be from 100 mm above the bottom of the pile cap to 5 metre under the river bed or into firm strata. If the permanent casing is used in the boring operation or if the handling and transport require a greater thickness to avoid deformation or buckling, the increase in thickness shall be provided by the Contractor at his own expense.

The steel casing shall be furnished in appropriate lengths and the joints shall be approved by the Engineer. The casing shall be handled and stored in a manner that shall prevent buckling and other deformation as well as accumulation of dirt, oil and paint. When placed in the work it shall be free from dirt, oil, grease, paint, mill scale and loose or thick rust.

The outside surface of the permanent casing of piles to river piers, for the depth indicated on the Drawings from the underside of the pile cap shall receive two coats of anti-corrosion tar type paint. The paint shall be approved by the Engineer and its application shall follow the manufacturer's instructions.

10102 Concrete

The concrete shall conform to Section 8 of these Specifications. In addition it should be of flowing type, and plasticizer may need to be introduced in order to get the required workability of concrete.

Concrete placed under water or drilling mud by tremie shall have a cement content of not less than 400 kg/m^3.
The density and consistency of the concrete shall conform to the tremie casting method and the maintenance of sufficient workability (slump) of all the concrete during the casting and casing handling period, including reasonably calculated delays, shall be secured by a design mix, (including the necessary readers and plasticizers), tested by trial mixes prior to the pile construction.

All relevant concrete properties such as slump, time of setting, temperature and strength shall be measured on the trial mixes.

10103 Reinforcement

The reinforcement shall conform to Section 7 of these Specifications.

10104 Drilling Fluid

The following clauses shall be complied with if bentonite mud is used to stabilise the boreholes:

A) Supply

A certificate shall be obtained by the Contractor from the manufacturer of the bentonite powder, showing the properties of the consignment delivered to the site. This certificate shall be made available to the Engineer on request. The properties to be given by the manufacturer are the apparent viscosity range (in centipoises) and the gel strength range for solids in water.

Any other material proposed by the Contractor for the drilling fluid shall be approved by the Engineer.

B) Mixing

Bentonite and any other material shall be mixed thoroughly with clean water to make a suspension which shall maintain the stability of the pile excavation for the period necessary to place concrete and complete construction.

Where saline or chemically contaminated groundwater occurs, special precautions shall be taken to modify the bentonite in fresh water so as to render it suitable in all respects for the construction of piles.

C) Tests

The frequency of testing drilling fluid and the method and procedure of sampling shall be proposed by the Contractor and approved by the Engineer prior to the commencement of the work. The frequency may subsequently be varied as required, depending on the consistency of the results obtained. The control tests shall cover the determination of density, viscosity, gel strength and pH values.
The Contractor shall supply all equipment and experienced operators required to carry out tests on the drilling mud. No additional payment shall be made for these tests which shall be considered as an essential part of the drilling operations.

10200 Construction Methods

10201 General

The Contractor shall demonstrate to the satisfaction of the Engineer that his proposed construction methods for the piles do not result in the pile shafts being weakened by contamination of the concrete, by sectional reduction, by washing out of cement, by breaking during pulling of temporary casings or in any other way, including the construction of neighbouring piles.

A) Assumed Procedure

The following construction procedure has been assumed in the tender design. The final construction procedure shall be as approved by the Engineer prior to commencing piling operations.

1. Place permanent steel casing, if required, in position and embed casing toe into river bed or firm strata. If no permanent steel casing is specified a sufficient length of temporary steel casing shall be used to stabilise the upper part of the borehole.

2. Bore and excavate inside the steel casing down to casing toe level, or to a level approved, and continue excavation to final pile tip level using either temporary casing under water or using drilling mud. The fluid level inside casings shall at all times be at least 2 metres higher than outside the casings.

3. Carefully clean up all mud or sedimentation from the bottom of borehole.

4. Place reinforcement cage, inspection pipes etc.

5. Concrete continuously under water or drilling fluid by use of the tremie method.

6. Withdraw the temporary boring casing concurrently with concreting to the instructed level.

7. After hardening, break out the top section of the concrete pile to reach sound concrete.

B) Approval of Construction Method

In the tender, the Contractor shall describe the construction method he proposes, including name of proposed Sub-contractor (if any), information on boring equipment, materials, methods of work and control of quality. The Contractor shall submit references from similar jobs carried out by him and/or his proposed Sub-contractor.

During contract negotiations, the Contractor shall submit all requested supplementary detailed information in writing.
After the Contract has been awarded, the Contractor shall prepare a detailed programme and establish a procedure for the pile construction. The detailed programme shall contain all required information on materials, equipment, methods of work etc. and be approved in writing by the Engineer. Such approval shall not however relieve the Contractor of his responsibilities for pile construction.

The import of any boring equipment or materials by the Contractor, before he has received the Engineer's approval of proposed construction methods, shall be at the Contractor's risk.

10202 Setting out Piles

The Contractor shall check the casing position for each pile during and immediately after placing the casing, and agree it with the Engineer.

10203 Diameter of Piles

The diameter of a pile shall be not less than the specified diameter.

10204 Tolerances

The centre of the completed pile at the cut off level shall not deviate more than 100 mm from the theoretically correct position shown on the Drawings. The inclination of the pile shall not deviate more than 1:100 from vertical. The Contractor shall provide suitable equipment, such as an inverted pendulum, to check the verticality of the boreholes at intervals during drilling and prior to concreting.

10205 Boring

A) Methods

Method of excavation shall be proposed by the Contractor and approved by the Engineer. Water or air jetting for boring of the piles shall not be allowed.

B) Boring Near Recently Cast Piles

Piles shall not be bored so close to other piles which have recently been cast and which contain workable or unset concrete so that a flow of concrete could be induced from or damage caused to any of the piles. Boring and excavation for a pile shall not be commenced until 24 hours after completion of any pile within a radius of 6 metres, centre to centre.

C) Temporary Casings

Temporary casing of approved quality or an approved alternative method shall be used to maintain the stability of pile excavations which might otherwise collapse.

Temporary casings shall be free from significant distortion. They shall be of uniform cross-section throughout each continuous length. During concreting they shall be free from internal projections and encrusted concrete which might prevent the proper formation of piles.

D) Stability of Pile Excavation Using Drilling Fluid

Where a borehole is formed without casing under water or using drilling fluid for maintaining the stability of a boring, the level of the water or fluid in the excavation shall be maintained so that the water or fluid pressure always exceeds the pressure exerted by the soils and external ground water. The water or fluid level shall be maintained at a level not less than 2 metres above the level of the river water level or any artesian pressure level.

In the event of a rapid loss of water or bentonite suspension from the pile excavation, the excavation shall be backfilled without delay and the instructions of the Engineer shall be obtained before excavation at that location is resumed.

E) Disposal of Excavated Material

No excavated material shall be dumped into the river or any connecting waterway without the written approval of the Engineer. Excavated material shall be removed from site and dumped either beyond areas affected by dredging, or taken to the Contractors approved dumping areas on land. The Contractor shall be fully responsible for costs involved in removing the excavated material to spoil.

F) Pumping from Boreholes

Pumping from a borehole shall not be permitted unless a casing has been placed into a stable stratum which prevents the flow of water from other strata in significant quantities into the boring, or unless it can be shown that pumping will not have a detrimental effect on the surrounding soil or property.

G) Obstructions

Where boulders or other obstructions render it impossible to bore the pile, excavation operations inside pile casing as directed by the Engineer shall be carried out to remove obstructions and the Contractor shall be reimbursed for such operations only when the largest dimension of the obstruction exceeds 200 mm and the obstruction is found more than 2 metres below river bed.

H) Unexpected Ground Conditions

The Contractor shall report immediately to the Engineer any circumstances which indicate that in the Contractor's opinion the ground conditions differ from those expected by him from his interpretation of the site investigation reports.

I) Boring Records

During the boring of the pile, the Contractor shall compile a 'boring log' indicating depths and types of the various soil layers encountered. Disturbed samples shall be submitted to the

Engineer as requested.
The Contractor shall allow for carrying out sampling and tests to check soil strengths as required by the Engineer.

J) Final Pile Toe Level

The final pile toe level shall be as indicated on the Drawing or as instructed by the Engineer after due consideration of the Contractor's proposals, boring logs and test results.

The final toe level of other piles may subsequently be altered according to the results of the test loadings detailed in Section 10.4.

K) Inspection and Cleaning Bottom of Excavation

The time between final excavation and bottom cleaning and the start of concreting shall be reduced as much as possible and shall not exceed 6 hours. To achieve this, the final 2 metres of excavation shall not start until all preparations for cleaning, reinforcing and concreting are finished. In case of unexpected delay the Contractor shall dump sand or gravel in the bore to 2 metres above toe level.

On completion of excavation, the bottom of the excavation shall be carefully cleaned of mud, sedimentation and other soft material. A 15 minute interval is required between completion of drilling and cleaning out, to allow the fine materials to settle.

The cleaning shall be by an approved method. Before cleaning of every pile, notice shall be given to the Engineer.

The Contractor shall show, to the satisfaction of the Engineer, that the bottom of the excavation is clean. Sedimentation tests shall be carried out by the Contractor in the presence of the Engineer.

If boring without casing, the diameter of the boring hole for a representative number of piles shall be measured by calliper prior to the placing of concrete. The verticality of boreholes will be checked as directed by the Engineer. These measurements shall be done by the Contractor using approved equipment and no reimbursement shall be made.

10206 Placing Reinforcement

The reinforcement shall be placed as indicated on the Drawings. Reinforcement in the form of a cage shall be assembled with additional support, such as spreader forks and lacings, necessary to form a rigid cage. Hoops, links or helical reinforcement shall fit closely around the main longitudinal bars and be bound to them by approved wire, the ends of which shall be turned into the interior of the pile or pour. Reinforcement shall be placed and maintained in position.

The cover to all reinforcement shall be not less than 75 mm.

Joints in longitudinal steel bars shall be permitted unless otherwise specified. Joints in reinforcement shall be such that the full strength of the bar is effective across the joint and shall be made so that there is no relative displacement of the reinforcement during the construction of the pile.

Joints in longitudinal bars in piles with tension (for instance for test loading) shall be carried out by welding unless another method has been approved by the Engineer.

If the final pile toes level instructed by the Engineer is deeper than that indicated on the Drawings, the section of the pile deeper than the toe level indicated on the Drawings is not required to be reinforced.

10207 Placing Concrete

A) Approval

No concreting shall take place before the bottom of the excavation has been cleaned, the borehole inspected and approval obtained in writing from the Engineer.

Methods:

- The method of placing and the workability of the concrete shall be such that a continuous monolithic concrete shaft of the full cross section is formed.
- The concrete shall be placed continuously, and without such interruption as would allow the previously placed batch to have hardened. In this respect the Contractor shall submit details of his contingency plans, standby plant etc. to be utilised in the event of an equipment failure.
- The use of pumped concrete and the methods in its use shall be approved.
- The Contractor shall take all precautions in the design of the mix and placing of the concrete to avoid arching of the concrete in a casing. No spoil, liquid or other foreign matter shall be allowed to contaminate the concrete.

B) Workability of Concrete

Slump measured at the time of discharge into the pile boring shall be in accordance with Table 10.1-1.

Table 10-1

Piling Mix Workability	Slump		Typical Conditions of Use
	Minimum (mm)	Range (mm)	
A	75	75 - 150	Placed into water-free unlined or permanently lined bore of 600 mm diameter or over, or where casting level lies below temporary casing: reinforcement widely spaced, leaving ample room for free movement of concrete between bars.
B	100	100 - 200	Where reinforcement is not spaced widely; where cut-off level of concrete is within temporary casing; where pile bore is water-free and the diameter is less than 600 mm.
C	150	150 or more	Where concrete is to be placed by tremie under water or drilling mud or by pumping.

C) Placing Concrete Under Water or Drilling Fluid

Concrete to be placed under water or drilling fluid shall be placed by tremie and shall not be discharged freely into the water or drilling fluid.

Before placing concrete, measures shall be taken to ensure that there is no accumulation of silt or other material at the base of the boring and the Contractor shall ensure that heavily contaminated bentonite suspension, which could impair the free flow of concrete from the pipe of the tremie, has not accumulated in the bottom of the hole.

A sample of the bentonite suspension shall be taken from the base of the boring using an approved sampling device. If the specific gravity of the suspension exceeds 1.25, the placing of concrete shall not proceed. In this event the Contractor shall modify the mud quality.

The concrete shall be a rich coherent mix of high workability in accordance with Section 10.1.2.2.

The concrete shall be placed in such a manner that segregation does not occur.

During and after concreting, care shall be taken to avoid damage to the concrete from pumping and dewatering operations.

The hopper and pipe of the tremie shall be clean and watertight throughout. The pipe shall extend to the base of the boring and a sliding plug or barrier shall be placed in the pipe to prevent direct contact between the first charge of concrete in the pipe of the tremie and the water or drilling fluid. The pipe shall at all times penetrate the concrete which has previously been placed and shall not be withdrawn from the concrete until completion of concreting. The bottom of the tremie pipe shall be kept at least 1.5 metres under the surface of concrete. At all times a sufficient quantity of concrete shall be maintained within the pipe to ensure that the pressure from it exceeds that from the water or drilling fluid. The internal diameter of the pipe of the tremie shall be not less than 150 mm for concrete made with 20 mm aggregate and not less than 200 mm for concrete made with 40 mm aggregate. It shall be so designed that external projections are minimised, allowing the tremie to pass through reinforcing cages without causing damage. The internal face of the pipe of the tremie shall be free from projections.

The Contractor shall maintain a continuous record of the volume of concrete used and the level of the concrete in the pile. Any deviations from the theoretical, or expected, volume/level relationship shall be immediately reported to the Engineer.

10208 Extraction of Temporary Casing

A) Workability of Concrete

Temporary casings shall be extracted while the concrete within them remains sufficiently workable to ensure that the concrete is not lifted.

B) Concrete Level

When the casing is being extracted a sufficient quantity of concrete shall be maintained within it to ensure that pressure from external water, drilling fluid or soil is exceeded and that the pile is neither reduced in section nor contaminated. The toe of the temporary casing shall be kept a minimum of 2 metres under the outlet of the tremie.

No concrete shall be placed in the boring once the bottom of the casing has been lifted above the top of the concrete; it shall be placed continuously as the casing is extracted until the desired head of concrete is obtained.
Adequate precautions shall be taken in all cases where excess heads of water or drilling fluid could be caused as the casing is withdrawn because of the displacement of water or fluid by the concrete as it flows into its final position against the walls of the shaft.

The pile shall be concreted with certain over height to allow for chiselling off the top concrete down to sound hard concrete.

The pile top shall after clean-cutting be embedded 100 mm in the foundation.

C) Vibrating Extractors

The use of vibrating casing extractors shall be permitted.

D) Reinforcement Cage

During concreting and pulling the casing, the reinforcement cage shall be secured against uplift and the top shall be kept under close inspection.

E) Supervision

The execution of the pile concreting shall be supervised by a qualified person of the Contractor's staff, who will keep records on the relation between quantity of concrete used, level of concrete and withdrawal of casing.

10209 Temporary Support

The Contractor shall ensure that free standing piles are temporarily braced or stayed immediately after driving to prevent loosening of the piles in the ground and to ensure that no damage resulting from oscillation, vibration or movement of any free-standing pile length can occur.

10210 Records

The Contractor shall keep records as indicated below for the installation of each pile and shall submit two signed copies of these records to the Engineer not later than noon of the next working day after the pile was installed. The signed records shall form a record of the work. The following data are required:

a) Pile location
b) Pile reference number
c) Pile type
d) Nominal cross-sectional dimensions or diameter
e) Date and time of boring
f) Date and time of concreting
g) River bed level at commencement of installation of pile
h) Working level
i) Pile toe level
j) River water levels
k) Pile head level
l) Length of temporary casing
m) Length of permanent casing
n) Soils samples taken and in situ tests carried out
o) Standing water level
p) Length and details of reinforcement
q) Concrete mix

r) Volume of concrete supplied to pile and corresponding levels of concrete and casings
s) All information regarding obstructions, delays and other interruptions to the sequence of work

10211 Measures in Case of Rejected Piles

If any pile is found unsatisfactory in the opinion of the Engineer for utilisation in the structure, it shall be cut off below the pile cap if so ordered by the Engineer.

The pile shall be replaced as directed by the Engineer. All extra expenses shall be borne by the Contractor and payment shall be made on the basis that no replacement pile had to be provided for the unsatisfactory pile.

When the safe bearing value of any pile is found by test to be less than the design load, longer piles or additional piles shall be installed as ordered in writing by the Engineer.

10212 Measurement

The unit of measurement for bored cast in place piling shall be the linear metre of pile constructed and accepted in the structure. The payable lengths of the satisfactory bored piles shall be measured from the toe level to cut off 100 mm above the bottom level of pile cap. Reinforcement steel shall be measured in accordance with Specifications Section 5.2.10.

10213 Payment

Bored piles shall be paid for at the Contract unit price per linear metre. The rate shall constitute full compensation for all materials including reinforcement, casings and concrete. The rate shall also include boring equipment, boring, excavation, concreting, inspection and control, cutting off, welding, coupling and all related tools, rigs, cranes, jets, frames, leads, labour, and other incidental equipment and work necessary to complete the work.

Payment for bored cast in place pilot piles (see Section 10.10.1.2(e) for definition of pilot pile), completed and accepted, shall be made at the Contract unit price per linear metre for providing piles of the size specified. When pilot piles are incorporated in the foundation as working piles, no additional payment shall be made for the piles.

Payment for reinforcement steel shall be at the Contractor’s rates per tonne for mild steel and high yield deformed steel bars.

No payment shall be made for unauthorised, defective, unsound or unsatisfactorily piles or for any costs incurred by the Contractor for such piles.

Payment for testing of piles shall be made separately, as detailed in Section 10.10.

Pay items

		Unit
101/1	Bored Cast in Place Piles (Diameter as indicated on the Drawings and stated in the Bill of Quantities)	Linear-M
101/2	Bored Cast in Place Pilot Piles	Linear-M

	(Diameter as indicated on the Drawings and stated in the Bill of Quantities)	
101/3	Mild Steel Reinforcing Bars	Tonne
101/4	High Yield Deformed Steel Reinforcing Bars	Tonne

10300: Pile Test Loading

10301 General

This Section deals with the testing of a pile by the application of an axial load or force. It covers vertical piles tested in compression.

10302 Definitions

a) Allowable Load
The load which may be safely applied to a pile after taking into account its ultimate bearing capacity, negative friction, pile spacing, overall bearing capacity of the ground below and allowable settlement.

b) Compression Pile
A pile which is designed to resist an axial force such as would cause it to penetrate further into the ground.

c) Kentledge
The dead weight used in a loading test.

d) Maintained Load Test
A loading test in which each increment of load is held constant either for a defined period of time or until the rate of movement (settlement or uplift) falls to a specified value.

e) Pilot Pile
A pile installed before the commencement of the main piling works or a specific part of the works for the purpose of establishing the suitability of the chosen type of pile and for confirming its design, dimensions and bearing capacity. Pilot piles may be utilised as working piles, subject to the Engineer's approval.

f) Proof Load
A load applied to a selected pile to confirm that it is suitable for the load at the settlement specified. A proof load should not normally exceed 200% of the working load on a pile except in circumstances where Special Provisions are provided for the testing of precast piles driven to a set. In these circumstances, 300% is specified.

g) Reaction System
The arrangement of kentledge, piles, anchors or rafts that provides a resistance against which the pile is tested.

h) Tension Pile
A pile which is designed to resist an axial force such as would cause it to be extracted from the ground.

i) Test Pile

Any pile to which a test loading is, or is to be, applied.

j) Ultimate Bearing Capacity
The load at which the resistance of the soil becomes fully mobilised.

k) Working Load
The load which the pile is designed to carry.

l) Working Pile
One of the piles forming the foundation of a structure.

10303 Supervision

All tests shall be carried out only under the direction of an experienced and competent supervisor conversant with the test equipment and test procedure. All personnel operating the test equipment shall have been trained in its use.

10400: Safety Precautions

10401 General

When preparing for, conducting and dismantling a pile test the Contractor shall carry out the requirement of the various regulations and other statutory instruments that are applicable to the work for the provision and maintenance of safe working conditions, and shall in addition make such other provision as may be necessary to safeguard against any hazards that are involved in the testing or preparations for testing.

10402 Kentledge

Where kentledge is used the Contractor shall construct the foundations for the kentledge and any cribwork, beams or other supporting structure in such a manner that there will not be differential settlement, bending or deflexion of an amount that constitutes a hazard to safety or impairs the efficiency of the operation. The kentledge shall be adequately bonded, tied or otherwise held together to prevent it falling apart, or becoming unstable because of deflection of the supports.

The weight of kentledge shall be greater than the maximum test load and if the weight is estimated from the density and volume of the constituent materials an adequate factor of safety against error shall be allowed.

10403 Tension Piles and Ground Anchors

Where tension piles or ground anchors are used the Contractor shall ensure that the load is correctly transmitted to all the tie rods or bolts. The extension of rods by welding shall not be permitted unless it is known that the steel will not be reduced in strength by welding. The bond stresses of the rods in tension shall not exceed normal permissible bond stresses for the type of steel and grade of concrete used.

10404 Testing Equipment

In all cases the Contractor shall ensure that when the hydraulic jack and load measuring device are mounted on the pile head the whole system shall be stable up to the maximum load to be applied. Means shall be provided to enable dial gauges to be read from a position clear of the

kentledge stack or test frame in conditions where failure in any part of the system due to overloading, buckling, loss of hydraulic pressure and so on might constitute a hazard to personnel.

The hydraulic jack, pump, hoses, pipes, couplings and other apparatus to be operated under hydraulic pressure shall be capable of withstanding a test pressure of 1.5 times the maximum working pressure without leaking.

The maximum test load or test pressure expressed as a reading on the gauge in use shall be displayed and all operators shall be made aware of this limit.

10500: Construction of a Pilot Pile to be Test Loaded

10501 Notice of Construction

The Contractor shall give the Engineer at least 48 hours notices of the commencement of construction of any pilot pile which is to be test loaded.

10502 Method of Construction

Each pilot test pile shall be constructed in a manner similar to that to be used for the construction of the working piles, and by the use of similar equipment and materials. Any variation shall only be permitted with prior approval.

Extra reinforcement and concrete of increased strength shall be permitted in the shafts of pilot piles at the discretion of the Engineer.

10503 Boring or Driving Record

For each pilot pile which is to be tested a detailed record of the soils encountered during boring, or of the progress during driving shall be made and submitted to the Engineer daily not later than noon on the next working day.

10504 Cut-Off Level

The pile shaft shall terminate at the normal cut-off level or at a level required by the Engineer.

The pile shaft shall be extended where necessary above the cut-off level of working piles so that gauges and other apparatus to be used in the testing process are not damaged by water or falling debris.

10505 Pile Head for Compression Tests

For a pile that is tested in compression, the pile head or cap shall be formed to give a plane surface which is normal to the axis of the pile, sufficiently large to accommodate the loading and settlement-measuring equipment and adequately reinforced or protected to prevent damage from the concentrated application of load from the loading equipment.

10506 Preparation of a Working Pile to be tested

If a test is required on a working pile the Contractor shall cut down or otherwise prepare the pile for testing as required by the Engineer in accordance with Sections 10.4.4.4 and 10.4.4.5.

10507 Reaction Systems

10508 Compression Tests

Compression tests shall be carried out using kentledge, tension piles or specially constructed anchorages.

Where kentledge is to be used, it shall be supported on cribwork disposed around the pile head so that its centre of gravity is on the axis of the pile. The bearing pressure under supporting cribs shall be such as to ensure stability of the kentledge stack. Kentledge shall not be carried directly on the pile head, except when directed by the Engineer.

10509 Working Piles

Where working piles are used as reaction piles their movement shall be measured to within an accuracy of 0.5 mm.

10510 Spacing

Where kentledge is used for loading vertical piles in compression, the distance from the edge of the test pile to the nearest part of the crib supporting the kentledge stack in contact with the ground shall be not less than 1.3 metres.
The centre to centre spacing of vertical reaction piles, including working piles used as reaction piles, from a test pile shall be not less than three times the diameter of the test pile or the reaction piles or 2 metres, whichever is the greatest.

10511 Adequate Reaction

The size, length and number of the piles or anchors, or the area of the rafts, shall be adequate to transmit the maximum test load to the ground in a safe manner without excessive movement or influence on the test pile.

10512 Care of Piles

The method employed in the installation of any reaction piles, anchors or rafts shall be such as to prevent damage to any test pile or working pile.

10513 Loading Arrangement

The loading arrangement used shall be designed to transfer safely to the test pile the maximum load required in testing. Full details shall be submitted to the Engineer prior to any work related to the testing process being carried out on the Site.

10514 Equipment for Applying Load

The equipment used for applying load shall consist of one or more hydraulic rams or jacks. The total capacity of the jacks shall be at least equal to the required maximum load. The jack or jacks shall be arranged in conjunction with the reaction system to deliver an axial load to the test pile. The complete system shall be capable of transferring the maximum load required for the test.

10515 Measurement of Load

Suitable approved measuring devices for determining the load on the pile shall be supplied by the Contractor. Certificates of calibration shall be supplied to the Engineer.

In addition, large diameter (i.e. exceeding 1.2 metre) test piles shall be instrumented at 5 different depths to measure the load distribution along the piles. The instrumentation shall consist of both a mechanical system and strain gauges for measuring the pile deformation. The mechanical system shall consist of 6 mm steel rods or high tensile steel wires gauge No. 23, placed in steel tubes down to the various depths, and connected to dial gauges at the top. The strain gauges shall be of a stable type, wholly protected by a steel capsule. They shall be welded to the steel reinforcement, 2 gauges at each depth.

The type of gauges to be used and other details on the instrumentation shall be approved by the Engineer.

10516 Adjustability of Loading Equipment

The loading equipment shall be capable of adjustment throughout the test to obtain a smooth increase of load or to maintain each load constant at the required stages of a maintained loading test.

10600: Measuring Movement of Pile Heads

10601 General

In a maintained load test movement of the pile head shall be measured by two of the methods as described below. One method for settlement measurements, the other method for control.

10602 Levelling Method

An optical or any other levelling method by reference to an external datum may be used.

Where a level and staff are used, the level and scale of the staff shall be chosen to enable readings to be made to within an accuracy of 0.5 mm. A scale attached to the pile or pile cap may be used instead of a levelling staff. At least two datum points shall be established on permanent objects or other well-founded structures, or deep datum points shall be installed. Each datum point shall be situated so that only one setting up of the level is needed.

No datum point shall be affected by the test loading or other operations on the site.

Where another method of levelling is proposed this shall be approved in writing.

10603 Independent Reference Frame

An independent reference frame may be set up to permit measurement of the movement of the pile. The supports for the frame shall be founded in such a manner and at such a distance from the test pile, kentledge support cribs, reaction piles, anchorages and rafts that movements of the ground in the vicinity of the equipment do not cause movement of the reference frame during the testing. Check observations of any movements of the reference frame shall be made and a check shall be made of the movement of the pile head relative to an external datum during the progress of the test. In no case shall the supports be less than three test pile diameters or 2 metres, whichever is the greater, from the centre of the test pile.

The measurement of pile movement shall be made by two dial gauges rigidly mounted on the reference frame that bear on surfaces normal to the pile axis fixed to the pile cap or head. Alternatively the gauges may be fixed to the pile and bear on surfaces on the reference frame.

The dial gauges shall be placed in diametrically opposed positions and be equidistant from the pile axis. The dial gauges shall enable readings to be made to within an accuracy of 0.1 mm.

The reference frames shall be protected from sun and wind.

10604 Other Methods

The Contractor may submit for approval any other method for measuring the movement of pile heads.

10605 Protection from Weather

Throughout the test period all equipment for measuring load and movement shall be protected from the weather.

10606 Prevention of Disturbance

Construction equipment and persons who are not involved in the testing process shall be kept at a sufficient distance from the test to avoid disturbance to the measurement apparatus.

10607 Notice of Test

The Contractor shall give the Engineer at least 24 hours notice of the commencement of the test.

10608 Records

During the progress of a test, the testing equipment and all records of the test as required in Section 10.4.14.2 shall be available for inspection by the Engineer.

10700: Test Procedure

10701 Proof Test by Maintained Load Test

The maximum load which shall be applied in a proof test is shown on the Drawings. The loading and unloading shall be carried out in stages as shown in Table 10.4-1 or as required by the Engineer.

Following each application of an increment of load the load shall be held for not less than the period shown in Table 10.4-1 or until the rate of settlement is less than 0.25 mm/hour and is slowing down. The rate of settlement shall be calculated from the slope of the curve obtained by plotting values of settlement versus time and drawing a smooth curve through the points.

Each stage of unloading shall proceed after the expiry of the period shown in Table 10.4-1.
For any period when the load is constant, time and settlement shall be recorded immediately on reaching the load and at approximately 15 minute intervals for 1 hour, at 30 minute intervals between 1 hour and 4 hours, and at 1 hour intervals between 4 hours and 12 hours after the application of the increment of load.

The Engineer may require that the full loading, or any portion of the loading, be maintained on the pile for periods longer than shown in Table 10.4-1.

Table 10-1

Loading Sequence			
Load as Percentage of Working Load		Minimum Time of	
Bored Piles	Driven Piles	Holding Load	
25	50	1 hour	
50	100	1 hour	
75	125	1 hour	
100	150	1 hour	
75	125	10 minutes	
50	100	10 minutes	
25	50	10 minutes	
0	0	1 hour	
100	150	6 hours	
125	200	1 hour	
150	250	6 hours	
175	275	1 hour	
200	300	24 hours	Proof Load
175	275	10 minutes	
150	250	10 minutes	
125	225	10 minutes	
100	200	10 minutes	
75	150	10 minutes	
50	100	10 minutes	
25	50	10 minutes	
0	0	1 hour	

10702 Presentation of Results

Results shall be submitted as:

a) A summary in writing to the Engineer, unless otherwise directed within 24 hours of the completion of the test, which shall give for a proof test by maintained load for each stage of loading, the period for which the load was held, the load and the maximum settlement or uplift recorded.

b) The completed schedule of recorded data as in Section 10.4.14.2 within seven days of the completion of the test.

10703 Schedule of Recorded Data

The Contractor shall provide information about the tested pile in accordance with the following schedule where applicable.

A) General
1) Site location
2) Contract identification
3) Proposed structure
4) Date of test

Pile Details

1) Identification (number and location of the test pile)
2) Ground level at pile position
3) Head level as which test load is applied
4) Type of pile
5) Length in ground
6) Level in ground
7) Level of toe
8) Details of Permanent casing

Installation Details

1) Dates and times of boring, driving and concreting of test pile and adjacent piles
2) Date and time of casting concrete
3) Driven length of pile or temporary casing at final set
4) Hammer type, size or weight
5) Dolly and packing, type and condition before and after driving
6) Driving log (depth, blows per 250 mm, interruptions or breaks in driving)
7) At final set and at redrive set, for drop or single acting hammers, the length of the drop or stroke, for diesel hammers the length of the stroke and the blows per minutes, for double-acting hammers the number of blows per minute
8) Condition of pile head or temporary casing after driving

D) Test Procedure
1) Weight of kentledge
2) Tension pile, ground anchor or compression pile details
3) Plan of test arrangement showing position and distances of kentledge supports, rafts, tension or compression piles and reference frame to test pile
4) Jack capacity
5) Method of Load measurement
6) Method(s) of penetration measurement
7) Relevant dates and times

Test Results

1) In tabular form
In graphical form: loads plotted against movements and time

10704 Completion of a Test

10705 Measuring Equipment

On completion of a test all equipment and measuring devices shall be dismantled, checked and either stored so that they are available for use in further tests or removed from the Site.

10706 Kentledge

Kentledge and its supporting structure shall be removed from the test pile and stored so that they are available for use in further tests or removed from the Site.

10707 Temporary Piles

On completion of a preliminary test, temporary tension piles shall be cut off below ground level, removed from the Site and the ground made good with approved material as specified.

10708 Pile Integrity Test

Contractor shall carry out Pile Integrity Test as instructed by the Engineer.

10709 Measurement and Payment

Load tests on large diameter (i.e. exceeding 1.2 metre) cast in place bored piles shall normally be carried out on working piles using other working piles as anchor piles. The test pile and anchor piles will be paid for at the normal rates for working piles as provided in Section 10.1. Separate payments will be made for carrying out each load test, individual rates shall be provided for different proof loads. Payment for load tests on large diameter cast in place bored piles shall include provision of special instrumentation to test piles, anchor bars to reaction piles, provision of all testing equipment, carrying out of the tests, dismantling of equipment and removal from site, breaking out pile heads etc. in accordance with the requirements for working piles, preparation of all reports etc.

Load tests on pilot driven piles shall normally be carried out using temporary anchor piles or kentledge. The pilot pile will be paid for at the rates provided for pilot piles in Section 10.2. Separate payment shall not be made for anchor piles. Separate payments will be made for carrying out each load test and individual rates shall be provided for different proof loads. Payment for load tests on pilot driven piles shall include provision of anchor piles or kentledge, provision of all test equipment, carrying out of the tests, dismantling of equipment and removal from site, cutting off below level of temporary anchor piles, preparation of all reports etc.

Load tests on pilot cast in place piles, less than 1.2 metre diameter, shall normally be carried out using temporary anchor piles or kentledge. The pilot pile will be paid for at the rates provided for pilot piles in Section 10.1. Separate payment shall not be made for anchor piles. Separate payments will be made for carrying out each load test and individual rates shall be provided for different proof loads which are specified in the Bill of Quantities. Payment for load tests on pilot piles shall include provision of anchor piles or kentledge, provision of all test equipment, carrying out of the tests, dismantling of equipment and removal from site, cutting off below level of temporary anchor piles, preparation of all reports etc.

Pile Integrity Test required to carry out in the works shall be deemed to be included and shall not be paid separately.

Pay items
Unit

104/1	Load Test on Cast in Place Working Pile	Number
104/2	Load Test on Cast in Place Pilot Pile	Number
104/3	Load Test on Pilot Driven Pile	Number

10800: BITUMEN SLIP LAYER FOR PILES

10801 Description

This work shall consist of a bitumen slip layer placed on the upper part of concrete piles before driving.

Bitumen slip layer is provisional, and shall be used only if directed by the Engineer. The use of a slip layer to reduce negative skin friction on the piles will be evaluated after completion of pile load tests.

The bitumen layer shall be used on the upper part of the pile through soft and medium stiff clay. Any shorter length may be decided by the Engineer. This part of the pile shall be primed and uniformly coated with a bituminous material as specified below. No priming or coating shall be allowed below the designated elevation of the installed pile.

10802 Materials

10803 Primer

Before priming, the pile shall be completely clean and dry. The primer shall consist of the relevant bitumen for the slip layer and a petroleum solvent, or RC 250 as decided by the Engineer. The bitumen and the solvent shall be suitably blended to produce a liquid coating which may be applied cold, and which produces a suitable bond between the pile surface and the asphalt enamel. The primer shall have good spraying, brushing and levelling properties and a minimum tendency to produce bubbles during application. It shall be homogeneous and free from water.

The amount of primer shall be 0.2 litre/m^2, applied with brushing or spraying to achieve a uniform continuous film.

The primer shall be allowed to set thoroughly, for minimum 6 hours or more as needed, before the slip layer is applied.

10804 Bitumen

The bitumen slip layer shall consist of a straight run bitumen, penetration grade 80-100.

The bitumen shall be heated to a liquid state, that is approximately 200°C, and applied by brushing or other approved means. The thickness shall be minimum 3 mm.

Special measures such as wrapping sprayed surfaces with suitable paper or plastic sheet shall be taken to prevent the bitumen from flowing and stripping and from damage during handling and storage. During storage the piles shall be protected from sun-heat, and if necessary cooled with spraying of water.

10805 Field Storage and Installation

Precautions shall be taken to prevent damage to the bitumen slip layer during installation as deemed necessary by the Engineer.

Piles shall not be placed directly on the ground: wood sleepers shall always be used. The sleepers shall be placed beneath the uncoated end parts. When lifting piles the wire rope should not be in direct contact with the bitumen slip layer.

10806 Measurement

The unit of measurement shall be square meters of pile covered by bitumen slip layer and accepted by the Engineer. Cut off lengths shall not be measured for payment.

10807 Payment

This work measured as provided above shall be paid for at the Contract unit prices per square metre for the particular Bill Items. The unit rate shall constitute full compensation for all materials, equipment and workmanship necessary to provide the slip layer and the protective layer inclusive of protective metal rings if required, and the additional costs incurred during handling and driving of the piles.

Payment shall only be made if bitumen slip layer is selected and ordered in writing by the Engineer.

Pay item		Unit
109/1	Bitumen Slip Layer to Concrete Piles	Square Metre

11000: METALWORK - GENERAL

11100 General

a) Pay items included in this part are :

- Item 11.03 - furnish and install miscellaneous metalwork.

b) The Contractor shall furnish and install metalwork in accordance with the detailed requirements of this part.

c) During the course of the Contract, miscellaneous items of metalwork which are not mentioned in the Specification may be required to be furnished and installed by the Contractor. Payment for these items of metalwork will be made in accordance with Clause 11.3.

11101 Standards

a) Except as otherwise specified, all material shall conform to the applicable requirements of AASHTO standards.

b) Structural metalwork shall be welded and fabricated in accordance with the AASHTO Standard Specifications for Highway Bridges. All joints in metalwork, which is to be galvanised after fabrication, shall be seal welded.

c) Except where otherwise specified, threaded fasteners shall comply with the ISO metric system, normal series, coarse pitch.

11102 Embedded Metalwork

a) Embedded metalwork shall be embedded in the concrete when the concrete is being placed or, if shown on the Drawings or directed by the Engineer, recesses or block outs shall be made in the concrete and the metalwork shall be cement grouted in place or embedded in second stage concrete.

b) Metalwork shall be accurately positioned and aligned as shown on the Drawings and shall be held securely in the correct position during placing and setting of the concrete.

11103 Grout and Dry pack for Metalwork

a) Grout or dry pack concrete for metalwork shall be mixed in the proportions and to the consistency approved by the Engineer. The Contractor shall furnish all cement and fine aggregate for grout or dry pack complying with the requirements of Clauses 6.3 and 6.6.

b) The cost of all work in connection with the grouting or dry packing operations and the cost of the cement and fine aggregate for grout shall be included in the rates tendered in the Bill of Quantities for furnishing and installing the various items of metalwork for which the grout or dry pack is required.

c) Before placing grout or dry pack, the surfaces of existing concrete on which the grout or dry pack will be placed shall be roughened and shall be cleaned of all laitance, loose or defective concrete, coatings and other foreign material by effective means followed by thorough washing. Such surfaces shall be kept moist immediately prior to the placing of the grout or dry pack.

11200 CORROSION PROTECTION

11201 General

a) The Contractor shall furnish, prepare and apply all material for cleaning and corrosion protection of all metalwork as hereinafter specified.

b) Except as otherwise specified, surfaces of metalwork that will be in contact with other metalwork or concrete shall receive three coats of priming paint. The type of priming paint and the method of surface preparation shall be consistent with the requirement for other surfaces of the same metalwork.

c) Field weld preparations and the adjacent blast cleaned surfaces shall be protected with one coat of an approved paint as a corrosion inhibitor. This paint shall be of a type which will not adversely affect the welded joint and which is readily removable for the restoration of the specified coatings to the satisfaction of the Engineer.

d) Surfaces that have been coated shall be handled with care so as to preserve the coating in the best practicable condition and shall be protected as approved by the Engineer from the harmful effects of heat and weather conditions.

e) The cost of furnishing, preparing and applying all materials which are required for the cleaning and coating operations, including all labour, tools and equipment, shall be included in the rates bid in the priced Bill of Quantities for furnishing and installing miscellaneous metalwork.

f) Partially embedded reinforcement, which is exposed to the harmful effects of heat and weather conditions, shall be protected with corrosion inhibitor as approved by the Engineer. Prior to fully embedding the reinforcement in concrete the corrosion inhibitor shall be removed by grit blasting or other approved method.

g) Metalwork shall have the corrosion protection system applied to it prior to installation in the works.

11202 Coating System

a) Unless otherwise directed by the Engineer, all metalwork shall be hot-dip galvanised.

b) Zinc metallising may be used in lieu of hot-dip galvanising.

c) Pile splice plates and field welds require no corrosion protection.

11203 Surface Preparation

a) All cleaning and surface preparation of metalwork shall be performed by skilled personnel under the supervision of staff experienced in the surface preparation of metalwork.

b) Weld spatter, burrs and any other objectionable surface irregularities on metalwork shall be carefully removed or repaired before cleaning.

c) Steel surfaces to be coated shall be cleaned of all detrimental foreign matter such as oil, grease, soil or other contaminants.

d) The surfaces of all embedded and non-embedded metalwork, whether galvanised or zinc metallised, shall be cleaned.

e) The Contractor shall use a steel grit or other abrasive approved by the Engineer to obtain the required surface preparation. The abrasive shall be hard and sharp and free from dust.

f) Before being coated the blast cleaned surface shall be fibre brushed and vacuum-cleaned to remove all blast products and abrasives from the entire surface including pockets and corners. Final blast cleaning operations shall not be conducted on surfaces that will become wetted after blasting and before painting, or on surfaces the temperature of which is less than 3 degrees above the dew point of the surrounding air, or when the relative humidity of the surrounding air is greater than 85 per cent.

g) Cleaned surfaces shall be kept free from any contamination and shall not be touched by bare hands. The operators shall wear fabric gloves of an approved type whilst carrying out cleaning and coating duties and any areas inadvertently touched by hands or bare parts of the body shall be solvent cleaned immediately.

h) The cost of surface preparation prior to the application of a coating system shall be included in the cost of the application of the coating.

11204 Application of Coating Materials - General

a) The application of all coating materials shall be carried out in a neat, workmanlike manner by skilled personnel under the supervision of staff experienced in the application of the particular system and in accordance with the manufacturer's written application instructions as approved by the Engineer in accordance with this Specification.

b) All equipment used in the application of coating materials shall be as recommended by the manufacturer and approved by the Engineer. The equipment shall be in first class order and where power driven equipment is used, deliver the coating materials at the rate specified in the application Specification.

c) Cleaned surfaces shall be treated as specified for the appropriate coating system as soon as practicable and in any case within 8 hours after cleaning. Blast cleaned surfaces must not be allowed to stand overnight without having received the first coat of paint. Should rust form or the surface become otherwise contaminated in the interval between cleaning and coating, re-cleaning shall be performed.

d) When the coating material is applied by spraying, suitable means shall be provided to prevent segregation during the coating operation. Free oil and moisture shall be removed from the air supply lines of all spraying equipment. Each coat shall be uniform and free from runs, sags and other imperfections. The time between successive coats shall be not less than the minimum or more than the maximum re-coating time specified by the manufacturer.

e) Surfaces that have been coated shall be handled with care to preserve the coating in the best practicable condition and be protected from mechanical damage and the harmful affects of heat and weather conditions.

f) All coated areas which are defective or damaged, shall be cleaned and repaired in accordance with the field application instructions. Coatings that are loose, weakly bonded, blistered, abraded or otherwise defective shall be removed and the surface re-cleaned in accordance with the method prescribed for the specified coating at the Contractor's expense. The surface shall then be recoated in accordance with the appropriate Clause in this Specification.

g) Suitable traps shall be fitted to remove moisture and oil from the air supply for all cleaning and spraying equipment.

11205 Application of Zinc Metallised Coating

a) Surfaces shall be thoroughly clean and dry before the zinc metallised coating is applied and the latter shall not proceed during foggy, damp, dusty or other unsuitable weather, unless suitable precautions are taken to exclude the effects of such weather.

b) The Contractor shall, if requested, supply test certificates covering chemical and physical properties of the metal and shall supply samples of material for chemical analysis by the Engineer.

c) If any metal already applied as a coating is found to contain foreign material likely to cause or assist corrosion, then the whole of the area coated with metal shall be grit blasted to remove the coating and then recoated at the Contractor's expense.

d) A commencement in the application of the metal coating shall be made within 4 hours of completion of final blasting and the completion of such coating (exclusive of any priming or sealing coats) shall be achieved within 8 hours of blasting or within such longer period as approved by the Engineer, but in any case, before any deterioration or discoloration of the surface occurs.

e) Should any of the surfaces to be coated show signs of moisture, rust, scale, discoloration or other contamination, such portions shall be re-blasted before any metal coating is applied.

f) A minimum thickness of 0.2 mm of zinc shall be applied in not less than 3 passes of the metal spraying pistol. The thickness of the coating shall not exceed 0.25 mm.

g) The metallised surface shall, before any contamination can take place, be sealed using an approved coating.

h) Unsealed metallised surfaces, due to their porous nature, present a serious problem in cleaning after they have become contaminated. Extreme care is required to prevent spreading of the contamination or causing it to penetrate into the pores of the metal. Washing the metallised surface with water is not permitted except in special circumstances as determined by the Engineer.

i) The cost of all metallising shall be included in the rate in the priced Bill of Quantities for furnishing and installing miscellaneous items of metal work.

11206 Galvanising

a) Galvanising shall be in accordance with the Specifications for zinc (Hot-Dip Galvanised) Coatings, AASHTO M111. In addition, materials, such as welding slag, paint and grease, likely to resist attack by pickling liquid shall be removed prior to pickling and where specified, surfaces shall be grit blasted which shall be carried out in accordance with the relevant requirements of sub-clause 3 of this Clause.

b) The surface after galvanising shall carry an unbroken covering of 600 grams of zinc per square metre, uniform in appearance and thickness not less than 0.09 mm at any point.

c) Where possible, welding, drilling and other working required for fabrication of the material shall be completed and all burrs and other defects removed before the galvanising process commences. All joints shall be seal welded prior to galvanising.

d) Where the galvanised coat has been broken during fabrication or damaged in handling, the exposed surface shall be painted as soon as possible in accordance with the following procedure and as directed by the Engineer:

i. clean back to bright steel

ii. feather the edges of the surrounding galvanised coating.

iii. Degrease

iv. apply 2 coats of zinc rich primer giving a total dry film thickness of not less than 0.075 mm.

e) Zinc rich primer shall consist of fine zinc powder, epoxy resin base and polyamide accelerator which, mixed in the correct proportions, produce a paint suitable for brush or spray application with or without thinning as recommended by the manufacturer. The dry paint film shall contain at least 92 per cent fine zinc powder.

f) Metalwork that would be distorted or otherwise damaged by hot-dip galvanising or from which runs and sags resulting from hot-dipping could not easily be removed and elsewhere, as approved by the Engineer, may be zinc metallised in accordance with sub-clause 5 of this Clause.

g) The cost of galvanising shall be included in the rates bid in the priced Bill of Quantities for furnishing and installing miscellaneous metalwork.

11207 Inspection

a) All work shall be subject to inspection by the Engineer. Full and uninterrupted access to the Contractor's and any of his Sub-Contractor's works shall be provided. The works shall possess illumination which, in the opinion of the Engineer, is adequate for the application and inspection of protective coatings.

b) Thickness of coatings will be measured by the Engineer with calibrated magnetic or electromagnetic thickness metres. In addition, coating or thickness may be checked by any direct method of measurement deemed suitable by the Engineer.

c) For the purpose of measuring adhesion or thickness directly, the Engineer may remove a small section of the coating. Such areas shall be repaired by the Contractor at his own expense.

d) The Engineer may use test methods other than those listed above to determine the coating's compliance with this Specification.

11300: MISCELLANEOUS METALWORK

11301 General

The Contractor shall furnish and install miscellaneous embedded and non-embedded steel metalwork as follows:

i. galvanised tapped sockets in precast beams.

ii. galvanised brackets to support services through bridges;

iii. galvanised drainage scuppers in bridge; and elsewhere as shown on the Drawings or directed by the Engineer.

iv. galvanized steel gtatting

11302 Payment

a) Payment for furnishing and installing miscellaneous metalwork will be made at the rate per kilogram bid therefore in the priced Bill of Quantities (Item 11.03)

b) Payment for metalwork associated with bridge deck joints shall be in accordance with Clause 13.5.

110/1 Dia 150 mm Corrugated Steel Pipe (CSP) Sub-drain, unit meter

11400: STRUCTURAL STEEL

11401 General

The items shall include all bracing, diaphragms, longitudinal and vertical stiffeners, stud shear connectors, field splices, etc. all as shown on the drawings and as required to give a complete structure.

For the contract prices for the above Items, the contractor shall complete the structural steel as shown on the drawings or as described herein and in accordance with AASHTO Code, Section 11.

The specification herein, and as denoted, covers the requirements for the supply and erection of structural steel for the structure.

11402 MATERIAL

(a) All structural steel shall conform with AASHTO M270 (ASTM A 709 Grades 350 A or 350 W

(b) All bolted connections shall be made with 22 mm diameter high strength bolts conforming to A.S.T.M. Specifications A 325, Type 3, unless noted otherwise. The nuts shall be heavy, hexagon, semi-finished as per ASA Specification B18.2.

(c) All welding shall conform to the requirements of ANSI/AASHTO/AWS D1.5 Bridge Welding Code. and shall be carried out by a welder qualified under this code. The weld processes shall produce a weld bead having corrosion resistance similar to the base metal.

All blasted surfaces shall be commercial blast cleaned in accordance with AASHTO section 11.3.6.3. and 13.2.3 and shall be cleaned with clean brushes made of hair, bristle or fiber; blown off with compressed air, from which all oil and water has been removed; or by overruns to remove all traces of blast products from the surface and from pockets and corners.

All blasted girder surfaces shall be carefully protected, following blasting and until such time that the girders have been erected, to ensure that all blasted surfaces receive identical exposure to the elements, for complete uniformity of appearance, colour, texture, etc. of all blasted surfaces.

Field blasting of the surfaces, in accordance with above, shall be subject to the prior approval of the engineer, in writing.

If any apparent color, texture, etc. contrast between blasted surfaces in evident after erection, all the stipulated surfaces shall be re-blasted to commercial blast clean in field immediately following erection, and in accordance with the above and at the Contactor’s expense.

Any concrete or foreign material that comes in contact with exposed areas of structural steel during construction operations is to be carefully removed. Stains resulting therefore are to be removed by blast cleaning as specified above. Use of acids for cleaning will not be permitted.

11403 DELIVERY OF STRUCTURAL STEEL

The Contractor's attention is drawn to the provisions of the Highway Traffic Act regarding dimensions and weight of vehicles.

When it is planned to deliver structural steel by highway transport, the Contractor must contact Ministry of Transportation and communications prior to submitting his bid to ensure that the hauling operation will comply with the regulations.

If delivery cannot be made by Highway transport then some other means of transportation must be arranged and no additional payment will be allowed for such arrangement.

11404 ERECTION OF STRUCTURAL STEEL

The structural steel members shall be supplied by the Contractor.

The installation of high strength bolts, nuts and washers, shall conform to the requirement of AASHTO M 164 (ASTM A 325)

Where bolts are installed by the calibrated wrench tightening method, the following bolts tension will apply; for 22 mm diameter bolts 175 KN; for 19 mm diameter bolts 126 KN.

The Contractor shall submit shop drawings and erection plans to Engineer for review as required elsewhere in the Specifications and in accordance with AASHTO section 11.2

11405 Payment

114/1 Procurement of Structural Steel Bridge along with all bracing, diaphragm, etc. Payment will be made after procured at site,
Unit - Lump Sum

114/1 (a) Construction steel railing on wing wall:- The cost will include delivery of Steel pipe, I-beam, steel plate, anchor bolt including loading, labour, transportation and unloading, welding, fixing in place, painting etc complete.
Unit - m

114/2 Delivery Structural Steel at site, payment will be made including labour, transport, all complete. Unit - Lump Sum

114/3 Erection Structural Steel in place, payment will be made including labour, temporary supports, equipments, all complete. Unit – Lump Sum

12000: Bridge Bearings

12100- General

a) Pay Items included in this Part are:
   i. Item 12.06/1 - Furnishing and installing elastomeric bearings.
   ii. Item 12.06/2 - Furnishing and installing bridge deck joints.

b) Elastomeric bridge bearing shall be manufactured and furnished in accordance with this Specification and the Drawings and shall be installed at the locations shown on the Drawings or directed.
c) Throughout this Clause the term 'elastomeric bearing' or bearing refers to a rubber bearing consisting of one or more vulcanised natural rubber slabs bonded to metal plates to form a sandwich arrangement.
d) All bearings shall comply with AASHTO M 251-92 unless otherwise specified.

12200: Bearing Performance Characteristics

12201 Dimension

The dimensions and bearing of the bearing shall be as shown on the Drawings performance requirements and properties.

12202 Materials

Properties of Elastomer*:*

The elastomer to be used for bearing shall be made from chloroprene rubber only satisfying to the requirements of these specifications.
Grades of raw elastomer of proven use in elastomer bearings with low crystallization rates and adequate shelf life (e.g. Neoprene WRT, Bay-preen 110 or equivalent) shall be used. No reclaimed elastomer or vulcanized wastage shall ne used. The raw elastomer content of the compound shall not be lower than 60% and the ash content shall not exceed 5%. Elastomer having all properties as given following table shall be used. Elastomer shall high environmental resistance compatible with conditions of use. Elastomer complying with the requirements of IS.3400 for adhesive strength and for environmental conditions shall be used. The adhesion strength to steel plates shall not be less than 7 KN/m. Shear modulus of elastomer bearing shall not be less than 0.80 MPa nor greater than 1.40 MPa. Laminated mild steel conforming to IS 226 shall be used and use of any other materials like fibre glass or similar fabric as laminated shall not be allowed.

12203 Properties of Elastomer.

Properties	Unit	Test method, IS. Specification	Value of the Characteristics specified
Physical properties			
1. Hardness (Durometer)	IRHD	IS: 3400(Part II)	60 ±5
2. Minimum tensile strength	MPa	IS: 3400 (Part I)	16
3. Minimum elongation at break	%	IS: 3400(Part I)	400
Maximum compression set	%	IS: 3400 (Part X) Duration (Hour) Temperature (^{0}C) 0 to 24-2 100 1	35
Accelerated ageing		IS: 3400 (Part IV) Duration (Hour) Temperature (^{0}C) 70 100	
Maximum change in hardness	IRHD		15
Maximum change in Tensile strength	%		15
Maximum change in elongation	%		40

Fabrication Tolerances :

Bearing shall be fabricated with following specified tolerances :

Overall plan dimensions (Le, be): -0,+6 mm

Total elastomer thickness :	-0, 5%
Thickness of individual internal layer of elastomer (hi):	-0, +1 mm 20%
Thickness of individual outer layer(ha)	-0, +1 mm
Parallelism	
Top surface of bearing with respect to bottom surface as datum	1 in 200
One side surface with respect to the other as datum	1 in 100
Plan dimensions of laminates (l, b)	-3, +0
Thickness of laminates	10%
Parallelism of laminates with respect to bearing base as datum	1 in 100

Drawings:

The contractor shall have to supply, fix in position and maintain the bearings strictly in accordance with the drawings and designs of this contract.

Acceptance Specification:

The manufacturer shall have all test facilities required for the process and acceptance control tests installed at his plant to the complete satisfaction of the Engineer. The test facilities and their operation shall be open to inspection by the Engineer on demand.
Acceptance testing shall be commenced with the prior submittal of testing programme by the manufacturer to the Engineer and after obtaining his approval.
Quality control Certificate:

The size and composition of acceptance lot shall be got approved by the Engineer. The manufacturer shall certify for each lot of bearing under acceptance:

(a) That an adequate system on continuous quality control was operated in his plant.

(b) A certified copy of results of process control testing done on samples of elastomer used in the production of the lot shall be appended and shall include at least the following information:

Composition of the compound: Raw elastomer and ash content; the grade of raw elastomer used (include name, source, age on shelf).
Test results: Hardness, tensile strength, elongation at break, compression set, accelerated ageing, adhesion strength etc.

12204 Certificate and Marking:

Bearing shall be transported to bridge site after final acceptance by Engineer and shall be accompanied by an authenticated copy of the certificate to that effect.
An information card giving the following details for the bearing, duly certified by the manufacturer shall also be appended.

(a) Name of manufacturer
(b) Date of manufacture
(c) Elastomer grade used
(d) Bearing dimensions
(e) Production batch no
(f) Acceptance lot no
(g) Date of testing

(h) Specific bridge location
(i) Explanation of marking used on the bearing

All bearing shall have suitable index markings identifying the information as given above. The markings shall be made in indelible ink or flexible paint and if practicable should be visible after installation. The top of the bearing and direction of installation shall be indicated.

12205 Testing

No bearings shall be installed until tests in accordance with AASHTO M251-92 have been completed by an approved laboratory on randomly selected bearings and the bearings, having achieved all requirements, have been approved.

b) i. Bearings for testing shall be selected by the Engineer and the Engineer shall be present at any testing.

ii. The rate of testing of bearings shall be in accordance:

Bearing	Rate of Testing
Type A	1 in 4
Type B	all bearings

c) Each bearing shall be indelibly marked with white paint with an identifying number as directed by the Engineer on the side. This number shall be the bearing identification number for test certificates.

Any bearing which fails to pass these requirements shall be indelibly marked `FAILED' and shall not be used in the works. `FAILED' bearings will not be paid for.

d) Each bearing which passes these tests and complies with this Specification in all other respects shall be indelibly marked 'PASSED'.

e) The Contractor shall submit, for approval, a copy of a test certificate giving test results of the bearings which have passed the tests.

f) Notwithstanding anything to the contrary contained in this Specification, the inspection, examination and testing of bearing samples by the Engineer and any consent to proceed with the manufacture of the bearings resulting from such acts shall not prohibit the Engineer from making further inspection, examination, or tests on the bearings subsequently and rejecting any bearings if shown to be in non-compliance with this Specification. The Engineer may reject any bearing with flaws or irregularities.

12300: Installation of Bearings

12301 Installation Tolerances

a) Elastomeric bearings and cement mortar bearing pads shall be installed to the following tolerances:

i. The level of the top surface of the elastomeric bearing when installed shall not vary from that shown on the Drawings by more than 3mm.

ii. No point on either surface in contact with any bearing shall vary from the plane of that surface by more than 1mm.

iii. The out of parallel of each face of the bearing after beam installation shall not exceed 1 in 300.

iv. The slope of each face of the bearing shall not vary from that specified by more than 5mm per metre.

v. The horizontal position of any point on any bearing shall not vary from the location shown on the Drawings by more than 10mm.

b) Cement mortar bearing pads which do not meet these tolerances may be repaired by either grinding the surfaces which will be in contact with the bearings to achieve the desired tolerances or by roughening these surfaces and casting a layer of an approved mortar over the complete surface to a minimum of 3mm and grinding as necessary.

c) If the above tolerances are not achieved, the Engineer may direct that the bearing pad be removed and replaced by a new pad within the specified tolerances.

12302 Cement Mortar Bearing Pads

a) The cement mortar shall have a minimum compressive strength at 7 days of 30 MPa and shall be composed of one part of cement to 2 parts of sand, unless otherwise approved. All of the sand used in preparation of the mortar shall pass a 4.75mm sieve.

b) Before placing the cement mortar bearing pads, the Contractor shall prepare a trial mix of his proposed cement mortar mixture. The equipment used to make the trial mix shall be the equipment to be used during the Contract.

c) Three standard 95mm test cubes shall be cast for compression strength testing and cured for 7 days to the satisfaction of the Engineer. The cubes will be air cured on site in a sheltered location.

d) The three cubes shall be tested for compressive strength at 7 days and each cube shall have a compressive strength of at least 30 MPa. Construction of the bearing pads shall not proceed until the strength of the proposed mix has been approved.

e) The provision of all necessary equipment and carrying out of the sampling of the mortar, the moulding, on-site curing and testing of specimen's shall be done by the Contractor at his cost.

12303 Installation of Bearings

a) The concrete surface areas on which the cement mortar bearing pads are to be installed and the bearing surfaces on the precast concrete beams shall be kept free of oil, grease, dirt, laitance and all other foreign materials.

b) Before placing the cement mortar bearing pads or the elastomeric bearings or the precast concrete beams, the contact areas shall be clean and dry to the satisfaction of the Engineer.

12304 Care of Bearings

a) Bearings at all times shall be handled carefully and protected from extremes of heat and cold. They shall be stored under cover and after installation they shall be adequately protected from the elements until the superstructure has been placed.

b) The Engineer may reject any bearings or have them retested at the Contractor's cost if they show signs of deterioration before installation.

12400: Bridge Deck Joints

12401 General

a) The Contractor shall furnish and install bridge deck expansion joints and accessories as shown on the Drawings or directed by the Engineer. The accessories shall include bolt assemblies, metal work, elastomers and sealants as required.

b) The Contractor shall nominate the type of deck joint and shall submit with his Tender for approval, all relevant details of the proposed deck joint including drawings, manufacturer's specifications if applicable, and methods of installation and securing the joint.

c) Should the proposed deck joints require changes to the basic concrete outline of the bridge decks, the Contractor shall also submit all relevant details to the Engineer for approval.

d) Grout or dry pack concrete shall conform to clause 12.1

12402 Joint performance Requirements

a) The joints shall be completely watertight. Special attention shall be paid to the detailing to ensure full water tightness at the faces of the parapets.

b) All metal work shall be galvanised in accordance with Clause 12.2.

c) The movement capacity of deck expansion joints shall be as shown on the Drawings.

12403 Joints Installation

a) Not less than 30 days prior to placing an order for a proprietary joint, or 60 days before commencing installation of the deck joints, the Contractor shall submit for approval, complete shop drawings showing details of fabrication and installation.

b) Where the Contractor proposes to fabricate the deck joints he shall submit to the Engineer for approval a sample of the deck joint to be used in the Works. The sample shall be not less than 1 metre in length or be one complete unit when the unit is less than 1 metre in length.

c) Expansion deck joints as shown on the Drawings have been located on the bridge decks showing the longitudinal movement in the bridge decks due to shrinkage, creep and thermal effects in either the precast beams or the concrete deck slab as zero. The Contractor shall take into account at the time of installation of the deck joints the actual movement that has taken place in the bridge deck and shall take such measures as directed by The Engineer to ensure that the deck joint openings as installed are satisfactory

12500 GI Pipe Railing

GI pipe railing composed of GI pipe with diameter as shown on the drawing cutting to required size, coupling, welding and place in position. GI pipe should be as follows:

1. 150 mm outer diameter with 5mm thickness
2. 100mm outer diameter with 5mm thicknes

12501 GI Pipe Barrier for Culverts

GI pipe Barrier with diameter as shown on the drawing cutting to required size, filling it from concrete, and place in position. GI pipe should be as follows:

1. 150 mm outer diameter with 5mm thickness

12502 Measurement

a) Measurement, for payment, for furnishing and installing GI pipe railing will be made for the linear meter of GI pipe railing furnished and installed as shown on the drawings or directed by the Engineer, It should include complete cost of its fitting, welding, galavanizing, etc. The completed railing according to drawings, and specification, accepted to the engineer will be measured per linear meter of the railing and will be paid upon contract unit price.

b) Measurement, for payment, for furnishing and installing GI pipe, will be made for the length of the pipe, this price should include all cost of furnishing, installing, filling it from concrete, labor, etc. and will be paid

12502 Payment

Payment will be made at the Contract Unit Price for each of the items listed below which is shown in the Bill of Quantities. Such price is full compensation for all labour and materials necessary to furnish, install and test the items.

Pay Item	Unit
121/1- Furnish and Install Elastomeric Bearings -	set
121/2- Furnish and Install Deck Joints -	L.m.
121/3- Furnish and Install GI Pipe Railing -	L.m.
121/4 - Furnish and Install GI Pipe -	m.

14000: Bridge Repair

14100 General

The Contractor shall carry out bridge repairs in accordance with this Part where and as shown on the Drawings, or as directed by the Engineer.

14101 Requirements

Bridge repairs may include but may not necessarily be limited to the following items:

a) Repairs to concrete or brickwork in piers or abutments including all necessary temporary cofferdams or other measures to dewater working areas.

b) Repairs to concrete or brickwork in piers, abutments or bridge decks including all staging and temporary works necessary to carry out and inspect the works. Repairs to concrete shall include for the removal of all unsatisfactory concrete, cleaning existing reinforcement and making good with fresh concrete or epoxy resin based mortars.

c) Repairs and replacement of concrete bridge parapets and railings to existing profiles or to new designs including all necessary shuttering, reinforcement, concrete and mortars.

d) Repair or replacement of bridge expansion joints, elastomeric bearings or other forms of bearing, including all necessary staging, false work for the temporary support of bridge decks, arrangements for jacking and removal of all staging, false work etc.

e) Placing and compacting road embankment material and aggregate backfill about and adjacent to existing structures to replace scoured and eroded materials and the placing of brick pitching (gabion type) or other forms of protection.

f) Preparation of bridge decks to receive asphaltic concrete wearing/regulating course materials to be placed concurrently with general road surfacing operations.

14200: Repair of Existing Concrete Structures

14201 Materials

Concrete shall comply with Clause 7300 of these Specifications.
Cement mortar shall comply with Clause 8200 of these Specifications except that the mix may vary as shown on the Drawings.

14202 Construction Methods

General:

The Contractor and the Engineer shall jointly survey structures to be repaired, and the location of all repairs shall be permanently marked in paint on each structure. The repair work shall be carried out by skilled, experienced personnel well-versed in this work.

14203 Repair of Existing Localized Defective Concrete:

Where existing defective concrete is to be repaired, or extended, the existing concrete shall be carefully broken back to ensure that all defective material is removed and that, where necessary, sufficient reinforcement is exposed.
All loose concrete shall be removed, the exposed reinforcement shall be carefully cleaned, and the exposed concrete shall be cleaned of all dust. A construction joint shall be prepared on the exposed face to ensure a good feature between the existing section and the repair/extension work.

The construction of replacement concrete work, and of any extension, shall conform to Clauses 7300 and 7400. The prepared face shall be inspected and approved by the Engineer before new work commences.

14204 Repairs to Concrete Surfaces*:*

Defective concrete on the face of substructure walls, particularly adjacent to the water line; in soffits to beams, slabs and other superstructure; and on the web faces of main beams and other superstructures shall be carefully removed in a sequence and in accordance with the strict instructions of the Engineer. Such works shall be permanently supervised by a representative of the Engineer and the Contractor shall ensure technical staffs are permanently available on the Site to receive instructions. The structural integrity of existing members shall not be impaired and the Contractor shall be fully responsible for ensuring strict procedures are followed. Defective concrete shall be carefully and cleanly removed by manual methods using hammers and chisels. The concrete exposed shall be cleaned of all dust and loose material. Any reinforcement shall be carefully cleaned using wire brushes unless alternative instructions are given by the Engineer.

The removed concrete shall be replaced by a method proposed by the Contractor and approved by the Engineer after inspection of the exposed work. The Contractor shall demonstrate that the method he proposes to adopt is capable of giving a facing equivalent to the workmanship standards that would be accepted in new works.

14205 Repair of Minor Cracks in Concrete*:*

Minor cracks shall be cleaned to remove all loose material to expose a sound surface. After approval by the Engineer of the cleared crack it shall be grouted to full depth with cement mortar and trimmed flush with the face of the concrete.

14206 Anchoring and Tying:

Structural concrete members that exhibit cracking and relative movement may be anchored or tied as instructed by the Engineer. Prior to commencing work, the Contractor shall obtain the approval of the Engineer of the methods to be adopted. This shall cover the provision of temporary stages; the drilling methods; safety measures; anchoring methods and subsequent testing for ground anchors to ensure tie bars are capable of carrying twice the working load; stressing methods and ultimate grouting of anchor bars. The Contractor shall take instructions from the Engineer on the precise requirements for the provision, installation and anchoring of all tie bars incorporated in the Works.

14207 Measurement and Payment

Item		Unit
142/1	Repair of Existing Defective Concrete	Cubic metre
142/2	Repair of Existing Concrete Surfaces	Square metre
142/3	Repair of Minor Cracks in Existing Concrete	Linear metre
142/4	Supply and Fix Anchors and Tie Bars	Tonnes

Repair of defective concrete shall be measured as the volume in cubic metres marked up, replaced to original lines and accepted. Concrete surface repairs shall be measured as the area in square metres marked up, repaired and accepted. Repair of minor cracks shall be measured as the length in linear metres marked up, grouted and accepted.
Anchoring and tieing shall be measured as the weight in Kg of anchors and tie bars ordered, installed and accepted.

The work measured shall be paid at the relevant Contract unit prices per cubic metre, per square metre, per linear metre or per Tonnes. The payment shall be full compensation for the work including all materials, preparatory work and removal of defective materials, Temporary Works, and all labour, equipment, tools and incidentals necessary to complete the work. For anchoring and tieing the payment shall also be full compensation for fixing or drilling, installation, grouting in stages and stressing.

14300: Pavement Repair

14301 General

All areas of existing pavement which exhibit deterioration by cracking, ravelling, potholing and miscellaneous distortions shall be brought to a proper standard as specified herein before resealing or overlay.

Repairs made previous to this contract shall be checked for soundness and if necessary further corrected as directed by the Engineer.

The Engineer may in some cases require the whole pavement section to be reconstructed or overlaid in such a way as to restore structural strength and surface evenness.

The repair methods shall be in accordance with the following Specifications or as shown on the Drawings and to the requirements of the Engineer.

14302 Marking

All areas to be repaired shall be marked, in advance by the Engineer, on the pavement surface using yellow or white paint or pegs on hard shoulders. Areas shall be of rectangular shape with one side parallel to the centre line of the road.

14303 Surface Cleaning

The surface of all areas to be repaired shall be thoroughly cleaned of all deleterious matter using mechanical brooms, hand brooms, compressed air, water jets or a combination of these methods as required. Special attention shall be given to areas of dried mud, animal dung or spilled oils. The Engineer shall approve the surface cleaning before subsequent operations begin.

14304 Tolerances

After repair the pavement surface shall have an even appearance and shall not present deviations of more than 10 mm from a 2.0 m long straight edge laid at any angle with the road alignment.

14305 Equipment

Pavement repairs shall be carried out using equipment which conforms to the following criteria.

a) Distributors

Bitumen distributors shall in general conform to the requirements of Section 4.4.6 except that for small repairs a hand spray may be used instead of the main spray bar. For small areas the Engineer may approve other equipment so long as the general conditions of 4.4.6 including temperature control, volume measurement and distribution rate uniformity are met.

b) Compactors

Compactors for repair works shall be selected for their particular application. It shall be the Contractor's responsibility to select compaction equipment which is capable of producing the specified densities or surface compaction. The following guide is given on the types of equipment which normally produce satisfactory maintenance repairs. Any equipment considered unsatisfactory for the particularly repair work by the Engineer shall be replaced by the Contractor.

1) Steel double drum vibrating rollers with a 2.5 tonne minimum weight are considered suitable for brick khoa compaction, bituminous premix compaction, and shoulder compaction.

2) Plate compactors may be used for brick khoa patching, bituminous premix patching.

3) Mechanical tampers are considered suitable for brick khoa and bituminous premix compaction in small areas.

4) Pneumatic tyre rollers shall be used for seal coat or surface treatments.

14400: Brick Khoa/Crushed Gravel Pothole Patching

14401 Description

This work shall consist of excavating and trimming potholes, cracked, ravelled or otherwise damaged or depressed areas greater than 50 mm in depth and marked on the road. These areas will then be filled with compacted brick khoa and primed in preparation for placement of an overlay or surface treatment.

14402 Hole Excavation and Trimming

The areas to be repaired are as shown on the Drawings, as marked on the road, or as directed by the Engineer. The area shall be excavated to a uniform depth with vertical walls. All loose, cracked and unsuitable materials shall be removed from the hole as directed by the Engineer until a strong pavement level is attained. The hole shall be carefully cleaned and dried out before filling.

14403 Hole Filling and Compaction

The bottom and walls of the holes to be repaired shall be moist and shall be watered as required but there shall be no standing water in the hole.

Brick khoa complying with Section 3.4 for Base Course aggregate shall be used in layers not greater than 100 mm and compacted to 98% of maximum dry density as determined by AASHTO T-180. The completely filled area shall be primed according to Section 4.2 shortly after the completion of compaction and before it is exposed to traffic.

14404 Measurement

The area of the patching shall be measured when the excavation has been completed by the Contractor. The volume of patching shall be obtained by multiplying its surface area by its average depth.

Prime or tack coat will not be measured for payment, but shall be considered to be included in the price bid for the work.

14405 Payment

Payment for the measured and accepted work of patching using brick khoa shall be made at the Contract unit prices per units of measurement for each of the items listed below which is shown in the Bill of Quantities.

The payment shall be full compensation for provision of all materials, labour, equipment, tools and incidental necessary to perform the work as prescribed in the Clauses of this section and in conformity with the orders of the Engineer.

Pay items and units of measurement shall be :

Pay Item No		Unit
144/1	Pothole patching using Brick Khoa/crushed gravel	cu.m

14500: Pothole Patching and Edge Repair Using Bituminous Mixtures

14501 Description

This work shall consist of excavating and trimming the pothole, ravelled or cracked areas marked by the Engineer, applying a tack coat/prime coat to the bottom and walls of the excavation, and filling by compacted layers of bituminous mixture and final surface sealing or in preparation for an overlay.

14502 Hole Excavation and Trimming

The area to be repaired shall be marked on the pavement surface by the Engineer.

This area shall then be excavated to a hole with uniform depth with vertical walls. All loose, cracked and unsuitable materials shall be removed from the hole as directed by the Engineer until a strong pavement level is attained.

The hole shall be carefully cleaned, drained of any water ponding by appropriate means and allowed to dry before the tack coat is applied.

14503 Excavation and Trimming for Edge Breaks

Ravelled and broken edges requiring repair shall be marked and the Engineer shall specify the width and depth of repair.

The Contractor shall place a tight string line along the pavement edge, excavate a trench having uniform, specified width and depth and remove all cuttings. The vertical walls and bottom of the trench shall be trimmed to the specified dimension, carefully cleaned of all loose materials, drained of any water ponding by appropriate means and allowed to dry before the tack coat is applied.

14504 Tack/Prime Coat

The tack/prime coat shall either be cut-back bitumen or bitumen emulsion complying with the requirements of Clause 4.0.3.

The tack/prime coat shall be applied at uniform rate to the bottom and vertical surfaces of the hole to be repaired without excess and in such a way as to achieve total coating of these surfaces.

14505 Hole Filling and Compaction

The surface of the hole shall be dry at commencement of filling.

Bituminous premix as specified in Clause 4.3/4.5 as shown on the Drawings or directed by the Engineer shall be provided and the hole filled by layers starting from the corners and periphery and proceeding to the centre of the hole.

The thickness of any single layer before compaction shall not exceed 70 mm. Every layer shall be regraded by means of a straight edge and compacted by means of a plate compactor or tamper with square section starting from the centre and proceeding to the periphery and corners of the patching.

The level of the top layer shall be higher than the pavement surface and adjusted in such a way as to provide for a final compacted and sealed patch surface higher than the surrounding pavement surface by between 5 to 10 mm.

14506 Measurement

The volume of patching shall be obtained after excavation and trimming by multiplying its measured horizontal area by its average depth.

Prime or tack coat will not be measured for payment.

14507 Payment

Payment for the measured and accepted work of pothole patching using bituminous concrete shall be made at the Contract unit price per unit of measurement for each of the items listed below which is shown in the Bill of Quantities.

The prices and payment shall be full compensation for provision of all materials, labour, equipment, tools and incidental necessary to perform the work as prescribed in the Clause of this section and in conformity with the orders of the Engineer.

Pay items and units of measurement shall be :

Pay Item No.		Unit
145/1	Pothole/Edge Patching Using Bituminous Mixtures	cu.m.

14600: Edge Repair Using Bricks on End and Brick Khoa

14601 Description of Works

This works shall consist of excavating and trimming a trench along the pavement edge, placing bricks on end and backfilling between the bricks and the undisturbed pavement by compacted brick khoa layers and compacting the shoulder to ensure that the bricks retain a straight line. The final step shall be the placement of bituminous premix on top of the brick khoa work between the edge brick and the existing pavement according to Clause 16.2.

14602 Hole Trimming and Excavation

The line of the pavement edge shall be attained with a taut string placed to line and level. The area between the string line and the pavement shall be trimmed to a uniform depth and adequate base as directed. A trench shall be excavated outside the string line and bricks shall be placed on end in the trench and aligned with the string to position and level.

14603 Hole Filling and Compaction

The trimmed area between the brick and the pavement edge shall be backfilled using brick khoa "Base Course" to a level 50 mm below brick top level, properly compacted using a plate compactor, tamper or other mechanical compaction. The shoulder outside the brick edging shall be placed and compacted to the upper level of the bricks and mechanically compacted. Care shall be taken to avoid misplacement of the bricks by placing uniform lifts of filling materials on either side of the brick/edging.

14604 Materials

1) Bricks shall conform to section 5.8 for picked jhama bricks.

2) Brick khoa backfill shall conform to Aggregate for "Base Course" Section 3.4.

3) Shoulder backfill conform to shoulder fill Specification Section 5.1.
4) Bituminous Premix and Prime or Tack coat shall conform to Section 4.2.

14605 Measurement

The finished work of bricks on end-edging shall be measured as the length of the brick alignment along the pavement edge including the shoulder works compacted to the requirements of Section 7.1. Brick khoa shall be measured as provided in Section 16.1. Prime or tack coat will not be measured separately.

14606 Payment

Payment for the measured and accepted work of edge repair using brick khoa and bricks on end-edging shall be made at the Contract unit prices for the item shown below which is included in the Bill of Quantities.

Pay item		unit
No. 146/1	- Bricks on end edging	metre

14700: Depression Patching or Levelling using Bituminous Mixtures

14701 Description

This Work shall consist of cleaning areas marked by the Engineer for receiving a tack coat, and one or more compacted layers of bituminous premix conforming to Section 4.3/4.5 as instructed by the Engineer. The levelling course normally will be covered later by a bituminous overlay or surface treatment. Unless otherwise directed by the Engineer or shown on the Drawings, this Specification will apply only to areas of depressed pavement where the depression deviates from a 2 metre straight edge by more than 25 mm. All other areas will be treated as potholes according to Section 16.2.

14702 Materials

Bituminous mixture shall conform to the requirements of Section 4.3/4.5, for the type of mixture shown on the Drawing and in the Bill of Quantities. Where no type is specified bituminous premix conforming to Section 4.5 will be used.

14703 Surface preparation

The area to be patched or levelled shall be marked on the pavement surface, by the Engineer, in rectangular form by straight lines parallel and perpendicular to the road alignment.

Where necessary the existing pavement shall be cut away so that no part of the of the patch is less than 25 mm in compacted thickness and all edges are vertical, and free of loose material. This requirement may be waived by the Engineer where the patching will later be covered by a hot premix overlay.

This area shall be carefully cleaned in accordance with Clause 16.0.3 and as required by the Engineer.

14704 Tack Coat

The tack coat shall consist of cut-back bitumen or cationic emulsion complying with the requirements of Section 4.0 of this Specification.

The tack coat shall be allowed to cure and be protected from dust, dirt and traffic until application of the bituminous premix.

14705 Patching and Compaction

After curing of the tack coat a sufficient quantity of bituminous mixture shall be provided, spread and levelled on the patch area. The thickness of the layer before compaction shall be adjusted in such a way as to fill the depression and give a final compacted surface within the tolerance limits required under Section 16.0.4. Compaction shall proceed from the periphery to the centre by means of a vibrating roller or a plate compactor.
Where the depth of a depression is greater than 75 mm, the depression filling shall be placed in layers not exceeding 75 mm in thickness.

14706 Measurement

The length and width of the marked surface shall be measured before patching to obtain its area. The volume of patching shall be obtained by multiplying its surface area by its average depth.

Prime or tack coat will not be measured for payment.

14707 Payment

Payment for the measured and accepted work of depression patching or levelling using bituminous premix including prime or tack coat shall be made at the Contract unit price per unit of measurement for the item listed below and shown in the bill of quantities.

Pay item and unit of measurement shall be:

Pay Item No.		Unit
147/1	- Depression patching using Bituminous Premix –	cu.m.

14800: Base Course Levelling Course

14801 Description

This work shall consist of cleaning and scarifying the bituminous surfacing of the pavement areas marked by the Engineer for receiving a levelling layer of compacted base course to a level of 50 mm below final bituminous premix level to be applied according to Section 14.5. The scarified bituminous materials may either be stockpiled or fragmented and incorporated in the levelling course. This Specification shall be applied generally to areas larger than 25 sq.m. Smaller areas shall be treated as pothole and repaired in accordance with Section 14.2.

14802 Surface Preparation

The pavement surface requiring a base course levelling course shall be clearly marked by the Engineer.

The Contractor shall clean the pavement surface for all organic debris, dirt, clay and other foreign matter as required under Clause 14.0.3 of these Specifications.

He shall then, as directed by the Engineer, either scarify and stockpile the existing bituminous layer or scarify the existing bituminous layer and the top 50 mm of the existing base course and reduce the sizes of all aggregates to the proper grading for incorporation into the new base course.

The scarified materials then shall be watered as required and levelled. Compaction of the scarified materials will be required by the Engineer prior to placement of the base course levelling course.

Where the bituminous material to be removed appears to contain excessive bitumen, or is otherwise unsuitable for use in the base aggregates, the Engineer may direct that it be hauled to a designated spoil area.

14803 Materials

Base course shall comply with the requirements of section 3.4 of this Specification.

The materials shall be spread in layers, the compacted thickness of which generally shall not exceed 100 mm. However the Engineer may allow compacted thickness up to 150 mm if he is satisfied that the specified degree of compaction can be achieved throughout such greater thickness of layer with the compaction equipment and methods used by the Contractor.

Any irregularities that develop in the surface of the aggregate during compaction shall be corrected by loosening the surface, adding or removing material and recompacting until the surface presents a smooth regular appearance. The finished surface shall nowhere vary more than 10 mm from a straight edge, 2.0 metres long, applied to the surface.

Any damage which is done to the finished aggregate surface by the traffic shall be repaired by the loosening, reshaping, recompacting, use of necessary water and the addition of more aggregate material if necessary. Reshaping, adding of materials and recompacting operation shall be done at the expense of the Contractor.

The surface area of the compacted base course shall be primed and prepared to receive a bituminous overlay or surface treatment as soon as possible after an acceptable surface is achieved.

14804 Compaction

Before commencing the work, the Contractor shall furnish to the Engineer a sufficient quantity of the materials intended for use including crushed old pavement or base to be recompacted, in order that the Engineer can determine the density requirements in accordance with AASHTO T-180 (Method D). The density requirement for the project shall be at least 98% of the maximum dry density so determined. During the construction, the grading of new material shall be checked on samples from each 50 cubic metres of

stockpiled aggregate and if there is an appreciable change in grading of the aggregate, or a change of source of aggregate, the Contractor shall furnish sufficient samples to the Engineer in order to establish a new maximum dry weight for the density requirements. Field tests for moisture content and unit weight shall be in accordance with AASHTO T-191 or other methods approved by the Engineer. At least one test shall be carried out for each 50 cubic metres of completed levelling course.

14805 Measurement

Base course levelling course shall be measured by the number of cubic metres of material complete in place and accepted. Levelling course width measurements shall be made at the top surface of the levelling course and thickness measurements shall be made by using measuring scales to obtain the average depth. The Contractor shall include in his rate the cost of repairing any test pits required for measurement purposes.

Prime Coat shall be measured according to Section 4.2 by the area of base course accepted, except that areas of prime 50 sq.m. or smaller shall not be measured separately for payment.

14806 Payment

The work as measured above shall be paid for at the contract unit prices per unit of measurement for each of the items listed below and shown in the bill of quantities.

The prices and payment shall be compensation for performing the work including furnishing the materials, water, carrying out all surface preparation, mixing, placing, compaction, protection of works, trials, tests and all other procedures described herein and providing all labour, tools, equipment and incidentals necessary to do the work.

Prime Coat shall be paid for under Section 4.2.

Pay Items and units of measurement shall be:

Pay Item No.		Unit
148/1	Base Course Levelling Course	cu.m.

Islamic Republic of Afghanistan
Ministry of Communication and IT
Plan &Policy Directorates

Technical Specifications For Laying Of HDPE Ducts To House Optical Fiber Cables(OFC) on All Highways With Carrying Out Road Construction

Under Infrastructure Sharing Initiative of the Islamic Republic of Afghanistan, presidents Decree and the Infrastructure Sharing policy were issued in 2013 under which it has been directed to lay HDPE Duct for housing OFC while constructing the highway and Metro Road of the Country . Specifications for laying HDPE Ducts on Highway are given as Under :

Specifications of HDPE Silicon Duct:

Product	HDPE Silicon Duct	**Size**	40 / 33
Testing Reference	1. YD/T841-1996 Plastic Pipe for Underground Telecommunications; 2. JT/T496-2004 HDPE Silicon Duct for Underground Telecommunication of Highway;		
Testing Instruments	Micrometer Scope : 0-25 mm πRuler Scope : 20-110mm Caliper Scope : 0-100mm Computer-controlled Stress Tester Type : WDW-30 Drop Hammer Impact Tester Plump Tester Low-Temperature Refrigerator Electro thermal Blast Oven Type : 101-1 Fusion Exponent Meter Type : RL-Z1 Exactitude Scale Type : BP190S		
Testing Environment	Temperature: 23 C		

Detailed Specifications of HDPE Silicon Duct:

Pos.	Item	Specifications	
1	Appearance	Smooth inner & outer wall without decomposing stripe or visible impurity; well-proportioned color, no bubble or crack; silicon inner wall tightly welded without deviation; with outstanding marks on outer wall	
2	Structure Size, mm	Outer Diameter : 40 (+0.4, 0)	
		Thickness : 3.5±0.2	
		Ellipticity : ≤3%	
3	Axial Resisting Force, kn/m²	≥40	
4	Hardness	≥59 (Shao Shi Type D)	
5	Air-tightness	The duct, sealed with pyro condensed plugs at both ends and charged to 0.2MPa, should keep 0.18MPa at least inside after 24 hours.	
6	Flatness	Pressed vertically till a 50% distortion of the original outer diameter, the duct should not crack or be layered.	
7	Press Resistance	Pressed vertically till a 70% distortion of the original outer diameter and unloaded immediately, the duct should not crack or be layered and the outer diameter can recover to no less than 90%	
8	Stretch Force, MPa	≥18MPa	Referring to primal report
9	Rupture Extend Ratio %	≥350	Referring to primal report
10	Max Pulling Load, N	≥8000	Referring to primal report
11	Drop Hammer Impact Testing	Placing 10 pieces of duct for 2 hours at -19℃ dropping a 2Kg hammer from 2 meters above once to each piece, at least 9 pieces remain unbroken.	
12	Longitudinal Shrinkage, %	Undergoing a temperature drop from 110℃to 20℃ the shrink of the length should ≤2.0%	
13	Min Curving Diameter, mm	450	
14	Inner Friction Coefficient	≤0.25	

WARNING TAPE

A suitable orange PVC tape 0.7mm thick and 100mm wide shall be placed minimum at 30cm above the installed optical fiber cable for indication of the excavators of the presence of optical fiber cable. WARNING"OPTICAL FIBER CABLE" **contact this phone number before digging**" shall be printed on the tape in black letters 6cm high and 2cm wide at each one meter interval. The color shall be typical orange and tape shall be 200 to 250 meters in continuous length.

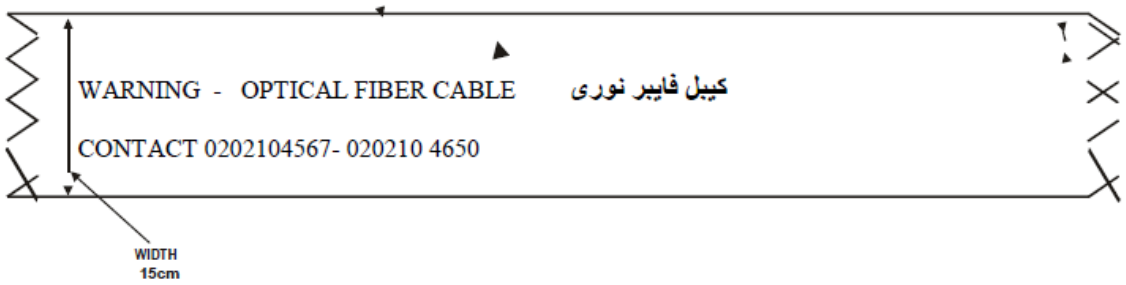


Fig : Warning Tape

Man Hole/Hand-holes

All cast-in-place Manholes and hand-holes must be equipped with cable racks, pulling eyes, supports and miscellaneous fittings. All metal hardware must be hot dipped and galvanized. All Manholes and hand-holes and their associated covers must be rated as traffic bearing, i.e., Manholes and hand-holes designed to withstand subsurface water table at a depth of 1m and H20 traffic loading requirements set forth by the American Association of State Highway and Transportation Officials (AASHTO) HB-11th Edition, 1973. This requirement requires deformed reinforcing bars in all floors and walls (grade 60 reinforcing steel) and 4000 PSI concrete.

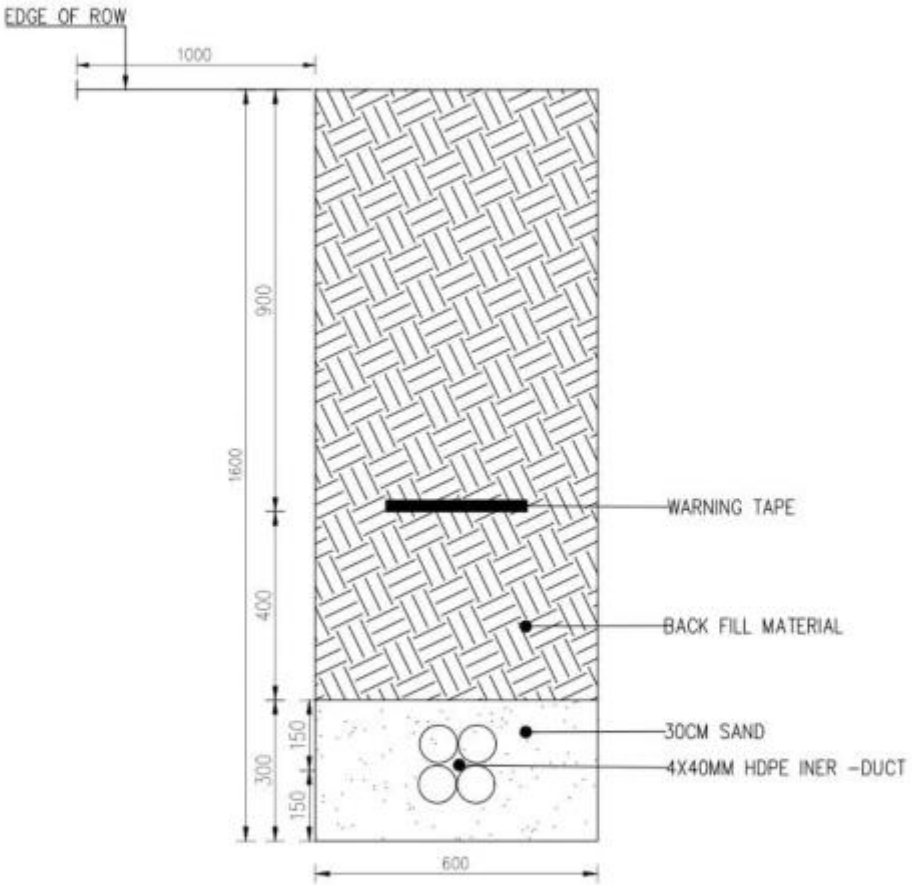
Generally, all Manholes must be equipped with a 60cm high collar, 25cm high frame, and a 75cm frame and cover. Preferably, the collar should be constructed of brick and mortar to allow for easier future level modifications and adjustments. All hand hole/Manhole covers must be stenciled and be equipped with a hole or other device for cover extraction. Hand hole cover plates, should be constructed of steel with an antiskid design and be traffic

bearing. The hand hole shall be equipped with a recessed metal ring to accept and cradle the cover.
Typical manhole/hand-hole sizes and racking requirements to be used most frequently in city areas distance must be 250 meters per 250 meters.
Typical manhole requirements to be used most frequently were road Crossing.

Collar/ Item	Size	Chimney Cover Type
Manhole	1.6m x 1.2m x 1.8m	Minimum 75cm Traffic bearing Headroom ring and cover
Hand-hole	1.2m x 1.2m x 1.8m	Ground Line Traffic bearing metal plate

- Concrete with 28-day compressive strength of 4000 PSI.
- Reinforcing steel with yield strength of 60,000 PSI grade 60.
- Reinforcing bars with kinks or bends are not to be used except where bends are specified.
- Reinforcing bars should be clean and free of loose rust, oil or other matter that might weaken the concrete-metal bonding.
- Forms fore cast-in-place Manholes should be designed to permit easy removal, constructed to conform to the required Manhole dimensions, substantially leak-proof, and capable of being placed and secured to prevent displacement while concrete is being poured.

In Excavated Trench:

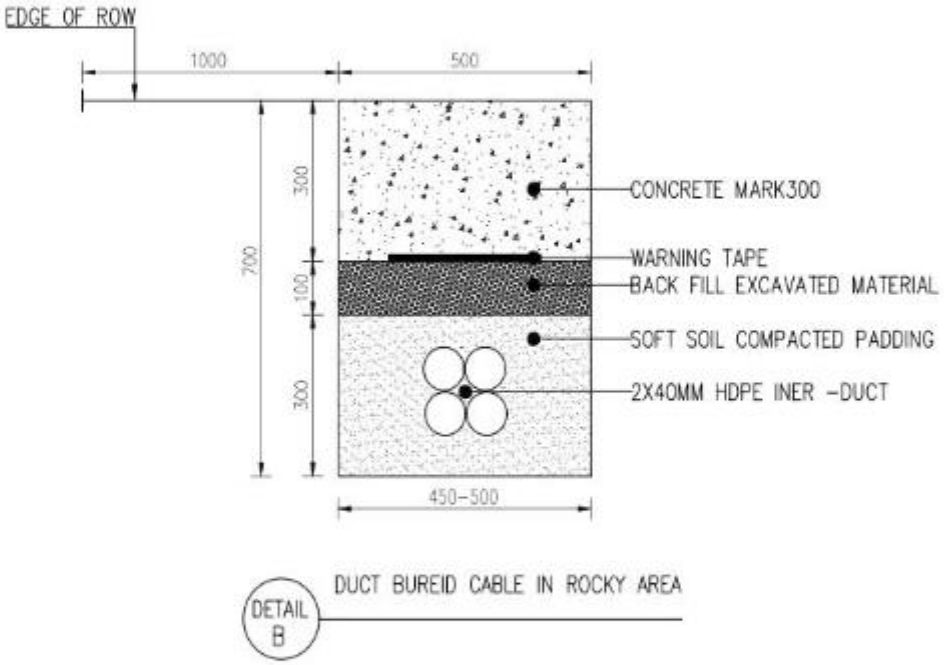


DETAIL A DUCT BUREID CABLE IN NORMAL SOIL

5

Pure Rocky Area:

In rocky area the trench depth shall be 70cm wide. The width at the top shall be 50 cm and width of the bed shall be 50cm too. All the sharp edges of rock shall be removed, 20 cm thick layer of soft soil cushion above and 10cm below the cable shall be provided. Then small pebbles shall be dropped first in the trench and the thickness of this layer shall be 10cm till the level of warning tape.
Minimum 30cm thick concrete (PCC) layer shall be casted in trench over the warning tape.



6

Hidden Rocky area

If the normal soil appears on the surface and after some depth rock appears or vice versa, then the specification as shown in **Fig. 23** shall be adopted.

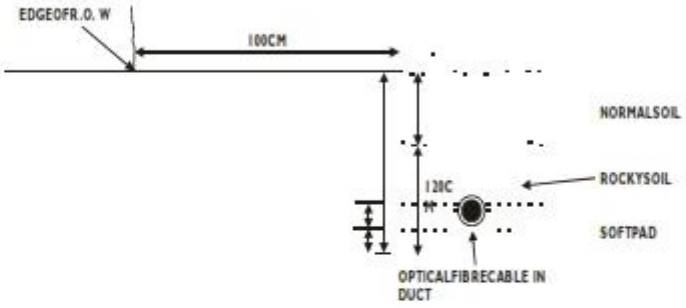


Fig. 23. Dig the Trench in Hidden Rock till the Trench Depth of 1.2 meters in Rock or 1.6meter Trench Depth from the Ground Surface (which ever is achieved earlier)

- There will be situations where it is not practical to excavate in extremely hard rock to a depth of 1.2 meter, these situations shall be particularly highlighted on the installation route plan. For such area, a committee with members from construction and maintenance Regions shall be deputed to work out the solution.

EROSION SOIL:

Where the line of excavation passes through eroded areas, affected area shall be reinstated and firmly compacted.

RAIN WASHABLE AREA

The depth of the trench shall be as per specification but within G.I. Pipe sub ducted with PVC Pipe and instead of using HDPE Pipe, the GI Pipe sub ducted with PVC shall be covered with 15cm thick concrete.

E) SLOPE CROSSING

Every effort shall be made to prepare the trench at end point of the slope. If it is not possible then stone pitching shall be provided to create space for the trench at the base of the slope. For durability, stone pitching with wire mesh is recommended. The committee constituted by project manager shall decide the size of wall. Contractors should cover the estimated quantity in its to be prepared during joint surveys

The trench depth shall be one meter at the base of the slope and 50cm at the top. Concrete step wall {(1x0.5x.15 M) (Length x Height x Thickness)} shall be constructed after every 2 Meters across the trench. The wall shall be constructed from the level of pipe in the trench. The HDPE pipe shall be used if one-meter trench depth at the top of the trench can be maintained otherwise GI-Pipe sub ducted with PVC Pipe shall be used.

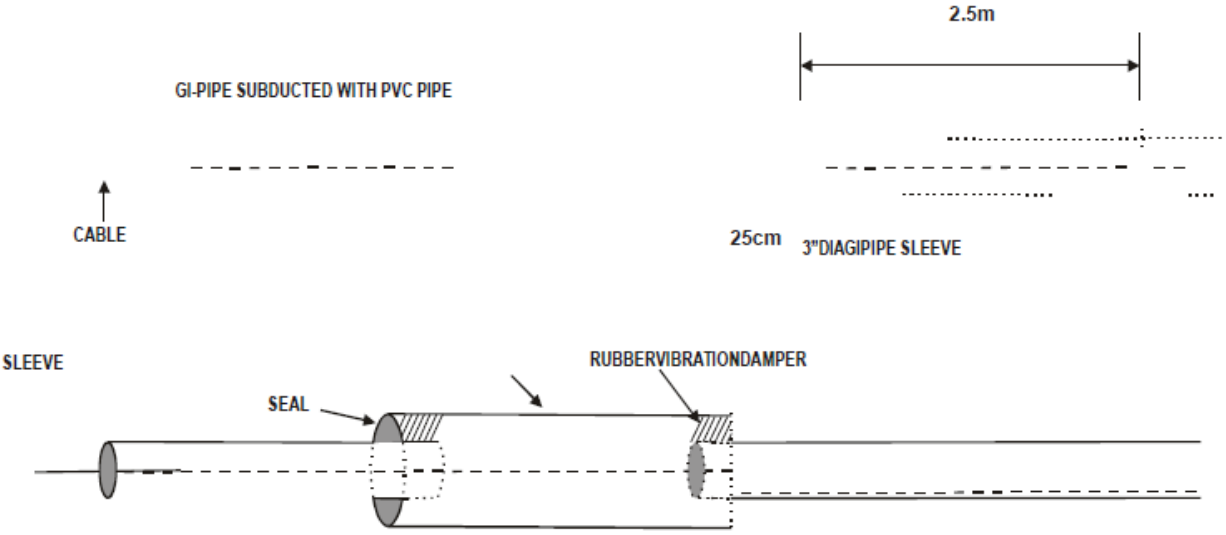
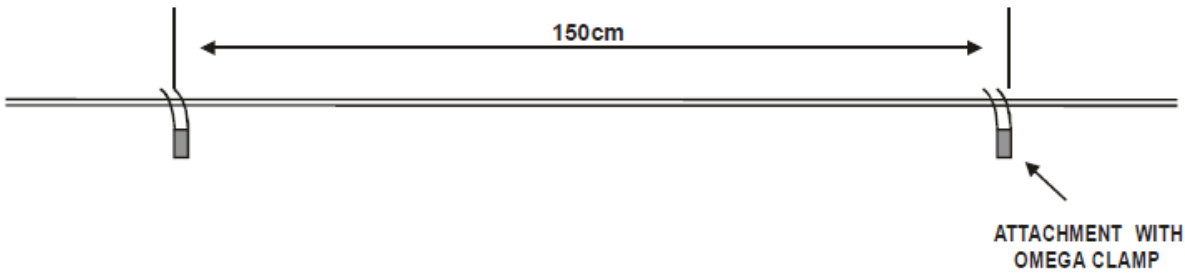
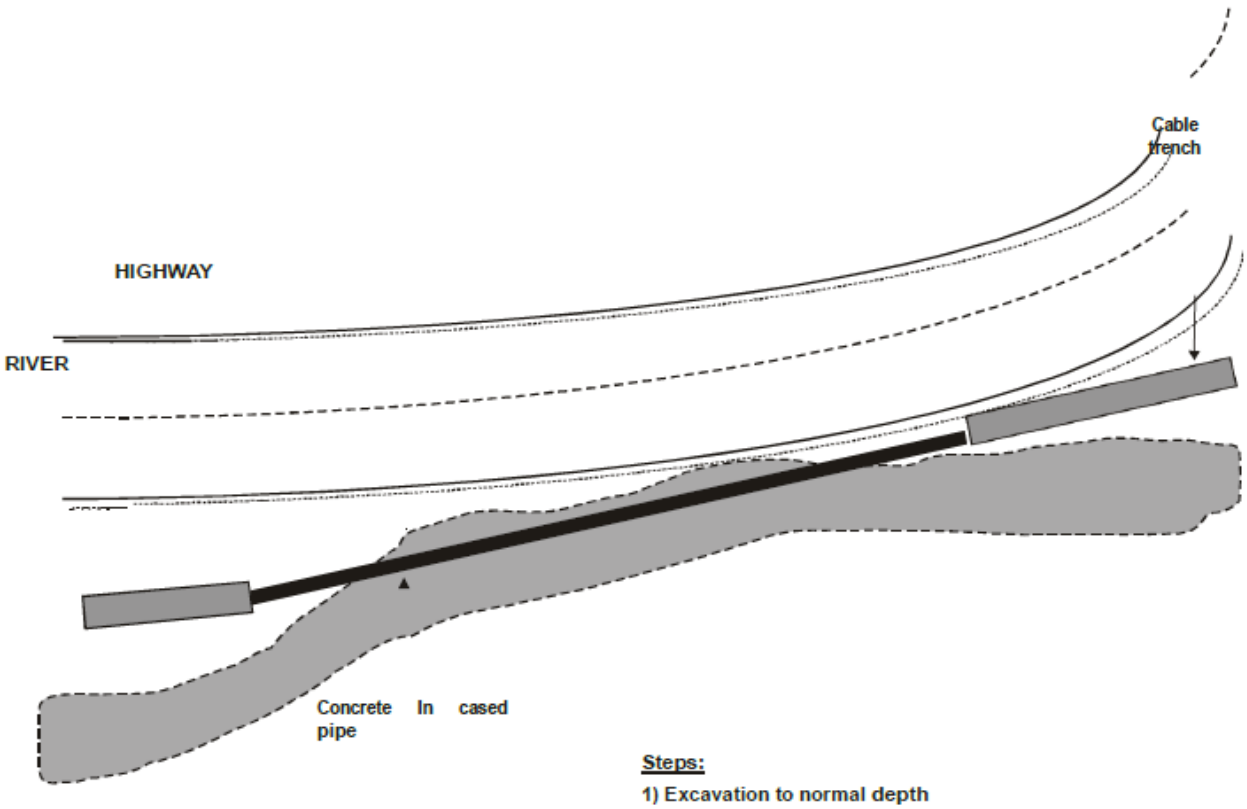


Fig. 31 (a). Installation Practice on Bridge with Existing Chase using Heat Expansion GI-Pipe Joint. The arrangement is also used for provision of Hand Holes for pulling of Optical Fiber Cable



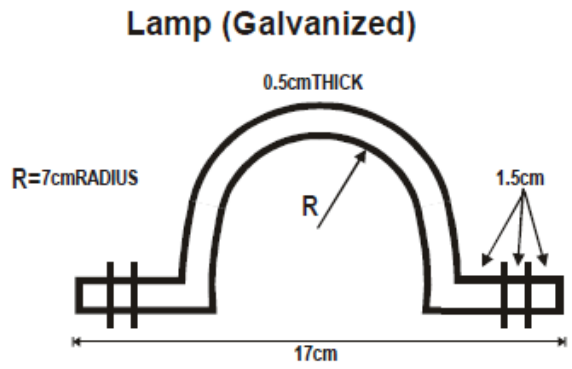
9

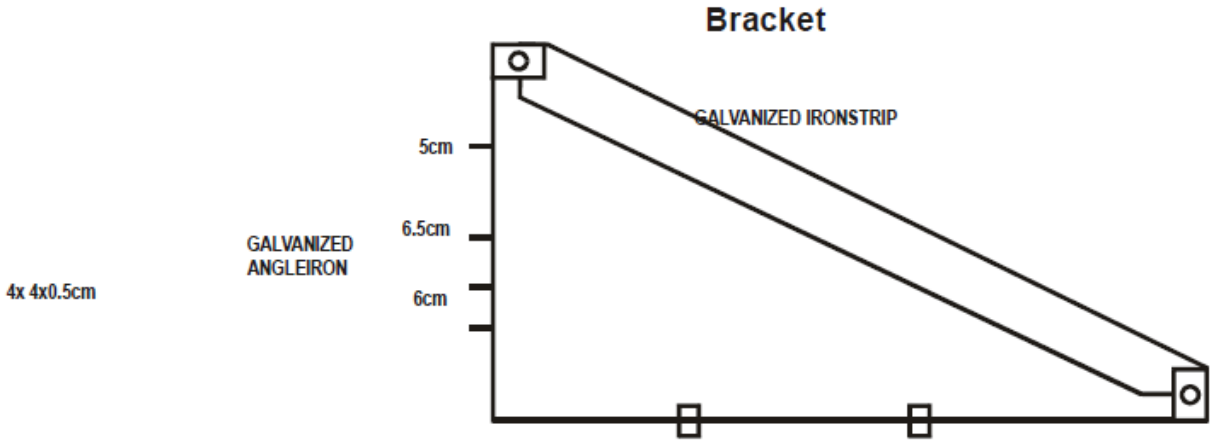
Fig. Laying of Pipe along Bed of a Dry River



Steps:

1) Excavation to normal depth
2) Lay pipe
3) Pour30cm concrete over the pipe
4) Back fill the trench and compact
5) Place route marker on both sides of the river





Measurement & Payment

Measurement and payment of these items will be made based on the units, and unit prices in Bill of Quantities

16000 GENERAL

The contractor shall provide all necessary personnel, vehicles, transportation, equipment, tools, and fill material to install chain link fence with fence screening at Kabul Ring Road Highway, Section#01. The contractor shall perform all site preparation and installation of fencing as described in this Statement of Work. ASTM A 392, Class 1, zinc-coated galvanized steel wire with minimum coating. Fabric shall be fabricated with standard wire woven in 50 mm mesh. Fabric height shall be as shown. Fabric shall be twisted and barbed on the top selvage and knuckled on the bottom selvage.

The chain link fence will have the following dimensions:

16001 Chain Link Fence

1. Installation

1.1. Posts & Braces

The post spacing and configuration shall be arranged per Chain Link Fence Site Plan and Details.
Braces shall be used in each bay adjacent to the corner posts. Braces and posts shall be of 7.5 cm diameter pipes. The base metal shall be wieldable steel of commercial quality, or better. The steel shall be galvanized or have an equivalent protective coating.
The posts shall be 1.52m in height and embedded a minimum of 0.6m into the concrete. The posts shall be set in concrete foundation with diameter of 1 ft (0.31m) and minimum 2 ft (0.61m) in depth. The concrete shall be placed according to the specification.

1.2. Fence Fabric

The fence fabric shall be 3 mm diameter that is woven into approximately 5 cm (2 in) mesh. The fence fabric shall have knuckled finish on the top and bottom edges.
The fence fabric shall be stretched and securely fastened to corner posts with stretcher bars having dimensions of not less than 0.6 cm x 1.9 cm (1/4 in x 3/4 in) and stretcher bar bands having dimensions of not less than 0.3 cm x 1.9 cm (1/8 in x 3/4 in) spaced at 30.5 cm (12 in) intervals. The fence fabric shall also be fastened to intermediate posts with tie wires or post clips and to tension wires with tie wires or hog rings. The fasteners shall be spaced at approximately 35.5 cm (14 in) on intermediate posts and at approximately 50 cm (18 in) on tension wires.
Tie wires and hog rings shall be at least 3 mm diameter steel and post clips shall be at least 4 mm diameter steel. Wire ties shall be given at least one complete turn. Hog rings shall be closed with ends overlapping. The tension wires shall be wrapped around end posts. The tension wires shall be at least 4mm diameter coil spring steel. Tension wires shall be stretched tight. The bottom tension wire shall be installed on a straight grade between posts by excavating the high points of ground and in no case will filling of depressions be permitted.
All tension wire, tie wires, hog rings and post clips shall be of good commercial quality and shall be galvanized or be coated with an equivalent protective coating.

1.3. Concrete for Post Foundations

ASTM C 94/C 94M, using 19 mm maximum size aggregate and having minimum compressive strength of 21 MPa at 28 days. Grout shall consist of one part Portland cement to three parts clean, well-graded sand and the minimum amount of water to produce a workable mix

16002 Measurement and Payment

The Fence work will be measured on linear meter basis, this should include complete work from excavation of foundation, compaction, concrete placement, steel post, braces, fence, labor, etc. The competed and accepted work according to this specification and drawings, will be measured and paid as linear meter.

Pay items		**unit**
160/1	Completed and accepted fence work as per specification and drawings	Cum