SERIES 3000: DRAINAGE

TABLE OF CONTENT

TABLES AND FIGURES **5**

DIVISION 3100: DRAINS **6**

3101 Scope 6
3102 Dimensions 6
3103 Open Drains (Ditches) 6
3104 Furrow Ditches 7
3105 Mitre Drains 7
(a) Mitre Drains Type 1 7
(b) Mitre Drain Type 2 7
3106 Banks And Dykes 7
3107 Subsoil (Subsurface) Drains 8
(a) Materials 8
(b) Construction of subsoil drainage systems 10
(c) Test flushing 12
3108 Manholes, Outlet Structures And Cleaning Eyes 12
3109 Classification Of Materials 12
(a) Hard material: 12
(b) Soft material: 13
3110 Measurements And Payment 13
Item 31.01 Excavation for open drains 13
Item 31.02 clearing and shaping existing open drains 13
Item 31.03 Excavation for subsoil drainage Systems 13
Item 31.04 Impermeable backfilling to subsoil drainage systems 14
Item 31.05 Banks and dykes 14
Item 31.06 Natural permeable material in subsoil drainage systems (crushed stone) 14
Item 31.07 Natural permeable material in subsoil drainage systems (sand) 15
Item 31.08 Pipes in subsoil drainage systems: 15
Item 31.09 Polyethylene sheeting,0.15 mm thick, or similar approved material, for lining subsoil drainage systems 15
Item 31.10 Synthetic-fibre filter fabric 15
Item 31.11 Composite in-plane drainage systems 16
Item 31.12 Concrete outlet structures, manhole boxes, junction boxes and cleaning eyes for subsoil drainage systems: 16
Item 31.13 Concrete caps for subsoil drain pipes 16
Item 31.14 Repairing or replacing existing drainage Systems 16
Item 31.15 Overhaul for material hauled in excess of 1.5 km free-haul 16
Item 31.16 Backfilling existing eroded side drains 17
Item 31.17 Test flushing of pipe subsoil drains 17
Item 31.18 Excavation for the clearing of existing drainage Systems 17
Item 31.19 Selected backfill material under concrete-lined side drains 17

DIVISION 3200: CULVERTS AND APPURTENANT STRUCTURES 18

3201 Scope.....18
3202 Dimensions.....18
3203 Types of Culverts.....18
3203 Materials.....18
(a) Concrete Pipes..... 18
(b) Corrugated Metal Pipes..... 19
(c) PVC Drain Pipes..... 19
(d) Corrugated polyethylene drainage tubing drain pipe..... 19
(e) Corrugated polyethylene drain pipe..... 19
3204 Construction Methods.....19
3205 Excavation by Trench Method.....20
(a) Depth of excavation..... 20
(b) Width of excavation..... 21
3206 Unsuitable Foundation Conditions.....21
3207 Excavation For Embankment Conditions.....22
3208 Disposal Of Excavated Material.....22
3209 Bedding And Laying Of Prefabricated Culverts.....22
(a) Concrete Pipe Culverts and Drains..... 22
(b) Box/slab culverts..... 23
(c) Metal Culverts..... 24
(d) Extension of existing culverts..... 24
(e) Construction of culverts in half widths in existing roads..... 24
(f) General..... 24
3210 Backfilling Of Prefabricated Culverts And Stormwater Drains.....25
3211 Inlet And Outlet Structures, Catchpits And Manholes.....26
(a) Excavation and Backfilling..... 26
(b) Concrete Work..... 26
3212 Removal Of Existing Work.....26
3213 Joining New Work To Old.....27
3214 Service Ducts.....27
3215 Culverts On Steep Gradients.....28
3216 Stormwater Ducts, Treamies And Other Closed Conduits.....28
3217 Measurement And Payment.....28
Item 32.01 Excavation..... 28
Item 32.02 Backfilling..... 29
Item 32.03 Concrete pipe culverts..... 30
Item 32.04 Portal and rectangular (Box or Slab) culverts..... 30
Item 32.05 Metal and other culverts..... 30
Item 32.06 Extra over items 32.03, 32.04 and 32.05 for constructing inclined culverts 31
Item 32.07 Cast in- situ concrete and formwork..... 31
Item 32.08 Concrete backfill for culverts (class indicated)..... 31
Item 32.09 Prefabricated concrete inlets and outlets to culverts..... 32
Item 32.10 Steel reinforcement:..... 32
Item 32.11 Dowels for joining old and new concrete..... 32
Item 32.12 Removing existing concrete..... 32
Item 32.13 Removing and relaying existing pipes..... 32
Item 32.14 Removing and stacking existing prefabricated culverts..... 33
Item 32.15 Treating surfaces with epoxy resin for joining new to old concrete..... 33

Item 32.16 Protective mastic asphalt coating for corrugated metal culvert units.....33
Item 32.17 Manholes, catchpits, pre-cast inlet and outlet structures complete 33
Item 32.18 Accessories 34
Item 32.19 Anchors for pipes (description) 34
Item 32.20 Service ducts.....34
Item 32.21 Duct marker blocks.....34
Item 32.22 Chambers for ducts.....34
Item 32.23 Hand excavation to determine the positions of existing services.....35
Item 32.24 Reinstating trenches crossing roads:.....35
Item 32.25 Prefabricated reinforced concrete skew end units for concrete culverts constructed at a skew angle type and dimensions of unit and class of bedding indicated) 35

DIVISION 3300: CURBING, CHANNELLING, OPEN CHUTES, DOWNPIPES, AND CONCRETE LINING OF OPEN DRAINS.....37

3301 Scope 37
3302 Curbing And Channelling.....37
(a) Dimensions 37
(b) Material Requirements for Curbing and Channelling 37
(c) Construction Requirements for Curbing and channelling 38
(d) Construction sequence 41
3303 Open Concrete Chutes and Downpipes, and Concrete Linings for Open Drains.....42
(a) Dimensions 42
(b) Material Requirements for Open Chutes, Downpipes, and Concrete linings for open drains.....42
(c) Construction Requirements for Open Chutes, down pipes, and linings for open drains 42
3304 Inlet and Outlet Structures and Transition Sections 43
3305 Construction Tolerances and Surface Finish 44
(a) Concrete curbing and channelling 44
(b) Concrete-lined channels 44
(c) Surface finish.....45
3306 Measurement And Payment.....45
Item 33.01 Curbing 45
Item 33.02 Curbing -Channelling combination 45
Item 33.03 Chutes 45
Item 33.04 Cast in- situ concrete chutes 45
Item 33.05 Inlet, outlet, transition and similar structures (typical designs).....46
Item 33.06 Inlet, outlet, transition and similar structures (measured by components)...46
Item 33.07 Trimming of excavations for concrete-lined open drains.....46
Item 33.08 Concrete lining for open drains 47
Item 33.09 Formwork to cast in- situ concrete lining for open drains (class F2 surface finish).....47
Item 33.10 Sealed joints in concrete linings of open drains 47
Item 33.11 Concrete screed or backfill below chutes 47
Item 33.12 Steel reinforcement.....47
Item 33.13 Polyethylene sheeting (0.15 mm thick) for concrete-lined opendrains 48
Item 33.14 Cutting bituminous surfacing and pavement layers for concrete kerbing, channelling or concrete-lined drains 48

Item 33.15 Pre-cast concrete blocks in outlet structures 48

DIVISION 3400: PITCHING, STONEWORK, AND EROSION PROTECTION 49

3401 Scope 49
3402 Materials 49
(a) Stone 49
(b) Cement 49
(c) Sand 49
(d) Pre-cast concrete blocks 50
(e) Concrete 50
(f) Wire 50
(g) Permeable material for filter layer 50
(h) Synthetic fiber filter fabric (Geotextiles) 50
3403 Stone Pitching 51
(a) Dry stone pitching 51
(b) Grouted stone pitching 51
(c) Wired and grouted stone pitching 52
(d) Grouted stone pitching on a concrete bed 52
3404 Riprap 52
(a) General 52
(b) Filter bed 52
(c) Packed riprap 53
(d) Dumped riprap 53
3405 Dry Stone Masonry Walls 54
(a) General 54
(b) Dry stone masonry walls 54
(c) Cement mortared stone masonry walls 55
3406 Concrete Block Pitching 55
(a) General 55
(b) Interlocking type concrete blocks 56
(c) Pre-cast concrete blocks for sidewalk pavements 56
3407 Cast In Situ Concrete Pitching 56
3408 Measurement And Payment 57
Item 34.01 Stone Pitching 57
Item 34.02 Riprap 57
Item 34.03 Stone masonry walls 57
Item 34.04 Concrete pitching 58
Item 34.05 Concrete in edge beams and foundation trenches 58
Item 34.06 Excavations for edge beams and foundation trenches 58
Item 34.07 Provision Of approved herbicide and ant poison 58

LIST OF TABLES AND FIGURES

Table 3107/1 Range of Grading of Filter Material 8
Table 3107/2 Natural permeable materials: sand 9
Table 3107/3 Physical Requirements For Subsurface Drainage Geotextile 10
Table 3404/1 Gradation Requirements for Riprap 54

DIVISION 3100: DRAINS

3101 SCOPE

This Division covers all work in connection with the excavation and construction of open drains, subsoil (Sub surface) drainage and banks and dykes at the locations and to the sizes, shapes, grades and dimensions as shown on the drawings or as directed by the engineer, and the test flushing of subsoil drains.

It also covers the cleaning of open drains and the repairing of subsoil (Sub surface) drainage. In special circumstances this work may be executed outside the road reserve.

It also covers the clearing of existing culverts, including amongst others the removal of all undesirable materials that have accumulated in and around Inlet and outlet structures and in the barrels of the culverts.

3102 DIMENSIONS

Excavations for open drains and trenches for piped and sub-soil drains shall be true to line, gradient and cross section as described in the Contract.

The alignment of pipes for piped and sub-soil drains shall be true to line, gradient and cross section as described in the Contract.

The lining of open drains shall be constructed in accordance with the dimension described in the Contract.

3103 OPEN DRAINS (DITCHES)

(a) Open drain excavation shall consist of re-excavating or excavating open drains and channels inside or outside the road reserve, including channels to direct the course of streams, all as shown on the Drawings or directed by the Engineer.

(b) Open drain excavation shall include all excavation required to construct V- shaped channels with side slopes as defined on the drawings. Any excavation required to construct a channel with side slopes equal to or flatter or a width more than those indicated on the drawings shall be classed as cut and shall be measured and paid for under Division 4000.

Furthermore, drains within the road prism consisting of median drains, side drains, miter drains, furrow ditches and drains on excavated slope benches shall be classed as cut and shall be measured and paid for under Division 4000, except where, due to the shape of such drains, excavation by bulk excavating equipment would not be feasible and either hand excavation or special excavating equipment, such as draglines or similar, would be required, in which case such excavation shall be paid for as open drain excavation.

(c) Open drains shall be constructed true to line, grade, and cross section and shall be so maintained for the duration of the Contract.

Care shall be exercised to avoid excavation below the required grade for the drains and any excavation carried below the required grade shall be backfilled with suitable material and compacted to at least 93% of modified AASHTO density at the Contractor's own expense.

(d) Material resulting from the excavation of open drains shall be used in the construction of fills, banks and dykes, or for other purposes, or disposed of to spoil, depending on the classification of such material.

In respect of material resulting from open drain excavation and not taken to spoil but used elsewhere in the construction of the Works, payment shall be made for open drain excavation as well as for any item of permanent construction built from such material. Material from open drain excavation and taken to spoil will be paid as open drain excavation only.

3104 FURROW DITCHES

Furrow ditches shall be formed by ploughing a continuous furrow along the line indicated in the Contract or as directed by the Engineer. Methods other than ploughing may be used if acceptable to the Engineer. The excavated material shall be placed on the downside of the ditch and shall be compacted to 90% of modified AASHTO density in layers not exceeding 150 mm in thickness. The bottom of the finished ditch shall be at least 500 mm below the crest of the down hill material. Flow lines shall provide satisfactory shape to provide drainage to the outlet without causing scour, sedimentation or damage to adjacent property.

3105 MITRE DRAINS

(a) Mitre Drains Type 1

Mitre Drain Type 1 shall be constructed of suitable material, to be approved by the Engineer, and shall be placed in such a way that the water will flow on the natural ground and against the mitre bank. The mitre bank shall be compacted to 90% of modified AASHTO density in layers not exceeding 150 mm in thickness, unless the Engineer has approved thicker layers.

(b) Mitre Drain Type 2

Mitre Drain Type 2 shall be constructed from rip rap in accordance with Division 3400 Riprap. The interstices shall be filled with a suitable cohesive soil, to be approved by the Engineer.

3106 BANKS AND DYKES

Mitre banks, catchwater banks and dykes shall be constructed of approved soil or gravel obtained from open drain excavation or, if no suitable material can be obtained from the source, from suitable alternative sources, and be placed in such a way that the water will flow on the natural ground and against the bank.

The banks and dykes shall be properly compacted to 90% of modified AASHTO density in layers not exceeding 150 mm in thickness, unless thicker layers have been approved by the engineer.

If so preferred by the contractor and approved by the engineer, mitre banks may also be constructed of handpacked stone, provided that the interstices are filled with an approved cohesive soil.

3107 SUBSOIL (SUBSURFACE) DRAINS

(a) Materials

(i) Pipes

Pipes for subsoil drainage shall have the specified internal diameter, which shall be not less than 100 mm, and shall be one of the following types:

Perforated or slotted PVC pipes complying with AASHTO M304.

Perforated polyethylene pipes complying with the requirements of AASHTO M252.

The size of perforations in perforated pipes shall in all cases be 8 mm in diameter ± 1.5 mm and the number of perforations per meter shall be not less than 26 for 150 mm pipes and 52 for 150 mm pipes. Perforations shall be spaced in two rows for 100 mm pipes and as shown on the drawings for 150 mm pipes.

Slotted pipes shall have a slot width of 8 mm ± 1.5 mm. The arrangement of slots shall be subject to the engineer's approval, but the total slot area shall be not less than that presented for perforations.

Pipes without slots or perforations required for conveying ground water from the subsoil drainage proper to the point of discharge, shall be PVC or polyethylene pipes of the types specified above, or concrete pipes complying with the requirements of AASHTO M86M or M175M.

(ii) Natural Filter Materials for Sub-soil Drains

Natural permeable filter materials for subsoil drainage shall consist of sand and/or crushed stone or natural gravel of suitable grading. The grading shall comply with the requirements of Table 3107/1.

Gravel filter material shall consist of Type A, Type B or Type C filter material within the grading limits shown in Table 3107/1. The filter material shall be clean, hard, durable and free from organic impurities crushed rock or gravel. The aggregate crushing value of the material shall not exceed 30 per cent. The material passing the 425 μm BS Sieve shall be non-plastic when tested in accordance with BS 1377.

Table 3107/1 Range of Grading of Filter Material

BS sieve size	Percentage by mass passing		
	Type A	Type B	Type C
63 mm	-	100	100
37.5 mm	100	85 - 100	0
20 mm	45 - 100	0 - 20	-
10 mm	45 - 100	0 - 5	-
3.35 mm	25 - 80	-	-
600 μm	8 - 45	-	-
150 μm	0 - 10	-	-
75 μm	0 - 5	-	-

Sand shall be clean, hard sand obtained from approved borrow pits. The sand shall comply with the requirements of series 4000. The nominal maximum particle size for the various grades shall be as shown in Table 3107/2.

Table 3107/2 Natural permeable materials: sand

Grade	Nominal maximum Particle size (mm)
Coarse	4.75
Medium	2.00
Fine	0.20

Crushed stone shall comply with the requirements given in series 4000. Stone for concrete, and shall be either coarse (19.0 mm nominal size) or fine (13.2 mm nominal size) as specified.

The aggregate shall be evenly graded. The aggregate crushing value of the stone shall not exceed 30 when tested in accordance with methods given in series 4000.

When no suitable sand and/or crushed stone is available from borrow pits, the engineer may require that it be procured from commercial sources outside the site.

The engineer shall indicate the grades of sand and crushed stone to be used in each case to comply with the requirements.

In the case of any sand and/or crushed stone, not more than 5% of the material shall pass through the 0.075 mm sieve.

(iii) Synthetic-fiber filter fabric

Should the use of synthetic-fiber filter fabric in subsoil drainage, or as filter blankets, or for any other purposes, be specified, it shall comply with the requirements as specified in table 3104/2.

Table 3107/3 Physical Requirements For Subsurface Drainage Geotextile

Property	Test Method ASTM	Units	Specifications[1]					
			Type I-A	Type I-B	Type I-C	Type I-D	Type I-E	Type I-F
Grab Strength	D 4632	N	1100/700	1100/700	1100/700	800/500	800/500	800/500
Sewn Seam Strength	D 4632	N	990/630	990/630	990/630	720/450	720/450	720/450
Tear Strength	D 4533	N	400[3]/250	400[3]/250	400[3]/250	300/175	300/175	300/175
Puncture Strength	D 4833	N	400/250	400/250	400/250	300/175	300/175	300/175
Burst Strength	D 3786	kPa	2750/1350	2750/1350	2750/1350	2100/650	2100/950	2100/950
Permittivity	D 4491	s^{-1}	0.5	0.2	0.1	0.5	0.2	0.1
Apparent Opening Size	D 4751	mm	0.45[2]	0.25[2]	0.22[2]	0.45[2]	0.25[2]	0.22[2]
Ultraviolet Stability	D 4355	%	50% after 500 hours of exposure					

The first values in a column apply to geotextiles that break at <50 percent elongation (ASTM D 4632).

The second values in a column apply to geotextiles that break at ≥50 elongation (ASTM D 4632). Maximum average roll value.

The minimum average roll tear strength for woven monofilament geotextile is 245 N.

(iv) Composite in-plane draining fabric

The make and class of fabric shown on the drawings or approved by the engineer shall be used.

(v) Concrete

All concrete work shall be carried out in accordance with the requirements of series 8000 and with the details shown on the drawings.

(vi) Galvanized woven wire mesh

Galvanized woven wire mesh manufactured from 3.5 mm dia wire, 250 mm x 250 mm in area, with a 12 mm x 12 mm maximum mesh size, shall be built into the outlets of subsoil drainage systems in accordance with the details shown on the drawings.

(b) Construction of subsoil drainage systems

(i) With natural permeable material

Trenches for subsoil drainage systems shall be excavated to the dimensions and gradients shown on the drawings or as directed by the engineer.

A layer of natural permeable material of the grade and thickness as shown on the drawings shall be placed on the bottom of the trench and be lightly tamped and finished to the required gradient.

Pipes of the type and size required shall then be firmly bedded on the natural material, true to level and grade, and be coupled in accordance with requirements. Thereafter the trench shall be backfilled with natural permeable material to such height above the pipes as shown on the drawings or as directed by the engineer. The natural permeable material shall be lightly compacted and trimmed to the required level. Further layers of finer natural permeable materials shall then be placed, lightly compacted and finished to an even surface, as directed by the engineer. The remainder of the trench, if any, shall be backfilled with approved impermeable material and as required by the engineer, in layers not exceeding 100 mm, and compacted to at least the same density as the surrounding material. The trench shall be specially protected against the ingress of water until the impermeable layer has been completed. The width of the backfill that will be measured for payment shall not exceed the specified width of the trench.

Natural permeable material shall be placed in layers not exceeding 300 mm in thickness at a time and be lightly compacted. The total thickness of each type of natural permeable material shall be carefully controlled, and when the thinner layers are placed suitable spacers shall be used. When successive layers are placed, the lower layer shall not be walked on and, as for as possible, shall not be disturbed. Care shall be taken to prevent the contamination of natural permeable material during construction of the subsoil drainage system and all natural permeable material contaminated by soil or silt shall be removed and replaced by the contractor at his own expense.

Perforated and slotted pipes shall be jointed by means of couplings. Perforated pipes shall be laid with perforations at the top or bottom as may be prescribed.

The higher end of each subsoil drainage pipe shall be sealed off with a loose concrete cap of class 20/19 concrete, as shown on the drawings, and at the lower end the pipe shall be built into a concrete head wall providing a positive outlet or it shall be connected to storm water pipes or culverts. The complete system together with head walls, shall be constructed in one process starting at the lower head wall.

Any section of a subsoil drainage system constructed of pipes without perforations or slots shall be backfilled with impermeable backfill material as described herein. Where suitable, the excavated material may be used for backfilling.

(ii) With polyethylene lining to trenches for subsoil drainage systems

Where shown on the drawings or directed by the engineer, trenches for subsoil drainage systems shall be limed with approved polyethylene sheeting 0.15 mm thick. The polyethylene sheet shall cover the bottom of the trench and shall extend upwards on both sides for as far as may be directed by the engineer in each particular case, in order to form a waterproof channel. At joints the polyethylene sheeting shall be heat-welded together or lapped by a minimum of 200 mm.

When backfilling the trench with natural permeable material, care shall be taken not to displace or damage the polyethylene liming in any way. The use of plastics other than polyethylene will be considered provided that the material is of equal quality and is approved by the engineer.

(iii) With synthetic-fiber filter fabric

Where specified that synthetic-fiber filter fabric shall be used for liming in subsoil drainage systems, it shall be procured, furnished and installed as specified and shown on the drawings. The lining shall not be displaced or damaged in any way when the trench is being filled with natural permeable material. The filter fabric shall be lapped both longitudinally and transversely by the least 300 mm or as instructed by the manufacturers. The transverse lap shall be positioned on top of the box forming the drain and shall be stitched together with plastic/galvanized wire or strong synthetic thread at meter intervals. The longitudinal lap shall be in the direction of flow.

Filter fabric shall be stored under suitable cover and shall not be exposed to direct sunlight for prolonged periods and shall be protected from mechanical damage during installation and construction.

(iv) With composite in-plane drainage fabric

Wherever specified, composite in-plane drainage systems shall be constructed in accordance with the details shown on the drawings. The elements of the system shall be assembled above ground in manageable lengths, and all exposed surfaces shall be sealed with an approved geofiber seal. The trench sides shall be vertical, and the composite in-plane system shall be installed against the side through which the subsoil flow is expected. The trench shall then be backfilled with sand, which shall be saturated with water after placement up to the prescribed level. The upper part of the trench shall be backfilled with impermeable material, which shall be compacted to the density of the surrounding material, in layers not exceeding 100 mm in thickness.

(c) Test flushing

Final acceptance of longitudinal subsoil drains will be subject to satisfactory test flushing after completion and installation of the rodding eye inlets. Flushing tests shall be carried out in the presence of the engineer's representative by flushing the drain and metering outflow to ensure the drain is clear of blockage. Should blockages be apparent the contractor shall locate and clear the obstruction and repeat the test.

3108 MANHOLES, OUTLET STRUCTURES AND CLEANING EYES

Manholes, outlet structures and cleaning eyes for subsoil drainage systems shall be constructed in accordance with the details shown on the drawings or in positions as instructed by the engineer.

3109 CLASSIFICATION OF MATERIALS

All excavated materials for open drains and subsoil drainage system shall be classified as follows for payment purposes:

(a) Hard material:

Material which cannot be excavated except by drilling and blasting or the use of pneumatic tools or mechanical breakers and boulders in excess of 0.10 m^3 in volume, shall be classified as hard material.

Where more than 40% of any material (by volume) consists of boulders each exceeding 0.10 m^3 in size, the material shall be classified as hard material.

(b) Soft material:

All material not classified as hard material shall be classified as soft material. Notwithstanding the above classification, all material excavated from previously constructed fills, subgrades and subbases shall be classified as soft material.

3110 MEASUREMENTS AND PAYMENT

Item 31.01 Excavation for open drains

(a) Excavating soft material situated within the following depth ranges below the surface level:

(i) 0 m up to 1.5 m ..... cubic metre (m^3)

(ii) Exceeding 1.5 m and up to3.0m ..... cubic metre (m^3)

iii) Etc, in increments of 1.5 m

(b) Extra over sub item 31.01(a) for excavation in hard material, irrespective of depth .... cubic metre (m^3)

(c) Mitre Drains

(i) Type 1..... cubic metre (m^3)

(ii) Type 2..... cubic metre (m^3)

The unit of measurement shall be the cubic metre of material excavated in accordance with the authorized dimensions, measured in place before excavation. Excavation for open drains only as defined in clause 3103 and 3105 shall be measured.

Irrespective of the total depth of the excavation, the quantity of material in each depth range shall be measured and paid for separately.

The tendered rates shall include full compensation for the excavation of the material to the required lines, levels and grades and the disposal of the material as directed, including a free haul of 1.5 km.

For payment purposes a distinction shall be made between soft and hard material as defined in clause 3109.

Item 31.02 Clearing and shaping existing open drains .....cubic metre (m^3)

The tendered rate shall include full compensation for excavating the material, protecting the existing drainage structures, trimming the floors and sides of the open drains and disposing of material as prescribed including free-haul over a distance of 1.5 km.

Item 31.03 Excavation for subsoil drainage Systems

(a) Excavating soft material situated within the following depth ranges below the surface level:

(i) 0 m up to 1.5 m ..... cubic metre (m^3)

(ii) Exceeding 1.5 m and up..... cubic metre (m^3)

(b) Extra over sub item 31.03(a) for excavation in hard material irrespective of depth ....cubic metre (m^3)

The unit of measurement shall be the cubic metre of material excavated in accordance with the authorized dimensions, measured in place before excavation, irrespective of the total depth of excavation, the quantity of the material in each depth range shall be measured and paid for separately.

The tendered rates shall include full compensation for the excavation of the material to the required lines, levels and grades, all temporary shoring and strutting, and the disposal of the material as directed, including a free haul of 1.5 km. For payment purposes a distinction shall be made between soft and hard material, as defined in clause 3109.

Where subsoil drainage systems are adjacent to structures such as culverts, that part of the excavation for subsoil drainage systems which can be made by widening the excavation for the structure shall be measured and paid for under excavation for such structure, and not under excavation for the subsoil drainage systems.

Item 31.04 Impermeable backfilling to subsoil drainage systems ..... cubic metre (m3)

The unit of measurement shall be the cubic metre of completed backfill, measured in place in the subsoil drainage systems and calculated in accordance with the authorized dimensions.

The tendered rate shall include full compensation for procuring, furnishing, placing and compacting the backfilling for a free haul of 1.5 km.

Item 31.05 Banks and dykes..... cubic metre (m3)

The unit of measurement shall be the cubic metre of material, measured in place in the banks or dykes, and calculated in accordance with the authorized dimensions.

The tendered rate shall include full compensation for procuring, furnishing, placing, watering, compacting, shaping and trimming the material in the banks and dykes and a free haul of 1.5 km.

Item 31.06 Natural permeable material in subsoil drainage systems (crushed stone)

(a) Crushed stone obtained from approved sources on the site (state grade)..... ..... cubic metre (m^3)

The unit of measurement shall be the cubic metre of approved crushed stone in place in the drains, calculated in accordance with the authorized dimensions. The volume occupied by the pipes shall be deducted when calculating the volume of the permeable material.

The tendered rate shall include full compensation for procuring, furnishing and transporting from the borrow areas over a free-haul distance of 1.5 km and placing the material as specified.

For payment purposes a distinction shall be made between the different grades of crushed stone.

(b) Crushed stone obtained from commercial sources (state grade) ..... cubic metre (m^3)

The unit of measurement shall be the cubic metre of crushed stone in place in the drains, calculated in accordance with the authorized dimensions. The volume occupied by the pipes shall be deducted when calculating the volume of the permeable material.

The tendered rate shall include full compensation for procuring; furnishing and transporting approved crushed stone from commercial suppliers, including the cost of transporting the material to the site, and placing the materials as specified. For payment purposes a distinction shall be made between the different grades of crushed stone.

Item 31.07 Natural permeable material in subsoil drainage systems (sand)

(a) Sand obtained from approved sources on the site (state grade) ..... cubic metre (m^3)

The unit of measurement shall be the cubic metre of approved sand in place in the drains, calculated in accordance with the authorized dimensions. The volume occupied by the pipes shall be deducted when calculating the volume of the permeable material.

The tendered rate shall include full compensation for procuring, furnishing, transporting from the borrow areas over a free-haul distance of 1.5 km, and placing the sand as specified.

For payment purposes a distinction shall be made between the different grades of sand.

(b) Sand from commercial sources (state grade) ..... cubic metre (m^3)

The unit of measurement shall be the cubic metre of sand in place in the drains, calculated in accordance with the authorized dimensions. The volume occupied by the pipes shall be deducted when calculating the volume of the permeable material.

The tendered rate shall include full compensation for procuring, furnishing and transporting approved sand from commercial suppliers, including the cost of transporting the material to the site, and placing the material as specified.

Item 31.08 Pipes in subsoil drainage systems:

(a) Pitch-fiber pipes and fittings complete with couplings (state size and whether or not perforated) ..... metre (m)

(b) Unplasticized PVC pipes and fittings, normal duty, complete with couplings (state size and whether or not perforated or slotted) ..... metre (m)

(c) High-density type poly ethylene pressure pipes and fittings, complete with couplings (state size, type and class and whether or not perforated) ..... metre (m)

(d) Concrete pipes (state type and diameter) ..... metre (m)

The unit of measurement for pipes shall be the metre of pipe, measured in place along its centre line, including the length of fittings.

The tendered rate shall include full compensation for procuring, furnishing, laying and jointing the pipes and fittings as specified.

Item 31.09 Polyethylene sheeting,0.15 mm thick, or similar approved material, for lining subsoil drainage systems ..... square metre (m^2)

The unit of measurement shall be the square metre of polyethylene sheeting installed, measured net from the specified dimensions.

The tendered rate shall include full compensation for procuring, supplying, cutting, overlapping, jointing, placing and protecting the sheeting as specified, as well as for wastage.

Item 31.10 Synthetic-fibre filter fabric (describe type, grade, etc) ..... square metre (m^2)

The unit of measurement shall be the square metre of filter fabric supplied and installed as specified.

The tendered rate shall include full compensation for furnishing, procuring, cutting, overlapping, jointing, placing and protecting the filter fabric as specified, as well as for wastage.

Item 31.11 Composite in-plane drainage systems (state size, type, grade, etc). ....metre (m)

The unit of measurement shall be the metre of composite in-plane drainage system measured in place along the centre line of the system.

The tendered rate shall include full compensation for procuring, furnishing, assembling, installing and jointing the composite in-plane drainage system, including perforated or other types of pipes, complete as specified.

Item 31.12 Concrete outlet structures, manhole boxes, junction boxes and cleaning eyes for subsoil drainage systems:

(a) Outlet structures ..... number(No)

(b) Manholes boxes .....number(No)

(c) Junction boxes..... number (No)

(d) Cleaning eyes..... number (No)

The unit of measurement shall be the number of outlet structures, manhole boxes, junction boxes and cleaning eyes for subsoil drainage systems constructed in accordance with the details on the drawings and the engineer's instructions.

The tendered rates shall include full compensation for all excavation, backfilling, compacting to 90% of modified AASHTO density, disposing of surplus excavated material, keeping the excavations safe, dealing with any surface or subsurface water, procuring and furnishing all materials, providing, erecting and removing formwork, mixing, transporting, placing and curing the concrete, and all labour and construction plant required for constructing the concrete outlet structures, manhole boxes, junction boxes and cleaning eyes, complete as specified.

Item 31.13 Concrete caps for subsoil drain pipes..... .number (No)

The unit of measurement shall be the number of caps supplied, and the tendered rate shall include full compensation for supplying and installing the caps.

Item 31.14 Repairing or replacing existing drainage Systems..... provisional sum

The provisional sum given for repairing or replacing existing drainage systems shall be expended in terms of the general conditions of contract.

Item 31.15 Overhaul for material hauled in excess of 1.5 km free-haul (normal overhaul) ..... cubic metre-kilometre (m^3-km)

The measurement and payment for overhauling material referred to in items 31.01, 31.02, 31.03, 31.04, 31.05, 31.06, 31.07 and 31.16 shall be in accordance with Division 1700, and the overhaul quantities shall be listed in sub clause 3110.

Item 31.16 Backfilling existing eroded side drains .....cubic metre (m^3)

The unit of measurement shall be the cubic metre of approved granular material placed and compacted to 93% of modified AASHTO density, measured in place after compaction, where instructed by the engineer.

The tendered rate shall include full compensation for trimming the side drains disposing of the resulting material and procuring, furnishing, transporting, placing and compacting the granular material and a free-haul of 1.5 km.

Item 31.17 Test flushing of pipe subsoil drains .....number (No)

The unit of measurement shall be the number of tests satisfactorily completed on unblocked sections of drain. No payment will be made for tests, which have to be repeated due to blocked pipes or faulty workmanship.

The tendered rate shall include full compensation for the provision of a water tanker, water, equipment and labour necessary to carry out the tests, complete as specified.

Item 31.18 Excavation for the clearing of existing drainage Systems:

(a) Manholes and inlet and outlet structures ..... cubic metre (m^3)

(b) Culvert barrels ..... cubic metre (m^3)

(c) Concrete side drains ..... cubic metre (m^3)

The unit of measurement shall be the cubic metre of material excavated and removed, measured in place before excavation.

The tendered rate shall include full compensation for excavating the material, protecting the existing drainage structures, dealing with any surface or subsurface water, and disposing of the excavated material, including shaping and levelling-off piles of spoil material. The tendered rate shall also include full compensation for transporting the excavated material for a free-haul distance of 1.5 km.

Item 31.19 Selected backfill material under concrete-lined side drains compacted to 93% of modified AASHTO density .....cubic metre (m^3)

The unit of measurement shall be a cubic metre of compacted material and the quantity shall be calculated from the authorised dimensions given on the drawings.

The tendered rate shall include full compensation for procuring, as if from soft excavation or borrow pits, breaking down, placing and compacting the material in 150 mm layers, transporting for a free haul distance of 1.5 km, and for shaping the top surface in accordance with the drawings.

DIVISION 3200: CULVERTS AND APPURTENANT STRUCTURES

3201 SCOPE

This Division covers the work in connection with the construction of in-situ and prefabricated culverts together with inlet and outlet structures, and other appurtenant structures.

3202 DIMENSIONS

Culverts shall be constructed to the dimensions and levels described in the Contract.

Excavations for culverts and appurtenant structures shall be true to line, gradient and cross section as described in the Contract or as instructed by the Engineer.

The alignment of culverts and appurtenant structures shall be true to line, gradient and cross section as described in the Contract or as instructed by the Engineer.

3203 TYPES OF CULVERTS

(a) Prefabricated concrete pipes of circular section, hereinafter called 'concrete pipe culverts'.

(b) Prefabricated corrugated metal pipes and pipe arches, hereinafter called 'metal culverts'. These may be of steel or aluminium construction.

Box/slab culverts may be cast in place or prefabricated. In-situ reinforced concrete box culverts/slab culverts constructed in accordance with series 8000 prefabricated concrete culverts other than pipe culverts are hereinafter called portal culverts or rectangular culverts.

Other types of prefabricated culverts not mentioned above, if required, will be shown in the drawings.

3203 MATERIALS

(a) Concrete Pipes

In-situ concrete culverts, bidding concrete and surrounds to metal culverts shall conform to the requirements of series 8000.

Pre-cast concrete pipes used for the construction of culverts shall be manufactured in accordance with the requirements of AASHTO M-170 (ASTM C 76 or ASTM C 118) or AASHTO M-242 and shall be the Class as described in the Contract.

Concrete used for the construction of culverts shall be Class 20/40 in accordance with the requirements of Division 8400.

Reinforcement used for the construction of pre-cast or in-situ concrete culverts shall be steel reinforcement complying with the requirements of Division 8300.

(b) Corrugated Metal Pipes

Corrugated metal pipes sections used for the construction of culverts shall be manufactured in accordance with the requirements of AASHTO M-36 from material, which shall have minimum yield strength of 229 N/mm^2. Nuts and bolts shall comply with the requirements of AASHTO M-167.

Fabricate under drain pipe from steel sheets with a minimum thickness of 1.32 millimetres. Use any class of perforation specified in AASHTO M 36M.

Coatings for Corrugated Metal Pipes shall be :

(a) Galvanized zinc coatings shall comply with the requirements of AASHTO M 36. Units on which the zinc coating has been damaged shall be re-galvanized or the surface prepared and painted with 2 coats of zinc-rich paint.

(b) Bituminous coatings shall comply with the requirements of AASHTO M-190.

Coupling bands for zinc coated (galvanized) or aluminium coated (aluminized) corrugated iron or steel under drain pipe shall meet the requirements of coupling bands for Type III pipe of AASHTO M 36.

(c) PVC Drain Pipes

PVC drainpipe shall meet the requirements of AASHTO M 278. The maximum size of pipe shall be 8 inches (200 mm) in diameter.

(d) Corrugated polyethylene drainage tubing drain pipe

Corrugated polyethylene drainage tubing drainpipe shall meet the requirements of AASHTO M 252. The maximum size of pipe shall be 8 inches (200 mm) in diameter.

(e) Corrugated polyethylene drain pipe

The corrugation shall form smooth continuous curves and tangents. Corrugations shall form circumferential rings about the longitudinal axis of the structure.

3204 CONSTRUCTION METHODS

Prefabricated culverts shall be installed under either:

(a) 'trenched conditions', where the units are laid in a trench excavated below existing ground level or in a trench excavated in previously constructed subgrade and, if necessary, subbase layers; or

(b) 'embankment conditions', where the units are laid approximately on the existing ground surface and the subgrade is then constructed on either side and over the culvert.

Unless otherwise approved by the Engineer, all pipe culverts shall be constructed under trenched conditions. The only exceptions shall be those permitted by the Engineer.

Surface drainage must be controlled by the construction of temporary earth berms and drainage channels to prevent stormwater from entering the trench.

The Contractor shall make good with bedding materials any excavation at or below the bottom of drainage trenches if the Contractor allows the trench bottom to become soft or otherwise unsuitable for the construction of the culvert.

3205 EXCAVATION BY TRENCH METHOD

(a) Depth of excavation

In the case of culverts to be constructed under trenched conditions, the Contractor shall first construct the fill, subgrade and, if necessary, the subbase to such a level as will provide a minimum cover above the proposed level of the top of the culvert as described hereinafter for the various types of culvert. Thereafter, the Contractor may commence excavation of the trench for the culvert.

Where authorized by the Engineer, and in particular in areas of swampy or marshy conditions, the Contractor may construct the fill to the top of subgrade before commencing excavation for the trench for the culvert.

The side of trenches shall be adequately supported at all times. Except where otherwise authorised by the Engineer, they shall not be battered.

The amount by which the excavation is to exceed the proposed level of the invert of the culvert shall be sufficient to allow for the type and thickness of bedding material to be placed as specified or as shown on the Drawings.

The minimum cover above the top of the culvert and minimum depth of excavation below the underside of the culvert shall be as follows:

(i) Concrete Pipe Culverts

The minimum height of embankment construction over the top of the proposed pipe culvert before excavation may commence if the minimum cover specified on the Drawings for the type of pipe and bedding condition is used.

The minimum amount by which the excavations is to exceed the proposed level of the underside of the pipe shall be 250 mm or such other amount required to accommodate the type of bedding required for the pipe in each case.

(ii) Box/slab culverts

The minimum height of embankment construction over the top of the proposed culvert before excavation may commence if 100 mm or such greater height as may be shown on the Drawings, whichever is the greater.

The minimum amount by which the excavation is to exceed the proposed level of the underside of the culvert invert slab shall be 250 mm in the case of culverts with pre-cast invert slabs. In the case of culverts with cast in situ invert slabs, the excavations shall exactly accommodate the invert slab.

(iii) Metal Culverts

The minimum height of embankment construction over the top of the proposed metal culvert before excavation may commence if the minimum cover specified on the Drawings for the type of metal culvert, or 0.25 times the diameter of pipes or 0.25 times the span of pipe arches, whichever is the greater.

The minimum amount by which the excavation is to exceed the proposed level of the bottom of the pipe shall be 250 mm or such other amount required to accommodate the type of bedding required for the culvert in each case.

(b) Width of excavation

The widths of trenches shall be sufficient to allow for proper laying, bedding and backfilling culverts, but shall not exceed four-thirds of the external diameter of the pipe(s), plus 400mm for single barrel culverts and also plus the allowable gap between each pipe for multiple barrel culverts.

If the width of any trench is increased by slipping or collapsing of the trench, the Contractor shall immediately inform the Engineer and not proceed with any further pipe-laying or backfilling until the Engineer has reviewed the circumstances and given instructions as to the need for any altering of the class of pipe or bedding conditions.

(i) Concrete Pipe Culverts

The width of excavation shall be equal to the nominal internal diameter of the pipe plus 0.5 m on each side.

(ii) Box/slab culverts

Where it is required to backfill the trench with concrete as described hereinafter, the width of excavation shall be equal to the total outside width of the culvert portal plus 0.5 m for both single and multiple openings. In the case of rectangular culverts up to 1.200 mm span, which are located so that the tops of the culverts are in or just below the subbase layer, the Engineer may require that the excavation width shall be the net width of the cast in-situ invert slabs or the net width of pre-cast invert slabs plus 100 mm.

Where backfilling is to be done with soil or gravel material, the width of excavation shall be the outside width of the portal plus 200 mm on either side, for both single and multiple culverts.

(iii) Metal Culverts

The width of excavation shall be equal to the internal diameter or span of the metal pipe or pipe arch plus 0.5 m on each side of the culvert.

Where metal culverts consist of two or more units next to each other, the minimum clearance between adjacent culverts shall be as shown on the drawings.

3206 UNSUITABLE FOUNDATION CONDITIONS

Where the bottom of the trench as excavated does not provide a suitably firm foundation for the culvert, due to soft or otherwise unsuitable material being encountered, the unsuitable material shall be excavated to a depth below the bottom of the culvert as indicated by the Engineer and replaced with gravel or other approved material properly compacted to provide a firm earth cushion. When ordered by the Engineer, the Contractor shall construct a blinding layer of concrete to provide a suitable working floor.

The width of the excavation and earth cushion shall be as directed by the Engineer but, in the case of culverts to be constructed under embankment conditions, the width shall be at least one diameter or span, as the case may be, wider than the culvert on either side.

Other special construction methods may be shown on the Drawings.

3207 EXCAVATION FOR EMBANKMENT CONDITIONS

Where culverts are to be constructed under embankment conditions as defined in clause 3204 above, the Contractor shall level the existing ground by excavating and filling and compacting as required so that the foundation for the culvert is true to grade and of uniform density over the whole length of the culvert.

The finished level of the ground on which the culvert is to be bedded shall be below the proposed level of the underside of the culvert by the same amounts as specified in clause 3205 (A) above, for the various types of culverts.

3208 DISPOSAL OF EXCAVATED MATERIAL

Where excavated material does not comply with the requirements for backfilling material as specified hereafter or is surplus to backfilling requirements, such excavated material shall be removed from the Site and disposed of in disused borrow pits or other places. Material suitable for use in the Works, shall however, be used as prescribed by the engineer.

Payment for such material will be made as for excavation under item 32.01, and also under the appropriate item for such part of the works as may be constructed from such material.

All excavated material shall be subject to a free-haul distance of 1.0 km.

3209 BEDDING AND LAYING OF PREFABRICATED CULVERTS

(a) Concrete Pipe Culverts and Drains

Concrete pipe culverts and drains shall be laid on Class A, B, C or D bedding as shown on the Standard Detail Drawings and as directed by the Engineer. The pipes shall be laid hard up against each other so as to obtain tight joints. Ogee type pipes must be laid with the spigot ends pointing downstream.

The inside of the pipes shall be smooth with no displaced joints. All pipes shall be laid true to line and level.

(i) Class A bedding

The pipe shall be laid with the bottom portion on Class 20/40 concrete of specified thickness below the lowest part of the pipe and extending upwards on each side of the pipe to a specified proportion of its height. The thickness of concrete below the pipe and the height to which it is extended upwards shall be as indicated on the Drawings. Pipes shall be supported on suitably shaped temporary cradles during concreting. No longitudinal construction joints on the horizontal plane will be permitted.

(ii) Class B and class C beddings

The pipe shall be laid on a bedding cradle of compacted selected granular material as specified. The bedding shall extend upwards on both sides of the pipe to a specified portion of its height, as shown on the drawings. Joint holes shall be formed in the bedding cradle for pipe sockets and couplings, to ensure that each pipe is fully supported throughout the length of its barrel on the bedding cradle.

(iii) Class D bedding

The pipe shall be laid on the in situ material in the excavation bottom after the bottom has been hand trimmed to support the pipe along the entire length of its barrel in accordance with the details shown on the drawings. Wherever necessary, the in situ material shall first be stabilized in accordance with the details shown on the drawings or as prescribed by the engineer. Joint holes shall be formed in the trench bottom for pipe sockets and couplings.

(iv) Rock foundation

Where rock, shale or other hard material is encountered on the bottom of excavations, construction of pipes on Class A bedding shall proceed as follows:

The material below the pipe shall be excavated and replaced with an equalizing bed of sand or approved gravel or soil to a depth as shown on the Drawings or directed by the Engineer.

The backfill material shall be watered and compacted to provide a firm earth cushion. Class A bedding shall then be prepared as described in clause (a)(ii) of this Clause.

(v) Concrete casing

Where shown on the Drawings or ordered by the Engineer, pipes shall be fully encased in Class 20/40 concrete with the dimensions as shown on the Drawings or as ordered by the Engineer. Temporary supports shall be provided near the pipe ends to support the pipes during placing of the concrete. The placing of concrete shall be such that all spaces under the pipe are completely filled. Use shall be made of poker vibrators to ensure proper filling of all spaces under and around the pipes with concrete. Concrete casing shall be cast in one continuous operation until completed.

(b) Box/slab culverts

(i) Cast in situ invert slabs

Cast in situ invert slabs shall be constructed to the dimensions and at the locations as shown on the Drawings or as directed by the Engineer. They shall be reinforced with steel reinforcement as detailed on the Drawings.

(ii) Precast invert slabs

A layer of fine granular material of at least 250 mm thickness shall be placed on the bottom of the excavation, levelled, compacted to 98% Mod AASHTO and trimmed to grade and line, to form a bed to receive the pre-cast invert slabs.

The slabs shall be carefully placed on the prepared bed, true to line and grade, and bedded in such a manner that they are uniformly supported over their whole area on the bedding.

(iii) Placing of upper portion of culverts

The upper portion of box/slab culverts shall be placed accurately on the invert slabs, with a thin layer of 1:3 cement sand mortar between the contact surfaces to ensure a firm and uniform support.

Where two or more culverts are placed side by side to form a multi-barrel culvert, the space between the culverts shall be filled with concrete up to the level of the top of the culvert. Where prescribed, filter fabric shall be applied to the vertical outer faces in accordance with the details shown on the drawings.

(c) Metal Culverts

The excavation shall be trimmed to the contour of the invert of the culvert and shaped to enable the culverts to be bedded as shown on the Drawings.

Where rock is encountered, the depth of excavation shall extend to a depth of at least 325 mm below the contour of the culvert and filled with granular material as before.

The culverts shall be installed in accordance with the manufacturer's recommendations as approved by the Engineer. In case of conflict between these Specifications and the manufacturer's recommendations, these Specifications shall apply. Anchor bolts where specified or shown on the drawings shall be installed at the ends of metal pipe culverts in accordance with the manufacturer's instructions to tie them to inlet and outlet head walls.

(d) Extension of existing culverts

Where an existing culvert requires extension or portal replacement, the new section shall be placed at the same grade and, where it joints the existing structure, at the same level as the existing structure.

Any sections of existing wing walls, approach slabs and head walls, which may obstruct any new work, shall be demolished and removed. Existing culverts ends shall not be damaged, but, should damage occur, the repair work shall be done before the placement of any fresh concrete or new culverts. Loose material shall be removed and joint faces thoroughly cleaned to the satisfaction of the engineer.

Jointing shall be done in accordance with Sub clause 8704.

After completion of the extension or partial replacement of a culvert, new approach slabs, head walls, wing walls, catchpits, etc, shall be constructed in accordance with the drawings.

(e) Construction of culverts in half widths in existing roads

If necessary for taking up traffic or for any other reasons, or if so instructed by the engineer, culverts shall be constructed in half widths.

Unless otherwise prescribed, the downstream section shall be constructed first. The end of the excavation adjoining the traffic lane shall be properly supported to prevent displacement from occurring. The necessary warning signs shall be erected in accordance with the requirements of Division 1500.

Where the culvert is constructed in an existing road and it has been so prescribed by the engineer, the pavement layers at least shall be benched and recompacted during backfilling. The depth of benching shall equal the respective layer thicknesses, and the width shall be at least 150 mm.

(f) General

Construction of culverts shall begin at the one end, the position of which shall be fixed as shown on the Drawings or as directed by the Engineer. The position of the other end of the pipe shall normally be determined by the end of the last whole unit, the top of which breaks through the fill slope. However, in the case of skew culverts or culverts with a cover of less than 0.5 m at the shoulder, the Engineer may order that the end unit be cut to the length and skew required.

Any units which deform or crack, or which are not constructed to the required lines, levels and grades, or which become displaced in the process of the work or during the Maintenance Period, shall be removed and replaced by the Contractor at his own expense.

Pre-cast units shall be lifted and handled by means of approved lifting devices only. Lifting eyes shall be caulked with a suitable mortar after the units are installed.

The Contractor shall exercise due care not to damage, overstress or displace any prefabricated pipes with his own traffic or compaction equipment. Where loads in excess of those prescribed in the Schedule for Drainage Works or Drawings are likely to pass over completed culverts, the Contractor shall provide additional cover over the pipes so as to ensure that the design stresses on the pipes are not exceeded.

All concrete work shall be carried out in accordance with the provision of Series 8000 of these Specifications.

3210 BACKFILLING OF PREFABRICATED CULVERTS AND STORMWATER DRAINS

After the pipes have been firmly laid on the required bedding as described above in clause 3209, backfilling shall be carried out as follows:

The material used for the backfilling of those portions of culverts or pipes subject to traffic loads shall be selected material of at least subbase quality. Where the excavated material is not of adequate quality, selected material shall be imported for this purpose.

Metal culverts shall be temporarily ballasted during backfilling to prevent them from lifting.

Backfilling alongside and over all pipes shall be placed and compacted in layers not exceeding 150 mm after compaction, to a density of at least the density required for the material in adjoining layers of fill, subgrade and subbase. The density of backfilling in excavations made in the natural ground shall be at least 90% of modified AASHTO density. Backfilling shall be carried out simultaneously and equally on both sides of a pipe to avoid any unequal lateral forces.

Where the Engineer so directs, metal culverts with large diameters or spans, or culverts with multiple openings, shall be constructed under embankment conditions as defined in clause 3204(b). In such cases, the backfilling shall be carried out to the same standard as described above, simultaneously and equally on both sides of the culvert and over the culvert until the minimum specified cover is obtained. The width of backfill on each side of the culvert, after completion, shall be at least equal to the diameter (or span) of one of the openings of the culvert.

Metal culverts shall be backfilled symmetrically to prevent distortion of the units and the Contractor shall also ensure that the required cover, as specified in clause 3205 (A) (iii), is provided over the culvert before routing his construction equipment across the culvert.

Whenever specified or as may be instructed by the engineer, the backfilling shall consist of concrete placed between the side of the culvert and the excavation up to the top of the culvert.

When specified or ordered by the engineer, the backfilling of culverts shall be done using a wet or a stiff mixture of soil cement in lieu of a compacted gravel or lean concrete. A wet mixture of soil cement shall consist of an approved soil or gravel mixed with 5% of Portland cement and only sufficient water to give a consistency that will permit the soil cement to be placed with vibrators so that all voids between the pipes and the sides of excavations and

between culverts in the case of multi-barrel culverts will be properly filled. A stiff mixture of soil cement shall contain 3% of Portland cement and just sufficient water for it to be placed and compacted like ordinary backfill material. The height to which the soil cement backfill shall be taken shall be as prescribed by the engineer or shown on the drawings, and any remaining backfill shall be carried out as described above with a granular material.

The aggregate used for soil cement shall preferably be a sandy material but may contain larger particles up to 38 mm, and it shall not have a plasticity index exceeding10. Detrimental percentages of silt or clay shall be avoided, and the aggregate shall be obtained from an approved source.

The soil cement shall be mixed on the site with suitable concrete mixers, and the water and cement contents shall be carefully controlled. The material shall be placed and then thoroughly compacted so that all voids are filled as described above. At culvert ends stones shall be packed to prevent the soil cement from flowing beyond the required limits.

Soil cement shall not be used for backfilling corrugated metal culverts.

A free-haul distance of 1.0 km shall apply in respect of all imported materials used for backfilling the culverts but no overhaul shall be paid on any cement, water or concrete aggregates used.

3211 INLET AND OUTLET STRUCTURES, CATCHPITS AND MANHOLES

Inlet and outlet structures for prefabricated culverts as well as catchpits and manholes shall be constructed in accordance with the details shown on the Drawings.

(a) Excavation and Backfilling

The Specifications given in this Division for the excavation and backfilling of culverts, shall apply for inlet and outlet structures, catchpits and manholes.

(b) Concrete Work

Concrete work shall be carried out in accordance with the provision of series 8000 of these Specifications. Unless otherwise specified, all concrete shall be Class 20/20.

3212 REMOVAL OF EXISTING WORK

Where shown on the Drawings or where directed by the Engineer, existing inlets or outlets to pipe culverts shall be broken down or demolished and debris or rubbish removed off site. Existing pipes shall be removed when necessary. All such work shall be carried out in a manner to prevent damage to old work which is to remain.

The Contractor's attention is directed to the provisions of Series 2000 which specifies the structures that have to be removed as part of the clearing and grubbing operations and the removal of which will, therefore, not be measured and paid for under this Division.

For the removal of existing concrete, payment shall distinguish between plain concrete and reinforced concrete, the latter being defined for this purpose as concrete containing not less than 0.2% steel reinforcement measured by volume.

Undamaged pipes shall be re-used in the works where indicated by the engineer. Pipes which cannot be re-used shall remain the property of the employer and shall be stacked within the road reserve or where directed by the engineer.

3213 JOINING NEW WORK TO OLD

Where partial demolition is required for extension work to existing structures, the contact face shall be cut to predetermined lines and levels, any loose and fragmented material shall be removed, and projecting steel cleaned and bent as directed by the engineer. Where partial demolition is not required but extension work only, the contact surface shall be roughened and cleaned of all dirt and loose particles.

If dowels are required, they shall be installed in holes drilled into the existing structure, in accordance with the details shown on the drawings, and secured by means of an approved type of epoxy resin grout.

Fresh concrete shall be bonded to the old concrete in accordance with the requirements specified in series 8000.

Reinforced or plain concrete removed in the process of partial demolition shall be measured and paid for under item 32.12 and the installation of dowels and those surfaces treated with an epoxy bonding compound will be paid for separately, but no separate payment will be made for any other work described above, the cost of which shall be deemed to be included in the rates tendered for the concrete supplied for the extensions to the existing structures.

3214 SERVICE DUCTS

Where required, the contractor shall construct service ducts for the easy installation and maintenance of existing, new and future cables and other services. Services ducts shall be constructed from one or more of the following materials:

(i) Normal-duty PVC pipes in accordance with AASHTO M278.

(ii) Reinforced concrete pipes in accordance with AASHTO M170M.

Where required, the pipes shall be cut lengthwise and accurately in two halves. The actual type of pipe required shall be in accordance with the specifications. The pipes shall be installed in the required positions, and accurate records shall be kept regarding the depth, position and number of pipes installed in each duct. Pipes shall be laid at the grades shown on the drawings to facilitate flushing with water and shall, where required, be encased in concrete or soil cement.

The width of excavation for service-duct trenches shall be equal to the nominal inside diameter of the pipe, plus 150 mm on each side of the duct. Where ducts consist of two or more units, the minimum spacing between the units shall be 75 mm, and the 150 mm side clearance specified above shall apply to the outside units of the group.

Below the carriageway the depth of excavation shall accommodate a minimum cover of 1.0m above the upper side of the installed service duct.

All pipes shall be joined with watertight couplings made from the same material as the pipe. Fibre-cement couplings shall be of the rubber-ring type.

Split pipes shall normally be used only for providing ducting for existing services which cannot be severed and threaded through the ducts. The pipes shall be accurately cut longitudinally in two halves and opposite halves shall be matched as sawn. Split pipes shall be placed around the service as required, firmly bound by steel straps and finally encased in concrete if required.

Excavating, laying and bedding the pipes shall be in accordance with the specifications for prefabricated culverts with any modifications as may be necessary or specified here.

Duct ends shall be provided with suitable conical wooden stoppers to prevent dirt from entering the ducts. Two strands, 2.5mm in diameter, of galvanized steel wire shall be threaded through each unit and shall extend 2m beyond each end and firmly wedged into position with the wooden stoppers.

The end of each duct shall be marked with a marker block constructed to the details shown on the drawings. Each duct marker block shall be at least 50mm proud of the finished surface level.

3215 CULVERTS ON STEEP GRADIENTS

Where culverts are constructed on gradients exceeding 1 in 4, they shall be referred to as inclined culverts. Inclined culverts shall be constructed from the type of unit required, normally either circular concrete pipe units or metal culvert units as described in sub clause 3203.

Particular care shall be taken to protect excavations against storm water damage. The trenches shall be excavated down to firm ground, and backfilled with selected gravel or concrete if it is necessary to over-excavate for obtaining a firm floor.

After the outlet structure has first been completed, the culvert units shall be laid in the normal manner by starting from the lower end and placing successive units firmly against each other to prevent subsequent movement. The lower unit shall be securely cast into the outlet structure, and metal culverts shall be provided with the necessary anchor bolts at both inlet and outlet structures and also at all thrust and anchor blocks.

Thrust and anchor blocks shall be constructed from concrete as required in accordance with the drawings and details furnished by the engineer. Anchor bolts, straps and other anchoring devices required at anchor and thrust blocks shall be provided.

The backfilling of trenches shall be done in horizontal layers starting at the lower end.

3216 STORMWATER DUCTS, TREAMIES AND OTHER CLOSED CONDUITS

The specifications given in this Division for culverts, shall apply mutatis mutandis to the construction of storm water ducts, tremies or any other closed conducts constructed from the prefabricated units described in sub clause 3203, whether intended for drainage or for any other purpose.

No distinction will be made in the schedule of quantities between the construction of culverts as defined in Division 3100 and that of the other closed conduits described above, all being classed as culverts.

Tremies constructed from prefabricated units shall be classed as inclined culverts where laid to a grade steeper than 1 in 4.

3217 MEASUREMENT AND PAYMENT

Item 32.01 Excavation

(a) Excavating soft material situated within the following depth ranges below the surface level:

(i) 0 m up to 1.5 m.....cubic metre (m^3)

(ii) Exceeding 1.5 m and up to3.0m .....cubic metre (m^3)

(iii) Etc, in increments of 1.5 m

(b) Extra over sub item 32.01(a) for excavation in hard material, irrespective of depth.... ..... cubic metre (m^3)

The unit of measurement shall be the cubic metre of material excavated within the specified widths over the lengths and depths authorised by the Engineer in each case. Excavation in excess of the widths specified or authorised by the Engineer shall not be measured for payment.

When measuring excavation for removal of existing culverts, the volume occupied by the culvert shall not be subtracted from the calculated volume of excavation.

In case of manholes and catchpits, the dimensions for determining the volume of excavation shall be the neat outside dimensions of the structure and plus an allowance of 0.5 m of working room around the structure.

The tendered rate shall include full compensation for all excavation, temporary timbering, shoring and strutting, for preparing the bottom of the excavation for the culvert beds, for disposal of excavated material unsuitable for backfilling, for keeping excavations safe, for dealing with any surface or sub-surface water and for any other operations necessary to complete the work as specified.

Payment shall distinguish between soft and hard material as defined in clause 3109.

Item 32.02 Backfilling

(a) Using the excavated..... cubic metre (m^3)

(b) Using imported selected material ..... cubic metre (m^3)

(c) Extra over subitems 32.02(a) and (b) for soil cement backfilling (Percentage of cement indicated)..... cubic metre (m^3)

The unit of measurement shall be cubic metre of material in place after compaction and the quantity shall be calculated from the specified dimensions of the backfilling as specified or authorised by the Engineer.

If excavations are carried out in excess of the dimensions authorised by the Engineer, quantity of backfilling will nevertheless be based on the authorised dimensions. The volume occupied by the culvert or pipe shall be subtracted when calculating the volume of backfilling.

Payment at tendered rates shall include full compensation for backfilling under, alongside and over conduits, for watering and for compacting the backfill material to the specified density. The tendered rate for subitem 32.02(b) shall, in addition, include full compensation for supplying selected material of subbase quality from approved sources, including a free haul of 1.0km.

The tendered rate for subitem 32.02(c) shall be additional to the rates tendered for subitems 32.02(a) and (b) and shall include full compensation for all incidentals required for the complete backfilling with soil cement as specified.

The cost of backfilling of excavations for manholes, catchpits and structures after construction will not be paid for, and the Contractor must allow, in his prices, for backfilling around manholes, catchpits and structures.

Item 32.03 Concrete pipe culverts

(i) On Class A bedding (type and diameter indicated) .....metre (m)

(ii) On Class B bedding (type and diameter indicated) .....metre (m)

(iii) On Class C bedding (type and diameter indicated) .....metre (m)

(iv) On Class D bedding (type and diameter indicated) .....metre (m)

The unit of measurement for concrete pipe culverts shall be the metre of culvert laid as shown on the drawings or ordered by the engineer. The length shall be measured along the soffit of the culvert.

The tendered rates shall include full compensation for providing, testing, loading, transporting and unloading the culverts, for providing and placing the selected granular material, where required, and for the installation, laying and jointing of the culverts, as specified.

Should it be inevitable for a section to be cut off from a concrete pipe unit of standard length, the full standard length of the unit shall be measured for payment. No additional compensation for cutting and disposing of such section will be paid.

Upon payment, differentiation shall be made between the various types and sizes of culverts and between the culverts placed on A, B, C and D classes of bedding.

Item 32.04 Portal and rectangular (Box or Slab) culverts

(a) Complete with pre-cast invert slabs (size and type indicated) .....metre (m)

(b) Without pre-cast invert slabs (size and type indicated) .....metre (m)

The unit of measurement for prefabricated portal or rectangular culverts shall be the metre of culvert laid as shown on the drawings or as directed by the engineer.

The length shall be measured along the soffit of the culvert.

The tendered rates shall, include full compensation for supplying, testing, loading, transporting and off-loading the culverts, for providing and placing fine-grained material where required for the installation of culverts, and installing, laying and jointing the culverts as specified, including cutting them on the site, and waste.

Payment shall be made separately for floor slabs of cast in- situ concrete. Payment shall distinguish between the different sizes and types of culverts and between culverts installed with or without prefabricated floor slabs.

Item 32.05 Metal and other culverts

(Metal Culverts, PVC Drain Pipes, Corrugated polyethylene drainage tubing drain pipe and Corrugated polyethylene drain pipe)

(a) Size, wall thickness and type indicated .....metre (m)

(b) Bevelled ends (size and type indicated).....Number (No)

The unit of measurement shall be the metre of culvert laid as shown on the drawings or ordered by the engineer.

In all cases, the culvert length shall be measured along the pipe centre line. In the case of a metal pipe arch, the culvert length shall be measured along the bottom of the pipe arch. In both cases the length of bevelled and/or skew ends shall be included.

The tendered rates shall include full compensation for providing, testing, loading, transporting and off-loading the culverts/drain pipes, for providing and placing fine-grained material where required for the installation, and for installing, laying and jointing the culverts as specified. Upon payment, a differentiation shall be made between the various types and sizes of culverts/drain pipes and also between culverts with differing wall thicknesses.

Payment shall be made separately for the cutting of bevelled and/or skew ends, and the tendered rate shall include full compensation for all work in connection with the cutting of ends.

Item 32.06 Extra over items 32.03, 32.04 and 32.05 for constructing inclined culverts .. ..metre (m)

The unit of measurement shall be the metre of culvert installed at a grade steeper than 1:4 as specified in clause 3215.

The tendered rate shall include full compensation for additional or more difficult work of any nature in regard to laying, excavating and backfilling as may be required for installing the culverts at a grade steeper than 1:4.

Item 32.07 Cast in- situ concrete and formwork

(a) In Class A bedding, screeds and the encasing for pipes, including formwork (class of concrete indicated)..... cubic metre (m^3)

(b) In invert slabs to portals or rectangular (box /slab) culverts, including formwork, joints and Class U2 surface finish (class of concrete indicated) ..... cubic metre (m^3)

(c) In inlet and outlet structures, skewed ends, catchpits, manholes, thrust and anchor blocks, excluding formwork but including Class U2 surface finish (class of concrete indicated) ..... cubic metre (m^3)

(d) Formwork of concrete under Item 32.07 (c) above (type of finish indicated) .... square metre (m^2)

(e) In concrete linings for the inverts of metal culverts under Item 32.05, including formwork and class U2 surface finish (class of concrete indicated)..... cubic metre (m^3)

Measurement of formwork and concrete cast in-situ shall be as specified in Division 8200 and 8400 of these Specifications, except that formwork for pipe beddings and invert slabs shall not be measured for payment.

Payment for formwork and concrete cast in-situ shall be made as provided for in Division 8200 and 8400 of these Specifications, except that payment for the formwork for concreting in subitems 32.07 (a),(b) and (e) shall not be payable separately, and the Contractor's rates for concrete shall include full compensation therefor.

No separate payment shall be made for the construction of joints in culvert floor slabs or at inlet and outlet structures, and the tendered rates for concrete shall include full compensation for forming the joints complete in accordance with the details shown on the drawings.

Item 32.08 Concrete backfill for culverts (class indicated).....cubic metre (m^3)

The unit of measurement shall be the cubic metre. The quantity shall be calculated from the dimensions of the excavation as specified or as may be authorized by the engineer, minus the volume taken up by the culverts, irrespective of whether the actual excavation to be backfilled exceeds the specified or authorized dimensions.

Payment shall be made as for concrete in item 32.07(a) above.

Item 32.09 Prefabricated concrete inlets and outlets to culverts

Prefabricated concrete inlets and outlets for concrete pipe culverts shall be measured per inlet or outlet, complete in position.

The tendered rate shall include full compensation for procuring, providing, loading, transporting, off-loading and installing the inlets or outlets as specified.

Item 32.10 Steel reinforcement:

(a) Mild steel .....ton (t)

(b) High tensile steel.....ton (t)

(c) Mild steel mesh..... .Kilogram (kg)

(d) High tensile steel mesh ..... Kilogram (kg)

Measurement and payment for steel reinforcement shall be made as specified in Division 8300 of these Specifications.

Item 32.11 Dowels for joining old and new concrete .....kilogram (kg)

The unit of measurement shall be the kilogram of steel dowels installed.

The tendered rate shall include full compensation for supplying all materials, all cutting, drilling and grouting, and any other operation or thing necessary for the proper execution of the work.

Item 32.12 Removing existing concrete

(a) Plain concrete.....cubic metre (m^3)

(b) Reinforced concrete .....cubic metre (m^3)

The unit of measurement shall be the cubic metre of existing concrete removed.

The tendered rate shall include full compensation for all demolition and for the loading, transporting and disposal of the products of demolition, including a free haul of 1.0 km.

Payment shall distinguish between plain and reinforced concrete. For the purposes of this item, reinforced concrete shall be defined as concrete containing at least 0.2% of steel reinforcement measured by volume. The tendered rates shall also include full compensation for cutting straight grooves of the specified depth at joint positions where shown on the drawings.

Item 32.13 Removing and relaying existing pipes (size and type of bedding indicated) .. ..metre (m)

The unit of measurement shall be the metre of existing pipe removed and re-laid.

The tendered rate shall include full compensation for lifting, loading, transporting for a free-haul distance of 5.0 km. off-loading, and laying pipes according to the ..... specifications.

Payment for any excavation and backfilling required for the removal and relaying of existing pipes shall be made separately under items 32.01 and 32.02.

Where existing pipes are loaded, transported and used in temporary diversions, they shall not be measured for payment under this item, but payment therefor shall be made in terms of Division 1500.

Item 32.14 Removing and stacking existing prefabricated culverts (type and size indicated) ..... metre (m)

The unit of measurement shall be the metre of existing prefabricated culverts removed and stacked.

The tendered rate shall include full compensation for lifting, loading, transporting to stack, off-loading, and stacking the prefabricated culverts.

Payment for any excavation and backfilling required for removing and stacking the existing prefabricated culverts shall be made separately under items 32.01 and 32.02. The free-haul distance shall be 5.0 km.

Item 32.15 Treating surfaces with epoxy resin for joining new to old concrete (type of epoxy resin specified)..... litre (l)

The unit of measurement shall be the litre of epoxy-resin compound used at the specified rate of application.

Item 32.16 Protective mastic asphalt coating for corrugated metal culvert units (state whether to be applied by brush or by spray gun)..... square metre (m^2)

The unit of measurement shall be the square metre of protective coating applied as specified and as directed by the engineer. When both inside and outside surfaces are treated, both surfaces shall be measured.

The tendered rate shall include full compensation for procuring and furnishing the mastic asphalt, applying the material, and for all other additional work and incidentals required for providing the protective coating as specified.

Item 32.17 Manholes, catchpits, pre-cast inlet and outlet structures complete

(a) Manholes (type indicated) ..... Number (No.)

(b) Catchpits (type indicated) ..... Number (No.)

(c) Pre-cast inlet and outlet structures (type indicated) ..... Number (No.)

(d) Extra over or less than subitem 32.17(a) for variations in the depths of manholes from the standard depth designated for tendering purposes (standard depth and type of manhole indicated) ..... .Number (No)

(e) Extra over or less than subitem 32.17(b) for variations in the depths of catchpits from the standard depth designated for tendering purposes (standard depth and type of catch-pit indicated) ..... metre (m)

The unit of measurement, in the case of subitems (a), (b) and (c) above, shall be the complete unit as shown on the drawings, including all concrete, brickwork, covers, frames, grids and other accessories.

The tendered rates shall include full compensation for procuring, furnishing and installing, and laying where applicable, the complete units except for excavation and backfilling, which shall be measured separately. The tendered rate shall also include full compensation for connecting up to and building any conduits into the walls of the various structures.

The unit of measurement in the case of subitems (d) and (e) above shall be the metre of increased or decreased depth of the manhole or catchpit measured in relation to the standard depth furnished for tendering purposes.

The tendered rates per metre shall be an adjustment to the compensation for the standard item, payable either as an increased compensation to the contractor in the case of an increased depth, or as a decrease in compensation in the case of a decreased depth in relation to the standard depth.

Concrete and formwork shall be measured and paid for under subitems 32.07(c) and (d) respectively, excavation under item 32.01, and backfilling under item 32.02.

Item 32.18 Accessories

(a) Manhole covers including frames (description) .....number (No)

(b) Inlet grids including frames (description).....number (No)

(c) Step irons (description).....number (No)

(d) Etc for other accessories .....number (No)

The unit of measurement shall be the number of each type of accessory delivered and installed.

The tendered rates shall include full compensation for procuring, furnishing and installing the accessories.

Item 32.19 Anchors for pipes (description) ..... number (No)

The unit of measurement shall be the complete anchor installed, including straps, bolts, etc. but excluding any concrete work, which shall be measured under subitem 32.07(c) and (d).

Item 32.20 Service ducts

(a) Ordinary pipes (type and diameter indicated).....metre (m)

(b) Split pipes (type and diameter indicated) .....metre (m)

The unit of measurement shall be a metre of service duct laid.

The tendered rates shall include full compensation for procuring, providing and laying the pipes, including end stoppers, draw wires and complete installation, but shall exclude excavation, backfilling, and encasing with concrete, which shall be measured for payment under the appropriate items of payment of this Division.

Item 32.21 Duct marker blocks (type indicated).....Number (No.)

The unit of measurement shall be the number of marker blocks installed and the tendered price shall include full compensation for the manufacture, delivery and installation of the marker blocks, complete as shown on the drawings.

Item 32.22 Chambers for ducts.....Number (No.)

The unit of measurement shall be the number of chambers.

All tendered rate shall include full compensation for procuring, furnishing all materials and for constructing the chambers complete.

Item 32.23 Hand excavation to determine the positions of existing services ....cubic metre (m^3)

The unit of measurement shall be a cubic metre of material excavated within the lengths and widths authorized by the engineer and the depth required to expose the service. Excavation in excess of the authorized dimensions shall not be measured for payment.

The tendered rate shall include full compensation for all excavation, backfilling, compacting to 90% of modified AASHTO density, disposing of any surplus excavated material, keeping the excavations safe, dealing with any surface or subsurface water, taking special care to ensure that services are not damaged in any way and any other operation necessary for completing the work. The tendered rate shall also include the transporting of surplus excavated material for a free-haul distance of 1.0 km. Any damage to a service caused by the contractor shall be repaired at his own cost, to the satisfaction of the owner of the service and the engineer.

No distinction will be made between hard and soft material, neither will distinction be made between the various types of services to be exposed or the depths to which excavations are taken.

Item 32.24 Reinstating trenches crossing roads:

(a) Selected layers ..... square metre (m^2)

(b) Subbase ..... square metre (m^2)

(c) Base (including prime coat) ..... square metre (m^2)

(d) Bituminous surfacing(including tack coat) ..... square metre (m^2)

(e) Kerbing ..... metre (m)

The unit of measurement for subitems (a) to (d) shall be the square metre of the layer reinstated where instructed by the engineer.

The unit of measurement for subitem (e) shall be the metre of kerbing replaced due to trench excavations where instructed by the engineer.

Any reinstatement required beyond the agreed or instructed dimensions owing to damage caused by the contractor will not be measured for payment.

The appropriate Divisions of the specifications shall also be applicable to the reinstatement of the trenches.

The tendered rates shall include full compensation for procuring, furnishing, placing, compacting and finishing all materials, providing all labour and constructional plant, cutting and preparing the edges of the existing surfacing, and protecting and maintaining the completed reinstatement as specified.

Item 32.25 Prefabricated reinforced concrete skew end units for concrete culverts constructed at a skew angle type and dimensions of unit and class of bedding indicated) .....number (No)

The unit of measurement shall be the number of each type and size of prefabricated reinforced-concrete skew end unit provided and installed, irrespective of the angle of skew.

The tendered rates shall include full compensation for providing, testing, loading and unloading the units, constructing the prescribed class of bedding, and for installing, laying

and joining the units, complete as specified and in accordance with the details shown on the drawings.

DIVISION 3300: CURBING, CHANNELLING, OPEN CHUTES, DOWNPIPES, AND CONCRETE LINING OF OPEN DRAINS

3301 SCOPE

This Division covers the construction of concrete curbing and channeling, curb inlets, chutes and downpipes, and concrete linings for open drains, at the locations and to the details as shown on the Drawings or as directed by the Engineer.

3302 CURBING AND CHANNELLING

Curbing may include barrier curbs, mountable or semi-mountable types. All these elements may be pre-cast units or constructed in a continuous operation using slip forms.

Channelling may be formed in- situ, using fixed forms or slip forms construction. The concrete lining of open channels shall be cast in- situ or pre-cast concrete.

(a) Dimensions

Curbing and channelling shall be provided and constructed in accordance with the details, dimensions, lines and levels shown in the Contract.

(b) Material Requirements for Curbing and Channelling

(i) General

Curbs shall be of natural stone, concrete or asphalt, as described in the Contract. Natural stone and pre-cast concrete curbs shall have a maximum length of 1 metre and a minimum length of 400mm.

The ends of all natural stone and pre-cast concrete curbs shall be at right angles to the longitudinal axis of the element.

(ii) Natural Stone

Natural stone shall be obtained from cutting or blasting limestone, sandstone, or granite from an approved source. Unless other wise directed one type of stone shall be used for a particular section. Stone with visible drill marks or holes on the exposed faces shall not be used.

Natural stone shall be sawn or dressed to the cross-sectional profiles shown in the Contract.

(iii) Concrete for Curbing and channelling

Concrete for curbing and Channelling shall be class 30/20 concrete complying with the requirements of Division 8400 of these Specifications.

Pre-cast curbing and Channelling shall comply with the requirements of BS 340, or class 20/20 when not specified. In- situ Channelling shall be of the class of concrete indicated.

Concrete for Curbing and channelling Foundations and Backing (Excluding Asphalt Curbs)

Concrete for foundations and backing shall be Grade 20 concrete complying with the requirements of Division 8400, except where foundations and backing are cast monolithically

with the curbing and channelling, in which case it shall be class 30/20. Curing of the completed foundation shall be carried out in accordance with the requirements of Clause 8410.

Concrete shall not be placed during rain. Surface water shall not be allowed to come into contact with the freshly compacted concrete.

(iv) Mortar for Bedding of Curbing and channelling

Mortar for bedding shall be a semi-dry mixture of four parts by volume of fine aggregate complying with the requirements of clause 8402(c) to one part by volume of cement complying with the requirements of clause 8402(a).

(v) Water for Curbing and channelling

Mixing water for concrete and mortar shall be water quality Type A as stipulated in clause 8402(d).

(vi) Asphalt Curbing

The constituents of the asphalt mix shall be 60-70 penetration grade bitumen complying with the requirements of clause 63A02(a), and aggregates complying with the requirements of clause 63A02(c) .The percentage of binder by mass of the total mixture shall be between 6 and 9 percent. The nominal size of aggregate shall not exceed 20mm.

The mix shall be designed by the Contractor within the above limitations. The Contractor shall carry out trial mixes of the asphaltic composition using the same plant as will be used in the works to the satisfaction of the Engineer. When a proposed mix has been approved, no variations shall be made in the mix proportions or in the type, size, grading or source of any of the constituents without the agreement of the Engineer, who may require further tests to be made.

(c) Construction Requirements for Curbing and channelling

(i) General

Natural stone curbs shall be laid on separately constructed foundations.

Concrete Curbing and channelling shall be of either pre-cast elements laid on separately constructed foundation, or constructed in-situ between fixed or sliding side forms.

Asphalt curbs shall be constructed in-situ.

(ii) Equipment

Equipment for constructing in-situ concrete Curbing and channelling shall be purpose made slip forming or extruding equipment approved by the Engineer.

Equipment for constructing asphalt curbs between sliding forms shall be purpose made extruding equipment approved by the Engineer.

(iii) Excavation for Foundations

Foundations for natural stone, pre-cast and in-situ concrete Curbing and channelling shall be excavated to the required width and depth indicated in the Contract, and all unsuitable material shall be removed and replaced with a layer of approved bedding material at least 75 mm thick.

The bedding shall be compacted and accurately shaped to the required grade. No concrete shall be placed on uncompacted or disturbed material.

The sides and bottoms of excavations shall be neatly trimmed to the lines and levels described in the Contract and any unsuitable material shall be removed and replaced with approved granular material compacted to a density of not less than 95% of the maximum dry density when determined in accordance with AASHTO T-180.

The bottom of excavations shall be compacted to a density of not less than 95% of the maximum dry density when determined in accordance with AASHTO T-180.

(iv) Laying Natural Stone or Pre-cast Concrete Curbing and channelling

Mortar complying with the requirements of clause 8904(c) shall be evenly spread on the concrete foundations to the required depth.

Curbing and channelling shall be placed vertically to line and level on the mortar bed relative to a guide line fixed along the top front edge of the curb and firmly tamped into position. Each curb laid shall be firmly abutted against the end of the previously laid curb.

Curbs laid on horizontal curves shall be either purpose made radius curbs or 400mm long straight curbs.

Prior to the placing of the backing concrete, the laid curbs shall be approved by the Engineer.

Backing concrete shall be placed against the back of the laid Curbing and channelling shall be lightly compacted by hand to the satisfaction of the Engineer. The backing concrete shall be cured with hessian and polythene sheeting for a minimum period of four days.

Natural stone or pre-cast concrete Curbing and channelling shall not be damaged during transport or laying. Broken or spalled elements shall not be used and shall be removed and replaced by undamaged elements.

The Curbs and channels shall be constructed true to line and elevation and shall have a neat appearance. Where transverse cracks occur, the contractor shall replace the entire section between the contraction joints at his own cost.

Cast In-situ Concrete Curbing and channelling (Fixed Forms)

Cast in-situ concrete curbs and channels may be cast monolithically with the foundation and/or backing.

Formwork shall consist of materials as specified in division 8200.

Concrete for cast in-situ concrete curbs and channels shall be mixed, transported, placed and compacted in accordance with the requirements of Division 8400.

Forms shall be placed to line and level to a guideline accurately fixed along the top front edge of the curb.

Curbs constructed on horizontal curves shall be constructed using either purpose made radius forms or straight forms not exceeding 400mm in length.

Forms shall be removed from any concrete surfaces that will be exposed, within a period of 24 hours of the concrete having been placed. Minor defects shall be repaired with 2:1 sand: cement mortar. Plastering shall not be permitted on exposed faces and all rejected portions shall be removed and replaced at the contractor's expense. When completed, the sections shall be cured in accordance with the requirements specified in clause 8410.

The completed kerbs and channels shall be true to line and elevation and shall have an even and neat appearance.

Joints shall be constructed at intervals not exceeding 3 metres and at right angles to the longitudinal axis of the completed curb either by wet forming in the plastic concrete or by sawing in the hardened concrete in a manner approved by the Engineer.

Curing of the completed curb shall be carried out in accordance with the requirements of CLAUSE 8410.

Concrete Curbs and Channels shall not be placed during rain. Surface water shall not be allowed to come into contact with the freshly compacted concrete.

Cast In-situ Concrete Curbs and Channels (Sliding Forms)

Curbs and Channels may be constructed in-situ between sliding forms either on previously constructed foundations or monolithically with the foundation, and/or backing.

Slip form or extruding machines used for constructing in-situ curbs shall be electronically guided for line and level along a guide line accurately fixed relative to the finished line and level of the Curbs and Channels.

The guide line shall be off-set at a constant height above, and parallel to, the top edge of the Curbs and Channels to an accuracy that will ensure compliance with the tolerances given in this Division. The guideline shall be supported from stakes not more than 5 metres apart by connectors capable of fine adjustment. The spacing of stakes on horizontal curves shall be appropriate to the radius of the curve.

The guide wires shall be supported from stakes not more than 8 metres apart by connectors capable of fine horizontal and vertical adjustment. The guide wires shall be tensioned on the stakes so that a 500 gram weight shall produce a deflection of not more than 20mm when suspended at the mid point between any pair of stakes. The ends of the guide wire shall be anchored to fixing points which shall not be closer to the edge of the slab than the row of stakes and in no circumstances shall a guide wire be anchored to a stake.

The stakes shall be positioned and the connectors maintained at their correct height and alignment from 12:00 hours on the day before concreting takes place until 36 hours after the concrete has been finished. The guide wire shall be erected and tensioned on the connectors at any section for at least two hours before concreting that section.

The Contractor shall submit to the Engineer, for his approval of line and level; the stakes, connectors and guide wires which are ready for use alongside the length of slab to be next constructed, by 09:00 hours on the working day prior to the day on which the slab is to be constructed. Any deficiencies, which are notified by the Engineer, shall be rectified by the Contractor who shall then reapply for the approval of the affected stakes. Work shall not proceed until the Engineer has given his approval. If any deficiencies are rectified by the Contractor and approved by the Engineer before 18:00 hours, or such later time agreed by the Engineer, the Contractor may proceed with construction the next day. Otherwise the Contractor shall resubmit any rectified stakes for approval on the next day.

Concrete for in-situ concrete Curbs and Channels constructed between sliding forms shall be mixed and transported in accordance with the requirements of Division 8400.

Curbs and Channels constructed between sliding forms shall have a Class F2 formed surface finish in accordance with the requirements of CLAUSE 8205.

Concrete shall be provided to the slip form or extruding machine at such frequency as will enable the machine to move forward continuously at the planned rate of progress.

Joints shall be constructed at intervals not exceeding 3 metres and at right angles to the longitudinal axis of the completed curb either by wet forming in the plastic concrete or by sawing in the hardened concrete in a manner approved by the Engineer.

Curing of the completed Curbs and Channels shall be carried out in accordance with the requirements of CLAUSE 8410.

Concrete Curbs and Channels shall not be placed during rain. Surface water shall not be allowed to come into contact with the freshly compacted concrete.

(v) Cast In-situ Asphalt Curbs

The materials shall be weighed and measured into a mechanical mixer and thoroughly mixed so that all particles of the aggregate are completely and uniformly coated. The temperature during mixing shall be within the range of 165^0C to 185^0C.

The curbs shall be laid on a tack coat complying with the requirements of Division 6200 as soon as practicable after the completion of the surface on which they one to be laid. The asphalt curb shall firmly adhere to the underlying surface.

Asphalt curbs shall not be placed during rain.

(d) Construction sequence

(i) Where Curbs and Channels are constructed before the base

In this case slip-form units or cast in-situ units may be constructed. During working and constructing the base, precautionary measures shall be taken to prevent the concrete work from being damaged or shifted.

(ii) Where Curbs and Channels are constructed after the base

The base shall be constructed wider than the specified width, after which a neat trench shall be dug for the Curbing or channelling. Any over-excavation shall be filled with concrete cast simultaneously with the Curbing and Channelling.

(iii) Where Curbs and Channels are constructed after the asphalt base and/or asphalt surfacing

The asphalt base and/or asphalt surfacing shall be constructed wider than the specified width and shall then be cut back accurately with a mechanical saw to a marked line to give a neat joint line between the Curbs and Channels and the asphalt layer. The base shall then be removed to the required depth.

Any concrete spilt onto the asphalt surface shall be removed. Where so required by the engineer, the contractor shall, without any additional compensation, paint emulsion over the stained surface.

3303 OPEN CONCRETE CHUTES AND DOWNPIPES, AND CONCRETE LININGS FOR OPEN DRAINS

(a) Dimensions

Open concrete chutes, down pipes, and concrete linings for open drains shall be constructed to the lines, gradients and cross sections shown in the Contract or as instructed by the Engineer.

(b) Material Requirements for Open Chutes, Downpipes, and Concrete linings for open drains

(i) Concrete

Concrete used for the construction of Open concrete chutes, down pipes, and concrete linings for open drains shall be Class 20/40 in accordance with the requirements of Division 8400.

(ii) Reinforcement

Reinforcement used for the construction of Open concrete chutes, down pipes, and concrete linings for open drains shall be steel reinforcement complying with the requirements of Division 8300.

(iii) Masonry and Stone Pitching

Masonry and stone pitching used for the construction of open chutes, down pipes, and linings for open drains shall be in accordance with the requirements of Division 8600.

(c) Construction Requirements for Open Chutes, down pipes, and linings for open drains

(i) Excavation, and preparation of bedding

The Contractor shall take the utmost care to avoid excavation below the required levels. Any excavation carried out below the required level due to over excavation or removal of unsuitable material or the presence of voids, shall be reinstated with suitable material approved by the Engineer and placed and compacted.

(ii) Concrete linings

The excavation work for open drains shall be executed and paid for in accordance with the provisions of section 4200.

The excavations shall then be neatly trimmed to the lines and levels specified so as to permit the accurate construction of the concrete linings. All loose material shall be compacted to a density of not less than 93% of modified AASHTO density.

Where the in-situ material is unsuitable, the Engineer may order that it be removed to the required depth and replaced with selected material compacted to a density of 93% of modified AASHTO density.

Where excavations for open drains are in rock, overbreak shall be backfilled as ordered, either with mass concrete or with selected natural gravel or soil compacted to a modified AASHTO density of at least 93%.

(iii) Chutes

Excavations for chutes shall be neatly trimmed. All loose material shall be thoroughly compacted, and where overbreak occurs in hard material, the excavations shall be backfilled with mass concrete. If required by the engineer, the excavations shall be taken deeper to accommodate a concrete screed cast to act as a working platform for the construction of the chutes.

Prefabricated chutes and downpipes on side slopes of fills and cuts

Prefabricated chutes and down pipes shall be manufactured in accordance with the dimensions shown on the drawings, and the units shall fit neatly into each other as shown.

The bottom unit shall rest against the outlet structure or footing as shown on the drawings.

The units shall be laid true to line and grade from the bottom up so that each unit fits neatly into the previous one.

A transition section shall be constructed at the inlet to lead the water into the chute or downpipe as shown on the drawings.

(iv) Cast in situ chutes on cut slopes

Cast in situ concrete chutes on cut slopes, together with the inlet and outlet structures, shall be constructed in accordance with the drawings. The class of concrete shall be as indicated on the drawings.

Where required by the engineer, a concrete screed shall first be cast on excavations that cannot be trimmed accurately. The screed shall be accurately finished to the level of the underside of the chute floor slab and allowed to set before the floor slab is cast. Where the material being excavated cannot be accurately trimmed or where the chute sides have to extend above the surface of cut slopes, the outer faces of the sides shall be cast against formwork.

(v) Concrete-lined open drains

The exposed surfaces of the concrete linings of open drains shall be given a class U2 surface finish. Concrete shall be cured in accordance with the requirements of clause 8410.

Sealed joints in concrete shall be in accordance with the details indicated on the drawings and the provisions of section 8408. Cold joints shall be painted with a coat of approved bituminous emulsion containing 60% of pure bitumen by mass, or with an approved anti-adhesive before any adjoining slabs are cast.

Expansion joints shall be made in accordance with the drawings.

Where required, the surfaces on which concrete lining is to be cast shall, after having been trimmed, be covered with polyethylene sheeting 0.15 mm thick and all joints in the sheeting shall be overlapped by at least 150 mm.

3304 INLET AND OUTLET STRUCTURES AND TRANSITION SECTIONS

Transition sections on curbing, curbing-channelling combinations and concrete-lined channels shall be constructed to the same standards and using the same methods described for the uniform sections, but with the required modifications. Sections may be either pre-cast or cast in- situ units.

Inlet and outlet structures may be either pre-cast or partially pre-cast concrete units or cast in situ concrete.

3305 CONSTRUCTION TOLERANCES AND SURFACE FINISH

(a) Concrete curbing and channelling

Concrete curbing and channelling shall be constructed to within the following dimensional and alignment tolerances:

(i) Horizontal alignment

Maximum deviation of edges, centre line, or vertical surfaces from specified positions, 25 mm.

(ii) Vertical alignment and level

The inside edge of channelling shall nowhere be above the finished road level nor more than 10 mm below the finished road surface. The invert level of channels and drains and the top of curbing shall nowhere deviate more than 10 mm from the required level and nowhere shall channels or drains have any adverse grade.

(iii) Trueness of exposed surfaces

When tested with a 3 m straight edge no surface irregularities shall exceed 6 mm.

(iv) Cross-sectional dimensions

All cross-sectional dimensions shall be within 6 mm of the specified dimensions except that the underside of channelling may extend up to 25 mm below the level at which it would have the required thickness.

(b) Concrete-lined channels

Concrete-lined channels shall be constructed to within the following tolerances:

(i) Horizontal alignment

The maximum deviation from the true position of the edges or centre line shall be 25 mm.

(ii) Vertical alignment

The invert level of concrete-lined open channels shall nowhere deviate more than 25 mm from the required level and nowhere shall the channel inverts have an adverse grade.

(iii) Trueness of exposed surfaces

When tested with a 3 m straight edge no exposed surface shall show surface irregularities or more than 10 mm.

(iv) Cross-sectional dimensions

All cross-sectional dimensions shall be within 10 mm of the specified dimensions and the average thickness of any invert or side slab shall not be less than the specified thickness when considering any complete slab or any slab section having a surface area of 10 sq m or

more and disregarding any thickness of more than 10 mm in excess of the specified thickness.

(c) Surface finish

All exposed concrete surface shall be Class U2 surface finish for unformed work and Class F2 surface finish for formed surfaces.

3306 MEASUREMENT AND PAYMENT

Item 33.01 Curbing

(a) Concrete Curbing (class of concrete indicated for in situ concrete) (Descriptions of type with reference to Drawing)..... metre (m)

(b) Stone Curbing (type of stone indicated) (Descriptions of type with reference to Drawing).....metre (m)

Item 33.02 Curbing -Channelling combination

(a) Concrete (class of concrete indicated for in situ concrete) (Descriptions of type with reference to Drawing).....metre (m)

(b) Stone (type of stone indicated) (Descriptions of type with reference to Drawing)..... .....metre (m)

The unit of measurement shall be the metre of concrete or stone curbing or curbing-channelling combination complete as constructed, measured along the front face of the curb.

The tendered rate for each metre of concrete or stone curbing and /or curbing -channelling combination shall include full compensation for the necessary excavation, bedding, backfilling formwork, concrete haunching or stone sawing, finishing, and for procuring, furnishing and installing all materials as specified.

Item 33.03 Chutes

(a) Concrete (class of concrete indicated for in situ concrete) (Descriptions of type with reference to Drawing).....metre (m)

(b) Stone (type of stone indicated) (Descriptions of type with reference to Drawing) .....metre (m)

The unit of measurement shall be the metre of completed chute as constructed, including any overlap, measured along the slope as laid but excluding transition sections and inlet and outlet structures measured separately.

The tendered rate per metre shall include full compensation for procuring, furnishing and installing the completed chutes as specified and for all excavation and the preparation of bedding, backfilling, formwork and finishing required.

Item 33.04 Cast in- situ concrete chutes (measured by components)

(a) Concrete (class indicated) .....cubic metre (m^3)

(b) Formwork (surface finish indicated) ..... square metre (m^2)

Measurement and payment for formwork and concrete shall be as specified in sections 8200 and 8400, except that payment for excavation and gravel or soil backfilling shall be deemed to be included in the rates tendered for concrete and shall not be measured and paid for separately.

Item 33.05 Inlet, outlet, transition and similar structures (typical designs)

(a) Concrete (Description of structure, type, etc, with reference to drawing and class of concrete).....number (No)

(b) Stone masonry (Description of structure, type, etc, with reference to drawing) ....Number (No)

The unit of measurement and payment shall be the number of completed units of each type of structure constructed, and payment shall include full compensation for all formwork, concrete or stone, excavation, trimming and backfilling, including such accessories as grids, etc, as may be specified on the typical drawings.

Item 33.06 Inlet, outlet, transition and similar structures (measured by components)

(a) Concrete (class indicated).....cubic metre (m^3)

(b) Stone masonry (class indicated).....cubic metre (m^3)

(c) Formwork (surface finish indicated).....square metre (m^2)

(d) Other components.....number (No)

The measurement and payment for formwork and concrete and shall be as specified in sections 8200 and 8400, except that excavation, trimming and backfilling shall not be measured and paid for separately, the cost of which shall be deemed to be included in the rates tendered for concrete and stone masonry.

The unit of measurement for other components such as grids shall be the number of each type of component installed. The tendered rates shall include full compensation for procuring, furnishing and installing the components, including any painting or protective coating specified in the project specifications or as shown on the drawings.

Item 33.07 Trimming of excavations for concrete-lined open drains

(a) In soft material.....square metre (m^2)

(b) In hard material.....square metre (m^2)

The unit of measurement shall be the square metre of excavation trimmed to receive concrete lining.

The tendered rates shall include full compensation for all labour, plant, materials and other additional work and incidentals necessary for trimming the excavations for open drains to the standard of finish required for the construction of concrete linings. All excavation, including the removal of unsuitable ground and backfilling with suitable material, shall be measured and paid for under section 4200. Payment shall distinguish between trimming in soft material and trimming in hard material as defined in clause 4204. No extra payment shall be made in respect of any soil or gravel backfilling, additional concrete or mass-concrete backfilling required on account of overbreak or unavoidable unevenness of the excavations in difficult ground, the cost of which shall be deemed to be included in the tendered rates for trimming in hard material.

Item 33.08 Concrete lining for open drains

(a) Cast in-situ concrete lining (concrete and type of open drain indicated)..... ..... cubic metre (m^3)

(b) Class U2 surface finish to cast in situ concrete (type of open drain indicated) .... square metre (m^2)

Measurement of and payment for concrete shall be as specified in section 8400, but the tendered rate shall include full compensation for painting open joint surfaces as specified.

The unit of measurement for surface finish shall be the square metre of finished surface.

The tendered rate for surface finish shall include full compensation for all labour, plant, material and other additional work and incidentals required for trimming the concrete lining as specified.

Item 33.09 Formwork to cast in- situ concrete lining for open drains (class F2 surface finish)

(a) To sides with formwork on the internal face only..... square metre (m^2)

(b) To sides with formwork on both internal and external faces (each face measured) .... square metre (m^2)

(c) To ends of slabs ..... square metre (m^2)

Measurement of and payment for formwork shall be as specified in section 8200. Formwork under item 33.09(a) shall be measured and paid for only when the side slope of the slabs exceeds 1 in 2 and the slabs cannot be constructed without formwork even when a stiff concrete mix is used. When the contractor elects to use pre-cast side slabs, payment will be made for formwork as if cast in- situ concrete had been used.

Item 33.10 Sealed joints in concrete linings of open drains (description of type with reference to drawing) .....metre (m)

The unit of measurement shall be the metre of completed joint of each size and type.

The tendered rate shall include full compensation for the supply of all materials and for all labour, formwork and incidentals necessary for sealing the joint as shown on the drawings or specified in the project specifications.

Item 33.11 Concrete screed or backfill below chutes (class of concrete indicated)) ....cubic metre (m^3)

The unit of measurement shall be the cubic metre of concrete screed or backfill as may be instructed by the engineer to be placed below chutes.

The tendered rate shall include full compensation for furnishing, procuring and placing the concrete in screed or backfill.

Item 33.12 Steel reinforcement

(a) Mild steel bars .....ton (t)

(b) High-tensile steel bars .....ton (t)

(c) Welded steel fabric .....kilogram (kg)

Measurement and payment shall be in accordance with the provisions of section 8300.

Item 33.13 Polyethylene sheeting (0.15 mm thick) for concrete-lined opendrains..... .....square metre (m^2)

The unit of measurement shall be the square metre of area covered with polyethylene sheeting.

The tendered rate shall include full compensation for procuring, furnishing and installing the polyethylene sheeting, including wastage and overlap.

Item 33.14 Cutting bituminous surfacing and pavement layers for concrete kerbing, channelling or concrete-lined drains .....metre (m)

The unit of measurement shall be the metre of bituminous surfacing and pavement layers cut where instructed by the engineer, irrespective of the depth of cut. The various layers shall not be measured separately for payment.

The tendered rate shall include full compensation for all labour, construction plant and materials required for cutting the surfacing and pavement layers to the required depth, removing and disposing of the debris, and protecting and keeping the surfacing clean, all as specified.

Item 33.15 Pre-cast concrete blocks in outlet structures ..... number (No)

The unit of measurement is the number of pre-cast concrete blocks provided and installed as shown on the drawings or directed by the engineer.

DIVISION 3400: PITCHING, STONEWORK, AND EROSION PROTECTION

3401 SCOPE

This Division 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 all as shown on the Drawings or ordered by the Engineer.

3402 MATERIALS

(a) Stone

(i) Stone for pitching shall be sound, tough and durable, with no stone less than 200 mm in minimum dimension, except that smaller pieces or spalls may be used for filling 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 job shall receive the prior approval of the Engineer.

(ii) Stone for riprap 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 required size of stone will be determined by the "critical mass" specified. At least 50% by mass 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.

(b) Cement

Cement shall be ordinary Portland cement complying with the requirements of BS 12 Part 2 or Type II, AASHTO M 85.

(c) Sand

(i) Sand for cement mortar

Sand for the cement mortar shall comply with the requirements of BS 882.

(ii) Sand for bedding

Sand for bedding used for paving blocks shall not contain any deleterious impurities and shall comply with the following grading requirements:

Sieve size (mm)	% Passing through
9.52	100
4.75	95-100
2.36	80 - 100
1.18	50-85
0.600	25 - 60
0.300	30 - 10
0.150	5 - 15
0.075	50 - 10

(iii) Sand for joints

Sand used for being brushed into the joints between pavement blocks shall all pass through a 1.18 mm sieve, and between 10 and 15 per cent of it shall pass through a 0.075 mm sieve.

(d) Pre-cast concrete blocks

Interlocking concrete blocks shall be factory produced pre-cast concrete blocks manufactured from concrete having a 28- day crushing strength of not less than 20 MPa. The design shall be subject to the Engineer's approval and must ensure a sound interlock between adjacent blocks. The thickness shall be as indicated on the Drawings and the blocks shall be manufactured to a tolerance of 3 mm in any dimension.

Square precast concrete blocks for sidewalks shall, unless otherwise specified, measure 450 x 450 x 50 mm and shall be manufactured from Class 20/20 concrete. The requirements for appearance shall be as specified in BS 368. The upper surface of the concrete block shall have an approved skid resistant pattern.

(e) Concrete

Concrete work shall be carried out in accordance with the provisions of Division 8400.

(f) Wire

Wire for wired pitching shall consist of 4.0 mm diameter galvanized wire complying with the requirements of BS 183.

(g) Permeable material for filter layer

Permeable material for filter layer shall comply with the requirements specified for permeable material for subsurface drains in Sub-clause 3107 (ii).

(h) Synthetic fiber filter fabric (Geotextiles)

Synthetic fiber filter fabric shall be of the grade and type specified in the Schedule of Quantities or project specifications, and shall comply with the requirements of sub-clause 3107 (iii)

3403 STONE PITCHING

(a) Dry stone pitching

The area shall be prepared by excavation, shaping and trimming to accommodate the stone work and shall be thoroughly compacted by hand-ramming to minimize subsequent settlement. 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 streams.

(i) Method 1

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 invert 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.

(ii) Method 2

The technique and requirements laid down in method 1 shall also apply to method 2, except in the following aspects:

(i) No small stones or spalls shall be used to fill in spaces between larger stones.

(ii) Simultaneously with the placing of stones, topsoil shall be introduced between individual stones, and sufficiently rammed so as to provide a firm bonded structure. The topsoil shall be provided to the full depth of the stone pitching at any point.

(iii) Rooted grass or tufts of grass shall then be planted in the topsoil between stones, and watered immediately and copiously and thereafter at regular intervals until grass has been established.

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

(b) Grouted stone pitching

This work shall be done in accordance with all the requirements specified for dry pitching in Subclause 3403(a) above, except that the spaces between the stones shall be filled with cement mortar composed of one part of cement to three parts of sand. Before the mortar is applied the surfaces of the stones shall be thoroughly cleaned of adhering dirt and clay and then moistened.

The mortar shall be placed in a continuous operation for any day's run at any one location. The mortar shall be worked into the pitching so as to ensure that all spaces or voids between the stones are completely filled with mortar, and 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 a period of not less than 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.

(c) Wired and grouted stone pitching

The pitching shall be held in position below and above with wire nets of 150 mm square mesh. The lower net with wire ties fastened to it at 600 mm centers and projecting outwards, shall fist be placed over the surface to be pitched. The stone shall then be laid on this net in accordance with the requirements specified for dry stone pitching in Subclause 3403(a) above. After the stone has been laid the upper wire net shall be drawn tightly over the stone course and securely fastened down by means of the wire ties passing from the lower net through the pitching. After tying, these ties shall be turned down into the pitching. The whole area of wired pitching shall then be grouted and finished off with cement mortar in accordance with all the requirements specified for grouted stone pitching in Subclause 3403(a) above.

(d) Grouted stone pitching on a concrete bed

The area to be pitched shall be prepared as described in subclause 3403(a) and a concrete bed in accordance with the provisions of Division 6400 with a thickness of at least 75 mm shall then be placed. The stone pitching shall be of stones with a minimum dimension of 200 mm, which shall be laid while the concrete is still fresh. Openings between stones shall be filled with cement grout as described in subclause 3403(b), and care shall be taken not to spill the grout onto the finally exposed surfaces of the stones. Grout spilt onto the exposed surfaces of the stones shall be removed while still soft, and the joints between stones shall be neatly finished.

Curing shall be done as described for grouted stone pitching in subclause 3403(b).

The completed pitching shall have an even compacted appearance, and nowhere may the surface deviate by more than 25 mm from the specified lines and grades.

3404 RIPRAP

(a) General

Riprap shall consist of a course or courses of large rock placed on bank slopes and toes, river and streambeds and other localities where protection of this type may be required. Stone for riprap shall conform to 3402(a)ii. Two types of riprap are specified, one type where the rocks are individually packed, designated as packed riprap and another type where the stone is dumped and then spread by machines, designated as dumped riprap.

The surface of areas to receive riprap shall be neatly trimmed to line and level and all loose material compacted. 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.

(b) Filter bed

Filter bed shall consist of a layer or layers of permeable material placed on the prepared surface to the required thickness and finished to an even surface and thickness after placing

each layer. Compaction of previous material will not be required. Care shall be taken neither to mix various grades of filter materials nor to disturb material already placed when constructing subsequent layers or riprap.

When the use of synthetic fibber filter fabric is required the material shall be placed on the prepared surface, or on the filter backing as may be required. The overlap between adjacent sheets shall be 150 mm unless otherwise specified. Care shall be taken not to damage the filter fabric when placing subsequent layers, nor to expose the filter fabric when placing subsequent layers, nor to expose the filter fabric to the sun for periods of more than a day before covering up.

(c) Packed riprap

Packed riprap shall be constructed from rocks individually placed to break joints and firmly bedded on the prepared surface. The spaces between larger stones shall be filled with spalls and smaller stones securely rammed into place. On inclined surfaces the rock shall be laid in long horizontal lengths starting from the bottom and not in strips up the slope. The completed riprap shall present an even, tight surface. Local surface irregularities of the riprap shall not exceed 150 mm.

(d) Dumped riprap

Dumped riprap shall be constructed by dumping the stone on the prepared surfaces, spreading it by means of bulldozers, or other suitable earthmoving equipment and trimming to the required lines and levels. The material shall be placed in a manner that will prevent segregation of the small and larger stone and the final layer shall be tight with a minimum of voids.

The gradation requirements for riprap are shown in Table 3404/1:

Table 3404/1 Gradation Requirements for Riprap

Class	Mean Diameter D50	Critical Mass Kg.	Percent of Rock By Mass	Mass Kg.	Approximate Cubic Dimension Mm
1	125	5	20	10 to 15	150 to 200
			30	5 to 10	125 to 150
			40	0.5 to 5	50 to 125
			10	0 to 0.5	0 to 50
2	175	10	20	25 to 50	200 to 250
			30	10 to 25	150 to 200
			40	1 to 10	75 to 150
			10	0 to 1	0 to 75
3	300	50	20	100 to 150	350 to 400
			30	50 to 100	250 to 350
			40	5 to 50	125 to 250
			10	0 to 5	0 to 125
4	400	100	20	250 to 350	450 to 500
			30	100 to 250	350 to 450
			40	10 to 100	150 to 350
			10	0 to 10	0 to 150
5	500	350	20	700 to 1000	650 to 700
			30	350 to 700	500 to 650
			40	25 to 350	200 to 500
			10	0 to 25	0 to 200
6	600	500	20	850 to 1600	700 to 850
			30	500 to 850	550 to 700
			40	50 to 500	250 to 550
			10	0 to 50	0 to 250

3405 DRY STONE MASONRY WALLS

(a) General

Stone masonry walls may be plain with dry joints or constructed with stones set in cement mortar as indicated on the Drawings, specified or ordered.

The minimum mass of stone shall be 10 kg. The minimum dimension of stone shall be 75 mm.

(b) Dry 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 laid with their largest dimension in the horizontal plane.

The finished surface of the wall shall present an even, tight and neat appearance with no stones varying by more than 50mm from the specified surface grade or line.

All stones shall be carefully set with a bond stone provided at the rate of not less than one to every square meter of exposed face. Bond stones shall measure not less than 150mm by 150mm on the exposed face and not less than 450mm in length or the full thickness of the wall if the latter is less than 450 mm.

(c) Cement mortared stone masonry walls

The walling shall be constructed as specified in (b) above, with the exception that the stones shall be wetted and set in a 6:1 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.

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 walling shall be protected from the elements and kept moist for a minimum period of four days after completion.

3406 CONCRETE BLOCK PITCHING

(a) General

The underlying layers for surfaces to be pitched shall be constructed as specified or as indicated on the drawings. Where no specified requirements have been set in respect of the underlying layers, the top layer shall be mechanically compacted to at least 90% of modified AASHTO density down to at least 150 mm from the top. During this process the top layer shall be trimmed to the required grades and levels.

Where specified or required by the engineer the prepared surface shall be treated with approved environmentally friendly herbicide and ant poison before the layer of sand for bedding is placed.

Where required a layer of sand for bedding shall be placed on top of the prepared surface, and, when still loose, accurately floated to an uncompacted thickness of 30 mm (plus or minus 5 mm) so as to afford the correct level to the pavement after compaction. Sand for bedding shall be placed immediately before the paving blocks are laid and shall not be compacted before the blocks have been laid.

The pattern for laying the paving blocks shall be that as shown on the drawings or approved or prescribed earlier on by the engineer. Unbroken blocks shall first be laid and filler pieces afterwards. Filler pieces shall be neatly sawn or hewn to fit exactly into the space to be filled.

Spaces of less than 25% of a full-sized block may be filled with 25 MPa concrete. The joints between blocks shall be sized between 2 and 6 mm, and the top faces of blocks shall be flush. After the paving blocks have been laid, and where required, the pavement shall be compacted by vibrating-plate compactor. After compaction of the pavement as described above, joint sand shall be spread and brushed into the joints until the joints have been properly filled. Any

surplus sand shall then be broomed off and where required the pavement shall then be subjected to two further passes by the plate vibrator.

(b) Interlocking type concrete blocks

On surfaces paved for pedestrian or cycle traffics a 50 mm layer of sand shall first be spread and leveled on the surfaces to be paved. When required the prepared surfaces shall be treated with approved vegetation destroyer and/or ant poison in accordance with the Engineer's instructions. The concrete blocks shall then be laid up against each other with each block interlocking with the previously laid blocks.

At edges special edge blocks shall be placed or the edges shall be finished by means of concrete edge beams to the dimensions shown on the Drawings. Concrete shall be Class 20/20 concrete. Earth cuts may be used as forms for the vertical surfaces of edge beams if such cuts are suitable. Where formed vertical faces are used they shall be Class F2 finish. The upper surface shall be Class U2 surface finish.

The finished surface of the pitching shall present an even and neat appearance with no concrete blocks projecting above the surface. The pitching shall not vary by more than 15 mm from the specified lines and grades.

(c) Pre-cast concrete blocks for sidewalk pavements

The areas shall be prepared as specified for interlocking type concrete blocks including a 50 mm sand bed. Hereafter the concrete blocks shall be placed on the prepared areas. Where required the joints shall be grouted with 3:1 sand: cement mortar. The finished surface shall not vary by more than 10 mm from the specified surface lines and grades and shall be flush with any kerbing at the edges.

3407 CAST IN SITU CONCRETE PITCHING

The areas where cast in- situ concrete pitching is to be constructed shall be compacted, trimmed and prepared as described in subclause 3406 for concrete block pitching. The areas shall also be treated with vegetation destroyer and ant poison if required.

Prior to the placing of concrete the surface shall be watered and kept damp until concrete is placed. The type of concrete used shall, unless otherwise specified, be Class 25/20 and shall be accurately laid in alternate panels to the lines and levels indicated. Accurate screeds shall be set to achieve the required line and slope. The concrete shall be thoroughly compacted and finished to a Class U2 surface finish.

Where indicated the concrete pitching shall be contained by the construction of concrete edge beams constructed as described in Clause 3406(b) for interlocking type concrete blocks.

The concrete pitching shall be cured for at least seven days and no traffic shall be allowed to move across the pitching before the specified 28-day strength has been reached.

The final surface may nowhere deviate by more than 25 mm from the specified levels and planes, and no irregularities exceeding 10 mm may occur during testing with a 3 m straight-edge.

3408 MEASUREMENT AND PAYMENT

Item 34.01 Stone Pitching

(a) Plain pitching

i) Method 1 ..... square meter (m^2)

ii) Method 2 ..... square meter (m^2)

(b) Grouted pitching ..... square meter (m^2)

(c) Wired and grouted pitching ..... square meter (m^2)

The unit of measurement for pitching shall be the square meter of each type of pitching in place.

The tendered rate for each type of stone pitching shall include full compensation for furnishing all materials, excavations excluding trench and bulk excavations, compaction and trimming of excavated areas, forming and cleaning of weep holes, placing of stones, grouting where applicable; and for all other work necessary to complete the pitching as specified. The tendered rate for grouted stone pitching on a concrete bed shall also include full compensation for the concrete bed.

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

Item 34.02 Riprap

(a) Packed riprap (class indicated) ..... cubic meter (m^3)

(b) Dumped riprap (class indicated)) ..... cubic meter (m^3)

(c) Filter layer [Subclause 3104(a)] and 3104 (b)

(i) Crushed stone ..... cubic meter (m^3)

(ii) Filter sand obtained from borrow pits) ..... cubic meter (m^3)

(d) Synthetic fiber filter fabric (type class and grade stated) ..... square meter (m^2)

The unit of measurement for riprap, (sub items (a), (b) and (c) above) shall be the cubic meter of riprap in place including rock in trench backfill. The unit of measurement for sub-item (d) shall be the square meter of filter fabric laid as specified including overlaps.

The rates tendered for sub items (a), (b) and (c) shall include full compensation for the preparation of surfaces, including excavation but excluding excavation for trenches and bulk excavations and for the furnishing, transporting, handling, and placing of riprap. The rate tendered for subitem (d) shall include full compensation for procuring and furnishing the filter fabric and for laying it as specified, including wastage. Collectively the rates shall also include full compensation for all other incidentals necessary for completing the work as specified.

Item 34.03 Stone masonry walls

(a) Dry stone masonry walls ..... cubic meter (m^3)

(b) Cement-mortared stone walls ..... cubic meter (m^3)

The unit of measurement for stone masonry walls shall be the cubic meter of actual walling constructed and accepted.

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 and all other work necessary to complete the walls as specified. Excavation of foundation trenches will be paid separately.

Item 34.04 Concrete pitching

(a) Cast in situ concrete pitching (Class of concrete and thickness of pitching indicated) .....square meter (m^2)

(b) Interlocking pre-cast concrete block pitching (Type and thickness indicated)..... .....square meter (m^2)

(c) Pre-cast concrete blocks for side walk pavement (thickness indicated)..... ..... square meter (m^2)

The unit of measurement shall be the square meter of each type constructed.

The tendered rates shall include full compensation for furnishing all materials, all excavation (but excluding bulk excavation and excavation for foundation trenches and edge beams), compacting and trimming of all excavated areas, provisions of sand bedding (Sub- items (b) and (d) topsoiling and grassing, (Sub-item (c)), the forming and cleaning of weep holes (Sub-item (a) and for all other work necessary to complete the Work as specified.

Item 34.05 Concrete in edge beams and foundation trenches (Class of concrete indicated)..... cubic meter (m^3)

The unit of measurement shall be the cubic meter of concrete in edge beams and foundation trenches constructed as instructed.

The tendered rates shall include full compensation for furnishing all materials and labor, including formwork as necessary, for placing concrete and shaping all surfaces.

Item 34.06 Excavations for edge beams and foundation trenches

(a) In solid rock (material requiring blasting) .....cubic meter (m^3)

(b) In all other classes of material .....cubic meter (m^3)

The unit of measurement in each class of material shall be the cubic meter of excavation made in accordance with the authorized dimensions.

The tendered rates shall include full compensation for excavation in each class of material including for overbreak and any additional concrete necessitated by overbreak, for trimming of trenches and compaction of the trench inverts and for the disposal of surplus excavated material to spoil.

Item 34.07 Provision Of approved herbicide and ant poison

(a) Provision of materials .....prime cost sum

(b) Contractor's charges and profit added to the prime cost sum .....per cent (%)

Payment under the prime cost sum for providing ant poison and herbicide and the contractor's costs and profit in this respect shall be made in accordance with the provisions of the general conditions of contract, but, in addition, the contractor's tendered rate for costs and profit shall include full compensation for applying the chemicals as specified.