INFRASTRUCTURE FOR BIODIVERSITY CONSERVATION IN KIDEPO VALLEY NATIONAL PARK

Construction of Kidepo River Low Water Stream Crossing

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BIDDING DOCUMENTS
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TECHNICAL SPECIFICATION

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SERIES 2000

DRAINAGE

CONTENTS OF THE GENERAL SPECIFICATIONS:

SERIES 2000: DRAINAGE

SECTION 2100: DRAINS

CONTENTS:

2101 SCOPE

This Section covers all work in connection with the excavation and construction of open drains, subsoil drainage, french drains 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 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.

2102 OPEN DRAINS

Open-drain excavation shall involve the excavating of open drains and channels, including channels to direct the course of streams, all as shown on the Drawings or as directed by the Engineer.

Any excavation required for constructing a channel or open drain within the road prism, such as median drains, side drains and open drains on excavation-slope benches, shall be classed as Common Excavation or Rock Excavation as defined in CLAUSE 3603 and shall be measured and paid for under SECTION 3600.

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 taken to avoid excavation below the required grades for the open drains and any excavation carried beyond the required grade shall be backfilled with suitable, approved, material and compacted to at least 90% of BS-Heavy density by the Contractor at his/her own expense.

Material resulting from the excavations for open drains shall be used in the construction of fills, banks and dykes, or for other purposes, or shall be disposed of to spoil, all as directed by the Engineer.

If ordered by the Engineer, all existing open drains, but excluding open drains constructed by the Contractor himself/herself, shall be cleared and, where necessary, shaped by removing the sediment and trimming the floors and sides.

Any pitching of open drains ordered by the Engineer shall be done in accordance with the requirements of SECTION 2500. The concrete lining of open drains shall be done as specified in SECTION 2300.

All culverts indicated by the Engineer shall be cleared. The Contractor shall remove all undesirable materials, all silt, sediment, driftwood, debris and rubble that have accumulated in and around the culvert inlet and outlet structures and in the culvert barrels. All materials resulting from the clearing operations shall be disposed of at locations approved by the Engineer. The clearing shall preferably be done by means of hand tools in order to prevent damage to existing drainage and other structures. The Contractor shall repair all structures damaged by him/her at his/her own cost, and to the satisfaction of the Engineer.

2103 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 that 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 BS-Heavy density in layers not exceeding 150 mm in thickness or as approved by the Engineer.

If so preferred by the Contractor and approved by the Engineer, mitre banks may also be constructed of hand-packed stone, provided that the interstices are filled with an approved cohesive soil.

2104 SUBSOIL DRAINAGE

(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:

(1) Perforated pitch-fibre pipes complying with BS 2760:1973 or equivalent.

(2) Perforated or slotted unplasticised PVC pipes complying with BS 4660:2000 and BS EN 1401-1:1998 or equivalent.

(3) Perforated high-density polyethylene pressure pipes complying with the requirements of BS EN 253:2003 or equivalent.

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 metre shall be not less than 26 for 100 mm pipes and 52 for 150 mm pipes. Perforations shall be spaced in two rows for 100 mm pipes and four rows for 150 mm pipes. All rows shall be in the lower half of the pipe but no row shall be closer than 36 degrees to the invert. Perforations in each row shall be a maximum of 100 mm centre to centre.

Slotted pipes shall have a slot width of 3 mm ±1.0 mm and slot length of 8 mm ±1.5 mm and the inlet area per metre shall not be less than 22.5 cm^2/m pipe. The arrangement of slots shall be to the Engineer's approval.

Pipes without slots or perforations required for conveying ground water from the subsoil drainage proper to the point of discharge, shall be unperforated pitch fibre, PVC or polyethylene pipes of the types specified above, or concrete pipes complying with the requirements of BS 5911-1:2002 and BS EN 1916:2002 or BS 5911-110:1992, or equivalent.

(ii) Permeable filter material
Permeable filter materials for bedding and surrounding of drain pipes shall consist of crushed stone of suitable grading. Crushed stone shall be of hard, clean rock. If permeable filter material conforming to the criteria given below is not obtainable in the opinion of the Engineer, then geotextile shall be used as directed by the Engineer.

Permeable filter material shall be free of organic material, silt or clay lumps and shall conform to the following requirements:

(1) d_{85} for the permeable filter material shall be minimum 1.25 times the width of the slots in the drainage pipe

(2) d_{15} for the permeable filter material shall be maximum 5 times d_{85} for the adjacent soils

(3) d_{50} for the permeable filter material shall be maximum 25 times d_{50} for the adjacent soils

(4) d_{15} for the permeable filter material shall be minimum 5 times d_{15} for the adjacent soils

(5) the permeable filter material shall have maximum 50 % passing the 2 mm sieve

(6) the permeable filter material shall have maximum 3 % passing the 0.075 mm sieve

Where:
d_{15}, d_{50} and d_{85} are the corresponding grain sizes which 15%, 50% and 85% respectively passes in the sieve analysis

The filter criteria shall be complied with for both the surrounding soil (subgrade) and for possible pavement layers above the drain pipe.

Sieve analysis of the surrounding subgrade and or subbase shall be performed at each 100 m trench and the filter material shall be adjusted according to the above specified filter criteria. If necessary, the Engineer can at any position demand further sieve analysis.

The sieve analysis for the subgrade, subbase and filter materials must be approved by the Engineer before commencement of the drain pipe works. All costs to perform sieve analysis are to be included in the rates for subsoil drains.

(iii) Geotextile fabric
Should the use of geotextile fabric in subsoil drainage, or as filter blankets, or for any other purposes, be specified, it shall comply with the requirements as specified in SECTION 2700. The fabric shall not be exposed to direct sunlight for prolonged periods and shall be protected from mechanical damage during installation and construction.

(iv) Composite in-plane draining fabric
The make and class of fabric shown on the Drawings or approved by the Engineer shall be used.

(b) Construction of subsoil drainage systems

(i) With natural permeable filter 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 filter 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 permeable filter material, true to level and grade, and be coupled in accordance with the requirements. Thereafter the trench shall be backfilled with natural permeable filter material in layers not exceeding 250 mm thickness and lightly compacted to such height above the pipes as shown on the Drawings or as directed by the Engineer. The natural permeable filter material shall be lightly compacted and trimmed to the required level. Further layers of finer natural permeable filter material 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.

The total thickness of each type of natural permeable filter 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 far as possible, shall not be disturbed. Care shall be taken to prevent the contamination of natural permeable filter material during construction of the subsoil drainage system and all natural permeable filter material contaminated by soil or silt shall be removed and replaced by the Contractor at his/her 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 lined 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 filter material, care shall be taken not to displace or damage the polyethylene lining in any way. The use of plastic other than polyethylene will be considered, provided that the material is of equal quality and is approved by the Engineer.

(iii) With geotextile fabric
Where specified that geotextile fabric shall be used for lining in subsoil drainage systems, it shall be procured, furnished and installed as specified and shown on the Drawings. The fabric shall not be displaced or damaged in any way when the trench is being filled with natural permeable filter material. The filter fabric shall be lapped both longitudinally and transversely by at least 300 mm or as prescribed by the manufacturers. The transverse lap shall be positioned on top of the box forming the drain and shall be stitched together with plastic/galvanised wire or strong synthetic thread at 1.0 m intervals. The longitudinal lap shall be in the direction of flow.

Geotextile fabric shall meet the requirements in SECTION 2700 and shall be stored under suitable cover. The fabric 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 geofibre 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 the 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.

(d) Transport and storing of drain pipes
The full length of the pipe shaft shall rest on the loading area of the lorry used for transporting the pipes. Overhanging of pipes, to prevent sagging and deformation shall be avoided. Rough handling and dragging of pipes and fittings shall be avoided. All pipes and fittings shall be protected from sunlight during transportation by use of tarpaulins. Grass cover will not be accepted.

The Contractor shall advise the manufacturer of the climatic and transporting conditions at the site of the Works and shall seek his/her advice on the storage of PVC materials on site. Subject to the Engineer's approval, this advice shall be followed at all times.

PVC pipes shall not be stored on top of each other to a height exceeding 1.5 m. Pipes shall be staggered to prevent the sockets to rest on the shaft of the pipes. The first tier shall be placed on a well drained layer of sand.

(e) Drain Markers
Subsoil drains shall be marked on the ground as follows:

(i) Wherever practicable, concrete markers in accordance with SECTION 5100 shall be placed at the start of the subsoil drain. The concrete markers shall be painted and provided with identification number as directed by the Engineer.

(ii) In rock cuttings or where concrete kerb or lining are provided, paint marks, approximately 150 mm x 150 mm in size, shall be used in lieu of the above concrete markers. No separate payment for provision of such paint mark will be made.

2105 FRENCH DRAINS

French drains shall be constructed at the locations and to the dimensions shown on the Drawings or as directed by the Engineer.

The trench shall be excavated to the required width and depth, levelled, and smoothened to the satisfaction of the Engineer prior to filling with aggregates. The specified gradation of fine or coarse aggregate shall then be placed to the required depth and covered with the next specified layer of material.

When the use of geotextile is specified for lining the trench, the geotextile shall be delivered to the Site in such a manner to facilitate handling and incorporation into the work without damage. In no case shall the geotextile be stored and exposed to direct sunlight that might significantly diminish its strength or toughness. Torn or punched geotextile shall not be used.

After the trench has been approved by the Engineer, the geotextile shall be loosely rolled out so the centre of the geotextile is at the centreline of the excavated trench, and it will not tear when the aggregate is placed. When more than one section of the geotextile is used, the geotextile shall overlap a minimum of 600mm or to the manufacturer's specification (whichever is more). Enough geotextile shall remain uncovered after the trench is filled to provide for geotextile overlap at the top.

Measurement and payment shall be made under ITEMS 21.01, 21.04, 21.06 and 21.10.

2106 CLASSIFICATION OF MATERIALS

All excavations for open drains and subsoil drainage systems shall be classified as follows for payment purposes.

(a) Rock material
Material that conforms to the definitions in Clause 3603 shall be classified as rock material.

(b) Soft Material
All materials not classified as rock material in accordance with CLAUSE 3603 shall be classified as soft material.

2107 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.

2108 MEASUREMENT AND PAYMENT

ITEM	UNIT
21.01 EXCAVATION FOR OPEN DRAINS:	
(a) EXCAVATING SOFT MATERIAL SITUATED WITHIN THE FOLLOWING DEPTH RANGES BELOW THE SURFACE LEVEL:	
(i) 0.5 m UP TO 1.5 m	CUBIC METRE (m^3)
(ii) Exceeding 1.5 m AND UP TO 3.0 m	CUBIC METRE (m^3)
(iii) Exceeding 3.0 m PER INCREMENT OF 1.5 m	CUBIC METRE (m^3)
(b) EXTRA OVER SUBITEM 21.01(a) FOR EXCAVATION IN ROCK AS DEFINED IN CLAUSE 3603, IRRESPECTIVE OF DEPTH:	CUBIC METRE (m^3)

The unit of measurement shall be the cubic metre of material excavated in accordance with the authorised dimensions, measured in place before excavation.

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

ITEM	UNIT
21.02 CLEARING AND SHAPING EXISTING DRAINS:	CUBIC METRE (m^3)

The unit of measurement shall be the cubic metre of material excavated in accordance with the authorised dimensions, measured in place before excavation.

The bid rates shall include full compensation for excavating the material to the required lines, levels and grades, protecting the existing drainage structure, trimming the sides and floors of the open drains and the disposal of the material as directed, including all haulage.

The clearing of existing concrete side drains will be measured and paid for under ITEM 21.17.

ITEM	UNIT
21.03 EXCAVATION FOR SUBSOIL DRAINAGE SYSTEMS:	
(a) EXCAVATING SOFT MATERIAL SITUATED WITHIN THE FOLLOWING DEPTH RANGES BELOW THE SURFACE LEVEL:	
(I) 0.5 m UP TO 1.5 m	CUBIC METRE (m^3)
(II) Exceeding 1.5 m AND UP TO 3.0 m	CUBIC METRE (m^3)
(III) Exceeding 3.0m PER INCREMENT OF 1.5 m	CUBIC METRE (m^3)
(b) EXTRA OVER SUBITEM 21.03(a) FOR EXCAVATION IN ROCK AS DEFINED IN CLAUSE 3603, IRRESPECTIVE OF DEPTH:	CUBIC METRE (m^3)

The unit of measurement shall be the cubic metre of material excavated in accordance with the authorised dimensions, measured in place before excavation.

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

The bid 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 determined according to SUBCLAUSE 1602(c).

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	UNIT
21.04 IMPERMEABLE BACKFILLING TO SUBSOIL DRAINAGE SYSTEMS	CUBIC METRE (m^3)

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 authorised dimensions.

The bid rate shall include full compensation for procuring, furnishing, placing and compacting the backfilling including all haulage.

ITEM	UNIT
21.05 BANKS AND DYKES	CUBIC METRE (m^3)

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 authorised dimensions.

The bid rate shall include full compensation for procuring, furnishing, placing, watering, compacting, shaping and trimming the material in the banks and dykes including all haulage

ITEM	UNIT
21.06 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)
b) CRUSHED STONE OBTAINED FROM COMMERCIAL SOURCES (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 authorised dimensions. The volume occupied by the pipe shall be deducted when calculating the volume of the permeable material.

The bid rate for Item 21.06(a) shall include full compensation for procuring, furnishing and transporting from the source and placing the material as specified.

The bid rate for Item 21.06(b) shall include full compensation for procuring and furnishing 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	UNIT
21.07 NATURAL PERMEABLE MATERIAL IN SUBSOIL DRAINAGE SYSTEMS (SAND):	
(a) SAND OBTAINED FROM APPROVED SOURCES ON THE SITE	CUBIC METRE (m^3)
(b) SAND OBTAINED FROM APPROVED SOURCES OUTSIDE THE SITE	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 authorised dimensions. The volume occupied by the pipes shall be deducted when calculating the volume of the permeable material.

The bid rate shall include full compensation for procuring, furnishing, transporting from the borrow areas on the site or outside the site as the case may be and placing the sand as specified.

ITEM	UNIT
21.08 PIPES IN SUBSOIL DRAINAGE SYSTEMS:	
(a) PITCH-FIBRE PIPES AND FITTINGS COMPLETE WITH COUPLING (STATE SIZE AND WHETHER OR NOT PERFORATED)	METRE (m)
(b) UNPLASTICISED PVC PIPES AND FITTINGS, NORMAL DUTY, COMPLETE WITH COUPLINGS (STATE SIZE AND WHETHER OR NOT PERFORATED 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 bid rate shall include full compensation for procuring, furnishing, laying and jointing the pipes and fittings as specified.

ITEM	UNIT
21.09 POLYETHYLENE SHEETING, 0.15 mm THICK, OR SIMILAR APPROVED MATERIAL, FOR LINING SUBSOIL DRAINAGE SYSTEM	SQUARE METRE (m^2)

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

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

ITEM	UNIT
21.10 SYNTHETIC-FIBRE FILTER FABRIC (DESCRIBE TYPE AND GRADE)	SQUARE METRE (m^2)

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

The bid 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	UNIT
21.11 COMPOSITE IN-PLANE DRAINAGE SYSTEMS (DESCRIBE TYPE AND GRADE)	SQUARE METRE (m^2)

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

The bid 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	UNIT
21.12 CONCRETE OUTLET STRUCTURES, MANHOLE BOXES, JUNCTION BOXES AND CLEANING EYES FOR SUBSOIL DRAINAGE:	
(a) OUTLET STRUCTURES	NUMBER (no)
(b) MANHOLE 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 bid rates shall include full compensation for all excavation, backfilling, compacting to 90% of BS-Heavy 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 constructional plant required for constructing the concrete outlet structures, manhole boxes, junction boxes and clearing eyes, complete as specified.

ITEM	UNIT
21.13 CONCRETE CAPS FOR SUB SOIL DRAIN PIPES	NUMBER (no)

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

ITEM	UNIT
21.14 REPAIRING OR REPLACING EXISTING DRAINAGE SYSTEMS	PROVISIONAL SUM

The provisional sum given for repairing existing drainage systems shall be expended in terms of Clause 1209.

ITEM	UNIT
21.15 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 90% of BS-Heavy density, measured in place after compaction, where instructed by the Engineer.

The bid 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 all haulage.

ITEM	UNIT
21.16 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 bid 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	UNIT
21.17 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 bid rate 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 soil material. The bid rate shall also include full compensation for all haulage of the material.

ITEM	UNIT
21.18 SELECTED BACKFILL MATERIAL UNDER CONCRETE-LINED SIDE DRAINS COMPACTED TO 92% BS-HEAVY DENSITY	CUBIC METRE (m^3)

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

The bid rate shall include full compensation for procuring the material and transporting from borrow pits, breaking down, placing and compacting the material in 100 mm layers, in accordance with the Drawings.

SERIES 2000: DRAINAGE

SECTION 2200: PREFABRICATED CULVERTS

CONTENTS:

2201 SCOPE

This Section covers work in connection with the construction from prefabricated units of culvert and other closed conduits such as storm water ducts, tremies and service ducts, together with inlet and outlet structures, manholes and other appurtenant structures.

2202 TYPES OF CULVERTS

For the purpose of this specification, the term "prefabricated culvert " shall mean culvert constructed from:

- prefabricated concrete pipes with circular sections, hereafter referred to as "concrete pipe culverts".
- prefabricated concrete culvert other than pipe culvert hereafter referred to as "portal culvert "or "rectangular culvert ".
- prefabricated corrugated metal pipes and pipe arches, hereafter referred to as "metal culvert"

Other types of prefabricated culvert not mentioned above such as wooden culverts or others, will be specified in the Special Specifications or Bill of Quantities or on the Drawings as required.

2203 MATERIALS

The prefabricated culvert units shall be factory produced by a reputable manufacturer of these articles and shall comply with the following requirements:

(a) Prefabricated concrete pipe culvert units

Prefabricated concrete pipe culvert units shall comply with the requirements of BS 5911-1:2002 and BS EN 1916:2002 or BS 5911-110:1992 or equivalent. Pipes with ogee joints shall be provided, unless otherwise specified.

(b) Portal and rectangular prefabricated concrete culvert units

Portal and rectangular prefabricated concrete culvert units shall comply with the requirements of BS 6073-2:1981 or equivalent.

(c) Corrugated metal culvert units

Corrugated metal culvert units shall comply with the requirements of UNI-EN 10025 or equivalent for pipes and pipe arches, and for multi-plate pipes and pipe arches.

Metal culvert shall be supplied with inlet and outlet ends finished by one of the following two methods whichever is shown on the Drawings or has been prescribed by the Engineer:

(i) Where no concrete inlet and outlet structures but bevelled pipe ends are required, inlet and outlet units shall be bevelled to suit the skew angle of the culverts and the side slope of the fill and pavement.

(ii) Where concrete inlet and outlet structures are required, the ends of the culvert units shall be cut to the required plan skew (if any) and provided with anchor bolts projecting radially around the edge as shown on the Drawings for bonding the metal culvert into the concrete inlet and outlet structures.

The Contractor shall not store any nestable culvert units on the site in such a manner that moisture can accumulate between the contact faces of the nested units, as this may adversely affect the spelter coating and render the units liable to rejection. Any units damaged by corrosion shall, if not rejected, be repaired by cleaning all affected areas and applying at least two coasts of an approved zinc- rich epoxy primer which complies with the requirements of SABS 926:1968 or equivalent, in accordance with the manufacture's instructions, or as directed by Engineer.

(d) Fine granular material

Wherever the use of fine granular material is specified in this Section for bedding of culvert, it shall mean sand or other cohesionless material, all of which shall pass through a 6.3 mm sieve and not more than 10% which shall pass through a 0.15 mm sieve.

(e) Protective coating for metal culverts

Where soil or water conditions are likely to cause excessive corrosion of metal culvert, the Engineer may order that prefabricated units be protected by the application of a mastic asphalt protective coating. The coating shall be applied to the inside, the outside or both sides of the metal culvert units as may be directed by the Engineer.

The mastic asphalt shall bear a registered trademark, and approved filler and shall be supplied as a spray or brush-grade material as prescribed.

The surfaces to be protected shall be cleaned to remove all moisture, dirt, oil, paint, grease, alkalis, rust, mill scale or other deleterious matter.

The material shall be mixed until all filler is uniformly distributed.

Spray-grade mastic shall be applied by means of an airless gun and shall be of a suitable consistency without the addition of harmful amount of thinners.

Brush-grade mastic shall be applied with an ordinary roofing brush, with the second coat being applied at right angles to the first coat.

The final film thickness measured on the crest of corrugations shall be a minimum of 1.3 mm or such other thickness as may be specified.

Care shall be taken not to damage the protective coating, and all damage to the coating shall be repaired before the culvert is put to use.

(f) Skewed ends
Where culverts are to be constructed at a skew angle, the culvert shall be supplied with skew ends by the manufacturer, if required. The cutting of skewed ends on site shall not be allowed.

Portal and rectangular units shall be provided with square ends and any portions that would otherwise be cut off, shall project beyond the culvert head walls.

Where instructed by the Engineer, portal and rectangular culverts shall be provided with skewed ends constructed from cast in situ reinforced concrete in accordance with the details shown on the Drawings.

(g) Defects
All broken, bent, chipped, cracked, dented, corroded or otherwise damaged units shall be repaired to the Engineer's satisfaction or where this is not possible, they shall be removed and replaced with undamaged units.

Culvert units, which are thinner than the specified thickness, or the spelter coating of which has been bruised or broken, or which may exhibit signs of faulty work, will be rejected.

The following defects will be rejected as poor work, and the presence of any of or all such defects or any other defects in any individual unit or in general shall constitute adequate reason for rejection: Uneven joints, distorted shapes, deviations from a straight centre line, irregular or diagonally ruptured sides, loose rivets not in line or irregularly spaced, poorly finished rivet heads, illegible trade marks, or a lack of rigidity.

(h) Material at joints
Joint filter seating material shall comply the requirements of CLAUSE 6603.

(i) In situ concrete
All concrete work shall be carried out in accordance with the requirements of SECTIONS 6200, 6300 and 6400.

2204 CONSTRUCTION METHODS

Prefabricated culverts shall be installed by either:

- the "trench method", where the units are laid in a trench excavated below the existing ground lever or in a trench excavated in previously constructed subgrade and if necessary, subbase layers; or
- the "embankment method", where the units are laid approximately on the existing ground surface and the subgrade is then constructed on either side and over the culvert.

Culverts shall be constructed by the method shown on the Drawings or given in the Special Specifications.

The large sizes of metal culvert and the large portal or rectangular culverts shall normally be constructed by the embankment method.

Surface drainage shall be controlled by the construction of temporary earth berms and drainage channels.

The Contractor shall comply strictly with all the appropriate statutory provisions in regard to trench excavations.

2205 EXCAVATION FOR CONSTRUCTION BY THE TRENCH METHOD

(a) Depth of excavation
In the case of culverts to be constructed by the trench method, the Contractor shall first construct the fill, subgrade and if necessary, the subbase to such level of the top of the culvert, as described herein after for the various types of culvert. The Contractor may then commence excavating the trench for the culvert.

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

Notwithstanding the provisions of SUBCLAUSE 2205(a), the base shall be constructed before the culvert and the backfill have been completed.

(i) Concrete pipe culverts
The minimum height of embankment construction over the top of the proposed pipe culvert before excavation may be commenced, shall be the minimum cover specified on the Drawings for the type of pipe and bedding onto which it shall be laid.

The minimum amount by which the excavation is to exceed the proposed level of the bottom side of the pipe shall be 75 mm or such other as may be required for accommodating the type of bedding required for the pipe in each case.

(ii) Portal and rectangular culverts
The minimum height of embankment construction over the top of the proposed culvert before excavation may be commenced, shall be 100mm 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 bottom of the culvert invert slab shall be 75 mm in the case of culvert with pre cast invert slabs. In the case of culverts with cast in situ invert slabs, the excavation 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 be commenced, shall be 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 greatest.

The minimum amount by which the excavation is to exceed the proposed level of the bottom of the pipe shall be 75 mm or such other amount required for accommodating the type of bedding required for the culvert in each case.

(b) Width of excavation
The width of excavations shall be sufficient to allow the proper laying, bedding and backfilling of culverts. The widths of the excavation for each type and size of culvert shall be as shown on the Drawings or as may be prescribed by the Engineer in writing.

If the width of an excavation is increased by the side of the trench slipping or collapsing, the Contractor shall immediately inform the Engineer and shall not proceed with any further laying of culverts or backfilling until the

Engineer has reviewed the circumstances and has given instructions as to the need for altering the class of culvert or type of bedding.

2206 PREPARATION FOR CONSTRUCTION BY THE EMBANKMENT METHOD

Where culvert are to be constructed by the embankment method as defined in CLAUSE 2204, the Contractor shall level existing ground by excavating, filling and compacting as may be necessary so as to provide exactly the required slope and a uniform density over the entire length of the culvert.

The finished level of the ground for the bedding of the culvert shall be the same depth below the proposed bottom level of the culvert as specified in CLAUSE 2205 for the various types of culverts.

2207 UNSUITABLE FOUNDING CONDITIONS

Where the bottom of the trench does not provide a suitably firm foundation for the culvert on account of soft, mucky or otherwise unsuitable material being encountered, the unsuitable material shall be excavated to a depth below the bottom of the culvert as may be indicated by the Engineer.

The Contractor shall excavate the unsuitable material to the depth indicated and shall replace it with gravel or other approved material properly compacted to provide a firm earth cushion.

The width of the excavation shall be as prescribed by the Engineer, but in the case of culverts to be constructed by the embankment method, the width shall be at least one diameter or span, as the case may be wider than the culvert on each side.

Other special construction methods may be shown on the Drawings or specified in the Special Specifications in specific cases.

2208 CLASSIFICATION OF EXCAVATION

All excavations for prefabricated culverts shall be classified as provided in CLAUSE 3603 for payment purposes.

2209 DISPOSAL OF EXCAVATED MATERIAL

Where excavated material does not comply with the requirements for backfilling material as specified hereinafter or is surplus to backfilling requirements, such excavated material shall be removed from the site and used for rehabilitation of borrow pits or at other places as directed by the Engineer.

Material suitable for use in the Works, however, shall be used as prescribed by the Engineer.

Payment for such material will be made as for excavation under ITEM 22.01, and also under the appropriate item for such part of the Works as may be constructed from such material.

No haulage will be paid for excavated material.

2210 LAYING AND BEDDING OF PREFABRICATED CULVERTS

(a) Concrete pipe culverts

Concrete pipe culverts shall be laid on Class A, B ,C or D bedding as shown on the Drawings or as directed by the Engineer. The pipe ends shall be laid hard up against each other so as to obtain tight joints. Ogee pipes shall be laid with their spigot ends downstream. The joints shall be sealed on the outside with two layers of bitumen impregnated burlap as specified in SUBCLAUSE 2210(b).

The insides of the culvert shall be smooth and without any displaced joints. All pipes shall be laid true to line and level.

(i) Class A bedding
The pipe shall be laid with its bottom part on a 20 MPa concrete bedding of specified thickness below the lower part of the pipe, which concrete shall extend upwards on both sides of the pipe to a specified portion of its height.

Before concreting, the pipes shall be supported on suitably shaped cradles at the correct level. No longitudinal construction joints on the horizontal plane will be permitted.

(ii) Class B and 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 pipes 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 stabilised in accordance with the details shown on the Drawings or as prescribed by the Engineer.

(iv) Rock foundation
Where rock, shale or other hard material is encountered on the bottom of excavations, the installation of pipes on Class B bedding shall proceed as follows:

(1) The material below the pipe shall be excavated and replaced with a bed of sand or approved gravel or soil to a depth as shown on the Drawings or prescribed by the Engineer. Such material shall be classed as backfill for purposes of payment.

(2) The backfill material shall be watered and compacted to provide a firm earth cushion. Class B bedding shall then be prepared as described in SUBCLAUSE 2210(a).

(v) Concrete casing
Where shown on the Drawings or ordered by the Engineer, pipes shall be partly or fully encased in concrete according to class and dimensions as shown on the Drawings or as ordered by the Engineer. Supports shall be provided close to the pipe ends to support the pipes during the placing of concrete. The concrete shall be so placed as to fill all spaces below the pipe completely. Poker vibrators shall be used to ensure the proper filling of all spaces below and around the pipes with concrete. Concrete casing shall be cast in one continuous operation until completed.

(b) Portal and rectangular culverts

(i) Cast in situ floor slabs
Cast in situ floor slabs shall be constructed to the dimensions and at the locations as shown on the Drawings or as may be prescribed by the Engineer. They shall be reinforced with steel reinforcement as detailed on the Drawings. Joints of the types detailed on the Drawings shall be formed in the floor slabs, and the inlet and outlet structures.

(ii) Prefabricated floor slabs
A layer of fine-grained material at least 75 mm thick shall be placed on the bottom of the excavation, levelled, compacted and trimmed to line and grade to form a bed to receive the precast slabs.
The slabs shall be carefully placed on the prepared bed, true to line and grade and so bedded that they will be uniformly supported over their whole area on the bedding.

(iii) Placing the portal portions of culverts
The portal portions of portal and rectangular culverts shall be placed accurately and symmetrically on the floor slabs with a thin layer of mortar of one part of cement and six parts of sand between the contact surface to ensure a firm and uniform support.

The units shall be butted end to end with butt joints, which joints shall be covered with two layers of burlap of 340 g/m^2, pre-impregnated with a bituminous emulsion, or a similar approved material. The strip of burlap shall be at least 150 mm wide and placed symmetrically over the joint. The units shall first be treated with a primer of 60% bitumen emulsion over the width of the strip of burlap.

Where two or more culverts are placed side by side to form a multi-barrel culvert, the space between the culvert shall be filled with concrete up to the level of the top of the culvert. Where prescribed, filter fabrics 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 shape of the invert of the culvert and a bed of fine granular material not less than 75 mm thick shall be placed, watered, compacted and shaped to enable the culvert to be bedded as shown on the Drawings.

Where rock is encountered, the depth of excavation shall extend to a depth of at least 200 mm below the invert of the culvert, and shall be filled with granular material as before.

The culverts shall be installed in accordance with the manufacturer's recommendations as approved by the Engineer. Where these Specifications are inconsistent with the manufacturer's recommendations, these Specifications shall have preference. Anchor bolts shall be installed at the ends of metal pipe culverts in accordance with the manufacture's instructions to bond them into inlet and outlet head walls, which head walls shall be constructed as soon as possible after installation of the culverts.

No concrete bedding or casing shall be used in the installation of metal culverts.

Where prescribed, the invert of metal culverts with diameters or spans exceeding 1500 mm which are laid on steep grades shall be protected with a layer of concrete with dimensions and class shown on the Drawings.

(d) Extension of existing culverts

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

Any sections of existing wing walls, approach slabs and head walls which may obstruct any work shall be demolished and removed. Existing culvert 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 CLAUSE 2214.

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 and CLAUSE 2212.

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

If necessary for accommodating 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 requirements of SECTION 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 thickness, and the width shall be at least 150 mm.

(f) General

The construction of culverts shall be commenced at one end of the culvert, the position of which shall be fixed as shown on the Drawings or as prescribed by the Engineer.

Units which have been deformed or cracked, or which are not constructed to the required lines, levels and grades or which become displaced in the process of the work during the defects liability period shall be removed and replaced by the Contractor at his/her own expense.

Prefabricated 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 have been installed.

The Contractor shall exercise due care not to damage, overstress or displace any prefabricated culverts with his/her own traffic or compaction equipment. Where loads exceeding those prescribed in the appropriate statutory provisions are likely to pass over completed culverts, the Contractor shall provide additional cover over the culverts to ensure that design stresses on the culverts will not be exceeded.

All concrete work shall be carried out in accordance with provisions of SERIES 6000.

When the Contractor is required to supply and install culverts at slope exceeding 1:4, the work shall be carried out as specified in CLAUSE 2216.

2211 BACKFILLING OF PREFABRICATED CULVERTS

After the culverts have been firmly laid on the required bedding as described in CLAUSE 2210, backfilling shall be carried out as follows:

(a) Material for backfilling

The material used for the backfilling of those portions of culverts subject to traffic loads shall be selected material of at least subbase quality or such other lower quality as may be permitted by the Engineer. Where the excavated material is not of adequate quality, selected material shall be imported for this purpose. The Contractor shall in advance, ascertain from the Engineer as to which portions will require selected-quality material for backfilling.

In the case of concrete pipe culverts on Class B bedding and metal culverts the backfilling material shall be thoroughly tamped in under the flanks of the culverts to provide a uniform bedding all to the Engineer's satisfaction. Metal culverts shall be temporarily ballasted during backfilling to prevent them from lifting.

(b) Backfilling

Backfilling alongside and over all culverts shall be placed at or near the optimum moisture content of BS-Heavy and compacted in layers not exceeding 150 mm after compaction, or less if required, to a density of at least the density required for the material in adjoining layers of fill, subgrade and subbase. The density of backfilling in excavations made in natural ground shall be at least 90% of BS-Heavy density.

Backfilling shall be carried out simultaneously and equally on both sides of a culvert to prevent unequal lateral forces from occurring.

Where the Engineer so directs, metal culverts with large diameters or spans or multi – barrel culverts shall be constructed by the embankment method as defined in SUBCLAUSE 2204. 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 placed 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 is in place to allow construction equipment to pass over it without causing damage.

(c) Backfilling with concrete

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.

(d) Backfilling with soil-cement

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 compacted gravel or lean concrete. A wet mixture of soil cement shall consist of an approved soil or gravel mixed with 5% of a common cement complying with the requirements of US 310-1:2001/EAS 18-1, BS EN 197-1:2000 or equivalent standard on approval of the Engineer 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 a common cement complying with the requirements of US 310-1:2001/EAS 18-1, BS EN 197-1:2000 or equivalent standard on approval of the Engineer 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 as 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 large particles up to 38 mm. It shall not have a Plasticity Index exceeding 10%. 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.

(e) Haulage

When haulage is paid for in accordance with the Special Specifications a free haul distance determined according to SUBCLAUSE 1602(c) shall apply in respect of all imported materials used for backfilling the culverts. No overhaul shall be paid on any cement, water or concrete aggregates used.

2212 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 elsewhere in this Section for excavating and backfilling the culverts shall apply with changes as required to inlet and outlet structures, catchpits and manholes.

No backfilling of a concrete structure may be done for a period of at least seven days after the structure has been completed, unless otherwise specified or directed by the Engineer.

(b) Concrete work

Concrete work shall be carried out in accordance with the provision of SERIES 6000 and the Drawings.

(c) Brickwork

Bricks shall be engineering bricks conforming to the requirements of BS 3921:1985, BS EN 772-3:1998, BS EN 772-7:1998 or equivalent.

The limit for water absorption in the 24-hour immersion test shall be 8%.

Brickwork shall be built in English bond in a mortar consisting of one part of cement and six parts of sand, or in stretcher bond where its thickness does not exceed 115 mm. It shall be well and regularly bonded without any false headers. All bricks shall be unbroken, except where required as closers. Bricks shall be well wetted before laying and each brick shall be exceeding 10 mm in thickness. All joints shall be filled solid with mortar, and joints for exposed faces shall be pointed as the work proceeds.

Where pipes enter brickwork they shall be thoroughly caulked into the wall and rendered with mortar.

(d) Plaster
Where the plastering of brickwork is required, all joints shall be well raked out and the brick face thoroughly wetted before plaster is applied. Plaster shall not be less than 12 mm or more than 20 mm thick. Plaster finish shall be smooth and even and shall not show any trowel marks. Unless otherwise specified, all plaster shall be finished with a steel trowel. Plaster shall consist of one part of cement to four parts of approved fine sand.

(e) Manhole covers, grid inlets etc
Manhole covers and frames, grid inlets and other metal accessories shall be supported and/or manufactured in accordance with the details shown on the Drawings. Road and pavement manhole covers and frames shall comply with the requirements of BS 7903:1997 and BS EN 124:1994 or equivalent and shall be of the size and type indicated.

Before fixing manholes covers and frames they shall be dipped in an approved preservative and gratings and frames painted with two coats of bituminous paint. Manhole frame shall be set firmly in a cement mortar to leave the covers flush with the final surface.

(f) Prefabricated concrete chambers and shafts
Prefabricated chambers and shafts shall be constructed from non-pressure concrete pipes which comply with the requirements of BS 5911-110:1992 or equivalent. Pipes with ogee joints shall be provided unless otherwise specified. The pipes shall be to the diameters specified. All chambers and shafts shall be installed with the spigot ends pointing upwards and shall be bedded in mortar thoroughly caulked to ensure watertight joints.

(g) Benching
All benching shall be rendered in 20 mm granolithic plaster and finished smooth and true with a steel trowel. Corners shall be rounded to dimensions shown on the Drawings.

(h) Prefabricated inlet and outlet structures
Where specified for use, prefabricated inlet and outlet structures shall be manufactured in accordance with the dimensions shown on the Drawings. The units shall be laid and jointed generally as specified for prefabricated concrete pipe culverts.

(i) Prefabricated energy dissipaters in outlet structures
Where shown on the Drawings, the Contractor shall supply and install in the outlet structures, prefabricated reinforced concrete energy dissipaters of Class 25/19 concrete with dimensions as shown on the Drawings. All concrete work shall comply with the requirements of SERIES 6000.

2213 REMOVAL OF EXISTING WORK

Where shown on the Drawings or directed by the Engineer existing inlets and outlets to pipe culverts shall be demolished and debris or rubbish disposed of in an approved waste site as directed by the Engineer. Existing pipes shall be removed where necessary and saved for later use. All such work shall be carried out to prevent damage being done to former work which is to remain.

The Contractor's attention is directed to the provisions of SECTION 3100 which specifies any structures which have to be removed as part of the clearing and grubbing operations, the removal of which will therefore not be measured and paid for under this Section.

Pipes shall be carefully removed from existing culverts and thoroughly checked.

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.

2214 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 structures, 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 SECTION 6400.

Reinforced or plain concrete removed in the process of partial demolition shall be measured and paid for under ITEM 22.12 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 bid for the concrete supplied for extensions to the existing structures.

2215 SERVICE DUCTS

Where required the Contractor shall construct services 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:

- Normal duty PVC pipes in accordance with BS 4660:2000 and BS EN 1401-1:1998 or equivalent.
- Pitch-fibre pipes in accordance with BS 2760:1973 or equivalent.
- Fibre-cement pressure pipes in accordance with BS EN 512:1995 or equivalent. Class C pipes shall be used unless other types are specified.
- Reinforced-concrete pipes in accordance with BS 5911-110:1992 or equivalent.

Where required, the pipes shall be cut length-wise 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 record 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 1.0 m above the upper side of the installed services duct.

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

Spit 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, 2.5 mm in diameter of galvanised steel wire shall be threaded through each unit and shall extend 2 m beyond each end and firmly wedge 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 50 mm proud of the finished surface level.

2216 CULVERTS ON STEEP GRADIENTS

Where culverts are constructed on gradients exceeding 1:4, 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 CLAUSE 2203.

Particular care shall be taken to protect excavations against stormwater 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 structures 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 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.

2217 STORMWATER DUCTS, TREMIES AND OTHER CLOSED CONDUITS

The specifications given in this Section for culverts, including the method of measurement and payment, shall apply with changes as required to the construction of stormwater ducts, tremies or any other closed conduits constructed from the prefabricated units described in CLAUSE 2203, whether intended for drainage or for any other purpose.

No distinction will be made in the Bill of Quantities between the construction of culverts as defined in SECTION 1100 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 1:4.

2218 MEASUREMENT AND PAYMENT

ITEM	UNIT
22.01 EXCAVATION:	
(a) EXCAVATING SOFT MATERIAL SITUATED WITHIN THE FOLLOWING DEPTH RANGES BELOW THE SURFACE LEVEL:	
(I) UP TO 1.5 m	CUBIC METRE (m^3)
(II) Exceeding 1.5 m AND UP TO 3.0 m	CUBIC METRE (m^3)
(III) Exceeding 3.0 m AND UP TO ...(PER INCREMENT OF 1.5 m)	CUBIC METRE (m^3)
(b) EXTRA OVER SUBITEM 22.01(a) FOR EXCAVATION IN ROCK AS DEFINED IN CLAUSE 3603, 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.

The quantity of material within each depth range shall be measured and paid for separately.

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

In the case of manholes, catch pits and inlet and outlet structures, the dimensions for determining the volume of excavation shall be the neat outside dimensions of the structure, plus an allowance of 0.5 m of working space around the structure.

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

No haulage will be paid.

ITEM	UNIT
22.02 BACKFILLING:	
(a) USING EXCAVATED MATERIAL	CUBIC METRE (m^3)
(b) USING IMPORTED SELECTED MATERIAL	CUBIC METRE (m^3)
(c) EXTRA OVER SUBITEMS 22.02 (a) AND (b) FOR SOIL CEMENT BACKFILLING (PERCENTAGE OF CEMENT INDICATED)	CUBIC METRE (m^3)

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

If excavations were carried out in excess of the dimensions authorised by the Engineer, the quantity of backfilling will nevertheless be based on the authorised

dimensions. The volume occupied by the culvert shall be subtracted when calculating the volume of backfilling.

The bid 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 bid rate for SUBITEM 22.02(b) shall, in addition, include full compensation for supplying selected material of sub base quality from approved sources, including a free haul determined according to SUBCLAUSE 1602(c) in the cases where haulage is paid for in accordance with the Special Specifications.

The bid rate for SUBITEM 22.02(c) shall be additional to the rates bid for SUBITEMS 22.02(a) and (b) and shall include full compensation for all incidentals required for the complete backfilling with soil cement as specified.

ITEM	UNIT
22.03 CONCRETE PIPE CULVERTS:	
(a) ON CLASS A BEDDING (TYPE AND DIAMETER INDICATED)	METRE (m)
(b) ON CLASS B BEDDING (TYPE AND DIAMETER INDICATED)	METRE (m)
(c) ON CLASS C BEDDING (TYPE AND DIAMETER INDICATED)	METRE (m)
(d) 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 bid rates shall include full compensation for providing, testing, loading, transporting and unloading the culverts, for providing and placing the fine-grained material, where required, and for the installation, laying and jointing of the culverts, as specified. The bid rate shall also include for jointing with existing pipes where culverts have to be extended. Any concrete required for the jointing or for bedding, haunching and surround will be paid for separately under ITEM 22.07.

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	UNIT
22.04 METAL CULVERTS:	
(a) SIZE, WALL THICKNESS AND TYPE INDICATED	METRE (m)
(b) CUTTING OFF BEVELLED AND/ OR SKEW ENDS (SIZE AND TYPE INDICATED)	NUMBER (no)
(c) ANCHOR BOLTS	NUMBER (no)

The unit of measurement shall be the metre of culvert laid, the number of cuts made and the number of anchor bolts installed as shown on the Drawings or ordered by the Engineer.

In the case of a metal pipe, 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 bid rates shall include full compensation for providing, testing, loading, transporting and off-loading the culverts, for providing and placing fine-grained material where required for the installation of culverts, 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 and also between culverts with differing wall thicknesses. The bid rate shall also include for jointing with existing pipes where culverts have to be extended. Any concrete required for the jointing will be paid for separately under ITEM 22.07.

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

The bid rate per anchor bolt shall include full compensation for procuring, providing and installing the bolts.

ITEM	UNIT
22.05 PORTAL AND RECTANGULAR CULVERTS:	
(a) COMPLETE WITH PREFABRICATED FLOOR SLABS (SIZE AND TYPE INDICATED)	METRE (m)
(b) WITHOUT PREFABRICATED FLOOR 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 bid rates shall include full compensation for supplying, testing, loading, transporting and off-loading all culverts, providing and placing the fine-grained material where required for installing the culverts, and installing, laying and jointing the culverts as specified, including cutting them on the site, and waste.

Payment will 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	UNIT
22.06 EXTRA OVER ITEMS 22.03 22.04 AND 22.05 FOR CONSTRUCTING INCLINED CULVERTS STEEPER THAN 1:4.	METRE (m)

The unit of measurement shall be the metre of culvert installed at a grade steeper than 1:4 as specified in CLAUSE 2216.

The bid 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		UNIT
22.07	CAST IN SITU CONCRETE AND FORM WORK:	
(a)	IN CLASS A BEDDING, SCREEDS, HAUNCHING AND ENCASING FOR PIPES, INCLUDING FORMWORK, (CLASS OF CONCRETE INDICATED)	CUBIC METRE (m^3)
(b)	IN FLOOR SLABS FOR PORTAL OR RECTANGULAR CULVERTS, INCLUDING FORMWORK AND CLASS U2 SURFACE FINISH (CLASS OF CONCRETE INDICATED)	CUBIC METRE (m^3)
(c)	IN INLET AND OUTLET STRUCTURES, 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 SUB ITEM 22.07 (C) ABOVE (CLASS OF FINISH INDICATED)	SQUARE METRE (m^2)
(e)	IN CONCRETE LININGS FOR THE INVERTS OF METAL CULVERTS, INCLUDING FORMWORK AND CLASS U2 SURFACE FINISH (CLASS OF CONCRETE INDICATED)	CUBIC METRE (m^3)

The unit of measurement for cast in situ concrete shall be the cubic metre of concrete in place. Quantities shall be calculated from the dimensions shown on the Drawings or as authorised. No deduction in volume measured for payment shall be made for the volume of any reinforcing steel, inserts and pipes or conduits under 150 mm in diameter embedded in the concrete.

Measurement of formwork shall be by the square metre as specified in SECTION 6200.

The bid rate for cast in situ concrete shall include full compensation for procuring and furnishing all the materials, storing the materials, providing all plant, mixing, transporting, placing and compacting the concrete, forming the inserts, construction of joints, curing and protecting the concrete, repairing defective surfaces, and finishing the concrete surfaces as specified. Payment shall distinguish between the different classes of concrete.

No separate payment shall be made for any formwork required for concreting in SUBITEMS 22.07(a), (b) and (e) and the Contractor's rates for concrete shall include full compensation for formwork
.
Payment for formwork for concreting in SUBITEM 22.07(c) shall be made under SUBITEM 22.07(d) as specified in SECTION 6200.

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

ITEM		UNIT
22.08	CONCRETE BACKFILL FOR CULVERT (CLASS INDICATED)	CUBIC METRE (m^3)

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

Payment shall be made as for concrete in ITEM 22.07 (a) above.

ITEM		UNIT
22.09	PREFABRICATED CONCRETE INLETS AND OUTLETS TO CULVERTS (SIZE AND TYPE INDICATED)	NUMBER (no)

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

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

ITEM		UNIT
22.10	STEEL REINFORCEMENT:	
(a)	MILD STEEL BARS	TONNE (t)
(b)	HIGH-TENSILE STEEL BARS	TONNE (t)
(c)	WELDED STEEL FABRIC	KILOGRAMME (kg)

Measurement and payment for steel reinforcement shall be made as specified in SECTION 6300.

ITEM		UNIT
22.11	DOWELS FOR JOINING OLD AND NEW CONCRETE	KILOGRAMME (kg)

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

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

ITEM		UNIT
22.12	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 bid rates shall include full compensation for all demolition and for loading, transporting and disposing of the products of demolition, including a free haul determined according to SUBCLAUSE 1602(c).

Payment shall distinguish between plain and reinforced concrete. For the purpose of this item, reinforced concrete shall be defined as concrete containing at least 0.2% of steel reinforcement measured by volume. Plain concrete shall, for the purpose of this item, be deemed to include stone masonry and brickwork.

The bid rates shall also include full compensation for cutting straight grooves of the specified depth at joint positions where shown on the Drawings.

ITEM	UNIT
22.13 REMOVING AND RE-LAYING 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 bid rate shall include full compensation for lifting, loading, transporting, off-loading, and laying pipes according to the Specifications. No haulage will be paid.

Payment for any excavation and backfilling required for the removal and relaying of existing pipes shall be made separately under ITEMS 22.01 and 22.02.

Where existing pipes are used in diversions, they shall not be measured for payment under this item, and payment therefor shall be made only if provided in SECTION 1500 and included in the Bill of Quantities.

ITEM	UNIT
22.14 REMOVING AND STACKING EXISTING PREFABRICATED PIPES (ALL SIZES)	METRE (m)

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

The bid 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, transporting and stacking the existing prefabricated culverts shall be made separately under ITEMS 22.01 and 22.02. No haulage will be paid.

ITEM	UNIT
22.15 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.

The bid rate shall include full compensation for providing and applying the epoxy-resin compound.

ITEM	UNIT
22.16 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 bid 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	UNIT
22.17 MANHOLES, CATCHPITS, PRECAST INLET AND OUTLET STRUCTURES COMPLETE:	
(a) MANHOLES (TYPE AND STANDARD DEPTH INDICATED)	NUMBER (no)
(b) CATCHPITS (TYPE AND STANDARD DEPTH INDICATED)	NUMBER (no)
(c) PRECAST INLET AND OUTLET STRUCTURES (TYPE INDICATED)	NUMBER (no)
(d) EXTRA OVER OR LESS THAN SUBITEM 22.17 (a) FOR VARIATIONS IN THE DEPTHS OF MAN HOLES FROM THE STANDARD DEPTH DESIGNATED FOR BIDDING PURPOSES	METRE (m)
(e) EXTRA OVER OR LESS THAN SUB ITEM 22.17 (b) FOR VARIATIONS IN THE DEPTHS OF CATCHPITS FROM THE STANDARD DEPTH DESIGNATED FOR BIDDING PURPOSES	METRE (m)

The unit of measurement, in the case of SUBITEMS 22.17 (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 bid 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 bid 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 bidding purposes.

The bid 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.

Where the above items of work cannot be conveniently standardised for payment according to complete units, the various types of work and items of material provided shall be measured separately in accordance with ITEMS 22.18 to 22.21 and such other items as may be necessary.

Concrete and formwork shall be measured and paid for under SUBITEMS 22.07 (c) and (d) respectively, excavation under ITEM 22.01 and backfilling under ITEM 22.02.

ITEM	UNIT
22.18 BRICKWORK:	
(a) 115 mm THICK	SQUARE METRE (m^2)
(b) 230 mm THICK	SQUARE METRE (m^2)
(c) 345 mm THICK	SQUARE METRE (m^2)

The unit of measurement shall be the square metre of brickwork built, calculated from the leading dimensions of the brickwork. Areas in walls occupied by conduits, shall not be included in the areas measured, and corners and intersections common to more than one brick wall shall be measured only once.

The bid rates per square metre shall include full compensation for the brickwork complete as specified, including pointing and the building in of conduits.

ITEM	UNIT
22.19 PLASTER:	SQUARE METRE (m^2)

The unit of measurement shall be the square metre of plaster work provided.

The bid rate shall include full compensation for raking out joints in the brick work and applying a 1:4 plaster, as specified, to all surfaces where required.

ITEM	UNIT
22.20 BENCHING:	SQUARE METRE (m^2)

The unit of measurement shall be the square metre of benching, measured in plan, constructed in Class 20/19 concrete with granolithic rendering.

The bid rate shall include full compensation for procuring and furnishing all materials, placing the concrete benching and rendering with the specified granolithic rendering.

ITEM	UNIT
22.21 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 bid rates shall include full compensation for procuring, furnishing and installing the accessories.

ITEM	UNIT
22.22 ANCHORS FOR PIPES (DESCRIPTION)	NUMBER (no)

The unit of measurement shall be the number of complete anchors installed, including straps, bolts, etc, but excluding any concrete work, which shall be measured under SUBITEMS 22.07(c) and (d).

The bid rate shall include full compensation for procuring, providing and installing the anchors.

ITEM	UNIT
22.23 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 bid 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 Section.

ITEM	UNIT
22.24 DUCT MARKER BLOCKS (TYPE INDICATED)	NUMBER (no)

The unit of measurement shall be the number of marker blocks installed, and the bid rate shall include full compensation for manufacturing, delivering and installing the marker blocks, complete as shown on the Drawings.

ITEM	UNIT
22.25 HAND EXCAVATION TO DETERMINE THE POSITIONS OF EXISTING SERVICES	CUBIC METRE (m^3)

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

The bid rate shall include full compensation for all excavation, backfilling, compacting to 90% of BS-Heavy 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 bid rate shall also include all haulage of material. Any damage to a service caused by the Contractor shall be repaired at his/her own costs, to the satisfaction of the Owner of the service and the Engineer.

No distinction will be made between the various types of services to be exposed or the depths to which excavations are taken.

ITEM	UNIT
22.26 REINSTATING TRENCHES CROSSING ROADS:	
(a) IMPROVED SUBGRADE LAYERS	SQUARE METRE (m^2)
(b) SUBBASE LAYERS	SQUARE METRE (m^2)
(c) BASE COURSE LAYERS	SQUARE METRE (m^2)
(d) BITUMINOUS SURFACING INCLUDING TACK COAT)	SQUARE METRE (m^2)
(e) KERBING	METRE (m)

The unit of measurement for SUBITEMS 22.26(a) to (d) shall be the square metre of the layer reinstated where instructed by the Engineer.

The unit of measurement for SUBITEM 22.26(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 Sections of the Specifications shall also be applicable to the reinstatement of the trenches.

The bid 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		UNIT
22.27	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 bid rates shall include full compensation for providing, testing, loading and unloading the units, constructing the prescribed class of bedding, except Class A bedding, and for installing, laying and joining the units, complete as specified and in accordance with the details shown on the Drawings. Concrete in Class A bedding, haunching and surrounds shall be paid for under Sub-Item 22.07(a).

SERIES 2000: DRAINAGE

SECTION 2300: CONCRETE KERBING, CONCRETE CHANNELLING, OPEN CONCRETE CHUTES AND CONCRETE LININGS FOR OPEN DRAINS

CONTENTS:

2301 SCOPE

This Section covers the construction of concrete kerbing and channelling, open concrete chutes and concrete linings for open drains at the locations and to the details as shown on the Drawings or as directed by the Engineer.

2302 MATERIALS

(a) Concrete

All concrete work shall be carried out in accordance with the requirements of SECTIONS 6200, 6300 and 6400.

(b) Kerbing and channelling

Prefabricated kerbing and channelling shall comply with the requirements of BS 7263-1:2001 and BS 7263-3:2001 or equivalent. Cast in situ kerbing and channelling shall be of the class of concrete indicated.

(c) Joint sealant

- Cold-applied joint sealant shall be a two-part polysulphide sealing compound conforming to the requirements of BS 4254:1983.
- Polyurethane-based joint sealants shall comply with the requirements of SABS 1077:1984 or equivalent.
- Silicone-based joint sealants shall comply with the requirements of the Special Specifications.

(d) Bedding material

The material on which concrete kerbs and channels are to be bedded shall consist of crushed stone, cinders, slag, sand or other approved porous material with a maximum particle size of 14 mm.

Concrete may also be prescribed as bedding material, in which case it shall comply with the requirements of SECTION 6400.

2303 TYPES OF STRUCTURES

Kerbing shall include barrier kerbs, mountable and semi-mountable types. All these elements may be prefabricated units or constructed in a continuous operation using slipforms. Channelling may be cast in situ, prefabricated units or else of slipform construction. Chutes may be either prefabricated units or cast in situ, and the concrete lining of open channels shall be cast in situ only, except that side slabs may be precast. Downpipes shall be prefabricated units.

2304 CONSTRUCTION

(a) Excavation, and preparation of bedding

(i) Kerbs and channels

Trenches for kerbs and channels shall be excavated to the required depth 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 or precast concrete unit shall be placed on uncompacted or disturbed material.

(ii) Concrete linings

The excavation work for open drains shall be executed and paid for in accordance with the provisions of SECTION 2100.

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 90% of BS-Heavy 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 90% of BS-Heavy density.

Where excavations for open drains are in rock, over break shall be backfilled as ordered, either with mass concrete or with selected natural gravel or soil compacted to a BS-Heavy density of at least 90%.

(iii) Chutes

Excavations for chutes shall be neatly trimmed. All loose material shall be thoroughly compacted, and where overbreak occurs in rock 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.

(b) Prefabricated concrete kerbing and channelling

Prefabricated concrete kerbing and channelling shall be laid on the approved bedding with close joints filled with 3:1 sand:cement mortar not exceeding 10 mm in thickness and neatly pointed with a pointing trowel. The exposed faces of kerbs and edging shall be constructed true to line and elevation. Kerbing around curves shall first be laid along the full curve length before the joints are filled, unless otherwise allowed by the Engineer. Kerbs shall be temporarily propped during construction.

Unless otherwise instructed by the Engineer, prefabricated concrete kerb units shall be 1.0 m in length, except at curves at road junctions, where they shall be 0.3 m in length.

Prefabricated concrete kerbs shall be laid with a Class 1:4:8/25 cast in situ concrete support behind the kerbs in accordance with the details shown on the Drawings.

(c) Prefabricated concrete chutes on side slopes of fills and cuts

Prefabricated concrete chutes 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 as shown on the Drawings.

(d) Slip – form kerbing
Slip-form kerbs and channels shall be placed on an approved bedding by a continuous process with an approved machine. Contraction joints shall be sawn at intervals shown on the Drawings or prescribed by the Engineer in a manner so as not to cause the concrete to spall at the joint. The concrete shall be cured in accordance with the requirements of CLAUSE 6409.

The kerbs 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/her own cost.

(e) Cast in situ kerbs and channels
Forms for kerbs and channels shall be accurately set to line and elevation and shall be firmly held in position during the placing of the concrete. Stops and jointing material at the ends of sections shall be accurately placed so as to ensure that joints between adjacent sections are truly perpendicular to the surface of the concrete and at right angles to the edge of the road.

After concrete has been placed in the forms, it shall be tamped and worked until mortar entirely covers any exposed faces. Exposed faces shall then be finished to smooth and even surfaces and edges shall be rounded to the radii shown on the Drawings.

Forms shall be removed from any concrete surface that will be exposed, within a period of 24 hours of the concrete having been placed. Minor defects shall be repaired with a 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 6409.

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

(f) 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.

(g) Concrete-lined open drains
The exposed surfaces of the concrete linings of open drains shall be given a Class U2 surface finish as defined in CLAUSE 6209. Concrete shall be cured in accordance with the requirements of CLAUSE 6409.

Sealed joints in concrete shall be in accordance with the details indicated on the Drawings and the provisions of SECTION 6600. 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.

(h) Backfilling
After completing the concrete work, the spaces at the backs of kerbs shall be backfilled with approved material to pavement or road shoulder level. Spaces adjoining chutes shall be backfilled level with the side slope. Such backfill shall be placed in layers not exceeding 150 mm, or less as required, and each layer shall be compacted to 90% of BS-Heavy density at or around optimum moisture content before the succeeding layer is placed thereon.

Where kerbs and channels are laid after construction of the base, the spaces between the concrete and adjoining base shall be backfilled with premixed bituminous material.

(i) Construction sequence

(i) Where kerbs and channelling are constructed before the base course:
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 kerbs and channelling are constructed after the base course:
The base shall be constructed wider than the specified width, after which a neat trench shall be dug for the kerbing or channelling. Any over-excavation shall be filled with concrete cast simultaneously with the kerbs and channelling.

(iii) Where kerbs and channelling are constructed after the asphalt surfacing:
The asphalt surfacing shall be constructed wider than the specified width and shall be cut back accurately with a mechanical saw to a marked line to give a neat joint line between the kerbs or channelling 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.

(j) Protection
During transporting and laying care shall be taken to protect all precast units against chipping or breakage.

Concrete kerbing and channelling as well as any other structures adjacent to the road shall be protected against staining by bitumen being sprayed or premix being placed. Where bitumen is to be sprayed, all such work shall be completely covered with polyethylene sheeting at least 0.25 mm thick, specially reinforced paper or other approved material, properly secured to prevent the sheeting from lifting during windy conditions. Any work stained by bitumen shall be broken down and replaced, unless all such bitumen is completely removed so as not to show any stains. Painting over stained concrete is strictly prohibited.

(k) Cutting existing bituminous surfacing and pavement layers

Where the Engineer instructs kerbing, channelling or concrete – lined drains to be constructed against existing bituminous surfacing, the full depth of the bituminous surfacing, and the base and subbase if necessary, shall be accurately cut with a mechanical saw to the required line before the kerbing, channelling or concrete- lined drain is constructed. The edge shall be vertical for kerbing and channelling. The concrete shall then be placed directly against the cut edge without formwork. All material outside the cut edge shall be removed to the required depth before the concrete is placed. The debris shall be disposed of at a dumping site to be provided by the Contractor subject to the approval of the Engineer. The bituminous surfacing shall be protected and kept clean to the Engineer's satisfaction.

2305 INLET AND OUTLET STRUCTURES AND TRANSITION SECTIONS

Transition sections on kerbing, kerbing-channelling combinations and concrete- lined open drains shall be constructed to the same standards and by the same methods as described for the uniform sections, but with the required modifications. Sections may be either precast or cast in situ units.

Inlet and outlet structures may be either precast or partially precast concrete units or of cast in situ concrete.

Where shown on the Drawings or instructed by the Engineer, the Contractor shall supply and install in the outlet structures energy dissipaters consisting of prefabricated reinforced concrete blocks of Class 20/19 concrete of the dimensions shown on the Drawings or listed in the Bill of Quantities. All concrete work shall comply with the requirements of SERIES 6000.

Components such as grids, covers and frames shall be in accordance with the details shown on the Drawings and the requirements of SUBCLAUSE 2212(e).

2306 CONSTRUCTION TOLERANCES AND SURFACE FINISH

(a) Concrete kerbing and channelling

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

(i) Horizontal alignment
The maximum deviation of edges, centre line, or vertical surfaces from the specified position shall be 25 mm.

Further to the above, the maximum deviation of edges, centre line or vertical surfaces from the specified alignment, shall be 1:500 when taken over any section exceeding 10 m in length.

(ii) Vertical alignment and level
The inside edge of channelling shall nowhere be above the finished road nor more than 10 mm below the finished road level. The invert level of channels and open drains and the top of kerbing shall nowhere deviate by more than 10 mm from the required level and nowhere shall channels or drains have 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 opens drains and concrete chutes

Concrete – lined open drains and concrete chutes 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 deviated by more than 25 mm from the required level and nowhere shall the open drain inverts have an adverse grade.

(iii) Trueness of exposed surface
When tested with a 3 m straight edge, no exposed surface shall show surface irregularities exceeding 10 mm.

(iv) Cross- – sectional dimensions
All cross-sectional dimensions shall be within 10 mm of the specified dimensions and the average thickness of a floor or side slab shall not be less than the specified thickness when considering any complete slab or slab sections with a surface area of 10 m^2 or more, and disregarding a thickness exceeding 10 mm of the specified thickness.

(c) Surface finish

All unformed exposed concrete surfaces shall have a Class U2 surface finish and all formed exposed concrete surfaces shall have a Class F2 surface finish as defined in CLAUSE 6209.

2307 MEASUREMENT AND PAYMENT

ITEM	UNIT
23.01 CONCRETE KERBING (CLASS OF CONCRETE INDICATED FOR CAST IN SITU CONCRETE):	
(a) (DESCRIPTION OF TYPE WITH REFERENCE OF DRAWING)	METRE (m)
(b) ETC FOR OTHER TYPES	METRE (m)

ITEM	UNIT
23.02 CONCRETE KERBING – CHANNELLING COMBINATION (CLASS OF CONCRETE INDICATED FOR CAST IN SITU CONCRETE):	
(a) (DESCRIPTION OF TYPE WITH REFERENCE OF DRAWING)	METRE (m)
(b) ETC FOR OTHER TYPES	METRE (m)

The unit of measurement shall be the metre of concrete kerbing, or a combination kerbing and channelling, complete as constructed, measured along the front face of the kerb.

The bid for each metre of concrete kerbing and/or kerbing channelling combination shall include full compensation for the necessary excavation and preparation of bedding, backfilling, formwork, finishing and for procuring, furnishing and installing all materials, kerbing and channelling and protecting it against

staining, supporting the kerbs with in situ cast concrete and filling and painting all joints, all complete as specified.

ITEM	UNIT
23.03 CONCRETE CHUTES (TYPICAL DESIGNS):	
(a) (DESCRIPTIONS OF TYPE WITH REFERENCE TO DRAWING. STATE WHETHER PREFABRICATED OR CAST IN SITU AND CLASS OF CONCRETE	METRE (m)
(b) ETC FOR OTHER TYPES	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 bid rate per metre shall include full compensation for procuring, furnishing and installing the completed chutes as specified and all excavation and the preparation of bedding, backfilling, formwork and finishing required.

ITEM	UNIT
23.04 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 6200 and 6400 respectively except that payment for excavation and gravel or soil backfilling shall be deemed to be include in the rates bid for concrete and shall not be measured and paid for separately.

ITEM	UNIT
23.05 INLET , OUTLET, TRANSITION AND SIMILAR STRUCTURES (TYPICAL DESIGNS):	
(a) (DESCRIPTION OF STRUCTURE, TYPE, ETC, WITH REFERENCE TO DRAWING AND CLASS OF CONCRETE)	NUMBER (no)
(b) ETC FOR OTHER TYPES	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, excavation, trimming and backfilling, including such accessories as grids, etc as may be specified on the Drawings.

ITEM	UNIT
23.06 INLET, OUTLET, TRANSITION AND SIMILAR STRUCTURES (MEASURED BY COMPONENTS):	
(a) CONCRETE (CLASS INDICATED)	CUBIC METRE (m^3)
(b) FORMWORK (SURFACE FINISH INDICATED)	SQUARE METRE (m^2)
(c) OTHER COMPONENTS	NUMBER (no)

The measurement and payment for formwork and concrete shall be as specified in SECTIONS 6200 and 6400, 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 bid for concrete.

Measurement and payment for other components such as grids shall be made at the relevant Item in SECTION 2200 for the number of each type of component installed. The bid rates shall include full compensation for procuring, furnishing and installing the components, including any painting or protective coating required in the Special Specifications or as shown on the Drawings.

ITEM	UNIT
23.07 TRIMMING OF EXCAVATIONS FOR CONCRETE- LINED OPEN DRAINS:	
(a) IN SOFT MATERIAL AS DEFINED IN CLAUSE 3603	SQUARE METRE (m^2)
(b) IN ROCK AS DEFINED IN CLAUSE 3603	SQUARE METRE (m^2)

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

The bid rates shall include full compensation for all labour, constructional plant, material 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.

Payment shall distinguish between trimming in soft material and trimming in rock material as defined in CLAUSE 3603. 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 bid rates for trimming.

All excavation, including the removal of unsuitable material and backfilling with selected backfill material shall be measured and paid for under SECTION 2100.

ITEM	UNIT
23.08 CONCRETE LINING FOR OPENS DRAINS:	
(a) CAST IN SITU CONCRETE LINING (CLASS OF 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 cast in situ concrete lining shall be as specified in SECTION 6400, but the bid rate shall include full compensation for painting of cold joints with bitumen emulsion as specified.

Sealed joints shall be measured and paid for under ITEM 23.10 and polyethylene sheeting, if required, shall be measured and paid for under ITEM 23.13.

The unit of measurement for surface finish shall be the square metre of finished surface. The bid rate shall include full compensation for all labour, equipment, material and incidentals required for finishing the concrete lining as specified.

ITEM	UNIT
23.09 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 6200. Formwork under SUBITEM 23.09(a) shall be measured and paid for only when the side slope of the slabs exceeds 1:2 and the slabs cannot be constructed without formwork even when a stiff concrete mix is used. When the Contractor elects to use precast side slabs, payment will be made for formwork as if cast in situ concrete had been used.

ITEM	UNIT
23.10 SEALED JOINTS IN CONCRETE LININGS OF OPEN DRAINS (DESCRIPTION OF TYPE WITH REFERENCES TO DRAWING)	METRE (m)

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

The bid 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 set out in the Special Specifications.

ITEM	UNIT
23.11 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 bid rate shall include full compensation for furnishing, procuring and placing the concrete in screed or backfill.

ITEM	UNIT
23.12 STEEL REINFORCEMENT:	
(a) MILD STEEL BARS	TONNE (t)
(b) HIGH TENSILE STEEL BARS	TONNE (t)
(c) WELDED STEEL FABRIC	TONNE (t)

Measurement and payment shall be in accordance with the provisions of SECTION 6300.

ITEM	UNIT
23.13 POLYETHYLENE SHEETING (0.15 mm THICK) FOR CONCRETE-LINED OPEN DRAINS	SQUARE METRE (m^2)

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

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

ITEM	UNIT
23.14 CUTTING BITUMINOUS 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 cut. The various layers shall not be measured separately for payment.

The bid rate shall include full compensation for all labour, constructional 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	UNIT
23.15 PRECAST CONCRETE BLOCKS IN OUTLET STRUCTURES	NUMBER (no)

The unit of measurement shall be the number of precast concrete blocks provided and installed as shown on the Drawings or directed by the Engineer.

ITEM	UNIT
23.16 SIDE DRAIN PEDESTRIAN CROSSING	NUMBER (no)

The unit of measurement shall be the number of pedestrian crossings constructed in accordance with the Drawings.

The bid rate shall include full compensation for furnishing all materials and labour including excavation, trimming, backfilling, and removing any surplus excavated material.

SERIES 2000: DRAINAGE

SECTION 2400: ASPHALT AND CONCRETE BERMS

CONTENTS:

2401 SCOPE

This Section covers the construction of asphalt or concrete berms at outer edge of paved shoulders. Berms shall be cast in situ in moulds or by means of a suitable machine to the dimensions shown on the Drawings or as directed by the Engineer.

2402 MATERIALS

(a) Bituminous binder
Bituminous binder shall be penetration-grade bitumen or mix-grade bituminous emulsion as may be prescribed by the Engineer. Spray-grade emulsion may be used as primer and tack coat.

The various bituminous materials shall comply with the following specifications:

- Penetration- grade bitumen: AASHTO M20-70 or equivalent
- Bituminous emulsions: AASHTO M140-88 and M208-96 or equivalent

(b) Asphalt
Asphalt containing penetration- grade bitumen shall comply with the requirements of SECTION 4200. The aggregate grading shall lie between the limits indicated in TABLE 4202/3 for a fine continuously graded mix.

The material of asphalt which contains mix –grade bitumen emulsion shall comply with the requirements of the Special Specification.

The grading of the aggregate shall be subject to the prior approval of the Engineer.

(c) Concrete
All concrete work shall be carried out in accordance with the details shown on the Drawings and the requirements of SECTION 6400.

2403 COMPOUNDING, MIXING AND TRANSPORTING ASPHALT MIXES

(a) Compounding the mixtures
Asphalt containing penetration grade bitumen shall contain by mass of the dry aggregate, 7% by total weight of 60/70 or 80/100 penetration grade bitumen or as specified, and 1% of active filler.

Asphalt containing mix- grade bitumen emulsion shall contain by mass of the dry aggregate, 7% of net bitumen. The asphalt mix shall be in accordance with the requirements of the Special Specifications.

The composition of the asphalt mix shall in all cases be subject to the prior approval of the Engineer.

(b) Contractor's mixing plant
The Contractor's mixing plant shall be in accordance with the requirements of CLAUSE 4204.

(c) Mixing, transporting and placing
Asphalt with penetration – grade bitumen shall be mixed, transported and placed in accordance with the requirements of SECTION 4200, and asphalt with mix-grade bitumen emulsion in accordance with the requirements of the Special Specification.

2404 PREPARING THE BERM FOUNDATION

If shown on the Drawings, the prime coat sprayed onto the base and shoulders shall extend over a wider area to allow space for the berms to be placed.

Where the Engineer so instruct that berms shall be constructed, the specified width of the base projecting beyond the sides of the paved shoulders shall be thoroughly cleaned. The shoulder material adjacent to the base shall be compacted and trimmed to the upper level of the base and all loose material removed.

A prime coat consisting of 30% bitumen-emulsion shall be applied at a rate of 0.40 l/m^2 onto that part of the berm foundation falling outside the paved surface of the road. In the case of asphalt berms, a tack of 0.40 l/m^2 over the entire berm foundation. The tack coat shall be left to break before the berm is placed.

2405 PLACING

When the berms are placed, proper care shall be taken at all times to ensure that the toe of the berm does not encroach on the side of the carriageway or shoulder by more than 25 mm.

(a) Placing by hand
The mixture shall be placed and shaped in situ in a rigid portable mould to form a trapezoidal kerb of the dimensions indicated on the Drawings.

In the case of asphalt berms the mixture shall be thoroughly compacted to form a hard unyielding berm, true to level shape and line with the specified tolerances. The moulds may be removed as soon as the material has cooled to air temperature, or in the case of a cold asphalt mix as soon as it has hardened.

(b) Placing by machine
A machine of approved design may be used for placing the berm. In general, machine- placed work will not require any additional compaction. In areas where, in the opinion of the Engineer, the compaction is inadequate, the machine shall be weighted with additional mass, or other measures shall be taken to ensure that adequate compaction is obtained.

(c) Placing under guardrails
Should the berm be placed first, the holes for the guardrail posts shall be excavated with care to prevent damage being done to the berm. Where chutes are required against fills, the berm shall be discontinued for the width of the top of the chute and finished to form a proper inlet for the water into the chute, as indicated on the Drawings.

(d) General requirements
The berms shall be placed true to level, shape and line. All berms deviating more than 10 mm from the specified line when measured at the inner edge of either their crests or their bases, or of which the height or width, measured at the crest, varies by more than 5mm from the specified height or width, will be rejected and shall

be removed and replaced at the Contractor's own expenses.
The surface of concrete berms placed by machine, and all unformed surface, shall be given a Class U2 finish, and formed surfaces a Class F2 finish. Joints shall be provided at 3 m intervals in all concrete berms either by casting in alternate sections or by cutting machined-placed sections. All such joints shall be neatly formed and finished so as not to leave any irregularities or loose concrete at the joints.

2406 MEASUREMENT AND PAYMENT

ITEM	UNIT
24.01 ASPHALT BERMS:	
(a) PLACED WHERE THERE ARE NO GUARDRAILS (TYPES OF ASPHALT AND BINDER INDICATED)	METRE (m)
(b) PLACED AT EXISTING GUARDRAILS (TYPES OF ASPHALT AND BINDER INDICATED)	METRE (m)

The unit of measurement shall be the metre of asphalt berm placed as specified.

The bid rates shall include full compensation for procuring, furnishing, mixing and placing the material and all other work necessary for completing the asphalt berms as specified.

The prime and tack coats shall be paid for under ITEM 24.03.

ITEM	UNIT
24.02 CONCRETE BERMS:	
(a) PLACED WHERE THERE ARE NO GUARDRAILS (CLASS OF CONCRETE INDICATED)	METRE (m)
(b) PLACED AT EXISTING GUARDRAILS (CLASS OF CONCRETE INDICATED)	METRE (m)

The unit of measurement shall be the metre of concrete berm placed as specified.

The bid rates shall include full compensation for procuring, furnishing, mixing and placing the material and all other work necessary for completing the concrete berms as specified. The prime coat shall be paid for under ITEM 24.03

ITEM	UNIT
24.03 PRIME AND TACK COATS:	
(a) PRIME COAT:	
(i) UNDER ASPHALT BERMS (PRIME INDICATED)	SQUARE METRE (m^2)
(ii) UNDER CONCRETE BERMS (PRIME INDICATED)	SQUARE METRE (m^2)
(b) TACK COAT (TYPE INDICATED)	SQUARE METRE (m^2)

The unit of measurement shall be the square metre of completed prime coat or tack coat applied in accordance with the Specifications.

The bid rates shall include full compensation for procuring and providing all material and for mixing and applying the adhesive and primer complete as specified, including cleaning, compacting and trimming the coat being primed.

Payment shall be made under this item for the coat if, as instructed by the Engineer, it is applied in a separate strip independently from the prime coat of the road or shoulder surface.

If applied as an integral part of the prime coat of the road or shoulder surface by the prime coat being sprayed over a wider area to provide space for the berms, payment for the prime coat will not be made under this item.

ITEM	UNIT
24.04 TRANSITION SECTIONS FOR NEW JERSEY TYPE OF RAILS	NUMBER (no)

The unit of measurement shall be the number of completed asphalt transition sections constructed to the details shown on the Drawings.

The bid rate shall include full compensation for procuring, providing, mixing and placing all material and for all labour, formwork and incidentals required for constructing complete transition sections as specified.

SERIES 2000: DRAINAGE

SECTION 2500: PITCHING, STONEWORK AND PROTECTION AGAINST EROSION

CONTENTS:

2501 SCOPE

This Section covers the furnishing of materials and the construction of a protective covering in stone pitching, cast in situ concrete pitching, bricks or prefabricated concrete blocks on exposed surfaces such as earth slopes, drains and stream beds, as well as heavier protective layers in the form of riprap and the construction of stone masonry for walls, all as shown on the Drawings or ordered by the Engineer.

2502 MATERIALS

(a) Stone

(i) Pitching
Stone for pitching shall be sound, tough and durable, without any stones less than 200 mm in minimum dimension, except that smaller pieces or spalls may be used for filling spaces between the large stones. The shapes of the rocks or stones shall be so as to form a stable protective layer of the required thickness. Rounded boulders shall not be used on slopes steeper than 2:1 unless grouted.

All stone intended for use on a particular pitching job shall be subjected to the prior approval of the Engineer.

(ii) Riprap
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 quantity of elongated stones.

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

(b) Cement

Cement shall comply with the requirements of US 310-1:2001, BS EN 197-1:2000 or equivalent standard on approval of the Engineer.

(c) Sand

(i) Sand for concrete
Sand for concrete, cement slurry and cement mortar shall comply with the requirements of AASHTO M6-93 or equivalent.

(ii) Sand bedding
Sand for bedding used for paving blocks shall not contain any deleterious impurities and shall comply with the grading requirements in TABLE 2502/ 1

TABLE 2502/1
GRADING REQUIREMENTS FOR BEDDING SAND

Sieve size (mm)	% Passing
10	100
5	95-100
2.36	80-100
1.18	50-85
0.600	25-60
0.300	10-30
0.150	5-15
0.075	0-10

(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% of it shall pass through a 0.075 mm sieve.

(d) Paving blocks

Paving blocks shall comply with the requirements of US 65:2002, BS 6717:2001 or equivalent for Class 25 paving blocks where paving blocks are made from concrete, and bricks used as paving blocks shall be facebrick units which shall comply with the requirements of BS EN 772-3:1998, BS EN 772-7:1998, SABS 227:2002 or equivalent. Engineering units may also be used instead of facebrick units.

The surface texture and colour of all units shall be uniform.

Paving blocks for sidewalks shall be square prefabricated concrete blocks, 450mm x 450 mm x 50 mm in size and fabricated from Class 30 concrete. As to appearance, the blocks shall comply with the requirements of US 65:2002, BS 6717:2001 or equivalent. The upper surface shall have an approved pattern to provide proper skid resistance.

Concrete grass blocks shall consist of concrete slabs of the dimensions shown on the Drawings, with openings through the slab totalling at least 20% of the surface area.

(e) Concrete

Concrete work shall be carried out in accordance with provision of SECTION 6200, 6300 and 6400.

(f) Wire

Wire for pitching kept in position by wires shall consist of 4 mm diameter galvanised wire, which complies with the requirements of BS 1052:1980 or equivalent.

(g) Permeable material for filter layer

Permeable material for filter layers shall comply with the requirements specified for permeable material for subsoil drains in CLAUSE 2104.

(h) Geotextile fabric

Synthetic- fibre filter fabric shall be of the grade and type specified in the Bill of Quantities or Special Specifications and shall comply with the requirements of SECTION 2700.

2503 STONE PITCHING

(a) Plain stone pitching
The area shall be prepared by excavating, shaping and trimming necessary for pitching and by thoroughly compacting the area by hand ramming to prevent subsequent settlement. A trench shall be excavated as directed by the Engineer along the toe of any slopes to be pitched or along the unprotected edge of the pitching in the beds of streams. Two pitching methods follow, and the method to be adopted shall be decided on by the Engineer.

(i) Method 1
Commencing at the bottom of the trench, the stones shall be laid and firmly bedded into the slope and against adjoining stones. The stones shall be laid with their longitudinal axes at right angles to the slope and with staggered joints. 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 spalls 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:

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

(2) Simultaneously with the placing of stones, top soil 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.

(3) Rooted grass or tufts of grass shall then be planted in the soil between stones and watered immediately and copiously and thereafter at regular intervals until the 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
The work shall be done in accordance with all the requirements specified for plain pitching in SUBCLAUSE 2503(a) above, except that the stone shall be thoroughly cleaned of adhering dirt or clay, moistened and embedded in freshly laid cement mortar composed of one part of cement to six parts of sand. Any spaces between the stones shall be filled with cement grout of the same composition as the mortar. The mortar and the grout shall be placed in a continuous operation for any days run at any one location. The grout shall be worked into the pitching to ensure that all spaces or voids between the stones will be completely filled with grout to the full depth of the stone pitching. Grout spilt onto exposed surface of the stone shall be removed while still soft, and the joints between stones shall be neatly finished.

The grouted pitching shall be cured with wet sacking or other approved wet cover for a period of not less than four days after grouting, 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 area to be pitched shall be prepared as described in SUBCLAUSES 2503(a) and 2503(b) concrete bed (Class 15 Mpa concrete) 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 2503(b), and care shall be taken not to spill the grout onto the finally exposed surfaces of the stones. Grout spilt onto the exposed surface of the stone 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 2503(b). Where required, weep holes shall be formed in the pitching.

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.

2504 RIPRAP

(a) General
Riprap shall consist of a course of large rock placed on bank slopes and toes in stream and river beds and at other localities where protection of this type may be required.

Two types of riprap are specified here, viz. one type where the rocks are individually packed, which is designated as packed riprap, and the other type where the rock is dumped and then spread by machines, which is 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 areas 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 that used in the construction of the adjoining riprap, but any voids shall be filled with similar stone and the entire backfill shall be well compacted.

(b) Filter bed
The filter bed shall consist of a layer or layers of permeable material placed on the prepared surface to the required thickness and each layer shall be finished to an even surface and thickness. Compaction of pervious material will not be required. Care shall be taken not mix various grades of filter material nor to disturb material already placed when subsequent layers or riprap are being placed.

When the use of synthetic- fibre filter fabric is required, the material shall be placed on the prepared surface on the filter bed, depending on the instructions. The overlap between adjacent sheets shall be 150 mm unless otherwise specified. Care shall be taken not to damage the filter fabric when subsequent layers are being placed, nor to expose the filter fabric to the sun for periods exceeding three days before it is covered.

(c) Packed riprap
Packed riprap shall be constructed from rocks placed individually to stagger the joints and so as to be firmly bedded in the prepared surface. The spaces between larger stones shall be filled with spalls or smaller stones securely rammed into place. On inclined surfaces the rock shall be laid in long horizontal strips starting from the bottom, and not in strips up the slope.

The completed riprap shall present a tight and even surface. Local surface irregularities of the riprap shall not exceed 150 mm.

(d) Dumped
Dumped riprap shall be constructed by dumping the stone on the prepared surface, spreading it by bulldozer or other suitable earth-moving equipment, and trimming it to the required lines and levels. The material shall be placed in a manner that will prevent the segregation of the smaller and larger stones and the top layer shall be tight with a minimum of voids.

2505 STONE MASONRY WALLS

(a) General
Stone masonry walls may be plain packed stone walls with dry joints or otherwise mortared stone walls with stones bedded in cement mortar as indicated on the Drawings, as specified or as may be ordered.

The minimum mass of each stone used shall be 10 kg and its minimum dimension 75 mm.

(b) Plain packed stone walls
A foundation trench shall be excavated down to rock or to material with an adequate bearing capacity at a minimum depth of 300 mm below ground lever. Larger selected stones shall be used for the foundation layer. Flat and stratified stones shall be laid with the largest dimension in the horizontal plane. Stones shall be packed individually to stagger the 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 for filling the voids. The top and ends of the wall shall be neatly finished with selected coping stones.

The appearance of the completed wall shall present an even and tight surface.

(c) Cement – mortared stone 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. The exposed parts of the stones on the wall faces shall be cleaned of all mortar by washing or wire brushing. The mortar shall be flush pointed to the satisfaction of the Engineer, who may require a capping and end treatment of the same mortar.

Weep holes shall be provided as prescribed and shall be cleaned of mortar or 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.

2506 SEGMENTAL BLOCK PAVING

(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 BS-Heavy 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 compatible herbicide and ant poison before the layer of sand for bedding is placed.

(b) Sand for bedding
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 (±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.

(c) Laying the paving blocks
The pattern for laying the paving blocks shall be that as shown on the Drawings or approved or prescribed 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, the pavement shall be compacted by two passes of a suitable vibrating-plate compactor operating at a frequency of 65 to 100 Hz and a low amplitude. Its plate surface shall be 0.2 to 0.4 m^2 and shall develop a centrifugal force of 7 to 16 kN.

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 pavement shall then be subjected to two further passes by the plate vibrator.

(d) Edge beams
Concrete edge beams or any such other edge supports shall be constructed onto the supporting layer in accordance with the details shown on the Drawings, and shall be constructed and left to cure before any paving blocks are laid.

(e) Paving blocks for sidewalks
Paving blocks for sidewalks shall be laid in the same way as that described above for paving blocks, also on a bed of sand but on the proviso that where so specified, joints shall be filled with a 6:1 sand:cement mortar instead of with sand only. In this case the width of the joints between the stones shall be strictly in accordance with the dimensions shown on the Drawings and the pavement shall be fully compacted before the joints are filled.

(f) Concrete grass blocks
Concrete grass blocks of the size specified or shown on the Drawings shall be placed on areas prepared for grassing as specified in SECTION 5600. The holes in the blocks shall be filled with topsoil, and grassed with grass cuttings or hydro-seeding as specified in SECTION 5600.

(g) Finishing requirements

(i) Segmental block paving
The completed paving shall be even and neat, flush with the kerb or edge beam and may not lie below the side of the kerbing. The final surface levels shall nowhere deviate by more than 15 mm from the specified levels and planes, and no irregularities exceeding 10 mm may occur during testing with a 3m straight-edge.

(ii) Grass block pavement
The completed grass-block pavement shall have a neat and even appearance. The final surface of the pavement may nowhere deviate by more than 15 mm from the specified levels and planes.

2507 CAST IN SITU CONCRETE PITCHING

The areas where cast in situ concrete pitching is to be constructed, shall be trimmed and prepared as described in CLAUSE 2506 for block paving. The areas shall also be treated with an environmentally compatible herbicide and ant poison if required. The concrete shall comply with the requirements of SECTION 6400.

Prior to placing the concrete the surface shall be watered and kept damp until the concrete has been placed. The type of concrete used shall, unless otherwise specified, be Class 20 MPa and the concrete shall be accurately laid in alternate panels to the lines and levels indicated, after which the remaining panels shall be similarly placed. Accurately set-up guides shall be used to achieve the required line and slope. The concrete shall be thoroughly compacted and finished to a Class U2 surface finish as defined in CLAUSE 6209.

Where indicated, the concrete pitching shall be contained by concrete edge beams being constructed as described in CLAUSE 2506.

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-days 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 occur during testing with a 3 m straight edge.

2508 MEASUREMENT AND PAYMENT

ITEM	UNIT
25.01 STONE PITCHING:	
(a) PLAIN PITCHING	
(i) METHOD 1	SQUARE METRE (m^2)
(ii) METHOD 2	SQUARE METRE (m^2)
(b) GROUTED STONE PITCHING	SQUARE METRE (m^2)
(c) WIRED AND GROUTED STONE PITCHING (TOTAL THICKNESS INDICATED)	SQUARE METRE (m^2)

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

The bid rate for each type of stone pitching shall include full compensation for furnishing all materials, making all excavations excluding trench and bulk excavations, compacting and trimming the excavated surfaces, forming and cleaning the weep holes, placing stones and grouting or wiring and grouting where applicable, grassing and watering (applicable to Method 2) and for all other work necessary for completing the pitching as specified. The bid rate for grouted stone pitching on a concrete bed shall also include full compensation for the concrete bed.

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

ITEM	UNIT
25.02 RIPRAP:	
(a) PACKED RIPRAP (CRITICAL MASS OF STONES INDICATED)	CUBIC METRE (m^3)
(b) DUMPED RIPRAP (CRITICAL MASS OF STONE INDICATED)	CUBIC METRE (m^3)
(c) FILTER BACKING (SUBCLAUSE 2104(a)(ii) AND 2504(b) CONSISTING OF:	
(i) CRUSHED STONE	CUBIC METRE (m^3)
(ii) FILTER SAND OBTAINED FROM BORROW PITS	CUBIC METRE (m^3)
(d) SYNTHETIC FIBRE FILTER FABRIC (TYPE , CLASS AND GRADE STATED)	SQUARE METRE (m^2)

The unit of measurement for riprap and filter layer (SUBITEMS 25.02(a), (b) and (c) above) shall be the cubic metre of riprap or filter layer in place and shall include rock used in trench backfill. The unit of measurement for SUBITEM 2502 (d) shall be the square metre of filter fabric laid as specified, including overlaps.

The rates bid for SUBITEMS 25.02(a), (b) and (c) shall include full compensation for preparing the surfaces, including excavation (but excluding excavation for trenches and bulk excavations) and for the furnishing, transporting, handling and placing of riprap or filter layers. The rate bid 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	UNIT
25.03 STONE MASONRY WALLS:	
(a) PLAIN PACKED STONE WALLS	CUBIC METRE (m^3)
(b) CEMENT-MORTARED STONE WALLS	CUBIC METRE (m^3)

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

The bid rate for each type of stone wall shall include full compensation for furnishing all materials, trimming the areas, placing the stones and cement-mortared masonry where necessary, and all other work necessary for completing the walls in accordance with the Specifications. Excavation of foundation trenches will be paid for separately.

ITEM	UNIT
25.04 CONCRETE PITCHING AND BLOCK PAVING:	
(a) CAST IN SITU CONCRETE PITCHING (CLASS OF CONCRETE AND THICKNESS OF PITCHING INDICATED)	SQUARE METRE (m^2)
(b) SEGMENTAL BLOCK PAVING (TYPE AND THICKNESS INDICATED)	SQUARE METRE (m^2)
(c) PREFABRICATED CONCRETE GRASS BLOCKS	SQUARE METRE (m^2)
(d) PREFABRICATED CONCRETE PAVING BLOCKS FOR SIDEWALK PAVEMENT (THICKNESS INDICATED)	SQUARE METRE (m^2)

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

The bid rates shall include full compensation for furnishing all material, all excavation (but excluding bulk excavation and excavation for foundation trenches and edge beams), compacting and trimming all the excavated areas, providing a sand bedding (SUBITEMS 25.04 (b) and (d)), laying and compacting the paving blocks (SUBITEMS 25.04 (b) and (d)), laying concrete grass blocks (SUBITEM 25.04 (c)), topsoiling and grassing, (SUBITEM 2504 (c)), constructing concrete pitching, including normal formwork and the shaping of surfaces (SUBITEM 25.04 (a)), making and cleaning weepholes (SUBITEM (a)) and for all other work necessary for completing the work as specified.

ITEM		UNIT
25.05	CONCRETE EDGE BEAMS (CLASS OF CONCRETE INDICATED)	CUBIC METRE (m^3)

The unit measured shall be the cubic metre of concrete in edge beams constructed as instructed.

The bid rate shall include full compensation for furnishing all materials and labour, including formwork as necessary, placing concrete and shaping all surfaces and all excavations required (in all classes of material).

ITEM		UNIT
25.06	PROVISION OF HERBICIDE AND ANT POISON:	
(a)	PROVISION OF MATERIALS	PROVISIONAL SUM
(b)	CONTRACTOR'S OVERHEAD CHARGES AND PROFIT	PER CENT (%)

Payment under the provisional sum for providing environmentally compatible ant poison and herbicide and the Contractor's overhead and profit in this respect shall be made in accordance with the provisions of Clause 1209 and in addition the Contractor's bid rate for overhead and profit shall include full compensation for applying the chemicals as specified.

ITEM		UNIT
25.07	FOUNDATION TRENCHES	CUBIC METRE (m^3)

The unit of measurement shall be the cubic metre of material excavated for foundation trenches irrespective of the class or depth of material. The quantity shall be calculated according to the dimensions shown on the Drawings or instructed by the Engineer.

The bid rate shall include full compensation for the excavation of the foundation trenches irrespective of the class or depth of material complete as specified, or as shown on the Drawings or as instructed by the Engineer.

SERIES 2000: DRAINAGE

SECTION 2600: GABIONS

CONTENTS:

2601 SCOPE

This Section covers the construction of gabion walls and aprons for constructing retaining walls, lining channels, revetments, bridge and culvert protections, protection of road embankments and other anti erosion structures.

Gabions shall be flexible galvanised steel – wire wire-mesh cages packed with rock.

2602 MATERIALS

(a) Rock

Rock used as filling for cages shall be clean, hard, un-weathered boulders or rock fragments. No rock fragment shall exceed the maximum size given in TABLE 2602/ 1, and at least 85% of the rocks shall be of a size equal to or above the average least dimension size in TABLE 2602/1.

The minimum density of rock shall be 2,300 kg/m^3, but the Contractor must get approval from the Engineer to use lower density rock.

TABLE 2602/1
ROCK SIZES

Depth of cage (m)	Rock size according to the largest dimension of rock	
	Average least dimension (mm)	Maximum (mm)
0.2	125	150
0.3	125	200
0.5	125	250
1.0	125	250

(b) Wire

All wire for making the gabions and for tying during the construction of the gabions shall comply with the following requirements:

(i) Tensile strength:
350-500 N/mm^2 as per EN 10223-3.

(ii) Coating:
All the wire shall be heavily zinc coated in accordance with the provisions of EN 10244-2. The minimum mass of the coating shall be according to EN 10244-2, see TABLE 2602/2 below:

TABLE 2602/2
WIRE COATING

	Mesh wire diameter (mm)						
	2.0	2.2	2.4	2.7	3.0	3.4	3.9
Coating (gr/m^2)	215	230	230	245	255	265	275

(iii) Elongation:
Elongation shall be not less then 10% as per EN 10223-3.

(c) PVC- coated wire

The gabions of PVC–coated mesh shall be of an acknowledged make which shall be subject to approval by the Engineer.

(d) Galvanising

All wire used in the making of gabions shall be galvanised in accordance with the provisions of BS 1052:1980 or equivalent for Class A heavy galvanised mild- steel wire.

(e) Wire mesh

Wire mesh shall comply with the requirements of BS 4483:1998 or equivalent.

(f) Geotextile filter fabric

Geotextile filter fabric shall comply with the requirements of SECTION 2700.

2603 CONSTRUCTING GABION CAGES

(a) General

Gabion cages shall be made from wire mesh of the size and type and selvedge as specified below. The cages shall be subdivided into cells by wire mesh diaphragms and will be of two types.

(i) Boxes which are generally used for the construction of gabion walls. These boxes are subdivided into cells by diaphragms spaced at 1.0 m intervals. No diaphragms are required for a box of which the length does not exceed 1.5 m. The standard sizes of gabions are as shown in TABLE 2603/1 below:

TABLE 2603/1
GABION SIZES

Mesh type (mm)	Wire diameter	Sizes
80x100	2.7 mm	Length: 1.5-2-3-4 m
		Width: 1 m
		Height: 0.5-1 m

(ii) Mattresses which are generally used as single-layer aprons only in revetments, channel linings, etc and in which the maximum width shall be subdivided by diaphragms into cells with a width of 1.0 m as specified in the Bill of Quantities.

The standard sizes of mattresses are as shown in TABLE 2603/2 below:

TABLE 2603/2
MATTRESS SIZES

Mesh type (mm)	Wire diameter	Sizes
60x80	2.2 mm	Length: 3-4-5-6 m
		Width: 2 m
		Height: 0.17-0.23-0.30 m
50x70	2.0 mm	Length: 3-4-5-6 m
		Width: 2 m
		Height: 0.15-0.20-0.25 m

Other sizes of gabion boxes and mattresses may be supplied, provided that the Engineer's prior permission has been obtained.

The cut edges of all mesh used in the construction of gabions, except the bottom edge of diaphragms and end panels, shall be selvedged with wire as specified in TABLE 2603/03

(b) Selvedges
The cut edges of all mesh used in the construction of gabions, except the bottom edges of diaphragms and end panels, shall be selvedged with wire having a diameter as specified in TABLE 2603/3. The selvedge wire and the wire used for lacing operation must have the same technical specification of the mesh wire. The combination of the diameters of mesh wire, selvedge wire and lacing wire shall be as specified in TABLE 2603/3.

TABLE 2603/3
DIAMETER OF MESH WIRE, SELVEDGE WIRE AND LACING WIRE

Mesh wire diameter (mm)	2.0	2.2	2.4	2.7	3.0
Selvedge wire diameter (mm)	2.4	2.7	3.0	3.4	3.9
Lacing wire diameter (mm)	2.0	2.2	2.2	2.2	2.2

Where the selvedge is not woven integrally with the mesh but has to be tied to the cut ends of the mesh, it shall be attached by tying the cut ends of the mesh to the selvedge, so that a force of not less than 8.5 kN applied in the same plane as the mesh at a point on the selvedge of a mesh sample of 1.0 m in length will be required to separate it from the mesh.

(c) Diaphragms and end panels
The diaphragms and end panels shall be selvedged on the top and vertical sides only. The end panels shall be attached by the cut ends of the mesh wires at the bottom of the panel being twisted around the selvedge on the base of the gabion. Similarly, the diaphragms shall be attached by the cut ends of the mesh being twisted to the twisted joints of the mesh in the base of the gabion. In each case the force required to separate the panels from the base shall be not less than 6 kN/m.

(d) Binding and connecting wire
Sufficient binding and connecting wire for all the tying to be done during construction of the gabions as specified in CLAUSE 2604 below, shall be supplied with the gabion cages. The diameter of the wire shall be 2.2 mm.

(e) Tolerances
The tolerance on the specified diameter of all wire shall be $\pm$2.5%. The length of the cages shall be subject to a tolerance of $\pm$10% and the width of the cages shall be subject to a tolerance of $\pm$5% and the depth of the cages shall be subject to a tolerance of $\pm$5%.

2604 CONSTRUCTING GABIONS

(a) Preparing the foundation and surface
The surface on which the gabion cages are to be laid prior to their filled with rock shall be levelled to the depth shown on the Drawings or as directed by the Engineer so as to present an even surface. If necessary, cavities between rock protrusions shall be filled with material similar to that specified in SUBCLAUSE 2602(a). Where required, a foundation trench along the toe of the revetment or wall shall be excavated to the dimensions shown on the Drawings or indicated by the Engineer.

(b) Filter fabric
One layer of Grade 3 filter fabric shall be placed where indicated on the Drawings or ordered by the Engineer. The material shall placed, in accordance with the instructions, in strips with a minimum overlap of 300 mm at the joints, and shall be properly fastened to prevent any movement or slipping while the gabions are being placed.

(c) Assembly
The methods of constructing, stretching, placing in position, wiring and filling the gabions with rock shall generally be in accordance with the manufacturer's instructions which have been approved by the Engineer, but nevertheless sufficient connecting wires shall be tensioned between the vertical sides of all the outer visible cells to prevent the deformation of boxes as they are being filled with stone.

It is essential that the corners of gabion cages be securely wired together to provide a uniform surface and ensure that the surface does not resemble a series of block or panels.

The layout and the tolerances for the layout of the boxes shall be as shown on the Drawings or as instructed by the Engineer.

(d) Rock filling

(i) Boxes in retaining walls
Particular care shall be taken in packing the visible faces of gabion boxes, where only selected stone of the specified size shall be used so as to obtain as even–faced finish. The boxes shall be filled in layers to prevent deformation and bulging. Boxes shall be filled to just below the level of the wire braces, after which the braces shall be twisted to provide tension. Care must be taken to ensure that consecutive layers of cages are filled evenly to a level surface ready to receive the next course.

(ii) Mattresses used in revetments and aprons
The gabion mattresses forming aprons and revetments shall be filled by random stones being packed in the first layer and selected stones being used for the top layer so as to resemble normal stone pitching.

2605 MEASUREMENT AND PAYMENT

ITEM	UNIT
26.01 FOUNDATION TRENCH EXCAVATION AND BACKFILLING:	
(a) IN SOLID ROCK AS DEFINED IN CLAUSE 3603	CUBIC METRE (m^3)
(b) IN ALL OTHER MATERIAL THAN ROCK AS DEFINED IN CLAUSE 3603	CUBIC METRE (m^3)

The unit of measurement shall be the cubic metre of each class of excavation made in accordance with the authorised dimensions.

The bid rates shall include full compensation for excavating in each class of material, including unavoidable overbreak, the trimming of trenches and compacting the trench inverts, backfilling and compacting the backfill, and the disposing of surplus excavated material.

No haulage will be paid.

ITEM	UNIT
26.02 SURFACE PREPARATION FOR BEDDING THE GABIONS	SQUARE METRE (m^2)

The unit of measurement for levelling and preparing surfaces for receiving the gabions shall be the square metre to the neat dimensions of revetments, aprons or wall foundations.

The bid rate shall include full compensation for excavating, filling any cavities with rock and levelling the ground surface so as to be ready for receiving the gabion cages for retaining walls, aprons and revetments.

ITEM	UNIT
26.03 GABIONS:	
(a) GALVANISED GABION BOXES (DIMENSIONS OF BOX AND MESH SIZE INDICATED)	CUBIC METRE (m^3)
(b) PVC- COATED GABION BOXES (DIMENSIONS OF BOX AND MESH SIZE INDICATED)	CUBIC METRE (m^3)
(c) GALVANISED GABION MATTRESSES (DIMENSIONS OF MATTRESS, MESH SIZE AND DIAPHRAGM INDICATED)	CUBIC METRE (m^3)
(d) PVC- COATED GABION MATTRESSES, MESH SIZE AND DIAPHRAGM SPACING INDICATED)	CUBIC METRE (m^3)

The unit of measurement shall be the cubic metre of the rock – filled cages and the quantity shall be calculated from the dimensions of the gabions indicated on the Drawings or prescribed by the Engineer, irrespective of any deformation or bulging of the completed gabions.

The bid rates shall include full compensation for supplying all the materials, including rock fill, wire–mesh cages, tying and connecting wires, loading transporting and off-loading, the assembling and filling of the cages, and any other work necessary for constructing the gabions.

ITEM	UNIT
26.04 FILTER FABRIC (TYPE AND GRADE INDICATED)	SQUARE METRE (m^2)

The unit of measurement shall be the square metre of area covered with filter fabric placed in position.

The bid rate shall include full compensation for supplying the filter fabric, cutting, waste, placing, joining, overlapping and securing the material in position.

SERIES 2000: DRAINAGE

SECTION 2700: FILTER FABRIC AND DRAINAGE COMPOSITE

CONTENTS:

2701 SCOPE

This Section covers the geotextile filter fabrics and drainage composites to be used in drainage systems such as surface drainage, drainage trenches, perforated pipes wrap, retaining wall backfill and vertical drainage where the function of the geotextile filter fabric is to allow the water to go through preventing the fine soil particles to enter the drainage system (filtration) that can be obtained by the use of filling gravel material or synthetic core (drainage composite).

2702 MATERIALS

(a) Geotextile for drainage applications
The geotextile used as filter (as filter itself or as filter of the drainage composite) shall meet the mechanical and hydraulic properties listed in TABLE 2703/3 and the following general requirements:

- The geotextile shall be a "non-woven" type manufactured with a heat-bonding process with continuous spundbonded filaments.
- The raw material of the filament yarns shall be produced with a mixture of polypropylene and polyethylene where the polyethylene content will not exceed the 30% of the overall mass and will be used as external revetment of each filament.
- The geotextile will be manufactured and supplied according to a certified quality control process.
- The geotextiles shall be rolled in an UV resistant package and it will be itself resistant to wearing out, rotting, solvents, acids, alkalis, bacteria and other microorganism and to any chemical reaction occurring in standard natural soils.
- Geotextiles can be easily transported and installed. During transportation and storage the geotextile rolls shall be kept wrapped to avoid damage. Each geotextile roll shall be labelled and marked for identification during quality control of product.

In drainage applications a drainage composites can be used to replace the drainage system composed by granular material and filter. The drainage composite shall meet the mechanical and hydraulic properties listed in TABLE 2703/2 and the following general requirements:

(i) Drainage composite shall be a laminated filter drain composed of two layers of the above described geotextile which is used as a filter separated by a high density polyethylene net.

(ii) The three components (nonwoven-net-nonwoven) shall be bonded together over the entire surface by thermal lamination.

(iii) The filters will be larger than the core width to guarantee (at least at one side) an overlapping to prevent the intrusion of fine soil into the drainage core.

(iv) The geocomposite will be manufactured and supplied according to a certified quality control process.

2703 STANDARD TESTING PROCEDURES

(a) Test standards
Table 2703/1 lists test standards for geotextiles. Any other standard meeting the basic requirements stated here can be accepted at the discretion of the Engineer provided that the Contractor has provided the Engineer with the manufacturers test certificate.

TABLE 2703/1
TESTS FOR NON-WOWEN GEOTEXTILE FILTERS FOR DRAINAGE APPLICATIONS AND DRAINAGE COMPOSITES

Test	Test Standard
Wide width strip tensile (kN/m)	BS EN ISO 10319:1996
Elongation (%)	BS EN ISO 10319:1996
CBR Puncture resistance (N)	BS EN ISO 12236:1996
Trapezoidal tear resistance (N)	ASTM D4533-91(1996)
Permeability -10 cm head (l/sqmxsec)	BS 6906-3:1989
Pore Size (μm)	BS 6906-2:1989

TABLE 2703/2
TESTS FOR NON-WOWEN FILTERS OF DRAINAGE COMPOSITES

Test	Test Standard
Tensile breaking load (kN/m)	BS EN ISO 10319:1996
CBR Puncture resistance (N)	BS EN ISO 12236:1996
Compressive strength at 10% compression (kN/sqm)	ASTM D1621-00
Water flow –hydraulic gradient = 1.0 hard/hard (l/sec/m)	BS EN ISO 12958:1997

The Engineer reserves the right to reject any geotextile material he/she considers unsuitable for the Works.

In addition to that, the Engineer reserves the right to take samples of the geotextile during the course of the work and subject them to the tests he/she deems necessary in a suitably equipped laboratory on behalf of the Contractor.

(b) Characteristics of non-woven geotextile
The locations of the geotextiles employed for drainage function shall be shown in the Drawings or as directed by the Engineer. The required mechanical and hydraulic properties of the geotextile conform to the minimum property requirements as specified in the TABLE 2703/3.

In addition to the properties given in table 2703/3 the filter geotextile shall be unaffected by chemical materials and will be resistant to all natural occurring soil alkalis and acids (pH range 2-13)

The geotextile shall remain wrapped in a black polyethylene wrapper to protect it from the harmful

effects of UV-rays. During the placement the temporary exposure to the light shall not exceed 10 hours.

TABLE 2703/3
GEOTEXTILE PROPERTIES

Test	Minimum Requirement
Wide width strip tensile (kN/m)	8.0
Elongation (%)	Max. 30
CBR Puncture resistance (N)	1500
Trapezoidal tear resistance (N)	300
Permeability -10 cm head (L/sqmxsec)	90
Pore Size (μm)	100

(c) Characteristics of Drainage Composites
The purpose of usage and application locations of the geocomposites employed for drainage function shall be stated in designs and shall be used if the engineers approves. The required mechanical and hydraulic properties of the geocomposite selected at the end of the design phase shall be stated and the geocomposite shall meet the minimum property requirements as specified in the TABLE 2703/4.

TABLE 2703/4
PROPERTIES OF GEOCOMPOSITE

Test	Minimum Requirements	
	Type A	Type B
Tensile breaking load (kN/m)	16	20
CBR Puncture resistance (N)	2700	3400
Compressive strength at 10% compression (N)	150	193
Water flow (m/sec) 20 kPA 200 kPa 300 kPa 400 kPA		 0.52 0.41 0.31 0.27

Type A drainage composite shall be used for vertical applications as retaining walls or in flat applications where the vertical loading is limited to 60 kPa. Type B shall be used in flat applications exceeding the 60 kPa.

In addition to the properties given in TABLE 2703/4 the drainage composite elements shall be unaffected by chemical materials and will be resistant to all natural occurring soil alkalis and acids (pH range 2-13).

The geocomposite shall remain wrapped in a black polyethylene wrapper to protect it from the harmful effects of UV-rays. During the placement the temporary exposure to the light shall not exceed 10 hours.

The performance of the filter geotextiles of the drainage composite will comply with the specification limits indicated in CLAUSE 2702.

(c) Quality control
For the purpose of quality control of the geosynthetics to be used, the number of roll to be tested out of the total number of rolls supplied shall be in accordance with ASTM D4354-99 and 5 test samples shall be taken from each test roll and tested in the main direction. If the average value of the results of five tests satisfies the specifications limits, the geosynthetic material shall be accepted otherwise rejected. If one or more rolls fall below the specification limits, the procedure defined above shall be repeated by resampling. If the average test results of the resampled roll exceed the specification limits, the geosynthetics of the batch shall be accepted.

(d) Construction methods
When the use of geosynthetics is required with purpose of drainage applications at specified locations in projects, the geosynthetics should not be damaged during transportation, placement and compaction of the granular fill material (if required by the application) in/on which the geosynthetics will be placed. In case of damage, the damaged sections will be repaired in away approved by the Engineers either by patching or by replacement of the damaged section by new material.

2704 MEASUREMENT AND PAYMENT

Measurement and payment for geotextile filter fabric will be according to the relevant pay ITEMS included in SECTIONS 2500 and 2600.

SERIES 3000

EARTHWORKS AND PAVEMENT LAYERS OF GRAVEL OR CRUSHED STONE

CONTENTS OF THE GENERAL SPECIFICATIONS:

SERIES 3000: EARTHWORKS AND PAVEMENT LAYERS OF GRAVEL OR CRUSHED STONE

SECTION 3100: CLEARING, GRUBBING AND REMOVAL OF TOPSOIL

CONTENTS:

3101 SCOPE

This Section covers the clearing of the Site and the grubbing and removal of topsoil necessary for construction of the Works covered by the Contract, in accordance with these Specifications.

3102 DESCRIPTION OF WORKS

(a) General

No clearing and grubbing shall be done unless approved by the Engineer. The Contractor shall note that, in order to avoid re-clearing, the clearing and grubbing may have to be done at the last practicable stage of construction.

The Contractor shall take all necessary precautions to prevent damage to structures and other private or public property.

Any unauthorised damage to or interference with private or public property including trees shall be made good to the satisfaction of the Engineer and the owner at the Contractor's sole expense.

(b) Area to be cleared, grubbed and removed of topsoil

The area to be cleared, grubbed and removed of topsoil shall generally extend to 3 metres beyond the top of the slope in cuts and 3 metres beyond the toe of the slope of embankments in accordance with the Drawings or as directed by the Engineer. The Engineer shall designate the areas to be cleared, which shall not necessarily be limited to those mentioned above.

The shoulders on each side of existing carriageways are included in the clearing and grubbing, but not the existing carriageway itself.

No trees which fall between the extent of works and the limits of clearing and grubbing shall be removed or damaged without the written authorisation of the Engineer. Individual trees designated by the Engineer shall be left standing and uninjured.

Within built up areas clearing and grubbing shall be strictly limited to the extent of cut or fill as shown in the Drawings or as directed by the Engineer. No private property e.g. buildings, crops, signs, fences etc shall be removed, relocated or altered without the authorisation of the Engineer.

(c) Clearing and grubbing

Clearing shall consist of the removal of all trees, bush, shrubs and other vegetation, rubbish, fences and all other objectionable material, including the disposal of all material resulting from the clearing and grubbing. The clearance of trees within the extent of the Works shall include Baobab trees. Clearing shall also include the removal of all rocks and boulders of up to 0.15 m^3 in size which are exposed or lying on the surface.

Clearing shall include complete removal and disposal of structures that obtrude, encroach upon or otherwise obstruct the work, including existing bridge structures and removal of foundations to a depth of one metre below the bed level shown on the Drawings.

Structures which cannot be cleared by reasonable means in the opinion of the Engineer shall be broken down in accordance with the requirements of the Special Specifications.

Clearing shall include removal of mounds and nests from termites, ants or other insects or burrowing animals. Such removal shall be carried out by excavation to the required depth as directed by the Engineer, and subsequent poisoning with approved pesticides in the case of ants and termites. No additional payment will be made for removal of such nests, but backfilling and compaction with approved fill materials will be paid as ordinary earthworks fill under the relevant pay item. Poisoning with approved pesticides will be paid for separately.

In the roadway all stumps and roots exceeding 50 mm in diameter shall be removed at least to the depth which is the larger of the following:

- 600 mm below the finished road level
- 100 mm below the ground level after removal of topsoil
- 300 mm below the top of improved subgrade or formation level.

All stumps and roots, including matted roots, shall be removed to a depth of at least 300 mm below the formation level (top of improved subgrade).

The cavities resulting from the grubbing shall be backfilled with approved material and compacted to comply with the Specifications for the relevant layer.

(d) Removal of topsoil

Topsoil shall be removed to a depth as specified in the Special Specifications or as instructed by the Engineer and conserved as instructed by the Engineer. The entire roadway shall be stripped of topsoil as directed by the Engineer. The rate paid for clearing, grubbing and removal of topsoil shall include all cost for the removal of topsoil to the depth instructed by the Engineer. Payment for removal of any material below this level will be paid for as Common Excavation to Spoil in accordance with SECTION 3600 in case the material is spoiled. No additional payment will be made for conservation measures, stockpiling or re-handling of topsoil, whether paid for as Common Excavation to Spoil, or included in the rate for pay ITEM 31.01.

(e) Conservation of topsoil

If not used immediately, the topsoil shall be transported and deposited in stockpiles or spoil banks provided by the Contractor at his/her own expense and at locations approved by the Engineer. No additional payment will be made for stockpiling or re-handling topsoil. The cost of stripping and disposal of topsoil shall be included in the price bid for clearing, grubbing and removal of topsoil.

(f) Conservation of vegetation and cutting of trees

Where provided for in the Special Specifications, certain designated plants and trees encountered in the road reserve shall be carefully protected by the Contractor. He/she/she shall then include in his/her bid rates for clearing and grubbing full compensation for omitting or the careful removal and planting of the plants in a protected and fenced-off area, and, on completion of

the road, the replanting of the plants in suitable positions in the road reserve in accordance with the Engineer's instructions. The Contractor's attention is in this respect specifically drawn to SECTION 1700: Environmental Protection and Waste Disposal.

In the cases where cutting of trees has been approved by the Engineer they shall be cut in sections from the top downwards. The branches of trees to be left standing shall be trimmed so as to leave a 7 m clearance above the carriageway.

Where clearing and grubbing would involve the cutting down of indigenous forest containing a significant number of trees with a trunk diameter exceeding 200 mm, the Contractor shall inform the officials of the Forestry Department before commencing with clearing and grubbing of such areas so as to enable that Government Department either to salvage any usable timber or to identify the trees before they are removed by the Contractor.

(g) Disposal of material
Material obtained from clearing, grubbing and removal of topsoil, shall be disposed of as indicated by the Engineer, in stockpiles for later use in the case of topsoil, borrow pits or other suitable places and covered up with soil or gravel in the case of other debris. The burning of material will only be permitted on the prior written approval of the Engineer. All statutory provisions with regards to air pollution shall be carefully observed.

All tree trunks and branches in excess of 150 mm in diameter shall be cleared of secondary branches, sawn into suitable lengths and stacked at sites indicated by the Engineer. Such timber shall not be used by the Contractor and shall remain the property of the Employer unless otherwise agreed on with the Engineer.

(h) Re-clearing of vegetation
When portions of the road reserve or other areas have been cleared in accordance with the Specifications, but vegetation grows again in the course of time during construction, the Engineer may, if he/she/she considers it necessary, order that the area be re-cleared. No additional payment will be made for such re-clearing.

Such re-clearing of areas previously cleared includes the removal and disposal of grass, shrubs and other vegetation in the same manner as for the first clearing operation.

3103 MEASUREMENT AND PAYMENT

No payment will be made for the moving of soil or gravel material which may be inherent in or unavoidable during the process of clearing.

Clearing, grubbing and removal of topsoil required for quarries, borrow areas and any other natural material sources, for haul roads and all temporary construction will not be measured for payment.

ITEM	UNIT
31.01 CLEARING, GRUBBING AND REMOVAL OF TOPSOIL:	
(a) CLEARING AND GRUBBING	HECTARE (ha)
(b) REMOVAL OF TOPSOIL	CUBIC METRE (m^3)

The unit of measurement for SUBITEM 31.01(a), clearing and grubbing, shall be the hectare (to the nearest 0.1 ha) designated by the Engineer and cleared of the vegetation cover and grubbed and in accordance with these Specifications, all to the satisfaction of the Engineer. The unit of measurement for SUBITEM 31.01(b), removal of topsoil as specified or instructed by the Engineer, shall be the cubic metre measured in place at the depth and width specified.

The bid rate shall include full compensation for all work necessary for the clearing of the surface, any necessary de-watering, removal of topsoil to the depth as specified or as instructed by the Engineer after removal of the vegetation cover, the removal and grubbing of trees and tree stumps (except large trees and stumps as defined below), cutting of branches, backfilling of cavities, demolishing and disposal of buildings and structures (except for removal of drainage structures as provided for in SECTION 2200), and the removal, transporting and disposal or conservation of material all as specified in this SECTION 3100. The Contractor's attention is drawn to SUBCLAUSE 3102(d) for further explanation of the work included under this pay item.

ITEM	UNIT
31.02 REMOVAL AND GRUBBING OF LARGE TREES AND TREE STUMPS:	
(a) GIRTH EXCEEDING 1.0 m UP TO AND INCLUDING 2.0 m	NUMBER (no)
(b) GIRTH EXCEEDING 2.0 m UP TO AND INCLUDING 3.0 m	NUMBER (no)
(c) GIRTH EXCEEDING 3.0 m	NUMBER (no)

The girth of trees or stumps shall be measured at the narrowest point of the tree or stumps in the first metre of its height above ground level. Trees and stumps with a girth exceeding 1.0 m shall be measured individually and classified according to the size in increments of 1.0 m as indicated above.

The bid rates shall include full compensation for all work necessary for the clearing and grubbing of trees and stumps with girth exceeding 1.0 metre, the backfilling of holes and the removal and disposal of material, all as described in this SECTION 3100.

Where construction is carried out through plantations or where the number of trees with a girth exceeding 1.0 m renders individual measurement impractical, the Special Specifications may provide that the clearing and grubbing of trees in such areas be measured in hectares. If this method of measurement is used, the areas where it applies will be shown on the Drawings or stated in the Special Specifications. Where the Special Specifications provide for the cleaning and grubbing of large trees per hectare in such specific cases, the bid price shall include full compensation for all work as described in connection with individual trees above.

ITEM	UNIT
31.03 APPLYING APPROVED PESTICIDES TO ANT AND TERMITE NESTS	LITRES (l)

The unit of measurement for applying approved pesticides to ant and termite nests shall be the litres as instructed by the Engineer applied in accordance with these Specifications.

The bid rate shall included full compensation for all work necessary for applying approved pesticides to ant and termite nests.

SERIES 3000: EARTHWORKS AND PAVEMENT LAYERS OF GRAVEL OR CRUSHED STONE

SECTION 3200: REMOVAL OF EXISTING STRUCTURES

CONTENTS:

3201 SCOPE

This Section covers the requirements for removing the existing kerb and gutter, grouted stone side ditch, buildings, concrete entrance slabs and other obstructions that are not designated to remain.

3202 GENERAL

The Contractor shall remove and dispose of all buildings, foundations, bridges, drainage structures and other obstructions within the limits of the Works, except items designated to remain and utilities and obstructions to be removed under other provisions of this Contract. Refer also to SECTION 3100: CLEARING, GRUBBING AND REMOVAL OF TOPSOIL.

All existing structures designated as salvage material shall be removed, without damage, in sections or pieces that may be readily transported, and shall be stored by the Contractor at locations specified in the Special Specifications. Unusable perishable material shall be destroyed. Non-perishable material, waste concrete and masonry shall as far as practicable be placed in slopes of embankments. Any broken concrete or masonry which cannot be used in construction, and all other materials not considered suitable for use elsewhere, shall be disposed of by the Contractor. In no case shall any discarded materials be left in windrows or piles adjacent to or within the Site. The manner and location of disposal of materials shall be subject to the approval of the Engineer and shall not create an unpleasant or objectionable view. When the Contractor is required to locate a disposal area outside the Site at his/her own expense, he/she/she shall obtain and file with the Engineer, permission in writing from the property occupier for the use of his/her property for this purpose.

Basements or cavities left by structure removal shall be filled to the level of the surrounding ground and, if they are within the roadbed, the backfill shall be compacted in accordance with the relevant requirements in this Specification.

Existing utilities through, at or near existing structures shall be protected and/or relocated as directed by the Engineer.

3203 REMOVAL OF GROUTED STONE SIDE DITCHES

Existing grouted stone side ditches shall be preserved as far as feasible, in accordance with the instructions of the Engineer. However, where necessary, they shall be totally or partially removed, as directed by the Engineer, and if required the salvaged stones shall be stockpiled where directed by the Engineer.

3204 REMOVAL OF BRIDGES, CULVERTS AND OTHER DRAINAGE STRUCTURES

Bridges, culverts, and other drainage structures shall not be removed until satisfactory arrangements have been made to accommodate traffic and the flow of water.

Unless otherwise indicated, the existing substructures shall be removed down to the natural stream bottom and those parts outside the stream shall be removed 300 mm below natural ground surface. Portions of existing structures within the limits of a new structure shall be removed to accommodate the construction of the proposed structure.

Bridges designated as salvage material shall be dismantled without damage and match marked. Structures designated to become the property of the Contractor shall be removed from the Site.

Blasting or other operations necessary to remove existing structures or obstruction, which may damage new construction, shall be completed prior to placing the new work.

3205 REMOVAL OF PIPE CULVERTS

Sections of pipe lost from storage or damaged by negligence shall be replaced at the Contractor's expense. Pipes shown on the Drawings or directed by the Engineer to be plugged shall be left in place and the ends plugged.

3206 REMOVAL OF CONCRETE ENTRANCES, KERBS, ETC

All concrete pavement, kerbs, channels, buildings, foundations, slabs, etc designated for removal shall be disposed of by the Contractor at approved dump sites at a maximum haul distance of 10 km as ordered by the Engineer, unless otherwise specified.

Concrete designated for use as riprap shall be broken into pieces not exceeding 80 kg and stockpiled at designated locations for use on the project.

3207 REMOVAL OF UTILITIES

The removal of existing utilities required to permit orderly progress of work will be accomplished by local agencies, unless otherwise provided for in the Special Specifications or shown on the Drawings. Whenever a telephone or telegraph pole, pipeline, conduit, sewer, or other utility is encountered and must be removed or relocated, the Contractor shall advise the proper local authority or owner to arrange for its removal/relocation.

3208 MEASUREMENT AND PAYMENT

ITEM		UNIT
32.01	REMOVAL OF EXISTING STRUCTURES:	
(a)	REMOVAL OF EXISTING PIPE CULVERTS OF ANY SIZE	LINEAR METRE (m)

(b) REMOVAL OF REINFORCED CONCRETE IN BRIDGES, BOX CULVERTS AND SLABS INCLUDING HEADWALLS, WINGWALLS AND APRON	CUBIC METRE (m^3)
(c) REMOVAL OF PLAIN CONCRETE AND MASONRY IN BRIDGES AND CULVERTS INCLUDING ABUTMENT, HEADWALLS, WINGWALLS AND APRON	CUBIC METRE (m^3)
(d) REMOVAL OF KERB AND CHANNEL	LINEAR METRE (m)
(e) REMOVAL OF EXISTING GROUTED STONE PITCHING	SQUARE METRE (m^2)

The unit of measurement for removal of existing pipe culverts shall be the linear metre of pipe acceptably removed, as directed by the Engineer.

The unit of measurement for removal of reinforced or plain concrete in bridges and culverts shall be the cubic metre of concrete acceptably removed, as directed by the Engineer.

The unit of measurement for removal of kerb and channel shall be the number of linear metres of kerb and channel acceptably removed, as directed by the Engineer.

The unit of measurement for removal of grouted stone pitching shall be the square metres of surface of grouted stone side ditch acceptably removed, as directed by the Engineer.

The tendered rate for removal of pipe culverts shall include full compensation for all materials, labour, equipment, tools and incidentals necessary to complete the work for demolishing of pipes of any size and type including any concrete bedding and surround, removing and disposing of all materials including supply and compaction of material for backfilling. Removal of concrete and masonry in headwalls, wingwalls and apron will be paid for separately under ITEMS 32.01(b) and 32.01(c) as applicable.

The tendered rate for removal of reinforced or plain concrete and masonry in bridges and culverts shall include full compensation for all materials, labour, equipment, tools and incidentals necessary to complete the work for demolishing of the bridge and culverts, removing and disposing of all materials including supply and compaction of material for backfilling.

The quantities, determined as provided above for kerb, channel and grouted stone pitching shall be paid at the rate per unit of measurement, respectively, for each of the particular pay items, included in the Bill of Quantities which price and payment shall be full compensation for all materials, labour, equipment, tools and incidentals necessary to complete the work of demolishing, removing, disposing or stockpiling, as applicable, including supply and compaction of material for backfilling.

SERIES 3000: EARTHWORKS AND PAVEMENT LAYERS OF GRAVEL OR CRUSHED STONE

SECTION 3300: BREAKING UP EXISTING PAVEMENT LAYERS

CONTENTS:

3301 SCOPE

This Section covers the breaking up and excavation of existing pavement layers by conventional means or by milling, selecting the material, and the removal thereof to spoil dumps or to stockpiles for later reprocessing or recycling.

3302 SELECTING THE MATERIAL

Where directed by the Engineer, the Contractor shall remove the layers of the existing pavement, taking care not to damage the existing kerbs and/or gutters, if any. In case of damage to the existing kerbs or gutters, they shall be replaced to the satisfaction of the Engineer at the Contractor's expense.

Material from existing pavements may only be used for purposes approved by the Engineer. The material shall be so excavated that material from the various pavement layers, or materials of different types, will not be mixed unless so permitted by the Engineer.

3303 CLASSIFYING THE MATERIAL

Material from existing pavements shall be classified as follows for excavation and processing purposes:

(a) Existing bituminous material
Existing bituminous material shall be asphalt or other bituminous seal or base course material removed separately from the pavement on the instruction of the Engineer. Where underlying material is broken down or excavated together with bituminous materials, the mixture will not be classified as bituminous material.

(b) Non-cemented material
Non-cemented material shall be existing pavement material which in the opinion of the Engineer can be ripped with the teeth of a bulldozer, such as Caterpillar D6 or equivalent, and which can be made usable for pavement material by breaking with the tracks of the bulldozer by reasonable efforts in the opinion of the Engineer.

(c) Cemented material
Cemented material is classified as existing pavement materials made from gravel or crushed stone, which, in the opinion of the Engineer, cannot be ripped and made usable for pavement material by the method described in SUBCLAUSE 3303(b). Unless specified as such in the Special Specifications, cemented material will not be classified as concrete.

(d) Concrete
Concrete is classified reinforced or un-reinforced concrete when specified as such in the Special Specifications or as decided by the Engineer.

(e) Milled material
Milled material shall be bituminous material or cemented material excavated with an approved milling machine. Milled material will be classified as such only when milling is specified or ordered by the Engineer. Payment will distinguish between milling of asphalt, concrete and of cemented material where so specified in the Bill of Quantities.

3304 EQUIPMENT

(a) General
The equipment to be used for the conventional breaking-up and excavation of existing pavement layers will be determined by the size and depth of the pavement section to be processed or excavated, taking consideration of the fact that work may have to be carried out in restricted areas. Only approved cutting or sawing equipment may be used for cutting or sawing the pavement layers. The equipment shall be capable of cutting the pavement layers to the specified depth in one operation without fragmenting the material, and in straight lines within the required tolerances.

(b) Milling equipment
Only approved milling equipment may be used. The equipment shall be capable of milling asphalt and/or cemented material to the prescribed depth in one operation over the width specified in the Special Specifications. The milling depth shall be controlled electronically.

The direction and speed of the milling machine and the speed of rotation of the milling drum shall be adjustable so as to obtain the required grading of the milled material. The machine shall be capable of making a neat vertical cut at the outer edges when milling the layer and to leave the floor of the cut level and with a uniform texture.

Unless otherwise specified in the Special Specifications, the milling machine shall be equipped with a self-loading conveyor belt, which can be easily removed and installed and adjusted for slope and direction.

3305 CONSTRUCTION

(a) General
Where all or a part of the existing surfacing material is to be reprocessed together with the underlying layer, the surfacing shall be properly broken down and mixed through the full depth of the existing base material to the satisfaction of the Engineer. Fragments of bituminous material shall be broken down to sizes not exceeding 40 mm.

Where specified in the Special Specifications or ordered by the Engineer, the existing bituminous material shall first be removed before the underlying layers are broken up.

Bituminous material may be milled out or otherwise broken up and removed to stockpile sites approved for recycling or to spoil sites, whichever is required. The exposed surface shall be cleaned to the satisfaction of the Engineer after removal of the bituminous material.

The existing pavement material shall be broken down to the specified depth and removed, or reprocessed in place, whichever may be required. The underlying

layers may not be damaged, and material from one layer may not be mixed with that of another layer. Where such mixing occurs or where the material is contaminated in any other way by the actions of the Contractor, he/she/she shall remove such material and replace it with other approved material, all at his/her own cost.

Where a layer or layers require to be broken down over part of the pavement width only, the limit of the work shall be clearly demarcated, which limit shall not be exceeded by the Contractor by more than 100 mm. Pavement layers broken down outside the specified limits shall be repaired by the Contractor at his/her own cost, to the satisfaction of the Engineer.

Where so ordered by the Engineer, asphalt and cemented layers shall be cut or sawn through to the specified depth along the measured limit with approved equipment. Payment will be made for sawing only where specified on the Drawings or ordered, in writing, by the Engineer.

Payment will not be made for sawing or cutting work where the existing layer requires removal by milling.

Where existing roads have to be widened, the existing pavement layers shall be cut back to a firm, well compacted or cemented material. Material so broken up, if acceptable, may be used together with imported material in the widening process provided the mixture consistently meets all requirements for the material type specified for the layer in question.

Where pavement layers are broken down over a section of the road width or where pavement layers are widened, the Engineer may order, that the various pavement layers be excavated in benches in accordance with his/her instructions. No additional payment will be made for excavating benches.

Where underlying layers are still structurally sound and are included as structural layers in the new design drawings, care must be taken not to break them up during removal of the surfacing or underlying layers.

(b) Milling

(i) Preparing the pavement surface
Before milling may be commenced, the pavement surface shall be clean and free from soil or other deleterious material. Where only part of the pavement is to be milled out, the milling area shall be properly demarcated. Milling may not exceed the required width by more than 50 mm. Payment will not be made for milling beyond the required width, and such additional milling shall be backfilled with approved material in accordance with the provisions for the specified pavement material at the cost of the Contractor.

(ii) Trial milling
Where ordered by the Engineer, the Contractor shall execute trial milling on the various materials to be milled. During the trial work, the Contractor will be expected to vary the direction and speed of the milling machine, the speed of rotation of the milling drum, and also the milling depth, in order to obtain milled material of the required grade. No payment will be made for trial milling.

(iii) Asphalt
Where the asphalt and/or the cemented base must be reused, the asphalt shall be removed separately. Where the asphalt consists of layers of various mixes or grades, the Engineer may instruct the separate removal of the layers to different stockpiles. Where the milled material is not conveyed directly by conveyor belt and then loaded, and the Engineer so approves, the material shall first be cut to windrow and then loaded. During loading, the floor of the excavation or the underlying material shall not be damaged.

The milled material shall be inspected and classified in accordance with the various types of asphalt and its suitability for recycling. Different stockpiles shall be used for the different types of material as ordered by the Engineer. Contamination of the asphalt with underlying material will not be permitted, and the Contractor shall adjust the depths of milling in accordance with the thickness of the layer.

(iv) Cemented material
Unless otherwise specified milled cemented material to be reprocessed on the road shall first be windrowed with a view to inspecting the underlying surface for any patches of poor or unsuitable material. Where unsuitable material is encountered in the floor of the excavation, such material shall first be removed by further milling (where the underlying layer also consists of the cemented material), or by other approved methods, all to the satisfaction of the Engineer. The unsuitable material shall be replaced with approved material of the required type, which shall be placed in accordance with the specifications for the relevant underlying layer.

Where in the opinion of the Engineer, it may be necessary, he/she may instruct the Contractor to taper the ends or edges of a milled excavation. No additional payment will be made for tapering the ends or edges of a milled excavation.

(v) Coring of cemented material
Where existing cemented layers are to remain as a structural layer in the new pavement the Engineer may instruct the Contractor to drill cores from the layer and have them tested for compressive strength in accordance with the provisions of BS EN 12504-1 or equivalent. The number of cores to be drilled out and the drilling locations will be determined on site by the Engineer.

(vi) General
The floor of the milled excavation shall have an even texture and any loose patches or patches of unsuitable material shall be remedied in accordance with the instructions of the Engineer. Payment for removing and replacing unsuitable material and remedying loose patches shall be as specified elsewhere.

The floor of an excavation shall comply with the requirements of the surface level, grade and regularity for the layer which it will form in the new pavement.

Payment for milling will not distinguish between various types of milled material and between various milling depths unless such distinction is given in the Bill of Quantities.

(c) Sawing or cutting

Where required in the opinion of the Engineer, diamond blade sawing or cutting shall be employed if necessary to achieve the required edge finish of milled layers. No additional payment will be made for sawing or cutting unless deemed necessary and approved by the Engineer.

(d) Treatment of pavement excavation floor
The floor of any pavement excavation, whether or not excavated by milling, shall be treated and paid for as specified in the relevant sections of the Specifications.

(e) Scarification of existing pavement
Wherever shown on the Drawings or directed by the Engineer, the existing pavement surfacing and base course material or part of the existing base layer shall be scarified, watered and recompacted. The depth of scarification and density of compaction shall be according to the Drawings and the Specifications.

Unless specified otherwise existing bituminous surfacing shall, if located within 1.0 m of new pavement surface, be scarified by such method and to such depth that will ensure that any lumps of surfacing is not more than two-thirds of the specified scarification depth and ensuring that a homogeneous mix is obtained.

3306 STORING RECOVERED PAVEMENT MATERIAL

Excavated pavement material intended for reprocessing but which cannot be reprocessed in place or, in the opinion of the Engineer, cannot be windrowed next to the excavation, nor placed in position directly at any other place, and material intended for recycling or reprocessing in a plant, shall be transported to approved stockpiles with the written permission of the Engineer.

Stockpile sites for material intended for recycling or reprocessing in a plant shall be set out at the corresponding mixing or crushing plant or at such other locations as approved by the Engineer.

The stockpile site shall be cleaned, and all loose stones, vegetation and other materials which may cause contamination shall be removed. The site shall be graded smooth with an adequate slope to ensure proper drainage. Where so instructed by the Engineer, the surface shall be watered and compacted to a depth of at least 150 mm to a density of 90% of BS Heavy density.

The compacted surface shall be firm without any loose patches. Where asphalt is recovered for recycling, the Engineer may order the surface to be chemically stabilised to a depth of 150 mm. Upon completion, this surface shall be swept clean.

Stockpile sites shall be sufficiently large to allow the placing of stockpiles of different types of material or types of recovered asphalt without the stockpiles overlapping or the limits of the prepared site being exceeded. The enlargement of the stockpile site after the stockpiles have already been placed will not be permitted without the approval of the Engineer.

Stockpiles of milled material shall be made in a manner which prevents segregation and undesirable consolidation or changes in moisture content. Adequate approved covers shall be provided as required in the opinion of the Engineer to prevent them from undesirable wetting or drying, or being contaminated by dust.

Upon completion of the work, the stockpile sites shall be broken up in accordance with the instructions of the Engineer.

The stockpiling of excavated material will not be paid for directly, but full compensation therefore shall be included in the rates for the various items of work in which the stockpiled material will be used. Separate payment will not be made for the preparation of storage sites.

3307 MEASUREMENT AND PAYMENT

(a) General

(i) Material to be reprocessed
Direct payment will be made for breaking up and excavating or milling of existing pavement material that is to be reprocessed and reused, when:

(1) The material is excavated or milled out in accordance with the provisions of the Special Specifications or upon the written instruction of the Engineer.
(2) Bituminous surfacing or other bituminous pavement layers are removed separately from the underlying material in accordance with the Special Specifications or the written instructions of the Engineer.

(ii) Material from an existing pavement which is not reprocessed
Existing gravel pavement material, or existing bituminous material not intended for reprocessing, may be spoiled or be used in other layers or items of work where approved by the Engineer. Payment for the excavation of pavement material to be spoiled will be made directly under ITEM 36.01(a). Dumping shall only occur on approval of the Engineer in an approved waste site.

Where used for other purposes full compensation for excavating shall be included in the rates bid for the various pavement layers and items or work in which the material is used.

(iii) Measurement for excavating existing pavement material and underlying fill
Where payment is made separately for the excavation of existing pavement material and underlying fill, the quantity will be calculated in accordance with the authorised horizontal dimensions of the excavated layer and the average depth of excavation. The average depth of excavation will be determined in accordance with the test holes made or cores drilled at intervals not exceeding 10 m, and which are so distributed over the surface that a realistic estimate of the depth can be obtained.

ITEM	UNIT
33.01 EXCAVATING OR MILLING OF MATERIAL FROM AN EXISTING PAVEMENT:	
(a) GRANULAR MATERIAL	CUBIC METRE (m^3)
(b) BITUMINOUS MATERIAL	CUBIC METRE (m^3)
(c) CEMENTED MATERIAL	CUBIC METRE (m^3)
(d) CONCRETE (INDICATE WHETHER REINFORCED OR UN-REINFORCED)	CUBIC METRE (m^3)

The unit of measurement shall be the cubic metre of material excavated or milled from the existing pavement using approved equipment and methodology.

The bid rate shall include full compensation for excavating or milling the material from the existing pavement irrespective of layer thickness, for loading, transporting, off-loading, and placing the material in approved spoil dumps or stockpiles as directed by the Engineer.

ITEM	UNIT
33.02 SAWING OR CUTTING CONCRETE, ASPHALT OR CEMENTED PAVEMENT LAYERS:	
(a) BITUMINOUS MATERIAL	LINEAR METRE (m)
(b) CEMENTED MATERIAL	LINEAR METRE (m)
(c) CONCRETE (INDICATE WHETHER REINFORCED OR UN-REINFORCED)	LINEAR METRE (m)

The unit of measurement shall be the linear metre of sawcut calculated in accordance with the authorised length of sawcut.

The bid rate shall include full compensation for all material and sawing or cutting costs and for all incidentals for cutting or sawing the pavement in accordance with the instructions of the Engineer.

ITEM	UNIT
33.03 DRILLING AND TESTING CORES FROM CONCRETE, ASPHALT OR CEMENTED PAVEMENT LAYERS:	
(a) BITUMINOUS MATERIAL	NUMBER (no)
(b) CEMENTED MATERIAL	NUMBER (no)
(c) CONCRETE (INDICATE WHETHER REINFORCED OR UN-REINFORCED)	NUMBER (no)

The unit of measurement shall be the number of cores drilled on the instructions of the Engineer.

The bid rate shall include full compensation for setting out the core locations, for drilling the cores and testing their strength in the laboratory as specified.

ITEM	UNIT
33.04 SCARIFICATION AND RECOMPACTION OF EXISTING PAVEMENT LAYERS (STATE SCARIFICATION DEPTH AND DENSITY OF COMPACTION)	CUBIC METRE (m^3)

The unit of measurement shall be the cubic metre of existing pavement materials scarified to the specified depth using approved equipment and methodology.

The bid rate shall include full compensation for scarification of the existing pavement materials to specified depth irrespective of individual pavement layer thicknesses, mixing with imported materials if required, shaping, and compacting the material as specified.

SERIES 3000: EARTHWORKS AND PAVEMENT LAYERS OF GRAVEL OR CRUSHED STONE

SECTION 3400: BORROW PIT AND QUARRY ACQUISITION AND EXPLOITATION

CONTENTS:

3401 SCOPE

This Section covers the work involved in obtaining borrow materials for work under this contract, including negotiations with Owners or Legal Occupants of the land on which borrow areas and quarry sites are situated. Legal Occupants of Land are holders of legal documentation giving them permission to occupy the land according to law.

3402 NEGOTIATIONS WITH LANDOWNERS, AUTHORITIES AND LEGAL OCCUPANTS OF LAND

As specified in Clause 1215 it is entirely the Contractor's own responsibility to obtain and pay all royalties in respect of all land required by the Contractor outside the road reserve for opening of borrow pits and quarries, including access roads. Such provision of land shall be considered part of the Contractor's general obligations as defined in Section 1300.

Nevertheless, the approval of the Engineer must be sought before entry upon the land.

In all cases, the Contractor shall be required to make all necessary arrangements with local authorities and owners or legal occupants of the land and to pay the cost of compensation. For this purpose, the Contractor shall liaise with the Regional Administration and/or the appropriate district authority and advise these authorities and the Engineer of the intention to commence work of any kind in borrow areas and quarry sites.

The attention of the Contractor is drawn to the provisions of CLAUSE 1214 as regards his/her/her activities on private land.

The Contractor shall observe all the legal provisions and the provisions of Section 1700 the Specifications in respect of his/her activities at borrow pits and quarries and when finishing off the borrow pits and quarry areas.

3403 ACCESS TO BORROW PITS AND QUARRIES

The Contractor shall satisfy himself/herself that all necessary negotiations have been made with the Owner or Legal Occupants of the land on which any borrow area or quarry site is situated, prior to the entry upon such land.

The Contractor shall notify the affected Owners or Legal Occupants of land both verbally and in writing at least seven days before prospecting for materials.

The Contractor shall give the Engineer at least thirty days notice of his/her intention to enter a borrow area or quarry and shall not enter thereon until compensation to owners or legal occupants is effected and the approval of the Engineer has been given.

3404 OBTAINING BORROW OR QUARRIED MATERIALS

(a) General

Borrow materials shall be obtained from approved sources of supply listed and described on the borrow area plans that may have been provided, or from such other sources as may from time to time be identified and tested by the Contractor and approved by the Engineer. Borrow pit material complying with the requirements of the Specifications for the use for which the material is intended, shall be selected from these approved sources. Such selection shall take into account that the specified requirements apply to the material on the road after final compaction.

(b) Borrow area and quarry site plans

Borrow area and quarry site plans are not included in the contract documents unless so specified in the Special Specifications. The information shown on the plans reflects the results of site investigations and laboratory tests conducted by or for the Employer and is supplied in good faith as to the sufficiency in quantity and quality of the material for the due and proper completion of the Works. The provision of these plans shall not in any way be construed as limiting the obtaining of borrow or quarry material to the indicated areas nor to the depth of working that may be shown on the plans or as necessarily limiting the use of the material to that described on the plans.

If, at any time during construction, it appears that the quality or quantity of material available in a borrow pit or quarry is inadequate or insufficient, the Contractor shall locate and make use of other borrow or quarry areas approved by the Engineer, irrespective of whether or not such other areas are shown on the plans for borrow pits or quarries.

(c) Use of borrow or quarry materials

Payment will not be made for moving the Contractor's plant from one location to another at any of the individual sources.

The Contractor shall search for and test all possible sources from which he/she intends to obtain material. This shall include sources designated by the Engineer within an economic haulage distance, or sources mentioned in the information provided whether or not the information form part of the Contract Documents. The Contractor shall excavate the necessary trial holes, take such samples and conduct or have conducted such tests as are deemed to be necessary by the Engineer. The Contractor shall submit the results in a report with sufficient details and sketches to the Engineer to satisfy him/her that the quality and quantity of the material available in the proposed area are

acceptable for the intended use, all at the Contractor's own expense.

The Contractor shall plan his/her exploitation of the borrow pits or quarries in such a manner that the various types of materials extracted can be selected and utilised without contamination or admixture of unsuitable material.

(d) Borrow materials obtainable in the road prism or within the road reserve boundaries

Where suitable sources of materials are available in existing cuttings and side drains, such materials may be used for the Works if approved by the Engineer.

3405 OPENING AND WORKING BORROW PITS

a) Excavating borrow material

The Contractor's attention is drawn to the provisions of CLAUSE 1702 regarding provision of an Environmental Management Plan.

All opening and working of borrow pits shall be undertaken in a manner which prevents contamination or undesirable mixing of materials.

Where any borrow pit contains different types of materials which require mixing to produce a suitable product, the materials shall be excavated and handled by use of methods approved by the Engineer.

The Contractor shall take all precautionary measures so as to avoid contamination of the suitable material by the inclusion of clayey or otherwise unsuitable material from the floor of the borrow pit, the overburden, any unsuitable layers, or areas beyond the approved limits of the borrow area. During loading, any hard oversize material which will not break down during processing on the road shall be excluded as far as is practicable.

During borrow operations, and especially when excavating material near the floor and outer boundaries of the borrow areas, the Contractor shall plan his/her operations so as to reduce, in so far as is possible, the amount of earth moving work that will be necessary for finishing-off the borrow pits. Indiscriminate excavation without due regard being had to the desired final shape of the borrow pit will not be permitted.

The material in borrow pits shall be blasted or ripped and excavated in a manner that will ensure the effective breaking-down of the material in the borrow pit before it is loaded. Rippable material which tends to break into large blocks shall be cross-ripped.

b) Control at borrow pit

The Contractor shall be responsible for controlling his/her operations at every borrow pit where material is being excavated to ensure compliance with all the requirements of the Specifications.

The Contractor shall carry out sufficient tests on the material being excavated from the borrow pit to satisfy himself/herself/herself that the quality of the material will comply with the specific requirements for the particular layers for which it will be used. If required for the proper control of quality, in the opinion of the Engineer, the materials shall be stockpiled prior to loading and tests of the stockpiles carried out as required.

If there is any doubt concerning the quality of the borrow material being excavated at any time, the Contractor shall notify the Engineer immediately, and in any case before such material is brought onto the road. The results of all tests carried out by the Contractor shall be submitted without delay to the Engineer. The Engineer may, after further testing or inspection if necessary, approve the use of the material in the borrow area, or he/she may order the borrow pit to be finished off and abandoned. Any such approval by the Engineer does not indemnify the Contractor with regards to his/her obligations to fulfil all requirements of the Specifications in respect of the quality of materials for earthworks or pavement layers.

c) Protecting borrow pits and quarries

Borrow pits and quarries shall be continuously protected against the ingress of surface water, and the Contractor shall construct such temporary banks as may be required for diverting surface water, and, in so far as is possible, his/her operations shall be planned in such a way that the borrow pit and quarry will be self draining. Where this is not possible, borrow pits and quarries shall be dewatered by pumping. The Contractor shall be solely responsible for keeping borrow areas and quarry sites dry and ensuring that borrow material is sufficiently dry when required for use.

d) Access roads

The Contractor shall obtain the Engineer's prior approval to the siting of junctions of access roads with existing roads and shall comply with the Engineer's conditions of access particularly regarding clearance of obstructions to provide adequate sight lines, temporary drainage or culverts and the provision of signs and traffic control.

The provision of access roads shall not be measured for payment.

e) Private access roads

Where private roads are to be used as access roads, the Contractor shall after consultation with the Owner or Authority having control of such road, carry out any repairs, alterations or additions to such roads as may be required to bring them to an acceptable condition suitable for traffic. Where materials from a borrow pit or quarry are hauled on private access roads, such roads shall be maintained properly to the satisfaction of the Engineer during borrow and quarry operations. No additional payment will be made for this work, and full compensation for maintaining private access roads used as haul roads will be regarded as being included in the bid rates and paid for in the various items of work where the materials are used.

3406 REINSTATING BORROW AND QUARRY AREAS AND HAUL ROADS

a) Borrow and quarry areas

On completion of his/her operations in borrow and quarry areas, the Contractor shall reinstate the entire area so as to blend it with the surrounding area and to permit the re-establishment of vegetation. For this purpose the borrow area shall be shaped to even contours without any slopes being steeper than 1:3, except where the Engineer so permits in specified cases. In such cases the Contractor shall, if so instructed by the Engineer, construct berms and contour banks to prevent erosion.

All material in and around the borrow areas, where spoil from clearing and grubbing operations or excess overburden, shall be used or disposed of as directed by the Engineer. Solid waste and rubbish may not be dumped into the borrow area. Material incapable of supporting vegetation shall be buried and used for shaping the borrow area and shall subsequently be covered with soft material. All available soft material shall be spread evenly to the prescribed thickness, and where sufficient material is not available for so covering the entire area, the remaining portions shall be scarified along contours so as to avoid undue erosion.

The shaping and reinstatement of the borrow pit shall be done in such a manner that the borrow pit will be properly drained wherever practicable, and, where required, the Contractor shall place earth banks to divert surface water from the borrow area. If so directed, the borrow and quarry area shall be fenced off and provided with gates as specified in SECTION 5300, and topsoiled and/or hydro-seeded as specified in SECTION 5600.

The reinstatement of the borrow and quarry areas shall be to the entire satisfaction of the Engineer and the Contractor shall submit to the Engineer a signed certificate from the Landowner, or Legal Occupants of land or relevant Government Agency stating that the finishing-off complies with all necessary legal provisions. The Contractor's attention is drawn to the provisions of CLAUSE 1214 in this respect.

(b) Haul roads

Unless otherwise specified or instructed by the Engineer all haul roads shall be obliterated and their surfaces scarified, earth banks shall be constructed to prevent erosion, and all damaged fences and other structures shall be reinstated.

Where materials from a borrow pit or quarry are hauled on private access roads, such roads shall be restored to their original condition to the satisfaction of the Engineer when operations at the borrow pit and quarry are completed, unless otherwise specified.

No additional payment will be made for obliteration, or restoration respectively, of haul roads or access roads to borrow pits or quarries. Full compensation for this work is regarded as being included in the bid rates and paid for elsewhere

3407 DISPOSAL OF BORROW OR QUARRY MATERIAL

The Contractor shall not have the right to use material obtained from borrow pits or quarries for any purpose other than for the execution of this Contract. He/she shall not dispose of any such material whether processed or not either by sale or donation to any person without the authorisation of the Employer.

3408 MEASUREMENT AND PAYMENT

No separate measurement and payment will be made for procuring and providing borrow or quarry material, but it will be regarded as an obligation on the part of the Contractor to be covered by the contract prices paid for the various items of work for which the material is used as prescribed in these Specifications.

Such bid rates related to procuring and providing borrow or quarry material shall also include full compensation for all obligations, costs, activities and work as prescribed in SECTION 1200, including all necessary de-watering as well as for all supervision, labour, plant, tools and incidentals required, including all costs as may be necessary for conducting control tests on all materials, draining and protecting all borrow or quarry areas, and concluding all negotiations with Owners or Legal Occupants of land (except negotiations that are conducted by the Employer himself/herself) as specified, also for finally shaping and finishing the borrow pits and quarries.

SERIES 3000: EARTHWORKS AND PAVEMENT LAYERS OF GRAVEL OR CRUSHED STONE

SECTION 3500: SELECTING AND UTILISING MATERIAL FROM BORROW PITS AND CUTTINGS

CONTENTS:

3501 SCOPE

This Section describes the selection of materials from borrow pits and cuttings for the various purposes for which they are required in the Works, stockpiling the materials excavated but which can not be dumped directly where required, breaking down the material during the excavation process when it is processed on the road, or when special processing for breaking-down by crusher is required, controlling the moisture content, placing and compacting the soil and gravel layers and constructing the rock fills.

In addition, this Section describes the treatment of material recovered from existing pavements, and construction in restricted areas during rehabilitation work.

Unless inconsistent with the context, the provisions of SECTION 3500 relating to borrow pits or the material obtained from borrow pits shall apply with changes as required to such places where material is recovered from an existing road, and to the material recovered from an existing road respectively.

3502 SELECTING AND STOCKPILING MATERIALS

The Contractor shall use materials strictly in accordance with the purpose for which they have been approved. During his/her activities in borrow pits or cuttings, he/she shall ensure that approved materials are not polluted with unsuitable material or that approved materials are not unnecessarily wasted.

Unless otherwise directed by the Engineer, the Contractor shall so plan his/her activities that materials excavated from borrow pits and cuttings, in so far as is possible, can be transported direct to and placed at the point where it is to be used. However, where utilisation of materials in this manner is impracticable, or if so instructed by the Engineer, materials shall be temporarily stockpiled for later loading and transportation to where it will be used. If, in the opinion of the Engineer, materials need to be stockpiled for the purpose of quality control or for mixing to become sufficiently homogenous, the Contractor shall carry out stockpiling as required to ensure proper quality control and to meet the Specifications consistently.

Stockpiling areas and maximum height and extent of stockpiles shall be approved by the Engineer. Before any stockpiling of material may be done, the site shall be cleaned, and all material which may cause pollution shall be removed. During use, the lower 100 mm of stockpiled material shall not be utilised for construction. After the stockpiled material has been removed, the site shall be reinstated as closely as possible to its original condition, and the surface shall be lightly scarified to promote vegetation growth.

No separate payment will be made in regard to stockpiling of materials.

3503 BREAKING DOWN OVERSIZE MATERIALS

(a) Material from cuts or borrow pits

The material from cuttings and borrow pits shall be broken down in the cuttings or borrow pits, alternatively in the road, to the maximum size specified for the respective layer where it will be used.

Spoil material need be broken down only sufficiently for convenient loading and transporting, but the Engineer may require sufficient material to be broken down to a maximum size of 500 mm with a view to effectively trimming the spoil areas.

Material intended for crushing need only be broken down sufficiently to permit acceptance by the crusher.

In order that the material can be broken down to the appropriate sizes, the Contractor shall adjust and control his/her blasting, ripping, excavating and other operations so that the desired result can be achieved as effectively as possible.

Care shall be taken not to load oversize material and to bring it onto the road. The Contractor shall, at his/her own cost remove such oversize material from the road or break it down further to the required size on the road.

If, in the opinion of the Engineer, the working methods of the Contractor are such that unnecessarily large quantities of oversize material are produced, the Contractor shall change his/her methods in order to produce less oversize material, and the material shall be broken down to the sizes as specified for each layer by using equipment suited to this purpose. The Contractor shall be at liberty to employ any methods and equipment he/she may prefer, but where any difference of opinion may arise in regard to the practicability of the breaking-down process or the suitability of the methods and equipment employed by the Contractor, the Engineer may require use of grid-rollers, pad-foot rollers or other equipment giving similar effect as a grid roller to be used on the road. The results so obtained will then serve as the norm of the degree to which the breaking-down shall be attained by any alternative methods. No separate payment will be made for breaking down material to the required size.

Where surplus oversize material is available and the Engineer so agrees, the Contractor, instead of breaking down any oversize materials may spoil it. The Engineer may also require oversize materials to be used for other purposes, such as for rock fills or rip-rap.

Any oversize material still remaining after processing in accordance with any of the processes described above shall be removed from the road.

The Contractor's attention is drawn to the risk of causing excessive breaking down of the finer fraction of the materials and thereby altering the properties of the material by inappropriate working methods or

equipment. Any material which does not meet the requirements of these Specifications after compaction shall be replaced or made good on the Contractor's expense.

(b) Existing cemented layers
Existing cemented layers to be broken down and reprocessed may be reprocessed either on the road, or it may be hauled to a crusher for processing, whichever is specified or required by the Engineer.

(c) Crushing and screening
Where the material intended for use in pavement layers cannot be suitably broken down by the methods set out herein, the Contractor shall use alternative sources or apply crushing or screening, or both, as required to meet the Specifications. The crushing plant shall be capable of breaking down oversize material to the maximum size specified for the layer concerned.

No separate payment will be made for crushing or screening material to the required size unless specifically allowed for in the Special Specifications and the Bill of Quantities.

(d) Disposing of oversize materials
All oversize materials removed from the road and all excess material removed from the road shall be disposed of at the Contractor's cost or may be used in the Works for other suitable purposes on the approval of the Engineer.

The bid rates for constructing all pavement layers shall include full compensation for the removal of oversize material without any additional payment being made to the Contractor.

3504 CONTROLLING THE MOISTURE CONTENT OF MATERIALS

The Contractor shall take all necessary precautions to prevent material in borrow pits, excavations, stockpiles and on the road from becoming excessively wet as a result of rain or groundwater or stormwater. Therefore, the excavation of borrow pits and cuttings shall be so planned and executed as to prevent the damming-up of water in the borrow pits or cuttings, and the Contractor shall also provide the necessary temporary drainage for this purpose.

Material that is too dry shall be mixed thoroughly with water until the required moisture content for compaction is achieved.

During the rainy season the Contractor shall take all necessary precautions to prevent material from becoming excessively wet. The methods may include, but are not restricted to, the following: spreading on the road with a proper cross slope and temporarily rolling with flat-wheeled roller in order to improve water run off, covering of stockpiles with tarpaulins, applying special measures to prevent water to dam up against material heaps or windrows.

The Contractor shall so plan his/her construction programme that material with high natural moisture content will be used in the dry season and not in the wet. Where material is too wet, for whatever reason, to comply with the requirements in regard to moisture content during compaction, the Contractor shall correct the moisture content of the material until it is adequately dry for compaction, by drying out the material, alternatively mixing with approved dry material, spoiling and replacing with drier approved material, or applying treatment with lime or cement.

No separate payment will be made in regard to measures for keeping material dry, nor for any measures for correcting the moisture content, neither for addition of stabiliser for the purpose of using wet material. The Contractor himself/herself shall decide and submit his/her proposed method of work for the approval of the Engineer.

3505 LAYER THICKNESSES AND SPREADING OF MATERIALS

(a) General
All material shall be placed in the correct quantity, and to the required grade, line and thickness, in a manner which prevents segregation and contamination of any kind.

The thickness of layers compacted in one operation shall not exceed the maximum that the equipment and method of operation can process to meet the requirements of the Specifications in terms of tolerances and density to the full depth of the layer.

The thickness of layers compacted in one operation shall not be less than the minimum that the equipment and method of operation can process without lamination unless special precautions are taken on the approval of the Engineer.

(b) Fill and improved subgrade layers (G15, G7, G3, DR)
The maximum layer thickness for fill or improved subgrade layers made of soils or gravel (G15, G7, G3), compacted in one operation, shall be 250 mm (compacted thickness).

For rock fill (DR) the maximum compacted layer thickness shall be 1 metre except in areas where compaction plant is not accessible or is impracticable to use in the opinion of the Engineer.

The maximum particle size for all fill and improved subgrade layers shall not exceed two thirds of the compacted layer thickness. In order to prevent the layer thicknesses from being determined by the presence of isolated large fragments, the Contractor shall remove such isolated fragments as directed by the Engineer.

Where a new layer is constructed on an existing or already constructed fill or improved subgrade layer and the new layer will be less than 100 mm in compacted thickness, the existing layer shall be scarified to such a depth as will give a layer thickness after compaction of not less than 100 mm of the new plus the scarified material together. No additional payment will be made for this operation.

(c) Pavement layers
The layer thickness shall comply with the requirements as indicated on the Drawings and in the Special Specifications or as directed by the Engineer.

Spreading material in restricted areas shall be done in a manner approved by the Engineer to comply with the required levels, grade, line and density to the full depth of the layer.

Where the thickness of any existing pavement layer requires to be supplemented and the thickness of the added material after compaction will be less than 100 mm, the existing layer shall be scarified to a depth that will give a layer thickness of at least 100 mm after compacting together the loosened existing and added material. In the case of gravel or crushed aggregate base course, the Engineer may direct the existing layer to be broken down to its full depth.

3506 COMPACTION OF MATERIALS

(a) General requirements

Compaction shall be carried out in a series of continuous operations covering the full width of the layer concerned according to the Drawings. The Contractor shall reduce the length or width of any layer compacted in any single operation if the proper compaction or finish of such layer is not being achieved in the opinion of the Engineer.

The method of work, type of compaction equipment to be used and the amount of rolling to be done, shall be such as to ensure that specified density and finish is obtained without damage being done to adjacent or lower layers or structures. During compaction the layer shall be maintained to the required shape and cross-section, and all holes, ruts and laminations shall be removed or repaired to the satisfaction of the Engineer.

Suitable equipment and methods acceptable to the Engineer shall be used in restricted areas so that the required densities will be obtained throughout the thickness of the layer. If necessary, the layers shall be placed in thicknesses which are less than the specified layer thickness.

Rock fill material shall be compacted with vibratory rollers to achieve a good mechanical interlock of the rock and the maximum compaction of the finer material in the spaces between the rock. The type of vibratory roller used, the operating speed, the number of passes and the layer thicknesses shall be determined after field trials and the proposed method shall be to the satisfaction of the Engineer.

(c) In place reworking of pavement layers

Where so specified or instructed by the Engineer, and the material in any existing layer complies with the requirements for the new layer, the Contractor shall scarify the layer to the specified depth, add extra approved material if necessary, and reprocess the layer in place. Reprocessing includes watering, mixing, and compaction of the layer to the level, grade line, finish and density specified for the layer concerned. Payment will be made as determined for the respective pavement layers.

3507 DRAINAGE AND PROTECTION

The compacted layers shall be adequately drained and shaped to prevent water from standing on or along or causing damage to the completed work. Windrows shall be removed to facilitate the drainage of water from the surface.

No material for a subsequent layer may be placed if the underlying layer has been softened by excessive moisture and requires repair in the opinion of the Engineer.

3508 MEASUREMENT AND PAYMENT

No separate measurement and payment will be made for procuring and providing borrow material, selection, stockpiling and breaking down material from borrow pits and cuttings, nor for placing materials, adding water, drying, mixing and compacting the layers. It will be regarded as an obligation on the part of the Contractor to be covered by the contract prices paid for the various items of work for which the material is used as prescribed in these Specifications.

SERIES 3000: EARTHWORKS AND PAVEMENT LAYERS OF GRAVEL OR CRUSHED STONE

SECTION 3600: EARTHWORKS

CONTENTS:

3601 SCOPE

This Section covers work in connection with the construction of cuts and fills, the removal to spoil of material unsuitable for use or surplus materials not required for fill, the construction and compaction of fills and improved subgrade layers with cut material from the road prism or borrow material from approved borrow pits, the compaction of the roadbed and finishing of cuts and fills, up to the stage where fills are ready for the placing of the pavement layers.

This Section covers the requirements for the following types of material:

- **G15** natural gravel/soils with minimum CBR value of 15
- **G7** natural gravel/soils with minimum CBR value of 7
- **G3** natural gravel/soils with minimum CBR value of 3
- **DR** Dump Rock, un-graded waste rock

3602 MATERIALS

(a) General

Any test results provided in design documents such as the Materials Report, read in conjunction with these Specifications, may give a preliminary indication as to the purpose for which the cut material may be used as well as the treatment, if any, which the roadbed shall receive. Any test results or recommendations of method of work in the Material Report are solely for information. The Contractor shall undertake his/her own assessment and any tests required and submit his/her proposed methods of work and test results of all material he/she intends to use for the approval of the Engineer.

The material types (G15, G7, G3, DR) given in the Drawings denote the minimum quality for a particular use in the Works, either specified in the Drawings or as instructed by the Engineer. In the cases where a minimum quality of earthworks material is not specified, the following guidelines shall apply and the Engineer's instruction shall be the standard to which materials quality control is applied:

Material type	Typical use
G15	Upper improved subgrade layers and fill
G7	Lower improved subgrade layers and fill
G3	Fill only
DR	Lower improved subgrade layer and fill

Irrespective of the minimum required quality specified or the above guidelines the highest quality of approved earthworks material available at economical haul distances, complying with the requirements of the Specifications and Drawings, shall be selected for fill or improved subgrade layers. Rock fill materials (DR) complying with the requirements of the Specifications shall be the preferred material type unless otherwise specified or directed by the Engineer.

(b) Material requirements for fill and improved subgrade layers

Materials for earthworks shall be non-expansive soils or dump rock meeting the requirements given in TABLES 3602/1 and 3602/2.

TABLE 3602/1
REQUIREMENTS FOR FILL AND IMPROVED SUBGRADE LAYERS

Material properties	Material class		
	G15	G7	G3
CBR (%) BS1377:Part 4	Minimum 15 after 4 days soaking ***1)***	7 after 4 days soaking ***1)***	3 after 4 days soaking, measured at 90% of MDD of BS-Heavy compaction
CBR-swell (%) BS1377:Part 4	Maximum 1.5	Maximum 2	Maximum 2
Plasticity index (%) BS1377:Part 2	Maximum 25	Maximum 30	(no requirement)
Max. particle size BS1377:Part 2	1/2 of compacted layer thickness but not >50mm.		
Maximum layer thickness	250 mm compacted thickness placed in one operation		

1. CBR values are measured at the specified field density for the respective layer.

TABLE 3602/2
REQUIREMENTS FOR DUMP ROCK (DR) IN FILL AND IMPROVED SUBGRADE LAYERS

Material properties	Material class: DR (dump rock)
Maximum particle size:	Two thirds of compacted layer thickness.
Maximum layer thickness:	1 m placed in one operation.
The content of fines shall be sufficiently low so that the larger particles rest against each other when placed in earthworks layers. The Engineer's decision shall be the final in cases where doubt or disagreement exists whether the material can be classified as DR.	

3603 EXCAVATIONS

(a) Classification

(i) General
This SUBCLAUSE 3603(a) sets out the criteria and assessment methods to classify all excavations for measurement and payment. The classification is valid for excavations of cuts, for structures, drains, services and for removal of unsuitable materials or any other excavations measured and paid for separately.

(ii) Classification criteria
The excavation of material shall be classified in accordance with TABLE 3603/1 for purposes of measurement and payment. Payment will be made for rock excavation only if one of the methods described under rock excavation is actually used for loosening the material.

TABLE 3603/1
CLASSIFICATION OF MATERIALS FROM CUT EXCAVATIONS

Classification	Description
Rock excavation	Rock excavation shall be excavation in material that requires drilling and blasting or the use of hydraulic or pneumatic jackhammers to be loosened sufficiently for loading and transportation.
Common excavation	Common excavation shall be excavation in all material other than rock as defined above, whether the material is suitable for use in the Works, or to be spoiled and paid for as Common Excavation to Spoil. The classification includes excavation in earthworks or any pavement layers of an existing pavement not covered by a separate item in the Bill of Quantities regardless of the nature of the material excavated, other than rock excavation.

(iii) Classification assessment
The Engineer shall decide under which one of the above classes any excavation shall be classified for purposes of payment. In the event of a disagreement between the Contractor and the Engineer, the Contractor shall, at his/her own cost, make available such mechanical plant as required by the Engineer in order to determine whether or not the material can reasonably be removed. The decision of the Engineer as to the classification shall be final and binding.

The Contractor shall immediately inform the Engineer if and when the nature of the material being excavated changes to the extent that a new classification for further excavation is warranted. Failure on the part of the Contractor to advise the Engineer thereof in good time shall entitle the Engineer to classify, at his/her discretion, such excavation as may have been executed in material of a different nature.

(iv) Boulders
Individual boulders greater than one cubic metre in volume shall be classified as rock when their nature and size are such that, in the opinion of the Engineer, they cannot be removed without recourse to one of the methods described under rock excavation in TABLE 3603/1. Where a portion of excavation contains 50% or more by volume of boulders of this order, such portion shall be considered as rock excavation throughout.

(b) Dimensions of cuts
The dimensions of cuts shall be in accordance with the details of the Drawings and may further be defined or amended during the course of construction by instructions from the Engineer. The Contractor shall obtain instructions beforehand from the Engineer regarding the slope of the sides of cuttings and the depth to which cuttings are to be taken, including the dimensions of any in situ treatment of cuts that may be required below the formation level. Cuts in soils shall be trimmed to a smooth finish to prevent initiation of slope erosion.

In rock cuts, the rock shall be removed to the level that will permit the construction of the subbase layer, unless otherwise instructed.

The Contractor shall take proper care when excavating cuts not to loosen any material outside the specified cut line, whether by ripping, blasting or by other means. Care shall also be taken not to undercut any slopes, and proper control shall at all times be exercised by regular survey checking and by using batter poles at close intervals.

All cuts made outside the specified cut line or below the specified level without the approval of the Engineer shall be backfilled with approved material, compacted to the satisfaction of the Engineer and re-trimmed, all at the Contractor's own expense and in accordance with SECTION 7400.

The Engineer may, when he/she considers it necessary, instruct the Contractor to widen existing, completed or partly completed cuttings either uniformly or by altering the slope of the sides of the cutting, or by cutting benches, or in any other way.

(c) Utilisation of excavated material

(i) General
As far as practical in the opinion of the Engineer, the material resulting from cuts, widening of cuts or other excavations in the road reserve shall be utilised for construction of earthworks or pavement layers depending on their quality. The Engineer's approval to use any material does not indemnify the Contractor with regards to his/her obligations to fulfil all requirements of the Specifications in respect of the quality of materials for earthworks or pavement layers.

The Contractor shall plan his/her operations in such a manner that all cut material may be used to the best advantage of the Employer. This would mean that no material shall be unnecessarily spoiled, borrowed or hauled. The Contractor shall neither borrow nor spoil any material without the Engineer's approval and without satisfying the Engineer that this is necessary and the most economical method of constructing the Works.

Material which will not be used in the pavement or earthworks due to quality or other reasons may be stockpiled for future use as topsoil or side fill as required by the Engineer.

(ii) Conservation of topsoil
Topsoil encountered in excavations shall be conserved as described in SECTION 3100 where directed by the Engineer. No additional payment will be made for conservation of topsoil.

3604 PREPARATION OF THE ROADBED

(a) Removing unsuitable material

(i) Poor material quality
Any roadbed material which the Engineer considers to be of a quality that would be detrimental to the performance of the completed road shall be removed to such widths and depths as he/she may instruct, and shall be disposed of as prescribed. The excavated spaces shall then be backfilled with approved material and compacted according to the Specifications.

For roadbed material which the Engineer considers to have high swelling potential the Contractor shall carry out plasticity and hydrometer tests according to BS 1377: Part 2 and determine the Activity defined as:

$$Activity = \frac{PI}{(C - 10\%)}$$

where
PI = Plasticity Index
C = Percentage of clay size finer than 0.002 mm, where C>10

Material with very high swelling potential as defined in TABLE 3604/1 shall be considered detrimental for the performance of the completed road and must be replaced or stabilised in accordance with SECTION 3800 or covered by geogrid or similar crack arresting measures as instructed by the Engineer.

TABLE 3604/1
SOILS WITH HIGH SWELLING POTENTIAL

Percent Clay Sizes (<0.002 mm)	Very High Swelling Potential
10	Activity >7
20	Activity >3
30	Activity >2
40	Activity >1.5
50	Activity >1.1
60	Activity >0.9
70	Activity >0.7
80	Activity >0.6
90	Activity >0.5

(ii) Wet material
The Engineer may order that roadbed material which is too wet to provide a stable platform for the construction of the embankment be removed to such widths and depths as he/she may instruct and be replaced with approved dry material and compacted according to the Specifications. Payment for this work will only be made if the Engineer is satisfied that the high moisture content is not a result of inappropriate or insufficient measures by the Contractor to protect the roadbed from getting wet and that drying of the material could not be done with reasonable efforts and within a reasonable time, all in the opinion of the Engineer.

(b) Preparing and compacting the roadbed

(i) Compaction
Unless otherwise instructed by the Engineer the roadbed shall be scarified, watered and compacted to a density and depth according to the Drawings and the Specifications or as directed by the Engineer. If necessary, roadbed material may have to be temporarily bladed off to windrow in order to achieve the necessary depth of compaction. The Engineer may instruct that expansive soils are given different treatment such as watering to maintain natural moisture content and timely dumping and spreading of following layers. No separate payment will be made for any such operations or alternative techniques to achieve the specified depth and degree of compaction. The Contractor shall carry out field trials as required by the Engineer to show that his/her proposed method and equipment for processing and compaction of the roadbed gives the desired result in accordance with the Specifications and to the satisfaction of the Engineer.

(ii) Adjustment of levels
Where any additional material has to be imported to obtain the required level and layer thickness, and where the thickness of the layer of imported material would be less than the specified layer thickness after compaction, then the roadbed material shall be scarified, the necessary imported material placed, and this combined material mixed and compacted to the full specified depth of the layer. No separate payment will be made for such operations.

(iii) Rock or hard material
Wherever shown on the Drawings or as may be directed by the Engineer, the roadbed shall be treated in situ by undesirable formations of hard or rocky materials being broken down in order to achieve a uniform standard of compaction and strength, or to prevent water-logging and improve drainage.

(c) Draining and protecting the roadbed
The Contractor shall take all necessary precautions to ensure that the roadbed is kept drained. In the cases where the roadbed needs to be kept moist due to the presence of expansive soils he/she shall carry out watering and timely dumping and spreading of following layers as required to the satisfaction of the Engineer. No separate payment will be made for any such operations or adjustments of schedules to fulfil such requirements.

Waterlogged roadbed, such as saturated material overlying less pervious strata, shall first be drained by the installation of all permanent surface or subsoil drainage shown on the Drawings, or as directed by the Engineer, before any other construction may be started on these sections. Such drains shall be constructed, measured and paid for in accordance with the requirements of SECTION 2100.

(d) Expansive soils treatments
If so specified in the Special Specification or directed by the Engineer particular remedial measures shall be taken to reduce the risk of future damage to the road caused by swelling or shrinkage of expansive roadbed material. If cost considerations prohibit full replacement of the expansive soils, the remedial measures should aim at providing nearest possible constant moisture content over the full width of the carriageway below the embankment. The remedial measures may include one or more of the following:

- replace the upper layer of the expansive soil, i.e. the zone where the largest proportion of the volumetric changes takes place,
- provide wider paved shoulders to move the zone of seasonal changes in moisture content further away from the roadway,
- provide embankment with minimum height of about 1 m and with side slopes of 1:4 or flatter,
- provide an impermeable membrane in the full embankment width under the pavement and sandy drainage layer on top of the membrane,

– chemical stabilisation, normally by use of lime, to counteract volumetric changes in the expansive soils, but although this is technically possible it requires careful appraisal of the associated construction costs as well as the potential practical problems in admixing stabilisers into deep layers of clayey soils.

3605 EMBANKMENTS

(a) General
Embankments shall be constructed to comply with all requirements in the Specifications and Drawings or as further instructed or amended by the Engineer in respect of dimensions of embankments, installation of subsoil drainage or other structures, work method, such as benching or roadbed preparation. Before the start of construction the Contractor shall submit plans showing his/her proposed method of work, the selection of materials, the method of compaction, and any other matter that may affect the construction of the embankment or sequence of operations.

All material used for the construction of embankments shall meet the requirements of CLAUSE 3602 and shall be selected so that the minimum required quality of material is used in the respective positions of the embankment according to the Drawings and the Specifications. The density of embankment layers shall comply with the requirements of CLAUSE 3606.

Embankment shall be placed in successive layers parallel to the final road surface, and the construction of wedge-shaped layers shall be restricted to the bottom layers of embankment where this may be unavoidable on account of cross-fall, the tapering out of embankments, or the superelevation of the final road surface.

(b) Materials for earthworks layers
Materials for earthworks layers shall meet the requirements as set out in CLAUSE 3602 in respect of the specified respective material types given in the Drawings or as directed by the Engineer. The better soil qualities shall be selected where alternative fill materials all meet the minimum material requirements. In the situation where material quantities are limited, the better quality materials shall be used in the upper layers. Dump Rock shall in the cases where instructed by the Engineer be the preferred type of material for earthworks. Under special conditions, such as where a near impermeable material is desirable, the Engineer may instruct that Dump Rock is not to be used in the earthworks.

(c) Benching
Where the natural cross-fall of the roadbed or existing or already constructed embankments exceeds 1:6, the fills shall be bonded to the roadbed by means of benches excavated in the roadbed or existing embankment. Where the existing fill is loose on the outside and shows inadequate compaction, benches shall be cut back further than may be necessary to accommodate construction equipment until adequately compacted material is found.

Benches in rock shall be jagged to give sufficient resistance to slippage.

The height of the benches shall be maximum 0.75 metres or as directed by the Engineer. The benches shall be wide enough to accommodate sufficiently effective compaction equipment.

The measurement and payment for benching will be made under the normal payment items for fills and no additional payments will be made for benching.

(d) Constructing pioneer layers on unstable ground
Where fill is to be constructed across waterlogged or soft ground exhibiting excessive movement under normal compaction equipment and haulage trucks, and such conditions preclude the effective compaction of the bottom fill layers, the Engineer may direct that a pioneer layer be constructed on the unstable ground. This layer shall be constructed by placing suitable coarse material in a uniform layer with a thickness sufficient to provide a stable working platform for constructing the further fill layers which are to be compacted to a controlled density.

A sand filter blanket of approved materials, alternatively approved geotextile filters shall be placed at the bottom of the pioneer layer if so directed by the Engineer. Geotextile shall meet the requirements given in TABLE 3605/1.

Light hauling equipment shall be used, and where necessary end tipping undertaken for placing the material. The layer shall be compacted by light compaction equipment which will give the most effective compaction without the roadbed being over-stressed. Pioneer layers will not require compaction to a controlled density unless so directed by the Engineer. Payment for pioneer layer will be made under Pay Item 36.02(h).

(e) Sand filter blankets and geotextiles
At the bottom of fills, and sometimes at intermediate levels, the construction of sand filter blankets may be required to facilitate the drainage of fills and to separate layers of materials where there is a risk of undesirable infiltration of fine material into the coarse material. Sand filter blankets shall be constructed in accordance with the details on the Drawings and shall consist of a layer of selected sand with suitable grading to provide effective drainage and to prevent the infiltration of fill or roadbed material into the sand filter blanket.

The sand filter material shall meet the requirements given in SUBCLAUSE 2104(a) (ii), however the requirements with reference to the slot size of drainage pipes shall only apply where drainage pipes are to be constructed adjacent to the sand filter material.

The surface on which the sand filter blankets is to be constructed, shall be smooth and even and the sand shall be spread evenly to the required thickness and be given a light compaction with suitable rollers. The final surface of the sand filter blanket shall be finished off true to line and level. The Engineer may require the layers immediately below and above the filter blanket to be constructed from selected soil or gravel.

Geotextiles, where specified, shall meet the requirements given in TABLE 3605/1. The fabric shall not be exposed to direct sunlight for prolonged periods and shall be protected from mechanical damage during installation and construction.

Separate payment for construction of sand filter blankets or specially selected gravel to be placed in conjunction with the construction of sand filter blankets will only apply as an extra over rate to the layer in question on the approval of the Engineer.

TABLE 3605/1
REQUIREMENTS FOR GEOTEXTILES

Aggregate placed adjacent to the geotextile		**Geotextile, weight per area of the geotextile material (g/m2)**	
Aggregate type	Maximum particle size, d_{max}	Placed on firm, dry subsoil ***1)***	Placed on soft, wet subsoil ***2)***
Gravel, sand or graded, crushed material:	Maximum 50 mm	Minimum 140	Minimum 200
Sorted crushed rock:	Maximum 200 mm	Minimum 200	Minimum 320
Dump rock (DR), unsorted:	-	Minimum 320	Special reinforcement shall be considered

1) Dry subsoil refers to moisture contents below OMC of BS-Light according to BS1377:Part4.
2) Soft, wet subsoil is silty or clayey materials in waterlogged areas or as defined by the Engineer.

(f) Placing of rock fill (DR)
Rock material containing particles larger than two thirds of the compacted layer thickness shall not be used in the fill unless otherwise authorised by the Engineer.

The Contractor shall, by the judicious planning of the operation by selecting the smaller sized material for placing in the thinner fill layers, avoid unnecessary spoiling of the larger sized rock material and shall ensure its fullest practicable utilisation in fills.

(g) Construction of high fills
The Contractor shall make allowance for all required measures, special techniques and scheduling of work to prevent the development of excessive pore pressure and to ensure the stability of high fills during and after construction where such measures are required in accordance with the Special Specifications or as directed by the Engineer. No separate payment will be made for any special measures taken in conjunction with the construction of high fills.

(h) Constructing rock protection at the toes of fills
Where required, the toes of fills shall be protected against erosion by special rock protection, which shall be installed as shown on the Drawings and as further directed by the Engineer, by the outer part of the toes of fills being constructed from assorted boulders and/or blasted rock, as described below.

The rock protection shall be constructed simultaneously with the rest of the fill and shall consist of selected durable rock material varying in size between 150 mm and 750 mm. If required, a layer of approved geotextile filter shall be installed at the interface between the normal fills and the rock protection.

The outer part of the rock protection shall consist of larger boulders properly bedded by means of smaller fragments so as to form a stable interlocking rip-rap surface. The rock protection shall otherwise be constructed and compacted as rock fill as described in the SPECIFICATIONS.

(i) Widening of fills
Where required in accordance with the Special Specifications, or as instructed by the Engineer, special measures shall be taken to prevent differential settlements where high fills are being widened. Such measures may include the use of material from the existing fill in the construction of the widened part of the new fill or alternative measures as directed by the Engineer. Unless otherwise stated in the Special Specifications and the Bill of Quantities, no additional payments will be made for employing such techniques in the widening of fills, and payment will be made under the normal payment items for fills.

(j) Embankment construction in swamps
Construction of embankments across swamps and other waterlogged or low-lying areas will require special techniques to prevent differential settlements especially where the existing embankment is to be widened.

Two different techniques may be employed when constructing the embankments across swamps and wetlands as directed by the Engineer:

(1) In shallow swamps where tracked earthmoving plants can operate without getting stuck, the soft material shall be removed by tracked earthmoving plant and immediately be replaced with G7 material.

Where filling takes place under the water table, the fill materials shall be selected, well draining sandy and gravelly materials, having a maximum percentage passing the 0.075 mm sieve of 15 % and a maximum Plasticity Index of 25%. This layer is to be constructed by dumping and spreading successive loads of material in a uniform layer thickness just sufficient to provide a stable working platform for the construction of further fill layers above the water table which are to be compacted according to the Specifications. The stable working platform shall be compacted using light compaction equipment which will give the most effective compaction without over-stressing the material. Light hauling equipment shall be used when driving on top of this staple platform as instructed by the Engineer.

The fill placed under the water table cannot be compacted to the normally required density for fill, and will be allowed to settle under the dead weight of the embankment, until the movements in the surface of the embankment have diminished.

(2) In swamps where the above technique cannot be used due to the thickness of the soft and unsuitable material, the embankment shall be constructed using the displacement method. In this method the excavation of soft and unsuitable materials shall be done by a tracked excavator, followed by end-tipping G7 material up to a height above the water-table which can provide a stable working platform for the construction of further fill layers up to the top of the embankment. The end-tipping of the G7 material shall be done before soft or unsuitable material flows into the excavation for the embankment. The inflow could possible be reduced by excavating outside the boundary of the material to be backfilled.

The stable working platform shall be compacted using light compaction equipment which will give the most effective compaction without over-stressing the material. Light hauling equipment shall be used when driving on top of this staple platform as instructed by the Engineer.

The fill material under the water table shall be selected, well draining sandy and gravelly materials, having a maximum percentage passing the 0.075 mm sieve of 5 % and a maximum Plasticity Index of 6%. It is not expected that it will be possible for the excavator to excavate all soft materials as similar ground will be flowing into the excavation. However, as the soft material has a

very low strength, which has been further reduced by the excavation operation, the soil is expected to be displaced by the dead weight of the embankment.

The operation shall move along the existing embankment and displace the soft and unsuitable material in an outgoing direction. Displacement without excavation by excavator will not be permitted due to the risk of leaving highly compressible material below the embankment soil.

The fill above the water table shall be compacted according to the Specifications, whereas the fill placed under the water table cannot be compacted to the normally required density for fill, and will be allowed to settle under the dead weight of the embankment.

The slope of the embankment sides in swamps where this technique is employed shall be increased to 1 in 4.

After construction of the embankment, the Contractor shall carry out auger drillings through the constructed embankment and into the in-situ subsoil below the fill at intervals not exceeding 40 square metres. The Engineer may at his/her discretion instruct further auger drillings at no additional cost. The findings shall satisfy the Engineer that all soft materials such as peat and soft clay have been excavated/displaced by the embankment soil. Any sections not constructed to the satisfaction of the Engineer shall be reworked.

In order to minimise differential settlements in the finished road surface, the widening of embankments shall be carried out well in advance of placing the pavement layers on that particular section. This is expressly important where the new road will be placed partly on a new constructed embankment and partly on the existing road embankment. In such cases, where the height of the new embankment exceeds 2.0m, the existing embankment shall be cut to the level of the stable working platform of the embankment widening but in no case lower than 0.5m above the water level/adjacent ground level. Embankment fill material shall be placed full width according to normal and approved construction methods over both the existing and widened embankment foundation. The existing embankment material shall where possible be used for this filling operation and be compacted according to the Specifications.

Widening of the embankments through the swampy areas shall be performed as early as possible and be completed within 12 months of Notice to Commence. The time lap between finished embankment up to formation level and placement of the pavement layers will depend on the rate of settlement in the surface. To monitor this rate of settlement, the Contractor shall, unless otherwise instructed by the Engineer, erect secure concrete beacons on the finished embankment, and perform accurate levelling at times determined by the Engineer. No compensation will be paid to the Contractor for a delay in time of up to four months between finishing the embankment and commencement of the pavement layers on that particular section.

The rates for construction of the embankment fill is deemed to include all extra cost relating to the special techniques used in constructing the embankment across swampy areas, use of material from the existing fill in the construction of the widened part of the new fill and any other measures directed by the Engineer except excavation for widening of the embankment as specified in Clause 3610.

(k) Preloading

Preloading if required, including vertical drains, shall be as specified in the Special Specifications.

3606 COMPACTION OF EARTHWORKS

(a) General requirements

(i) Moisture content

The moisture content of earthwork at the time of compaction shall not be higher than the optimum moisture content (OMC) measured at BS-Light compaction for roadbed, and BS-Heavy compaction respectively for earthworks layers. The corresponding lowest allowed moisture content shall be 75% of OMC. SUBCLAUSE 3605(d) shall apply if the natural moisture content of the roadbed is too high and drying it back could not be done with reasonable efforts and within a reasonable time, all in the opinion of the Engineer.

Dry compaction techniques shall not be employed unless prescribed in the Special Specifications or directed by the Engineer.

The Engineer may instruct that expansive soils are given treatment such as watering to maintain natural moisture content and timely dumping and spreading of following layers. He/she may also instruct compaction to be omitted on such soils as he/she finds it appropriate.

(ii) Density

The minimum required compacted density of earthworks shall be as given in TABLE 3606/1.

(b) Compaction method specification

The Engineer may at his/her own discretion allow compaction to be carried out in accordance with a method specification instead of density control in cases where material characteristics or site conditions in his/her opinion makes compaction density control inappropriate. Trials shall be undertaken to the full satisfaction of the Engineer in order to establish the required type of equipment, processing method and number of roller passes. The outcome of the trials shall be satisfactory to the Engineer for a method specification to be employed. All costs for undertaking such trials shall be carried by the Contractor.

The use of a compaction method specification may at the Engineer's discretion be discontinued any time he/she finds it necessary for contractual or technical reasons.

(c) Proof rolling

Proof rolling of any earthworks layer or roadbed using loaded trucks or suitable rollers shall be carried out as required by the Engineer. The equipment and method of operation shall be as directed by the Engineer and the Contractor shall make all required equipment available for proof rolling at any time as required by the Engineer.

(d) Side fill and spoil dumps

Spoil material for side fill shall be spread in successive layers of maximum 300 mm loose thickness, shaped and given a smooth surface and compacted by bulldozers or other heavy plant to the satisfaction of the Engineer. Where required by the Engineer the same procedure shall be followed in the case of spoil dumps.

TABLE 3606/1
COMPACTION REQUIREMENTS FOR EARTHWORKS

Layer and typical material type specified	**Minimum dry density, lower specification limit *1)*, BS 1377: Part 4**
Upper improved subgrade layer, **G15** material or better, for layers less than 150 mm below the formation level	95% of BS-Heavy
Lower improved subgrade layer, **G7** material or better, for layers from 150 mm to 300 mm below the formation level	93% of BS-Heavy
Fill, **G3** material or better, for layers more than 300 mm below the formation level	90% of BS-Heavy
Fill or improved subgrade layers using rock fill (**DR**)	Compaction method specification shall apply
Roadbed compaction to 150 mm depth after clearing, grubbing and removal of topsoil or other unsuitable material, where the roadbed level is:	
– less than 150 mm below the formation level	97% of BS-Heavy
– 150 mm to 300 mm below the formation level	95% of BS-Heavy
– 300 mm to 600 mm below the formation level	93% of BS-Heavy
– more than 600 mm below the formation level	100% of BS-Light
1) Refer to SUBCLAUSE 7203(c)	

3607 PROTECTING THE EARTHWORKS AND STRUCTURES

During construction all earthworks shall be kept well drained and protected at all times as specified in SECTION 1200. All windrows shall be cut away after construction to prevent the concentrated flow of water on completed earthworks layers, but, where necessary, flat berms shall be constructed to prevent the undue erosion of fill slopes. All permanent drains shall be constructed as soon as possible, together with sufficient additional temporary drains as may be necessary to protect the road prism, and shall be maintained in a good working order. Ruts, potholes, soft spots or any other damage developing in the earthworks after completion shall be repaired, and the damaged portions shall be reshaped and re-compacted to the satisfaction of the Engineer at the Contractor's own cost.

All erosion and flood damage to slopes shall be promptly repaired as specified in SECTION 1200.

Side drains discharging water from cuts and all other drains shall be constructed in such a way that damage to the earthworks by erosion is avoided.
Proper precautions and temporary measures shall be taken in all cases to ensure that the method or procedure by which the fills are constructed will not impose loads on structures, especially on uncompleted structures, which may damage or overstress such structures.

3608 FINISHING THE SLOPES

(a) General
Except in solid rock, the tops and bottoms of all slopes including the slopes of drainage ditches shall be rounded as indicted on the Drawings or as ordered by the Engineer. Slopes at the junctions of cuts and fills shall be adjusted and warped to flow into one another or into the natural ground surfaces without any noticeable break.

When so directed by the Engineer, adjustment to the slopes shall be made in order to avoid damage being done to standing trees and to harmonise with existing landscape features. The transition to such adjusted slopes shall be gradual.

Cut and fill slopes shall be finished to a uniform appearance without any noticeable break which can be readily discerned from the road. The degree of finish required for all fill slopes and for cut slopes flatter than 1:4 shall be that normally obtainable by motor grader or hand-shovel operations.

The slopes of cuts and fills which are designated for grassing shall, after finishing, be prepared for grass planting and/or for topsoil for grass planting as specified in SECTION 5600.

All trimming of cut slopes shall be completed before any work on the subbase is commenced inside such cuttings.

(b) Cut slopes

(i) Cuts in soils
The slopes of cuttings shall be trimmed to neat lines and to a standard that is generally attainable with proper care and workmanship in the type of material concerned. All loose rocks, stones and nests of loose material shall be removed, especially in solid-rock cuts, which must be completely free from such material. The final surface of batters must be absolutely smooth to prevent initiation of slope erosion unless alternative methods for grassing or the establishment of natural vegetation is instructed by the Engineer.

(ii) Cuts in rock
Cuts in rock shall be cleared of all loose stones to the satisfaction of the Engineer.

(c) Fill slopes
Fill slopes shall be finished to neat lines with all loose rocks and un-compacted material removed. The degree of finish required shall depend on the nature of the material used for the fill slope but shall be as smooth as is consistent with the material involved and good workmanship to the satisfaction of the Engineer.

3609 CONSTRUCTION TOLERANCES AND TESTING

Construction tolerances and testing shall be in accordance with SERIES 7000.

3610 MEASUREMENT AND PAYMENT

The Engineer's decision regarding the cross-sections to be used for measurement and payment shall be final and binding on the Contractor in the cases where the Contractor proceeds with earthworks before the Engineer has approved the cross-section measurements.

ITEM		UNIT
36.01	EXCAVATIONS:	
(a)	COMMON EXCAVATION TO SPOIL	CUBIC METRE (m^3)
(b)	EXCAVATION IN SWAMPS OR WETLANDS TO SPOIL	CUBIC METRE (m^3)
(c)	ROCK EXCAVATION	CUBIC METRE (m^3)

The unit of measurement shall be the cubic metre of material removed as specified to be spoiled on the instruction of the Engineer, measured in its original position and computed by the method of average end areas from levelled cross-sections taken prior to excavating the cut, measured along the ground line. Measurements of common excavation to spoil shall exclude materials already paid for as removal of topsoil under ITEM 31.01.

"Common Excavation to Spoil" shall include material other than "Rock Excavation", which are surplus based on the total theoretical cut and fill volumes for the project, including material specified or instructed by the Engineer to be spoiled. The conversion of the fill volume to an equivalent cut volume shall assume a compaction factor of 1.15 or as determined by the Engineer.

"Excavation in Swamps or Wetlands to Spoil" shall include material excavated according to the special methods described in SUB-CLAUSE 3605(j) when so agreed with the Engineer. Quantities shall be measured in its original position and computed by the method of average end areas from levelled cross-sections taken prior to excavating into the material below the water level as directed by the Engineer. Final levels after excavation/displacement shall be determined either by levelling or the approved profile established by the auger measurements, as directed by the Engineer.

Excavation of rock according to the classification criteria in Table 3603/1 shall be paid for only as "Rock Excavation" if spoiled, but also under ITEM 36.02(d) if used for embankment construction or ITEM 36.02(h) if used for pioneer layer.

Excavation from within the road prism being used for embankment construction shall not be paid for under ITEM 36.01 but only be paid for as fill under Item 36.02 measured in its final compacted position.

No excavation in excess of that indicated on the Drawings or as directed by the Engineer shall be paid for, notwithstanding any tolerances in workmanship allowed.

The bid rates for excavation shall include full compensation for excavation as classified, any necessary de-watering, loading, off loading and disposing of the material as specified. No overhaul will be paid for transporting away the excavated material.

In case the material is used in pavement layers or earthworks, overhaul may be paid for as prescribed in SECTION 1600 when, and only when, payment of overhaul is prescribed in the Special Specifications. In such case the material measured for payment of overhaul shall be the compacted material in the respective pavement or earthworks layer for which overhaul is paid.

ITEM		UNIT
36.02	FILL AND IMPROVED SUBGRADE LAYERS:	
(a)	IMPROVED SUBGRADE LAYER AS SPECIFIED IN THE DRAWINGS TO REQUIRE MINIMUM G15 QUALITY MATERIAL	CUBIC METRE (m^3)
(b)	IMPROVED SUBGRADE LAYER AS SPECIFIED IN THE DRAWINGS TO REQUIRE MINIMUM G7 QUALITY MATERIAL	CUBIC METRE (m^3)
(c)	FILL AS SPECIFIED IN THE DRAWINGS TO REQUIRE MINIMUM G3 QUALITY MATERIAL	CUBIC METRE (m^3)
(d)	FILL OR IMPROVED SUBGRADE LAYER USING ROCK FILL	CUBIC METRE (m^3)
(e)	CROSSFILL	CUBIC METRE (m^3)
(f)	SIDE FILL COMPACTED BY DOZERS OR AS SPECIFIED	CUBIC METRE (m^3)
(g)	EXTRA OVER SUBITEM 36.02(a) TO (e) RESPECTIVELY, FOR CONSTRUCTION OF SAND BLANKETS AS SPECIFIED	CUBIC METRE (m^3)
(h)	PIONEER LAYER	CUBIC METRE (m^3)

The unit of measurement shall be the cubic metre of material measured in the compacted fill according to the Drawings or as directed by the Engineer. The quantity measured shall be computed by the method of average end areas from levelled cross-sections. The levelled cross-sections shall be prepared from the ground line prior to the construction of the fill after clearing and grubbing and after corrections for the instructed depth of the removal of topsoil and the instructed depth of any excavation and preparatory roadbed treatment specified or ordered by the Engineer. Filling to compensate for excessive depth of removal of topsoil, or excessive depth of spoil excavation, compared to that specified, ordered or approved by the Engineer, will not be paid for.

Where the road bed has been lowered due to subsidence under fills, or the roadbed levels are lowered due to the roadbed preparation, the quantities shall be adjusted to make allowance for such lowering, at the sole discretion of the Engineer. The Contractor shall lodge such request without delay, and he/she shall submit the required supporting evidence to the Engineer. Where the Engineer is satisfied that significant lowering is occurring, he/she shall decide to what extent, if any, the lowering will be compensated for in the measurement of earthworks fill. Such adjustment of quantities shall only be considered where a total lowering due to subsidence and processing of the roadbed is in excess of 100 mm. The Contractor shall allow in his/her rates for such lowering of up to 100 mm.

That part of the fill placed in excess of the cross-sections shown on the Drawings or as directed by the Engineer, will not be paid for irrespective of the tolerances in workmanship allowed under the Contract.

Measurement and payment of fill shall not distinguish between alternative methods of processing and compaction of the materials.

The bid rates shall include full compensation for procuring, excavating, any necessary de-watering, loading, furnishing, placing, preparing, processing, shaping, watering, mixing, and compaction of the materials to the densities according to the Specifications.

When payment for overhaul is specified in the Special Specifications, the rate shall include a free haulage distance as defined in SECTION 1600.

When payment for overhaul is not specified in the Special Specifications, the rate shall include for all transportation of the material.

Earthworks layers, except rock fill, shall be paid for as crossfill where the material on the instruction or approval of the Engineer is taken from cuts in the road reserve and placed in embankments at a distance of 50 m or less from its original position, measured along the centreline of the road. The unit of measurement for crossfill shall be the cubic metre of material measured in the compacted embankment according to the Drawings or as directed by the Engineer. No distinction shall be made for the earthworks layer in which crossfill is used, i.e. whether in improved subgrade layers or common fill.

The unit of measurement for pioneer layer shall be cubic metre determined on the basis of thickness of material determined by auger drillings as specified in SUBCLAUSE 3605(j)(2)

ITEM	UNIT
36.03 ROADBED PREPARATION AND COMPACTION OF MATERIAL:	
(a) COMPACTION TO 97% OF BS-HEAVY DENSITY	CUBIC METRE (m^3)
(b) COMPACTION TO 95% OF BS-HEAVY DENSITY	CUBIC METRE (m^3)
(c) COMPACTION TO 93% OF BS-HEAVY DENSITY	CUBIC METRE (m^3)
(d) COMPACTION TO 100% OF BS-LIGHT DENSITY	CUBIC METRE (m^3)

The unit of measurement shall be the cubic metre of roadbed material prepared and compacted as specified in SUBCLAUSE 3604(b)(i). The quantity shall be computed in accordance with the authorised dimensions of the completed layer.

The tendered rates shall include full compensation for shaping, scarifying, mixing of in-situ and imported material if required, any necessary de-watering and preparing and compaction of the material as specified. For payment purposes a distinction will be made between compaction to a percentage of BS-Heavy density.

SERIES 3000: EARTHWORKS AND PAVEMENT LAYERS OF GRAVEL OR CRUSHED STONE

SECTION 3700: PAVEMENT LAYERS OF NATURAL GRAVEL MATERIALS

CONTENTS:

3701 SCOPE

This Section covers the construction of subbase, base course, shoulders and gravel wearing course from natural gravel or partially crushed gravel.

This Section covers the requirements for the following types of material:

- **GW** Gravel wearing course
- **G80** natural gravel with minimum soaked CBR value of 80%
- **G60** natural gravel with minimum soaked CBR value of 60%
- **G45** natural gravel with minimum soaked CBR value of 45%
- **G30** natural gravel with minimum soaked CBR value of 30%

3702 MATERIALS

(a) General

Gravel material shall be obtained from approved sources. Any test results provided in design documents such as the Materials Report, read in conjunction with these Specifications, may give a preliminary indication as to the purpose for which cut or borrow material may be used as well as the treatment, if any, which the roadbed shall receive. Any test results or recommendations of method of work in the Materials Report are solely for information. The Contractor shall undertake his/her own assessment and any tests required and submit his/her proposed methods of work and test results of all material he/she intends to use for the approval of the Engineer.

The material type (G80, G60, G45, G30, GW) given in the Drawings denotes the minimum quality for a particular use in the Works, either specified in the Drawings or as instructed by the Engineer. In the cases where a minimum quality of earthworks material is not specified, the following guidelines shall apply and the Engineer's instruction shall be the applied standard to which materials quality control is applied:

(b) Material type and typical use

GW Gravel wearing course and gravel shoulders
G80 Base course
G60 Base course, low traffic roads
G45 Subbase
G30 Subbase

Irrespective of the minimum required quality specified or the above guidelines, the highest quality of approved gravel for pavement layers available at economical haul distances, complying with the requirements of the Specifications and Drawings, shall be selected for fill, improved subgrade and the individual pavement layers.

(c) Soluble salts

The Contractor shall discard the material or fulfil all requirements for appropriate construction techniques and timing of operations to the satisfaction of the Engineer if assessments of soluble salt contents in base course or subbase materials show deleterious values. Such assessments are only required where the pavement is going to receive a bituminous seal as the only surfacing. No additional payment will be made for any measures taken, or for any alterations of the material utilisation, due to presence of soluble salts in materials or construction water.

(d) Grading modulus (GM), grading coefficient (GC) and shrinkage product (SP)

Wherever grading modulus (GM) is referred to the value shall be calculated as follows:

$$GM = \left[3 - \left(\frac{\%pass2mm + \%pass0.425mm + \%pass0.075mm}{100}\right)\right]$$

Wherever grading coefficient (GC) is referred to the value shall be calculated as follows:

$$GC = \frac{(D_{30})^2}{D_{60} \times D_{10}}$$

where

D_{60} , D_{30} and D_{10} are the sieve sizes that 60%, 30% and 10% pass.

Wherever Shrinkage Product (SP) is referred to the value shall be calculated as follows:

SP = (LS)*(% pass 0.425 mm)

Where (LS) is Linear Shrinkage as determined according to BS 1377: Part 2.

(e) Gravel wearing course (GW) and unpaved shoulders

Materials for unpaved shoulders and gravel wearing course layers of GW materials as specified on the Drawings shall meet the requirements given in TABLE 3702/1.

(f) Material requirements for natural gravel base course (G80)

Materials for base course layers of G80 materials as specified on the Drawings shall meet the requirements given in TABLE 3702/2.

(g) Material requirements for natural gravel base course (G60) for low traffic roads

Materials for base course layers of G60 materials as specified on the Drawings shall meet the requirements given in TABLE 3702/3.

(h) Material requirements for natural gravel subbase (G45)

Materials for subbase layers of G45 materials as specified on the Drawings shall meet the requirements given in TABLE 3702/4.

(i) Material requirements for natural gravel subbase (G30)

Materials for subbase layers of G30 materials as specified on the Drawings shall meet the requirements given in TABLE 3702/5.

TABLE 3702/1
REQUIREMENTS FOR LAYERS OF GRAVEL WEARING COURSE GW MATERIALS

Material properties	**Material class GW**
CBR: BS 1377: Part 4	
CBR (%)	Minimum 25 after 4 days soaking ***1)***
Grading and Shrinkage limits *2)*	
% passing the 37.5 mm sieve	Minimum 95
Shrinkage product, SP	Minimum 120, maximum 400 ***3)***
Grading coefficient, GC	Minimum 16, maximum 34

1) CBR values shall be measured at 95% of MDD for BS-Heavy compaction. For minor gravel roads the required CBR value may be reduced to 15 on the approved of the Engineer.
2) It is emphasised that the Atterberg limits shall be measured according to BS 1377: Part 2. Other laboratory test procedures and equipment may not give comparable results and shall not be used unless proper correlation to BS has been carried out to the satisfaction of the Engineer. All grading parameters must be normalised for 100% passing 37.5 mm.
3) In built up areas the maximum SP value shall be 270 or as directed by the Engineer in order to minimise dust problems.

TABLE 3702/2
REQUIREMENTS FOR BASE COURSE LAYERS OF G80 MATERIALS

Material properties	**Material class G80**	
	General requirements	**Calcrete or other pedogenic materials**
CBR: BS 1377: Part 4		
CBR (%)	Minimum 80 after 4 days soaking ***1)***	
CBR-swell (%)	Maximum 0.5 measured at BS-Heavy compaction	
Atterberg limits: *2)*		
Max Liquid limit BS 1377: Part 2	30	35
Max Plasticity Index BS 1377: Part 2	8	10
Max Linear Shrinkage BS 1377 :Part 2	4	5
Grading: *BS 1377: Part 2*		
Sieve size (mm)	Grading limits (% passing sieve)	
63	100	– The largest particles d_{max} shall be maximum 1/2 of compacted layer thickness but not >50mm.. – Grading modulus, GM shall be minimum 2.0
37.5	80 – 100	
20	60 – 95	
5	30 – 65	
2	20 – 50	
0.425	10 – 30	
0.075	5 – 15	
Particle strength: BS 812: Part 111		
Minimum TFV_{dry}	80 kN	
Ratio dry to soaked value of TFV	TFV_{soaked} shall be minimum 60% of the corresponding TFV_{dry} value	

1) CBR values shall be measured at the specified field density for the layer.
2) It is emphasised that the Atterberg limits shall be measured according to BS 1377: Part 2. Other laboratory test procedures and equipment may not give comparable results and shall not be used unless proper correlation to BS has been carried out to the satisfaction of the Engineer.

TABLE 3702/3
REQUIREMENTS FOR BASE COURSE LAYERS OF G60 MATERIALS

Material properties	**Material class G60**	
	General requirements	**Calcrete or other pedogenic materials**
CBR: BS 1377: Part 4		
CBR (%)	Minimum 60 after 4 days soaking ***1)***	
CBR-swell (%)	Maximum 1.0 measured at BS-Heavy compaction	
Atterberg limits: ***2)***		
Max Liquid limit BS 1377: Part 2	35	40
Max Plasticity Index BS 1377: Part 2	10	12
Max Linear Shrinkage BS 1377: Part 2	5	6
Grading: BS 1377: Part 2		
Sieve size (mm)	Grading limits (% passing sieve)	
63 37.5 20 5 2 0.425 0.075	100 80 – 100 60 – 95 30 – 65 20 – 50 10 – 30 5 – 15	– The largest particles d_{max} shall be maximum 1/2 of compacted layer thickness but not >50mm. – Grading modulus, GM shall be minimum 2.0
Particle strength: BS 812: Part 111		
Minimum TFV_{dry}	50 kN	
Ratio dry to soaked value of TFV	TFV_{soaked} shall be minimum 60% of the corresponding TFV_{dry} value	

1) CBR values shall be measured at the specified field density for the layer.
2) It is emphasised that the Atterberg limits shall be measured according to BS 1377: Part 2. Other laboratory test procedures and equipment may not give comparable results and shall not be used unless proper correlation to BS has been carried out to the satisfaction of the Engineer.

TABLE 3702/4
REQUIREMENTS FOR SUBBASE LAYERS OF G45 MATERIALS

Material properties	**Material class G45**	
	General requirements	**Calcrete or other pedogenic materials**
CBR: BS 1377: Part 4		
CBR (%)	Minimum 45 after 4 days soaking ***1)***	
CBR-swell (%)	Maximum 0.5 measured at BS-Heavy compaction	
Atterberg limits: 2)		
Max Liquid limit BS 1377: Part 2	40	45
Max Plasticity Index BS 1377: Part 2	14	16
Max Linear Shrinkage BS 1377: Part 2	7	8
Grading: BS 1377: Part 2		
Requirements:	Grading modulus, GM shall be minimum 1.5	

1) CBR values shall be measured at the specified field density for the layer.
2) It is emphasised that the Atterberg limits shall be measured according to BS 1377: Part 2. Other laboratory test procedures and equipment may not give comparable results and shall not be used unless proper correlation to BS has been carried out to the satisfaction of the Engineer.

TABLE 3702/5
REQUIREMENTS FOR SUBBASE LAYERS OF G30 MATERIALS

Material properties	Material class G30	
	General requirements	Calcrete or other pedogenic materials
CBR: BS 1377: Part 4		
CBR (%)	Minimum 30 after 4 days soaking ***1)***	
CBR-swell (%)	Maximum 1.0 measured at BS-Heavy compaction	
Atterberg limits: 2)		
Max Liquid limit BS 1377: Part 2	45	45
Max Plasticity Index BS 1377: Part 2	16	18
Max Linear Shrinkage BS 1377: Part 2	8	9
Grading: BS 1377: Part 2		
Requirements:	Grading modulus, GM shall be minimum 1.2	

1) CBR values shall be measured at the specified field density for the layer.
2) It is emphasised that the Atterberg limits shall be measured according to BS 1377: Part 2. Other laboratory test procedures and equipment may not give comparable results and shall not be used unless proper correlation to BS has been carried out to the satisfaction of the Engineer.

3703 CONSTRUCTION

(a) Requirements applying prior to placing of the layer
No pavement layer shall be placed until approval is obtained from the Engineer and the underlying layer is placed, compacted and finished in accordance with the Specifications and is tested and found acceptable to the full satisfaction of the Engineer. Before placing any pavement layer the underlying layer shall be inspected and proof rolled as required by the Engineer in order to establish whether there is any damage, wet spots or other defects. Any such defect shall be rectified to the satisfaction of the Engineer before the next layer is placed.

(b) Processing to improve quality
The Contractor may elect to crush, screen or mix materials from different sources or undertake other processing of materials to meet the specified material requirements. No additional payment will be made for any such processing unless stated in the Special Specifications and the Bill of Quantities.

(c) Shoulders
Where the shoulders and the base course are to be constructed from the same material, they shall be constructed simultaneously.

Where the base course is to be constructed from a different material than the shoulders, the shoulders shall first be constructed and then neatly cut to the required line to provide lateral support for the base course. Care shall be taken not to contaminate the base course material with the shoulder material. Where the base course is made of a bituminous mix, the base course may however be constructed before the shoulders. Work shall be so constructed that the road will be adequately drained at all times by means of sufficient drainage pipes passing through the shoulders. The Contractor shall not start constructing the final bituminous surfacing of any part of the road before he/she has completed the shoulders of such section to the satisfaction of the Engineer.

Shoulder material shall be spread, broken down as required, watered, mixed and compacted in accordance with the Specifications, and shall be compacted to a density of not less than that specified in TABLE 3704/1 or as directed by the Engineer.

(d) Subbase and base course materials
Subbase or base course materials respectively shall be spread, broken down as required, watered, mixed and compacted in accordance with the Specifications, and shall be compacted to a density of not less than that specified in TABLE 3704/1 or as directed by the Engineer.

3704 COMPACTION REQUIREMENTS

(a) General requirements
The minimum required compacted density for pavement layers made of natural gravel shall be as given in TABLE 3704/1.

TABLE 3704/1
COMPACTION REQUIREMENTS FOR PAVEMENT LAYERS MADE OF NATURAL GRAVEL

Layer and typical material type specified	Minimum dry density, lower specification limit, BS 1377: Part 4
Base course layers, **G80** or **G60** material or better	98% of BS-Heavy
Subbase course layers, **G45** or **G30** material or better	95% of BS-Heavy
Gravel wearing course or unpaved shoulders **GW** material	

Unless otherwise specified in the Special Specifications, the compaction requirements shall comply with acceptance criteria according to the statistical method specified in Section 7200.

(b) Compaction method specification
The Engineer may at his/her own discretion allow compaction to be carried out in accordance with a method specification instead of density control in cases where material characteristics or site conditions in his/her opinion makes compaction density control inappropriate. Trials shall be undertaken to the full satisfaction of the Engineer in order to establish the required type of equipment, processing method and number of roller passes. The outcome of the trials shall be satisfactory to the Engineer for a method specification to be employed. All costs for undertaking such trials shall be carried by the Contractor.

The use of a compaction method specification may at the Engineer's discretion be discontinued any time he/she finds it necessary for whatever reason.

3705 MAINTENANCE OF EXISTING GRAVEL ROADS

(a) General
Maintenance of existing gravel road surfaces shall be classified as one or more of the following operations:

(i) shaping existing gravel roads
(ii) ripping and processing existing gravel roads
(iii) regravelling existing gravel roads

(b) Shaping existing gravel roads
Shaping existing gravel roads is paid for per square metre in SUBITEM 37.04(a). No payment shall be made for shaping existing gravel roads on sections where regravelling or ripping and processing is carried out. Shaping existing gravel roads comprises the following operation carried out to the satisfaction of the Engineer:

(i) Bringing loose material back to the road from the slopes and ditches if instructed by the Engineer.
(ii) Shaping by motor grader, or equivalent equipment approved by the Engineer.

(c) Ripping and processing existing gravel roads
Ripping and processing existing gravel roads is paid for per square metre in SUBITEM 37.04(b) and comprises the following operations:

(i) Ripping of the existing road to a depth of minimum 100 mm as required by the Engineer.
(ii) Bringing loose material back to the road from the slopes and ditches if instructed by the Engineer.
(iii) Mixing, breaking of lumps, removal of oversize particles and watering as required to make a homogenous material having suitable moisture content at or around the optimum moisture content of BS-Heavy density.
(iv) Shaping and finishing to the correct grade and crossfall and compaction to the requirements in CLAUSE 3704.

(d) Regravelling existing gravel roads
Regravelling comprises the following operation, paid for per cubic metre in SUBITEM 37.03(b).

(i) Addition of gravel wearing course material to an existing road.
(ii) Processing as specified for in CLAUSES 3703 and 3704 for GW material by mixing, breaking of lumps, removal of oversize particles and watering as required to make a homogenous material having suitable moisture content at or around the optimum moisture content of BS-Heavy density.
(iii) Shaping and finishing to the correct grade and crossfall and compaction to the requirements in CLAUSE 3704.

Ripping of the existing surface shall be carried out as required on the approval of the Engineer wherever the compacted layer thickness will not reach minimum 75 mm, or as instructed by the Engineer for other reasons. Ripping shall be carried out to a depth of minimum 100 mm as required by the Engineer. In such cases additional payment per square metre in SUBITEM 37.04(b) will apply.

Ripping and reprocessing in addition to regravelling may be required due to application of thin layers of imported gravel, poor shape of the existing road or whatever other reason as deemed necessary by the Engineer.

(e) Materials and compaction
The gravel wearing course material, and respectively the combination of imported and scarified material, shall meet the requirements for material class GW as given in CLAUSE 3702. Where the compacted layer thickness will exceed 200 mm the compaction shall be carried out in two operations. Each layer shall be shaped to the specified grade and compacted to the required density in accordance with CLAUSE 3704 before the succeeding layer is placed.

3706 PROTECTION AND MAINTENANCE

The compacted layers shall be adequately drained and shaped to prevent water from standing on or along or causing damage to the completed work. Windrows shall be removed to facilitate the drainage of water from the surface.

No material for a subsequent layer shall be placed if the underlying layer has been softened by excessive moisture and requires repair in the opinion of the Engineer.

3707 CONSTRUCTION TOLERANCES

Construction tolerances and testing shall be in accordance with SERIES 7000.

3708 MEASUREMENT AND PAYMENT

ITEM	UNIT
37.01 NATURAL GRAVEL FOR BASE COURSE:	
(a) NATURAL GRAVEL CLASS G80	CUBIC METRE (m^3)
(b) NATURAL GRAVEL CLASS G60	CUBIC METRE (m^3)

ITEM	UNIT
37.02 NATURAL GRAVEL FOR SUBBASE:	
(a) NATURAL GRAVEL CLASS G45	CUBIC METRE (m^3)
(b) NATURAL GRAVEL CLASS G30	CUBIC METRE (m^3)

ITEM	UNIT
37.03 NATURAL GRAVEL FOR GRAVEL WEARING COURSE AND UNPAVED SHOULDERS:	
(a) NATURAL GRAVEL CLASS GW USED FOR UNPAVED SHOULDERS FOR BITUMINOUS PAVEMENTS	CUBIC METRE (m^3)
(b) NATURAL GRAVEL CLASS GW USED FOR GRAVEL WEARING COURSE	CUBIC METRE (m^3)

The quantity of natural gravel shall be the number of cubic metres completed in place compacted to the depths and widths shown on the Drawings or as directed. The quantity shall be measured by the cross-section area shown on the construction drawings times the station length. Where gravel wearing course material, GW, is placed on an existing gravel road the measurement of levels before the start of the operation shall form the basis for calculating the cubic metre quantities. In the cases where gravel wearing course material is not to be compacted on the approval of the Engineer, the quantity shall be measured as cubic metres in un-compacted state.

The bid rates shall include full compensation for procuring, breaking down, placing, compacting, testing and proof rolling the material including the protection and maintenance of the layer, all as specified.

When payment for overhaul is allowed for in accordance with the Special Specifications, the rates

shall include the free haulage distance as defined in SECTION 1600. When GW materials are used as unpaved shoulders for paved roads the corresponding free haul distance shall as for natural gravel subbase material.

When payment for overhaul is not allowed for in the Special Specifications, the rates shall include for all transportation of the material.

ITEM		UNIT
37.04	MAINTENANCE OF EXISTING GRAVEL ROADS:	
(a)	SHAPING EXISTING GRAVEL ROADS WITHOUT SCARIFICATION OF THE SURFACE	SQUARE METRE (m^2)
(b)	SCARIFICATION, MIXING, WATERING AND COMPACTION	SQUARE METRE (m^2)

The quantity paid for in SUBITEM 37.04(a) shall be the square metres calculated as the horizontal distance along the centreline times the distance between the shoulder breakpoints in accordance with the cross-section drawings or as directed by the Engineer.

Imported gravel wearing course material shall be paid for under SUBITEM 37.03(b). Material brought in from the side shall be paid for as crossfill under ITEM 36.02 in the cases where the material on the instruction or approval of the Engineer is taken from cuts in the road reserve and placed in embankments at a distance of 50 m or less from its original position, measured along the centreline of the road.

The operation of bringing loose material back to the road from the slopes and ditches on the approval or instruction of the Engineer shall be included in the respective rate in ITEM 37.04 and will not be measured for payment per cubic metre as crossfill or imported fill or gravel.

The bid rates for in SUBITEM 37.04(a) shall include full compensation for shaping the existing road by motor grader as specified.

The bid rates for in SUBITEM 37.04(b) shall include full compensation for ripping the existing road by approved equipment, breaking of lumps, removal of oversize particles and watering as required to make a homogenous material having suitable moisture content at or around the optimum moisture content of BS-Heavy compaction and shaping of the layer to the required grade and crossfall as specified including the protection and maintenance of the layer, all as specified.

SERIES 3000: EARTHWORKS AND PAVEMENT LAYERS OF GRAVEL OR CRUSHED STONE

SECTION 3800: STABILISATION

CONTENTS:

3801 SCOPE

This Section covers the modification or stabilisation of materials used in the construction of the earthworks or pavement layers by mechanical modification of the material through the addition of soil binder or by the addition of a chemical stabilising agent such as cement or lime.

It includes the furnishing, spreading and mixing-in of the stabilising agent and compaction including and provision of a curing treatment.

This Section covers the requirements for the following types of material classified according to their minimum unconfined compression strength (UCS):

C1.5 stabilised material with a minimum UCS value of 1.5 MPa

C1.0 stabilised material with a minimum UCS value of 1.0 MPa

C0.7 stabilised material with a minimum UCS value of 0.7 MPa

CM: modified material with a minimum UCS value of 0.5 MPa.

3802 MATERIALS

(a) Alternative stabilising agents

The stabilising agent shall be either one or more of the following agents specified on the Drawings, in the Bill of Quantities or in the Special Specifications or as ordered by the Engineer.

(i) Hydraulic Road Binder
Hydraulic road binders shall comply with the requirements of US 371:2003, AASHTO M216-92, and road lime shall comply with US 288: 2001 or AASHTO M216-92 or equivalent standard on approval of the Engineer.

(ii) Cement
Cement shall comply with the requirements of US 310-1:2001 (CEM I or II), AASHTO M85-98 or equivalent standard on approval of the Engineer. The use of rapid-hardening cement shall not be permitted.

(iii) Blast-furnace cement
Blast-furnace cement may be used if specified in the Special Specifications, and shall comply with the requirements of US 310-1:2001 (CEM III), AASHTO M240-97 or equivalent standard on approval of the Engineer.

(iv) Other chemical stabilising agents
Other chemical stabilising agents such as fly-ash or liquid ionic stabiliser may be used if allowed for in the Special Specifications or if instructed by the Engineer.

(b) Selection of stabiliser

The most suitable type of stabiliser to use for a particular type of soil shall be as given in the Special Specifications, or as directed by the Engineer whereby TABLE 3802/1 may be used as guidance.

TABLE 3802/1
GUIDE TO SELECTION OF STABILISER.

% passing the 0.075 mm sieve BS 1377-2	**Plasticity Index (%)** BS 1377: Part 2	**Best suited stabiliser**
Less than 25%	PI is less than 6 or PI x (% passing 0.075 mm) is less than 60	Cement only ***1)***
	6 – 10	Cement preferred
	More than 10	Cement and/or lime
More than 25%	Less than 10	Cement preferred
	10 – 20	Cement and/or lime
	More than 20	Lime preferred ***2)***

1) Lime requires presence of clay particles to react and is therefore used for materials with high PI. Admixture of pozzolans, such as pulverised slag or fuel ash from coal fired power plants, can make stabilisation with lime possible also for materials with low PI.
2) Cement can be used for stabilisation of material with high PI although lime is normally preferred in such cases. To use cement under such circumstances requires that the workability of the material is improved by a pre-treatment with 2% lime prior to cement stabilisation.

(c) Purchase and storage of stabilisers

From the time of purchase to the time of use, all stabilising agents shall be kept under proper cover and be protected from moisture.

Consignments of these materials shall be used in the same sequence as that in which they are delivered at the Works. Stock which have been stored on the Site for periods longer than three months shall not be used in the Works, unless authorised by the Engineer.

(d) Material properties

(i) Durability
In order to ensure that an irreversible stabilisation reaction occurs, the amount of stabiliser added shall not be less than the initial consumption of lime (ICL) as determined according to BS 1924: Part 2 plus 1%.

(ii) Material requirements
The requirements for materials before and after treatment are given in TABLE 3802/2. The Grading Modulus (GM) is defined in Sub-Clause 3702 (d).

TABLE 3802/2
REQUIREMENTS FOR MATERIALS IN CEMENTED LAYERS

Material properties	**Material class**			
	C1.5	**C1.0**	**C0.7**	**CM**
Minimum CBR (%) for lime or liquid ionic stabilised materials	80	60	45	30
After stabilisation:				
Minimum UCS (MPa) BS 1924: Part 2 ***1)***	1.5	1.0	0.7	0.5
Before stabilisation:				
Soaked CBR (%) at 95% MDD of BS-Heavy, BS 1377: Part 4	Minimum 30	Minimum 20	Minimum 20	(no requirement)
Plasticity index (%), BS 1377: Part 2 ***2)***	Maximum 20	Maximum 25	Maximum 25	Maximum 35
Aggregate strength TFV_{dry} , BS 812: Part 111	Minimum 50 kN	(no requirement)	(no requirement)	(no requirement)
Grading modulus (GM), BS 1377: Part 2	Minimum 1.5	Minimum 1.2	Minimum 1.0	(no requirement)
Organic content BS 1377: Part 3	Maximum 0.5%	Maximum 1.0%	Maximum 1.0%	Maximum 2.0%
Sulphate (SO_3) content BS 1377: Part 3	Maximum 0.25%			
Max. particle size BS 1377: Part 2	1/2 of compacted layer thickness but not >50mm.			

1) The unconfined compression strength (UCS) shall be measured after 7 days airtight curing and 7 days soaking in water at 27 ± 2°C in accordance with BS 1924: Part 2. The compaction degree of the specimens shall be 97% MDD.

   For each source of material to be stabilised the unconfined compression strength (UCS) shall also be determined on specimens cured airtight for 14 days. The ration of UCS measured after 7 days curing and 7 days soaking and the UCS measured on specimen cured for 14 days shall not be less than 75%. A lower ratio might be a result of to high sulphate content.

2) It is emphasised that the Atterberg limits shall be measured according to BS 1377: Part 2. Other laboratory test procedures and equipment may not give comparable results and shall not be used unless proper correlation to BS has been carried out to the satisfaction of the Engineer.

3803 CONSTRUCTION

(a) Preparing the layer
The material to be stabilised shall be prepared and placed as specified in SECTIONS 3600 and 3700, and given at least one pass with a flatwheel roller. The material shall be damp.

(b) Applying and mixing in the stabilising agent
Mixing of gravel and soils with stabiliser and water in stationary or portable plant and laying with pavers shall be the preferred method. Where specified in the Special Specification this method shall be adhered to unless otherwise approved by the Engineer.

Where mixing on the road is employed the stabilising agent shall be spread uniformly over the full area of the prepared layer at the prescribed rate of application by means of an approved type of mechanical spreader in a continuous process, or it may be spread by other methods such as motor grader or by hand. Any equipment and method to be used shall be approved by the Engineer.

Immediately after the stabilising agent has been spread, it shall be mixed with the loose gravel for the full depth of treatment. Care shall be taken not to disturb the compacted layer underneath, nor to mix the stabilising agent in below the desired depth. Mixing shall be continued for as long as necessary and repeated as often as required to ensure a thorough, uniform and intimate mix of the soil or gravel and the stabilising agent over the full area and depth of the material to be treated and until the resulting mixture is homogeneous and of uniform appearance throughout.

Mixing shall be done by grader, disc harrow, rotary mixer or equivalent plant approved by the Engineer, working over the full area and depth of the layer to be stabilised by means of successive passes of the equipment.

(c) Watering
Immediately after the stabilising agent has been properly mixed with the soil or gravel, the moisture content of the mixture shall be determined, and the required amount of water shall be added.

Each application or addition of water shall be well mixed with the gravel or soil so as to avoid the concentration of water near the surface or the flow of water over the surface of the layer.

Particular care shall be taken to ensure satisfactory moisture distribution over the full depth, width and length of the section being stabilised and to prevent any portion of the work from getting excessively wet after the stabilising agent has been added. Any portion of the work that becomes too wet after the stabilising agent has been added and before the mixture has been compacted, will be rejected, and such portions shall be allowed to dry out to the required moisture content and shall then be scarified, re-stabilised, re-compacted and again finished off in accordance with the requirements specified herein, all at the expense of the Contractor. The water supply and watering equipment shall be adequate to ensure that all the water required will be added and mixed with the material being treated within a short enough period to enable compaction and finishing to be completed within the period specified in SUBCLAUSE 3803(g).

(d) Compaction

During compaction the layer shall be continuously bladed by motor grader, and loss of moisture by evaporation shall be corrected by further light applications of water.

During compaction of the stabilised layers, the Contractor shall lightly harrow or scarify the crust before final rolling if so required by the Engineer, in order to prevent the formation of laminations near the surface of the layer. Final rolling shall be done with equipment that will give a smooth surface finish which conforms to the surface tolerances specified. Low patches on the surface may not be filled after compaction. The minimum compaction requirements shall be as specified for the particular layer in the various SECTIONS of these Specifications.

A sufficient number of compacting units shall be employed on the work to ensure that, from the time the stabilising agent is first applied to the layer, the mixing process, watering, compacting, shaping and final finishing will be completed within the periods specified in SUBCLAUSE 3803(g).

(e) Finishing at junctions
Any finished portion of the stabilised layer adjacent to new work, which is used as a turn-round area by equipment in constructing the adjoining section, shall be provided with a protective cover of soil or gravel of at least 100 mm thick over a sufficient length to prevent damage to work already completed. When the adjoining section is being finally finished, such cover shall be removed to permit the making of a smooth vertical joint at the junction of the different sections. Material in the vicinity of the joint which cannot be processed satisfactorily with normal construction equipment shall be mixed and compacted by hand or with suitable hand-operated machines.

(f) Curing the stabilised work
The stabilised layer shall be protected against rapid drying-out for at least seven days following completion of the layer.

The methods of protection may be any one or more of the following:

(i) The stabilised layer shall be kept continuously wet or damp by watering at frequent intervals. This method will be permitted for up to a maximum period of 24 hours, but one of Methods (ii) or (iii) shall be applied as soon as the moisture content of the stabilised layer so permits. Work which is not kept continuously wet or damp but is subjected to consecutive wet-dry cycles, may be rejected by the Engineer should he/she consider the layer to have been adversely affected.

(ii) The stabilised layer shall be covered with the material required for the following layer while the stabilised layer is still in a wet or damp condition. The material forming the protective layer shall be watered at such intervals as may be required to keep the stabilised layer continuously wet or damp, and in dry weather this shall be done at least once in every 24 hours.

(iii) The stabilised layer shall be covered with a curing membrane consisting of a spray-grade emulsion or cutback bitumen applied at the rate specified or instructed by the Engineer. The provisions of Section 4100 shall apply with changes as required to the application of a curing membrane. Cutback bitumen may be used instead of bitumen emulsion if trials show no adverse effect to the stabilised layer, such as loosening of the surface, and the result is to the full satisfaction of the Engineer.

No additional payment will be made for curing as described above, except that the application of a curing membrane when specified or ordered by the Engineer shall be paid for separately under SECTION 4100.

(g) Construction limitations
For cemented layers, the stabilising agent shall be applied only to an area of such size that all processing, watering, compacting and finishing can be completed within the period given in TABLE 3803/1.

TABLE 3803/1
CONSTRUCTION LIMITATIONS

Stabilising agent and material class	Maximum time for completion after stabilising agent comes in contact with the material to be stabilised
Cement, C1.5, C1.0, C0.7 and CM	4 hours
Lime, C1.5, C1.0, and C0.7	8 hours
Lime, CM	48 hours

No stabilisation shall be applied when the moisture content of the material to be stabilised exceeds the optimum moisture content by more than 2% of the dry mass of material. No stabilisation shall be done when weather conditions may adversely affect the stabilising operations in the opinion of the Engineer. Excessive drying out or rain falling on the working area during the process of stabilisation may be sufficient cause for the Engineer to order any affected areas to be reconstructed at the Contractor's own cost.

No traffic or any equipment not actually used for processing the layer may be allowed to pass over the freshly spread stabilising agent. Only equipment required for curing or priming may be allowed over the treated layers during the specified curing period. Where water spraying equipment causes damage to the layer, the Contractor shall carry out watering by side-spraying tankers travelling off the stabilised layer or alternative methods employed to the satisfaction of the Engineer.

(h) Quality of materials and workmanship
The Contractor shall keep detailed records of the quantities of stabilising agent applied to the road and the volume of material stabilised, and shall make these records available to the Engineer. He/she shall also monitor the rate of application when using bulk spreading equipment, by taking a canvas patch or tray test every 200 metres or as required by the Engineer.

All spreader equipment shall be calibrated and approved by the Engineer before use on the road.

The requirements for testing compaction control shall be in accordance with SERIES 7000.

(i) Compaction requirements
The minimum required compacted density for pavement layers made of natural gravel shall comply with a lower specification limit of 97% of MDD BS-heavy compaction.

(j) Defective work or materials
Any material or work which does not comply with the requirements specified shall be removed and replaced with new materials or be repaired as specified to comply with the specified requirements if the Engineer permits.

3804 MECHANICAL MODIFICATION

The modification of soils and gravels, by the addition of a soil binder, hereinafter referred to as mechanical modification, shall consist of the addition of an approved soil binder to the material, in order to improve the load bearing capacity, plasticity index, grading and other proper-ties of material.

The material to be treated shall be prepared, broken down and spread to the required loose thickness all as specified in Section 3700. Thereafter an approved binder material shall be spread over the prepared material at the required rate and the materials shall be dry mixed by means of motor graders, ploughs and other suitable equipment, until the binder material is uniformly mixed with the material being treated. Thereafter the mixed materials shall be watered, mixed and compacted as described in Clause 3803."

3805 CONSTRUCTION TOLERANCES

Construction tolerances and testing shall be in accordance with SERIES 7000.

3806 MEASUREMENT AND PAYMENT

(a) General

The curing membrane, where required, shall be paid for under SECTION 4100. The stabiliser agent shall in all cases be paid for separately under ITEM 38.03. The process of stabilisation may be paid for in one of the two alternative ways given below, as specified in the Special Specifications and the Bill of Quantities:

- As an **extra-over** rate for admixture of the stabiliser and curing, where all costs for furnishing the natural gravel layer including compaction has been paid for already under SECTION 3600 or SECTION 3700 of these Specifications as relevant, or
- as a payment for **full cost** of providing the material to be stabilised, admixture of stabiliser, compaction and curing, however at separate payment for the stabiliser.

(b) Payment as an extra-over rate

ITEM	UNIT
38.01 CHEMICAL STABILISATION; EXTRA-OVER THE RELEVANT PAY ITEM FOR STABILISING MATERIALS ALREADY PAID FOR UNDER SECTION 3600 OR SECTION 3700	
(a) EARTHWORKS MATERIALS	CUBIC METRE (m^3)
(b) PAVEMENT MATERIALS	CUBIC METRE (m^3)

The unit of measurement shall be the cubic metre of stabilised material, the quantity of which shall be determined in accordance with the authorised dimensions of the layers treated as instructed by the Engineer.

The bid rates for chemical stabilisation under ITEM 38.01 shall be paid as an extra-over the rate bid for constructing the un-stabilised layers. The bid rate for chemical stabilisation shall therefore include full compensation for spreading and mixing the stabilising agent, curing the stabilised sections, any extra water required, and all supervision, labour, equipment, tools and incidentals (extra over those provided for in the rates bid for constructing the un-stabilised layer) necessary for completing the specified work, but excluding the cost of supplying the stabilising agent. No distinction shall be made in respect of the type of stabilising agent used or the time for curing.

(c) Payment as a full cost rate

ITEM	UNIT
38.02 CHEMICAL STABILISATION, PAYMENT FOR FULL COST OF PROVIDING:	
(a) STABILISED LAYER, MATERIAL CLASS C1.5	CUBIC METRE (m^3)
(b) STABILISED LAYER, MATERIAL CLASS C1.0	CUBIC METRE (m^3)
(c) STABILISED LAYER, MATERIAL CLASS C0.7	CUBIC METRE (m^3)
(d) STABILISED LAYER, MATERIAL CLASS CM	CUBIC METRE (m^3)

The unit of measurement shall be the cubic metre of stabilised material, the quantity of which shall be determined in accordance with the authorised dimensions of the layers provided and treated as instructed by the Engineer.

The bid rates for chemical stabilisation under ITEM 38.02 shall include full compensation for providing the material to be stabilised, breaking down, placing, spreading and mixing the stabilising agent, curing the stabilised sections, any extra water required, and all materials, supervision, labour, equipment, tools and incidentals compacting, testing the material including the protection and maintenance of the layer, but excluding the cost of supplying the stabilising agent

When payment for overhaul is allowed for in the Special Specifications and included in the Bill of Quantities, the rates shall include a free haulage distance as defined in SECTION 1600.

When payment for overhaul is not allowed for in the Bill of Quantities, the rates shall include for all transportation of the materials.

(d) Payment for the stabiliser agent

ITEM	UNIT
38.03 CHEMICAL STABILISER AGENTS:	
(a) ROAD LIME	TONNE (t)
(b) COMMON CEMENT	TONNE (t)
(c) BLAST-FURNACE CEMENT	TONNE (t)
(d) OTHER STABILISING AGENT (STATE TYPE)	TONNE (t)

The unit of measurement shall be the tonne of stabilising agent. When mixtures of slag and cement or lime are used, the quantity of each constituent shall be measured separately and not the mixture as a whole.

The quantity shall be determined in accordance with the authorised rate of application within the layer concerned.

The bid rates shall include full compensation for providing the stabilising agent at the Works irrespective of the rate of application specified or ordered by the Engineer. The rate for milled blast-furnace slag shall include full compensation for premixing the blast-furnace granulated slag with other stabilising agents in the required proportion.

SERIES 3000: EARTHWORKS AND PAVEMENT LAYERS OF GRAVEL OR CRUSHED STONE

SECTION 3900: CRUSHED AGGREGATE ROAD BASE

CONTENTS:

3901 SCOPE

This Section covers the procuring, furnishing and placing of approved crushed aggregate base course layers in accordance with the requirements of these Specifications.

This Section covers the requirements for the following types of material:

CRS crushed stone or quarried rock compacted to a percentage of the maximum dry density of the material at BS-Heavy compaction, with normal requirements for workmanship during construction

CRR crushed, fresh, quarried rock compacted to a percentage of the maximum dry density of the material at BS-Heavy compaction, with enhanced requirements for workmanship during construction

3902 MATERIALS

(a) Source of material, crushing and screening

(i) General
The aggregate used for crushed aggregate course shall contain no contamination or deleterious material such as decomposed rock, clay or shale. The Contractor shall take all necessary measures to prevent segregation of the material, including watering during crushing and screening and any other measures required in the opinion of the Engineer.

(ii) CRS class of crushed aggregate
Crushed aggregate class CRS shall be made of hard, durable and un-weathered fragments made by the crushing of stones, boulders, oversize from borrow pits or quarried rock. Minimum 50% by mass of particles larger than 5 mm shall have at least one fractured face. Maximum 30% by mass of material passing 5 mm can be approved soil fines.

(iii) CRR class of crushed aggregate
Crushed aggregate class CRR shall be made of hard, durable and un-weathered fragments made by the crushing of fresh quarried rock or boulders of minimum 0.3 m diameter. Single stage crushing shall not be allowed and all particles shall be crushed, no soil fines is allowed. If the multi-stage crushing do not directly and continuously provide materials complying with the grading requirements specified in TABLE 3902/2 the crushed material shall be screened into a sufficient number of fractions and reconstituted and mixed thoroughly in a pug mill or by other suitable means to ensure compliance with the grading requirements.

(b) Soluble salts
The Contractor shall discard the material or fulfil all requirements for appropriate construction techniques and timing of operations to the satisfaction of the Engineer if assessments of soluble salt contents in base course materials show deleterious values. Such assessments are only required where the pavement is going to receive a bituminous seal as the only surfacing. No additional payment will be made for any measures taken, or for any alterations of the material utilisation, due to presence of soluble salts in materials or construction water.

(c) Material requirements – class CRS
Materials for base course layers of material class CRS crushed aggregate as specified on the Drawings shall meet the requirements given in TABLE 3902/1.

(d) Material requirements – class CRR
Materials for base course layers of material class CRR crushed aggregate as specified on the Drawings shall meet the requirements given in TABLE 3902/2.

3903 CONSTRUCTION

(a) Preparation of the subbase
No base course shall be placed until approval is obtained from the Engineer and the subbase is placed, compacted and finished in accordance with the Specifications and is tested and found acceptable to the full satisfaction of the Engineer. Before placing the base course, the subbase shall be inspected and proof rolled as required by the Engineer in order to establish whether there is any damage, wet spots or other defects. Any such defect shall be rectified to the satisfaction of the Engineer before the next layer is placed. Pre-tipping of material prior to subbase processing shall be over a maximum distance of 300m.

(b) Shoulders
Bitumen surfaced shoulders made with the same base course material as the carriageway shall be the preferred method for construction of shoulders. Where the shoulders are nevertheless to be constructed with a different material than the carriageway, or where any other obstruction such as kerbstones could impair drainage of the base course, all work shall be so constructed that the base course will be adequately drained at all times during and after construction by means of sufficient drainage pipes through the obstructions or by the use of freely draining materials passing through shoulders. The Contractor shall not start constructing the base course of any part of the road before he/she has ensured sufficient drainage through the shoulders to the satisfaction of the Engineer.

(c) Spreading and mixing
Crushed aggregate complying with the requirements specified above shall be placed in quantities sufficient to ensure that the completed layer will comply with all the requirements in regard to layer thickness, level, cross-section and density. Segregation of the aggregate during spreading shall be prevented by appropriate choice of working method to the satisfaction of the Engineer. Allowance shall be made for sufficient extra material to enable the layer to be properly trimmed.

The maximum compacted thickness of any layer of crushed aggregate base course compacted in one process shall be 200 mm, unless otherwise specified or permitted by the Engineer.
The dumps of material shall be spread out to a flat-surfaced layer with a thickness that will be suitable for

mixing. The required quantity of water shall then be added and the material mixed until a homogeneous mixture is obtained.

CRR crushed aggregate base material shall, unless otherwise specified in the Special Specifications, be laid by an approved type of self-propelled mechanical spreader and finisher capable of laying to the required widths, thicknesses, profile, camber or cross-fall, without causing segregation, dragging or other defects.

TABLE 3902/1
REQUIREMENTS FOR CLASS CRS CRUSHED AGGREGATE BASE COURSE

Material properties	**Material class: CRS**	
Atterberg limits: ***1)***		
Max Plasticity Index BS 1377: Part 2	6	
Max Linear Shrinkage BS 1377: Part 2	4	
Grading: BS 1377: Part 2		
Sieve size (mm)	Grading limits - CRS (% passing sieve) **2)**	
	Coarse type	Fine type
50	100	
37.5	90-100	100
28	75-95	90-100
20	60-90	65-95
10	40-75	40-70
5	29-65	29-52
2	20-45	20-40
1.18	17-40	15-33
0.425	12-31	10-24
0.075	5-12	4-12
Particle strength and shape:		
Minimum TFV_{dry} BS 812: Part 111	110 kN	
Ratio dry to soaked value of TFV BS 812: Part 111	TFV_{soaked} shall be minimum 60% of the corresponding TFV_{dry} value	
Maximum flakiness index BS 812: Part 105	35%	

1) It is emphasised that the Atterberg limits shall be measured according to BS 1377: Part 2. Other laboratory test procedures and equipment may not give comparable results and shall not be used unless proper correlation to BS has been carried out to the satisfaction of the Engineer.

2) The base course material on the road after final compaction shall comply with above grading limits.

(d) Compaction

(i) General
After mixing, the crushed aggregate material shall be placed to the correct thickness and level and thoroughly compacted by suitable equipment so that the specified density is obtained throughout the entire layer.
The finally compacted layer shall be free from surface laminations, portions exhibiting segregation of the fine and coarse aggregate, corrugations, or other defects that may adversely affect the performance of the layer.

(ii) Compaction requirements
The minimum required compacted density for pavement layers made of crushed aggregate shall be as given in TABLE 3903/1. The Contractor's attention is drawn to the high density requirements for class CRR materials and the required high standards of workmanship necessary to achieve these on site.

TABLE 3903/1
COMPACTION REQUIREMENTS FOR BASE COURSE OF CRUSHED AGGREGATE

Material class specified	**Minimum dry density, lower specification limit, BS 1377: Part 4**
CRS	98% of BS-Heavy
CRR	102% of BS-Heavy

The Engineer may, if so specified in the Special Specifications, allow that nuclear method in accordance with SUBCLAUSE 7114(c) is used for control of density and moisture content.

Compaction method specifications shall not be used for compaction control of crushed aggregate base course.

(iii) Processing of class CRR materials
Class CRR shall be slushed as described herein to achieve the required field density. After completion of the compaction described above, short sections of the surface shall be thoroughly watered, rolled and slushed by means of steel-wheeled rollers with a mass of not less than 12 tonnes each, or with pneumatic-tyre rollers. The process shall continue until all excess fines are brought to the surface. The grout thus formed shall be uniformly broomed over the surface with stiff brooms to correct any areas still deficient in fines. Thereupon the excess fines shall be broomed from the surface of the layer. This process shall continue until all excess fines in the mixture have been brought to the surface of the layer and its specified density has been reached. Excess fines and loose aggregate shall then be swept from the surface while the surface is still damp. The layer shall then receive final rolling with pneumatic-tyre rollers and the layer shall then be allowed to dry out. During slushing operations, care shall be taken not to roll the surface out of shape.
The slushing process shall be carried out on each section in one continuous process, and each

section shall be completed before the next is proceeded on.

The completed layer shall be firm and stable with a closely-knit surface of aggregate exposed in mosaic and free from nests of segregated material, laminations or corrugations.

Excess crushed aggregate shall not be spread over the shoulders or side fills, but shall be loaded and removed from the road. It shall not be re-used unless it has been re-screened, re-tested and again approved for use. It shall not be mixed with approved material unless screened, tested and again approved for use on its own.

TABLE 3902/2
REQUIREMENTS FOR CLASS CRR CRUSHED AGGREGATE BASE COURSE

Material properties	**Material class: CRR**	
Atterberg limits: ***1)***		
Max Plasticity Index BS 1377: Part 2	Non-plastic	
Max Linear Shrinkage BS 1377: Part 2	3	
Grading: BS 1377: Part 2		
Sieve size (mm)	Grading limits - CRR (% passing sieve) **2)**	
	Coarse type	Fine type
37.5	100	
28	87-97	100
20	75-90	87-97
10	52-68	62-77
5	38-55	44-62
2	23-40	27-45
1.18	18-33	22-38
0.425	11-24	13-27
0.075	4-12	5-12
Particle strength and shape		
Minimum TFV_{dry} BS 812 :Part 111	110 kN	
Ratio dry to soaked value of TFV BS 812 :Part 111	TFV_{soaked} shall be minimum 75% of the corresponding TFV_{dry} value	
Maximum flakiness index BS 812: Part 105	35%	

1) It is emphasised that the Atterberg limits shall be measured according to BS 1377: Part 2. Other laboratory test procedures and equipment may not give comparable results and shall not be used unless proper correlation to BS has been carried out to the satisfaction of the Engineer.

2) The base course material on the road after final compaction shall comply with above grading limits.

3904 PROTECTION AND MAINTENANCE

The Contractor shall protect and maintain the completed layer at his/her own expense until the surfacing is applied. Maintenance shall include the immediate repair of any damage to or defects in the layer and shall be repeated as often as is necessary. Repairs shall be so made as to ensure an even and uniform surface to be restored after completion of the repair work. Traffic shall not be allowed directly on any un-primed crushed aggregate layer unless so authorised or directed by the Engineer.

3905 CONSTRUCTION TOLERANCES AND TESTING

The completed crushed aggregate layer shall comply with construction tolerances and testing requirements specified in SERIES 7000.

3906 MEASUREMENT AND PAYMENT

ITEM	UNIT
39.01 CRUSHED AGGREGATE FOR ROAD BASE	
(a) CRUSHED AGGREGATE CLASS CRS	CUBIC METRE (m^3)
(b) CRUSHED AGGREGATE CLASS CRR	CUBIC METRE (m^3)

The quantity of crushed aggregate shall be the number of cubic metres completed in place compacted to the depths and widths shown on the Drawings or as directed. The quantity shall be measured by the cross-section area shown on the construction drawings times the station length.

The bid rates shall include full compensation for procuring, placing, compacting, slushing as required and testing the material including the protection and maintenance of the layer, all as specified.

The bid rate shall also include full compensation for the provision and erection of the crusher ready for crushing, its later dismantling and removal after completion of the crushing operations, and the work involved in opening the quarry, including clearing, establishing a working face, and finishing-off the quarry area upon completion of the operations.

The rates shall include for all transportation of the material, no overhaul will be paid.

SERIES 4000

BITUMINOUS LAYERS AND SEALS

CONTENTS OF THE GENERAL SPECIFICATIONS:

SERIES 4000: BITUMINOUS LAYERS AND SEALS

SECTION 4100: PRIME AND CURING MEMBRANES

CONTENTS:

4101 SCOPE

This Section covers the application of a bituminous prime to a prepared pavement layer. This Section also covers the application of a bituminous curing membrane to a prepared pavement layer made of a cemented material.

4102 MATERIALS

(a) Material for priming

The priming material shall be one of the following as specified or directed by the Engineer, complying with the given relevant material specification or equivalent standards approved by the Engineer:

- MC-30 cutback bitumen complying with BS EN 12591:2000
- MC-70 cutback bitumen complying with BS EN 12591:2000
- Bitumen emulsion complying with BS 434 or SABS 308.

(b) Aggregate for blinding

The aggregate used for blinding the primed surface shall consist of crushed rock or river sand, with 100% passing the 6.3 mm sieve and should not have more than 10% passing the 2.36 mm sieve. The aggregate shall be clean and shall contain no clay, loam or other deleterious matter and shall have no excessive contents of fines in the opinion of the Engineer.

(c) Material for curing membranes

Curing membranes for cemented pavement layers shall be made of bitumen emulsion or as specified or directed by the Engineer.

Bitumen emulsion shall comply with the relevant requirements of BS 434, SABS 309 or equivalent standards approved by the Engineer.

4103 EQUIPMENT

(a) General

The following equipment shall be available and in good working order:

- Self propelled bitumen distributor and hand spray equipment.
- Water sprinkler. The water sprinkler shall have efficient spray equipment, capable of spraying a uniform film of water over the whole area to be primed.
- Rotary broom. The rotary broom shall be self-propelled or supplied together with a suitable pneumatic tyred towing vehicle.
- Other equipment such as compressors, hand brooms, reinforced paper for joints, string, nails and all other ancillary equipment as required to carry out the operation efficiently and neatly.

(b) Equipment for storage and heating bituminous materials

Tanks for the storage of bituminous material shall be equipped to heat and hold the material at the required temperatures. The circulating system for the bituminous material shall be designed to ensure proper and continuous circulation during the operating period. Storage tanks shall have sufficient capacity to provide for continuous operation.

Provision shall be made for measuring and sampling from the storage tanks. All heating or storage tanks shall be fitted with working thermometers. The storage tanks shall be calibrated and equipped with a device whereby the Engineer may determine the amount of bituminous material on hand at any time.

The equipment for heating bituminous materials shall be of adequate capacity to heat the material properly by circulating steam or hot oil through the coils and/or the jacket of a tank or by circulating the bituminous material around a system of heated coils or pipes or other approved means.

The heating device shall be so constructed that it will prevent the direct flame from a burner from striking the surface of the coils, pipes, or jacket through which the bituminous material is circulated. The heating device shall be operated in a manner that will not injure the bituminous material. The use of any equipment for the agitation of bituminous material to aid in heating will be prohibited if it injures or in any way changes the characteristics of the bituminous material or introduces free steam or moisture into the tank containing the bituminous material.

(c) Bitumen distributors

(i) General

The distributor vehicle shall be a self-propelled vehicle mounted distributor of nominal tank capacity not less than 2,000 nor more than 20,000 litres, equipped with a spray bar with a width of not less than 3.5 metres, nor more than 6.0 metres.

The spray rate of the bitumen must be controlled by one of the following methods:

Type A: Controlling the pressure constant in the spray bar and precisely controlling the speed of the vehicle.

Type B: Using a metering bitumen pump, precisely controlling the speed of the pump to give constant output, and precisely controlling the speed of the vehicle.

Type C: Using a metering bitumen pump driven at a speed proportional to the road speed of the vehicle, the vehicle being controlled to within 5% of a predetermined speed.

The exhausts of all motors on the vehicle shall be directed so that fumes do not reach driver or operator and there is no danger of sparks from the exhausts coming into contact with fumes or materials coming from the overflow pipe or any other inflammable material.

Self propelled distributors shall have sufficient engine torque to maintain the steady speeds required for any application rate between 0.4 and 2.7 litres per square metre on an ascending grade of 10% when fully laden.

Self-propelled distributors shall be equipped with a guide arm with suitable pointer and chain, to assist the sprayer driver in following the correct line. The guide arm shall be mounted on driver's side of the vehicle, forward of, and in full view of the driver, and shall be marked and numbered relative to the spray bar nozzles.

(ii) Distributor Tanks

(1) Construction
The tank shall be structurally sound, securely attached to and positively located on the distributor vehicle. No part of the tank or its fittings shall leak when filled with hot bitumen.

(2) Insulation
The tank shall be covered with suitable non-combustible insulation of adequate thickness. The insulating material shall be firmly secured so that it does not move in use and protected by a strong waterproof sheathing.

(3) Circulatory System
A system capable of circulating and thoroughly mixing the contents over the full length of the sprayer tank shall be provided.

(4) Dipstick
The tank shall be provided with a dipstick of rigid construction. It must be mounted in the centre of the tank, must hang from a 'T' piece so that wear can be detected and must not touch the bottom of the tank. A guide shall be provided to hold the dipstick in a vertical position as it is withdrawn and surging of bituminous material as the dipstick is lowered. The dipstick shall be graduated in litres, in increments not more than 50 litres. Where the spacing between any two markings is less than 10 mm, an alternative method of indicating the load quantity shall be provided.

The dipstick shall be marked at the level below which heating equipment shall not be used; this level shall be at least 150 mm above the highest part of the heating tubes or elements.

(iii) Heating Equipment
The distributor shall be provided with heating tubes and burners capable of maintaining the material in the tank at a steady temperature of up to 190°C, and also of raising it from 135°C to 175°C in not more than 4 hours when the ambient temperature is 15°C to 20°C and the tank is fully loaded. The heating tubes shall have a slight upward slope away from the burners. No part of the tubes or their flues shall pass through the vapour space above the bituminous material. Flue outlets shall be fitted with spark arresters. The burners and their controls shall be so arranged as to avoid the necessity for the operator to be directly behind the heating tubes when operating the burners.

A legible red warning sign shall be attached near the burners bearing the wording:

"This burner equipment must not be operated while the vehicle is loading or unloading or is in transit or when the level of bitumen in the tank is below the warning mark on the dipstick".

Alternative methods of heating the bituminous material, with or without heating tubes, may be applied on approval of the Engineer, provided the above levels of performance are achieved.

(iv) Thermometers
The tank shall be fitted with a thermometer located so as to accurately indicate the temperature of the material as it is sprayed. A second thermometer shall be fitted as close as possible to the heating line, near the other end of the tank. The thermometers shall be of dial type, located so that they can be read conveniently without parallax error. The thermometer dials shall read in increments of not more than 5°C and shall include a range of at least 70°C to 200°C over a scale distance based on 0-200°C of at least 150 mm. The thermometer assemblies shall be readily removable for checking and shall be accurate to within $\pm$5°C.

(v) Speed Control
Distributors shall be fitted with a dial type road speed indicator. The speed indicator shall be positioned near the driver's line of sight to the guide arm. The dial indicator shall be mounted so that it can be read without parallax error by the driver of the distributor.

The speed indicator shall comply with the requirements for an Industrial class 1.5 tachometer to BS 3403:1972. The indicator scale shall be calibrated in suitable metric units, marked in increments corresponding to a change in speed of not more than 5%, with not less than 3 mm spacing between such markings. The road speed indicator shall be operated from a separate retractable wheel attached to the distributor. The tyre of the wheel shall be at least 300 mm diameter and constructed of either solid rubber or permanently inflated rubber.

For Type C distributors a revolution counter or speedometer operated by the transmission may be substituted, provided that the mounting and accuracy of the instrument comply with this clause.

(vi) Pumping system

(1) General Requirements
The pumping system, comprising the pump and its associated valves and pipe network, shall be capable of the following operations:

- Loading and unloading bituminous materials: It shall be possible to empty the tank by either the distributor's own pump or by gravity flow.
- Mixing bituminous materials in the tank by circulation:

The circulation pipe inside the tank shall have suitably designed orifices so that the flow of bituminous material into each baffled compartment is proportional to the volume of the compartment divided by the total volume of the tank.

The pump shall have sufficient capacity when operating on the tank circulate mode to show turbulent mixing in each baffled compartment. The mixing efficiency shall initially be assessed by observation through the manhole when the tank is at least 30% full.

(2) Pump output
The pump outlet shall have a steady non-pulsating discharge. Where flat fan type spray nozzles are used, the design and operating procedures of the distributor shall be such that, when the spray bar is used to apply any application rate on spray width within the limits

specified the total spray output shall meet the following requirements, without recourse to pump system adjustments while spraying.

Type (A) and Type (B) distributors shall be operated so that the mean spray output per nozzle for any width of spray shall not differ by more than 5 percent from the optimal value recommended by the distributor manufacturer.

Type (C) distributors shall be operated in accordance with a spraying table that defines the vehicle speeds for all application rates and the pump speeds for all bar widths which correspond to the optimal output per spray nozzle recommended by the manufacturer.

For type (B) and type (C) distributors, the total pump outputs shall be delivered through the spray nozzles, for all spray widths.

For all distributors, spraying any particular spray width in the operating range, the pump output measured over any 60 second period shall not vary by more than $\pm$2.5% from the mean output over three such 60 second periods spraying the same width, where the controls are moved and then reset and the level of binder in the tank is varied between each measurement.

(3) Pump Drive
The binder pump drive shall be capable of driving the pump without appreciable pulsation or vibration. Where a separate engine drives the pump, the engine shall be capable of controlling the spray pump shaft revolutions within $\pm$2.5% of the predetermined spraying speed within the full operating range.

In the case of type (C) distributors (single engine for propulsion and spraying), the transmission between the engine and the pump shall be capable of being adjusted to different ratios.

(4) Strainers
A strainer must be provided in the pump suction line and/or the pump output line. It must be easily removable for cleaning and designed so that all the bitumen flow will pass through it. The maximum mesh orifice size shall be not greater than 3 mm and the total area of the orifices shall not be less than seven times the cross sectional area of the pipe in which the strainer is fitted.

(5) By-pass and relief valves
Where a by-pass valve is used for controlling the pressure and the discharge from the sprayer, it shall be capable of smoothly and uniformly varying the quantity of material by-passed in order to maintain the required pressure in the spray bar. It shall be capable of by-passing not less than 25% of the maximum output of the pump.

Means shall be provided to prevent excessively high pressures, due to blockages or other causes, from damaging the pumping system. Where relief valves are used, they shall be set to a pressure not less than 80% more than the recommended spraying pressure. Provision shall be made for checking the operating pressure of these valves.

(vii) Spraying equipment

(1) Pump Revolution Counter
A revolution per minute counter of an approved type shall be fitted to show the speed of the pump shaft. The instrument shall be calibrated in revolutions per minute and marked at intervals of not more than 5% of the full operating range which shall occupy a scale distance of not less than 150 mm. The instrument shall comply with the requirements for an Industrial Class 1.5 tachometer to BS 3403:1972.

(2) Pressure Gauge
A pressure gauge complying with BS EN 837:1998 'Bourdon Tube Pressure and Vacuum Gauges Part 2 Metric Units' shall be fitted.

Type (A) distributors (constant pressure type) shall be fitted with an Industrial Class I gauge of not less than 100 mm nominal size.

All other types of distributors shall be fitted with an Industrial Class I or II gauge of not less than 100 mm nominal size.

The gauge shall be fitted so as to measure the pressure in the spray bar and shall be mounted so that it is protected from heat and vibration in accordance with BS 837-1:1998.

(3) Spray bar

- Length:
The length of the spray bar, defined as the distance between centres of the two extreme end nozzles, shall comply with the requirements of SUBCLAUSE 4103(c) (I).

- Circulation and Check Valves:
The bar shall be of the fully circulating type, in which the bituminous material is pumped from the tank through the full length of the spray bar in use, and returned to the tank while the valves controlling the individual spray nozzles are closed. The spray nozzles in the bar shall be controlled by a linkage or other means which shall open or close the check valves of all nozzles equally, simultaneously, and fully, and which shall be capable of being operated by an operator positioned at the rear of the vehicle with a clear view of all parts of the spray bar. A check valve shall be provided for each nozzle for at least the 10 nozzles nearest one end of the spray bar. For the remainder of the bar, two spray nozzles may be controlled by a single check valve if desired. Each check valve shall be readily disconnected from the master control and operated independently.

- Extensions and Transverse Slew:
Spray bars fitted to self propelled distributors shall be fitted with readily removable or foldable extension sections to enable the bar to be reduced to less than 2.5 m and shall be capable of spraying when shortened. These bars shall also be capable of being moved at least 400 mm transversely while spraying, such movement being readily controlled by an operator at the rear of the vehicle. Operation of the transverse movement control shall not cause any associated rotating movements of the bar. Any associated vertical movements shall be less than $\pm$5 mm.

The spray bar shall be mounted on the sprayer in such a manner that the nozzle tips are maintained within plus and minus 10% of

the optimum height recommended by the distributor manufacturer irrespective of the loading of the sprayer. The maximum height of the bar shall in no case exceed 325 mm.

Hinged extensions and bar height adjustments shall incorporate positive stops and locks, non positive adjustment means such as chains, cables or pneumatic or hydraulic rams shall not be deemed sufficient.

(4) Spray Nozzles

- General
  Spray nozzles shall be of the flat fan (slot) type and apart from any approved special end nozzles shall be of similar construction and interchangeable. Nozzles shall be mounted with their flow axes vertical and so that all nozzle tips are within 3 mm of a straight line parallel with the rear axle of the vehicle. The nozzles shall be spaced at intervals of not more than 110 mm and no spacing shall vary more than $\pm$1.5 mm from the mean spacing. All nozzles except end nozzles must be mounted with the slots in the nozzles at the same horizontal angle. At least 1 spare nozzle shall be carried for every 5 mounted on the spray bar.

  The construction and mounting of the sprayer shall be such that all nozzles are positively and rigidly set and maintained. Plain screwed connections must not be used unless supplemented by some positive locking device, mark or approved adjustment tool or gauge to ensure that the correct alignment is maintained.

- End Nozzles:
  An end nozzle or other approved means shall be provided to reduce the cut off spray taper at the road shoulder edge of the spray bar to comply with SUBCLAUSE 4103(b) (viii). Where used, three such end nozzles (1 spare, 2 on the spray bar) shall be carried on the distributor.

(5) Hand spray equipment
Approved hand spray equipment shall be provided. This equipment shall be suitable for operation at a pressure of 6.0 bar but must be capable of withstanding a minimum test pressure of 20 bar and a temperature of 205°C.

(viii) Performance requirements

(1) Definitions

- *SPRAYED WIDTH:*
  The sprayed width of spray shall be the whole width of the spray.
- *EFFECTIVE WIDTH:*
  The effective width of spray shall be the sprayed width less the permitted spray taper widths specified below.
- *SPRAY TAPER WIDTH:*
  The spray taper width shall be the portion of spray fan width, at either edge of the sprayed width that is overlapped by a lower number of spray fans than an equivalent sprayed width within the effective width.
- *END NOZZLE TAPER:*
  The spray taper width shall be deemed to be 150 mm when an end nozzle or an approved equivalent is used.
- *END TAPER WITHOUT AN END NOZZLE:*
  The spray taper width shall be deeded to be 200 mm when an end nozzle or an approved equivalent is not used.

(2) Rate of Application
Distributors shall be capable of applying bituminous material evenly and uniformly to the road surface at any required temperature not exceeding 190°C and at any rate of application required in the range 0.4 to 2.7 litres per square metre.

The distributor shall be capable of achieving these spray rates at vehicle speeds not exceeding 25 km/hr.

(3) Transverse distribution

- Within the range of application rates stated above, transverse uniformity requirements, specified in terms of the amounts of bituminous binder applied to successive 50 mm widths, are as follows:
- The amount of bituminous material sprayed on to any width of 50 mm within the effective width shall not differ by more than 20% from the average application over the effective width.
- The mean amount of bituminous material sprayed on to any four adjacent widths of 50mm shall not differ by more than 12% from the average application over the effective width.
- The effective width shall be divided into three approximately equal sections. The mean amount of bituminous material per 50 mm width sprayed on any one section shall not vary by more than five percent from that on any other section.
- *End Nozzle TAPER:*
  The amount of bituminous binder sprayed onto any 50 mm width within the end nozzle taper shall be less than 120% of the average application over the effective width. In addition the mean amount of bituminous material sprayed onto the 3 adjacent 50 mm widths immediately outside the effective width shall be greater than 50% of the average application over the effective width.
- *END TAPER WITHOUT AN END NOZZLE:*
  The mean amount of bituminous material sprayed onto the four adjacent 50 mm widths within this taper shall be between 40% and 60% of the average application over the effective width. In addition the amount of bituminous material on each 50 mm width, within the taper, shall be less than the amount on the adjacent 50 mm width that is closer to the effective width.

(4) Longitudinal Distribution
Within the range of application rates stated above, longitudinal uniformity requirements specified in terms of the amounts of bituminous binder applied to 50 mm lengths are as follows:

- The effective length shall be the full sprayed length less 500 mm from each end.
- The full intensity of spray application shall be reached or cut-off within a length of travel of the sprayer not exceeding 500 mm.
- The amount of binder sprayed onto any length of 50 mm within the effective length shall not differ by more than 10% from the average binder application over the effective length.

(5) Uniformity of spray
In the case of self propelled distributors, the application rates and uniformity requirements specified above shall be met when any set of six or more adjacent nozzles are operated up to and including the full bar width.

(6) Calibration and check of distributors
All distributors shall be calibrated and checked to demonstrate compliance with this specification before being used on the Work. The calibration testing of the distributor will be done by the Contractor in the presence of the Engineer by the method prescribed by the manufacturer and/or as directed by the Engineer.

When the test results confirm compliance of the Equipment with this Specification the Contractor shall submit a written record of the calibration testing to the Engineer for approval.

A certificate of approval will be given to the distributor operator by the Engineer, showing the record of the calibration and check. This certificate shall be kept in the distributor at all times and shall be available to the Engineer or Inspector in charge on each location on which the distributor is used. This certificate may be revoked at any time due to unsatisfactory performance of the distributor and will be returned only when satisfactory repairs or adjustments have been made. Failure to present the certificate will necessitate a re-check and if deemed necessary, a re-calibration of the distributor before it can be used on the Works. The Contractor shall furnish at his/her own expense all necessary equipment, materials and assistance necessary for the calibration.

The operation of the distributor will be checked by the Engineer the first time it is used and as often as he/she deems it necessary thereafter, and when the operation is found to be satisfactory, a new certificate will be issued by the Engineer.

4104 WEATHER AND OTHER LIMITATIONS

(i) General
The Engineer's decision on whether or not to apply the curing membrane or prime coat under specific conditions shall be final.

(ii) Prime coat
No prime coat shall be applied under the following adverse conditions;
- during foggy or wet conditions;
- when rain is imminent;
- when wind is blowing sufficiently hard to cause uneven spraying;
- when the surface of the layer is visibly wet, i.e. more than damp;
- before sunrise;
- after sunset;
- when at any position the moisture content of the base layer is more than 50% of the optimum moisture content as determined by the Engineer
- when the layer is soft, i.e. sponging under load;

(iii) Curing membranes for cemented layers
No curing membrane shall be applied under the adverse conditions as decided by the Engineer.

Curing membranes shall be applied within the time limits given in the Special Specifications for the respective layer and type of cemented material.

4105 PREPARATION OF THE LAYER TO BE PRIMED OR TO RECEIVE A CURING MEMBRANE

Prior to prime coat application, the Contractor shall carry out the necessary field trials to allow the Engineer to check the methods of surface preparation and the performance of the pressure distributor and to establish the exact rate of application and the application temperatures of the bituminous material.

No longer than 24 hours before spraying, the layer to be sprayed with prime coat shall be cleaned by heavy mechanical brooming. The brooming shall clean the surface of dust and foreign matters and leave the coarse aggregate standing proud of the surface. The brooming shall be carried out in such a manner so that the surface is not damaged.

A light spray of water, sufficient to dampen the surface, shall be uniformly applied to the layer immediately before the application of the prime. If the water is over applied the layer shall be allowed to dry until a uniform damp surface is obtained.

Before any material is applied, the layer to be sprayed shall be checked by the Engineer for compliance with the surface and other requirements specified. Any sections not complying with the specified requirements shall be corrected as specified or directed by the Engineer.

4106 APPLICATION OF THE PRIME COAT OR CURING MEMBRANE

A minimum of 1.0 m of reinforced paper or other suitable approved material shall be used at all joints at the beginning and end of all sprays in order to obtain a neat start and cut-off.

The temperatures for storage and spraying shall be in accordance with TABLE 4106/1.

All cutback bitumen stored in a heated condition shall be stored in a container with a properly functioning circulation system and having a securely fitting lid.

The rate of application for tendering purposes may be assumed to be 1.0 l/m^2. The final rate of application shall be decided and agreed on by the Engineer after the Contractor has completed and documented trial sections.

TABLE 4106/1
TEMPERATURES FOR STORING AND SPRAYING PRIME OR CURING MEMBRANES

Type of prime or curing membrane	Maximum storage temperature (°C)		Spraying temperature range (°C)
	Up to 24 hrs	Over 24 hrs	
Cut-back bitumen:			
MC-30	65	40	45-60
MC-70	80	50	60-80
Bitumen emulsions (all types)	ambient	ambient	ambient above 10°C

The total width of the sprayed surface shall be as shown on the Drawings or as prescribed by the Engineer.

The bituminous material shall be applied in one or more lanes evenly over the full effective width and length and allowed to cure until traffic can pass over the surface without the wheels picking up the bituminous material. All traffic shall be kept off the surface until this condition is obtained.

Where no convenient detour is available for traffic, operation shall be confined to one half the roadway width at a time. The Contractor shall provide proper traffic control so that vehicles may proceed without damage to the primed area.

Where it is not feasible for traffic to use deviations, the bituminous material shall be applied and allowed to cure for as long as is practicable in the opinion of the Engineer before a blinding layer of aggregate is applied. Care shall be exercised in this operation to avoid the aggregate being applied too soon after spraying the bituminous material. Where practicable two to four hours shall elapse as directed by the Engineer. Any "caking" of aggregate which may take place and cause problems during the surfacing process and all loose aggregate shall be removed before the final surfacing is commenced.

The rate of application of blinding material shall be 0.0035 m^3/m^2 unless otherwise directed by the Engineer

If the bituminous material is applied in more than one strip, allowance shall be made for overlapping of strips by 100 mm. No additional payment will be made for the overlapping strips.

Care shall be taken to protect all kerbing and guttering, guard rails and channelling from the bituminous material by covering them with a suitable protective material when spraying. The Contractor shall, at his/her own cost, replace all soiled items, which cannot be properly cleaned. Painting the soiled surfaces will not be accepted as a suitable remedial measure.

4107 MAINTENANCE AND OPENING TO TRAFFIC

The Contractor shall maintain the prime coat until the next course is applied. Care shall be taken that the application of bituminous material is not in excess of the specified amounts; any excess shall be blotted.
All areas inaccessible to the distributor shall be sprayed manually using the device for hand spraying.

Where a blinding layer has been applied to the sprayed surface, the Contractor shall maintain the blinding layer and the sprayed surface during the period when the surface is opened to traffic, and shall repair all damage caused to the blinding layer or the sprayed surface by such traffic at no additional payment.

If it is desired to pass traffic for a period in order to reveal any weak spots in the pavement, the rate of application of prime coat may be increased as ordered by the Engineer and the treated areas shall be blinded with rock crusher dust or coarse sand at the approximate rate of 0.004 m^3/m^2.

The Contractor shall provide proper traffic control in order that vehicles may pass without damage to the primed area. The Contractor shall ensure that the primed surface is not excessively damaged by weather or traffic prior to the application of the next layer. Major patching of the primed surface will not be acceptable, and damaged sections of the prime and base gravel shall be reworked and re-primed at the Contractor's expense.

The primed surface shall be inspected and repaired if necessary prior to the next layer being placed if the surface has been opened to traffic.

4108 TOLERANCES

The actual spray rates measured at spraying temperature shall not deviate from the required spray rate as specified or agreed by the Engineer by more than 0.03 l/m^2. The average spray rate, calculated over any area of the work determined by the Engineer, shall not be less than the required spray rate.

The rate of application for the bituminous material shall be checked by weighing test trays before and after application.

The sprayed surface shall nowhere be narrower than the specified width.

4109 TESTING

The Contractor shall give the Engineer at least 24 hours notice of his/her intention to apply prime or curing membranes so that the actual spray rates can be verified and approved by the Engineer.

Unless otherwise agreed in advance the Contractor shall only spray when the Engineer or his/her representative is present and approval of the Engineer has been obtained.

4110 MEASUREMENT AND PAYMENT

ITEM	UNIT
41.01 PRIME COAT:	
(a) MC-30 CUT-BACK BITUMEN	LITRE (l)
(b) MC-70 CUT-BACK BITUMEN	LITRE (l)
(c) BITUMEN EMULSION (STATE TYPE AND BITUMEN CONTENT)	LITRE (l)

ITEM	UNIT
41.02 BITUMINOUS CURING MEMBRANE:	
(a) MC-30 CUT-BACK BITUMEN	LITRE (l)
(b) MC-70 CUT-BACK BITUMEN	LITRE (l)
(c) BITUMEN EMULSION (STATE TYPE AND BITUMEN CONTENT)	LITRE (l)

The unit of measurement shall be the litre of bituminous material measured at spraying temperature and sprayed as specified at the rate of application specified or approved by the Engineer.

The area of bituminous prime coat or curing membrane application shall be measured by length along the centreline of the road multiplied by the width as shown on the plans or as directed by the Engineer.

The bid rates shall include full compensation for supplying the bituminous material, cleaning and watering the layer to be sprayed as required, applying the bituminous material and maintaining the sprayed surface as specified.

ITEM		UNIT
41.03	AGGREGATE FOR BLINDING:	CUBIC METRE (m^3)

The unit of measurement shall be the cubic metre of aggregate for blinding applied at the approved rate over the area of prime coat as instructed by the Engineer.

The bid rate shall include full compensation for procuring, furnishing and applying the aggregate for blinding where directed by the Engineer, and for maintenance of the blinding layer as specified.

SERIES 4000: BITUMINOUS LAYERS AND SEALS

SECTION 4200: BITUMINOUS BASE COURSE AND ASPHALT CONCRETE SURFACING

CONTENTS:

4201 SCOPE

This Section covers all the work in connection with the construction of bituminous base courses and asphalt concrete surfacing for new roads, pavement rehabilitation, widening or maintenance. It includes the procuring and furnishing of aggregate and bituminous binder, mixing at a central mixing equipment, alternatively on the road, spreading and compaction of the mixture, all as specified for the construction of:

- Continuously graded asphalt concrete surfacing (**AC20**, **AC14**, **AC10, and 19.0, 12.5, 9.5 Nominal mixes**).
- Hot mixed bituminous base course (**DBM40**, **DBM30**, and **37.5, 25.0 Nominal mixes**).
- Cold mixed bituminous base course (**FBMIX**, **BEMIX**).

This Section also covers the recycling of bituminous materials by reprocessing recovered materials, adding fresh aggregate, bituminous binders and other agents for obtaining a bituminous mix, which will comply with the specified requirements, and placing the recycled material. The provisions of SECTION 4200 shall apply throughout to recycled bituminous materials, except where explicitly specified otherwise.

4202 MATERIALS

(a) General

Coarse and fine aggregate shall be clean and free from decomposed materials, vegetable matter and other deleterious substances and shall meet all relevant requirements in the Specifications.

The coarse and fine aggregate shall be produced by crushing of rock obtained by blasting of hard solid rock formation. The crushing shall be by multi-stage equipment in order to produce aggregates of angular shape.

All materials shall be handled and stockpiled in a manner that will prevent contamination, segregation or damage. Stocks of cement and lime shall be rotated in a manner whereby it is used in the order in which it has been received.

The Contractor shall, as often as necessary, test and control the materials produced by himself/herself or the materials received by him/her from suppliers to ensure that the materials always comply with the specified requirements.

The Contractor will not be expected to construct layers of which the compacted layer thickness is less than one and a half times the maximum aggregate size.

(b) Bituminous binders

(i) General

The various bituminous binders specified shall comply with the relevant specifications as stated in TABLE 4202/1 or equivalent standards according to the Special Specifications and on the approval of the Engineer:

TABLE 4202/1
SPECIFICATIONS FOR BITUMINOUS BINDERS

Type of binder	Specification
Penetration grade bitumen	BS EN 12591: 2000
Performance Grade Asphalt	SP-1*)
Cutback bitumen	BS EN 12591: 2000
Bitumen emulsions, anionic	BS 434: 1984
Bitumen emulsions, cationic	BS 434: 1984
*) Appendix A, Performance Graded Asphalt Binder Specification and Testing, Superpave Series No.1 (SP-1) [Asphalt Institute]	

The Type and grade of bituminous binders to be employed for the specific project shall be described in the Special Specifications.

Representative test certificates showing all relevant properties of the adhesion agent and bitumen shall be submitted for approval of the Engineer.

Such certificates shall be submitted minimum 28 days prior to proposed use or as required by the Engineer to conduct further testing of the materials. Samples of the materials shall be submitted together with the test results if required by the Engineer. New test certificates and samples shall be provided for approval in the event of changes in type or source of adhesion agent, bitumen grade, crude oil source, refinery equipment or refinery method, or as deemed necessary by the Engineer.

(ii) Additional requirements for foamed bitumen

In addition to the general requirements stated in this SUBCLAUSE foamed bitumen shall meet the following requirements when tested using a 10 litre cylindrical bucket:

The ratio between the volume of the bitumen in a foamed state and in an un-foamed state shall be minimum 15.

At least one of the following requirements shall be met:

- The time from the foam is ejected into atmospheric pressure until the volume has decreased to half its maximum volume shall be minimum 15 seconds.
- The ratio between volume of bitumen in a foamed state and in an un-foamed state shall be minimum 7.5 after 15 seconds have elapsed since the foam was ejected into atmospheric pressure.

(iii) Pre-construction binder investigations
The Contractor shall immediately after signing of contract prepare pre-construction binder investigations, including:

1. Identification of a capable and independent bitumen testing laboratory for comparative testing of binders
2. Collection of samples of potential bitumen
3. Documentation of sample origin, including:
   - The refinery (name of owner(s) and full address)
   - Date, and time of sampling.
   - Point of sampling, (tank number, flow line valve, truck, drum, etc.)
   - Person responsible for sampling.
   - Production data:
     - Manufacturing method (direct vacuum distillation, propane precipitation, etc.)
     - Feed stock data
     - Batch ID No.
     - Composition of product (raw materials, additives, etc.)
     - Product characteristics (penetration, softening point, etc.)
     - Storage temperature

   The sample should be accompanied with a signed certificate from the manufacturer with the above-mentioned information and a declaration that the sample to be tested is representative of their production and that a corresponding product will be available to the project during the construction period.
4. Prepare a bitumen testing programme according to the present Specifications.
5. The Contractor shall test the bitumen samples in accordance with this Specification and send the results to the Engineer for his/her approval.

(c) Aggregates
The aggregates employed for all the asphaltic pavement layers when tested shall conform to the following requirements unless otherwise stated in the individual clauses:

(i) Cleanliness
The Sand Equivalent of the fine aggregate shall be minimum 45 when tested in accordance with AASTHO T176. The plasticity index when tested in accordance with BS 1377-2: 1990 shall be less than 4%.

(ii) Particle Shape
The flakiness index when tested in accordance with BS 812-105: 1989 shall be less than 25%.

(iv) Aggregate strength
The TFV of the coarse aggregate used in asphalt concrete surfacing, when determined in accordance with BS 812-111: 1990 or equivalent shall not be less than 110 kN. The wet/dry strength ratio shall not be less than 75%.

(v) Absorption
The water absorption of the coarse aggregate shall not exceed 2% by mass, when tested in accordance with BS 812-2: 1995 or equivalent,

(vi) Soundness
The sodium soundness when tested in accordance AASHTO T104 shall be less than 12%.

(vii) Coating and Stripping Test
The coating of the aggregates when tested in accordance AASHTO T182 shall be greater than 95%.

(d) Aggregates grading and bitumen content for Asphalt Concrete Surfacing Courses
The grading of the combined aggregate including any filler added in an approved working mix shall be within the limits stated in TABLES 4202/2 - 4202/5 for the respective mixes.

The approved grading shall be designated as the target grading. The mean grading of each lot of the working mix (minimum of 6 tests per lot) determined from samples obtained in a stratified random sampling procedure, shall conform to the approved target grading within the tolerances specified in CLAUSE 4213.

The type of bitumen shall be 60/70 or 40/50 penetration grade, or Performance Grade Asphalt as specified in the Special Specifications, or as directed by the Engineer.

The bitumen content given in the tables is for bidding purposes. Exact percentage to use shall be determined after the Engineer's approval of mix design and result of field trials and the bitumen content shall thereafter be within the acceptance limits specified in CLAUSE 7205.

TABLE 4202/2
GRADING LIMITS FOR COMBINED AGGREGATE AND NOMINAL MIX PROPORTIONS FOR ASPHALT CONCRETE SURFACING EMPLOYING MARSHALL MIX DESIGN.

Sieve size (mm)	Asphalt Concrete, continuously graded		
	AC20	AC14	AC10
28	100	-	-
20	80-100	100	-
14	60-80	85-100	100
10	50-70	72-94	85-100
5.0	36-56	52-72	55-72
2.36	28-44	37-55	38-57
1.18	20-34	26-41	27-42
0.600	15-27	16-28	18-32
0.300	10-20	12-20	13-23
0.150	5-13	8-15	9-16
0.075	2-6	4-10	4-10
Aggregate	95%	94.5%	94%
Bitumen content ASTM 2172-88	5%	5.5%	6%

TABLE 4202/3
GRADING LIMITS FOR COMBINED AGGREGATE FOR A 19 MM NOMINAL SIZED ASPHALT CONCRETE SURFACING EMPLOYING SUPERPAVE™ MIX DESIGN.

Sieve Size (mm)	19 mm Nominal Size			
	Control Points		Restricted Zone*)	
	Min	Max	Min	Max
25	100	-	-	-
19	90	100	-	-
12.5	-	90	-	-
9.5	-	-	-	-
4.75	-	-	-	-
2.36	23	49	34.6	34.6
1.18	-	-	22.3	28.3
0.600	-	-	16.7	20.7
0.300	-	-	13.7	13.7
0.075	2	8	-	-
*) The Restricted Zone forms a band through which the gradation may not pass.				
Bitumen content for bidding purposes: 5.0%				

TABLE 4202/4
GRADING LIMITS FOR COMBINED AGGREGATE FOR A 12.5 MM NOMINAL SIZED ASPHALT CONCRETE SURFACING EMPLOYING SUPERPAVE™ MIX DESIGN.

Sieve Size (mm)	12.5 mm Nominal Size			
	Control Points		Restricted Zone*)	
	Min	Max	Min	Max
25	-	-	-	-
19	100	-	-	-
12.5	90	100	-	-
9.5	-	90	-	-
4.75	-	-	-	-
2.36	28	58	39.1	39.1
1.18	-	-	25.6	31.6
0.600	-	-	19.1	23.1
0.300	-	-	15.5	15.5
0.075	2	10	-	-
*) The Restricted Zone forms a band through which the gradation may not pass.				
Bitumen content for bidding purposes: 5.5%				

TABLE 4202/5
GRADING LIMITS FOR COMBINED AGGREGATE FOR A 9.5 MM NOMINAL SIZED ASPHALT CONCRETE SURFACING EMPLOYING SUPERPAVE™ MIX DESIGN.

Sieve Size (mm)	9.5 mm Nominal Size			
	Control Points		Restricted Zone*)	
	Min	Max	Min	Max
25	-	-	-	-
19	-	-	-	-
12.5	100	-	-	-
9.5	90	100	-	-
4.75	-	90	-	-
2.36	32	67	47.2	47.2
1.18	-	-	31.6	37.6
0.600	-	-	23.5	27.5
0.300	-	-	18.7	18.7
0.075	2	10	-	-
*) The Restricted Zone forms a band through which the gradation may not pass.				
Bitumen content for bidding purposes: 6.0%				

(e) Requirements for hot mixed bituminous base and binder courses

The grading of the combined aggregate including any filler added in an approved working mix shall be within the limits stated in TABLES 4202/6 - 4202/8 for the respective mixes.

The approved grading shall be designated as the target grading. The mean grading of each lot of the working mix (minimum of 6 tests per lot) determined from samples obtained in a stratified random sampling procedure, shall conform to the approved target grading within the tolerances specified in CLAUSE 4213.

The type of bitumen shall be 60/70 or 40/50 penetration grade, or Performance Grade Asphalt as specified in the Special Specifications, or as directed by the Engineer.

The bitumen content given in the tables is for bidding purposes. Exact percentage to use shall be determined after the Engineer's approval of mix design and result of field trials and the bitumen content shall thereafter be within the acceptance limits specified in CLAUSE 7205.

TABLE 4202/6
GRADING LIMITS FOR DENSE BITUMEN MACADAM BASE COURSE EMPLOYING MARSHALL MIX DESIGN.

Sieve size (mm)	DBM40 (% passing)	DBM30 (% passing)
50	100	-
37.5	95-100	100
28	70-95	90-100
20	-	70-95
14	56-76	58-82
10	53-70	52-73
5.0	39-56	40-56
2.0	24-40	24-40
1.18	19-35	19-35
0.425	9-25	9-25
0.300	7-21	7-21
0.075	2-9	2-9
Bitumen content, *ASTM 2172-88*	4.0%	4.5%
Maximum compacted layer thickness (mm)	80-200	60-150

TABLE 4202/7
GRADING LIMITS FOR A 37.5 MM NOMINAL SIZED ASPHALTIC BASE COURSE EMPLOYING SUPERPAVE™ MIX DESIGN.

Sieve Size (mm)	37.5 mm Nominal Size			
	Control Points		Restricted Zone*)	
	Min	Max	Min	Max
50	100	-		
37.5	90	100		
25	-	90	-	-
19	-	-	-	-
12.5	-	-	-	-
9.5	-	-	-	-
4.75	-	-	34.7	34.7
2.36	15	41	23.3	27.3
1.18	-	-	15.5	21.5
0.600	-	-	11.7	15.7
0.300	-	-	10	10
0.075	0	6	-	-
*) The Restricted Zone forms a band trough which the gradation may not pass.				
Bitumen content for bidding purposes: 4.0%				

TABLE 4202/8
GRADING LIMITS FOR A 25 mm NOMINAL SIZED ASPHALTIC BINDER COURSE EMPLOYING SUPERPAVE™ MIX DESIGN.

Sieve Size (mm)	25 mm Nominal Size			
	Control Points		Restricted Zone*)	
	Min	Max	Min	Max
50	-	-		
37.5	*100*	-		
25	*90*	*100*	-	-
19	-	*90*	-	-
12.5	-	-	-	-
9.5	-	-	-	-
4.75	-	-	*39.5*	*39.5*
2.36	*19*	*45*	*26.8*	*30.8*
1.18	-	-	*18.1*	*24.1*
0.600	-	-	*13.6*	*17.6*
0.300	-	-	*11.4*	*11.4*
0.075	*1*	*7*	-	-
*) The Restricted Zone forms a band trough which the gradation may not pass.				
Bitumen content for bidding purposes: 4.5%				

(f) Aggregates and mix design requirements for cold mixed bituminous base course

(i) Definitions
The following definitions apply for cold mixed bituminous base course materials:
- *FOAMED BITUMEN:* Bituminous binder temporarily expanded as specified in this SPECIFICATION by the aid of appropriate techniques for introducing water into hot bitumen.
- *FBMIX*: Bituminous base course material made in accordance with this SPECIFICATION with approved foamed bitumen by mixing in an appropriate equipment or as specified in a cold process.
- *BEMIX*: Bituminous base course material made in accordance with this SPECIFICATION with approved bitumen emulsion by mixing in an appropriate equipment or as specified in a cold process.
- *BITUMEN CONTENT:* Percentage of residual bitumen by weight of total mix excluding water.
- *MOISTURE CONTENT:* Percentage of water by weight of dry aggregate including bitumen when bitumen is present.
- *MARSHALL DENSITY:* Density of Marshall specimens excluding water. Standard Marshall compaction with 75/75 blows is assumed unless alternative compaction methods giving similar densities are used on approval of the Engineer.

(ii) General
The aggregate shall be natural gravel, crushed material or approved material milled off existing pavement layers. Unless otherwise approved by the Engineer the material shall be placed in stockpile prior to mixing with bitumen.

All operations to produce, stockpile and lay bituminous base course and shall be carried out in a manner which ensures a homogeneous mixture with even distribution of additives, bitumen and water without segregation or contamination or excessive variations in moisture contents within the material. All aggregate shall be free from lumps, soft or unsound particles, clay or other deleterious material. The aggregates shall be free of organic matter and the flakiness index shall not exceed 35%.

Unless otherwise approved by the Engineer the aggregate shall be screened into a minimum of two fractions before use. Minimum one fraction shall be free of fines within a tolerance of maximum 5% passing the 2.0 mm sieve. The fractions shall be combined to achieve the required grading uniformly throughout the production of bituminous base. The mix design shall be based on laboratory tests of parallel sets of representative samples with a minimum of 5 different bitumen contents respectively. The mix design shall adequately show test results that can be expected on material produced within the tolerances given. The mix design shall give one moisture content and one bitumen content for the proposed mix recipe.

(iii) Aggregate strength
The TFV of the coarse aggregate used in cold mixed bituminous base course, when determined dry in accordance with BS 812-111: 1990 or equivalent, shall not be less than:
- 110 kN for Traffic Load greater than 1 x 10^6 esa's
- 80 kN for Traffic Load less than 1 x 10^6 esa's

The appropriate Traffic Load Class shall be as given in the drawings or Special Specifications. Where such information is not given, the decision of the Engineer shall apply. The wet strength shall not be less than 75% of the dry strength.

(iv) CBR soaked 4 days
When tested in accordance with BS 1377-4: 1990 or equivalent, the CBR value shall not be less than 30% before admixture of bitumen.

(v) Plasticity index
When tested in accordance with BS 1377-2: 1990 or equivalent, the plasticity index before admixture of bitumen shall not be more than:
- FBMIX material: 14%
- BEMIX material: 8%

(vi) Properties of mixed material
The grading of the combined aggregate including any filler added in an approved working mix shall be within the limits stated in TABLE 4202/9 for the respective mixes. The approved grading shall be designated as the target grading. The mean grading of each lot of the working mix (minimum of 6 tests per lot) determined from samples obtained in a stratified random sampling procedure, shall conform to the approved target grading within the tolerances specified in SUBCLAUSE 4213(b).

TABLE 4202/9
GRADING LIMITS FOR COMBINED AGGREGATE FOR COLD MIXED BITUMINOUS BASE COURSE

Sieve size (mm)	FBMIX (% passing)	BEMIX (% passing)
37.5	100	100
28	80-100	80-100
20	60-95	60-95
10	42-78	35-70
5.0	30-65	25-50
2.0	20-50	18-35
0.425	10-30	10-25
0.075	5-15	5-8
Bitumen type *)	Foamed	Emulsion
*) Nominal consumption of bitumen (litres per m^3 of compacted material)	90	90
*) The nominal consumption of bitumen is for bidding purposes. Exact percentage bitumen content shall be determined after the Engineer's approval of mix design and result of field trials. The type of bitumen shall be according to the Special Specifications or as specified by the Engineer.		

(g) Fillers
If the grading of the combined aggregates for asphalt surfacing mixes shows a deficiency in fines an approved filler may be used to improve the grading. Filler may consist of active filler as defined hereinafter or of inert material such as rock dust having the required grading necessary to improve the grading of the combined aggregates. In no instance shall more than 2% by mass of active filler be used in asphalt mixes. Inert filler such as rock dust used to improve grading shall not be subject to this limitation.

The Engineer may order the use of any active filler to improve the adhesion properties of the aggregate. Active filler shall consist of milled blast furnace slag, hydrated lime, Portland cement (CEM I), Portland blast furnace cement fly-ash, or a mixture of any of the above materials. Individual materials shall comply with the requirements of the relevant specifications for such material.

Active filler shall have at least 70% by mass passing the 0.075 mm sieve, all passing the 0.600 mm sieve and a bulk density in toluene falling between 0.5 and 0.9 g/ml. The voids in dry compacted filler shall be between 0.3% and 0.5%, when tested in accordance with BS 812-103.2:1999.

Active fillers for use in bituminous base courses shall be introduced to the mix prior to wetting with the binder. Only active filler added on the instructions of the Engineer, for the purpose of improving adhesion, will be paid for. No payment will be made for filler added to improve the grading.

(h) Asphalt reinforcing
Asphalt reinforcing shall be of the type specified in the Special Specifications and shall be obtained from an approved manufacturer.

Where the use of reinforcing for asphalt has been specified, the Contractor shall, at least three months before the material is to be used, submit samples of the type he/she intends to use, together with complete specifications of the material, as well as the manufacturer's instructions for use, to the Engineer for approval. Where the material does not carry the mark of an acknowledged standards authority, the Engineer may instruct the Contractor to have the material tested by an approved laboratory and to submit the results.

(i) Recycling
For recycled asphalt the nominal mix ratios of recovered asphalt, new aggregate, new bituminous binders, and active mineral filler to be used for bidding purposes, shall be as specified in the Special Specifications.

(i) Recovered asphalt
The Engineer will test the existing asphalt in any part of the road and determine its suitability for recycling before removal. He/she may instruct the Contractor to drill additional cores at specified points. Recovered asphalt intended for recycling shall be stored separately from other asphalt, and the Engineer may also direct different types of asphalt to be stored separately.

The recovered asphalt shall be free from any underlying base material and other foreign matter.

Asphalt milled out shall be of a maximum size of 28 mm, unless another maximum size has been approved by the Engineer.

Asphalt not milled out shall be broken down in an approved manner so that it can be properly remixed in a equipment to the satisfaction of the Engineer.

Mixes of recycled asphalt containing fragments of recovered asphalt exceeding 28 mm in size, will not be accepted.

Payment for recovered asphalt will distinguish between milled out and non-milled out material.

Samples shall be taken from the recovered asphalt intended for recycled mixes in the stockpile and shall be tested for grading and quality of the aggregate, binder content and properties of the binder.

(ii) Bituminous binders
The provisions of CLAUSE 4202 shall apply. The grade of new binder used in the recycled asphalt mix shall be such that the mix of new and residual binder will comply with the requirements of the Special Specifications. Recycling agents such as blended oils and other additives may not be used without prior approval by the Engineer.

(iii) New aggregate
New aggregate required for use in recycled asphalt mixtures shall comply with the requirements of CLAUSE 4202.

(iv) Combined aggregate
The aggregate mix obtained from new aggregate and the aggregate in the recovered asphalt including any mineral filler, an approved quantity of which may be added in accordance with CLAUSE 4202, shall comply with the requirements specified in the Special Specifications for the relevant recycled asphalt layer.

(j) Hot in-situ surface recycling
With regard to new binder, recycling additives, new asphalt, new aggregate or combinations of these materials, hot in-situ surface recycling shall comply with the requirements in the Special Specifications.

(k) Cold in-situ recycling
Cold in-situ pavement recycling shall comply with the requirements in the Special Specifications.

4203 MIX DESIGN AND PROPERTIES OF MIXED MATERIALS

The Asphaltic mix design shall be carried out in accordance with the current edition (28 days prior to tendering) of one of the following standards:

Marshall Mix Design - Asphalt Institute Manual Series, MS-2;

Superpave™ Mix Design - Asphalt Institute Manual Series, SP-2.

(a) Properties of mixed materials
The Contractor shall, by conducting the necessary tests, prove to the satisfaction of the Engineer that he/she will be able to produce a mixture meeting the design requirements in TABLE 4203/1, 4203/3, 4203/4 or 4203/5 for the respective mixes, using the aggregate he/she proposes to supply, within the grading limits specified.

TABLE 4203/1
DESIGN REQUIREMENTS FOR ASPHALT CONCRETE SURFACING-MARSHALL MIX DESIGN

Property of mixture and laboratory test method			Asphalt Concrete, continuously graded, (AC20, AC14, AC10)
Marshall flow (mm)			2 – 4
Marshall stability at refusal compaction (Newton), all severely loaded areas*)			Minimum 9000
Marshall stability (2x75 blows) (Newton)	Traffic Loads	> 10 x 10^6 esa's	8000 – 18000
		1 - 10 x 10^6 esa's	7000 – 15000
		< 1 x 10^6 esa's	6000 – 10000
Air voids (%)			3 – 5
Voids in mineral Aggregat	Asphalt Mix	AC 20	min. 14%
		AC 14	min. 15%
		AC 10	min. 16%
Voids Filled with Bitumen	Traffic Loads	> 10 x 10^6 esa's	65 – 75%
		1 - 10 x 10^6 esa's	65 – 78%
		< 1 x 10^6 esa's	70 –80%
Requirement after refusal laboratory compaction to BS 594 (severely loaded areas only) *)			Air voids shall be minimum 3%
Indirect tensile strength (kPa) AASHTO T 283			Minimum 800 Tested at 25 °C
Indirect wet tensile strength (kPa) AASHTO T 283			80 % of dry strength
*) The appropriate Traffic Load Class, and whether requirements for severely loaded areas apply to any location, shall be as given in the drawings or Special Specifications. Where such information is not given, the decision of the Engineer shall apply.			

In general, the Marshall Mix Design method shall be employed unless the Superpave™ method is particularly specified in the Special Specifications.

When the Superpave™ Mix Design has been specified then the compaction efforts shown in Table 4203/2 shall be employed for the different traffic classes.

TABLE 4203/2
SUPERPAVE™ MIX DESIGN, GYRATORY COMPACTION EFFORTS

Design Traffic (esa x 10^6)	N_{intial}	N_{design}	$N_{maximum}$
< 0.3	6	50	75
0.3 - < 3	7	75	115
3 - < 30	8	100	160
≥ 30	9	125	205

TABLE 4203/3
DESIGN REQUIREMENTS FOR Superpave™ Mix Design

Property of mixture and laboratory test method			Asphalt, continuously graded, (37.5, 25, 19, 12.5, 9.5 Nominal Size)
Required Relative Density (% of G_{mm})	N_{intial}	< 0.3 x 10^6 esa's	<91
		0.3 - < 3 x 10^6 esa's	<90
		3 - < 30 x 10^6 esa's	<89
		≥ 30 x 10^6 esa's	<89
	N_{des}	All traffic loads	=96
	N_{max}	All traffic loads	<98
Voids in mineral Aggregate (%)	Agg. Size	37.5 mm	11.0
		25.0 mm	12.0
		19.0 mm	13.0
		12.5 mm	14.0
		9.5 mm	15.0
Voids Filled with Bitumen (%)		< 0.3 x 10^6 esa's	70 - 80
		0.3 - < 3 x 10^6 esa's	65 - 78
		3 - < 30 x 10^6 esa's	65 - 75
		≥ 30 x 10^6 esa's	65 - 75
Filler to binder ratio			0.6 -1.2
Target air voids at N_{des}			4%
Indirect Dry tensile strength (kPa) AASHTO T 283			Minimum 800 tested at 25°C
Indirect wet tensile strength (kPa) AASHTO T 283			80 % of dry strength

TABLE 4203/4
DESIGN REQUIREMENTS FOR DENSE BITUMEN MACADAM BASE COURSES-MARSHALL MIX DESIGN

Property of mixture and laboratory test method			DBM40 & DBM30
Marshall flow (mm)			2 – 4
Marshall stability (Newton), all severely loaded areas			Minimum 9000
Marshall stability (Newton)	Traffic Loads	> 10 x 10^6 esa's	Minimum 7000
		1.5 - 10 x 10^6 esa's	Minimum 6000
		< 1.5 x 10^6 esa's	Minimum 3500
Air voids (%)			4 - 8
Compaction levels	Traffic Loads	Severely loaded areas *)	To refusal **)
		> 10 x 10^6 esa's	To refusal **)
		1.5 - 10 x 10^6 esa's	2 x 75
		< 1.5 x 10^6 esa's	2 x 50
*) Severely loaded areas will only be identified during the detailed design, when information such as alignment, soil conditions and traffic volumes are determined, and therefore these areas should be identified in the Special Specifications.			
**) Requirement after refusal laboratory compaction to BS 594: Air voids shall be minimum 3%			

TABLE 4203/5
DESIGN REQUIREMENTS FOR COMBINED AGGREGATE AND MIX PROPERTIES FOR COLD MIXED BITUMINOUS BASE COURSE

Property of mixture and laboratory test method	FBMIX (% passing)	BEMIX (% passing)
Marshall stability tested at 40^0C, (N) *BS* EN 12591: 2000	6000	4500
Marshall flow tested at 40^0C, (mm) *ASTM D 1559-89*	2 - 4	2 - 4
Minimum E-modulus tested at 29^0C by indirect tensile strength method or alternative approved methods, (MPa) *ASTM D 3967*	1600	1200
Minimum moisture content at the time of laying, (%)	Mix design moisture less 1.5% points	
Maximum moisture content at the time of laying, (%)	Mix design moisture plus 0.5% points	
Minimum compacted field density, (% of Marshall dry density).	96%	

4204 COMPOSITION OF MIXTURES FOR BITUMINOUS BASE COURSE AND SURFACING

The rates of application and mix proportions of bituminous binder, aggregates and fillers which are given in this SPECIFICATION are nominal rates and proportions and shall only be used for tendering purposes. The rates and proportions actually used shall be determined to suit the materials used and conditions prevailing during construction and any approved variation on a nominal mix in the bitumen content or active filler content shall be the subject of an adjustment in payment for binder or active filler variations as described in CLAUSE 4215.

Before production or delivery of the bituminous material the Contractor shall submit samples of the materials he/she proposes to use in the mix, together with his/her proposed mix design as determined by an approved laboratory, to the Engineer in accordance with TABLE 7109/1, so that the Engineer may test the materials and confirm the use of the proposed mix if he/she is satisfied that it meets the specified requirements.

A mix design shall be submitted for the approval of the Engineer for each new material source the Contractor proposes to use or when significant changes in the material properties are encountered within a material source or as deemed necessary by the Engineer. Any proposed change of mix design for use in Permanent Works shall be notified to the Engineer for his/her approval minimum 7 days in advance of proposed use.

As soon as the materials become available the Contractor shall produce a working mix with the approved equipment in accordance with the design mix.

The working mix shall again be tested by him/her for compliance with the design requirements. Samples of the working mix shall also be made available to the Engineer, who will authorise the use of the working mix proportions finally approved for use.

The composition of the approved working mix shall be maintained within the tolerances given in TABLES 4213/3 and 4213/4.

The design of the bituminous mixes shall be in accordance with the relevant design guidelines and the mix properties and requirements shall be as specified in the Special Specifications.

4205 CONSTRUCTION EQUIPMENT

(a) General

The Contractor shall submit to the Engineer full details of the Construction Equipment he/she proposes to use and the procedures he/she proposes to adopt for carrying out the Permanent Works. The Engineer shall have access at all times to construction equipment for the purpose of inspection.

All equipment shall so be designed and operated to produce a mixtures complying with the requirements of this specification. The construction equipment used in the mixing, transportation, laying, and compaction of bituminous materials shall be of adequate rated capacity, in good working order and subject to approval by the Engineer. Obsolete and worn-out equipment will not be allowed onsite.

Prior to the start of the work the Contractor shall supply the Engineer with copies of the manufacturer's handbooks and copies of check lists where applicable pertaining to the mixing, remixing and paving equipments, containing details of the correct settings and adjustments of the equipment.

Any alteration which has been or is being effected to any construction equipment, and which does not comply with the specifications of the manufacturer, shall be brought to the notice of the Engineer.

(b) Mixing equipment

(i) General
Mixing of the bituminous mixture shall be carried out in appropriate equipment acceptable to the Engineer.

(ii) Stationery or portable mixing equipment
Bituminous mixture shall be mixed by means of an approved type mixer of proven suitability for producing a mixture complying with all the requirements of the Specifications.
The mixing equipment may be either automatically or manually controlled. Two control operators shall be provided.

The heating system of the tanks storing the binder shall be so designed that the binder will not be degraded during heating. A circulating system for the binder shall be provided which shall be of adequate size to ensure the proper and continuous circulation between storage tanks and mixer during the entire operating period.

Binder storage tanks shall be fitted with thermometers designed to provide a continuous record of the temperature of the binder in the tank. Copies of these records shall be supplied to the Engineer on a daily basis.

Satisfactory means shall be provided to obtain the proper amount of binder in the mix within the tolerances specified, either by weighing or volumetric measurements. Suitable means shall be provided for maintaining the specified temperatures of the binder in the pipelines, weigh buckets, spray bars and other containers or flowlines.

In the case of a drum type mixer, the system shall control the cold feeding of each aggregate fraction and of the filler by mass, by means of a load cell or another device regulating the feed automatically, and by immediately correcting any variation in mass which results from moisture or from any other cause. The

cold feed shall be regulated automatically in regard to the binder feed so as to maintain the required mix proportion.

Suitable dust collecting equipment shall be fitted to prevent pollution of the atmosphere in accordance with the provisions of any local Act governing pollution.

The fuel chosen and control of the burner shall be such as to ensure the complete combustion of the fuel in order to prevent pollution of the atmosphere and the aggregate.

(iii) Recycling
In addition to the requirements set out in CLAUSE 4205 the mixing equipment shall be specially adapted to deal with recycling and any such adjustments shall be in accordance with the instructions of the manufacturer of the mixing equipment on the approval of the Engineer. The recovered asphalt portion of the mix shall not be exposed directly to the heating source whilst the feeding rate and proportioning shall be accurately controlled. Before work is commenced, the Contractor shall submit full details of his/her mixing equipment to the Engineer for his/her approval.

(c) Spreading equipment, pavers
The bituminous base course shall be laid by an appropriate type of self-propelled mechanical spreader of a type approved by the Engineer and shall be kept in a good running condition and adjusted correctly according to the manufacturer's specifications.

The pavers shall be equipped with a powerful tamper and vibrating screed. The pavers shall be capable of laying the material to widths, lines, grades cross-fall and thickness within the specified tolerances without causing separation, dragging or other surface defects.

All pavers used for laying Permanent Works shall be fitted with automatic electronic screed controls to maintain the required levels, cambers and cross-falls. Where skids are used they shall be at least 9m long or as specified by the Engineer.
The paver shall be constructed in such a manner that the asphalt can be tipped from the trucks into the hopper without any spillage.

Where levelling beams on multiple skids or sliding beams are used they shall be at least 9 m long.

(d) Rollers, general requirements
Compaction shall be done by means of approved flat steel wheeled, vibratory or pneumatic-tyred rollers, sufficient in size and numbers to achieve the specified density through the entire depth of the layer. Minimum one roller shall be pneumatic tyred with a weight of minimum 2.5 tonnes per wheel and not less than 18 tons total un-ballasted weight. The frequency as well as the amplitude of vibratory rollers shall be adjustable. Vibratory rollers shall be used only where there is no danger of damage being done to the layer, structures of bridge decks, or other layers.

It will be indicated in the Special Specifications whether vibratory compaction equipment may be used on bridge decks and what the constraining parameters will be. The rollers shall be self-propelled and in good working condition, free from backlash, faulty steering mechanism and worn parts.

Rollers shall be equipped with adjustable scrapers to keep the drums clean and with efficient means of keeping the wheels wet to prevent mixes from sticking to the rollers. No leakage of any nature may occur in the rollers.

Rollers shall not be left stationary on fresh mat, compacted or not.

(e) Binder distributors
Where bituminous binders are to be sprayed onto areas before laying the asphalt is done, the binder distributors shall comply with CLAUSE 4103.

(f) Vehicles
All vehicles used for transporting asphalt shall be insulated. Delivery trucks should be fitted with rear spill trays to facilitate transfer of material to paver without spillage.

All vehicles used for transporting asphalt shall be fitted with canvas for transport in excess of 10 km or when weather conditions demand such cover in the opinion of the Engineer. Such covers shall be securely fixed over the asphalt from time of departure at the storage or mixing equipment until immediately prior to discharge of the asphalt into the paver.

(g) Construction equipment for recycled asphalt
Construction equipment for producing, hauling and placing the recycled asphalt shall comply with the provisions of Subclauses 4204(a) to 4204(f), as applicable, and subject to the following additional requirements:

The mixing equipment shall be capable of producing asphalt mixes with or without recovered material. Where necessary, the mixing equipment shall be specially adapted to deal with recycling, and any such adjustments shall be made in accordance with the instructions of the manufacturer. The equipment, with any necessary adjustments, shall be so designed, equipped and used that the measuring, heating and mixing of the material will give a uniform asphalt mix which complies with all the specified requirements in regard to temperatures within the limits necessary for properly placing and compacting the asphalt in accordance with the specified requirements. Before work is commenced, the Contractor shall submit full particulars of his/her mixing equipment to the Engineer.

4206 GENERAL LIMITATIONS AND REQUIREMENTS AND THE STOCKPILING OF MIXED MATERIAL

(a) Weather conditions

(i) General
Bituminous material may be mixed and placed only under favourable weather conditions, and shall not be mixed or placed when rain is imminent or during wet conditions.

(ii) Hot mixes (AC [Marshall & Superpave™ Mixes], DBM)
The following wind and temperature conditions are regarded as being suitable for paving work with hot mixed material:

While the air temperature is rising, work may be performed at temperatures of:
- 6°C with an allowable wind velocity of less than 25 km/h
- 10°C with an allowable wind velocity of less than 55 km/h, or for asphalt with a compacted thickness of less than 30 mm with an allowable wind velocity of less than 25 km/h.

With falling air temperatures, work must be stopped when the temperature reaches 6°C regardless of the

wind velocity and may not be restarted before the temperature is definitely rising.

(iii) Cold mixes (FBMIX, BEMIX)
The Contractor's attention is drawn to the fact that cold mixed material is likely to be pervious until sealed. Damage to unsurfaced layers may occur in wet weather. Due allowance should be provided in the programme of works during rainy seasons, such that exposure of un-sealed layers are kept to a minimum. Time limits for the laying operation are given in SUBCLAUSE 4212(b). The time limits are applicable only in dry weather working conditions. Allowance to weather conditions in the programme of works may include reduction of these maximum time limits and/or complete stoppage of the laying operations in wet weather.

(b) Moisture content

The mixing and placing of asphalt will not be allowed if the moisture content of the aggregate affects the uniformity of temperature or if free water is present on the working surface, or when the moisture content of the underlying layer, in the opinion of the Engineer, is too high.

No surfacing shall be placed unless the moisture content of the upper 50 mm of the base course is less than 50% of the optimum moisture content as determined by the Engineer. No overlay shall be placed immediately after a rainy spell on an existing partly cracked and/or highly permeable surfacing resulting in the trapping of moisture in the pavement structure. A minimum delay of 24 hours or such extended period as ordered by the Engineer shall apply.

(c) Surface requirements

(i) General
Any defects of the surface shall be made good and no bituminous material shall be laid until the surface has been approved by the Engineer.

(ii) Correction of base courses, or subbase in the case of bituminous base course.
The base course (after the prime coat has been applied) or the subbase, as the case may be, shall be checked for smoothness and accuracy of grade, elevation and cross section. Any portion of the base or subbase, as the case may be, not complying with the specified requirements, shall be corrected with asphalt at the Contractor's own expense, until the specified requirements are met. The Engineer may, however, in his/her sole discretion, allow minor surface irregularities to remain, provided they can be taken up in the following asphalt layer without adversely affecting that layer.

The bituminous material used for the correction of the base or subbase, shall be the same mixture as specified for the surfacing or as directed by the Engineer, and the maximum size of aggregate used shall be dictated by the required thickness of the correction in each case.

Notwithstanding these provisions for the correction of the base or subbase, the Engineer reserves the right to order the removal and reconstruction of the layer or of portions of the base and subbase layers not complying with the specified requirements, instead of allowing the correction of substandard work with asphalt material.

(iii) Cleaning of the surface
Immediately before applying the tack coat, or where there is no tack coat, before the application of the asphalt, the surface shall be cleaned of all loose or deleterious material by means of a rotary broom, and hand brooms, compressed air or as required to the satisfaction of the Engineer.

Where the prime coat (if any) has been damaged, it shall be repaired by hand brushing or spraying priming material over the damaged portions.

The prime coat shall be sufficiently dry before the tack coat and/or the asphalt may be applied. The Contractor's programme shall allow for delays that are a function of the type of prime, rate of application, base porosity and moisture content, and climatic conditions.

(iv) Tack coat
A tack coat shall be applied to the surface to be paved in accordance with the Specifications and Drawings or as instructed by the Engineer.

The tack coat shall consist of a stable-grade bitumen emulsion diluted to have a 30% bitumen content and shall be applied at a rate of 0.55 l/m^2 or as directed by the Engineer.

The use of hand operated equipment for the application of tack coats shall be at the sole discretion of the Engineer.

Portions of kerbing and guttering, bridge kerb and railing which will be exposed, shall be protected in terms of SECTION 2300 when the tack coat is applied.

The tack coat shall not be applied more than 24 hours before the paving is done.

(v) Preparation for placing overlays
The provisions of SECTION 4800 shall apply to any surface to be covered with overlays. The type of treatment to be applied, if any, will be specified in the Special Specifications or instructed in writing by the Engineer.

(vi) Preparation where asphalt layers are to be widened or where surfacing over a section of the road width requires replacement.

The existing asphalt shall be removed as described in SECTION 3800, where applicable, or as instructed by the Engineer.

Where a road has to be widened, the overlay shall be cut back not less than 100 mm from the existing edge. Unless otherwise indicated on the Drawings or instructed by the Engineer. Asphalt joints may not fall within a wheel track.

(d) Storage

(i) Hot mixes (AC [Marshall & Superpave™ Mixes], DBM)
Mixing shall not be allowed to take place more than four hours before paving begins unless provision has been made for storage. Storage of mixed material will only be permitted in approved hoppers, which are capable of maintaining the temperature of the mix uniform throughout.

in any case storage will not be permitted for a period longer than 12 hours after mixing.

(ii) Cold mixes (FBMIX, BEMIX)
The material for use in Permanent Works shall not be laid on the same day as it is mixed unless otherwise approved by the Engineer.

The length of time for mixed material to remain in stockpile before laying shall not be more than 7 days after mixing. Should the Contractor propose to use material that has been stockpiled for longer than 7

days, then the Engineer may allow a trial section to be constructed. The Engineer may subsequently allow the material to be used in the Permanent Works if the outcome of the trial is to his/her satisfaction.

All equipment used for stockpiling and transportation of the mixture shall have buckets that are cleaned of all foreign material, fuel, lubricants or other contamination before use.

4207 PRODUCING AND TRANSPORTING THE MIXTURE

(a) Mixing and storage temperatures of binder
Bituminous binders shall be stored at temperatures not exceeding those given in TABLE 4207/1 or the Special Specifications, and the aggregate and bituminous binders shall be heated at the mixing equipment to such temperatures that the mixed product shall have a temperature within the range given in TABLE 4207/1.

TABLE 4207/1
TEMPERATURE RANGES FOR BITUMINOUS BINDERS

Bitumen type, pen. grade	Max. storage temperature of binder (°C)		Temperature range of mix (°C)
	Over 24 hrs	Under 24 hrs	Continuously graded mixes
40/50 pen	145	175	140-165
60/70 pen	135	175	135-160

(b) Production of the mixture

(i) Hot mixes using batch equipments
(1) Heating the aggregate
The aggregate shall be dried and heated so that, when delivered to the mixer, its temperature shall be between 0°C and 20°C lower than the maximum temperature indicated in TABLE 4207/1 for the mixture. The moisture content of the mix shall not exceed 0.5%.

(2) Batching
Each fraction of the aggregate and binder shall be measured separately and accurately in the proportions by mass in which they are to be mixed. If filler is used, it shall be measured separately on a scale of suitable capacity and sensitivity. The error in the weighing apparatus used shall not exceed 2% for each batch.

(3) Mixing
The aggregate, filler and binder shall be mixed until a homogeneous mixture is obtained in which all particles are uniformly coated. Care shall be taken to avoid excessively long mixing times which can cause hardening of the binder.

(ii) Hot mixes using drum-type mixer equipments
The aggregate and filler shall be accurately proportioned and conveyed into the drum-mixing unit. The calibrated amount of binder shall be sprayed onto the aggregates at the correct position so that no hardening of the binder shall take place. A homogeneous mixture and uniform coating of binder must be achieved and the moisture content of the asphalt mixture shall not exceed 0.5%. Once the final mix temperature has been agreed upon it may not be altered without the prior consent of the Engineer.

(iii) Cold mixes using stationary, portable or in-situ mixing equipment
Mixing of bituminous base for use in Permanent Works shall only be carried out in mixing equipment approved by the Engineer and on the basis of an approved mix design. Any proposed change of mix design for use in Permanent Works shall be notified to the Engineer for his/her approval minimum 7 days in advance of proposed use.

The length of time for storage of additives from the moment of mixing with hot bitumen until mixed with aggregates shall be limited to maximum 2 hours, unless otherwise approved by the Engineer. Such approval shall be subject to proof that adhesion properties are adequate at the time of mixing bitumen with aggregate.

(c) Transporting the mixture
The mixture shall be transported from the mixing equipment to the Works in trucks complying with the requirements of CLAUSE 4205. Deliveries shall be made so that spreading and rolling of all the mixtures prepared for a days run can be completed during daylight, unless artificial lighting, as approved by the Engineer, is provided. Any asphalt which has become unusable in the opinion of the Engineer due to rain or any other cause will be rejected. Hauling over freshly laid material is not permitted.

The mix at delivery to the paver shall be not more than 10°C below discharge temperature at the mixing equipment. The minimum temperature for the commencement of breakdown rolling shall be determined on trial sections. Mix loads of temperature less than the minimum temperature shall be disposed of.

If there is consistent failure to meet the temperature requirement the paving operations shall be suspended until suitable measures are taken by the Contractor to ensure that the temperature requirements are met.

Hauling equipment for bituminous mixes shall have isolated, tight, clean and smooth beds, which are periodically coated with a lime solution or other approved material to prevent adherence of the mix. All hauling units shall be equipped with a canvas or other approved type of cover which shall be used to cover the material upon loading at the mixing equipment and shall not be removed until the mix is discharged into the paver.

The Engineer may instruct that hauling equipment shall have an engine exhaust system blowing the gas vertical not to cause inconvenience to the paving crew.

(d) Recycled asphalt
The provisions of SUBCLAUSES 4207(a) to 4207(c) shall apply with changes as required.

At least four weeks before paving with recycled material will commence, the Contractor shall submit to the Engineer full particulars regarding the recycling methods he/she intends to use.

Where recovered asphalt material is taken from a stockpile, it shall be done by excavating from the pile over its full depth. Where segregated material is fed into the mixing equipment, the Engineer will have the right to order the work to cease and to instruct the Contractor to remix the stockpile, retest the mixed material and redesign the asphalt mixture all at his/her own cost.

4208 SPREADING THE MIXTURE

(a) General

(i) The paver, general
The paver shall be kept in good working order, and adjustment of the screed tamping bars, feed screws, hopper feed, etc, shall be checked frequently to ensure uniform spreading of the mix.

If segregation or other imperfections occur, the spreading operations shall immediately be suspended until the cause is determined and corrected.

The mixer capacity and the operating speed of the paver are to be so co-ordinated as to ensure continuous laying and to avoid intermittent stopping of the paver.

Unless otherwise stated in the Special Specifications the paver shall be equipped to provide automatic control of levels and cross section. In the case of asphalt base construction, automatic control shall be run off guide wires and in the case of surfacing and overlays skids or guide wires shall be used.

(ii) Workmanship
The bituminous layer shall be laid and compacted in one or more layers giving a total thickness as specified.

The addition and removal of material behind the paver shall normally not be allowed and the paver shall be capable of spreading the mixture to the correct amounts that will provide the required compacted thickness and surface evenness without resorting to spotting, picking-up or otherwise shifting or disturbing the mixture.

Repairs to joint and isolated surface irregularities may be carried out by hand or other suitable methods, subject to approval of the Engineer.

On restricted areas, inaccessible to the paving equipment used, the mixture may be placed by hand or other means to obtain the specified results. Paving shall be carried out in a manner which will avoid segregation and which will allow control of levels.

Paving shall be carried out in accordance with good workmanship for such operations. This requirement includes, but is not restricted to, particular attention to the following:

- paving shall commence at the bottom of the grades and the lower edges of superelevated curves
- paving shall be done upgrade on grades steeper than 5%
- the paver shall be operated in a manner that provides the maximum possible degree of compaction exerted by the screed, evenly distributed across and along the layer.
- spreading shall be so arranged that longitudinal joints do not coincide with joints in lower layers of asphalt base or surfacing.

The mixture shall be delivered continuously to the paver to avoid stop-go paving operations. The temperature of the mixture shall be controlled by measuring in a random pattern in the truck immediately before emptying, and shall not be less than the minimum temperature defined during the trial section.

The adjustment of the screed, tamping bars, feed screws, hopper feed, etc. shall be checked frequently to ensure uniform pre-compaction and spreading of the mixtures.

If segregation occurs, the spreading operations shall immediately be suspended until the cause is determined and corrected.

The pavers shall be equipped with 60° sloped sideplates on the screed to confine and to form a stable and neat permanent outer shoulder edge.

(iii) Base course thickness paved in one operation
Base course with a compacted thickness greater than 100 mm may only be placed to its full thickness in one layer if site trials show that satisfactory finish, evenness and compaction of the full thickness can be achieved and the result is to the satisfaction of the Engineer.

(iv) Base course thickness, first layer
No bituminous base course material shall be placed as the first layer of the base course in a compacted thickness less than 60 mm or less than three times the aggregate's maximum particle size, whichever is smaller.

(v) Layer thickness, following bituminous layers
Following layers to be placed on freshly laid bituminous base or binder course layers may be placed in a compacted thickness less than the above subject to satisfactory results of site trials and on approval of the Engineer, but not less than twice the maximum aggregate size for the mix.

(vi) Weather
Paving shall stop when rain is imminent and compaction of all laid material shall be completed immediately.

(vii) Hot mixes, special requirements
The temperature of hot mixtures shall be controlled by measuring in a random pattern in the truck immediately before emptying, and shall not be more than 10°C below the minimum temperature specified for mixing in TABLE 4207/1.

(viii) Cold mixes: special requirements
No cold mixed bituminous base course material shall be laid unless the moisture content is within the specified limits. If the moisture content of stockpiled materials falls outside these limits, the Contractor may propose methods to bring the moisture content back to comply with the requirements.

The Engineer may then allow a Trial Section as described in CLAUSE 4211 to be constructed if the proposal is to his/her satisfaction. The Engineer may subsequently allow the material to be used in Permanent Works if the outcome of the Trial Section is to his/her satisfaction.

(b) Overlays
In the case of overlays, guide wires will be required during the placing of the mix if so specified in the Special Specifications. In all cases, including placing of levelling courses, the paver shall be provided with skid beams with electronically controlled equipment, which can ensure a constant crossfall and can even out local irregularities.

(c) Constrained areas
In areas constrained by insufficient space, bituminous material shall be placed with the aid of smaller specially equipped pavers, hand tools, or other approved equipment.
All the relevant provisions in regard to temperature, mix composition, uniformity, etc, shall remain applicable, but

layer thickness and control shall be such that the requirements for compaction and surface tolerances can still be attained.

(d) Recycled asphalt
Where the average thickness of a completed asphalt layer exceeds the specified thickness, and/or recovered asphalt has been wasted indiscriminately, and, if in the opinion of the Engineer it has resulted in a deficiency of recovered material, the Contractor shall supplement such deficiency at his/her own cost with a quantity of similar or better material equal to the quantity wasted, as determined by the Engineer.

4209 JOINTS

All joints between adjacent sections of the work shall be made by cutting back the layer against which the material is to be placed unless otherwise approved by the Engineer. All loose and incompletely compacted material shall be removed. A cutting wheel shall be used for cutting longitudinal joints.

Joints shall be either at right angles or parallel to the centre line, and joints in the final layer of the surfacing shall, where possible, correspond with the lane markings. Joints in lower layers shall be offset not less than 150 mm on either side of the edges of the traffic lanes.

Before a new layer is placed next to an existing layer, the cut edge of the existing layer shall be painted with a coat of bituminous emulsion of the same type and application rate as used for the tack coat.

Joints shall be neat and shall have the same texture and density as the remainder of the asphalt course. All joints shall be marked out with chalk lines prior to cutting.
The outside edges of the completed asphalt course shall be trimmed along the shoulder, and parallel to the centre line, to give a finished width, as shown on the Drawings, within the tolerances specified.

Any fresh mixture spread accidentally onto existing work at a joint shall be carefully removed by brooming it back with stiff brooms onto the uncompacted work, so as to avoid the formation of irregularities at the joint. Whenever the paving operation is stopped due to lack of mixture, the Contractor shall form a proper joint as specified above, if so directed by the Engineer.

The paved pre-compacted "over height" after the screed shall be carefully determined on the trial sections (with e.g. 10, 20 and 30 mm over height) and properly implemented for satisfactory joint construction.
Joints shall have the same texture and density as the remainder of the asphalt course.

4210 COMPACTION

The mix shall be rolled immediately after it has been laid by vibratory, steel wheel and pneumatic-tyred rollers in a sequence predetermined and approved during the laying of trial sections. Such rolling shall commence and be continued only for so long as it is effective and does not have any detrimental effect. The use of pneumatic-tyred rollers for continuously graded non-homogeneous modified binders shall be assessed in the trial section.

As many rollers shall be used as are necessary to provide the specified pavement density and the required surface texture. During rolling of surfacing only, the roller wheels shall be kept moist with only sufficient water to avoid picking up the material.

After longitudinal joints and edges have been compacted, rolling shall start longitudinally at the sides and gradually progress towards the centre of the pavement, except on super-elevated curves, or where the area to be paved has a straight cross-fall, when rolling shall begin on the low side and progress to the higher side, uniformly lapping each preceding track, covering the entire surface. During breakdown rolling, the rollers shall move at a slow but uniform speed (not to exceed 5 km/h) with the drive roller nearest the paver, unless otherwise specified on account of steep gradients.

No movement of the asphalt layer shall occur under steel wheel rollers once the asphalt temperature has dropped to below 100°C. Three-wheeled steel rollers, with large diameter rear wheels are preferable to tandem rollers and may be used in conjunction with pneumatic tyred rollers, provided pick-up of the asphalt on the wheels does not occur.

The sequence of rollers used in compaction is at the discretion of the Contractor provided the completed pavement shall have a density as measured on recovered cores equal to or greater than the nominal density specified in Table 7114/2 and assessed by the statistical method defined in SECTION 7200.

The Contractor shall utilise a calibrated nuclear gauge for process control during compaction operations. Notwithstanding this requirement, the acceptance control carried out for compaction by the Engineer shall still be based on cores taken from the compacted layer.

The nuclear device shall:
- be operated by a suitably trained technician.
- comply with all the safety regulations of the relevant regulatory Authority.
- be certified to be suitably calibrated.

The portion of trial section having the desired surface texture shall be designated as a reference for what is required in the permanent work.

The following requirements shall apply to rolling and compacting generally:
- The material shall not be excessively displaced in a longitudinal or transverse direction especially when changing gears, stopping or starting rollers.
- No cracks or hair cracks shall be formed and the bond with the underlying layer shall not be broken.
- The density shall be uniform over the whole area of the layer and extend over the full depth of the layer.
- Rollers shall not be left standing on the asphalt layer before it has been fully compacted.
- In restricted areas where the specified rollers cannot be used, compaction shall be carried out with hand-operated mechanical compaction equipment or approved smaller vibratory rollers. The prescribed density requirements remain applicable throughout, over the full layer thickness, irrespective of the method of compaction.

An adequate number of roller passes shall be used to provide the specified pavement density. The density shall be uniform over the whole area of the layer, as well as at the joints after approximately 10 cm back-cutting of tentative free edges.

The tyre pressure of pneumatic-tyred rollers shall be adjusted to the maximum that the mixture can carry without excessive displacement of the asphalt layer.

The Contractor shall, when necessary only employ approved slippage agents for the rollers. Diesel will under no circumstances be accepted.

The provisions of CLAUSE 4210 shall apply with changes as required, and with the approval of the Engineer, to recycled asphalt.

4211 LAYING TRIAL SECTIONS

A trial section of minimum 50 m length shall be constructed prior to the use of any new mix design, when there are changes in the type or numbers of construction equipment, or as required by the Engineer. The Trial Section shall demonstrate that the materials, equipment and procedures proposed are adequate to achieve a bituminous layer in accordance with the Specifications and to the satisfaction of the Engineer.

Any bituminous material laid in a trial area that forms part of the Permanent Works and subsequently found unacceptable, shall be removed or made good to comply with the Specifications.

The Engineer may require a number of different binder contents, and a number of different moisture contents in the case of cold mixed material, to be incorporated in one such trial section to verify the laboratory design recipe.

Cores extracted from the completed trial section and in locations determined in a stratified randomly sampled manner.

Only when such a trial section has been satisfactorily laid and finished, and complies with the specified requirements will the Contractor be allowed to commence with construction of the permanent work.
If the Contractor should make any alterations in the methods, processes, equipment or materials used, or if he/she is unable to comply consistently with the Specifications, the Engineer may require that further trial sections be laid before allowing the Contractor to continue with the permanent work. Any work that does not comply with the Specifications shall be removed or made good to comply with the Specifications to the satisfaction of the Engineer.

The trial sections shall be laid where indicated by the Engineer. The Contractor shall prepare the surface on which to lay the trial section and shall also, if required by the Engineer, remove the trial section after completion and restore the surfaces on which it was constructed, at his/her own cost.

The Contractor shall for each trial section prepare a plan for execution of the trial. It shall at least include the following subjects:

- date and time, location, sketch of location, type of asphalt
- preparation of surface, spray rate of tack coat or prime coat and curing time
- mixing and paving temperature, cooling rate, infrared camera photos and locations for temperature control
- paving speed, tamper settings and type/angle of screed side plates
- illustrate intended rolling pattern for at least 3 levels of compaction efforts (medium, high and extra high) and describe methods to record and control number of passes and the rolling pattern actually used
- joint construction method, over height of the second paving lane, control of the over height
- core drilling and test programme for testing of the mix and the finished pavement. The programme shall include recovered binder and mix properties, wheel track rutting test
- programme for instruction of every person involved in the trial section.

The activity plan for the trials shall be forwarded to the Engineer for approval not less than 7 working days before the planned trials.

The Contractor shall assess back-cuttings and separately document that finished joints satisfy the compaction requirements by taking asphalt cores at a distance of 50 mm from joints and tentative free edges.

The trial sections shall include continuous measurements of asphalt temperatures to determine the rate of cooling and the time available for compaction.

No payment shall be made for trial sections and the Contractor must allow for all costs in his/her rates.

4212 PROTECTION AND AFTERCARE

(a) General

The Contractor shall protect the bituminous base course and asphalt surfacing from all damage until the work is handed over to the Employer and he/she shall maintain the surfacing work until the date of substantial completion. Any damage occurring to the completed base or surfacing shall be made good by the Contractor at his/her own expense and to the satisfaction of the Engineer.

Traffic can under normal conditions be allowed on to the fresh layer immediately after compaction is completed unless otherwise directed by the Engineer.

(b) Special requirements for cold mixed base course material

Traffic can under normal dry conditions be allowed on the fresh layer immediately after the compaction is completed unless otherwise directed by the Engineer.

Where the base course is placed in more than one layer, no more than 7 days shall elapse between completion of consecutive layers. No more than 14 days shall elapse from completion of the base course until the surface dressing is constructed.

The time limits in the above paragraph are applicable only in dry weather working conditions. The Contractor's attention is drawn to the fact that the material is likely to be pervious until sealed.

Damage to unsurfaced layers may occur in wet weather. Due allowance should be provided in the programme of works during rainy seasons, such that exposure of un-sealed layers are kept to a minimum. This may include reduction of the above maximum time limits and/or complete stoppage of the laying operations in wet weather.

If the times specified above are not adhered to the Contractor shall place tack coat or priming in accordance with this Specification on approval of the Engineer without additional costs to the Employer.

Approved crusher dust or clean sand shall at no additional costs to the Employer be evenly spread at a rate of 0.005 m^3/m^2 immediately following the spraying of tack coat.

Notwithstanding the above, construction of consecutive layers or surface dressing shall not be unduly delayed. In no case shall more than 90 days elapse since completion of the previous layer.

4213 CONSTRUCTION TOLERANCES AND FINISH REQUIREMENTS

(a) Construction tolerances
Construction tolerances and finish shall meet all relevant requirements in SECTION 7300. The riding quality of the final layer shall be to the satisfaction of the Engineer.

(b) Grading
The combined aggregate and filler grading shall not deviate from the approved target grading for the working mix by more than that given in TABLES 4213/1 and 4213/2 respectively for Asphalt Concrete surfacing and bituminous base course materials.

TABLE 4213/1
AGGREGATE GRADING TOLERANCES FOR ASPHALT CONCRETE SURFACING MATERIALS

Size of aggregate: Material passing the following sieves (mm)	Permissible deviation from the approved target grading (%)
37.5	± 4.0
28	± 4.0
20	± 5.0
14	± 5.0
10	± 5.0
6.3	± 5.0
5	± 4.0
2.00	± 4.0
1.18	± 4.0
0.600	± 4.0
0.300	± 3.0
0.150	± 1.5
0.075	

TABLE 4213/2
AGGREGATE GRADING TOLERANCES FOR BITUMINOUS BASE COURSE MATERIALS

Size of aggregate: Material passing the following sieves (mm)	Permissible deviation from the approved target grading (%)
Sieve 5 mm and larger	± 10
Sieve smaller than 5 mm and larger than 0.075 mm	± 5
Sieve 0.075 mm	± 3

(c) Bitumen content

(i) Hot mixed material
The bitumen content for asphalt concrete surfacing and bituminous base course materials shall not deviate from the bitumen content of the approved mix by more than the value given below:

Bitumen content tolerance per single test:

±0.3%

where the bitumen content is in per cent by the total weight of the mixture.

(ii) Cold mixed material
The maximum accepted deviation in binder content of cold mixed bituminous base course material compared to that of the approved Mix Design is given in TABLE 4212/3.

TABLE 4213/3
ACCEPTANCE LIMITS FOR BINDER CONTENT FOR COLD MIXED BITUMINOUS BASE COURSE MATERIALS

Number of tests in lot	Maximum deviation from the approved binder content (%)	
	Sample mean	Single values
4 or less	0.30	0.60
5	0.28	0.62
6	0.27	0.64
7	0.26	0.65
8	0.24	0.66
9	0.22	0.68
10 or more	0.20	0.70

The average amount of bituminous binder in the total length of any layer, calculated as the product of the bitumen contents obtained from single tests and the volume represented by each test, shall not be less than the amount ordered.

The average amount of bituminous binder for each day's production calculated from the checked weights of mixes shall not be less than the amount ordered.

4214 SAMPLING AND TESTING

(a) General
All sampling and testing shall be carried out in accordance with sampling and testing standards laid down in these Specifications and standards of the Central Materials Laboratory or equivalent approved by the Engineer, and shall be carried out to adequately show compliance with the Specifications.

(b) Coring of asphalt layers
The Contractor shall provide suitable coring machines capable of cutting 100 mm diameter cores from the completed asphalt layers.

The cost of extracting cores for process control in accordance with the Specifications shall be included in the Contractor's rates for the construction of asphalt pavement layers and will not be paid for separately.

Cores in the carriageway lanes shall be taken at the outer permanent edge, at the centre of the paved lane and at the longitudinal joint. Cores at the outer edges and at the joints shall be taken 50 mm from the edge after back-cutting as directed. Cores in the shoulders shall be taken 300 mm from the outer shoulder edge and 50 mm from the longitudinal joints to the carriageway pavement.

All core holes shall be neatly repaired with asphalt and compacted to the specified density. The core holes shall be filled with the same mix as used for the layer tested.

(c) Laboratory testing
Testing shall be carried out by the Contractor at the site laboratory or an external laboratory approved by the Engineer. All operations of the testing shall be available for inspection by the Engineer at all times and the Contractor shall give notice well in advance of all testing as required by the Engineer. All test results shall at all times be available to the Engineer.

Testing and quality control of materials and workmanship shall be carried out in accordance with the relevant provisions for sampling, testing and acceptance given in SECTIONS 7100 AND 7200 of these Specifications.

All test results representative for Permanent Works shall meet the relevant requirements in the Specifications within the tolerances specified and shall be approved by the Engineer.

Test results (laboratory readings and measurements) as well as calculated results in digital form shall be submitted daily to the Engineer in continuously updated summary sheets.

4215 MEASUREMENT AND PAYMENT

ITEM	UNIT
42.01 ASPHALT CONCRETE SURFACING:	
(a) ASPHALT CONCRETE SURFACING (STATE TYPE OF MIX, TYPE OF BITUMEN AND COMPACTED LAYER THICKNESS)	CUBIC METRE (m^3)
(b) BITUMEN FOR ASPHALT CONCRETE SURFACING (STATE TYPE OF BITUMEN)	TONNES (t)

ITEM	UNIT
42.02 BITUMINOUS BASE COURSE:	
(a) HOT MIX (STATE TYPE OF MIX, TYPE OF BITUMEN AND COMPACTED LAYER THICKNESS)	CUBIC METRE (m^3)
(b) COLD MIX (STATE TYPE OF MIX, TYPE OF BITUMEN AND COMPACTED LAYER THICKNESS)	CUBIC METRE (m^3)
(c) BITUMEN FOR BITUMINOUS BASE COURSE MIXES (STATE TYPE OF BITUMEN)	TONNES (t)

The unit of measurement for bituminous mixes shall be the cubic metre of asphalt concrete or bituminous base course placed and compacted on the road as specified and to the specified thickness. The quantities shall be calculated as the product of the length instructed to be paved and the compacted cross-sectional area shown on the Drawings or instructed by the Engineer.

The bid rate for bituminous mixes shall include for procuring all materials, except the bitumen which is paid for separately, for preparing the surface to the satisfaction of the Engineer, providing, heating, drying as required, mixing, transporting, laying and compacting the mix in accordance with the Specifications and to the satisfaction of the Engineer. The rate shall also include for trial sections, process control testing, protecting and maintaining the work as specified.

The bid rate for the bituminous mixes shall be valid irrespective of which bitumen is selected for the mixes.

The bitumen for bituminous mixes, produced and placed as specified and accepted by the Engineer, is measured by the tonne and paid for separately. The quantity shall be calculated from the approved recipe of the mix at the specified compacted density. A new mix design and recipe shall be prepared if, in the opinion of the Engineer, this is warranted due to variations in mix density or other material properties

No payment will be made for material wasted.

ITEM	UNIT
42.03 TACK COAT OF 30% STABLE GRADE BITUMEN EMULSION	LITRE (l)

The unit of measurement for tack coat shall be the litre of 30% stable-grade bitumen emulsion applied as specified.

The quantity of tack coat (between asphalt layers) shall be calculated as the area in square metres specified to be coated multiplied by the approved spray rate in litres per square metre. The spray rate shall be verified by weighing of test trays before and after application.

The bid rate shall include for the cleaning the surface to the satisfaction of the Engineer, procuring, furnishing and application of the material as specified.

ITEM	UNIT
42.04 ADDITIVES (STATE TYPE)	KILOGRAMME (kg)

The quantity of additive shall be calculated as the number of kilograms used in accordance with the recipe of the mix approved of the Engineer.

Additives shall be paid for separately only where these are specified or instructed by the Engineer. Additives shall include active filler to improve adhesion properties, but no separate payment will be made for filler added to improve the grading.

SERIES 4000: BITUMINOUS LAYERS AND SEALS

SECTION 4300: GENERAL REQUIREMENTS FOR SEALS

CONTENTS:

4301 SCOPE

This Section covers the materials, construction equipment, construction and requirements common to the construction of all seals detailed in these Specifications.

4302 MATERIALS

(a) Bituminous binders

(i) Conventional bituminous binders
Bituminous binders shall comply with the following specifications or suitable equivalent:

Type of binder	Specification
Penetration grade bitumen:	BS EN 12591: 2000
Cutback bitumen:	BS EN 12591: 2000
Bitumen emulsions, anionic:	BS 434: 1984
Bitumen emulsions, cationic:	BS 434: 1984

The type and grade of bituminous binder to be used shall be as specified under the appropriate SECTION of these Specifications for each type of bituminous seal, or in the Special Specifications.

(ii) Non-homogeneous (heterogeneous) modified binders
If non-homogeneous modified binders are required, they shall comply with the requirements in the Special Specifications. Where applicable the following details will be indicated in the Special Specifications:

The bitumen-rubber binder shall comply with the following requirements:

(1) Base bitumen
The bituminous binder used in the production of the bitumen-rubber shall be a 60/70, 80/100 or 150/200 penetration-grade bitumen respectively, or a blend of any two or all three grades to provide a product with the required viscosity properties.

(2) Rubber
The rubber shall be obtained by processing and recycling pneumatic tyres. It shall be pulverised, free from fabric, steel cord and other contaminants. A maximum of 4% by mass of fine particle size calcium carbonate, or talc, may be added to the rubber crumbs to prevent the rubber particles from sticking together. At the time of use the crumbs shall be free flowing and dry and comply with the requirements of TABLE 4302/1.

TABLE 4302/1
RUBBER CRUMBS

Sieve analysis:		**Test Method**
Sieve size (mm)	Percentage passing by mass	
1.18 0.60 0.075	100 40-70 0-5	BR6T (Sabita) *)
Other requirements:		
Natural rubber hydro-carbon content	30% (minimum)	BS 903 Parts B11 and B12
Fibre length	6 mm (maximum)	-
Relative density (kg/m^3)	1100-1250	BR9T (Sabita) *)
*) Southern African Bitumen and Tar Association		

(3) Extender oils
The extender oil shall be petroleum derived material of high aromaticity and shall comply with the requirements of TABLE 4302/2.

TABLE 4302/2
EXTENDER OILS

Property	Requirements
Flash point	180°C
% by mass of saturated hydrocarbons	25% (max)
% by mass of aromatic, unsaturated hydrocarbons	50% (min)

(4) Dilutent
The dilutent shall be a distillate of hydrocarbon.

(5) Bitumen-rubber blend
The bitumen-rubber blend, including extender oil and/or dilutent, it necessary, shall comply with the requirements of TABLE 4302/3.

TABLE 4302/3
BITUMEN-RUBBER BLEND

Property	Requirements
% rubber by mass of total blend	20% - 24%
% extender oil by mass of total blend	6% (max)
% of dilutent by mass of total blend	7% (max)
Blending/Reaction temperature	170°C – 210°C
Reaction time	0.5 - 2 hours

Prior to commencement of the work, the supplier shall state in writing the percentage of rubber and the blending/reaction temperature he/she intends to use for his/her specific product. The actual

percentage of rubber shall not deviate by more than 1.0% from the stated value and the actual reaction temperature shall not deviate by more than 10% from the stated value.

A continuous record of both percentage rubber added and reaction temperatures shall be kept on site by the Contractor.

The bitumen-rubber binder shall comply with the requirements of TABLE 4302/4.

TABLE 4302/4
BITUMEN-RUBBER BINDER

Property	Requirements	Test Method (or equivalent method on approval of the Engineer)
Minimum compression recovery: -after 5 minutes: -after 1 hour: -after 4 hours:	 70% 70% 48-55%	BR3T (Sabita)
Ring-and-ball softening point	Minimum 55^0C	BS EN 12591: 2000
Resilience	13%-35%	BR2T (Sabita)
Dynamic viscosity (Haake at 190^0C)	20 35 cPas	BR5T (Sabita)
Flow (mm)	20 – 75	BR4T (Sabita)

The Contractor shall provide the Engineer with time-temperature ratios in regard to the above properties of his/her specific product before work may start in order to determine the final process and the acceptance limits.

The methods of testing bitumen-rubber material have been published in Manual 3 of the Southern African Bitumen and Tar Association (SABITA).

If a supplier uses a dilutent, an ageing test may be required in which the binder is placed in an oven for 5 hours at 150°C, after which time it shall comply with the above Specifications.

The Contractor shall provide the performance record for three recent projects of the materials he/she intends to use in order to assess the successful use of the materials. The information shall include mean values obtained for the prescribed tests as well as any relevant comments. This information shall be submitted at bidding stage.

(iii) Homogeneous cold applied modified binders
If any polymer other than the elastomer polymers styrene-butadiene rubber (SBR) or styren-butadiene-styrene (SBS) is required for the manufacture of cationic modified bitumen emulsions it shall comply with the requirements in the Special Specifications.

Where applicable the following details will be indicated in the Special Specifications:

(1) Type elastomer polymer
SBR or SBS. Unless otherwise specified SBR shall be used for bidding purposes.

(2) Grade base bitumen
80/100 penetration grade or 150/200 penetration grade. Unless otherwise specified 80/100 penetration grade road grade shall be used for bidding purposes.

(3) Modified binder content
65% or 70% unless otherwise specified 65% shall be used for bidding purposes.

The aforementioned components together with polymer content will dictate the attributes attainable.

Unless otherwise specified, the properties of cationic modified bitumen emulsion containing SBR or SBS solids shall comply with the requirements in TABLE 4302/5 (following page).

A volatile solvent flux content of up to 3% mass by mass of the bitumen may be added to enhance emulsion performance with regard to prevailing climatic conditions.

Any expected change to specified values shall first be discussed with the Engineer prior to the addition of any such enhancer.

The properties of the recovered modified bitumen using a rotary vacuum evaporation method or simple evaporation method as described in CLAUSE 7108 shall be required to comply with the requirements of TABLE 4302/6 (next page).

If there is any discrepancy in the test results on recovered modified binder, then the results on recovered binder obtained from the rotary vacuum evaporation method shall be binding.

(iv) Homogeneous hot-applied modified binders (summer grades)
The requirements for any polymer other than the generic types listed in TABLE 4302/7 (next page) used for the manufacture of homogeneous hot-applied modified binders will be indicated in the Special Specifications.

Where applicable the following details will be indicated in the Special Specifications:

(1) Generic type (plastomer or elastomer) and type polymer.

(2) Grade base bitumen (80/100 or 150/200) required. The aforementioned components together with polymer content will dictate the attributes attainable.

(v) Homogeneous hot-applied modified binders (winter grade)
Where applicable the requirements for homogeneous modified binders (winter grade) will be specified in the Special Specifications.

(b) Aggregates

The aggregate shall consist of approved crushed stone or natural material complying with the relevant requirements set out for each type of seal and the grading, flakiness index and hardness and soundness shall be as specified for each nominal size of stone.

All aggregates shall be clean and free from dust and other deleterious materials.

The polished stone value (PSV) when tested in accordance with BS EN 1097-8: 2000 or equivalent shall be at least 50, unless otherwise specified or approved by the Engineer.

The aggregates shall be tested for stripping employing the following method (the rolling bottle method):

1. Heat the bitumen to 163ºC.
2. Preheat the aggregate for 1 hour at 163ºC to remove all moisture before blending with bitumen.
3. Mix 150 g aggregate and 4.65 g bitumen manually with a spatula (to make a sample having 3% binder content).
4. Re-heat the mixture for 15 minutes at 163ºC in a pulvis bottle (250 ml).
5. Roll the bottle manually 2 minutes and put the coated aggregate in a 500 ml bottle containing 300 g of distilled water.
6. After cooling, remove the water from the bottle and store the cooled sample at room temperature for 24 hours.
7. Fill the bottle with distilled water and roll the bottle containing the sample in the rolling bottle machine for 96 hours.
8. After one week curing in the bottle, wash the sample with fresh water and evaluate the coating degree.

The degree of coating when measured in accordance with the test method described above shall be a minimum 60%.

The aggregates shall be washed when it is considered necessary by the Engineer or his/her appointed representative.

TABLE 4302/5
CATIONIC MODIFIED BITUMEN EMULSION

Polymer modifier	**Required properties, grade of base bitumen**	**Minimum modified binder content (%)**	**Minimum viscosity at 50°C Saybolt Furol (sec.)**	**Maximum residue on sieving (g/100ml)**	**Particle charge**	**Sediment-ation after 60 rotations**
SBR	80/100 150/200	70 65	80 70	0.25 0.25	Positive Positive	Nil Nil
SBS	80/100 150/200	70 65	80 50	0.25 0.25	Positive Positive	Nil Nil
Test Method	-	ASTM D244	ASTM D244	BS EN 1097-8: 2000		

TABLE 4302/6
RECOVERED MODIFIED BITUMEN

Polymer modifier	**Required properties**				**Elastic recovery (%)**		
	Grade of base bitumen	**Mini-mum Softening point (°C)**	**Minimum dynamic viscosity at 135°C (Pa.s)**	**Mini-mum ductility at 10°C (mm)**		**at 5°C (%)**	**at 50°C (%)**
SBR						90 90	100 100
SBS	80/100 150/200	60 47	1.2 1.0	500 500	55 60	90 90	100 100
Test Method	-	ASTM D36	ASTM D4402	DIN 52013	DIN 52013	DIN 52013	TMH method B11
Note: Modified binder is bitumen plus polymer. The dust content criteria shall be according to TABLE 4302/8 grade 2 stone for the adhesion test.							

TABLE 4302/7
HOT-APPLIED MODIFIED BINDERS, REQUIRED PROPERTIES

Genetic type of modified binder		**Required properties**							
		Grade of base bitumen	**Minimum Softening point (°C)**	**Minimum dynamic viscosity at 135°C (Pa.s)**	**Minimum ductility at 10°C (mm)**	**Minimum elastic recovery 10°C (%)**	**Maximum stability difference (°C)**	**Minimum adhesion**	
								at 5°C (%)	**at 50°C (%)**
Plastomerpolymer (EVA)		150/200	48	0.5	300	45	2	90	
Elasto-merpol-ymer	SBR SBS SBR SBS	80/100 80/100 150/200 150/200	47 49 45 47	1.0 1.0 0.5 0.5	1000 500 1000 500	55 60 55 60	2 2 2 2	90 90 90 90	100 100
Test Method	-	-	ASTM D36	ASTM D4402	DIN 52013	DIN 52013	DIN 52013	TMH 1 Method B11	

(c) Slurry

(i) Filler for slurry
Common cements shall comply with the requirements of US 310-1:2001/EAS 18-1, BS EN 197-1:2000 or equivalent standard on approval of the Engineer.

Road lime shall comply with the requirements of US 288:2001, AASHTO M216-92, or equivalent (Lime for Soil Stabilisation).

Only one of the above materials shall be used throughout in order to prevent undesirable colour differences in the surface.

(ii) Immersion index
The immersion index of briquettes made with slurry aggregate and penetration-grade bitumen at the specified net bitumen content for the slurry shall be not less than 75.

(d) Hydrophilic aggregates
Where hydrophilic or other aggregates that may cause problems are encountered, the Engineer may order that the stone chips be precoated, as described below, or that a fog spray be applied, as specified in SUBCLAUSE 4403(e).

(e) Precoating

(i) Precoating of aggregate for stockpiling or for immediate use.
The method to be employed for the precoating of chippings shall be described in the Special Specifications and be approved by the Engineer.

The wetting agent approved by the Engineer shall be added to the precoating fluid at a rate of 0.5% of the volume of precoating fluid.

The mixture of aggregate and precoating fluid shall then be dumped on a site prepared as specified in CLAUSE 4306. This process shall be repeated until a stockpile of approximately 15 m^3 to 20 m^3 has been built up.

This stockpile shall then be turned over with the front-end loader until the aggregate is uniformly coated with the precoating fluid. Three complete turnings of the stockpile may be required.

The time between the precoating and the placing of the aggregate shall not exceed the time given in the Special Specifications or agreed on by the Engineer and the Contractor. Before the aggregate is used the precoating fluids shall have set or dried sufficiently in the opinion of the Engineer.

All aggregates used with hot-applied homogeneous and non-homogeneous modified binders, shall be precoated.

Precoating stockpiles shall be covered to protection the chippings against rain and contamination.

(ii) Precoating constraints
No precoating shall be applied where emulsion binders are used unless specifically specified or ordered by the Engineer.

4303 CONSTRUCTION EQUIPMENT

(a) General
All construction equipment used on the Works shall be of an adequate rated capacity and in a good working condition.

All construction equipment that will be operated on the road during construction of the seal shall be free from any binder, fuel or oil leaks and no refuelling or servicing of any equipment will be allowed to take place while such equipment is on the road.

(b) Binder distributors

(i) General
The binder distributor shall comply with all the provisions of CLAUSE 4103.

(ii) Non-homogeneous modified binder
The binder distributor used for non-homogeneous modified binder shall be adapted to spray the rubber-modified binder satisfactorily. The Contractor shall provide proof by way of a test on the site that the binder distributor has sufficient reserve power to maintain the required constant speed up the steepest incline to which spray has to be applied, and to obtain a uniform distribution of the mix. The optimal spray-bar level shall be determined during testing, and the spray-bar level shall be adjusted accordingly before each spray. The uneven application of binder will be unacceptable. In addition to the requirements of CLAUSE 4103 the equipment shall be capable of heating the binder to 210°C.

(c) Chip spreaders
The chip spreaders shall be capable of spreading stone of the specified size uniformly over widths varying between 2.4 m and 4 m and shall be capable of adjustment to permit variation of the rate of application within the specified tolerances, and uniform spreading in both the transverse and longitudinal directions.

At least two chip spreaders shall be provided, one of which shall be self-propelled.

Spreaders that are not self-propelled shall be of a type that can be attached quickly to the rear of trucks, and operated while backed over the stone chippings being spread.

(d) Rollers
Sufficient operational rollers of each of the following types shall be available on the Works to maintain the required tempo of work:

(i) Pneumatic-tyred rollers
Pneumatic-tyred rollers shall be of a self-propelled type equipped with smooth flat profile pneumatic tyres of uniform size and diameter. The mass of the roller shall not be less than 15 tonnes (unloaded).

The rollers shall be equipped with suitable devices for keeping the wheels wet and clean during operation.

The wheels of the roller shall be so spaced that one pass of the roller will provide one complete coverage equal to the rolling width of the machine.

The Engineer at his/her discretion may vary the total operating mass and tyre pressure. Individual tyre pressures shall not differ by more than 35 kPa from one another.

(ii) Rubber-soled steel-wheeled rollers
Rubber-soled steel-wheeled rollers shall be self-propelled, and have a mass of between 6 and 8 tonnes. It shall be equipped with suitable devices for cleaning and moistening the wheels.

The wheels of the roller shall be so arranged as to give one complete coverage by one passage of the

roller over a width equal to the rolling width of the roller.

(iii) Steel-wheeled rollers
Steel-wheeled rollers shall be self-propelled three-wheel or tandem rollers of between 6 and 8 tonnes mass and shall be equipped with suitable devices for cleaning and moistening the wheels. The mass of the roller required shall be determined by the Engineer. No steel-wheeled rollers shall be used without the consent of the Engineer.

(iv) Additional requirements
The type and number of rollers shall be subject to the approval of the Engineer for each type of seal and the proposed programme.

No seal work shall continue if the required rollers are not on site or in an operational condition.

(e) Brooms

(i) Drag broom
The drag broom shall be of a size, type and mass that will enable the chips to be distributed evenly over the surface without dislodging any chips from the binder.

(ii) Rotary broom
An approved rotary broom, complete with towing vehicle fitted with smooth pneumatic tyres, shall be available at all times on the Works.

(f) Mixer for slurry
A mobile mixer of a type approved by the Engineer shall be provided. It may be either a batch mixer or a continuous type mixer. The paddles of the mixer shall be so designed as to ensure a complete blending of the constituents of the slurry.

For the rapid setting slurry types, the mixing and application of the slurry shall be done by a mixer designed to provide a rapid mixing time, and sufficient agitation within the spreading system to prevent segregation or premature hardening. The mixer shall be capable of continuous mixing and application.

The purpose designed mixer for continuous type mixing of either conventional or rapid setting slurries, shall be equipped with precise metering systems to enable the various constituents to be combined continuously to the prescribed formulation.

No central mixing equipment will be allowed. Details of the type of mixer shall be submitted in advance of actual construction, for approval by the Engineer.

(g) Loader for slurry
A loader, or equivalent capacity labour force where so required in the Special Specifications, compatible with the needs and capacity of the mixer unit shall be available at the stockpiling site.

(h) Spreader box for slurry
The type of spreader box used for spreading the slurry shall be submitted to the Engineer, in advance, for approval. The spreader box for rapid setting slurry shall be of a proven and approved type, fitted with a proven and approved device to ensure sufficient agitation within the spreader system.

The spreader box shall be so constructed as to distribute the weight onto metal skids in such a way that no damage shall be done to the surface when the box is in operation.

Soft rubber belting shall be attached to the framework in such a manner as to prevent slurry from being spilt past the sides of the spreader box when the box is in operation.

The spreader box shall be capable of spreading a uniform application of the slurry in adjustable widths from 1.5 m to 4 m, at specified rates, and it shall have efficient mechanical means of adjusting the rates and widths of application specified.

(i) Precoating equipment
The precoating of chips may be done in any suitable equipment capable of uniformly coating the chips.

(j) Mass-measuring device
Where payment per tonne is specified, the Contractor shall keep available on the site as directed by the Engineer, a suitable gauged mass-measuring device. The device shall be provided with a printer for printing the mass, the time and date. The printed data shall be submitted to the Engineer on a daily basis.

(k) Miscellaneous equipment
Sufficient equipment for handling and hauling aggregate, binder and slurry, and blending units for non-homogeneous modified binders, shall be provided to ensure prompt and continuous placing and application of bituminous materials as specified. The Contractor shall have available all the necessary ancillary equipment and hand tools to carry out the work efficiently.

Suitable fire-fighting equipment for dealing with bitumen fires shall be available on site, together with suitable first aid equipment for dealing with bitumen burns. (Refer to Sabita Manual 8: Bitumen Safety Handbook.)

The Engineer shall be entitled to request reserve equipment, should there be any doubt as to the efficiency or capability of the equipment provided.

4304 GENERAL LIMITATIONS AND REQUIREMENTS

(a) Weather limitations
The minimum road-surface temperatures at which the spraying of the different types and grades of binder may be done are:

(i) Conventional binders
- Penetration grade bitumen:
  150/200 penetration-grade bitumen: 20°C
  80/100 penetration-grade bitumen: 25°C
- Cutback grade bitumen MC800 / MC3000: 10°C
- Bitumen emulsions: 10°C

(ii) Non-homogeneous modified binders:
- Bitumen-rubber (spray application) 20°C

(iii) Other non-homogeneous modified binders:
As set out in the Special Specifications.

(iv) Homogeneous cold applied modified binders
- SBR modified cationic emulsion: 10°C
- SBS modified cationic emulsion: 10°C

(v) Homogeneous hot-applied modified binders
- Modified binder 150/200 penetration grade base bitumen: 20°C
- Modified binder 80/100 penetration grade base bitumen: 25°C

(vi) Other homogeneous hot-applied modified binders
As set out in the Special Specifications.

(vii) General

Whenever the temperature of the road surface falls below the aforesaid temperature for the binder in question, or, in the opinion of the Engineer, will probably fall below the required temperature before spraying the binder, no binder shall be sprayed.

No bituminous work shall be done during foggy or rainy weather, and, when a cold wind is blowing, the above temperatures shall be increased by 3°C to 6°C as directed by the Engineer.

Conventional slurry shall not be applied at an air temperature of less than 7°C when temperatures are rising, or less than 13°C when temperatures are dropping. Rapid setting slurry shall be sufficiently versatile to be laid in air temperatures of 4°C to 40°C, as well as capable of being laid under damp conditions.

During hot weather slurry operations shall be suspended when aggregate is being displaced by the spreader box or squeegees.

When the breaking process accelerates to such an extent that it renders the product unworkable to attain the required end result, for instance when the surface temperature is in excess of 60°C, or as otherwise prescribed by the Engineer, no sealing shall be done.

When strong winds are blowing which are likely to interfere with the proper execution of the work, no sealing, especially spraying of binder, shall be done.

(b) Moisture content

No seal shall be placed unless the moisture content of the upper 50 mm of the base is less than 50% of the optimum moisture content as determined by the Engineer. No reseal shall be placed immediately after a rainy spell on an existing partly cracked and/or highly permeable surfacing resulting in the trapping of moisture in the pavement structure. A minimum delay of 24 hours or such extended period as ordered by the Engineer shall apply.

(c) Other constraints

(i) The following curing periods shall apply to the various treatments listed, prior to applying a seal/reseal unless otherwise given in the Special Specifications:
- Texturing using fine slurries: 6 weeks
- Rapid setting slurry (rut filling, etc): 12 weeks
- Crack sealing: 2 weeks
- Repair of distressed patches: 6 weeks

(ii) Unless otherwise agreed by the Engineer, and subject to the outcome of a trial section, the Contractor shall programme all spraying to cease each working day at 15:00 hours.

(d) Preparation of areas to be sealed

(i) General
The areas to be sealed shall be cleaned of all dust, dirt, dung, oil or any other foreign matter that may be deleterious to the seal.

(ii) Newly constructed seals
Where newly constructed base or shoulder areas are to be sealed, the surfaces shall be checked for compliance with the surface tolerances and all other requirements specified. Any portions that do not meet these requirements shall first be either corrected or removed and reconstructed before they are sealed.

(iii) Existing surfaces to be resealed

Existing roads that require resealing shall, if so specified or ordered by the Engineer, be given a pre-treatment in accordance with one or more of the methods described in SECTION 4800.

Any failures shall be repaired as set out in the Special Specifications.

(e) Demarcation of working area

(i) New work
The Contractor shall demarcate the area of the primed base to be sealed by means of setting out wire lines down each edge of the specified seal width.

(ii) Reseal work
Immediately before the tack coat or bituminous binder is sprayed, the centre line of the road shall be marked by a 3 mm thick sisal or hemp twine, secured by nails driven, at 15 m intervals on straights and 5 m intervals on curves, into the existing surface.

This twine shall be left in position during all subsequent operations.

4305 HEATING AND STORAGE OF BITUMINOUS BINDERS

(a) Conventional binders

The temperature ranges between which bituminous binders are to be heated shall be as given in TABLES 4305/1 and 4305/2.

Binders stored in a heated condition shall be kept in a container with a securely fitting lid, the circulatory system of which is functioning properly.

The container shall be provided with a built-in thermometer.

Binders which have been heated above the maximum temperatures indicated in this table shall not be used and shall be removed from the site.

Every effort shall be made to maintain the binder temperature for spraying to within 5°C of the recommended temperature.

For single seals the temperature limits for 150/200 penetration-grade bitumen, cut back with the indicated amounts of kerosene in parts per 100 parts of bitumen by volume as described in SECTION 4400, shall be as set out in TABLE 4305/3.

TABLE 4305/1
MAXIMUM STORAGE TEMPERATURES, CONVENTIONAL BINDERS

Materials	Maximum storage temperature (°C)	
	Over 24 hours	Up to 24 hours
Pen. grade bitumens:		
- 150/200 pen grade	115	165
- 80/100 pen grade	125	175
Cut-back bitumen:		
MC-800	75	125
MC-3000	100	155
Bituminous emulsions: 60%, 65% or 70%	Air temperature (all types)	60 (all types)

(b) Cutting back bitumen on site
Kerosene shall be used as the cutter where correction of viscosity is required or cutback bitumen is to be made on site from penetration grade bitumen. Allowance shall be made for quantities between 0 – 45% by volume of the total quantity hot sprayed bitumen, as directed by the Engineer. The Contractor's attention is drawn to the potential hazards involved in the cutting back operation and he/she shall take all necessary precautions to prevent fire.

The temperature of the bitumen, when the kerosene is introduced, shall not be higher than 140°C.

TABLE 4305/2
HEATING AND SPRAYING TEMPERATURES, CONVENTIONAL BINDERS

Materials	Heating and spraying temperatures (°C)		
	Min	Max	Recom-mended
Pen. grade bitumens:			
150/200	150	175	165
80/100	175	190	180 - 185
Cutback bitumens:			
MC-800	110	135	125
MC-3000	135	155	145
Bituminous emulsions: 60%, 65% or 70%	Air temp. (all types)	60 (all types)	60 (all types)

The kerosene shall be sucked in measured quantities through the bitumen pump to the bottom of the tank and circulated with the bitumen for a minimum of 45 minutes. During this process all burners shall be shut off and no open flames allowed near the distributor.

The power paraffin shall not be introduced into the distributor through the manhole, which shall be kept closed. Each distributor shall at all times have two fire extinguishers in good working order available.

TABLE 4305/3
TEMPERATURE LIMITS FOR CUTBACK BITUMEN

Proportion of kerosene (% of total volume of mixed binder)	Spraying temperature	
	Lower limit °C	Upper limit °C
5%	140	155
10%	125	145
15%	105	125
20%	90	110

(c) Non-homogeneous (heterogeneous) modified binders modified with rubber
After completion of the bitumen-rubber reaction, the binder shall be cooled to below 160°C. The binder mixture may not be kept for more than 2 days. The mix may only be stored in tanks with circulation systems.

The spray and storing temperatures of the bitumen-rubber binder shall comply with the following requirements:
- Spray temperature (°C): Provided by supplier
- Max storing time at spray temperature: 4 hours
- Max storing temperature (up to 2 days): 35°C below spray temperature, but not more than 160°C

Binder that has failed to meet the requirements for storage and handling shall not be used and shall be removed from the site.

(d) Other Non-homogeneous modified binders
The Contractor shall comply with the requirements given in the Special Specifications with regard to the storage, heating and spraying temperatures, and with regard to the information to be provided in the bidding stage, unless otherwise approved by the Engineer.

(e) Homogeneous cold applied modified binders
Modified bitumen emulsions may be stored at ambient temperature for long periods, provided that some circulation/mixing takes place from time to time. The spraying temperatures of these emulsions are the same as for conventional bitumen emulsions.

Excessive temperature over extended periods will degrade all modified bitumen and negatively affect the properties of these binders.

The temperature limits for the storage and spraying of modified hot-applied binders shall be as set out in TABLE 4305/4 unless otherwise approved by the Engineer.

TABLE 4305/4
TEMPERATURE LIMITS FOR STORAGE AND SPRAYING, MODIFIED BINDERS

Bitumen grade used	Poly-mer type	Max storage temp.(°C)		Spraying temp. (°C)	
		Up to 24h.	24 to 48h.	Max.	Min.
80/100	EVA	175	150	180	170
150/200	EVA	175	150	180	170
80/100	SBR	175	150	210	190
150/200	SBR	175	150	200	180
80/100	SBS	175	150	180	165
150/200	SBS	175	150	180	165

Modified binders stored in a heated condition shall be kept in a container having a properly functioning circulation system and a securely fitting lid.

Many long chain polymers have low shear stability and can be degraded by the action of a high shear rate pump such as a close tolerance gear pump. Any material damaged by handling shall not be used on the road and shall be removed from site.

The Contractor shall comply with the requirements of the Special Specifications with regard to the storage, heating and spraying temperatures, and with regard to the information to be provided in the bidding stage, unless otherwise approved by the Engineer.

4306 STOCKPILING OF AGGREGATE

(a) General
Sites for the stockpiling of aggregates shall be prepared in such a manner that no grass, mud, dirt or other deleterious material will be included when the aggregates are loaded for use.

Access roads to stockpile sites shall be prepared and maintained in such a way that no dirt is conveyed by vehicle wheels onto the areas to be sealed or resealed whilst aggregate is being transported to or from the stockpiles.

Stockpiles shall be so sited that they will not be exposed to excessive contamination with dust arising from traffic on the road or access roads.

Aggregates contaminated to the extent that it contains more than the allowable percentage of material passing through the 0.425 mm sieve and 0.075 mm sieve shall not be used for sealing.

(b) Precoating
Areas used for stockpiling precoated aggregate shall be so sited that dust deposited on the chips is prevented. Where necessary, temporary diversions and access roads in the immediate proximity shall at the Contractor's own cost be watered, sprayed with a suitable chemical dust suppressant, or sealed.

During the wet season when there is danger of the precoating fluid being washed off the aggregate, the stockpiles shall be covered with tarpaulins or similar protective coverings.

During cooler periods the Engineer may order that stockpiles be covered with tarpaulins to ensure that the aggregate temperature remains compatible with the limiting temperature applicable to the specified binder type.

4307 CONSTRUCTION OF SEALS

(a) General
Adequate advance notice shall be given to the Engineer before the Contractor proceeds with any seal work.

(b) Single and double aggregate seals

(i) Application of binder coat and aggregate
A bituminous coat consisting of the type and grade of binder specified in these Specifications under each of the appropriate Sections for each type of bituminous seal, or in the Special Specifications, shall be sprayed on the properly cleaned and prepared base or existing surface over the full specified width of the seal.

Where the tank of the binder distributor could become empty during spraying against inclines, the spraying shall be done while the binder distributor is moving uphill. Should the Engineer be of the opinion that the Contractor is unable to place the sealant over the specified width in one movement, the Contractor shall execute the spraying and the distribution of the chips in strips. The spraying of adjacent strips shall overlap by 100 mm. Chips may not be placed on the 100 mm overlap before the adjacent strip has been sprayed. The adjacent strip may not be sprayed before the preceding strip, excluding the 100 mm overlap, has been covered satisfactorily with chips in compliance with the Specifications. In so far as is practicable, the Contractor shall so place the strips that the joint between two adjacent chip applications shall fall on the centre line of the road.

Immediately after the binder has been sprayed, it shall be covered with clean, dry aggregate of the size given in these Specifications under each of the appropriate Sections for each type of seal.

The actual rates of application of binder and aggregate to be used in the construction will be determined by the Engineer, after he/she has tested the aggregates the Contractor proposes to use for the seal and prior to any sealing being carried out.

The aggregate shall be applied uniformly by means of self-propelled chip spreaders, unless otherwise specified. In the case of single seals, the use of a self-propelled chip spreader shall be obligatory. The immediate application of the chips is of prime importance. The chip spreader shall be so operated that the tack coat shall be covered with aggregate before the wheels of the chip spreader or truck pass over the uncovered tack coat.

The quantity of bitumen sprayed in any single spray operation shall be governed by the quantity of aggregate, and the number of trucks available shall be sufficient to ensure the continuous application of stone behind the distributor. In addition the available roller capacity at normal operating speed shall also govern the extent of the tack coat and aggregate that may be applied.

(ii) Initial rolling of aggregate
Immediately after the aggregate has been applied, rolling shall be commenced. A self-propelled 15-tonne pneumatic-tyred roller only shall be used in the case of single seals, and a steel-wheeled roller may also be used in the case of double seals on condition that excessive crushing of the aggregate shall not take place. Rollers shall operate parallel to the centre line of the road, from the shoulders inwards towards the crown of the road, until the entire surface has been covered at least three times with the wheels of the roller.

(iii) Broom drag and final rolling of aggregate
After the bituminous binder has set-up sufficient to prevent any aggregate from being dislodged, the surface shall be slowly dragged with a broom drag to ensure even distribution of the aggregate.

If there are areas which are deficient in stone chips, additional material shall be added by hand so as to leave a single layer of chips lying shoulder to shoulder. If there are areas with an excess of stone chips, such excess shall be removed by hand so as to leave a single layer of chips lying shoulder to shoulder.

The importance of applying only a single layer of chips is stressed. Every care shall be taken to avoid an over-application of stone.

After completing the spreading of the aggregate, the surface shall be rolled with a 15-tonne pneumatic-tyred roller for three to four coverages.

Except in the case of single seals final rolling shall then be done with a steel-wheeled roller with a mass of 6 to 8 tonnes working parallel to the centre line of the road from the shoulders towards the crown of the road, until every portion of the surface concerned has been covered by at least two to four passes of the roller, provided that only a limited degree of crushing of the aggregate will take place, but if, in the opinion of the Engineer, general crushing occurs under the rollers, such rolling shall be stopped regardless of the number of passes completed by the roller.

The surface shall be well knit and have a uniform appearance free of roller-tyre marks; all aggregate contaminated by fuel, oil or grease shall be removed and replaced with clean aggregate.

(iv) Joints between binder sprays
In order to prevent overlapping at junctions of separate binder applications the previous work along the joint shall be covered with twin-reinforced building paper for a sufficient distance back from the joint to ensure that the sprayer is operating at the required rate before the untreated surface is reached, and also to prevent additional binder

application onto the previously treated section. The same method shall be used to ensure a neat joint at the end of the run.

(v) Protection of kerbs, channels, etc
Kerbs, channels, guttering, manholes, guard rails, bridge railings and any other structures which may be soiled by bituminous binders during spraying operations shall be protected in terms of SECTION 2300 during spraying operations.

The Contractor shall replace at his/her own cost any items that have been soiled and cannot be cleaned entirely. The painting of soiled surfaces will not be accepted as a suitable remedy.

(c) Slurry seals
Slurry seals shall be applied as specified in SECTION 4600.

4308 RATES OF APPLICATION

Whenever the terms or quantity of bitumen, spray rate or application rate are used in these Specifications to specify the rate of application of the binder for conventional or homogeneous modified binder, they shall mean at spraying temperature.

All rates of application for seal works shall be properly designed by the Contractor and approved by the Engineer prior to any trial sections of the works.

All rates of application for seal works shall be documented daily and recorded on a spray record sheet.

All binders, aggregates, and slurry used in the various types of seals shall be applied at the rates of application as determined by the Engineer after tests on the materials proposed for use.

No payment will be made for bituminous binder applied in excess of the rate ordered unless, in the opinion of the Engineer, such overspray or any shortages can be satisfactorily corrected in the case of a first application by the adjustment of the application rate of a subsequent spray.

Unless otherwise specified, the nominal rates of application of bituminous binders given in further sections, and also the variations in application rate, shall be measured at spraying temperature.
The nominal rates of application are for bidding purposes only and will not necessarily be used in construction. The actual rates of application to be used on the site shall in all cases be as instructed by the Engineer.

4309 DUST CONTROL

Any temporary diversions and construction roads shall be kept watered and damp, or sprayed with a suitable chemical dust suppressant, during all sealing operations and all dust shall be removed from surfaces before any binder, aggregate or slurry is applied.

The supply and application of water or chemical dust suppressants on temporary diversions will be paid for separately as specified in SECTION 1500, but payment for dust control on the haul and construction roads shall be included in the unit rates bid for the various types of seals used.

4310 OPENING TO TRAFFIC

The Engineer shall be responsible for determining when any sealing layer is to be opened to public traffic.

The road shall not be opened to traffic until the binder has set sufficiently to retain the aggregate, or in the case of slurry seals, the slurry has set sufficiently so as not to be picked up by the wheels of passing traffic.

The Contractor shall not allow any construction equipment, which is likely to cause damage, over the completed seal. The Contractor shall display speed restriction signs in accordance with SECTION 1500 and the instructions of the Engineer.

4311 DEFECTS

Where, in the opinion of the Engineer, any unacceptable loss of stone from, or bleeding of the road surface that occurs during the course of the Contract or during the maintenance period, and that can be attributed to the Contractor not observing any of the requirements of the Specifications, not using the correct rates of application, or to any other omission or fault on the part of the Contractor, the work shall be rejected, and any corrective work shall be at the Contractor's cost, including the supply, precoating, stockpiling at selected sites and later removal if not used, of any aggregate reserved for corrective work during the period of maintenance or thereafter.

The Contractor shall carry out an investigation to determine the reasons for the defect works and send a proposal of how the works should be repaired. No repair works shall be implemented prior to the Engineer's approval of the investigation of the cause of the defect and the Contractor proposal to repair them.

4312 MAINTENANCE

The Contractor shall maintain the bituminous surface until the work is handed over to the Employer. Any damage done to the surface or any defects which may develop before the date of substantial completion shall be corrected by the Contractor at his/her own cost and to the requirements of the Engineer.

4313 TOLERANCES AND FINISH REQUIREMENTS

(a) Binder spray rates
The following terms are used for measure of binder spray rates:

- *CONVENTIONAL BINDERS*: Conventional binders shall be measured at spraying temperature in litres per square metre.
- *MODIFIED BINDERS*: Whenever the terms "net bitumen" or "net quantity of bitumen" are used in these Specifications to specify the rate of application of the binder for conventional or homogeneous modified binder (hot or cold), they shall mean viscosity grade (penetration-grade) bitumen net cold. Non-homogeneous modified binders, however, shall be specified at spraying temperature.

(b) Surface tolerances, rate of application, conditional acceptance
The completed seal shall be free from corrugations or any other wave effect where depressions are preceded and followed by humps or ridges no matter how small the distance between the top of the hump to the bottom of the preceding or following depression.

The completed bituminous work shall comply with the requirements set out in SECTION 7300 regarding surface tolerances and finish. The provisions of SECTION 7200 shall apply to conditional acceptance.

(c) Surface appearance

The completed seal shall be of uniform texture without gaps or patches and shall be free from any loose aggregate or bitumen spillage.

Corrective work shall be carried out in such a manner as to blend in colour, texture and finish with adjacent work.

The completed seal should be an even mosaic of aggregates firmly held by the bitumen so that there is no stripping of the aggregates or bleeding and providing a good even skid resistant surface.

In double seal applications the aggregates should be matched to give the maximum mechanical interlock.

4314 MEASUREMENT AND PAYMENT

Measurement and payment will be made under the various sections where the different seals are described.

SERIES 4000: BITUMINOUS LAYERS AND SEALS

SECTION 4400: SINGLE SURFACE DRESSINGS

CONTENTS:

4401 SCOPE

This Section covers the supply and furnishing of all materials for the repair of existing surfaces and for the construction of reseals or new single seals.

The requirements of all relevant clauses of SECTION 4300 shall apply to this Section.

4402 MATERIALS

(a) Bituminous binders

The bituminous binder shall consist of one of the following binders, whichever is specified in the Special Specifications or the Bill of Quantities or ordered by the Engineer:

- 80/100 penetration-grade bitumen;
- 150/200 penetration-grade bitumen,
- 60%, 65% or 70% spray-grade emulsion;
- MC-3000 cut-back bitumen;
- Modified binder as specified.

(i) Bitumen coats
The specified bituminous binders shall comply with the conditions of SECTION 4300.

(ii) Fog spray
Fog spray, when specified, shall be 30% or 60% spray grade emulsion of anionic or cationic type, as specified or ordered by the Engineer.

(iii) Pre coating fluid
Pre coating fluid, when pre coating of aggregate is specified, shall be bitumen emulsion, or alternative approved types, as specified or ordered by the Engineer.

(b) Aggregate

Aggregate for surface dressing shall consist of clean, tough, durable fragments of crushed stone free from any deleterious matter and shall comply with the requirements given in TABLES 4402/1 and 4402/2.

TABLE 4402/1
GRADING LIMITS AND REQUIREMENTS FOR CHIPPINGS

	Chipping, nominal size of aggregates, (% passing)			
	20 mm	14 mm	10 mm	7 mm
Sieves (mm):				
25	100			
20	85-100	100		
14	0-30	85-100	100	
10	0-5	0-30	85-100	100
6.3	-	0-5	0-30	85-100
5	-	-	0-5	0-30
2.36	-	-	-	0-5
Fines: 0.425	< 0.5	< 1.0	< 1.0	< 1.5
Dust: 0.075	< 0.3	< 0.5	< 0.3	< 1.0

TABLE 4402/2
REQUIREMENTS FOR CHIPPINGS

Aggregate properties	**Chipping, nominal size of aggregates**			
	20 mm	14 mm	10 mm	7 mm
Maximum Flakiness index *BS 812 : 105.1*	20	25		30
Minimum strength, TFV dry. *BS 812 : 111*	***)** For AADT $\geq$ 1000: 160 kN			
	***)** For AADT < 1000: 120 kN			
Ratio dry to soaked value of TFV. *BS 812 : 111*	TFV_{soaked} shall be minimum 75% of the corresponding TFV_{dry} value			
***)** The appropriate traffic volume that applies to any location, shall be as given in the Drawings or Special Specifications. Where such information is not given, the decision of the Engineer shall apply.				

(c) Average Least Dimension (ALD)
The ALD of the chippings shall be tested by the following method:

1. A sieve analysis is first carried out on a sample of the chippings and the results plotted on a large scale grading curve. The median size of chipping is then determined as that theoretical sieve size through which 50 percent of the material will pass.
2. The flakiness index is determined.
3. Then using Figure 4402/1 the median size is marked on scale A and flakiness index on scale C. A straight line is drawn between the two marks and the ALD read off on scale B.

The ALD of the chippings when tested as described above shall meet the requirements of Table 4402/3.

FIGURE 4402/1
FIGURE FOR THE DETERMINATION OF THE AVERAGE LEAST DIMENSION

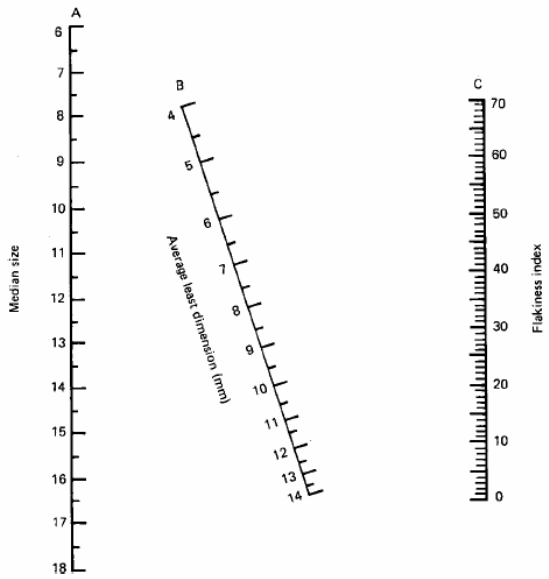

TABLE 4402/3
ALD REQUIREMENTS FOR CHIPPINGS

Nominal size of aggregate (mm)	ALD Requirement (mm)
20	11 - 15
14	8 -10
10	5 - 6.5
7	2 - 4

4403 CONSTRUCTION

(a) Preparation of the surface
Surface treatment shall not commence until the existing surface has been repaired of any defects and cleaned to the satisfaction of the Engineer by the use of brooms, water, compressed air or any other method required to give a satisfactory result.

Kerbs, channels, guttering, manholes, guard rails, bridge railings, and any other structures that may be soiled by bituminous binders during spraying operations shall be covered with suitable plastic sheeting during spraying operations.

The sheeting shall be kept firmly in position by soil, stones or adhesive tape in such a manner that it will not lift or be blown away during windy conditions but will keep the areas to be protected fully covered.

The use of paper bags, sand or other materials will not be permitted in lieu of plastic sheeting and the Contractor shall replace at his/her own expense any items that have been soiled and cannot be cleaned entirely. The painting of soiled surfaces will not be acceptable as a suitable remedy.

(b) Application of binder and aggregate

(i) General
The bitumen coat and aggregate, of the types and sizes specified in the Special Specifications, or ordered by the Engineer, shall be applied as specified in SUBCLAUSE 4307(b).

The Contractor shall demonstrate the suitability of the application rates together with construction equipment and methods by carrying out trial sections for the approval by the Engineer.

The Trial sections shall be carried out on surfaces identical to those used in the permanent works and shall include at least 3 different binder and aggregate application rates covering the range of application rates determined according to both publications mentioned above. Each combination of application rates shall be spread on a trial length of minimum 25 m.

Chip spreaders shall be checked and calibrated before starting any trial or permanent work and further when required by the Engineer.

(ii) Nominal rates of application
The nominal rates given are for information only. The application rates for which payment is calculated, are given in the Bill of Quantities. If, however, no application rates are given in the Bill of Quantities, then the rates in TABLE 4403/1 shall be used for bidding purposes.

TABLE 4403/1
NOMINAL RATES OF BINDER AND AGGREGATE APPLICATION, SINGLE SURFACE DRESSING

Nominal size of aggregate (mm)	Nominal rates of application	
	Binder hot spray rate (l/m^2)	**Aggregate spread rate (kg/m^2)**
20	1.80	19
14	1.50	14
10	1.10	11
7	0.80	7

(iii) Actual rates of application
The actual rates of application for use on site on any part of the Works, shall be as determined on site, on approval of the Engineer.

The difference in actual rates of application compared to the rates for bidding purposes are paid for separately in variation rates measured in tonnes and litres (hot sprayed) for aggregate and binder respectively, as specified in CLAUSE 4404.

Brooming of chippings after spreading to effect redistribution will not be permitted. Any excess of chippings shall be removed by hand and any

insufficiently chipped area shall be chipped by hand to obtain adequate coverage.

(c) Initial rolling
Initial rolling shall be carried out as specified in SUBCLAUSE 4307(b).

The main rolling shall be carried out with self propelled pneumatic-tyred rollers having a wheel load of more than 2 tonnes.

The tyres shall be smooth and the tyre pressure shall be minimum 0.4 N/mm^2. The number and capacity of rollers shall be sufficiently to ensure that rolling does not lag behind spreading. As a minimum 2 pneumatic rollers shall be used for each chip spreader.

Rolling shall begin immediately after the chippings have been spread and, in no case, later than 2 minutes after the application of the binder. Rolling shall continue until all chippings are firmly embedded into the binder.

The number of passes shall be as agreed with the Engineer, but as a rule all chippings shall receive at least six passes of the pneumatic tyred roller. Excessive rolling resulting in crushing of chippings shall be avoided.

The roller speed shall not exceed 8 km/hr, unless otherwise agreed with the Engineer.

The road shall not be opened to traffic until the binder has attained sufficient viscosity to prevent the chippings being whipped off.

(d) Final rolling
Any areas deficient in aggregate shall have additional material added so as to leave the carpet with a single layer of chippings lying shoulder to shoulder. It is essential to ensure that only one layer of chippings is applied and every care shall be taken to avoid over-application of chippings.

The final rolling shall be done with a pneumatic-tyred or a rubber-soled steel-wheeled roller only, applying a minimum of four coverages.

The finished surface shall be well-knit and have a uniform appearance free of roller-tyre marks. All aggregate contaminated by oil, fuel or grease shall be removed and dumped in an approved waste site and replaced by clean aggregate. All loose aggregate shall be broomed off the surface with a rotary broom or hard brooms as directed by the Engineer.

(e) Fog spray
If stated in the Special Specifications, or if so directed by the Engineer, a fog spray of 60% or 30% anionic or cationic emulsion shall be applied to the surface of the aggregate by means of a pressure distributor at the required rate.

(f) Blinding
If stated in the Special Specifications, or if so directed by the Engineer, a light blinding layer of natural or crusher sand shall be applied by the Contractor to prevent chippings from being picked up by traffic. The blinding layer shall be spread evenly over the full indicated surface. Should it be required by the Engineer, the layer shall be spread evenly by means of hand brooms.

(g) Precoating of aggregate
If stated in the Special Specifications, the aggregate shall be precoated with a precoating fluid as specified in SUBCLAUSE 4302(e).

(h) Protection of the new surface
Vehicle speed shall be restricted to a maximum of 30 km/hr until there is sufficient adhesion to ensure that chippings will not be dislodged by fast moving vehicles.

4404 MEASUREMENT AND PAYMENT

ITEM	UNIT
44.01 SINGLE SEALS (INDICATE TYPE OF BINDER AND HOT SPRAYED APPLICATION RATE IN LITRES PER SQUARE METRE):	
(a) USING 7 mm AGGREGATE	SQUARE METRE (m^2)
(b) USING 10 mm AGGREGATE	SQUARE METRE (m^2)
(c) USING 14 mm AGGREGATE	SQUARE METRE (m^2)
(d) USING 20 mm AGGREGATE	SQUARE METRE (m^2)

The unit of measurement shall be the square metre of completed and accepted seal.

The bid rates shall include full compensation for furnishing all materials, marking the centre or reference lines, spraying of binder, spreading of aggregate, rolling and all other incidentals necessary for completing the work as specified.

ITEM	UNIT
44.02 SINGLE SEALS. BITUMINOUS BINDER VARIATIONS:	LITRES (l)
(a) 150/200 PENETRATION GRADE BITUMEN	LITRES (l)
(b) 80/100 PENETRATION GRADE BITUMEN	LITRES (l)
(c) MC3000 CUTBACK BITUMEN	LITRES (l)
(e) BITUMEN EMULSION (STATE TYPE AND COMPOSITION)	LITRES (l)
(h) PRECOATING FLUID (STATE TYPE)	LITRES (l)
(g) OTHER TYPES OF BITUMEN (STATE TYPE AND COMPOSITION)	LITRES (l)

The unit of measurement of bituminous binder in respect of an increase or a decrease in the specified rates of application shall be the litres measured at spraying temperature.

Payment for variations shall be made as specified in CLAUSE 1212.

ITEM	UNIT
44.03 SINGLE SEALS. AGGREGATE VARIATIONS:	
(a) USING 7 mm AGGREGATE	TONNE
(b) USING 10 mm AGGREGATE	TONNE
(c) USING 14 mm AGGREGATE	TONNE
(d) USING 20 mm AGGREGATE	TONNE

The unit of measurement shall be the tonne of increased or decreased aggregate applied, as compared to the amounts required at the specified nominal rate of application.

Payment for variations shall be made as specified in CLAUSE 1212.

ITEM	UNIT
44.04 APPLICATION OF FOG SPRAY:	
(a) USING 60% SPRAY-GRADE EMULSION	LITRE (l)
(b) USING 30% SPRAY-GRADE EMULSION	LITRE (l)

The unit of measurement shall be the litre of emulsion sprayed as specified and measured at spraying temperature.

The bid rate shall include full compensation for furnishing the material and applying the fog spray as specified.

ITEM	UNIT
44.05 PRECOATING THE AGGREGATE (INDICATE TYPE OF PRECOATING FLUID AND RATE OF APPLICATION IN LITRES PER TONNE OF AGGREGATE)	TONNE

The unit of measurement for the precoating of aggregate shall be the tonne of aggregate so treated and used on the surfacing in quantities according to drawings or as instructed by the Engineer.

The bid rate shall include full compensation for furnishing the equipment and precoating fluid and precoating the aggregate as specified, including the handling, stockpiling and protecting of the stockpiles against inclement weather.

ITEM	UNIT
44.06 ADDITION OF APPROVED WETTING AGENT TO THE BINDER (STATE TYPE AND NOMINAL APPLICATION RATE PERCENT OF BINDER):	KILOGRAMS (kg)

The bid rate shall include full compensation for providing, handling the material, storing and introducing it into the mix, including any equipment required, for the work.

ITEM	UNIT
44.07 AGGREGATE FOR BLINDING:	
(a) NATURAL SAND	TONNE
(b) CRUSHER SAND	TONNE

The unit of measurement shall be the tonne of sand according to drawings or as instructed by the Engineer.

The bid rate shall include full compensation for providing the material and applying the blinding coat complete as specified, and, should it be required, stockpiling the sand at an approved locality.

SERIES 4000: BITUMINOUS LAYERS AND SEALS

SECTION 4500: DOUBLE SURFACE DRESSINGS

CONTENTS

4501 SCOPE

This section covers the supply and furnishing of all materials for the construction of a bituminous double seal for resealing or new construction. The seal shall be constructed using either 20 mm plus 10 mm aggregate or 14 mm plus 7 mm aggregate, whichever is shown in the Bill of Quantities.

The requirements of all relevant clauses of SECTION 4300 shall apply to this SECTION.

4502 MATERIALS

(a) Bituminous binders

The bituminous binder shall consist of one of the following binders, whichever is specified in the Special Specifications or the Bill of Quantities or ordered by the Engineer:

- 80/100 penetration-grade bitumen;
- 150/200 penetration-grade bitumen,
- 60%, 65% or 70% spray-grade emulsion;
- MC-3000 cut-back bitumen;
- Modified binder as specified.

(i) Bitumen coats
The specified bituminous binders shall comply with the conditions of SECTION 4300.

(ii) Fog spray
Fog spray, when specified, shall be 30% or 60% spray grade emulsion of anionic or cationic type, as specified or ordered by the Engineer.

(iii) Pre coating fluid
Pre coating fluid, when pre coating of aggregate is specified, shall be bitumen emulsion, or alternative approved types, as specified or ordered by the Engineer.

(b) Aggregate

Aggregate for surface dressing shall consist of clean, tough, durable fragments of crushed stone free from any deleterious matter and shall comply with the requirements given in TABLES 4502/1 and 4502/2.

TABLE 4502/1
GRADING LIMITS AND REQUIREMENTS FOR CHIPPINGS

	Chipping, nominal size of aggregates, (% passing)			
	20 mm	14 mm	10 mm	7 mm
Sieves (mm):				
25	100			
20	85-100	100		
14	0-30	85-100	100	
10	0-5	0-30	85-100	100
6.3	-	0-5	0-30	85-100
5	-	-	0-5	0-30
2.36	-	-	-	0-5
Fines: 0.425	< 0.5	< 1.0	< 1.0	< 1.5
Dust: 0.075	< 0.3	< 0.5	< 0.3	< 1.0

TABLE 4502/2
REQUIREMENTS FOR CHIPPINGS

Aggregate properties	Chipping, nominal size of aggregates			
	20 mm	14 mm	10 mm	7 mm
Maximum Flakiness index BS 812 : 105.1	20	25		30
Minimum strength, TFV dry. BS 812: 105-1: 1989	*) For AADT ≥ 1000: 160 kN			
	*) For AADT < 1000: 120 kN			
Ratio dry to soaked value of TFV. BS 812: 105-1: 1989	TFV_{soaked} shall be minimum 75% of the corresponding TFV_{dry} value			
*) The appropriate traffic volume that applies to any location, shall be as given in the Drawings or Special Specifications. Where such information is not given, the decision of the Engineer shall apply.				

(c) Average Least Dimension (ALD)
The ALD of the chippings shall be tested by the following method:

1. A sieve analysis is first carried out on a sample of the chippings and the results plotted on a large scale grading curve. The median size of chipping is then determined as that theoretical sieve size through which 50 percent of the material will pass.
2. The flakiness index is determined.
3. Then using Figure 4502/1 the median size is marked on scale A and flakiness index on scale C. A straight line is drawn between the two marks and the Average Least Dimension read off on scale B.

The ALD of the chippings when tested as described above shall meet the requirements of Table 4502/3.

FIGURE 4502/1
FIGURE FOR THE DETERMINATION OF THE AVERAGE LEAST DIMENSION

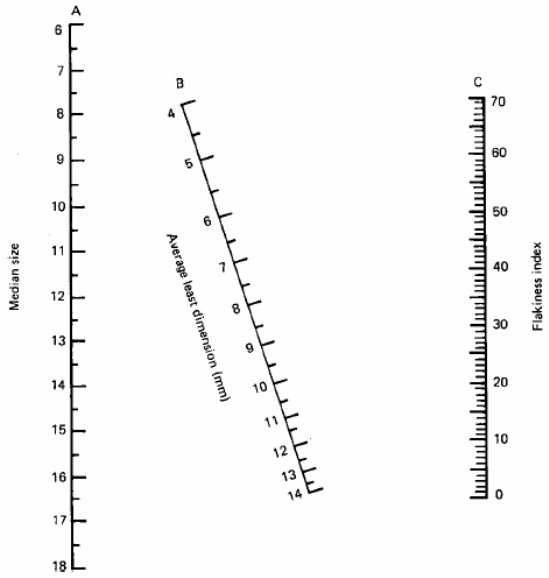

TABLE 4502/3
ALD REQUIREMENTS FOR CHIPPINGS

Nominal size of aggregate (mm)	ALD Requirement (mm)
20	11 - 15
14	8 -10
10	5 - 6.5
7	2 - 4

4503 CONSTRUCTION

(a) Preparation of the surface
Surface treatment shall not commence until the existing surface has been repaired of any defects and cleaned to the satisfaction of the Engineer by the use of brooms, water, compressed air or any other method required to give a satisfactory result.

Kerbs, channels, guttering, manholes, guard rails, bridge railings, and any other structures that may be soiled by bituminous binders during spraying operations shall be covered with suitable plastic sheeting during spraying operations.

The sheeting shall be kept firmly in position by soil, stones or adhesive tape in such a manner that it will not lift or be blown away during windy conditions but will keep the areas to be protected fully covered.

The use of paper bags, sand or other materials will not be permitted in lieu of plastic sheeting and the Contractor shall replace at his/her own expense any items that have been soiled and cannot be cleaned entirely. The painting of soiled surfaces will not be acceptable as a suitable remedy.

(b) Nominal rates of application of binder and aggregate
The bitumen coat and aggregate, of the types and sizes given in the Special Specifications, or ordered by the Engineer, shall be applied as specified in SUBCLAUSE 4307(b).

The Contractor shall demonstrate the suitability of the application rates together with construction equipment and methods by carrying out trial sections for the approval by the Engineer.

The Trial sections shall be carried out on surfaces identical to those used in the permanent works and shall include at least 3 different binder and aggregate application rates covering the range of application rates determined according to both publications mentioned above. Each combination of application rates shall be spread on a trial length of minimum 25 m.

Chip spreaders shall be checked and calibrated before starting any trial or permanent work and further when required by the Engineer.

Nominal rates of application of binder and aggregate are given in TABLES 4503/1 and 4503/2. The given nominal rates of application of binder and aggregate are for information only. The application rates for which payment shall be calculated, are given in the Bill of Quantities. If, however, no application rates are given in the Bill of Quantities, then the rates in TABLES 4503/1 and 4503/2 shall be used for bidding purposes.

(c) Actual rates of application of binder and aggregate
The actual rates of application for use on site on any part of the Works, shall be as determined on site, on approval of the Engineer. The difference in actual rates of application compared to the rates for bidding purposes are paid for separately in variation rates measured in tonnes and litres (hot sprayed) for aggregate and binder respectively, as specified in CLAUSE 4504.

Brooming of chippings after spreading to effect redistribution will not be permitted. Any excess of chippings shall be removed by hand and any insufficiently chipped area shall be chipped by hand to obtain adequate coverage.

(d) First layer of double surface dressings

(i) Nominal rates of binder and aggregate
The nominal rates of binder and aggregate shall be as given in TABLE 4503/1 for the first layer of double surface dressings.

TABLE 4503/1
FIRST LAYER OF DOUBLE SURFACE DRESSINGS. NOMINAL RATES OF BINDER AND AGGREGATE APPLICATION

Nominal size of aggregate (mm)	Nominal rates of application			
	Binder, hot bitumen (l/ m^2)			Aggregate (kg/m^2)
	AADT			
	<200	200-1000	>1000	
20	1.8	1.5	1.2	19
14	1.4	1.1	1.0	14

(ii) Rolling
Initial rolling shall be carried out as specified in SUBCLAUSE 4308(b). Any areas deficient in aggregate shall have additional material added so as to leave the carpet with a single layer of chippings lying shoulder to shoulder.

It is essential to ensure that only one layer of chippings is applied and every care shall be taken to avoid over-application of chippings.

(e) Second layer of double surface dressings

(i) Nominal rates of binder and aggregate
The bituminous binder specified by the Engineer shall be applied and followed by the second layer of aggregate of the size specified in the Special Specifications or as ordered by the Engineer.

The nominal rates of binder and aggregate shall be as given in TABLE 4503/2 for the second layer of double surface dressings.

The second application of binder shall preferably take place within 48 hours of the application of the first coat when penetration grade bitumen is used for the first coat and not less than ten days of the application of the fist coat when cutback bitumen is used in the first coat.

TABLE 4503/2
SECOND LAYER OF DOUBLE SURFACE DRESSINGS. NOMINAL RATES OF BINDER AND AGGREGATE APPLICATION

Nominal size of aggregate (mm)	Nominal rates of application			
	Binder, hot bitumen (l/ m^2)			Aggregate (kg/m^2)
	AADT			
	<200	200-1000	>1000	
10	1.2	1.0	0.9	11
7	0.9	0.8	0.7	7

(f) Fog spray applied to First Layer
If specified in the Special Specifications, or if so directed by the Engineer, a fog spray of 60% or 30% anionic or cationic emulsion shall be applied to the surface of the first layer of aggregate by means of a pressure distributor at the required rate.

(g) Blinding
If specified in the Special Specifications, or if so directed by the Engineer, a light blinding layer of natural or crusher sand shall be applied by the Contractor to prevent chippings from being picked up by traffic.

The blinding layer shall be spread evenly over the full indicated surface. Should it be required by the Engineer, the layer shall be spread evenly by means of hand brooms.

(h) Initial rolling of second layer
Initial rolling of the second layer of aggregate shall be carried out as specified in SUBCLAUSE 4307(b). The final rolling shall be done with a pneumatic-tyred or a rubber-soled steel-wheeled roller only, applying a minimum of four coverages.

The finished surface shall be well-knit and have a uniform appearance free of roller-tyre marks. All aggregate contaminated by oil, fuel or grease shall be removed and dumped in an approved waste site and replaced by clean aggregate.

All loose aggregate shall be broomed off the surface with a rotary broom or hard brooms as directed by the Engineer.

The main rolling shall be carried out with self propelled pneumatic-tyred rollers having a wheel load of more than 2 tonnes.

The tyres shall be smooth and the tyre pressure shall be minimum 0.4 N/mm^2. The number and capacity of rollers shall be sufficiently to ensure that rolling does not lag behind spreading. As a minimum 2 pneumatic rollers shall be used for each chip spreader.

Rolling shall begin immediately after the chippings have been spread and, in no case, later than 2 minutes after the application of the binder. Rolling shall continue until all chippings are firmly embedded into the binder.

The number of passes shall be as agreed with the Engineer, but as a rule all chippings shall receive at least six passes of the pneumatic tyred roller. Excessive rolling resulting in crushing of chippings shall be avoided.

The roller speed shall not exceed 8 km/hr, unless otherwise agreed with the Engineer.

The road shall not be opened to traffic until the binder has attained sufficient viscosity to prevent the chippings being whipped off.

(i) Broom drag and final rolling of second layer
Dragging and final rolling of the second layer of aggregate shall be carried out as specified in SUBCLAUSE 4307(b).

(j) Fog spray applied to Second Layer
When required by the Special Specifications or if so directed by the Engineer in writing, a fog spray of 30% or 60% bitumen emulsion shall be applied to the surface of the second layer of aggregate by means of a pressure sprayer at the rate of application specified by the Engineer.

(k) Precoating of aggregate
If stated in the Special Specifications the aggregate shall be precoated with a precoating fluid as specified in Subclause 4302(e).

(l) Protection of the new surface
Vehicle speed shall be restricted to a maximum of 30 km/hr until there is sufficient adhesion to ensure that chippings will not be dislodged by fast moving vehicles.

4504 MEASUREMENT AND PAYMENT

ITEM	UNIT
45.01 DOUBLE SURFACE DRESSING USING:	
(a) 20 mm AND 10 mm AGGREGATE IN 1ST AND 2ND LAYER RESPECTIVELY (STATE TYPE OF BINDER AND HOT BINDER APPLICATION RATE FOR EACH LAYER IN LITRES PER SQUARE METRE)	SQUARE METRE (m^2)
(b) 14 mm AND 7 mm AGGREGATE IN 1ST AND 2ND LAYER RESPECTIVELY (STATE TYPE OF BINDER AND HOT BINDER APPLICATION RATE FOR EACH LAYER IN LITRES PER SQUARE METRE)	SQUARE METRE (m^2)

The unit of measurement shall be the square metre of completed and accepted surface treatment.

The bid rate shall include full compensation for furnishing all materials, marking the centre line or reference lines, spraying of binder, spreading of aggregate, rolling, removing of dust or deleterious material, supplying of water and spraying of haul roads and construction roads, trimming the edges of the completed surface, and all other incidentals necessary for completing the work as specified, except the application of a fog spray and precoating of aggregate, which shall be paid for separately.

ITEM	UNIT
45.02 BITUMINOUS BINDER VARIATION:	
(a) 150/200 PENETRATION GRADE BITUMEN	LITRES (l)
(b) 80/100 PENETRATION GRADE BITUMEN	LITRES (l)
(c) MC3000 CUTBACK BITUMEN	LITRES (l)
(d) BITUMEN EMULSION (STATE TYPE AND COMPOSITION)	LITRES (l)
(e) PRECOATING FLUID (STATE TYPE)	LITRES (l)
(f) OTHER TYPES OF BITUMEN (STATE TYPE AND COMPOSITION)	LITRES (l)

The unit of measurement of bituminous binder in respect of variations in the specified rates of application shall be a litre, measured at spraying temperature.

Payment for variations shall be made as specified in CLAUSE 1213.

ITEM	UNIT
45.03 AGGREGATE VARIATION:	
(a) 20 mm NOMINAL SIZE AGGREGATE	TONNE
(b) 14 mm NOMINAL SIZE AGGREGATE	TONNE
(c) 10 mm NOMINAL SIZE AGGREGATE	TONNE
(d) 7 mm NOMINAL SIZE AGGREGATE	TONNE

The unit of measurement with respect to variations in application of aggregate shall be the tonne of aggregate specified on site by the Engineer minus the tonne of aggregate calculated from application rates given in TABLES 4503/1 and 4503/2 and already paid for in ITEM 45.01.

Payment for variations shall be made as specified in CLAUSE 1213.

ITEM	UNIT
45.04 APPLICATION OF FOG SPRAY CONSISTING OF BITUMEN EMULSION (STATE TYPE AND PERCENTAGE BITUMEN CONTENT IN THE EMULSION)	LITRES (l)

The unit of measurement shall be the litre of emulsion sprayed as specified and measured at the application temperature.

The bid rate per litre of emulsion shall include full compensation for procuring and furnishing the binder and applying the fog spray as specified.

ITEM	UNIT
45.05 PRECOATING SECOND APPLICATION OF AGGREGATE (STATE TYPE OF PRECOATING FLUID AND APPLICATION RATE IN LITRES PER TONNE)	TONNE

The unit of measurement for the precoating of aggregate shall be the tonne of aggregate so treated and used on the surfacing at the specified application rates according to drawings or as directed by the Engineer.

The bid rate shall include full compensation for furnishing the equipment and materials and precoating the aggregate as specified, including the handling. Stockpiling and protecting of the stockpiles against inclement weather.

ITEM	UNIT
45.06 ADDITION OF APPROVED WETTING AGENT TO THE BINDER (STATE TYPE AND NOMINAL APPLICATION RATE PERCENT OF BINDER):	KILOGRAMS (kg)

The bid rate shall include full compensation for providing, handling the material, storing and introducing it into the mix, including any equipment required, for the work.

ITEM	UNIT
45.07 AGGREGATE FOR BLINDING:	
(a) NATURAL SAND	TONNE
(b) CRUSHER SAND	TONNE

The unit of measurement shall be the tonne of sand according to drawings or as instructed by the Engineer.

The bid rate shall include full compensation for providing the material and applying the blinding coat complete as specified, and, should it be required, stockpiling the sand at an approved locality.

SERIES 4000: BITUMINOUS LAYERS AND SEALS

SECTION 4600: SAND SEALS AND SLURRY

CONTENTS:

4601 SCOPE

This SECTION covers the supply and application of all materials used for constructing sand seals and slurry seals. The requirements of all relevant clauses of SECTION 4300 shall apply to this Section.

4602 BINDER

The following grades of binder shall be used as set out in the Special Specifications or the Bill of Quantities or as ordered by the Engineer:

- MC-800 cut-back bitumen
- MC-3000 cut-back bitumen
- Spray-grade cationic emulsion (65% or 70% of net bitumen)
- Spray-grade anionic emulsion (65% or 70% of net bitumen)

4603 AGGREGATE

(a) Sand seal

The aggregate for sand seal shall be crusher dust clean river sand free from lumps of clay or any other deleterious matter. The grading shall conform with TABLE 4603/1.

TABLE 4603/1
GRADING LIMITS FOR SAND SEAL

Sieve size (mm)	Percentage passing sieve (% by mass)	
	Natural river sand	Crusher dust
10	100	100
5	85 – 100	85 – 100
1.18	20 – 60	20 – 80
0.425	0 – 30	-
0.300	0 – 15	-
0.150	0 – 5	0 - 30

The sand shall be screened or washed as required to ensure compliance with the Specifications.

(b) Slurry

The aggregate for slurry seals shall be approved crusher sand obtained from a parent rock having a TFV value of not less than 110 kN or a mixture of such crusher sand and an approved clean natural sand, where the mixture does not contain more than 25% of natural sand. The aggregate shall be clean, tough, durable, angular in shape, and shall comply with the grading requirements given in TABLES 4603/2.

TABLE 4603/2
GRADING LIMITS FOR SLURRY SEALS

Sieve size (mm)	Percentage passing sieve (% by mass)	
	Fine type	Coarse type
10		100
5	100	85-100
2	90-100	50-90
1.18	60-90	32-70
0.425	32-60	20-44
0.150	10-27	7-20
0.075	4-12	2-8

4604 SAND SEAL CONSTRUCTION AND AFTER CARE

(a) Equipment

The following equipment shall be readily available on the site:

- pneumatic-tyred rollers
- a rotary broom
- a drag broom
- mechanical aggregate spreaders if spreading by hand is not used

(b) Preparation of surface before application of seal

The road shall be cleaned of all loose or deleterious material to the satisfaction of the Engineer before the sand seal is applied.

The surface of the base shall be watered, rolled and swept until a smooth fine texture has been achieved. The base course shall then be primed in accordance with the provisions of SECTION 4100, or as instructed by the Engineer.

(c) Binder application rate for sand seal

The nominal rate of application of binder for bidding purposes shall be 1.2 litres per square metre of MC 3000 cutback bitumen measured at spraying temperature. The exact spray rate shall be determined on site on approval of the Engineer.

(d) Application of sand seal

(i) General
Granular base courses of non-calcareous materials do not normally require a prime, unless otherwise directed by the Engineer. Base courses of calcrete or coral material shall always be primed.

(ii) Application of surfacing
The binders, of the type and grade required, and the aggregates, of the size specified in the Bill of Quantities or ordered by the Engineer, shall be applied in accordance with the provisions of SECTION 4300.

(iii) Rolling
Rolling shall begin immediately after the aggregate has been spread and in no case later than 2 minutes after the application of the binder. Rolling shall continue until all aggregate is firmly embedded into the binder.

The rolling shall be carried out with self propelled pneumatic tyred rollers having a wheel load of more than 2 tonnes. The tyres shall be smooth and the tyre pressure shall be minimum 0.4 N/mm^2.

The number and capacity of rollers shall be sufficiently to ensure that rolling does not lag behind spreading of aggregate. A minimum of two

pneumatic tyred rollers shall be used for the rolling operations.

The number of passes shall be as agreed with the Engineer, but as a rule all aggregate shall receive at least six passes of the pneumatic tyred roller.

The roller speed shall not exceed 8 km/hr, unless otherwise agreed with the Engineer.

(iv) Subsequent trafficking
The road should be opened to traffic immediately after the sealing operations are completed, but a maximum speed limit of 50 km/h should be enforced during the initial period after construction. The Engineer may direct even trafficking of the sealed area and channelling of the traffic may be required for certain periods. Aggregate that has been dislodged by traffic during the immediate post construction period shall be broomed back into the exposed areas, as directed by the Engineer.

(v) Aftercare
After 2 - 3 weeks of trafficking the excess aggregate shall be swept off the road surface. If natural gravel is used with a fairly high content of fines, the period may be extended to 6 weeks or as directed by the Engineer.

4605 SLURRY CONSTRUCTION AND AFTER CARE

(a) Condition of surface
The surface shall be cleaned to remove all dust, mud, leaves, etc, and shall have a uniform closely knit appearance, with edges trimmed correctly to the specified width.

(b) Composition of slurry
The slurry shall consist of a mix of the grade of slurry aggregate ordered by the Engineer and specified in SUBCLAUSE 4302(b) together with a 60% stable-grade emulsion, filler and water in the proportions as directed by the Engineer. The following proportions shall apply for bidding purposes only:

- Slurry aggregate (saturated volume) 1 m^3
- Stable-grade emulsion 260 litres
- Cement 0.01 m^3
- Water (as directed by the Engineer) approximately 235 litres

If specified in the Special Specifications, the composition of the slurry shall be based on the following mass proportions for bidding purposes:

- Slurry aggregate (dry 100
- Stable-grade emulsion 20
- Cement 1-15
- Water +15

The saturated volume of slurry shall be determined by applying a correction for bulking of moist aggregate.

(c) Mixing of slurry

(i) General
A mixer of a type approved by the Engineer shall be provided in a good working order capable of producing uniform slurry of the constituent materials. It may either be a batch mixer or a continuous type mixer. Hand mixing may be used if the result is satisfactory to the Engineer.

Material which, in the opinion of the Engineer, is not properly mixed or in which the emulsion shows signs of having broken during mixing shall not be applied to the road and shall be removed from site.

(ii) Batch mixer
The slurry shall be mixed in an approved type of mixer as specified in SUBCLAUSE 4303(f).

All the constituents of the slurry shall be accurately proportioned and due care and attention shall be given to the sequence in which the ingredients are introduced into the mixer and to the period of mixing. Mixing shall be continued until the materials in each batch are thoroughly blended.

(iii) Continuous mixer
Aggregate and filler contained in separate bins shall be fed through metering devices at controlled rates to the mixer. Water and bitumen emulsion contained in separate tanks shall similarly be pumped to the mixer at controlled rates through metering devices. The mixing of the slurry shall be at a suitable rate adjusted to ensure complete blending of the ingredients and uniformity of mix.

(d) Application of slurry
Before slurry is applied, the road surface shall be thoroughly cleaned and lightly sprinkled with water but no free water shall be present on the surface when the slurry is applied. The nominal rate of application of slurry shall be in accordance with drawings or as directed by the Engineer. The slurry shall be applied in two layers in the case application rates of 0.008 m^3/m^2 or larger, or as directed by the Engineer.

The nominal rates of application given in the Bill of Quantities are intended for bidding purposes only and the actual rates of application on the site shall be as directed by the Engineer. When the slurry is applied in two layers, the first layer of slurry shall be struck off level with the tops of the stones in the aggregate layer so that, after application, the tops of the stones will be just visible.

The second layer of slurry shall not be applied until the first layer has dried. If required by the Engineer, the Contractor shall open the road to traffic before the second layer of slurry is applied. The surface shall be well rolled with a pneumatic-tyred roller. The second layer shall be applied only after sufficient time has been allowed for the first layer to cure. The Engineer will decide on the time necessary for proper curing, which will in any case be not less than 24 hours.

The surface shall be thoroughly cleaned of all dust, dirt or foreign materials before the second layer of slurry is applied. For seals using 14 mm nominal sized chipping the slurry shall be applied in one layer only. The slurry shall also be struck off so that the tops of the stone chipping will be just visible after the emulsion has set and cured.

Where slurry is spread by hand. the squeegee squad shall be allowed to complete the spreading of each batch discharged onto the road, using squeegees, before the next is discharged.

Where spreading is carried out by means of the spreader box, the slurry shall be discharged into the spreader box by means of a chute, which shall be so directed that an even supply of slurry is maintained against the full width of the strike-off blade of the spreader box. Areas where an excess of slurry has been applied by the spreader box shall be corrected by squeegees being used immediately after the passage of the spreader box.

Should breaking of the emulsion, segregation of the mix or formation of lumps occur during the application of the slurry, the slurry operations shall be discontinued at once and any defective material removed from the road.

Successive strips of slurry shall overlap transversely by not less than 25 mm nor more than 150 mm. Any overlapping on the longitudinal joints and any omitted areas shall be rectified with squeegees.

The Contractor shall ensure that either edge of the road surface is finished to the specified widths and lines. All stones dislodged in the process of applying the slurry shall be removed on the same day on which the slurry seal has been applied. All spillage of slurry or excess slurry shall be neatly removed from the road and buried in an approved waste site.

If the slurry is spread with a spreader box, a moist burlap drag shall be drawn behind the spreader box to ensure an overall even texture.

If applied by hand, the slurry shall be worked from side to side and criss-cross with the aid of squeegees so as to fill as many spaces as possible. In this case the final layer of slurry shall be struck off flush with the tops of the stone chipping so as to leave the chippings to be visible after the emulsion has stiffened and hardened.

The work must be so programmed, that the two half road widths of slurry shall be applied on two successive days to complete a full road width section in two days.

Any damage to the slurry seal by rain or traffic before the slurry has cured shall be rectified by the Contractor at his/her own expense.

4606 MEASUREMENT AND PAYMENT

ITEM	UNIT
46.01 APPLICATION OF SAND SEAL:	
(a) BINDER (STATE TYPE)	LITRE (l)
(b) SAND	CUBIC METRE (m^3)

The unit of measurement of binder shall be the litre, measured at spraying temperature. The unit of measurement for the sand shall be the cubic metre of sand applied to the road as specified.

The bid rate for binder shall include full compensation for procuring and furnishing the material and applying the binder, including all preparatory work to the surface prior to application of the binder.

The bid rate for sand shall include full compensation for supplying the sand, washing, screening and preparing the sand, applying the sand as specified, as well as brooming the sand back onto the surface as often as is required.

ITEM	UNIT
46.02 APPLICATION OF SLURRY (STATE NOMINAL APPLICATION RATE IN CUBIC METRE PER SQUARE METRE):	SQUARE METRE (m^2)

The unit of measurement shall be the square metre of completed and accepted slurry seal according to drawings or where directed by the Engineer.

The bid rate shall include full compensation, inter alia, for furnishing all materials, marking the centre line or reference lines, spraying of binder, spreading of aggregate, rolling, removing of dust or deleterious material, supplying of water and spraying of haul roads and construction roads, trimming the edges of the completed surface, and all other incidentals necessary for completing the work as specified.

The bid rates shall include full compensation for procuring and furnishing the material including all preparatory work to the surface prior to application of the seal.

ITEM	UNIT
46.03 VARIATION IN THE RATE OF APPLICATION OF THE SLURRY:	CUBIC METRE (m^3)

The unit of measurement for slurry variations shall be the cubic metre of saturated fine aggregate.

Payment for variations shall be made as specified in CLAUSE 1212.

SERIES 4000: BITUMINOUS LAYERS AND SEALS

SECTION 4700: SURFACING OF BRIDGE DECKS

CONTENTS:

4701 SCOPE

This Section covers the construction of a bituminous surfacing on bridge decks where shown on the Drawings or ordered by the Engineer.

4702 MATERIALS

Bituminous binders and aggregate shall comply with the requirements of SECTIONS 4200 and 4300 for asphalt surfacing and seals respectively.

4703 PREPARATION ON SURFACE

Before the surfacing is constructed, the concrete deck shall be thoroughly cleaned by washing and brushing to remove all loose material. After drying, a tack coat consisting of 30% bituminous cationic emulsion shall be applied to the surface at a rate of 0.4 l/m^2. The tack coat shall then be allowed to dry.

4704 TYPE AND THICKNESS OF SURFACING

The type and nominal) thickness of the surfacing shall be as Indicated on the Drawings and specified in the Bill of Quantities.

Before commencing with the construction of the surfacing, the actual levels of the bridge deck shall be determined by means of accurate levelling. The levels and grades to which the surfacing is to be constructed shall be as shown on the Drawings or as indicated by the Engineer. If the levels of the concrete deck as constructed by the Contractor deviate by more than the specified tolerances from the specified levels, he/she shall construct a levelling layer at his/her own cost. The nominal size of the aggregate in the levelling layer shall be 10 mm.

4705 CONSTRUCTION

Irrespective of the type of seal applications on the road on both sides of the bridge, asphalt surfacing shall be constructed in accordance with SECTION 4200, and seals in accordance with SECTION 4300.

4706 SURFACE TOLERANCES

The completed surfacing shall comply with the requirements for base of CLAUSE 7115 in respect of surface tolerances for grade, smoothness, cross section and width.

4707 MEASUREMENT AND PAYMENT

ITEM		UNIT
47.01	SURFACING ON BRIDGE DECK (STATE TYPE AND THICKNESS)	CUBIC METRE (m^3)

The unit of measurement shall be the cubic metre of surfacing completed in accordance with the Specifications to the nominal thickness indicated on the Drawings or to the instruction of the Engineer.

The bid rate shall include full compensation for procuring and furnishing all materials, heating the binder and aggregate, mixing, transporting, placing and compaction of the material, and the provision and application of the surfacing. The rate shall also include full compensation for variations in thickness within the specified tolerance for bridge deck levels and for cleaning of the surface to the satisfaction of the Engineer and the application of a tack coat.

SERIES 4000: BITUMINOUS LAYERS AND SEALS

SECTION 4800: TREATMENT OF SURFACE DEFECTS, PATCHING, REPAIRING EDGE-BREAKS AND CRACK SEALING

CONTENTS:

4801 SCOPE

This Section covers the work in connection with the treatment of existing road surfaces prior to the application of a seal or asphalt surfacing, patching, repairing edge breaks and crack sealing.

Provision is made for treating existing seals exhibiting any of the following defects:

- the existing surface is deficient in binder.
- marked differences in texture occur over the surface.
- the existing surface is open-textured.
- the surface is uneven on account of bumps, slacks, etc.
- edges require trimming and/or repairs.

Patching shall be any work to existing pavement layers (and in exceptional cases to fills and the roadbed) with the purpose of repairing local failures, and which is carried out in an area having a width of less than 1.0 m, or a length of less than 25 m or an area of less than 100 m^2. This does not include the repair of edge breaks, pre-treatment of the road surface, or the rehabilitation of concrete pavements.

Patching involves excavating the existing failed sections and reconstructing the excavated fills and pavement layers with the specified pavement material.

Compensation for work in restricted areas shall not be applicable to patching and repairing edge breaks.

The general requirements for seals given in SECTION 4300 shall apply to this SECTION.

4802 MATERIALS

The material shall comply with the requirements specified for the various types of material in the appropriate sections of the Specifications and the Special Specifications.

The following grades of binder may be used. The actual type or grade used shall be as specified in the Special Specifications or the Bill of Quantities or as ordered by the Engineer.

(a) Binder for fog spray (Treatment Type 1)
30% or 60% cationic or anionic spray-grade bituminous emulsion.

(b) Tack-coat binder (Treatment Type 2)
60% bituminous emulsion (Treatment Type 2)
30% bituminous emulsion (Treatment Types 3 and 4).

(c) Slurry binder (Treatment Type 3)
60% stable grade bituminous emulsion.

(d) Binder for asphalt skim coat (Treatment Type 4)
80/100 penetration grade bitumen.

(e) Screed (Treatment Type 5)
30% bitumen emulsion shall be used for the tack coat, and the binder for the asphalt shall be approved grade of penetration grade bitumen unless otherwise specified.

(f) Binder for asphalt used in reconstructing pavement edges
60% stable grade bituminous emulsion for tack coat and 80/100 penetration-grade bitumen in asphalt

(g) Rubber pellets
Rubber pellets for crack sealing shall be obtained by processing rubber tyres. The rubber shall be granulated and free from fibres, steel wire and other impurities. The rubber crumbs shall pass through a 2.00 mm sieve.

(h) Herbicide
Herbicide shall be a non-selective environmentally compatible herbicide approved by the Engineer.

4803 CONSTRUCTION EQUIPMENT

All equipment shall be suitable for the specified use and working areas and shall be capable of obtaining the specified results.

(a) Planing machine
The machine shall be of a design which will be suitable for planing the existing surfacing in order to remove and irregularities and to leave an even surface without tearing the underlying material. An approved milling machine may be used.

Before planing may start, the Contractor shall demonstrate to the Engineer that the machine is capable of executing the work in accordance with the Special Specifications.

(b) Patching and repairing edge breaks
Only approved cutting or sawing equipment may be used for cutting or sawing asphalt layers. The equipment shall be capable of cutting asphalt layers to depths of 200 mm in one operation without fragmenting the material, and in straight lines within the required tolerances.

The following items of construction equipment shall also be available and in good working order:

(i) A vibratory roller having a mass approximately equal to that of a Bomag 765 or similar vibratory roller, with an adjustable amplitude and frequency of vibration.

(ii) A mobile compressor capable of producing at least 3 m^3/minute compressed air at 750 kPa.

(iii) Appropriate paving breakers.

(iv) Manually operated pneumatic compactors as required.

(v) Appropriate concrete mixers.

(c) Crack sealing
Over and above the equipment normally used for surface treatments, the following additional equipment shall be available for crack sealing:

(i) Special spraying equipment with 2 mm nozzle openings and provided with spare nozzles.

(ii) Special heating equipment where appropriate for cleaning cracks, and custom-built applicators for applying sealants to cracks.

4804 TREATMENT OF SURFACE DEFECTS

Before any treatment is carried out, the area to be treated shall be cleaned and prepared and any major failures shall be repaired as specified in the Special Specifications.

(a) Treatment Type 1
This treatment shall be applied where the existing surface is deficient in binder.

The treatment shall consist of the application of a fog spray of the specified grade of emulsion to the existing surface by means of a pressure distributor at the rates of application as directed by the Engineer, in widths that may vary from 0.5 m to 4.0 m.

(b) Treatment Type 2
This Treatment, or a sand seal as specified in SECTION 4600, is intended for application where marked differences in texture occur in the existing surfacing, in order to obtain a uniform texture before resealing.

A tack coat of the specified type and grade of emulsion shall be applied to the surface as specified in SUBCLAUSE 4307(b) followed by an application of double-washed crusher sand. The crusher sand shall be the medium grade specified for slurry in CLAUSE 4302, but shall be on the coarse side of the grading envelope.

The nominal rates of application shall be:

- Emulsion 0.7 litres net bitumen per m2
- Aggregate 0.004 m^3/m^2

The actual rates of application shall be as instructed by the Engineer.

It can be anticipated that spraying and spreading will have to be carried out in narrow bands varying in width from 0.5 m to 4.0 m. The emulsion shall be allowed to break before the aggregate is applied.

As soon as the aggregate has been applied, the distribution thereof shall be corrected by light hand brooming or by means of a light broom drag.

Rolling shall be carried out as specified in SUBCLAUSE 4307(b). Any excess aggregate remaining on the road after it has been opened for two days or more shall be removed.

(c) Treatment Type 3
This treatment shall be used when an existing surface treatment, which is open-textured or exhibits cracking, requires treatment with bituminous slurry.

Prior to Treatment with a slurry, the surface shall be sprayed with a tack coat of 30% bitumen emulsion at the rate prescribed by the Engineer.

A distinction shall be made in respect of the payment for the following two methods of construction:

- Where the slurry can only be applied by hand methods or where the Engineer so directs or where it is specified that the slurry shall be applied by hand methods.
- Where the slurry can be applied mechanically with a spreader box.

The slurry shall be prepared, mixed and applied as specified in SUBCLAUSES 4605 (b), (c), and (d), with the following exceptions:

- Slurry to be applied by hand may be mixed in a suitable concrete mixer.
- When applied by hand with brooms or rubber squeegees, the slurry shall be worked into cracks and other open areas until a sound, uniform surface is obtained.

The slurry shall, in the case of application by spreader box, be applied in a single layer at a nominal rate, for bidding purposes, of 0.004 m3/m^2.

(d) Treatment Type 4
This treatment is intended for use where the road surface is uneven or contains slacks, bumps or minor rutting caused by deformation of the pavement layers, but not by failure of these layers.

The surface to be treated shall, after having been cleaned and prepared, be given a tack coat of 30% bitumen emulsion at rates directed in the field by the Engineer.

Asphalt shall consist of a medium or fine-grade asphalt surfacing mix manufactured as specified with 6% of 80/100 penetration-grade bitumen and 1.0% active filler. The actual composition of the mix shall be as dictated by the required thickness of the asphalt layer, or as directed by the Engineer.

The asphalt shall be applied as specified in SECTION 4200 in thicknesses varying between 6 mm and 25 mm depending on the nature of the irregularities that occur so that the final surface will conform to the surface tolerances for cross section and smoothness as specified in CLAUSE 4213. Where the thickness of asphalt required exceeds 25 mm, it shall be laid in separate layers each not exceeding 25 mm thickness.

If the final surfacing shows signs of ravelling, disintegration, or an uneven surface, the surface shall be given a Type 3 Treatment or removed and replaced, all at the Contractor's cost.

(e) Treatment Type 5
This treatment is used where the road surface is uneven and where depressions, humps or small grooves occur, which, in the opinion of the Engineer, are the result of the deformation of the pavement layers, but not of structural failure of the pavement.

Where both planing and screeding are specified, the screed shall be placed after the planing has been completed. Where milling is required, it shall be done in accordance with the requirements of CLAUSE 4803.

The existing surface shall be swept clean or cleaned by other approved methods to be free from dust, soil, gravel, loose stones or any other undesirable material. A tack coat of 30% anionic stable-grade emulsion shall then be applied at a rate prescribed by the Engineer.

The bituminous material used for the screed shall be asphalt or coarse slurry as specified in the Special Specifications.

4805 PATCHING

(a) Demarcation
The Engineer will demarcate any failed areas to be repaired, and shall instruct the Contractor in regard to the repair work to be done.

The Contractor shall give adequate notice to the Engineer of his/her intention to commence with repair work on any specific section of the road so that the Engineer will have sufficient time to demarcate the areas to be patched and repaired.

In addition to his/her specified responsibilities for the accommodation of traffic, the Contractor shall also be responsible for traffic accommodation during the demarcation work.

(b) Excavating pavement material
In addition to the provisions of this SECTION the various provisions of SECTIONS 3200, 3400, 3500, 3600, 3800, 4100 and 4200 amongst others shall apply with changes as required.

(c) Excavating pavement material
Unless otherwise instructed by the Engineer, the patching shall have a neat rectangular shape. The existing material shall be excavated and removed to the full specified depth. Asphalt layers and surfacing shall be cut with approved sawing equipment.

Excavation for patching shall be cut with side slopes of approximately 60° to the horizontal.

Where required, excavation shall be done with approved milling equipment in accordance with SECTION 3800.

Excavated material from each pavement layer shall be placed in separate stockpiles adjacent to the patch. The stockpiled material shall be re-used or spoiled in an approved manner in accordance with the Engineer's instructions. Stockpiled material shall not be spoiled next to the road.

After completion of the excavation to the specified depth, the Engineer shall be afforded the opportunity to examine it. Where required, the floor of the excavation shall be compacted to the specified density for the layer concerned.

(d) Backfilling excavations

(i) Excavations shall be backfilled with pavement material as specified in the Special Specifications or as ordered by the Engineer, and the backfilling shall be compacted and finished to the required levels. The requirements for material quality, density and finish specified in other appropriate SECTIONS shall remain applicable. Untested material from the sides of the road shall not be used.

Stabilised materials shall be mixed in concrete mixers or by other approved equipment.

(ii) Unless otherwise specified in the Special Specifications, the base shall be backfilled in accordance with the following requirements.

(1) The base material shall be placed in a concrete mixer, and water shall be added to moisten the material.

(2) A suitably diluted 60% stable grade anionic bitumen emulsion shall be added at the specified rate.

(3) Portland cement shall be added at a rate of 1.0% by mass to the dry aggregate before adding water, unless otherwise specified.

(4) During mixing the fluid content (water plus emulsion) shall not exceed the optimum fluid content (optimum moisture content + percentage residual bitumen) of the base. Mixing shall continue until a uniform mix of the base material and the emulsion is obtained.

(5) The Contractor shall place and spread the stabilised material by hand in layers of appropriate thickness. Each layer shall be compacted with a hand-operated self-propelled vibratory roller to the specified density. The process of placing, spreading and compacting shall be repeated until the required total thickness of base is obtained.

The stabilised materials shall be placed at a fluid content not exceeding the optimum fluid content for the base course.

The finished surface of patching shall be a minimum of 2 mm and a maximum of 5 mm above the adjacent existing pavement.

(iii) When backfilling with asphalt is specified in the Special Specifications, the asphalt mix specified for Treatment Type 4 above shall be used. The mix shall be well compacted by means of a suitable vibratory roller or compactor and shall be finished neatly to the required line and levels.

(e) Restrictions
Unless otherwise instructed in writing by the Engineer, the excavation, backfilling and all patching work, complete as specified, for any patch shall be carried out and completed on the same day. Special attention shall be given during patching to controlling and protecting traffic, as specified.

4806 REPAIRING EDGE BREAKS

This treatment is intended for use where trimming and/or repair of the edges of the surfaced area is required, including restoring the road edges to the true edge lines of the original road or to such other edge line as may be required.

Where the existing edge of the surfacing is sound but exceeds the required width by more than 150 mm, the excess surfacing shall be cut back to the required width keeping it parallel to the centre line of the road.

Where the edges of the surfacing have broken away or where the surfacing is narrower than the required new width, the existing broken edges shall be cut back until a sound edge can be obtained.

Where the edge of the surfacing, as cut back, requires building up to bring it to the required width, all material between the edge of the surfacing and the line to which the surfacing has to be built up, shall be removed to a depth of 60 mm below the final road surface or until firm material is found, and the surface so enclosed shall be cleaned, watered and primed at a rate of 0.6 l/m^2 with a 60% stable grade emulsion diluted with three parts of water to one part of emulsion. The enclosed surface may also be compacted with suitably sized vibratory rollers to ensure a sound surface.

The edges shall then be built up with the asphalt specified for Treatment Type 4 and shall be well compacted by means of a suitable vibratory roller or compactor. The built-up edges shall be finished neatly to the required line and levels.

4807 CRACK SEALING

(a) General
The types of cracks treated will be specified in the Special Specifications. The Engineer will instruct the Contractor regarding the type of treatment to be used in the various cases.

(b) Preparation
The cracks shall be blown clean with compressed air, and all foreign and loose material shall be removed from the cracks.

(c) Cracks narrower than 3 mm
Cracks narrower than 3 mm shall be treated with an emulsion or by means of resealing the surface.

(d) Cracks 3 mm and wider
After the primer has been applied, anionic stable grade emulsion shall be mixed with synthetic modifiers, as set out in the Special Specifications, and applied by means of pneumatic spraying equipment or other approved equipment at the rate given in the Special Specifications.

Where the cracks are to be rolled, the Contractor, in accordance with the Special Specifications or the prescriptions of the Engineer, shall treat the cracks as described below.

Where "Volcano" cracks occur and these require to be flattened, in accordance with the Special Specifications or the prescriptions of the Engineer, the Contractor shall treat the cracks as follows:

- The cracks shall initially be treated for cleaning out and priming the crack as described above.
- The surface on either side of the crack shall be sprayed with an approved rejuvenator for a width of 300 mm on either side of the crack and allowed to soften the existing surface.
- The crack shall then be filled with cold rubber slurry which shall be worked in with rubber squeegees. Any excess slurry shall be removed from the sides of the crack.
- Once the emulsion has broken, the crack can be rolled with a pedestrian vibratory roller until a smooth finish is obtained.

For other cracks, the instructions of the Engineer shall be implemented. Cracks shall be treated with cold rubber slurry, hot bitumen rubber, or any other approved sealant.

Where, in the opinion of the Engineer, the above treatments are not suitable for the existing cracks, the Contractor shall treat the cracks in accordance with the instructions of the Engineer.

(i) Rubber slurry
The rubber slurry mixture shall be proportioned as follows (by volume):
- 10.0 parts of rubber crumbs
- 4.5 parts of 60% anionic stable grade bitumen emulsion
- 0.2 parts of Portland cement
- parts of SBR (net rubber) (anionic emulsified rubber)

Water may be added to improve workability. The mixture shall be neatly worked into the cracks by rubber squeegees. Excess slurry shall be removed from the surface as soon as the emulsion has broken.

(ii) Bitumen rubber
Bitumen rubber may be used only where the Contractor is able to convince the Engineer that he/she is able to mix, heat and apply the material satisfactorily.

The bitumen rubber shall be mixed on the site or at another approved locality on condition that the Contractor is able to propose efficacious methods for controlling both the mixing process and the end product.

Approved heating equipment and mechanical equipment for mixing and applying the mixture shall be used.

The rubber content of the mix shall be at least 25% by mass of the total bitumen-rubber mix.

(iii) Other sealants
Other approved sealants shall comply with and be applied in accordance with the requirements of the Special Specifications.

(e) Restrictions
Cracks may be sealed only where the temperature of the road surface exceeds 10^0C.
Crack sealing may not be done within three days after rain has fallen on the site, unless otherwise instructed by the Engineer.

The Contractor shall note that a single application of crack sealant is usually insufficient and that the application will have to be repeated.

4808 OPENING TO TRAFFIC

The road shall be left open to traffic for such period as the Engineer may direct before further surface treatment work is carried out.

4809 JOINTS AND THE PROTECTION OF KERBS

The requirements of SUBCLAUSE 4307(b) regarding joints between sprays and the protection of kerbs, channels, etc, shall be observed.

4810 MEASUREMENT AND PAYMENT

ITEM	UNIT
48.01 TREATMENT TYPE 1 (FOG SPRAY):	
(a) 30% BITUMEN EMULSION	LITRE (l)
(b) 60% BITUMEN EMULSION	LITRE (l)

The unit of measurement for Treatment Type 1 (fog spray) shall be the litre of bituminous emulsion sprayed at application rates as instructed by the Engineer, measured at spraying temperature.

The bid rates shall include full compensation for cleaning and preparing the existing surface, for furnishing the material and applying the fog spray and for all other incidentals necessary for completing the work as specified.

ITEM	UNIT
48.02 TREATMENT TYPE 2: (APPLICATION OF SAND SEAL):	
(a) BINDER (STATE TYPE)	LITRE (l)
(b) SAND	CUBIC METRE (m^3)

The unit of measurement of binder shall be the litre, measured at spraying temperature. The unit of measurement for the sand shall be the cubic metre of sand applied to the road as specified.

The bid rates shall include full compensation for procuring and furnishing the material and applying the binder, including all preparatory work to the surface prior to application of the binder.

The bid rate shall include full compensation for supplying the sand, washing, screening and preparing the sand, applying the sand as specified, as well as brooming the sand back onto the surface as often as is required.

ITEM	UNIT
48.03 TREATMENT TYPE 3: (SLURRY) (STATE NOMINAL APPLICATION RATE IN CUBIC METRE PER SQUARE METRE):	SQUARE METRE (m^2)

The unit of measurement shall be the square metre of completed and accepted slurry seal according to drawings or where directed by the Engineer.

The bid rate shall include full compensation, inter alia, for furnishing all materials, marking the centre line or reference lines, spraying of binder, spreading of aggregate, rolling, removing of dust or deleterious material, supplying of water and spraying of haul roads and construction roads, trimming the edges of the completed surface, and all other incidentals necessary for completing the work as specified.

The bid rates shall include full compensation for procuring and furnishing the material including all preparatory work to the surface prior to application of the seal.

ITEM	UNIT
48.04 VARIATION IN THE RATE OF APPLICATION OF THE SLURRY:	CUBIC METRE (m^3)

The unit of measurement for slurry variations shall be the cubic metre of saturated fine aggregate.

Payment for variations shall be made as specified in CLAUSE 1212.

ITEM	UNIT
48.05 TREATMENT TYPE 4: (ASPHALT SKIM COAT):	
(a) TACK COAT USING 30% BITUMEN EMULSION	LITRE (l)
(b) CONTINUOUSLY-GRADED ASPHALT	TONNE (t)

The unit of measurement for the tack coat shall be the litre of emulsion applied, measured at spraying temperature. The unit of measurement for asphalt shall be the tonne of asphalt laid according to the Specifications.

The bid rate for tack coat shall include full compensation for procuring, furnishing and applying the tack coat and demarcating the areas to be sprayed, and for all incidentals necessary for completing the work as specified.

The bid rate for asphalt shall include full compensation for procuring, furnishing and mixing all the materials required for applying the asphalt, and for all transport and other incidentals necessary to complete the work as specified.

ITEM	UNIT
48.06 TREATMENT TYPE 5: (SCREED):	
(a) TACK COAT USING 30% BITUMEN EMULSION	LITRE (l)
(b) CONTINUOUSLY-GRADED ASPHALT (SPECIFY GRADE)	TONNE (t)
(c) COARSE GRADE SLURRY	CUBIC METRE (m^3)

The unit of measurement for the tack coat shall be the litre of emulsion applied, measured at spraying temperature. The unit of measurement for asphalt shall be the tonne of asphalt laid according to the Specifications. The unit of measurement for coarse grade slurry shall be the cubic metre of aggregate mix used in the slurry.

The bid rate for tack coat shall include full compensation for procuring, furnishing and applying the tack coat and demarcating the areas to be sprayed, and for all incidentals necessary for completing the work as specified.

The bid rate for asphalt shall include full compensation for procuring, furnishing and mixing all the materials required for applying the asphalt, and for all transport and other incidentals necessary to complete the work as specified.

The bid rate for slurry shall include full compensation for all materials, equipment and labour for producing and applying the slurry, irrespective of the number of applications required to attain the required thickness.

ITEM	UNIT
48.07 SAWING ASPHALT OR CEMENTED PAVEMENT LAYERS FOR PATCHING:	
(a) CONTINUOUSLY-GRADED ASPHALT:	
(i) NOT EXCEEDING 50 mm	SQUARE METRE (m^2)
(ii) EXCEEDING 50 mm BUT NOT EXCEEDING 100 mm	SQUARE METRE (m^2)
(iii) EXCEEDING 100 mm	SQUARE METRE (m^2)
(b) CEMENTED PAVEMENT LAYERS TO AN AVERAGE DEPTH:	
(i) NOT EXCEEDING 50 mm	SQUARE METRE (m^2)
(ii) EXCEEDING 50 mm BUT NOT EXCEEDING 100 mm	SQUARE METRE (m^2)
(iii) EXCEEDING 100 mm	SQUARE METRE (m^2)

The unit of measurement shall be the square metre of sawcut area calculated in accordance with the authorised length of sawcut and the average saw depth measured after excavation of the material.

The bid rate shall include full compensation for all equipment, labour supervision, materials, transport and

for all incidentals for sawing the asphalt and the cemented pavement layers, complete as specified and prescribed by the Engineer.

ITEM	UNIT
48.08 EXCAVATION IN EXISTING PAVEMENTS FOR PATCHING IN:	
(a) ASPHALT LAYERS	CUBIC METRE (m^3)
(b) CEMENTED LAYERS	CUBIC METRE (m^3)
(c) OTHER LAYERS (SPECIFY TYPE)	SQUARE METRE (m^2)

The unit of measurement shall be the cubic metre of material excavated from the existing pavement. The quantity shall be computed in accordance with the authorised dimensions of the excavation.

The bid rate shall include full compensation for demarcating the excavation, excavating the material, placing the excavated material in temporary stockpiles, spoiling of material in the stockpiles where ordered by the Engineer, including haul over a free-haul distance of 1.0 km, complete as specified.

ITEM	UNIT
48.09 BACKFILLING OF EXCAVATIONS FOR PATCHING WITH:	
(a) CHEMICALLY STABILISED PAVEMENT MATERIAL (SPECIFY THE PAVEMENT MATERIAL AND THE STABILISING AGENT) FOR A PATCH WITH A SURFACE AREA:	
(i) NOT EXCEEDING 5 m^2	CUBIC METRE (m^3)
(ii) EXCEEDING 5 m^2 BUT NOT EXCEEDING 100 m^2	CUBIC METRE (m^3)
(iii) EXCEEDING 100 m^2	CUBIC METRE (m^3)
(b) BASE COURSE MATERIAL STABILISED WITH BITUMINOUS EMULSION (SPECIFY THE EMULSION) FOR A PATCH WITH A SURFACE AREA:	
(i) NOT EXCEEDING 5 m^2	CUBIC METRE (m^3)
(ii) EXCEEDING 5 m^2 BUT NOT EXCEEDING 100m^2	CUBIC METRE (m^3)
(iii) EXCEEDING 100 m^2	CUBIC METRE (m^3)
(C) CONTINUOUSLY GRADED ASPHALT FOR A PATCH WITH A SURFACE AREA:	
(i) NOT EXCEEDING 5 m^2	TONNE (t)
(ii) EXCEEDING 5 m^2 BUT NOT EXCEEDING 100m^2	TONNE (t)
(iii) EXCEEDING 100 m^2	TONNE (t)

The unit of measurement for Items 48.09 (a) and (b) shall be the cubic metre of the specified chemically or bitumen stabilised pavement material placed in accordance with the specified requirements.

The quantities will be computed in accordance with the dimensions of the filling.

The unit of measurement for Item 48.09 (c) shall be the tonne of bituminous mix placed in accordance with the specified requirements.

The quantities will be computed in accordance with the dimensions of the filling and the density of the compacted bituminous mix.

The bid rates shall include full compensation for compacting the floor of the excavation, providing all the material, irrespective of its origin, including gravel (notwithstanding the provisions of SECTION 1600), for all mixing, placing, compacting and finishing as specified in this Section and other appropriate Sections of the Specifications, for all transport, work in restricted areas, and also for all machinery, equipment, labour, supervision and other incidentals for executing the work as specified.

The bid rate shall also include full compensation for chemical or bituminous stabilisation, including amongst others the provision and application of the stabilising agents and the bitumen.

ITEM	UNIT
48.10 EDGE BREAKS:	
(a) TRIMMING EDGES OF EXISTING SURFACING	METRE (m)
(b) RECONSTRUCTING EDGES FROM CONTINUOUSLY-GRADED ASPHALT	TONNE (t)

The unit of measurement for trimming edges shall be the metre of pavement edge cut back and trimmed as specified. The unit of measurement for reconstructing pavement edges shall be the tonne of continuously-graded asphalt furnished and compacted as specified.

The bid rate for trimming the edges shall include full compensation for cutting back the edges as directed, and removing and dumping of all excavated and loose material in an approved waste site.

The bid rate for reconstructing pavement edges shall include full compensation for compacting the surface on which the new edge is to be constructed and procuring, furnishing and mixing all materials and compacting and trimming the asphalt to the required lines and levels. It shall also include full compensation for applying a tack coat of emulsion to the surface to be treated.

The bid rates shall include full compensation for all transport, handling, labour, material and all incidentals necessary to complete all the work specified in the treatment of edge breaks.

ITEM	UNIT
48.11 CLEANING THE CRACKS WITH COMPRESSED AIR:	KILOMETRE (km)

The unit of measurement for cleaning the cracks with compressed air shall be the kilometre of road along which all the cracks have been blown clean.

The bid rate shall include full compensation for providing all equipment, labour, supervision and incidentals for blowing clean the cracks over the full width of the road to the satisfaction of the Engineer.

ITEM	UNIT
48.12 APPLYING BITUMINOUS BINDERS, AND SEALANTS FOR SEALING CRACKS:	
(a) MSP/1 OR SIMILAR PRIMER	LITRE (l)
(b) ANIONIC STABLE-GRADE EMULSION MIXED WITH SYNTHETIC MODIFIERS	LITRE (l)
(c) HOT BITUMEN RUBBER	LITRE (l)
(d) OTHER SPECIFIED AGENTS (TYPE INDICATED)	LITRE (l)

The unit of measurement shall be the litre of material applied as specified or as instructed by the Engineer.

The bid rates shall include full compensation for providing, mixing, heating (where required) and applying all the materials specified, and for all equipment, labour, supervision and incidentals for completing the work. No additional payment shall be made for multiple applications of material, and payment will not distinguish between the various types, widths or lengths of cracks.

ITEM	UNIT
48.13 COLD RUBBER-SLURRY FOR SEALING CRACKS	CUBIC METRE (m^3)

The unit of measurement for crack treatment with rubber slurry shall be the cubic metre of fine rubber crumbs used for preparing the mix.

The bid rate shall include full compensation for procuring and providing all the material, including emulsion synthetic modifiers, cement and water, and for mixing and applying the mixture, and for all equipment, labour, supervision, and incidentals for executing the work in accordance with the specifications.

Payment will not be made for redundant rubber pellets or redundant mixture or for mixture, which in the opinion of the Engineer has been wasted.

SERIES 5000

ANCILLARY ROADWORKS

CONTENTS OF THE GENERAL SPECIFICATIONS:

SERIES 5000: ANCILLARY ROADWORKS

SECTION 5100: MARKER AND KILOMETRE POSTS

CONTENTS:

5101 SCOPE

This Section covers the furnishing and installation of new as well as removal, renovating and re-erection of existing kilometre and marker posts, or delineators, in position and in accordance with the dimensions as shown on the Drawings or as directed by the Engineer.

5102 MATERIALS

(a) Concrete

Concrete work shall be carried out in accordance with the provisions of SECTIONS 6200, 6300 and 6400.

(b) Paint

Paint for marker and kilometre posts shall be non-reflectorised road-marking paint as specified in SECTION 5500. Paint, if specified, for the recess in the marker posts shall be an approved retro-reflective paint.

5103 FABRICATING

Marker and kilometre posts shall be fabricated to the dimensions shown on the Drawings. A mixture of four parts of concrete sand to one part of Portland cement shall be used. The forms shall be smooth and shall have accurate dimensions. The mixture shall be placed in the forms and vibrated on a vibrating table or by other approved means. The posts shall be reinforced as shown on the Drawings and shall have an F3 surface finish. The posts shall be true to shape, smooth, and without any honeycombing or other blemishes.

The posts may be made of plastic or similar material if specified in the Drawings and/or the Special Specifications.

The recess near the top of the marker post (delineator) shall be fitted with either retro-reflective sheeting applied to a plate, or a plastic corner cube retro-reflector, or shall be painted with retro-reflective paint, as specified in the Special Specifications. The remainder of the exposed portion of the post shall be painted with white road-marking paint.

5104 SPACING THE MARKER AND KILOMETRE POSTS

The marker posts shall be spaced as shown on the Drawings or as directed by the Engineer.

5105 ERECTING

Marker posts shall be erected after the seal has been completed. They shall be located at such spacing as the Engineer directs with their outside edges in line with the shoulder breakpoint. The edge on which the recess is located is the inner edge. The tops of the marker blocks shall be at a constant height above the centreline of the road.

Holes shall be excavated in the shoulder and the marker posts placed vertically and square to the road centre line.

Backfilling shall be compacted in 100 mm layers right from the bottom of the hole. Surplus excavated material shall be disposed of as directed.

The marker posts shall be painted immediately after having been placed.

Marker posts shall be maintained and protected during the entire construction period and any that are damaged or broken before the certificate of completion has been issued, shall be repaired or replaced, as may be required, at the Contractor's own cost.

5106 MEASUREMENT AND PAYMENT

ITEM	UNIT
51.01(a) NEW MARKER POSTS	NUMBER (no)
51.01(b) RENOVATING AND RE-ERECTION OF EXISTING MARKER POSTS:	NUMBER (no)

The unit of measurement shall be the number of marker posts supplied and erected in accordance with the Specifications.

The bid rate shall include full compensation for supplying all materials and labour, making and transporting the marker posts, setting out, excavating and backfilling all the holes and disposing of surplus excavated material, including all haulage, placing and painting the marker posts and all the equipment, the tools and incidentals necessary for completing and maintaining the Works described in this Section.

ITEM	UNIT
51.02 (a) NEW KILOMETRE POSTS	NUMBER (no)
51.02 (b) RENOVATING AND RE-ERECTION OF EXISTING KILOMETRE POSTS	NUMBER (no)

The unit of measurement shall be the number of kilometre posts supplied and erected in accordance with the Specifications.

The bid rate shall include full compensation for supplying all materials and labour, making and transporting the kilometre posts, setting out, excavating and backfilling all the holes and disposing of surplus excavated material, including all haulage, placing and painting the kilometre posts and all the equipment, the tools and incidentals necessary for completing and maintaining the Works described in this Section.

SERIES 5000: ANCILLARY ROADWORKS

SECTION 5200: GUARDRAILS

CONTENTS:

5201 SCOPE

This Section covers the supplying, installing and maintaining of metal guardrails at locations and in accordance with the details, dimensions and design shown on the Drawings or as directed by the Engineer.

5202 MATERIALS

(a) Guardrails
Guardrails shall comply with the requirements of AASHTO designation M180-98 or equivalent.

The dimensions of guardrails and end units shall be in accordance with the details shown on the Drawings.

Guardrails shall be supplied together with all the bolts, nuts, washers and fixing materials required, including the bolts for fixing the guardrails to the posts.

(i) Galvanising
Unless specified otherwise in the Special Specifications, all guardrails, bolts, nuts and washers shall be galvanised with a hot-dip (galvanised) zinc coating, which complies with the requirements of AASHTO designation M232M/97 or equivalent. Galvanised guardrails shall not be nested when stacked for storage.

(b) Guardrail posts
Guardrail posts shall be steel posts of UNP steel profiles 120 x 55 x 7 mm or of the type and size shown on the Drawings and/or described in the Special Specifications.

(c) Reflective plates
V-shaped reflective plates shall be manufactured from 1.5 mm thick mild steel plate to the dimensions shown on the Drawings. When supplied with galvanised guardrails, they shall also be galvanised, and when supplied with painted guardrails, they shall be finished in white baked enamel. The outer surfaces shall be coated with engineering-grade retro-reflective material that complies with the provisions of US 401:1993 or equivalent standards in the colours shown on the Drawings. Holes for fixing shall be drilled before the reflective plates may be galvanised or painted.

5203 CONSTRUCTION

(a) Erection
Steel posts shall be erected and fixed as shown on the Drawings. Unless otherwise approved by the Engineer, the posts shall be installed by driving them into the ground, preferably by a mechanical post driver.

The posts, spacer blocks (if applicable) and guardrails shall be erected and set true to line and level, so that the guardrails will be at the required height above the level of the completed road shoulder.

All guardrails shall be so erected as to have no projecting ends that might interfere with or endanger traffic. The edges and the centre of the guardrails shall touch either the spacer block or the post where no spacer blocks are used.

Guardrails, if specified, shall be provided with end units as shown on the Drawings. All splices of guardrails shall be at posts, and guardrails shall make contact over the entire area of the splice. All bolts shall be tightened and unless otherwise directed by the Engineer, spot-welded to protect against theft.

Reflective plates shall be fixed in accordance with the details shown on the Drawings. The reflective surfaces shall be arranged with the colours as shown on the Drawings.

(b) Painting
The following instructions shall apply where guardrails are to be painted:

(i) Before being fixed, the guardrails shall be cleaned, primed and painted as specified in CLAUSE 6908. After erection, all abraded or damaged surfaces shall be repainted as specified in CLAUSE 6908. Galvanised guardrails shall not be painted.

(ii) When existing guardrails are required to be repainted, they shall be thoroughly cleaned with wire brushes and descaled with suitable tools to remove all rust and loose and oxidised paint. They shall then be washed down and all exposed steel surfaces shall be given a coat of zinc based primer.

(iii) The entire prepared surface shall then be given a full coat of zinc-based primer and two coats of paint as specified in CLAUSE 6908.

5204 REQUIREMENTS

The completed guardrail shall have a neat appearance, and shall not show any visible deviations from line and grade. The posts shall be straight and vertical. The guardrails shall not be warped but shall be in a vertical plane parallel to the road centre line except at flared terminal sections. The painted or galvanised surface on the guardrail shall be smooth and continuous and free from abrasions or scratches. Any damage to the surface shall be repaired at the Contractor's expense.

5205 REMOVING, RENOVATING AND RE-ERECTING EXISTING GUARDRAILS

Every effort should be made to reuse existing guardrails rather than dispose of them and purchase new units. Where existing guardrails have to be removed, or removed and re-erected, or removed, renovated and re-erected, the three processes of removal, renovation and re-erection shall be carried out as follows:

(a) Removing the guardrails
All guardrails, reflective plates and end units shall be loosened. Posts shall be carefully dug out and the holes shall be filled and compacted in 150 mm layers. Items used for fixing, such as bolts, nuts and washers, together with the reflective plates, shall be placed into bags, after which all the material shall be transported to a store approved by the Engineer and all stored in groups by type.

Where material is intended for re-use, it shall first be unpacked for inspection by the Engineer for deciding which material will be suitable for re-use. Suitable

material shall then be stored separately from material that is unsuitable for re-use.

(b) Renovating the guardrails
Guardrails, end units and steel posts suitable for reuse shall be taken to the workshop for cleaning and painting. Rust and existing paint shall be completely removed and minor indentations hammered out. The guardrails shall then be re-galvanised or receive surface treatment and be painted as described in CLAUSE 6908.

Bolts, nuts and washers to be re-used shall be cleaned and all rust removed, and shall then be oiled.

(c) Re-erection
The guardrails shall be erected in the positions as indicated and all the removed material suitable for re-use and as much supplementary new material as may be necessary shall be used. Re-erection shall be as specified for new guardrails, including fixing the retro-reflective plates.

5206 MEASUREMENT AND PAYMENT

ITEM	UNIT
52.01 GUARDRAILS ON STEEL POSTS:	
(a) GALVANISED	METRE (m)
(b) PAINTED	METRE (m)

The unit of measurement shall be the metre of guardrail erected, excluding end units.

The bid rates shall include full compensation for furnishing all materials and labour and erecting and painting and galvanising the guardrail, complete with posts, spacer blocks, bolts, nuts, washers and reinforcing plates.

ITEM	UNIT
52.02 EXTRA OVER ITEMS 52.01 AND 52.10 FOR HORIZONTALLY CURVED GUARD-RAILS FACTORY BENT TO A RADIUS OF LESS THAN 45 m	METRE (m)

The unit of measurement shall be the metre of curved guardrail erected and measured in place.

The bid rate extra over the rates bid for ITEMS 52.01 and 52.10 shall include full compensation for incidentals in respect of supplying and erecting curved guardrails.

ITEM	UNIT
52.03 END UNITS:	
(a) END SECTIONS INCLUDING FOUNDATION IN THE GROUND WHERE SINGLE GUARDRAIL SECTIONS ARE USED (STATE LENGTH)	NUMBER (no)
(b) END SECTIONS INCLUDING FOUNDATION IN THE GROUND WHERE DOUBLE GUARDRAIL SECTIONS ARE USED (STATE LENGTH OF END SECTION)	NUMBER (no)
(c) CABLE STAYS COMPLETE WITH ANCHOR BLOCK	NUMBER (no)

The unit of measurement shall be the number of end units of each type erected.

The bid rates shall include full compensation for all labour, constructional equipment and materials required for installing the end units as shown on the Drawings, including posts and fittings and the bending of turned-down sections, excavations, concrete, backfilling, the removal of surplus backfill and bituminous sealing at posts where guardrail is erected through a bituminous surface.

ITEM	UNIT
52.04 ADDITIONAL GUARDRAIL STEEL POSTS:	NUMBER (no)

The unit of measurement for additional guardrail posts shall be the number erected over and above those erected in accordance with the normal spacing shown on the Drawings.

The bid rates shall include full compensation for supplying additional posts and erecting the posts.

ITEM	UNIT
52.05 REFLECTIVE PLATES	NUMBER (no)

The unit of measurement shall be the number of reflective plates installed.

The bid rate shall include full compensation for supplying all materials and labour required for manufacturing, painting and fixing the reflective plates as specified and as shown on the Drawings.

ITEM	UNIT
52.06 REMOVING EXISTING GUARDRAILS	METRE (m)

The unit of measurement shall be the metre of guardrail removed, and the quantity shall be measured between the terminal points of the sections removed, including the end units, but excluding the anchor blocks and anchor cables, if any, projecting beyond the end units.

The bid rate shall include full compensation for the work as described in SUBCLAUSE 5205(a), including loading, transporting to any point on the Site, and off-loading and stacking the material.

ITEM	UNIT
52.07 RENOVATING GUARDRAIL MATERIAL:	
(a) GUARDRAILS INCLUDING END SECTIONS	METRE (m)
(b) POSTS INCLUDING BOLTS, WASHERS AND NUTS	NUMBER (no)

The unit of measurement for SUBITEM (a) shall be the metre of single guardrail, whether straight or bent renovated as specified, the length of which shall be measured in accordance with the measurements of the guardrail after dismantling. The unit of measurement for SUBITEM (b) shall be the number of treated posts.

The bid rates shall include full compensation for the work as specified in SUBCLAUSE 5205(b), including the loading, transporting to and from the workshops, off-loading and storing of the material.

ITEM	UNIT
52.08 RE-ERECTION OF GUARDRAILS WITH RECOVERED MATERIAL:	
(a) SINGLE GUARDRAIL	METRE (m)
(b) DOUBLE GUARDRAIL	METRE (m)

The unit of measurement shall be the metre of single or double guardrail re-erected with used material and measured between the points where they are joined to the end units.

The bid rates shall include full compensation for re-erecting the guardrails as specified in SUBCLAUSE 5205(c), including the loading, transporting between any two points on the site and off-loading the material, and providing new fixing material. Payment shall be made separately for any new material required, including spacer blocks, but not for other fixing materials. Where sections are made entirely from new material, payment therefore shall be made under the appropriate items for new guardrails.

ITEM	UNIT
52.9 RE-ERECTION OF END UNITS WITH RECOVERED MATERIAL:	
(a) END WINGS	NUMBER (no)
(b) TERMINAL SECTIONS WITH SINGLE GUARDRAILS	NUMBER (no)
(c) TERMINAL SECTIONS WITH DOUBLE GUARDRAILS	NUMBER (no)
(d) TERMINAL SECTIONS COMPLETE WITH ANCHOR BLOCK	NUMBER (no)

The unit of measurement shall be the number of end units erected with recovered and, in part, new material.

The bid rates shall include full compensation for erecting the end units and for providing all anchors, fixing materials and anchor blocks. Apart from anchors, anchor blocks and fixing materials payment will be made separately for all new materials. End units made completely from new materials shall be paid for in accordance with the appropriate rates for new end units.

ITEM	UNIT
52.10 NEW MATERIAL REQUIRED FOR THE RE-ERECTION OF GUARD-RAILS WITH RECOVERED MATERIALS:	
(a) GUARDRAILS	METRE (m)
(b) STEEL POSTS	NUMBER (no)
(c) REFLECTIVE PLATES	NUMBER (no)
(d) SPACER BLOCKS	NUMBER (no)

The unit of measurement for SUBITEM (a) shall be the metre of guardrail provided, measured in accordance with the measurements of the loose guardrail. The unit of measurement for SUBITEMS (b), (c) and (d) shall be the number of new steel posts, reflective plates and spacer blocks provided, respectively.

The bid rates shall include full compensation for supplying the material as specified. ITEM 52.02 shall apply to horizontally bent guardrail factory bent to a radius of less than 45 m.

ITEM	UNIT
52.11 DRILLING AND BLASTING HOLES FOR GUARDRAIL POSTS, ERECTION AND BACKFILLING	NUMBER (no)

The unit of measurement shall be the number of holes drilled and blasted with explosives in rock material that cannot be removed by auger and where the posts cannot be installed by driving.

The bid rate shall include full compensation for all drilling, explosives, materials, labour and equipment and all incidentals to be incurred for making holes in rock materials and for backfilling the holes after erection of the posts, including concrete backfill and removing any surplus material.

SERIES 5000: ANCILLARY ROADWORKS

SECTION 5300: FENCING

CONTENTS:

5301 SCOPE

This Section covers the moving of existing fences and erecting new fences along the boundaries of the road reserve and elsewhere as indicated on the Drawings or as directed by the Engineer.

It shall also include the erection and later removal of temporary fences and dismantling of existing fences and stacking of the fencing material.

Except when the Engineer allows otherwise, temporary fences shall be erected before construction on a particular section of the road is commenced, or before temporary bypasses are opened to traffic.

This Section also covers the construction of cattle grids.

5302 MATERIALS

(a) Straining posts, stays, standards and droppers
Straining posts, stays, standards and droppers shall be of the type and size indicated on the Drawings. Steel sections shall comply with the requirements of BS 4-1:1993 or BS EN 10162:2003 or equivalent and timber posts with the requirements of BS 5268-2:2002 or equivalent. Timber posts shall be treated with a preservative in accordance with the requirements of Subclause 5202(b).

Unless otherwise specified or shown on the Drawings, rolled steel posts shall be 15 or 22 kg/m rails as shown on the Drawings. Standards shall be 2.5 kg/m Y-sections or timber standards according to SABS 457 or equivalent.

Droppers shall be 0.56 kg/m ridgeback-pattern droppers or timber droppers according to BS 5268-2:2002 or equivalent.

Tubular straining posts and stays shall be galvanised in accordance with BS EN 10240:1998, BS EN ISO 1461:1999 or equivalent for Class B1 articles, or shall be painted as specified in Section 5900 as may be required on the Drawings, and shall have a wall thickness of at least 2.95 mm. Unless otherwise shown on the Drawings, all tubular posts shall be provided with at least a 200 mm x 200 mm foot plate and a pressed-steel or cast-iron cap. Tubular stays shall have a nominal bore of at least 50 mm.

Rolled steel sections shall be provided with a protective coating of tar or other approved material.

(b) Bolts for stays
Bolts shall be galvanised steel bolts of the required length and a diameter, which shall not be less than 12 mm. All the necessary bolts, nuts and washers, shall be supplied with each post.

(c) Wire

(i) Barbed wire
Barbed wire shall comply with the requirements of US 193:2001, US 195:2001, BS EN 10223-1:1998 or equivalent and shall be one or more of the following types:

(1) High-tensile-grade single-strand 3.15 mm x 2.5 mm oval-shaped wires, with a 2.81-mm equivalent diameter and fully galvanised.

(2) High-tensile-grade single-strand fully galvanised (first-class coating), 2.8 mm x 1.9 mm in diameter, oval-shaped wire, with a 2.31 mm equivalent diameter. This wire shall not be used within 500 mm above ground level where bush fires are common.

(3) Mild-steel-grade double-strand uni-directional twist wire, each strand 2.5 mm in diameter, for use at any height above ground. The wire shall be fully galvanised.

Barbs shall be manufactured from 2 mm galvanised wire and shall be spaced at not more than 152 mm.

(ii) Smooth wire
Smooth wire shall comply with the requirements of US 193:2001, US 195:2001, BS EN 10223-1:1998 or equivalent and shall be of the types specified below:

(1) Straining wire shall be 4 mm in diameter and fully galvanised.

(2) Fencing wire shall be high-tensile-grade not less than 2.24 mm in diameter wire fully galvanised.

(3) Tying wire shall be not less than 2.5 mm in diameter mild-steel galvanised wire for tying fencing wire to standards and droppers and 1.6 mm mild-steel galvanised wire for tying netting and mesh wire to the fencing wire.

(d) Diamond mesh
Diamond mesh (chain-link fencing material) shall comply with the requirements of BS 1722-1:1999 or BS 1722-2:2000 or equivalent. The width shall be as shown on the Drawings and the edge finish shall be both sides clinched or barbed.

The nominal diameter of the wire shall be 2.5 mm and the mesh size shall be 64 mm x 64 mm.

The wire shall be fully galvanised.

(e) Wire netting
Wire netting shall be fully galvanised mild-steel wire with a minimum diameter of 1.8 mm, with 75 mm hexagonal mesh.

The width shall be as shown on the Drawings.

(f) Barbed-tape concertina wire
Barbed-tape concertina wire shall comply with the requirements of CKS 592 Type A or equivalent. The high-tensile steel wire shall be heavily galvanised (Class A), and the barbed tape and concertina clamps shall also be heavily galvanised (Class Z600). The diameter of the roll shall be 950 mm or 700 mm according to requirements.

(g) Gates
Gates shall be manufactured to the dimensions shown on the Drawings.

Gates shall be complete in every respect, including hinges, washers, bolts and locking chains attached to the gate.

Gate posts shall not be used as straining posts and shall be according to BS 5268-2:2002 or equivalent.

(h) Timber posts for wire mats
Timber posts for holding down wire mats where the fence crosses streams shall comply with the requirements of BS 5268-2:2002 or equivalent and shall be in accordance with the requirements of SUBCLAUSE 5202(b).

(i) Manufacturing tolerances for wire
The actual diameter of wire supplied shall nowhere be less than the specified diameter minus the following tolerances:

Specified diameter	Tolerance
1.00 - 1.80 mm	0.05 mm
2.00 - 2.80 mm	0.08 mm
3.15 - 4.00 mm	0.10 mm

5303 TYPES OF FENCING

The following types of fences shall be erected in accordance with the dimensions shown on the Drawings:

- Stock-proof fences
- Vermin-proof fences
- Pedestrian fences
- Security fences

Where existing fences have to be dismantled and re-erected, they shall be erected either to the same design as the original, but with such modifications as may be required by the Engineer, or they shall be erected up to one of the standards specified above, all as ordered by the Engineer.

5304 PROTECTING LIVESTOCK

From the time of occupancy up to the date of Taking Over Certificate being issued to the Contractor, he/she shall take all measures necessary for preventing the ingress of vermin, and for protecting and controlling livestock etc, on the sections of the properties affected by his/her operations. He/she shall provide gates at the positions in existing fences cut by him/her for gaining access and shall ensure that all gates are kept closed except when they are opened for admitting his/her traffic. No fences shall be cut without the approval of the Engineer, and consultation with the Owner of the fence.

Where alternative arrangements cannot be made, the Engineer may direct the Contractor to erect temporary fencing where necessary to protect livestock that may be lost or are exposed to vermin through his/her operations. Such fencing shall be of an adequate standard and shall be erected ahead of construction operations. The fencing shall be maintained in a good order during construction operations and, on completion of the work, it shall be removed from the site and all surfaces shall be restored. The Engineer may order that any permanent fencing which is required be erected ahead of construction operations, where practicable, instead of erecting temporary fencing.

Payment for the protection of livestock, excluding the erection of temporary fences, shall be included in the amounts bid for the Contractor's establishment on the site, as specified in SECTION 1300.

5305 CLEARING THE FENCE LINE

The fence line shall be cleared over a width of at least 1.0 m on each side of the centre line of the fence and surface irregularities shall be graded so that the fence will follow the general contour of the ground. Clearing the line shall include the removal of all trees, scrub, stumps, isolated boulders or stones and other obstructions, which will interfere with the construction of the fence. Stumps within the cleared space shall be grubbed as described in SECTION 3100. The bottom of the fence shall be located at a uniform distance above the ground line in accordance with the requirements shown on the Drawings. All material removed shall be burnt or disposed of in disused borrow pits.

Any areas outside the road reserve where clearing is not permitted by the Owner or is impracticable shall not be cleared if so directed by the Engineer.

5306 ERECTING STRAINING POSTS AND STANDARDS

Straining posts shall be erected at all terminal points, low points (as required), corners and bends in the fencing and at all junctions with other fences. Straining posts shall not be spaced further apart than shown on the Drawings. The length of posts above ground shall be such that the correct clearance between the lowest wire and the ground can be obtained.

Straining posts shall be accurately set in holes and shall be provided with concrete bases to the dimensions shown on the Drawings.

Holes shall be dug to the full specified depth. Where, on account of the presence of rock, the holes cannot be excavated by hand or by pneumatic tools and the Contractor has to resort to the use of explosives, he/she will be paid separately for the drilling and blasting operations required.

All straining posts shall be braced by means of stays or anchors as shown on the Drawings or as directed by the Engineer. Tubular stays shall be bolted to the posts. Gateposts shall not be used as straining posts but at each gatepost a straining post shall be placed as shown on the Drawings.

Standards shall be firmly planted into the ground at the spacing shown on the Drawings or as directed by the Engineer. The spacing of standards between any two successive straining posts shall be uniform and not greater than that shown on the Drawings. In rock or hard material standards shall be either driven or set in holes drilled into the rock. The size of drilled holes shall provide a tight fit to the standards. Care shall be taken when driving standards to prevent their buckling or being damaged.

All straining posts and standards shall be accurately aligned and set plumb. Where veranda-type security fencing is used, the posts shall be planted with the overhang on the roadside and perpendicular to the direction of the fence. After the straining posts and standards have been firmly set in accordance with the

foregoing requirements, fence wires shall be attached thereto at the spacing shown on the Drawings.

5307 ERECTING FENCE WIRES

All fencing wire shall be tied to the sides of standards or posts to prevent the wires from being displaced or becoming loose. The wire shall be carefully tensioned without sagging, and true to line, care being exercised not to tension the wire to such an extent that it will break, or that end, corner, straining or gate posts will be pulled out, or that it will be easily damaged during fires.

Each strand of fencing wire shall be securely tied in the correct position hard up to each standard with soft galvanised tying wire. The tying wire for each strand shall pass through a hole or notch in the standard, while the ends of the tying wire shall be wound at least four times around the fencing wire to prevent it from moving in a vertical direction.

At end, corner, straining and gate posts the fencing wire shall be securely wrapped twice around the post and secured against slipping by tying the end tightly around the wire by means of at least six neat tight twists.

Where high-tensile wire is used, two long twists may first be made followed by the six tight, neat twists around the post to prevent the wire from breaking at the first twist. When smooth wire is used, the loose end shall preferably be bent over and hooked into the notch between the fencing wire and the first twist.

Splices in the fencing wire shall be permitted if made in the following manner with a splicing tool. The end of each wire at the splice shall be taken at least 75 mm past the splicing tool and wrapped around the other wire by not less than six complete turns with the two separate wire ends being turned in opposite directions. After the splicing tool has been removed, the space left by it in the spliced wire shall be closed by pulling the wire ends together. Unused wire ends shall be cut close so as to leave a neat splice.

The gaps between gate posts and the adjacent straining posts shall be fenced off with short lengths of fencing wires.

Droppers shall be tied to each fence wire with soft tying wire in the required position as specified for standards to prevent slippage in a vertical direction. The spacing of droppers between any two straining posts shall be uniform. Anchoring to structures shall be done as shown on the Drawings.

Barbed-tape concertina wire shall be attached to the fence as shown on the Drawings at maximum spaces of 1.0 m between tying points. Barbed-tape concertina wire rolls shall be spliced by overlapping for one full circle and tied at four evenly spaced points along the circumference. Spliced ends shall coincide with the positions of the standards.

5308 ERECTING DIAMOND MESH OR WIRE NETTING

Where vermin-proof, pedestrian or security fences are erected, or where instructed by the Engineer, wire netting or diamond mesh shall be stretched against the fence and properly tied to the fencing wire as shown on the Drawings. The diamond mesh or wire netting shall be secured by soft tying wire at 1.2 m centres along the top and bottom wires and at 3 m centres along each of the other fencing wires, unless otherwise shown on the Drawings.

In the case of vermin-proof fencing, vermin shall be prevented from creeping under the fence by either one of the two methods described below as ordered by the Engineer:

(a) By folding back the bottom 130 mm of the wire netting so that it lies flat on the ground and by tightly packing stones (having a minimum dimension of 200 mm) end to end on this flap to secure it in position.

(b) By embedding the lower 130 mm of the wire netting in the ground and thoroughly compacting the earth around it on both sides, to secure the netting.

5309 CLOSING OPENINGS UNDER FENCES

At ditches, streams, drainage channels or other depressions where the fence cannot be erected so as to follow the general ground contour, the Contractor shall close the opening under the fence with horizontal barbed wires at 150 mm spacing. Stretched between additional posts or straining posts as shown on the Drawings or as directed by the Engineer. In the case of pedestrian, vermin-proof and security fences the opening shall be covered with strips of wire netting or diamond mesh 1000 mm wide, fixed to the barbed wires.

In the case of larger streams where damming of debris against the fence would constitute a hazard, the opening below the bottom fencing wire shall be closed with loose-hanging wire nets. For this purpose additional straining posts shall be planted on both sides of the stream with a cable consisting of at least five strands of smooth fencing wire stretched between them. Onto this cable vertical strips of diamond mesh hanging down to ground level shall be fixed. The edges of the various strips of diamond mesh shall be tied to each other so that the entire mat will be raised by water flowing underneath to leave a free stream area. These mats at streams shall be erected only when instructed by the Engineer. If it should be necessary to keep the bottoms of the mats on the ground, the Engineer may order that timber posts or pipes be fixed horizontally to the bottom ends of the diamond-mesh strips.

5310 EXISTING FENCES

Where a new fence joins an existing fence whether in line or at an angle, the new fence shall be erected with a new straining post positioned at the terminal point of the existing fence.

Existing fences that require to be taken down or moved to a new location shall be dismantled. Material not required for re-erection or unsuitable for re-use shall be neatly stacked at approved locations in accordance with the Engineer's instructions. Fencing wire and wire netting shall be stacked clear of the ground. Payment will be made only for fences removed in accordance with the written instruction of the Engineer.

Where fences require moving, the Contractor shall re-use all the material, declared to be suitable for this purpose by the Engineer, plus such new material as may be required to erect the fence again to the standard specified for new fences. The Engineer shall not be responsible for any delays or costs arising from the breaking of re-used wire during straining.

5311 ERECTING GATES

Gates shall be erected at the positions indicated by the Engineer. The gates shall be hung on gate fittings in accordance with the requirements shown on the Drawings. Gates shall be so erected as to swing in a

horizontal plane at right angles to the gateposts, clear of the ground in all positions. In pedestrian and security fences the double swing gates shall leave a gap not exceeding 25 mm between them when closed and other gates shall not be further than 25 mm from the gate post when closed.

Gates shall be stock-proof to the same extent as the adjoining fence. The clearance below the gates shall not exceed 75 mm with the gates closed. Where the gate crosses a public road, it shall be fitted with a disc or other device easily visible at night, as instructed by the Engineer.

5312 TEMPORARY FENCING, GATES AND MOTOR GATES

If required, the Contractor shall erect temporary fencing, gates and motor gates in accordance with the Drawings, Special Specifications or the Engineer's instructions. The material and erection shall be in accordance with the provisions of this Section, but the material need not necessarily be new. Where used materials are offered, they shall be in a good condition and approved in advance by the Engineer.

When no longer required, the temporary fencing, gates and motor gates shall be dismantled and removed.

5313 FINISHING REQUIREMENTS

The completed fence shall be plumb, taut, true to line and ground contour, with all posts, standards and stays firmly set. The height of the lower fencing wire above the ground at posts and standards shall not deviate by more than 25 mm from that shown on the Drawings. Other fencing wires shall not deviate by more than 10 mm from their prescribed vertical positions.

The Contractor shall, on completion of each section of fence, remove all cut-offs and other loose wire or netting so as not to create a hazard to grazing animals or a nuisance to the Owners of the ground.

5314 CATTLE GRIDS

A cattle grid is a structure that is designed to prevent the passage of cattle and other domestic animals while permitting other traffic to pass. Cattle grids are normally constructed across a road in connection with fencing and gates.

Cattle grids shall be constructed in conformity with the details, dimensions and design shown in the Drawings, and at locations shown in the Drawings or as directed by the Engineer.

5315 MEASUREMENT AND PAYMENT

ITEM	UNIT
53.01 CLEARING THE FENCE LINE, 2m WIDE STRIP:	KILOMETRE (km)

The unit of measurement for clearing the fence line shall be the kilometre of fence line measured along each fence line.

The bid rate shall be in full compensation for clearing the fence line as specified, including the removal of trees, stones, and other obstructions and the disposal of all waste material resulting from clearing operations, as may be directed. The removal of trees and stumps with a girth exceeding 1.0 m shall be paid for as specified in SECTION 3100.

ITEM	UNIT
53.02 SUPPLYING AND ERECTING NEW FENCING MATERIAL FOR NEW FENCES AND FOR SUPPLEMENTING MATERIAL IN EXISTING FENCES WHICH ARE BEING REPAIRED OR MOVED:	
(a) BARBED WIRE (GRADE, SIZE AND TYPE OF GALVANISING INDICATED)	KILOMETRE (km)
(b) SMOOTH WIRE (GRADE, SIZE AND TYPE OF GALVANISING INDICATED)	KILOMETRE (km)
(c) DIAMOND MESH	SQUARE METRE (m^2)
(d) WIRE NETTING	SQUARE METRE (m^2)
(e) BARBED-TAPE CONCERTINA WIRE	KILOMETRE (km)
(f) STEEL AND TIMBER STRAINING POSTS, INCLUDING ANCHORS (TYPE, SIZE AND LENGTH AND WHETHER GALVANISED, TREATED OR PAINTED INDICATED)	NUMBER (NO.)
(g) STEEL AND TIMBER STANDARDS (LENGTH AND TYPE INDICATED)	NUMBER (NO.)
(h) STEEL AND TIMBER DROPPERS (LENGTH AND TYPE INDICATED)	NUMBER (No.)
(i) TIMBER POSTS TO BE FIXED TO THE BOTTOM OF WIRE MESH IN STREAMS (DIAMETER INDICATED)	METRE (m)

The quantity of material used shall be determined by measuring the quantities of individual items of material used in the completed fence. The linear measurement of the completed fence shall not apply. The appropriate units of measurement are as follows:

(i) Fencing wire (SUBITEMS 53.02 (a) and (b))
The unit of measurement shall be the kilometre of each type of fencing wire measured between end posts. Tying wire and wire used for anchoring the posts shall not be measured for payment.

(ii) Diamond mesh and wire netting (SUBITEMS 53.02 (c) and (d))
The unit of measurement shall be the square metre of diamond mesh or wire netting, the quantity of which shall be calculated according to the prescribed width and the length between straining posts or gate posts, or the length of strips used for covering openings under fences, or the length used for covering the gates.

(iii) Barbed-tape concertina wire (SUBITEM 53.02 (e))
The unit of measurement shall be the kilometre of fence provided with barbed-tape concertina wire of which each concertina is opened to the maximum effective open concertina length as specified in the Drawings.

(iv) Straining posts (SUBITEM 53.02 (f))
The unit of measurement shall be the number of posts, as follows:
All straining posts erected in accordance with the maximum specified spacing or such lesser spacing as authorised by the Engineer, all corner posts authorised by the Engineer, and all end posts. Gate posts for new gates shall not be measured for payment.

(v) Standards and droppers (SUB-ITEMS 53.02 (g) and (h))
The unit of measurement shall be the number of standards and droppers erected to the maximum specified spacing or such lesser spacing as authorised by the Engineer.

(vi) Timber posts to be fixed to the bottom of wire mesh in streams (SUB-ITEM 53.02 (i)).
The unit of measurement shall be the metre of timber post of every diameter erected in accordance with the Drawings and the instructions of the Engineer.

The bid rate for each straining post, standard, dropper, each kilometre of fencing wire and barbed-tape concertina wire, and each square metre of diamond mesh or wire netting and for each metre of timber post, shall include full compensation for providing all the materials, including all concrete, tying wire, straining wire, bolts, washers and nuts, for excavating or drilling holes for standards, for erecting the posts, standards and droppers and the complete putting up of the fence as specified and as shown on the Drawings. No separate payment will be made in respect of stone packing and/or trenching in the case of wire netting.

The bid rate for posts shall include full compensation for erecting the stays of the types shown on the Drawings.

ITEM	UNIT
53.03 NEW GATES:	
(a) SINGLE LEAF (SIZE AND TYPE INDICATED)	NUMBER (NO.)
(b) DOUBLE LEAF (SIZE AND TYPE INDICATED)	NUMBER (NO.)

The unit of measurement shall be the number of new gates erected. At pedestrian and security fences the pair of gates shall be measured as one.

The bid rates shall include full compensation for procuring and furnishing all material, including gates, gate posts, hinges, bolts, disks, concrete and straining wire, and for erecting the gates as specified and as shown on the Drawings. It shall not include compensation for any fencing wire or mesh fitted onto the gate.

ITEM	UNIT
53.04 MOVING EXISTING FENCES AND GATES:	
(a) FENCES:	
(i) STOCK-PROOF FENCES	KILOMETRE (km)
(ii) VERMIN-PROOF FENCES	KILOMETRE (km)
(iii) PEDESTRIAN FENCES	KILOMETRE (km)
(iv) SECURITY FENCES	KILOMETRE (km)
(b) GATES	NUMBER (NO.)

The unit of measurement for moving existing fences shall be the kilometre of fence, the quantity of which shall be taken as the length of fence that has been put up permanently with material obtained from fences that have been dismantled elsewhere. Additional new material used during the re-erection of existing fences shall be measured under ITEM 53.02.

The unit of measurement for moving gates shall be the number of gates moved.

The bid rate for each kilometre of existing fence moved shall include full compensation for dismantling the old fence, coiling and stacking the material unsuitable for re-use, moving all material, including posts and wire and again putting up the fence at the new position and the provision of binding, tying and straining wire. New material used for re-erection of old fences shall be paid for under ITEM 53.02.

The bid rate for each gate moved shall include full compensation for taking down the gate and re-erecting it where required, including all new bolts, nuts and other accessories required but excluding new gate posts.

ITEM	UNIT
53.05 DISMANTLING EXISTING FENCES AND GATES	KILOMETRE (km)

The unit of measurement shall be the kilometre of existing fencing and gates taken down and dismantled on the instruction of the Engineer.

The bid rate shall include full compensation for taking down existing fences and gates, coiling wires, rolling netting into rolls, transporting the material to designated sites and stacking the material.

ITEM	UNIT
53.06 PROVIDING TEMPORARY FENCES AND GATES:	
(a) STOCK-PROOF FENCE	KILOMETRE (km)
(b) VERMIN-PROOF FENCE	KILOMETRE (km)
(c) PEDESTRIAN FENCE	KILOMETRE (km)
(d) TEMPORARY GATES (TYPE AND SIZE INDICATED)	NUMBER (NO.)
(e) TEMPORARY MOTOR GATES	NUMBER (NO.)

The unit of measurement for SUB-ITEMS 53.06 (a), (b) and (c) shall be the kilometre of each type of temporary fencing erected on the instructions of the Engineer.

The bid rates shall include full compensation for providing all labour, new or suitable second-hand material, putting up the temporary fence and when no longer required, dismantling and removing it from the site to any new locality where it is required.

The unit of measurement for SUB-ITEMS 53.06 (d) and (e) shall be the number of temporary gates provided by the Contractor.

The bid rates for SUB-ITEMS 53.06 (d) and (e) shall include full compensation for erecting the gates in accordance with the Drawings, by using new or second-hand material, and their dismantling and removal and again putting up any fencing removed from the positions where the gates were erected.

Where new or second-hand materials are used that have been provided by the Employer, e.g. material obtained from taking down existing fences, such material obtained from taking down the temporary fences or gates shall remain the property of the Employer. Material provided by the Contractor for temporary fences will become the Contractor's property after the temporary fences have been dismantled.

ITEM		UNIT
53.07	RINGBOLTS FOR ANCHORING FENCING TO STRUCTURES:	NUMBER (NO.)

The unit of measurement shall be the number of ringbolts supplied and fixed to the structure.

The bid rate shall include full compensation for supplying and fixing ringbolts of the type shown on the Drawings to the structure, including, where necessary, drilling holes, anchorage, grouting ringbolts in with epoxy resin, and for all incidentals.

ITEM		UNIT
53.08	DRILLING AND BLASTING HOLES FOR POSTS AND ANCHORS:	NUMBER (NO.)

The unit of measurement shall be the number of holes for posts and anchors made by drilling and/or blasting where excavation by pneumatic tools cannot be done economically.

The bid rate shall include full compensation for drilling and blasting the holes and for all other expenses in connection with providing, storing, transporting and using explosives.

ITEM		UNIT
53.09	CATTLE GRIDS (INDICATE TYPE)	NUMBER (no)

The unit of measurement shall be the number of cattle grids supplied; the type as indicated in the Drawings.

The bid rate shall include full compensation for providing the materials and constructing the cattle grids, including excavation, construction, curing finishing and protection of the works as instructed by the Engineer.

SERIES 5000: ANCILLARY ROADWORKS

SECTION 5400: ROAD SIGNS

CONTENTS:

5401 SCOPE

This Section covers the supply and erection of permanent and temporary road traffic signs alongside and over the carriageway, ramps and cross roads at intersections and interchanges and at the locations indicated on the Drawings or as directed by the Engineer.

5402 DESCRIPTION

This work shall consist of furnishing and placing road signs, in accordance with these Specifications, at the locations and of the dimensions shown on the Drawings or as directed by the Engineer.

5403 MATERIALS

Concrete for foundations shall be Class 30/19 to be executed as specified in SECTIONS 6100 and 6400 of these Specifications.

Signposts shall consist of steel pipes conforming to the requirements of ASTM A 52 Grade B, to be galvanised in accordance with ASTM A 123.

Sign plates shall consist of steel sheets conforming to the requirements of ASTM A 366 or aluminium alloy sheets conforming to ASTM B 209, 6061-T6 aluminium, degreased and alodine treated.

Reflective sheeting shall be of high intensity grade sheeting, with pressure sensitive adhesive or similar product, as approved by the Engineer. Reflective sheeting shall comply with ASTM D4956 and the class of sheeting shall be as specified in the Special Specifications.

Words, figures and other symbols shall be applied to the reflective sheeting by applying coloured overlay film onto white reflective sheeting. The overlay films and the base sheeting must come from the same manufacturer.

The Contractor shall provide, at his/her own expense, the sign manufacturer's specifications and certificate for all materials he/she intends to adopt. The certificate shall set forth the name or brand of the materials to be furnished, the results of tests proving the products meet the requirements, and any other data requested by the Engineer. The certificate shall be sworn to for the manufacturer by a person having legal authority to bind the company.

The Contractor shall also provide from the sheeting manufacturer a seven-year warranty for satisfactory field performance of the finished signs in respect of retroreflective performance, colour, fungus resistance, and adhesion. The retroreflective performance of the sign at the end of the warranty period should be specified in the warranty and the retroreflective values should not be less than 75% of the original values. Any sign that fails within that period shall be replaced at no cost to the Employer.

The Contractor shall not place any purchase order for road signs until the manufacturer's certificate and form of guarantee have been inspected by the Engineer and accepted.

At any time the Engineer may request any test he/she thinks necessary to verify the compliance of the material with the Specifications.

All the tests shall be carried out in a specialised laboratory previously approved by the Engineer; this laboratory shall certify the results of the tests in question.

All the above-mentioned tests shall be at the expense of the Contractor.

5404 CONSTRUCTION

Road sign plates shall be manufactured from galvanised steel sheet of at least 1.4 mm thickness, or from aluminium alloy sheet of at least 2.5 mm thickness or such other material that is approved by the Engineer.

Sign plates manufactured from sheet material shall be stiffened when the maximum dimension of the sign exceeds 600 mm.

The stiffening of the sign may be in the form of a flange at least 15 mm deep on all edges or by means of mild steel or aluminium sections. Material for fixing such as brackets, socket caps, clips, screws, bolts, nuts and washers, shall be corrosion resistant and to the Engineer's approval. Brass or copper will not be allowed for use in contact with aluminium.

The colours on all road signs, with the exception of black, will normally be reflectorised, unless otherwise specified or ordered by the Engineer. Reflective sheeting shall be applied with a squeeze roll applicator with sheeting that has a pressure sensitive adhesive. Retro-reflective background material shall be pre-applied to individual sections of big informative signs before assembly with the material taken around the face edges of each extension for at least 10 mm without damaging the material. Where possible, letters across the joint between two extrusions should be avoided.

Before painting all signs shall be pre-treated by an approved method, and all frames, brackets, metal stakes, clips, screws, nuts, bolts, rivets, and washers shall be corrosion-proofed prior to painting.

The signs shall be supported on a galvanised steel tube of not less than 75 mm outer diameter and securely bolted to it as shown on the Drawings. To avoid theft of the signs, the ends of bolts shall be hammered or spot-welded to prevent the nuts being removed.

Where details for the construction of sign faces, the framework of the sign faces and the attachment thereof to the supporting framework are not shown on the Drawings, the Contractor shall design these himself/herself and submit the details to the Engineer for approval before manufacture.

Care shall be taken to prevent the forced rotation of the sign round the post. A steel bar of 16 mm diameter x 450 mm long shall be welded in the middle horizontally

to the foot of the post to prevent the rotation of the post in its foundation. The length of the post shall be such that it is at least 0.65 m in the ground when the sign is at its correct height.

Additional road sign plates shall be provided and mounted on the support of the road sign, as directed by the Engineer.

Posts shall be thoroughly cleaned, free from grease, scale and rust and given at least one coat of rust inhibiting priming paint.

Posts and backs of signs, fittings, etc. shall be painted grey. The back of aluminium road signs will not require painting.

The foundations for road signs shall be as shown on the Drawings or as directed by the Engineer. Concrete foundations shall be poured using formwork.

After the concrete has set sufficiently, the spaces around the concrete foundation shall be refilled to the required elevation with suitable material, which shall be thoroughly tamped in layers of not more than 150 mm thickness.

All road signs shall be marked with the manufacturer's name or trademark, and year of make.

Mounting of the sign plate on the support shall be made by brackets, in accordance with the types proposed by the Contractor and approved by the Engineer, before the actual manufacture and erection in place.

The signs shall be erected at a distance from the edge of shoulder as shown on the Drawings or as directed by the Engineer.
The Contractor shall cut back trees and vegetation as may be necessary to ensure visibility of the signs.

All the structures must be such as to bear the stress caused by a wind blowing at 130 km/h on the support and the signs.

5405 STORAGE AND HANDLING

All road signs or parts of road signs shall be transported and handled so as to prevent any damage and deformation. All road signs shall be stored in a vertical position in a weatherproof storeroom. There shall be sufficient space between the road signs to permit free air circulation and moisture evaporation. Contact of road signs with treated timber, diesel, dirt or water shall not be permitted. When required, existing or newly erected road signs shall be fully or partially covered with burlap or other approved adequately ventilated material to obscure destinations that are temporarily inapplicable or irrelevant.

5406 ERECTING ROAD SIGNS

(a) Position
Road signs shall be erected in the positions shown on the Drawings or indicated by the Engineer.

(b) Excavation and backfilling
Excavations for the erection of road signs shall be made according to the dimensions shown on the Drawings. Where the excavations are to be backfilled with soil, a 12:1 soil-cement mixture shall be made if required by the Engineer.

The soil or soil-cement mixture shall then be compacted by tamping at optimum moisture content in 100 mm thick layers in the excavation.

Where posts or structures are to be fixed in concrete, or where concrete footings are to be cast, the concrete, formwork and reinforcement shall comply with the requirements of SECTIONS 6200, 6300 and 6400. The holes shall be completely filled with concrete up to the level shown on the Drawings or indicated by the Engineer. The upper surface of the concrete shall be neatly finished with sufficient fall to ensure proper drainage.

(c) Erection
Road signs shall be erected as shown on the Drawings or as directed by the Engineer. During erection the structural steelwork shall be firmly bolted and protected to prevent buckling or damage during erection, or by the equipment used for erection.

Posts to which road signs are to be fixed shall be vertical and the undersides of road signs shall be horizontal after having been erected.

Where timber posts are used for erecting the signs, all holes that are drilled in the timber shall be impregnated with creosote.

(d) Field welding
All welding done during erection shall comply with the requirements for welding during manufacture.

(e) On-site painting
All painting done after the road signs have been erected shall comply with the requirements for painting during manufacture.

All places where the paintwork has been damaged during erection shall be repaired by the Contractor at his/her own cost to the satisfaction of the Engineer.

(f) Time of erection
Road signs shall be erected immediately prior to the road being opened to public traffic, unless otherwise directed by the Engineer.

(g) General
All destinations and route numbers shown on the Drawings shall be subject to amendment, and confirmation of the details shall be obtained from the Engineer before any particular signs are made. Such particulars may be available only at a late stage, for which allowance shall be made by the Contractor in his/her program.

5407 PROTECTION AND MAINTENANCE

The Contractor shall protect the completed road signs against damage until they have been finally accepted by the Employer, and he/she shall maintain the road signs until the Performance Certificate has been issued. Damage or defects caused by negligence or faulty workmanship shall be rectified by the Contractor at his/her own cost to the satisfaction of the Engineer.

5408 DISMANTLING, STORING AND RE-ERECTING EXISTING ROAD SIGNS

Where ordered by the Engineer, the Contractor shall dismantle existing road signs, store them, and re-erect them at new positions indicated.

Where required by the Engineer, the signs shall be repainted or repaired and new materials shall be used for part or all of the supporting structure.

5409 MEASUREMENT AND PAYMENT

The quantity to be measured for payment shall be:

- The actual number of road signs complete in place, including support assembly and concrete foundation, and accepted.
- The actual number of additional road sign plates complete in place, regardless of the sizes.
- Guidance signs are to be measured as one sign per site with all names, route numbers and directional arrows shown on the one sign.

The quantities, determined as provided above, shall be paid for at the rate per unit of measurement for each of the pay items listed below, that is shown in the Bill of Quantities, which price and payment shall be full compensation for furnishing and placing all materials, for all labour, equipment, tools and incidentals necessary to complete the work prescribed in this section, including all necessary excavation and backfilling.

ITEM		UNIT
54.01	ROAD SIGN (STANDARD, STATE AREA FOR EACH TYPE)	NUMBER (NO.)

ITEM		UNIT
54.02	ADDITIONAL ROAD SIGN PLATE	NUMBER (NO.)

The unit of measurement shall be the number of standard size signs of approved materials as stated in the Specifications.

ITEM		UNIT
54.03	GUIDANCE SIGNS	SQUARE METRE (m^2)

The unit of measurement shall be the square metre of completed road signboard of approved materials.

The bid rates shall include full compensation for providing the completed road sign board, frame, fixing brackets, angle-irons, channel profiles, etc including painting, galvanising if specified, reflective lettering, symbols, legends and borders, attaching the road sign board to the road sign support, or to the overhead road sign structure, or to an over-bridge, and for all other materials and workmanship, brackets, bolts, nuts, etc, for the completion of the road sign boards as specified.

The rate for Guidance Signs and other Informative Signs shall include for the provision and erection of sign support in accordance with the Drawings.

ITEM		UNIT
54.04	DISMANTLING, STORING AND RE-ERECTING ROAD SIGNS (INDICATE SURFACE AREA)	NUMBER (NO.)

The unit of measurement shall be the number of signs dismantled and stored and re-erected in each size group.

The bid rates shall include full compensation for dismantling and storing the road signs and supporting structures, transporting the material to a new location, re-erecting the road signs, and restoring the location where they were dismantled.

Payment for excavations, and the new material and concrete required for re-erecting the road signs shall be made under the appropriate Item, and any repairs and painting which may be necessary, shall be paid for as "extra work". No separate payment shall be made for new bolts and nuts required for such re-erection, the cost of which shall be included in the rates bid above.

ITEM		UNIT
54.05	REMOVAL OF OBSOLETE ROAD SIGNS	NUMBER (NO.)

The unit of measurement shall be the number of signs dismantled and stored or disposed of as directed by the Engineer.

The bid rates shall include full compensation for dismantling and storing or disposing of the road signs and supporting structures as directed, and restoring the location where they were dismantled.

SERIES 5000: ANCILLARY ROADWORKS

SECTION 5500: ROAD MARKINGS

CONTENTS:

5501 SCOPE

This Section covers the permanent marking of the road surface with white or yellow painted or thermoplastic lines or symbols, the supply and fixing of retro-reflective road studs and the construction of rumble strips and speed humps as indicated on the Drawings or as specified by the Engineer.

All road markings shall be of the standard regulatory, warning and guidance markings as detailed on the Drawings and in accordance with the current Traffic Signs Manual.

This Section also covers the construction of rumble strips, speed humps and raised pedestrian crossings as indicated on the Drawings or as specified by the Engineer.

5502 MATERIALS

(a) Paint for road marking

The paint to be used for road marking shall be specifically manufactured for such purposes. The paint shall be reflectorised unless otherwise specified.

(i) Road-marking paint

Paint shall comply with the requirements of BS/EN 1871 or AASHTO M248, Type F.

The paint shall be delivered at the Site in sealed containers bearing the name of the manufacturer and the type of paint. The viscosity of the paint shall be such that it can be applied without being thinned.

(ii) Reflectorization

Retro-reflective road-marking paint shall comply with the requirements of SUB-CLAUSE 5502 (a) (i) above and BS/EN 1424. The retro-reflective glass beads shall conform to the requirements of BS/EN 1423 or equivalent, subject to a maximum nominal size of 0.8mm.

(iii) Colour

The colours to be used shall be bright white or yellow. The colour of the yellow marking material shall be to BS Colour No. 08E51 of BS 4800 and the colour of white markings shall be to BS colour number 00E55 of BS 4800 or as specified in the current Traffic Signs Manual.

When required by the Engineer, the Contractor shall submit with each consignment of paint delivered to the site, test certificates from an approved testing authority to show that the respective materials comply in all respects with relevant specifications.

(b) Thermoplastic road-marking material

Hot applied thermoplastic material shall comply with the requirements of BS/EN 1871. The material shall be applied to the pavement in a molten state by mechanical means.

(i) Thermoplastic Material

The hot-melt thermoplastic road-marking material shall be of tropical grade with a softening point of the binder of 45º - 50ºC. The binder shall be plasticized synthetic resin and the material shall be reflectorised by mixing in 20% by mass Class A glass beads. The thermo-plastic road marking material shall consist of light coloured aggregate, pigment and extender bound together with resin, elasticised with oil as necessary, in approximately the following proportions:

- Aggregate, including Ballotini beads: 60%
- Pigment and extender: 20%
- Binder: 20%

The maximum size of aggregate shall be 2 mm.

(ii) Reflectorization

Reflectorization shall be by Ballotini beads to BS EN 1423:1998, which shall make up approximately 20% by mass of the total mix, and shall be treated as part of the aggregate. The Ballotini shall be reasonably spherical and free from flaws and of a size suitable for this method of reflectorization, subject to a maximum size of 2 mm.

(iii) Colour

The colours to be used shall be bright white or yellow. The colour of the yellow marking material shall be to BS Colour No. 08E51 of BS 4800 and the colour of white markings shall be to BS colour number 00E55 of BS 4800 or as specified in the current Traffic Signs Manual.

(iv) Skid resistance

The skid resistance of all types of marking material shall comply with the requirements of BS 7941-1:1999 or BS 7941-2:2000 or equivalent.

The Contractor shall submit for each consignment of thermoplastic material delivered to the Site the manufacturer's certificate to show that the materials comply in all respects with the relevant product specifications.

(c) Road studs

Road studs shall comply with the requirements of BS EN 1463-2:2000 or equivalent and shall be of the size and type indicated on the Drawings or specified in the Special Specifications. The Contractor shall, prior to delivery, submit to the Engineer for approval, samples of the type of road studs he/she proposes to use.

(d) Rumble strips

Rumble strips shall be constructed of asphalt concrete, AC 10, having a high resistance to rutting and deformation, in accordance with the requirements of SECTION 4200 of this Specification and as directed by the Engineer. Rumble strips shall conform to the standards of the Ugandan Road Design Manual.

(e) Speed humps

Speed humps shall be constructed of reinforced concrete in accordance with the requirements of SECTIONS 6200, 6300, 6400 and 6800 of these Specifications unless otherwise specified in the

Drawings or instructed by the Engineer. Speed humps shall conform to the standards laid out in the Ugandan Road Design Manual and the Contractor should use an approved profile board to ensure that the correct shape of the hump is achieved

5503 WEATHER LIMITATIONS

Road marking material shall not be applied to a damp surface or at temperatures lower than l0°C or when, in the opinion of the Engineer, the wind strength is such that it may adversely affect the road marking operations.

5504 MECHANICAL EQUIPMENT FOR APPLICATION OF ROAD MARKING

The equipment shall consist of tools and equipment for cleaning the surfaces, a mechanical road-painting machine or automatic self-propelled thermoplastic laying machine as the case may be and all additional hand-operated equipment necessary for completing the work.

The mechanical road-marking machine shall be capable of marking at least two parallel lines simultaneously and shall apply the marking material to a uniform thickness at the rates of application specified. The machine shall be so designed that it will be capable of applying the road markings everywhere to a uniform width with sides within the tolerances specified. The machine shall further be capable of marking lines of different widths.

The road-marking machine shall be capable of applying the road marking at a speed of not less than 5.0 km/hr and it shall be provided with clearly visible amber warning flashing lights that shall always be in operation when the machine is working on the road.

5505 SURFACE PREPARATION

Road markings shall be applied to bituminous surfaces only after sufficient time has elapsed to ensure that damage will not be caused to the marking material by volatiles evaporating from the surfacing. In no case shall paint markings be applied until at least 48 hours after the completion of bituminous surfacings.

Before the marking material is applied, the surface shall be clean and dry and completely free from any soil, grease, oil, acid or any other material that will be detrimental to the bond between the marking material and the surface. The surface where the marking material is to be applied shall be properly cleaned by means of watering, brooming or compressed air if required. A suitable sealer shall be applied to concrete surfaces before thermoplastic marking material is applied.

Road marking material shall not be applied to damp surfaces or when the relative humidity exceeds 80%, or at temperatures lower than 10°C, or when, in opinion of the Engineer, wind strength is such that it may adversely affect the road marking operations.

5506 SETTING-OUT OF ROAD MARKINGS, ROAD STUDS AND SPEED REDUCING MEASURES

The lines, symbols, figures or marks shall be pre-marked by means of paint spots of the same colour as that of the final lines and marks. These paint spots shall be at such intervals to ensure that the road markings can be accurately applied, and in no case shall they be more than 1.5 m apart. Spots of approximately 10 mm in diameter should be sufficient.

The dimensions and positions of road markings shall be as shown on the Drawings or as specified in the appropriate statutory provisions and the current Traffic Signs Manual. After spotting, the positions of the proposed road markings shall be indicated on the road. These painted pre-markings shall be approved by the Engineer prior to any road marking operations being commenced.

The positions and outlines of special markings shall be produced on the finished road in chalk and shall be approved by the Engineer before they are carried out. Approved templates may be used on condition that the positioning of the markings is approved by the Engineer before marking is commenced.

The position of road studs shall be marked out on the road and shall be approved by the Engineer before they are fixed in position.

The position of rumble strips and speed humps shall be as shown in the Drawings and approved by the Engineer.

5507 APPLYING THE MARKING MATERIAL

Where two lines are required parallel to each other, the lines shall be applied simultaneously by the same machine. Paint shall be stirred before application in accordance with the manufacturer's instructions and shall be applied without the addition of thinners.

Before any road-marking machine is used on the permanent Works, the satisfactory operation of the machine shall be demonstrated and the application rate checked on a suitable site that is not part of the permanent Works. Adjustments to the machine shall be followed by further testing. Only when the machine has been correctly adjusted and the Engineer has approved its use after testing, may the machine be used on the permanent work. The operator shall be experienced in the use of the machine.

Where road-marking paint is applied by machine, it shall be applied in one layer. Where painting is done by hand, it shall be applied in two layers, and the second layer shall not be applied before the first layer has dried. As most road-marking paint reacts with the bitumen surface of the road, the paint shall be applied with one stroke only of the brush or roller.

Road-marking paint shall be applied at a nominal rate of 0.42 litre/m^2 or as directed by the Engineer.

Thermoplastic material shall be laid to a thickness of 3mm ±0.5mm or as directed by the Engineer. The method of thickness measurement shall be in accordance with BS 3262-3:1989, Appendix H.

Edge lines of thermoplastic material shall be broken by a 100mm gap for every 10m continuous line

Where acoustic lines of thermoplastic material are specified, the types and dimensions of the lines and thickness of the marking material shall be as shown in the Drawings and specified in the Special Specifications. Acoustic edge lines shall normally be not less than 150 mm wide.

5508 APPLYING THE RETRO-REFLECTIVE BEADS TO ROAD PAINT

Where retro-reflective paint is required, the retro-reflective beads shall be applied by means of a suitable machine in one continuous operation, immediately after the paint has been applied. Road-painting machines

applying the beads by means of gravity only shall not be used. The beads shall be sprayed onto the paint layer by means of a pressure sprayer.

The rate of application of the beads shall be 300 – 400 g/m^2 of paint or such other rate as the Engineer may direct.

5509 ROAD STUDS

Road studs shall be of the type and size specified in the SUB-CLAUSE 5502(b) and shall be fixed in position as shown on the drawings or as directed by the Engineer.

The roadstuds shall be fixed by means of an approved epoxy resin or bitumen adhesive in accordance with the manufacturer's instructions, subject to such amendments to the method as may be required by the Engineer. The studs shall be protected against impact until the adhesive has hardened. Before fixing the roadstuds, the surface shall be thoroughly cleaned as specified in CLAUSE 5505.

Roadstuds must be protected during marking of any lines and application of any surface treatments. Any road studs that become loose or are lost during the defects liability period are regarded as defects.

5510 TOLERANCES

The figures, letters, signs, symbols, broken or unbroken lines or other marks shall be marked as shown on the Drawings or as directed by the Engineer.

Road markings shall be applied to accuracy within the tolerances given below:

(a) Width
The width of lines and other markings shall not be less than the specified width, nor shall it exceed the specified width by more than 10 mm.

(b) Position
The position of lines, letters, figures, arrows, retro-reflective roadstuds and other markings shall not deviate from the true position by more than 100 mm in the longitudinal and 20 mm in the transverse direction.

(c) Alignment of markings
The alignment of the edges of longitudinal lines shall not deviate from the true alignment by more than 10 mm in 15 m.

(d) Broken lines
The length of segments of broken longitudinal lines shall not deviate by more than 150 mm from the specified length.

The length of segments and the gap between segments in broken lines shall be as indicated on the Drawings. If these lengths are altered by the Engineer, the ratio of the lengths of the marked section to the length of the gap between marked sections shall remain the same.

Lines on curves, whether broken or unbroken, shall not consist of chords but shall follow the correct radius.

5511 REMOVAL OF TEMPORARY AND REJECTED ROAD MARKINGS

The Contractor shall remove existing obsolete markings from the road surface by means of sand blasting, milling or other approved method. The use of black paint or chemical paint remover to obliterate existing markings will not be permitted, except where it is instructed by the Engineer as a temporary measure.

Rejected road markings and paint and marking material that has been splashed or dripped onto the pavement, kerbs, structures or other such surfaces, shall be removed by the Contractor at his/her own cost, in an approved manner so that the markings or spilt paint will not show up at all.

5512 PROTECTION

After the marking material has been applied, the road markings shall be protected against damage by traffic or other causes. The Contractor shall be responsible for erecting, placing and removing all warning boards, flags, cones, barricades and other protective measures which may be necessary in terms of any statutory provisions and/or as may be recommended in the current Traffic Signs Manual.

5513 MEASUREMENT AND PAYMENT

ITEM	UNIT
55.01 ROAD-MARKING USING ROAD-MARKING PAINT:	
(a) WHITE LINES (BROKEN OR UNBROKEN) (WIDTH OF LINE INDICATED)	METRE (m)
(b) YELLOW LINES (BROKEN OR UNBROKEN) (WIDTH OF LINE INDICATED)	METRE (m)
(c) WHITE LETTERING AND SYMBOLS	SQUARE METRE (m^2)
(d) YELLOW LETTERING AND SYMBOLS	SQUARE METRE (m^2)
(e) TRAFFIC-ISLAND MARKINGS (ANY COLOUR)	SQUARE METRE (m^2)
(f) KERB MARKINGS (ANY COLOUR)	SQUARE METRE (m^2)

The unit of measurement for painting the lines shall be the metre of each specified width of line and the quantity paid for shall be the actual length of line painted in accordance with the instructions of the Engineer, excluding the length of gaps in broken lines.

The unit of measurement for painting the lettering, symbols or traffic-island paintings shall be the square metre, and the quantity to be paid for shall be the actual surface area of lettering, symbols or traffic-island markings completed.

The bid rate per metre or per square metre as the case may be for painting the road markings shall include full compensation for procuring and furnishing all material and the necessary equipment, and for painting, protecting and maintenance as specified, including the setting-out of lettering, symbols and traffic-island markings, but excluding setting out and pre-marking the lines.

ITEM	UNIT
55.02 ROAD MARKING USING RETRO-REFLECTIVE ROAD-MARKING PAINT:	
(a) WHITE LINES (BROKEN OR UNBROKEN) (WIDTH OF LINE INDICATED)	METRE (m)
(b) YELLOW LINES (BROKEN OR UNBROKEN) (WIDTH OF LINE INDICATED)	METRE (m)
(c) WHITE LETTERING AND SYMBOLS	SQUARE METRE (m^2)

(d) YELLOW LETTERING AND SYMBOLS	SQUARE METRE (m^2)
(e) TRAFFIC-ISLAND MARKINGS (ANY COLOUR)	SQUARE METRE (m^2)

The unit of measurement for painting the lines shall be the metre of each specified width of line and the quantity paid for shall be the actual length of line painted in accordance with the instructions of the Engineer, excluding the length of gaps in broken lines.

The unit of measurement for painting the lettering, symbols or traffic-island markings shall be the square metre, and the quantity to be paid for shall be the actual surface area of lettering, symbols or traffic-island markings completed.

The bid rate per metre or per square metre as the case may be for painting the road markings shall include full compensation for procuring and furnishing all material, including the retro-reflective beads, and the necessary equipment, and for painting, protecting and maintenance as specified, including the setting-out of lettering, symbols and traffic-island markings, but excluding setting out and pre-marking the lines.

ITEM	UNIT
55.03 ROAD MARKING USING THERMO-PLASTIC ROAD-MARKING MATERIAL:	
(a) WHITE LINES (BROKEN OR UNBROKEN) (WIDTH OF LINE INDICATED)	METRE (m)
(b) YELLOW LINES (BROKEN OR UNBROKEN) (WIDTH OF LINE INDICATED)	METRE (m)
(C) ACOUSTIC LINES (WIDTH OF LINE INDICATED)	METRE (m)
(D) WHITE LETTERING AND SYMBOLS	SQUARE METRE (m^2)
(e) YELLOW LETTERING AND SYMBOLS	SQUARE METRE (m^2)
(F) TRAFFIC-ISLAND MARKINGS (ANY COLOUR)	SQUARE METRE (m^2)

The unit of measurement for marking the lines shall be the metre of each specified width of line and the quantity paid for shall be the actual length of line marked in accordance with the instructions of the Engineer, excluding the length of gaps in broken lines. Acoustic lines, where specified and approved by the Engineer, shall be measured as continuous for payment purposes.

The unit of measurement for applying the lettering, symbols or traffic-island markings shall be the square metre, and the quantity to be paid for shall be the actual surface area of lettering, symbols or traffic-island markings completed.

The bid rate per metre or per square metre as the case may be for applying the road markings shall include full compensation for procuring and furnishing all material, and the necessary equipment, and for application, protecting and maintenance as specified, including the setting-out of lettering, symbols and traffic-island markings, but excluding setting out and pre-marking the lines.

ITEM	UNIT
55.04 VARIATIONS IN RATE OF APPLICATION:	
(a) WHITE PAINT	LITRE (l)
(b) YELLOW PAINT	LITRE (l)
(c) RETRO-REFLECTIVE BEADS	KILOGRAMS (kg)
(d) THERMO-PLASTIC ROAD-MARKING MATERIAL (SPECIFY)	LITRE (l)

The unit of measurement for variations in the rate of applying of the paint, thermoplastic material and retro-reflective beads shall be the litre and the kilogram respectively.

Payment for variations shall be made as specified in CLAUSE 1212.

ITEM	UNIT
55.05 ROADSTUDS (TYPE STATED)	NUMBER (no)

The unit of measurement for roadstuds shall be the actual number of approved roadstuds placed.

The bid rate shall include full compensation for procuring and furnishing all the necessary material, labour and equipment, and for fixing and maintenance as specified. Distinction shall be made between various types of roadstuds.

ITEM	UNIT
55.06 SETTING OUT AND PRE-MARKING THE LINES (EXCLUDING TRAFFIC-ISLAND MARKINGS, LETTERING AND SYMBOLS)	METRE (m)

The unit of measurement for setting out lines shall be the metre of lines set out and marked. Where two or three lines are to be marked next to each other, the length of setting-out of such lines shall be measured only once.

The bid rate shall include full compensation for setting out and pre-marking the lines as specified, including all materials.

ITEM	UNIT
55.07 REMOVAL OF EXISTING, TEMPORARY OR PERMANENT ROAD MARKING BY:	
(a) SANDBLASTING	SQUARE METRE (m^2)
(b) OVER PAINTING AS A TEMPORARY MEASURE	SQUARE METRE (m^2)
(c) MILLING	SQUARE METRE (m^2)

The unit of measurement shall be the square metre of road marking removed.

ITEM	UNIT
55.08 REMOVAL OF EXISTING ROAD STUDS	NUMBER (no)

The unit of measurement shall be the actual number of road studs removed.

ITEM		UNIT
55.09	RUMBLE STRIPS AND SPEED HUMPS	
(a)	RUMBLE STRIP (SPECIFY TYPE/SIZE)	METRE (m)
(b)	SPEED HUMP (SPECIFY TYPE/SIZE)	METRE (m)

The unit of measurement for rumble strips and speed humps shall be the linear metre of each individual rumble strip of the different types and the linear metre of speed humps constructed to the cross sectional shape shown on the Drawings and in accordance with the instructions of the Engineer.

The bid rate for rumble strips shall include for preparing the surface, providing, mixing, transporting, laying and compacting the asphalt concrete mix for the rumble strips in accordance with the Drawings and to the satisfaction of the Engineer.

The bid rate for speed humps shall include provision of all materials, excavation, bedding, construction, curing and finishing required for the construction of reinforced concrete speed humps in accordance with the Drawings and to the satisfaction of the Engineer. Road marking for speed humps and other speed reducing measures will be paid for separately.

SERIES 5000: ANCILLARY ROADWORKS

SECTION 5600: LANDSCAPING AND GRASSING

CONTENTS:

5601 SCOPE

This Section covers landscaping of designated areas, establishment of vegetation for functional and aesthetic purposes on cut and fill slopes, landscaped areas and such other areas indicated on the Drawings and where it may be required.

5602 MATERIALS

Any declared noxious weeds, as well as any exotic tree, shrub, herb, grass or water plant which, in the opinion of the Engineer, may pose any problems in specified areas at certain times, is regarded as being undesirable.

(a) Fertiliser/soil-improvement material
The type of fertiliser/soil-improvement material to be used shall be one or more of the following types and any other type of fertiliser/soil-improvement material specified in the Special Specifications or prescribed by the Engineer.

(i) Soil-improvement materials such as dolomitic lime, basic slag, gypsum, superphosphate and agricultural lime.

(ii) Fertilisers such as limestone ammonium nitrate, 2:3:2 (22) and 3:2:1 (25).

(b) Grass cuttings
Grass cuttings shall be fresh cuttings of an approved type of grass with sufficient root material to ensure good growth.

(c) Grass seeds
Only fresh certified seed shall be used and the types of seeds in the seed mixture shall be as specified in the Special Specifications.

Mixing the various types of grass seeds for obtaining the prescribed grass-seed mixture shall be done on the Site in the presence of the Engineer. Storing and identifying the grass seeds and the grass-seed mixtures on the Site shall be the responsibility of the Contractor.

The grass seed or seed mixture shall consist of local varieties of Stenotaphrum secundatum, Cynodon dactylon or Pennisetum clandestinum grass or other grass seeds approved by the Engineer.

(d) Grass sods
Grass sods shall be either nursery-grown or bush sods as described below. Both types shall be harvested, delivered, planted and watered within 36 hours unless otherwise authorised by the Engineer. The grass sods shall be free from noxious weeds and diseases. Sods obtained from a nursery shall be in moist soil not less than 30 mm deep, and sods taken from the bush in moist soil not less than 50 mm deep.

(i) Nursery-grown sods
These sods shall have been grown specifically for sod purposes, mown regularly and cared for to provide an approved uniformity to the satisfaction of the Engineer.

The grass sods shall consist of local varieties of Stenotaphrum secundatum, Cynodon dactylon or Pennisetum clandestinum grass or other grass varieties approved by the Engineer.

(ii) Bush sods
These sods may be obtained from approved areas within or near the Site where a suitable type and density of grass and type of soil are found.

(e) Trees, shrubs and hedge plants
Plants shall be of the variety and size shown on the Drawings or in the Special Specifications.

The Contractor shall supply the number of plants as shown on the Drawings or in the Special Specifications and/or Bill of Quantities. The Contractor shall give at least six week's advance notice of his/her requirements to the Employer. Upon receipt of the plants, the Contractor shall ensure that the plants are in a good condition and free from plant diseases and he/she shall accept full responsibility for maintaining the plants in a good condition throughout the Contract and the Defects Liability Period. The plants shall be fully maintained and watered during this period and any losses of plants on account of lack of care or disease during the Contract and Defects Liability Period, shall be replaced at the Contractor's own cost.

Each plant shall be handled and packed in the approved manner for that species or variety, and all the necessary precautions shall be taken to ensure that the plants will arrive at the site of the Works in a suitable condition for successful growth. Trucks used for transporting plants shall be equipped with covers to protect the plants from windburn. Containers shall be in a good condition.

Plants supplied by the Contractor shall be healthy, correctly shaped, and well rooted. The plants must be hardened off and be exposed to direct sunlight for at least 6 months prior to planting in the road reserve. Roots shall not show any evidence of having been restricted or deformed at any time. Plants shall grow well and shall be free from insect pests and diseases.

(f) Anti-erosion compounds
Anti-erosion compounds shall consist of an organic or inorganic material to bind soil particles together and shall be a proven product able to suppress dust and form an encrustation. The application rate shall conform to the manufacturer's recommendations. The materials used shall be of such a quality that grass seeds may germinate and penetrate the crust.

(g) Topsoil
Topsoil shall consist of fertile loamy soil, obtained from areas with good soil coverage of natural vegetation, preferably grasses. It shall be free from deleterious matter such as large roots, stones, refuse, stiff or heavy clays and the seeds of noxious weeds, which will adversely affect its suitability for grass being planted. Topsoil tripped from areas infested with weeds shall be stockpiled separately.

Topsoil shall be obtained from wherever suitable material occurs either in the road reserve or from areas where cuts and fills are to be constructed. Topsoil stripped from borrow areas may not be removed from that site for topsoiling of other areas, but must be used to rehabilitate the borrow pit itself.

The Engineer shall communicate his/her requirements to the Contractor regarding the quantity of topsoil which is necessary and the areas from which it shall be selected and removed by the Contractor. Unless otherwise specified, topsoil shall be taken from not deeper than 400 mm from the surface. If the Contractor fails to conserve the topsoil as instructed, he/she shall obtain suitable substitute material from other sources at his/her own cost.

Where so specified, the Contractor shall procure and furnish topsoil from his/her own sources outside the Site, after such sources have been approved by the Engineer.

Topsoil shall be stockpiled in separate loose heaps as tipped from the trucks and shall not be stockpiled in heaps exceeding 2 m in height. Care shall be taken to prevent the compaction of the topsoil in any way, especially by trucks being driven over such material.

(h) Manure
Manure shall, unless another type has been approved by the Engineer, be pure kraal manure free from soil, weed seeds or other undesirable material. It shall not contain any particles that will not pass through a 50 mm screen and shall be approved by the Engineer before being delivered to the Site.

(i) Compost
Compost shall be well decayed, friable and free from weed seeds, dust or any other undesirable materials. It shall not contain any particles that will not pass through a 50 mm screen and shall be approved by the Engineer before being delivered to the Site.

5603 LANDSCAPING AREAS

(a) Shaping
Areas within the road reserve but outside the road prism which require shaping by means of bulk earthworks such as contoured areas at interchanges and intersections and rest areas which require earthworks shall be excavated, filled and compacted when required, and shaped to the correct contours to within a tolerance of plus or minus 150 mm. Such work shall be regarded as being earthworks and measurement and payment therefore shall be made under SECTION 3600, except that quantities may be measured by means of a grid system of levels taken at 10 m intervals before and after shaping or else it may be determined by levelled cross-sections.

(b) Trimming
Trimming shall consist of trimming the existing or previously shaped ground to an even surface with the final levels generally following the original surface. Trimming shall normally be done by grader, or in more confined or steep areas by bulldozer. Where machine operations are not practicable, because of confined spaces or steep slopes, or when approved by the Engineer, trimming shall be done with hand tools. When trimming is done on slopes steeper than 1:3, the ridges shall be made parallel to the contour. Such ridges shall be approximately 100 mm wide, and the centres between the ridges approximately 400 mm. Trimming shall be done where instructed by the Engineer to areas inside the road reserve but outside the road prism, ie normally outside the tops of cuts or the toes of fills, but trimming of rock outcrops will not be required.

Trimmed surfaces shall be left slightly rough to facilitate a better binding with topsoil or the natural establishing of vegetation.

When subsequent grassing is required or when it is ordered by the Engineer, areas previously shaped shall be trimmed as described above to within a tolerance of plus or minus 100 mm with all undulations following a smooth curve. The above tolerance shall apply only to areas where the final contours are given on the Drawings.

During trimming, all stones in excess of 100 mm in size and all excess material shall be removed. Areas which require grassing shall be trimmed in such a way that, after cultivation and the application of topsoil, the finished surface of the area shall be approximately 25 mm below the top of adjacent kerbing, channelling or pavement.

(c) Equipment rates
The Engineer shall be entitled to pay for shaping and trimming as described above on the basis of hourly equipment rates. The motor grader and bulldozer to be provided shall each have a flywheel power of not less than 93 kW. All machines shall be in a good condition. Any labour or other equipment required shall be paid for as extra work as specified in the Contract.

5604 PREPARING AREAS FOR GRASSING

The various areas to be grassed shall be prepared as follows:

(a) Soil ripping
Where soil is too hard to be ploughed with a light tractor, the soil shall be ripped up to a depth of 300 mm before it is loosened by plough to a depth of 150 mm.

After an area has been prepared for grassing, the grassing shall be completed before crusting. Where a crust has been formed before grassing is done, the Contractor shall, at his/her own cost, loosen the crust by ploughing to a depth of 150 mm.

(b) Areas which do not require topsoil
Where the areas to be grassed consist of organically suitable material, the topsoil shall be loosened by ploughing to a minimum depth of 150 mm. All loose stones exceeding 50 mm in size on areas to be mowed by machine and falling within the road reserve and all stones exceeding 150 mm in size in other areas shall be removed.

(c) Areas which require topsoil
Where areas to be grassed consist of organically unsuitable material, the surface shall be roughened to ensure a proper bond between the topsoil and the subsoil. If required, the area shall be scarified as described in paragraphs (a) or (b) above.

Topsoil shall be placed on the prepared surfaces and trimmed to the uniform thickness required. The topsoil shall be scarified by means of handraking or light rotavators and all stones removed as specified for areas not requiring topsoil in subparagraph (b) above.

Areas inaccessible for topsoil being placed after the construction works have been completed shall be covered with topsoil and protected against erosion during construction works.

(d) Fertilising
For all areas to be planted, the Contractor shall have the top 150 mm of the prepared surface tested to determine the quantity and type of fertiliser that will be required for establishing proper growth conditions for

the grass. The Contractor shall record the location of the soil sample taken and the Engineer shall be furnished with the test results. Only after approval by the Engineer of the nature and quantity of the fertiliser, may its application proceed. The fertiliser shall be evenly applied over all surfaces where grass is to be planted, and shall then be thoroughly mixed with the soil to a depth of 100 mm either mechanically or manually. Where hydro seeding is to be performed, the fertiliser may be mixed with the cellulose pulp and water used in hydro seeding.

5605 GRASSING AND SPRIGGING

The method of establishing grass shall depend on the circumstances relating to each case, and the Engineer shall decide which method is to be used. Provision is made for the following methods:

- Planting grass cuttings
- Sodding
- Hydro seeding
- Topsoiling only using, where available, topsoil with the presence of natural grass seeds
- Grassing with an approved grassing machine
- Hand seeding
- The use of any other method specified in the Special Specifications.

A grass sod shall be placed on the top of the side slopes in one metre width from the shoulder breakpoint in order to protect the pavement material against erosion by water runoff. The remaining disturbed area of the embankment is to be scarified and hydro seeded as specified in Sub-clause 5605 (c). The Engineer may prescribe an anti erosion compound to be added in the hydro seeding mixture for these areas.

Grass shall be planted as far as is practicable during periods of the year most likely to produce best growing results. The Contractor shall make every effort to programme his/her operations in such a manner that grass shall be planted during this period.

(a) Planting grass cuttings

The areas to be grassed shall, unless already wet, be thoroughly watered before the cuttings are planted to ensure that the soil will be uniformly wet to a depth of at least 150 mm when the planting is done.

An approved variety of grass cuttings shall be evenly planted by hand or mechanically at a rate of at least 600 kg of cuttings per hectare. Fresh cuttings only shall be used. Any grass cuttings that have been allowed to dry out shall be discarded. Immediately after having been planted, the grass cuttings shall be given a copious watering, and, when sufficiently dry, shall be rolled with a light agricultural roller.

(b) Sodding

Areas to be grassed by sodding shall be given a layer of topsoil of at least 50 mm in thickness unless, where suitable soil is present, the Engineer orders the topsoil to be omitted. The areas to be sodded shall be thoroughly watered beforehand so that it will be wet to a depth of at least 150 mm during sodding. The surface shall be roughened slightly to ensure a good penetration of roots into the soil. Sods shall be protected against drying out and kept moist from the time of harvesting until they are finally placed.

The first row of sods shall, where possible, be laid in a straight line, and if on a slope, laying the sods shall start at the bottom of the slope. The sods shall be butted tightly against each other, and care shall be taken not to stretch or overlap the sods. Where a good fit cannot be obtained, any intervening spaces shall be filled with topsoil. The next row shall be similarly placed tightly against the bottom row with staggered joints, and so on until the entire area has been covered with sods. On steep slopes, when instructed by the Engineer, the sods shall be held in position by a sufficient number of wooden stakes approximately 300 mm long by 20 mm in thickness and these stakes shall be knocked into the subsoil to a depth of 100 mm.

The Contractor shall water the sods directly after they have been placed to prevent undue drying out. As sodding is completed, each section shall be Lightly rolled and thoroughly watered.

(c) Hydro seeding

Where it is specified that hydro seeding should be carried out on topsoil, the thickness of the topsoil shall be as specified in the Special Specifications or as directed by the Engineer.

Areas to be hydro seeded shall be given a layer of topsoil of 100 mm in thickness unless, where suitable soil is present, the Engineer orders the topsoil to be omitted or applied in reduced thickness.

The types and mixtures of seeds to be used shall be as specified in the Special Specifications or, if not so specified therein, shall be agreed on by the Engineer and the Contractor before any seed he/she may wish to use is ordered by the Contractor. The Contractor shall be solely responsible for establishing an acceptable grass cover, and any approval by the Engineer of seed or seed mixtures intended for use by the Contractor shall not relieve him/her of this responsibility.

The seed mixture for hydro seeding or hand seeding is to be applied at 45 kg/ha and is to consist of:

– Eragrostis tef (teff)	5%
– Eragrostis curvula (weeping love grass)	20%
– Paspalum notatum (bahia grass)	10%
– Chloris gayana (rhodes grass)	25%
– Digataria eriantha (finger grass)	20%
– Dactylus glomerata (cocks foot)	10%
– Locally harvested grass seed	10%

All areas to be hydro seeded or hand seeded shall be scarified forming horizontal drills running parallel to the contours. The drills are to be spaced at intervals of 150 to 250 mm apart. Seeding to take place immediately after scarifying in order to avoid silting of the drills by rainwater.

Mulch shall be added to the hydro seeding mix at an approved rate.

Hydro seeding shall then be carried out with an approved hydro seeding machine at a rate of application of not less than 38 kg of seed mixture per hectare, unless otherwise specified in the Special Specifications.

When the use of anti-erosion compounds is required and such compound is to be applied simultaneously with the hydro seeding, it shall be mixed with the hydro seeding mixture before application.

(d) Topsoiling only

Where, in the opinion of the Engineer, the planting of grass or hydro seeding can be dispensed with on account of favourable climatic and other conditions, he/she may attempt to establish grass by topsoiling only. Topsoil shall be selected for the presence of natural grass and seeds and shall be removed and placed whenever possible at a time that would favour the establishing of grass. These areas shall be treated with an anti-erosion compound, if so instructed by the Engineer.

After the topsoil has been placed it shall be lightly rolled and well watered, and afterwards watered and mown whenever instructed by the Engineer.

The Contractor will not be held responsible for establishing an acceptable grass cover as defined in SUBCLAUSE 5606(d) when this procedure is followed, but will be responsible for the consequences of any omission to water, weed or mow the grass as instructed by the Engineer.

No payment for grassing shall be made other than for placing topsoil, and for mowing and watering the grass, which will be paid for at the bid rates, and for any replanting of grass on bare patches, repairs caused by erosion, and similar work, which will be paid for as extra work as allowed for in the Contract.

(e) Grassing with an approved grassing machine

The areas to be grassed shall be prepared as described in CLAUSE 5604 and the areas shall be thoroughly watered after completion of the operation.

Grassing shall be done with an approved grass planter which plants the seeds in rows spaced not more than 250 mm apart. The planter shall plant the seeds approximately 6 mm deep and shall lightly compact the soil. The prescribed fertiliser may be distributed simultaneously with the grass planting.

(f) Hand sowing

The areas to be grassed shall be prepared as described in CLAUSE 5604 and the areas shall be thoroughly watered after completion of the operation.

If approved by the Engineer, sowing may be done by hand. The seed shall be spread uniformly over the surfaces and then lightly raked into the soil.

(g) Other methods

Whenever specified in the Special Specifications, other methods of grassing may be employed.

(h) The grassing of borrow pits, temporary bypasses, camp sites, access roads and stockpile sites

Prior to any grassing that may be required on such areas, the finishing-off of borrow pits as described under SECTION 1700 AND CLAUSE 3406, obliterating the bypasses and access roads as described in CLAUSES 1514 and 5703 respectively and the clearing of camp sites as described in SECTION 1300 and 1700, shall have been carried out as specified in the relevant Sections and Clauses.

(i) Sprigging

(i) Description

This work shall consist of planting sprigs in close conformity with these Specifications, at the locations shown on the Drawings or required by the Engineer for the protection of slopes against erosion.

(ii) Materials

(1) Sprigs

Sprigs shall be healthy, living stems with attached roots of perennial turf-forming grasses harvested without adhering soil and obtained from approved sources in the locality of the work where the sod is dense and well rooted. The presence of weeds or detrimental materials will be cause for rejection.

The grass sprigging shall consist of local varieties of Stenotaphrum secundatum, Cynodon dactylon or Pennisetum clandestinum grass or other grass seeds approved by the Engineer.

(2) Fertiliser

Fertiliser shall consist of an approved compound containing not less than 10% nitrogen, 15% phosphoric acid and 10% pot-ash or similar approved composition.

(iii) Construction

(1) Topsoiling

Where directed by the Engineer the face of slopes or benches shall be covered with a layer of topsoil, as described in CLAUSE 5602 (g).

If topsoil is not available in the project area or soil and moisture conditions are generally not favourable for growth of grass, planting of grass should be tried on small sections of clay and sand slopes prior to planting of large areas.

All surfaces shall, immediately before planting, be reduced to a fine tilth to a depth of 150 mm and free from stones greater than 25 mm.

(2) Fertilisation

Fertilisation shall be carried out with an even distribution. The rate of application shall not be lighter than 70 kg to 1000 square metres.

(iv) Sprigging

(1) Harvesting sprigs

The Contractor shall obtain the Engineer's approval of his/her source of sprigs and shall notify the Engineer at least 5 days before the sprigs are to be harvested.

Sprigs that have dried out or are otherwise damaged during harvesting or delivery shall be rejected.

(2) Planting sprigs

Planting of sprigs shall preferably be carried out at the beginning of a rainy season. Not more than 24 hours shall elapse between harvesting and planting sprigs.

Sprigging shall not be done during windy weather, or when the ground is dry, excessively wet, or otherwise untillable. If the soil is not moist when the sprigs are being set, water shall be applied until the soil is moist and in a workable condition. One or more of the following methods shall be used, whichever is shown on the Drawings or ordered by the Engineer:

- *ROW SPRIGGING*: Furrows shall be opened along the approximate contour of slopes at the spacing and depth indicated on the Drawings or as instructed by the Engineer. Sprigs shall be placed at intervals not exceeding 150 mm in a continuous row in the open furrow, and shall be covered immediately.

- *SPOT SPRIGGING*: Spot sprigging shall be performed as specified under row sprigging, except that, instead of planting in continuous rows, groups of four sprigs or more shall be spaced 400 mm apart in the rows.

- Alternative methods of planting shall be subject to the approval of the Engineer.

(v) Maintenance of sprigged areas
The Contractor shall regularly water and maintain sprigged areas in a satisfactory condition for the duration of the Contract and until the end of the Defects Liability Period.

5606 MAINTAINING THE GRASS

(a) Traffic on grassed areas
The Contractor shall not plant any grass until all operations which may require road-building equipment to be taken over grassed areas have been completed. No road-building equipment, trucks or water carts shall be allowed onto areas which have been grassed and only equipment required for the preparation of areas, application of fertiliser, spreading of topsoil, watering and mowing will be allowed to operate on areas to be grassed. All damaged areas shall be reinstated by the Contractor at his/her own expense.

(b) Watering, weeding, mowing and replanting
All sodded and grassed areas shall be adequately watered at regular and frequent intervals to ensure the proper germination of seeds and growth of grass until the grass has established an acceptable cover and thereafter until the beginning of the defects liability period of the grass. The quantity of water and the frequency of watering shall be subject to the Engineer's approval. With hydroseeding the commencement of watering may be postponed until a favourable time of the year, but watering shall in any case commence and continue as soon as the seeds have germinated and growth has started.

The Contractor shall further mow the grass on all areas where grass has been established whenever so instructed by the Engineer, until the end of the defects liability period. All grass cuttings shall be collected and disposed of if so directed by the Engineer. Weeds shall be controlled by approved means. Any bare patches where the grass has not taken or where it has been damaged or has dried out shall be recultivated, planted, sodded or hydroseeded at the Contractor's own expense.

All grassed areas shall have an acceptable cover as defined below at both the beginning and the end of the Defects Liability Period.

(c) Acceptable cover
An acceptable grass cover shall mean that not less than 75% of the area grassed or hydroseeded shall be covered with grass and that no bare patches exceeding 0.25 m^2 in any area of 1.0 m x 1.0 m shall occur. In the case of sodding, acceptable cover shall mean that the entire area shall be covered with live grass at the end of any period not less than three months after sodding.

(d) Responsibility for establishing an acceptable cover
Notwithstanding the fact that the Engineer will determine the method of grassing and that the type of seed or grass used and the rate of application of the seed may be specified or agreed on by the Engineer, and that the frequency of mowing will be as ordered by him/her, the Contractor shall be solely responsible for establishing an acceptable grass cover and for the cost of replanting grass or re-hydroseeding where no acceptable cover has been established. Where however, in the opinion of the Contractor, it is doubtful from the outset if it will be possible to establish an acceptable cover he/she may inform the Engineer of his/her reasons therefore, and the Engineer may, if he/she agrees, either adopt another method of grassing or agree to accept whatever cover can be obtained, provided that all reasonable efforts shall be made to establish a good grass cover by the proposed method. Any such agreement shall be valid only if given in writing by the Engineer beforehand.

In the case of grassing by topsoiling only, the Contractor will not be held directly responsible for establishing an acceptable grass cover, but will be held responsible for the consequences of supplying workmanship which does not conform to the Specifications, or for lack of proper care.

(e) Re-fertilising
Should it become necessary, the Engineer may instruct the Contractor to undertake a Re-fertilising programme on grassed areas during the twelve month defects liability period. Payment for re-fertilisation will be made under SUB-ITEM 56.03(e).

(f) Defects Liability Period
The Defects Liability Period in respect of grass shall commence when an acceptable grass cover as defined in (c) above has been established and shall be one year. This means that the Defects Liability Period in respect of grass can commence earlier or later than the Defects Liability Period for other parts of the Contract.

If the Defects Liability Period in respect of grass expires before the end of the defects liability period for the other roadworks, the Contractor shall further mow the grass on such areas as instructed by the Engineer up to the end of the Defects Liability Period for the other roadworks. For mowing that is executed after the Defects Liability Period in respect of grass has expired, the Contractor shall be paid under ITEM 56.07.

5607 TREES, SHRUBS AND HEDGING PLANTS

Trees and shrubs shall be planted as far as is practicable during periods of the year most likely to produce best growing results. The Contractor shall make every effort to programme his/her operations in such a manner that trees and shrubs shall be planted during this period.

(a) Positions of trees and shrubs
Unless otherwise directed by the Engineer, the localities where trees and shrubs are to be planted are as follows:

(i) Trees and shrubs shall be planted at locations shown on the Drawings.

(ii) Plants in the median shall be planted in a line 1.5 m from the centre line of the median.

(iii) When the carriageways are at different levels, the plants in the median shall be planted 2 m from the edge of the shoulder on the high side of the median.

(iv) Where the road curves, the plants in the median shall be planted on the inside of the median centre line.

(v) Where the carriageways are at different levels as well as on a curve, the plants in the median shall be planted on the high side, provided they do not impede on sight distance.

(vi) At freeway crossings over roads or rivers, shrubs shall be planted in the positions shown on the Drawings.

(vii) At the headwalls of culverts or similar structures, trees and/or shrubs shall be planted to indicate the positions of these structures. The locations for

planting shall be as shown on the Drawings or as directed by the Engineer.

(viii) Care shall be taken not to obscure traffic signs by plants.

(ix) Trees shall not be planted closer than 10 m from the edge line on the outside shoulder.

(b) Preparing plant holes
Unless otherwise directed by the Engineer, holes shall be spaced and prepared as follows:

(i) All holes shall be square in plan and shall have loosened sides and bottoms to prevent root balling of plants and trees.

(ii) Holes for hedge plants and shrubs shall be at least 500 mm square by 600 mm deep and 1.5 m from centre to centre. Alternatively a 500 mm wide trench 600 mm deep may be dug.

(iii) Holes for trees shall be at least 600 mm square by 700 mm deep.

(iv) The holes for plants shall be refilled with selected and approved topsoil thoroughly mixed with manure or compost (one heaped spadefull added to every plant hole) and, depending on soil-test reports, the required quantity and type of fertiliser.

(v) The holes shall be thoroughly watered before plants are planted. Where the soil is poorly drained, 150 mm of crushed stone shall be placed at the bottom of the hole before it is filled with soil.

(c) Planting
Before trees, shrubs and hedging plants are removed from their containers for planting, they shall be well watered.

Directly after having been planted, each plant shall be well watered with a view to settling the soil. After the soil has settled, additional soil shall be added where necessary to bring the replaced soil in the hole to within 150 mm of the ground surface, so as to ensure that sufficient water can be retained in the hole around the plant. All trees shall be tied to a suitable creosote-treated timber stake with a minimum diameter of 35 mm or other suitable stake as approved by the Engineer and firmly planted in the ground. The stake shall be 300 mm longer than the planted tree, and its maximum length shall be 1.5 m above ground level. After planting, the ground surface around the plant shall be covered with straw or grass or any other type of mulch to minimise evaporation.

(d) Maintenance
During the defects liability period, which shall be twelve months after completion of the actual planting of trees, shrubs and hedges, the Contractor shall be responsible for watering the trees, shrubs and hedges and keeping the plants free from weeds and pests.

Every hedge plant, tree or shrub, which is not healthy or shows unsatisfactory growth shall be replaced by the Contractor at his/her own expense, within one month of having been notified by the Engineer in writing. Any replacement tree or shrub shall be maintained for a period of 1 year from the date of replacement.

5608 EROSION PREVENTION

(a) Requirements and works description
During construction the Contractor shall protect all areas susceptible to erosion by installing all the necessary temporary and permanent drainage works as soon as possible and by taking such other measures as may be necessary to prevent the surface water from being concentrated in streams and from scouring the slopes, banks or other areas.

All side slope areas which consist of a sandy material shall be hydro seeded with the addition of an anti erosion compound. The application rate will be as specified by the manufacturer. PAM (Polyacrylmide) or suitable alternative may be used.

Payment for the supply of the anti erosion compound will be made under ITEM 56.08.

Vetiver zizanioides (Vetiver grass) is to be planted as a soil conservation system of "Vegetative Contour Hedges " to minimise the erosion potential of surface water runoff where directed by the Engineer. The Vetiver grass slips are to be separated from the grass clump and planted in rows running parallel to the contour and at spacings of 10-15 centimetres apart. The rows of Vetiver grass are to be spaced at distances varying between 1 and 5 metres on 1:1.5 to 1:4 side slopes. On gentle sloping areas the distances between the rows can increase up to 30 metres apart.

Vetiver Hedge Rows can be considered for protection to cut and fill slopes, bridge approach embankments, gully erosion protecting, storm water and culvert outlets. Vetiver grass is available in Uganda.

Any runnels or erosion channels developing during the construction period or during the defects liability period shall be backfilled and compacted, and the areas restored to a proper condition. The Contractor shall not allow erosion to develop on a large scale before effecting repairs and all erosion damage shall be repaired as soon as possible and in any case not later than three months before the termination of the Defects Liability Period. All topsoil or other material accumulated in side drains shall be removed at the same time. Topsoil washed away shall be replaced.

(b) Proprietary brand materials used for erosion prevention
Certain proprietary brands of materials may be necessary for erosion prevention to enable natural grass to become established. In such case the specific brand shall be as described in the Special Specifications. The method of applying the material, the required surface preparation, the type of material to be provided and the method of payment, shall be as set out in the Special Specifications.

5609 MEASUREMENT AND PAYMENT

ITEM	UNIT
56.01 TRIMMING:	
(a) MACHINE TRIMMING	SQUARE METRE (m^2)
(b) HAND TRIMMING	SQUARE METRE (m^2)

The unit of measurement for trimming shall be the square metre of area trimmed on the instruction of the Engineer, including areas trimmed after having been shaped. No trimming within the road prism shall be measured for payment.

All bulk earth-moving operations as described under shaping in SUB-CLAUSE 5603(a) shall be measured and paid for under SECTION 3600.

The bid rates for trimming shall include full compensation for trimming the areas to the specified finishing requirements, including the moving of a relatively small quantity of material that would be

inherent in this process and the removal of surplus material and stones. Payment shall distinguish between machine trimming, which can reasonably be done by bulldozer or motor grader, and hand trimming.

ITEM	UNIT
56.02 USING MACHINES FOR TRIMMING OR SHAPING (ALTERNATIVE TO SUBITEM 56.01(a)):	
(a) BULLDOZER	HOUR (h)
(b) MOTOR GRADER	HOUR (h)

The unit of measurement shall be the hour actually worked by each machine in trimming or shaping areas. Standing time will not be measured.

The bid rates shall include full compensation for furnishing and using the machines, including the cost of fuel, operators, remedy of any defects, transporting the machine to and from the point where it is to be used, and for all other incidentals necessary for carrying out the work.

ITEM	UNIT
56.03 PREPARING THE AREAS FOR GRASSING:	
(a) SOIL RIPPING	HECTARE (ha)
(b) PLOUGHING	HECTARE (ha)
(c) TOPSOILING WITHIN THE ROAD RESERVE, WHERE THE FOLLOWING MATERIALS ARE USED:	
(i) TOPSOIL OBTAINED FROM WITHIN THE ROAD RESERVE OR BORROW AREAS (FREE-HAUL 1.0 km)	CUBIC METRE (m^3)
(ii) TOPSOIL OBTAINED FROM OTHER SOURCES BY THE CONTRACTOR (INCLUDING ALL HAUL)	CUBIC METRE (m^3)
(D) PROVIDING AND APPLYING CHEMICAL FERTILISERS AND/OR SOIL-IMPROVEMENT MATERIAL:	
(i) LIME	TONNE (t)
(ii) SUPER-PHOSPHATE	TONNE (t)
(iii) LIMESTONE AMMONIUM NITRATE	TONNE (t)
(iv) 2:3:2(22)	TONNE (t)
(V) 3:2:1(25)	TONNE (t)
(vi) OTHER FERTILISERS AND/OR SOIL-IMPROVEMENT MATERIALS IF REQUIRED (TYPE STATED)	TONNE (t)
(E) STOCKPILING TOPSOIL	CUBIC METRE (m3)

(a) Soil ripping
The unit of measurement for soil ripping shall be the hectare. Only areas ripped on the written instructions of the Engineer shall be measured for payment.

The bid rate shall include full compensation for ripping, complete as specified.

(b) Ploughing
The unit of measurement for loosening the topsoil by ploughing shall be the hectare of soil loosened and prepared in accordance with the Specifications. Only areas loosened by ploughing on the written instructions of the Engineer shall be measured for payment.

The bid rate shall include full compensation for loosening the topsoil by ploughing, removing stones, and levelling and trimming the surface.

(c) Placing the topsoil
The unit of measurement shall be the cubic metre of topsoil applied at the specified thickness or as directed by the Engineer measured in situ after the topsoil has been placed. The quantity shall be calculated from the net area of the topsoiled surface multiplied by the average thickness of the topsoil but before the grass sods are placed. Any topsoil placed in excess of the average thickness specified or prescribed will not be measured for payment.

Payment shall distinguish between topsoil obtained from designated areas within the road reserve or borrow areas and topsoil obtained by the Contractor from outside sources when sufficient topsoil is not available from the designated areas mentioned above.

The bid rates shall include full compensation for excavating and loading the topsoil, any royalties or compensation that may be payable, transport (except overhaul), off-loading, placing and spreading it to the required thickness, levelling it off to a smooth surface, for removing any stones as specified and for roughening the surface to be topsoiled.

The free-haul distance of topsoil obtained from the road reserve or borrow areas shall be 1.0 km. The bid rate for topsoil under SUB ITEM 56.03(c) (ii) shall also include full compensation for transporting the topsoil to the point of eventual use.

(d) Providing and applying fertiliser and/or soil-improvement material
The unit of measurement for fertiliser shall be the tonne of each type of fertiliser and/or soil-improvement material applied in accordance with the Specifications and as instructed by the Engineer.

The bid rates shall include full compensation for furnishing the fertiliser and/or soil-improvement material, transporting it to the point of use, spreading and mixing it into the scarified soil or topsoil, irrespective of the method of application.

(e) Stockpiling the topsoil
The unit of measurement shall be the cubic metre of topsoil stockpiled on the written instructions of the Engineer where this operation is unavoidable despite proper advance planning. Only material actually loaded, transported to and stockpiled on sites designated for stockpiling will be measured, but not any material merely pushed or bladed into heaps next to the area from which it is taken, unless it was done with the prior approval of the Engineer, and the material was stockpiled in an approved area.

The bid rate shall include full compensation for loading the topsoil, placing it in stockpile and for any payments to private Owners for the use of stockpile areas.

ITEM	UNIT
56.04 GRASSING:	
(a) PLANTING OF GRASS CUTTINGS (TYPE OF GRASS AS INDICATED)	HECTARE (ha)
(b) SODDING BY USING THE FOLLOWING TYPES OF SODS:	
(i) NURSERY SODS (TYPE OF GRASS SPECIFIED)	SQUARE METRE (m^2)
(ii) BUSH SODS	SQUARE METRE (m^2)

(c)	HYDRO SEEDING:	
	(i) PROVIDING AN APPROVED SEED MIXTURE FOR HYDROSEEDING	KILOGRAM (kg)
	(ii) HYDROSEEDING	HECTARE (ha)
(d)	PROVIDING AN APPROVED SEED MIXTURE FOR SOWING GRASS WITH MACHINE OR HAND	KILOGRAM (kg)
(E)	SOWING GRASS SEED WITH AN APPROVED GRASS-PLANTING MACHINE	HECTARE (ha)
(f)	HAND SOWING	SQUARE METRE (m^2)
(g)	SPRIGGING	SQUARE METRE (m^2)
(H)	OTHER METHODS (SPECIFY)	

Half the payments under ITEM 56.04 will become due when the grassing or hydro seeding has been done, and the remainder will become due when satisfactory cover has been established.

(a) Planting grass cuttings
The unit of measurement for planting grass cuttings shall be the hectare of established grass with an acceptable grass cover.

The bid rate shall include full compensation for furnishing and planting the cuttings, watering, weeding, and replanting if necessary, and all other incidentals which may be necessary for establishing an acceptable cover and maintaining the grass, except mowing.

(b) Sodding
The unit of measurement for sodding shall be the square metre covered with sods, which has an acceptable cover.

The bid rates shall include full compensation for procuring, excavating, loading, transporting, off-loading, placing and watering the sods, for replanting dead areas, for watering and weeding the grass, for supplying and placing timber stakes and for all other incidentals, except for mowing, which may be necessary for establishing an acceptable cover, and maintaining the grass. Payment shall distinguish between nursery-grown sods and bush sods obtained from within the road reserve or borrow areas. In the case of bush sods the bid price shall include levelling-off and trimming areas from which the sods are taken.

(c) Hydro seeding

(i) The unit of measurement for providing seed shall be the kilogram of seed of the specified seed mixture. The mass of any pulp added shall not be measured.
The bid rate shall include full compensation for procuring and furnishing the seeds.

(ii) The unit of measurement for hydro seeding shall be the hectare of grass established by hydro seeding, which has an acceptable cover.

The bid rate shall include full compensation for furnishing cellulose pulp and mixing it with seed and water and with any anti-erosion compound if required, applying the mixture, watering, weeding, re-seeding bare patches, and for any other work, except mowing, which may be necessary for establishing an acceptable cover and maintaining the grass.

(d) Providing grass seeds
The unit of measurement for providing seed shall be the kilogram of seed of the specified seed mixture.

The bid rate shall include full compensation for procuring and furnishing the seeds.

(e) Grassing with an approved grass planter
The unit of measurement for sowing any grass seeds by using an approved planter shall be the hectare of grass with an acceptable cover, where the seeds have been planted.

The bid rate shall include full compensation for all labour, material, equipment, weeding, and all incidentals that may be necessary for sowing the grass seeds and establishing an acceptable grass cover, except mowing. The bid rate shall also include full compensation for watering the planted areas until an acceptable grass cover has been established.

Payment for the grass seed will be made separately under SUB-ITEM 56.04(d).

(f) Hand-sowing
The unit of measurement for hand-sowing the grass seeds shall be the square metre of grass with an acceptable covering on surfaces instructed by the Engineer to be hand-sown.

The bid rate shall include full compensation for all labour, materials, equipment, weeding, and all incidentals that may be necessary for planting the grass seeds and establishing an acceptable grass cover, except mowing. The bid rate shall also include full compensation for watering the planted areas until an acceptable grass covering has been established.

Payment for the grass seeds shall be made separately under SUB-ITEM 56.04(d).

(g) Sprigging
The unit of measurement for sprigging shall be the number of square metres of sprigging which has been planted in accordance with these Specifications and accepted by the Engineer.

The bid rate include full compensation for furnishing and placing of all materials, fertilisers, water, labour, equipment, tools, transport and all costs necessary to complete the work as prescribed in this Section.

(h) Other methods
Whenever other methods of grassing are specified in the Special Specifications, measurement and payment shall be as specified.

ITEM		UNIT
56.05	WATERING THE GRASS WHEN ESTABLISHED BY TOPSOILING ONLY:	KILOLITRE (kl)

The unit of measurement for watering areas which have been topsoiled on the instruction of the Engineer but which have not been hydro seeded or planted with grass, shall be the kilolitre of water applied on the instructions of the Engineer and calculated from the number of tank loads applied, multiplied by the capacity of the tank used in each case.

The bid rate shall include full compensation for procuring, transporting and applying the water as specified.

ITEM		UNIT
56.06	WATERING THE ALREADY PLANTED GRASS, TREES AND SHRUBS IN PERIODS OF DROUGHT DURING THE DEFECTS LIABILITY PERIOD:	KILOLITRE (kl)

The unit of measurement for watering the grass, trees and shrubs shall be the kilolitre of water used as directed by the Engineer in dry periods during the defects liability period in respect of grass, trees and shrubs.

The bid rate shall include full compensation for obtaining, transporting and applying the water.

The Contractor shall keep a careful record of the quantity of water used by him/her for watering the grass, trees and shrubs planted and shall submit such information to the Engineer on a daily basis. When there are times during the normal growing season, as specified in the Special Specifications, when the monthly rainfall is less than 75% of the monthly average, the Contractor will be compensated under this item for the same percentage of the quantity of water used for watering as that for the monthly rainfall that fell short of the average rainfall.

ITEM		UNIT
56.07	MOWING THE GRASS:	HECTARE (ha)

The unit of measurement shall be the hectare measured each time when the grass has been cut on the instructions of the Engineer.

The bid rate shall include full compensation for all plant, equipment and labour, required for every cutting of the grass and disposing of the grass cuttings, i.e. payment will be made every time the grass has been cut on the instructions of the Engineer.

ITEM		UNIT
56.08	ANTI-EROSION COMPOUND (SPECIFY)	KILOGRAMME (kg)

The unit of measurement shall be the kilogram net mass of anti-erosion compound used with the approval of the Engineer.

The bid rate for each kilogram of anti-erosion compound applied with the hydro seeding or separately shall include full compensation for furnishing the material and mixing and applying it.

ITEM		UNIT
56.09	TREES AND SHRUBS:	
(a)	PROVIDING THE TREES AND SHRUBS (TYPES AND AGE/SIZE INDICATED)	NUMBER (NO.)
(b)	PLANTING AND ESTABLISHING:	
	(i) TREES	NUMBER (NO.)
	(ii) SHRUBS	NUMBER (NO.)

Unit of measurement of providing the trees and shrubs shall be the number of each species or variety and age/size of tree and shrub furnished and established.

The bid rate shall include full compensation for furnishing the plants at the point of final use including substitutes for plants that may become diseased or die.

The unit of measurement for planting and establishing trees and shrubs shall be the number of each type planted and established.

The bid rates shall include full compensation for excavating the holes to the specified dimensions, furnishing topsoil, wooden stakes, manure and compost and mixing them together with any fertiliser required for planting and refilling each hole with the topsoil mixture and other soil, for watering the plants until the end of the defects liability period, furnishing and planting substitutes for plants that have died and for maintaining the plants as specified until the end of the defects liability period, including any other incidentals which may be necessary for properly executing the work.

Where the Employer furnishes the plants, the above rates shall also include full compensation for taking delivery of the plants, maintaining them as required, transporting them to point of final use, and for providing substitutes for plants which die or become diseased during storage.

Any chemical fertiliser and/or soil-improvement material required will be measured and paid for under SUB-ITEM 56.03(e).

ITEM		UNIT
56.10	EXTRA WORK FOR LANDSCAPING	PROVISIONAL SUM

The provisional sum allowed shall be expended at the discretion of the Engineer to cover the cost of work in addition to the scheduled Items which may be required in respect of landscaping and re-vegetation or any other related Items of work required for which no pay Items have been provided.
Payment shall be made as specified in SUBCLAUSE 1209(h).

ITEM		UNIT
56.11	WEEDING THE GRASS WHEN ESTABLISHED BY TOPSOILING ONLY	HECTARE (ha)

The unit of measurement for weeding all grass-seeded areas that have been topsoiled on the instruction of the Engineer (but have not been hydroseeded or planted with grass) shall be the hectare weeded as instructed by the Engineer.

The bid rate shall include full compensation for weeding the prescribed areas in accordance with the Specifications.

ITEM		UNIT
56.12	SOIL ANALYSIS OF TOPSOIL TAKEN FROM THE SITE	NUMBER (no)

The quantity to be measured for payment shall be the number of soil analysis undertaken on topsoil samples taken from the Site in accordance with the Specifications or instructed by the Engineer.

The quantity measured as prescribed above shall be paid for at the bid rate, which price shall be full compensation for taking topsoil sample, laboratory testing and preparation of soil analysis report with recommendation on type and quantity of fertiliser / soil-improvement material, including all labour, equipment, tools, transport and all costs necessary to complete the soil analysis.

SERIES 5000: ANCILLARY ROADWORKS

SECTION 5700: FINISHING THE ROAD AND ROAD RESERVE AND TREATING OLD ROADS

CONTENTS:

5701 SCOPE

This Section covers the final finishing and cleaning up of the road and road reserve after construction, and scarifying and treating old roads and temporary diversions.

5702 FINISHING THE ROAD AND ROAD RESERVE

After completing the seal or surfacing, or gravel surface on gravel roads, the road and road reserve shall be cleared of all excess earth, stones, boulders, debris and other waste material resulting from the construction of the Works and disposed in an approved waste site.

Culvert inlets and outlets, culvert barrels, and open drains shall be cleared of all debris, soil, silt and other material. The surfacing shall be cleared of all dirt, mud and foreign objects. Dragging, pushing or scraping material across the finished surfacing shall not be permitted.

All junctions, intersections, islands, kerbing and other elements making up the completed Works shall be neatly finished off.

The Contractor shall ensure that all declared noxious weeds have been removed from the road-reserve and borrow-pit areas. All noxious weeds shall be burnt to prevent the spread of the seed and cut stumps or coppice shall be sprayed with a suitable herbicide.

All soil, stones, boulders and indigenous plant material resulting from the finishing operations shall be disposed of at locations not visible from the road, and where they will not pollute water sources or create a hazard for livestock or wildlife (e.g. old borrow pits). All other waste such as drums, excess steel, litter, etc which cannot be sold or recycled shall be dumped in an approved waste site. The Contractor himself/herself shall make his/her own arrangements with the owners of properties on which such materials are to be deposited. Disposal shall be carried out in a neat and uniform manner.

The finishing of the road and road reserve shall be regarded as part of the Works and the Contractor's obligations under the Contract and shall not be paid for separately.

5703 TREATING OLD ROADS

All old roads, temporary diversions, haul roads and construction roads, shall, in so far as is practicable, be levelled with the original ground. Surfaces shall be scarified and broken up to a depth of 150 mm for promoting plant growth. The old roads shall be rehabilitated as shown in the Drawings, provided in the decommissioning plans or as directed by the Engineer, and shall be re-vegetated in accordance with SECTION 5600.

Where required by the Engineer, in order to prevent soil erosion, banks, dykes or ditches shall be constructed over the old road to dimensions ordered by the Engineer. All roads and temporary diversions treated as above shall be left in a neat and tidy state.

5704 MEASUREMENT AND PAYMENT

ITEM		UNIT
57.01	TREATMENT OF OLD ROADS AND TEMPORARY DIVERSIONS	KILOMETRE (km)

The unit of measurement shall be the kilometre of old road or temporary diversion treated.

Any landscaping and grassing shall be measured and paid for under SECTION 5600.

The construction of banks, dykes or ditches shall be measured and paid for under SECTION 2100.

The bid rate shall include full compensation for levelling and scarifying any surfaces and tidying old roads and diversions as specified.

No payment will be made in regard to treating the Contractor's own haul roads and construction roads, which costs shall be included in the rates for constructing the relevant items of work for which such roads are necessary.

SERIES 6000

STRUCTURES

CONTENTS OF THE STANDARD SPECIFICATIONS:

SERIES 6000: STRUCTURES

SECTION 6100: FOUNDATIONS FOR STRUCTURES

CONTENTS:

6101 SCOPE

This Section covers all foundation work which, for the purposes of these Specifications, shall comprise those elements of construction below the level of the bottom surface of the footings, the pile-capping slabs or the caisson cover slabs, collectively hereinafter referred to as base or bases, which shall include all the associated temporary works. Foundations for prefabricated culverts are not included but are specified in SECTION 2200.

6102 MATERIALS

(a) General
Material used in the permanent foundation work shall comply with the requirements specified for the particular material in SERIES 6000.

(b) Rock (for rock fill)
Stones shall be hard, angular, natural or quarry stones of such quality that they will not disintegrate on exposure to water or weathering. The stones shall be free from soil, clay or organic material.

Neither the breadth nor thickness of a single stone shall be less than one-third its length. Not more than 10% of the total volume of rock fill shall consist of stones with a mass of less than 0.5 times the specified mass and not more than 10% of the total volume of rock fill shall consist of stones with a mass of more than 5 times the specified mass.

At least 50% of the total volume of rock fill shall consist of stones the mass of which exceeds the specified mass.

(c) Crushed stone
Crushed stone used for the construction of crushed-stone fill shall originate from sound unweathered rock approved by the Engineer.

(d) Granular fill
Granular material used for constructing the compacted granular fill shall be approved granular material of at least gravel subbase quality.

(e) Sand fill
Sand used for filling the caissons shall be clean, hard sand free from lumps of clay or organic or other deleterious matter.

(f) Structural steel
Steel in the steel piles shall comply with the requirements of BS 7613:1994, BS 7668:1994, BS EN 10029:1991, Parts 1 to 3 of BS EN 10113:1993, BS EN 10155:1993 and BS EN 10210-1:1994 or equivalent for the grade of steel specified on the Drawings. I and H sections shall comply with the requirements of BS 4-1:1993 and BS EN 10034:1993.

Fabricated sections shall comply with the details shown on the Drawings and the requirements of SECTION 6700.

(g) Permanent pile casings
Permanent pile casings shall be sufficiently rigid so as not to deform permanently or damage during handling and construction. The casings and their joints shall be sufficiently watertight to prevent the fluid components of the concrete from leaking during the placing of the concrete or from the ingress of groundwater prior to concreting. Where steel casings contribute to the strength of the pile, the casings shall have a minimum wall thickness of 4.5 mm and shall comply with the requirements of ASTM A 252-98:2002. Welded joints shall comply with the requirements of SECTION 6700.

(h) Driven pile casings
Driven pile casings shall have sufficient strength to permit their being driven and not being distorted by the driving of adjacent piles. They shall be sufficiently watertight to prevent water leaking through the casing walls, prior to during the placing of concrete.

(i) Grouting

(i) Cement grout
Cement grout shall meet the appropriate requirements of SUBCLAUSE 6503(g).

(ii) Proprietary-brand grout
Proprietary-brand grout shall be prepared and used strictly in accordance with the instructions of the manufacturer.

6103 GENERAL

(a) Subsurface data
The provisions of CLAUSE 1216 shall apply in regard to any information supplied regarding any subsurface conditions likely to be encountered.

If it is found during the course of excavating, founding-pile or caisson work that the soil or founding conditions differ greatly from those shown on the Drawings, the Contractor shall immediately notify the Engineer.

The Engineer shall, as often as he/she may deem necessary during the course of excavation, be entitled to call on the Contractor to conduct additional foundation investigations and/or tests at or below the respective founding levels in view of establishing safe bearing pressures and founding depths.

(b) Channel preservation
The flow of the watercourse and the conservation of marine and freshwater life shall be maintained at all times. Access to cofferdams, artificial islands and piling platforms shall be effected without unnecessarily disrupting the flow of the watercourses at the point of crossing, unless otherwise specified.

Precautions shall be taken by the Contractor to maintain water quality standards. Water contaminated with silt shall be settled in ponds before being pumped into streams. Water contaminated with chemicals shall be purified before being returned to the stream or disposed of in an appropriate manner as directed by the Engineer.

Precautions shall be taken by the Contractor to ensure that the natural pH, electrical conductivity and other indicators as prescribed of the water are not raised or lowered.

On completion of the work, surplus excavated materials including materials excavated from caisson compartments and holes for piles, materials used in cofferdams and other temporary works, as well as in-situ material, shall be removed and disposed of by the Contractor to the level of the original bed or such elevation as agreed to by the Engineer or required for stream channelisation.

6104 ACCESS AND DRAINAGE

(a) General
This Clause covers the provision of access, including the construction of cofferdams, and draining the excavations. Where it is unnecessary to provide access in terms of SUBCLAUSE 6104(b), the Contractor shall be paid separately for draining the excavations.

After completion of the permanent works, all temporary works shall be completely removed, the ground levelled and the site left neat. Where this is impracticable, such portions as have not been removed, shall be dealt with in accordance with the Engineer's instructions.

(b) Access
Where temporary banks or artificial islands are constructed in view of affording access to the location where structural members, piles or caissons are to be constructed, the banks or islands shall be adequately compacted in view of supporting any equipment and material without any undue settling which may have a harmful effect on the works.

The Contractor may use any material, with the approval of the Engineer, deemed by him/her to be suitable for constructing the islands, but no separate payment will be made for any obstructions, hard or unsuitable material occurring in the material used for constructing temporary banks or artificial islands.

Designing and constructing any cofferdams shall comply with the requirements of BS 8004:1986. Before starting with construction, the Contractor shall submit drawings to the Engineer, which show details of the cofferdams and the method of construction proposed.

(c) Drainage
The Contractor shall apply suitable, effective drainage methods for preventing the ingress of water into excavations and to keep them dry.

The drainage measures, with the exception of pumping, shall be maintained until the backfilling has been completed. Between the various construction stages pumping may be interrupted in consultation with the Engineer.

Any draining or pumping of water shall be done in a manner that will preclude the concrete or materials or any part thereof from being carried away.

6105 EXCAVATION

(a) General
This work shall include excavations not provided for elsewhere in these Specifications, which are required for founding the structures as well as for the excavating required in respect of the demolition, extension or modification of existing bridges and culverts.

Excavation required for diverting, channelling or widening streams within 5 m of concrete structures shall be measured and paid for under ITEM 61.02. Excavations beyond the 5 m limit shall be measured and paid for under the appropriate Items of SECTIONS 2100 and 3600.

(b) Surface levels agreed on for excavations
Prior to commencing with any excavation, the Contractor shall notify the Engineer in good time to ensure that levels be taken of the undisturbed ground surface for determining the ground surface from where the excavation can be measured, and this datum shall be agreed on by the Engineer and the Contractor.

(c) Excavation
Where in the opinion of the Engineer the casting of concrete against the excavated earth faces is not permissible, or where formwork has to be provided, the extremities of the excavation, for purposes of measurement and payment, shall be deemed to be the vertical planes parallel to and 0.5 m outside the perimeter of the member for which formwork is to be provided.

Where suitable, stable material is encountered during excavating, that part of the trench or foundation pit shall be excavated to the neat dimensions of the base unless otherwise directed by the Engineer. Over-excavation (overbreak) in hard material shall be backfilled with the same class of concrete as that in the base or with mass concrete fill as specified or as directed by the Engineer.

Where blasting is required, the Contractor shall complete the entire foundation excavation before the construction of any permanent concrete work is commenced, unless otherwise approved by the Engineer.

Boulders, logs or any other unsuitable material excavated shall be removed from the site.

When hard material suitable for founding is encountered at the founding level, it shall be cut and trimmed to a firm surface, either level, stepped or serrated, as may be required.

Where, in the opinion of the Engineer, unsuitable material is encountered at founding level, such material shall be removed and replaced with foundation fill in accordance with CLAUSE 6109 and as directed by the Engineer.

(d) Classification of excavated material
For payment purposes distinction shall be made between common excavation in soft material and rock excavation. All excavation for the foundations of structures shall be classified in accordance with CLAUSE 3603, which definitions are summarised as follows:

(i) Rock excavation:
Rock excavation shall be excavation in material which requires drilling and blasting or the use of hydraulic or pneumatic jackhammers to be loosened.

(ii) Common excavation:
Common excavation shall be excavation in all material other than rock as defined above.

(e) Blasting

Where blasting is permitted, it shall be carried out in accordance with the requirements of CLAUSE 1222.

(f) Deterioration of foundation excavations
Where soft material, or hard material which quickly deteriorates when exposed, is found at foundation level, the excavation shall be excavated to the final slope and level immediately before the blinding is placed.

Where the bottoms or sides of excavations, in which bases are to be cast, are softened on account of negligence on the part of the Contractor in allowing storm or other water to enter the excavations, the softened material shall be removed and replaced with foundation fill as directed by the Engineer, at the Contractor's expense.

(g) The safety of excavations
The Contractor shall take the necessary precautions to safeguard the stability and safety of the excavations and adjacent structures.

No person's safety shall be jeopardised neither shall any situation be allowed to arise which may result in damage of whatsoever nature.

Precautionary measures taken by the Contractor shall comply with the appropriate legal provisions.

(h) Inspection
No concrete shall be placed before the excavation has been properly cleaned by the Contractor and inspected and approved by the Engineer.

(i) Excavation by hand
In cases where mechanical excavators are not able to be used, the Engineer shall authorise supplementary payment to the Contractor for excavation by hand at the bid rates, provided that the Engineer is satisfied that the Contractor had done everything possible to ensure that hand excavation was the only possible solution. The supplementary rate for excavation by hand shall not apply to minor finishing or clearing jobs in excavations which are otherwise being done by mass excavation equipment.

6106 FOUNDING

As a consequence of possible variations of the anticipated founding conditions, the dimensions and founding levels specified or shown on the Drawings may have to be varied during construction.

The Contractor shall make such variations in the actual founding level for each foundation fill, base or caisson during construction as instructed by the Engineer.

The Contractor shall not be entitled to any additional payment as a consequence of any such variation in the dimensions or founding depths over and above that provided for in CLAUSE 6118, irrespective of the stage of construction at the time the instruction to make the variation is given. However, if as a consequence of such an instruction being given, the Contractor is compelled to substitute which were otherwise suitable machines or equipment, then the Engineer may reimburse the Contractor at a fair price for the relevant costs incurred.

No bases, caissons or piles shall be founded unless authorised by the Engineer. Each founding level shall be accurately measured and recorded and agreed on.

6107 UTILISATION OF EXCAVATED MATERIAL

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

Excavated material not used for backfill or not taken to spoil but used in the construction of embankments or other parts of the work, as directed by the Engineer, will be paid for under foundation excavation as well as under the relevant item for the purpose for which it is used.

The free haul distance on excavated material and imported material for backfill shall be determined according to Subclause 1602 (c).

Excavated and stockpiled material shall be so placed as not to endanger the uncompleted structure either by direct pressure or indirectly by overloading the fills contiguous to the structure, or in any other way.

6108 BACKFILL AND FILL NEAR STRUCTURES

(a) General
When backfill and fill are placed, the following precautionary measures shall be taken:

(i) The material shall be placed simultaneously, in so far as is possible to approximately the same elevation on both sides of an abutment, pier, or wall where appropriate. If conditions require the backfill or fill to be placed appreciably higher on one side than on the other the additional material on the higher side shall not be placed until authorised by the Engineer, and preferably not until the concrete has been in place for 14 days, or until tests show that the concrete has attained sufficient strength to safely withstand any pressure extended by the backfill or fill or by the method of construction.

(ii) The material behind abutments directly restrained at the top by the superstructure e.g. portal type of structures, shall be placed as shown on the Drawings or as directed by the Engineer.

(iii) The material behind the portal walls of portal structures shall not be placed until the top slab has been placed and cured for the specified length of time, unless otherwise authorised by the Engineer.

(b) Backfill
Excavated areas around structures shall be backfilled with approved material in horizontal layers not exceeding 150 mm in thickness after compaction to the level of the original ground surface. Each layer shall be moistened or dried to the optimum moisture content for the material and then compacted to a density of not less than 90% of BS-Heavy density for soils and gravels, and not less than 100% of BS-Heavy density for cohesionless sands, or the density of the surrounding soil whichever is the least, except that, in the road prism, the material shall be compacted to a density of not less than 93% of BS-Heavy density.

(c) Fill
Before the space either between the structure and the approach fill, or between the structure and the faces of the surrounding excavation is backfilled, the slope of the approach fill, or the faces of the excavation shall be shaped by benching or serrations to prevent wedge action from occurring between the structure and the approach fill or the excavation faces.

The distance between the exposed face of the structure and the toe of the approach fill or the excavation face shall not under any circumstances be less than the height of the exposed face of the structure.

(d) Fill within restricted area
That part of the fill within a horizontal distance of 3 m from the vertical and inclined concrete faces of the structure and that part between the pillars of the spill-through abutments or that part shown on the Drawings, shall be termed “fill within restricted area".

Fill within the restricted area shall comply with the requirements of SECTION 3600 except that it shall be compacted to a density of not less than 93% of BS-Heavy density. In order to achieve the specified density the Contractor shall, where necessary, import material of suitable quality.

Unless otherwise directed by the Engineer, only mechanical compaction equipment that is pushed or drawn by hand shall be used to achieve the required density within a horizontal distance of 3 m from any concrete structure. Fill in spaces below concrete soffits that are inaccessible for mechanical compaction equipment shall be constructed by methods specified or as approved by the Engineer.

Where a base is required to be constructed on mass concrete fill, the mass concrete fill shall be constructed accurately to the final levels of the underside of the base.

6109 FOUNDATION FILL

If it is found during the course of excavation that the material at the indicated founding depth does not have the required bearing capacity as specified on the Drawings, the excavations shall be extended at the discretion of the Engineer until satisfactory founding material is encountered. The Engineer may order the Contractor to make up the difference in levels with foundation fill.

Where the foundation fill consists of rock or crushed stone, it shall be constructed in accordance with the requirements of the Special Specifications or as directed by the Engineer. Foundation fill consisting of granular material shall be constructed in layers not exceeding 150 mm in thickness after compaction. Each layer shall be moistened or dried to the optimum moisture content for the material and compacted to a density of not less than 95% of BS-Heavy density for soils and gravels, and not less than 100% BS-Heavy density for cohesionless sands. Mass concrete fill to be used shall be of the class or mix of concrete fill as specified or directed by the Engineer.

Unless otherwise specified or directed by the Engineer, the foundation fill constructed from rock, crushed stone or compacted granular material shall be defined by a prism with vertical sides. The base of the prism lies in the founding plane and coincides with the base of a prismoid with trapezium-shaped inclined sides which extend downwards and outwards at an angle of 60^0 with the horizontal from each outer edge of the underside of the footing down to the founding level. The upper plane of the prism lies in the plane of the underside of the footing.

Concrete blinding which complies with the requirements shown on the Drawings shall be placed underneath all bases except where mass concrete fill is used or where authorised by the Engineer that this need not be done.

Where a base is required to be constructed on mass concrete fill, the mass concrete fill shall be constructed accurately to the final levels of the underside of the base.

6110 GROUTING OF ROCK FISSURES

Where specified, fissures in the rock below and around the bases shall be sealed by pressure grouting with a neat cement grout or sand-cement grout or with a proprietary brand grout as specified.

The cement water ratio of the grout shall be approved in advance by the Engineer.

The extent of the fissuring shall be established by means of water testing under pressure.

Holes of at least 40 mm in diameter shall be drilled at places indicated by the Engineer and grout shall then be pumped into these holes under suitable pressures. Grouting shall be done in 3 m stages to the maximum depth ordered. Care shall be taken to avoid further fracturing of the rock strata by excessive grouting pressures.

Grouting of the rock fissures shall be done by specialised operators with adequate experience in this class of work.

6111 FOUNDATION DOWELS

Where required, foundation dowels of specified material, diameter and length shall be installed at the positions and to the dimensions shown on the Drawings or as directed by the Engineer. After exposing, clearing and trimming the rock formation, holes with specified diameters and depths shall be drilled in the rock. After the holes have been cleared and prewetted, they shall be filled with grout. Within 15 minutes of having been filled with grout, the dowels shall be carefully driven into the holes. The cement and water in the grout shall be mixed in the ratio of 50 kg of cement to 20 litres of water, and an approved expanding additive which complies with the requirements of SUBCLAUSE 6402(e) shall be added.

The dowels shall comply with the requirements of CLAUSE 6305.

6112 FOUNDATION LINING

Where specified or directed by the Engineer, foundation linings shall be installed as described hereafter. The Engineer shall have the right to order the use of linings against the sides of excavations and the undersides of bases and slabs in lieu of formwork and concrete blinding.

All surfaces to be lined shall be covered with an approved sheeting to provide a clean impervious layer. The material shall be of sufficient strength to provide a durable working surface and to support the concrete and reinforcement without tearing. The joints of the material between strips shall have a 150 mm overlap and the lining shall be held firmly in position by nails, pegs, etc.

Polyethylene sheeting with a thickness of 0.150 mm is generally considered to be adequate for use below bridge approach slabs and bases.

6113 FOUNDATION PILING PRELIMINARY ITEMS

(a) General
This Clause covers the construction of bearing piles of concrete, steel, timber or a combination of these materials.

(b) Piling layout
The piling layout, the minimum pile size and/or bearing capacity and type together with the steel reinforcement

and class of concrete required for concrete piles shall be as detailed and specified on the Drawings unless otherwise specified in the Special Specifications.

(c) Alternative designs for piling and piling layouts

(i) Submission
The priced Bill of Quantities submitted for alternative designs shall be compiled strictly in accordance with the relevant measurement and payment clauses of these Specifications.

Where pay items defined in these Specifications have been omitted, it shall mean either that the items do not apply, or that where the Engineer requires work falling under such items to be done, it shall be done without any cost to the Employer. The inclusion of 'rate-only" items will not be permitted.

Where pay items not defined in these Specifications are used, the measurement and payment requirements for such items shall be specified in detail by the Contractor. In the absence of such definitions, or in the case of any ambiguity, the interpretation of the Engineer shall be final and binding.

Except in piling-only Contracts or where otherwise provided in the Special Specifications, the Contractor shall price the Bill of Quantities for the original design irrespective of whether or not an alternative design is offered.

(ii) Design
The critical design-load combinations acting upon the underside and the centre of gravity of the pile-capping slab, the maximum permissible set of the pile-capping slab, and the technical data required for designing alternative piles and or piling layouts will be indicated on the Drawings. Alternative designs shall comply with the provisions of CLAUSE 1212 and the prescriptions set out below.

For alternative designs submitted the Contractor shall submit with his/her bid a detailed description of the method of analysis used in the design of the piles and the pilegroup layouts. The average length of pile and/or of the piles per group on which the quantities in the Bill of Quantities for the alternative designs are based shall be stated in each case. The type of pile offered shall be defined in terms of size, materials, working and breaking load.

The Contractor shall be responsible for and shall bear the cost for redesigning, drafting and submitting the detail drawings for any structural element affected by the alternative pile design. Any economy or incidental caused by constructing such element as compared to the original design shall be for the account of the Contractor.

The Contractor shall, as specified in CLAUSE 1212 for alternative designs, submit to the Engineer at least three months prior to work being commenced, drawings detailing the piling-group layout and piles, incorporating such amendments to his/her original design as may be required by the Engineer, and drawings detailing the amendments required to the pile-capping slab dimensions and reinforcement as a result of the layout of the piles, all as applicable.

No work of whatsoever nature shall be commenced on the piling until the Drawings have been submitted to, and have been approved by, the Engineer, in writing.
After approval of the Drawings, no departure therefrom shall be made without the authorisation of the Engineer.

Final working drawings shall comply with the provisions of CLAUSE 1221.

Where the alternative piles fail in regard to the load test specified in SUBCLAUSE 6116(a), the Contractor shall be responsible for the cost of the work required for improving the piles and pile layout so as to comply with the design requirements.

(iii) Basis of payment
Where the quantities in the Bill of Quantities referred to in SUBCLAUSE 6113(c), differ from the number of piles and the average pile length given in the submission for the alternative pile design, the Engineer shall accept the sum in the Bill of Quantities, correct the quantities, and adjust the rates for the applicable pay items accordingly.

(d) Details to be furnished by the Contractor
In all cases where the choice of the type of pile to be used is left to the Contractor, full particulars, specifications, calculations and drawings of the piles proposed for use by the Contractor shall be submitted with the bid. The Contractor shall submit the following information to the Engineer, two weeks before any piles are driven or holes are formed:

(i) How the piles and casings will be installed or the holes will be formed;

(ii) How the piles and casings will be installed or the holes will be made through identified obstructions;

(iii) The weight of the piling hammer;

(iv) The set during the last ten blows;

(v) The expected size of the bulbous base, underream. rock socket, etc, if any;

(vi) How concrete is to be placed and compacted in the case of cast in situ piles;

(vii) How reinforcing steel is to be placed and held in place during the placing and compaction of the concrete in cast in situ piles;

(viii) Details of permanent casing, if any;

(ix) The mix design for the concrete together with an adequate quantity of cement and aggregate to enable the Engineer to conduct the necessary tests.

(e) Pile-installation frames and equipment
The pile-installation frames and equipment used for driving the piles or forming the holes or for other methods of sinking the piles shall be in a good working condition and to the prior approval of the Engineer and shall comply with the relevant legal provisions.

The Contractor shall supply the necessary equipment, gear and instruments required for the prescribed investigations and inspections.

The installation frames shall be so designed as to ensure that piles can be installed in their proper positions and true to line and slope.

(f) Piling platforms
Piling platforms shall include the prepared in situ material or artificial islands or any structure (excluding the piling equipment) constructed for gaining access to the position where the pile is to be installed and for carrying out the piling operations.
Structural piling platforms shall be rigid. Floating barges used for piling operations shall afford sufficient stability to enable piles to be properly installed.

On completion of the piling, the Contractor shall remove all the artificial, constructed platforms and reinstate the site to the satisfaction of the Engineer.

(g) Setting out
The Contractor shall set out the pile positions and shall stake these positions with a durable marker. Where the level from which the piling is undertaken is above the underside of the pile capping slab, due allowance shall be made for the offset of raking piles so that the pile at the underside of the pile-capping slab will be in the correct position.

(h) Ground surface for foundation piling
Before starting any piling work, the Contractor shall notify the Engineer in good time to ensure that levels of the ground surface be taken in order that an average ground surface from which the piling is to be measured can be established and agreed on by the Engineer and the Contractor. Where foundation piling at a site is preceded by excavation or the construction of fill, the surface from which the piling is to be done shall be formed as near as possible to the underside of the pile-capping slab as directed by the Engineer.

6114 TYPES OF PILES

(a) Cast in situ concrete piles

(i) Reinforcement
Reinforcement shall not be placed in the pile holes until immediately before concreting. Before the reinforcement is placed in position, all mud, water, and any loose or soft material shall be removed from the hole.

Steel reinforcing shall be accurately maintained in position without damage being done to the sides of the hole or the reinforcing itself. Spacers shall be used to keep the reinforcing steel at the required distance from the inside face of the pile casing and wall of the pile hole but shall not cause zones through which aggressive ground water may penetrate to the reinforcement.

Pile reinforcement will not be shown in the bending schedules. Only the number, diameter and type of bars and their arrangement will be shown on the Drawings. The Contractor, with the permission of the Engineer, may replace the bars shown on the Drawings with bars with different diameters and spacing and of different types, on a basis of equivalent strength.

The reinforcement shall be assembled in cages, which shall be sufficiently robust to prevent their permanent deformation during handling. In the case of cast in situ piles, the inner sides of the cages shall be left unrestricted for the placing of the concrete.

The longitudinal bars shall project above the cut-off point by the distance shown on the Drawings, or by 40 times the bar diameter if no dimension has been given.

Splicing the reinforcing may be ordered, and the Contractor shall keep available on the site sufficient steel reinforcing so that an additional length of pile reinforcing can be assembled whenever necessary.

The assembly of this additional reinforcing shall be carried out expeditiously and before any concreting of any specific pile commences. If splices have to be provided, the longitudinal bars shall overlap for a distance of 40 bar diameters, or as required by the Engineer.

(ii) The concreting of piles
The concreting of the piles shall not be commenced before the Engineer's permission has been given. Except in self-supporting pile holes, a temporary or permanent casing shall be installed for the full depth of the hole to prevent lumps of material from falling from the sides of the hole into the concrete. Where concrete is to be placed under the drilling mud, the temporary casing may be omitted, except at the top end of the hole.

The concrete shall be so proportioned as to be of sufficient strength, but shall be sufficiently workable to enable it being properly placed, and, where self-compacting concrete is not used, it shall be thoroughly compacted by approved means. Extraction of the temporary casing during placement of the concrete shall be such that no damage is caused to the pile and the advancing concrete level is at all times kept considerably above the temporary casing's trailing edge. Concrete shall generally be placed in the dry, but where this is impracticable; it shall be placed by tremie.

The requirements of SUBCLAUSE 6407(c) together with the following requirements shall apply when concrete is placed under water by tremie:

(1) The cement content shall be not less than 400 kg/m^3 and the slump shall be such that the concrete of the specified strength and desired density can be obtained.

(2) The hopper and tremie shall be a closed unit which cannot be penetrated by water.

(3) The tremie shall be at least 150 mm in diameter for 20 mm aggregate and of greater diameter for larger aggregates.

(4) The concrete shall be so placed as to prevent the mixing of water and concrete. The tremie shall at all times penetrate into the concrete.

(5) Placing the concrete in that part of the pile below the water level in the casing shall be done in one operation, and the same method of placing the concrete shall be maintained throughout.

(6) All tremies shall be scrupulously cleaned before and after use.

(7) Before placing the concrete in the water, the Contractor shall ensure that no silt or other materials have collected at the bottom of the hole, and where drilling mud is used, the Contractor shall ensure that no drilling mud suspension with a relative density exceeding 1.3 has collected at the bottom of the hole. Concrete shall be placed in a manner that prevents segregation.

(b) Precast concrete piles

(i) General
The piles shall be of reinforced or prestressed concrete and shall be manufactured, handled, stored and installed in accordance with BS 8004:1986, unless otherwise specified.

(ii) Manufacture
The piles may be manufactured in a factory or a casting yard on the site of the Works. The

Contractor shall ensure that the factory or casting yard will at all reasonable times be accessible for inspection by the Engineer.

The relevant requirements of SECTION 6400 shall apply to the concrete work.

Reinforcement shall comply with the requirements of BS 8004:1986.

The piles shall be cast on a rigid horizontal platform in approved moulds. Particular care shall be taken to keep the reinforcement, coupler sockets and pile shoes accurately in position. Adequate provision shall be made for lifting the piles.

Each pile shall be clearly marked with the date of casting, a reference number, and from the tip of the pile at 1.0m intervals, with distance marks.

Piles shall be cured for a period sufficient to develop the strength required to withstand, without damage to the pile the stresses caused by handling, transporting, storing and driving. The piles shall not be driven before the concrete in the pile has attained the specified 28-day strength.

(iii) Handling, transport and storage
Care shall be taken at all stages of lifting, handling and transporting to ensure that the piles are not damaged or cracked.

Piles shall be stored on firm ground which will not settle unequally under the weight of the stack of piles. The piles shall be placed on timber supports which are truly level and spaced so as to avoid undue bending in the piles. The supports in the stack shall be located vertically above one another.

(iv) Lengthening of precast piles
Piles shall be lengthened where required by such means and methods as approved by the Engineer. Care shall be taken to ensure that the additional length of pile joined is truly axially in line with the original pile within the tolerance requirements for straightness set out in SUBCLAUSE 6803(a). Driving shall not be resumed until the pile extension and any bonding agent used has attained the required strength.

(c) Steel piles

Steel piles shall be of hollow pipe construction or of H-section construction.

Hollow steel piles may be filled with cast in situ concrete and, provided that adequate connections are provided between the steel and the concrete with a view to transferring the load, the concrete may be deemed to assist in carrying the load.

Wherever steel piles are used, the outside surface shall be given a protective coating of bitumen, coal-tar pitch or synthetic resins to the satisfaction of the Engineer or as specified. The cross-sectional area of the steel shall be adapted to the aggressiveness of the subsurface conditions to compensate for possible reduction in the pile wall thickness caused by abrasion and corrosion during the service life of the pile.

Steel piles shall be used only where permitted by the Engineer.

(d) Timber piles

(i) General
Timber piles shall be of pressure treated round timber approved by the Engineer and shall be manufactured, handled and installed in accordance with BS 5268-2:2002 unless otherwise specified.

Tropical hardwoods shall be used for all permanent piles. Softwoods may be used for temporary structures subject to the approval of the Engineer.

(ii) Manufacture and testing
The piles may be manufactured in a factory or treated on the site of the Works in accordance with BS 5268-5:1989, unless otherwise specified.

When required, the Engineer will order and the Contractor shall carry out tests on the timber piles in accordance with BS 5268-5:1989 to satisfy himself/herself that the timber is fit for the purpose for which it is to be used.

The Contractor shall ensure that the factory or treatment yard will at all reasonable times be accessible for inspection by the Engineer.

The piles shall be treated and stored in a horizontal position and protected from the weather.

Each pile shall be clearly marked with the date of manufacture, type of tree, date of treatment, a reference number, and from the tip of the pile at 1.0 m intervals, with distance marks.

Piles shall be seasoned for a period sufficient to develop the strength required to withstand, without damage to the pile, the stresses caused by handling, transporting, storing and driving. The piles shall not be driven before they have attained the specified strength.

(iii) Handling, transport and storage
Care shall be taken at all stages of lifting, handling and transporting to ensure that the piles are not damaged or cracked.

Piles shall be stored on firm ground which will not settle unequally under the weight of the stack of piles. The piles shall be placed on timber supports which are truly level and spaced so as to avoid undue bending in the piles. The supports in the stack shall be located vertically above one another.

(iv) Lengthening of timber piles
Piles shall be lengthened where required by such means and methods in accordance with BS 5268:2002 or as instructed by the Engineer. Care shall be taken to ensure that the additional length of pile joined is truly axially in line with the original pile within the tolerance requirements for straightness set out in SUBCLAUSE 6803(a). Driving shall not be resumed until the pile extension and any bonding agent used has attained the required strength.

6115 DRIVING OF PILES

(a) Driving the piles

(i) Pile-installation frames
Piles and pile casings shall be driven with a gravity hammer, a rapid-action power hammer or by other approved means. Prestressed-concrete piles shall be driven with a hammer with a weight of at least equal to that of the pile. Other piles shall preferably be driven by a hammer with similar weight characteristics. The hammer shall not, during driving operations, damage any permanent component of the pile. Pile driving leaders shall be constructed in such a manner as to afford freedom of movement of the hammer and shall be held in position to ensure adequate support for the pile or

pile casing during installation. Inclined leaders shall be used for installing raking piles.

The heads of precast concrete piles shall be protected with packing of resilient material, care being taken to ensure that it is evenly spread and held in place. A helmet shall be placed over the packing, and a dolly of hardwood or other material not thicker than the diameter of the pile shall be placed on top.

(ii) Water jetting
The Contractor may employ water jetting to install piles in granular material. Jetting shall be discontinued before the leading end of the pile reaches a depth of 80% of the anticipated final depth or a depth as agreed on with the Engineer. After jetting, piles or their casings shall be driven to the required depth, level or set.

(iii) Installation sequence
Unless otherwise specified or ordered the sequence for installing the piles shall be left to the Contractor. However, the sequence for driving the piles in a group shall be programmed to minimise the creation of consolidated blocks of ground into which piles cannot be driven or which cause fictitious penetration values. Piling shall generally commence at the centre of the group and be progressively extended to the perimeter piles unless otherwise agreed on by the Engineer.

The installation of piles shall be undertaken in such a manner that structural damage, distortion or positioning defects will not be caused to previously installed piles or casings.

(iv) Heaving of piles
In soils in which the installation of piles may cause previously installed piles to heave, accurate level marks shall be placed on each pile immediately after installation and all piles that have heaved shall be redriven to the required resistance, unless redriving tests on neighbouring piles have shown this to be unnecessary. Piles shall not be concreted neither shall any pile-capping slab be constructed until the piles within a heave-influence zone have been redriven as required.

(v) Bulbous bases
Where required, bulbous (enlarged) bases shall be formed after the driven casing has reached the required depth. The base shall be formed by progressively displacing the surrounding subsoil with concrete placed by the repeated action of a gravity hammer. The size of the base will depend on the compressibility of the surrounding subsoil but shall in no case have a diameter of less than 1.5 times the diameter of the pile.

(vi) Piling alignment
Where the inclination of a precast concrete pile deviates from the correct slope during installation, the pile shall not be forced into the correct position. The slope of the guiding frame shall be adjusted so as to coincide with the actual inclination of the pile to preclude the bending of the pile. Where the verticality or the inclination of the installed pile falls outside the specified tolerances, the pile will be classified as being defective.

(b) Augering and boring

(i) Auger and bore pile holes
The augering and boring of pile holes shall be carried out as expeditiously as local conditions permit taking due account of services or other restrictions on the site.

Holes shall be cleaned after augering and boring to obtain a clean and level surface.

Where indicated by the Engineer, suitable casing shall be installed in those parts of the augered holes where the sides are in danger of caving in before the concreting has been completed.

During extraction of the casing, care shall be taken to avoid lifting the concrete and damaging the pile.

The use of water for augering and boring holes shall not be permitted unless approved by the Engineer. Surface water shall not be allowed to enter the hole.

(ii) Underreaming
Where required, the holes shall be enlarged or belled out to form an underream. The earth excavated shall be removed in a manner which will not damage the walls of the hole.

The shape of the underream shall be a truncated cone of which the base diameter depends on the bearing capacity of the founding material, but it shall be not less than twice the shaft diameter. The base angle of the cone between the inclined face and horizontal plane shall be not less than 60^0.

Full safety measures shall be enforced to protect workmen working at the bottom of the pile hole.

(iii) Bulbous bases
Bulbous bases shall comply with the requirements of SUBCLAUSE 6115(a) (v).

(iv) Inspecting preformed holes
Equipment for inspecting the pile shafts shall be provided and operated in accordance with BS 8008:1996 Safety Precautions and Procedures for the Construction and Descent of Machine-Bored Shafts for Piling and Other Purposes or similar document.

Immediately before the reinforcement is to be installed or the concrete placed, the Engineer shall be informed thereof with a view to inspecting the pile holes. When piles are to be underreamed, the excavation shall be inspected twice by the Engineer, firstly to ascertain that suitable founding material has been obtained before underreaming may start, and, secondly, after the underreaming has been completed for approval to be given by the Engineer for casting the pile.

(c) Rock sockets

Where required, rock sockets to the required dimensions shall be formed in rock formations of adequate strength, quality and thickness for transmitting the specified load.

(d) Obstructions

(i) Definitions

(1) Identified obstructions
Identified obstructions shall mean any obstruction described on the Drawings or in the Special Specifications and for which provision for payment has been made in the Bill of Quantities in respect of penetrating the obstructions.

(2) Unidentified obstructions
Where provision has been made in the Bill of Quantities in terms of ITEM 61.17 for penetrating identified obstructions and obstructions not

described are encountered, such obstructions shall be classified as unidentified obstructions and the penetration of such obstructions shall be paid for under ITEM 61.18 subject to the condition that the rate of penetration drops to below that achieved for identified obstructions when the same method and effort are used, or subject to additional methods and effort over and above those required for identified obstructions being required for penetrating the obstruction.

or

Where no provision has been made in the Bill of Quantities for penetrating identified obstructions and obstructions are encountered and, after resorting to the methods specified in the submission in terms of SUBCLAUSE 6113(d), it is found to be impossible to form the holes in the proper positions and at the proper inclinations and depths, and the Contractor has to resort to additional methods for forming the pile holes successfully, such obstructions shall be classified as unidentified obstructions.

(ii) Classification of materials
For piling, only the following classification of materials shall apply to the identification and description of obstructions.

(1) Matrix
The matrix shall comprise that part of the material which will pass through a sieve with 50 mm x 50 mm openings.

(2) Coarse gravel
Coarse gravel shall comprise that part of the material (stones, pebbles, cobbles, etc) which will pass through a 200 mm x 200 mm opening, but will not pass through a 50 mm x 50 mm opening. The gravel shall be obtained from material with at least a Class R2 hardness as defined in TABLE 6115/1.

(3) Boulders
Boulders shall mean any rock mass with a hardness of at least Class R2 which will pass through a square opening with dimensions equal to the maximum size boulder specified in the Bill of Quantities but will not pass through a 200 mm x 200 mm opening.

(4) Rock formation
A rock formation shall be any rock mass with hardness of at least Class R2 which will not pass through a square opening with dimensions equal to the maximum size boulder specified in the Bill of Quantities.

Where a boulder is cut through and part of it is left imbedded in the wall of the hole, such boulder obstruction shall be classified as rock formation.

For the identification of rock in terms of this Clause, the classification in TABLE 6115/1 shall apply.

(iii) Driven displacement and prefabricated piles
Where obstructions make it difficult to install driven displacement and prefabricated piles in the positions and at the inclinations shown and to the proper lengths by the methods specified in the submission in terms of SUBCLAUSE 6113(d), the Contractor shall resort to additional methods which are suitable for the type of pile. If the successful installation of a pile proves to be impossible after such methods have been tried, the Engineer may order an additional pile or piles to be installed.

All such work and additional piles shall be paid for in accordance with the bid rates where applicable, or where they do not apply, under ITEM 61.20.

(iv) Auger and bore pile holes
Where identified or unidentified obstructions are encountered when shaping holes for piles, payment for penetrating the obstructions shall be made against the appropriate pay items.

(e) Determining pile lengths
The design of the piles and pile groups, and the quantities in the Bill of Quantities are based on the subsurface data shown on the Drawings.

The Engineer will determine the depth of piles as work proceeds.

Where variations in the subsurface conditions occur as regards the material and height of the water table, the Engineer shall be informed immediately.

If the Contractor is not satisfied that the piles will be capable of carrying the specified loads at the depth determined by the Engineer he/she may, in consultation with the Engineer, lengthen the piles to reach a suitable founding depth. Where the Engineer and the Contractor cannot agree on the founding depth, the Engineer may require the Contractor to:

(i) undertake additional foundation investigations and/or core drilling in accordance with SUBCLAUSES 6103(a) and 6115(i) respectively, and/or

(ii) install one or more test piles and conduct a load test in accordance with SUBCLAUSE 6116(a). The Engineer will prescribe the positions for each test pile. Test piles shall comply with the specified requirements for piling.

(f) Piling data
The following data on each pile installed shall be recorded in a form prescribed by the Engineer:

(i) The effort used for driving the pile and the resistance to penetration at founding level.

(ii) A description of subsurface material, the presence of ground water and the quality of material on which the pile is founded.

(iii) The quality of the materials used in the construction or manufacture of the pile, as well as of the permanent casing if used. The method of placing and compacting the concrete in cast in situ piles.

(iv) The method of founding of the piles e.g. bulbous bases, underreams, rock sockets, etc, and their dimensions.

(v) The maximum working load of the pile.

(vi) The length of the pile and the accuracy of installation in respect of position and inclination.

(vii) Nominal dimensions and type of pile.

(viii) Length and details of any temporary and permanent casings used.

(ix) Date of piling, pile reference number and pile location (sketch) relative to the other piles of the same set.

TABLE 6115/1
ROCK CLASSIFICATION FOR PILING

Description of hardness			
Class	**Description**	**Field indicator tests**	**Unconfined compression strength (MPa)**
R1	Very soft rock	Material crumbles under firm (moderate) blows with the sharp end of geological pick and can be peeled off with a knife, it is too hard to cut a triaxial sample by hand. SPT refusal.	1 to 3
R2	Soft rock	Can just be scraped and peeled with a knife, firm blows of the pick point leave indentations 2 mm to 4 mm in specimens.	3 to 10
R3	Medium hard rock	Cannot be scraped or peeled with a knife; hand-held specimen can be broken with the hammer end of a geological pick with a single firm blow.	10 to 25
R4	Hard rock	Point load tests shall be conducted for distinguishing between these categories. These results may be verified by means of uniaxial compressive-strength tests.	25 to 70
R5	Very hard rock		70 to 200
R6	Extremely hard rock		> 200

Classification after Core Logging Committee, South African Section, Association of Engineering Geologists: "A guide to Core Logging for Rock Engineering" Bulletin of the Association of Engineering Geologists, Vol. XV, No. 3,1978.

(g) Stripping the pile heads
Precast and timber piles shall be installed to a level of at least 1.0 m above the cut-off level, and cast in situ piles shall be cast to a level of at least 150 mm above the cut-off level. The excess concrete shall be so stripped off that only sound concrete will project into the pile-capping slab.

Before a pile head is stripped, the cut-off plane shall be marked by cutting a 20 mm deep groove with a grinding-machine around the full circumference of the pile.

Heavy concrete demolishing equipment may not be used for the stripping of pile heads. All loose aggregate shall be removed from the cut-off plane.

The concrete shall be so stripped off that the pile below the cut-off level will not be damaged, or, should defective concrete be found in the completed pile, the damaged or defective concrete shall be cut away by the Contractor at his/her own cost and replaced with new concrete well bonded to the old concrete, or the pile shall be replaced as directed by the Engineer.

The main reinforcement of the piles shall extend at least 40 times the diameters of the main reinforcing bar beyond the cut-off level into the pile-capping slab. This reinforcement shall be left straight unless otherwise directed by the Engineer.

The cut-off level for piles shall be the level shown on the Drawings.

(h) Construction of pile-capping slab
The Contractor shall not construct the pile-capping slab before the Engineer has confirmed, in writing, that all the relevant load tests have been completed and the piles have been accepted.

(i) Core drilling
The Engineer may instruct core drilling to be done with a view to obtaining cores of the founding formation and/or of the concrete in the completed structural member. In the case of piling, the core drilling may precede the piling or may be done through the completed pile, as specified, or as instructed by the Engineer.

The Contractor shall supply the necessary equipment on the site for drilling under the above conditions. The equipment and techniques used shall be suitable for ensuring 100% core recovery. The diameters, depths and lengths of the cores shall agree with the specifications or the instructions of the Engineer.

The Contractor shall keep accurate records of the drilling, which, together with the cores, shall be handed over to the Engineer. The cores shall be placed in the correct sequence in a clearly identified wooden core box with a lid.

6116 TESTING OF PILES

(a) Load test

(i) General
The Engineer may order certain selected piles to be load tested. The procedure for loading tests shall comply with the requirements of SECTION 7100. During the period of testing, driving of other piles which may affect the testing shall cease.

No working pile shall be used as an anchor pile. Where anchor piles or earth anchors are required for providing reaction, they shall be so placed as to have a minimal effect on the test results. The minimum distance of the anchor piles to the test piles shall be approved by the Engineer.

The Contractor shall provide the complete testing assembly, the necessary equipment, instruments and labour for carrying out the test and for determining accurately the settlement of the piles under each increase or decrease of the load. The test assembly, equipment and instruments used shall be subject to the approval of the Engineer.

Within two days of having completed the tests, the Contractor shall supply the Engineer with the test results and neatly plotted load against settlement, load against time, and settlement against time graphs.

(ii) Loading
The maximum test load applied shall be equal to twice the specified working load or the ultimate test load, whichever shall be the smaller.

The maximum working load shall be half of the maximum test load or the test load which corresponds with the allowable settlement,

whichever shall be the smaller. The allowable settlement shall be as specified on the Drawings.

(iii) Ultimate test load
The ultimate test load in the compression-load test shall be the load where settlement suddenly increases disproportionately to the load applied.

The ultimate test load in the tension-load test shall be the load where the upward movement suddenly increases disproportionately to the load applied or the load producing a permanent rise of 10 mm at the top of the pile, whichever is the smaller.

(b) Defective piles
The test pile and the piles represented by the test pile shall be classified as defective if shown in terms of SECTION 6100 to have a maximum working load of less than the specified working load, or to exhibit excessive settlement. Defective piles shall also include piles damaged beyond repair, piles with structural defects, or piles which do not comply with the tolerance requirements of SECTION 6800.

If required, the defective piles shall be corrected by the Contractor at his/her own cost, by applying one of the following methods approved by the Engineer:

(i) Extracting the pile and replacing it with a new pile.

(ii) Installing a new pile adjacent to the defective pile.

(iii) Lengthening the pile to the correct length if defective in length only.

(iv) Altering the design to fit in with the new conditions caused by the defective pile(s).

(c) Standing time in respect of pile-installation frames
Standing time shall only be paid for pile installation frames standing during normal working hours as laid down in the General Conditions on Contract for such periods during which the pile installation work has come to a standstill following an action by the Employer.

As soon as the pile installation frames have come to such a standstill, the Contractor shall inform the Engineer, in writing that he/she intends to claim standing time, and shall also furnish:

(i) full particulars of the action which gave rise to the claim

(ii) a list of pile-installation frames in respect of which standing time will be claimed, complete with date and time.

The period in respect of which a claim is lodged shall become operative from the moment when the notice has been handed over to the Engineer and shall continue until the restriction has been removed and normal procedure may be resumed.

(d) Nuclear integrity
Integrity tests using both the nuclear and neutron method shall be performed on all bored piles. The purpose of these tests is to prove that the technique used in constructing the piles is satisfactory, by checking for necking of concrete in the pile shafts, checking concrete cover to reinforcement and by checking for honeycombing, grout loss and segregation of aggregates.

6117 CAISSONS

(a) General
Caissons shall, for the purposes of these Specifications, be hollow concrete vessels which are wholly or partly constructed at a higher level and lowered by internal excavation or kentledge to the desired founding level to form structural bearing members. Caissons may be of circular, rectangular or any other shape and may contain one or more excavation compartments, all as detailed on the Drawings.

Unless otherwise specified hereafter, the provisions of BS 8004:1986 shall apply in regard to the construction of caissons.

(b) Construction and sinking
A firm horizontal base shall be prepared on which the cutting edge of the caisson shall be laid truly horizontally. The level of the base shall be determined and shall be agreed on by the Engineer and the Contractor, and shall serve as the ground surface from which the excavation inside the caisson will be measured.

Successive stages of the caisson shall be of convenient height, or as directed by the Engineer, and shall be lined up accurately with the preceding stages.

All precast elements shall have properly constructed joints in accordance with the Drawings to ensure that they fit snugly together.

For in situ phase construction, all construction joints in the walls shall be reinforced and the joints shall be made as specified in CLAUSE 6408.

The lowest element of every caisson, which contains the cutting edges, shall be cured for at least four days or shall have attained at least 50% of the specified 28 day strength before sinking is commenced. Subsequent elements shall be cast in sufficient time to ensure adequate strength for safely resisting the applied forces.

During constructing and sinking, the caissons shall be maintained truly vertically and kept in their correct positions.

The position and inclination of each caisson shall be determined accurately by measurement after every 2m of sinking, or after sinking through the depth of one element, whichever distance is the smaller.

With a view to eliminating excess friction, the Contractor may use bentonite or a similar lubricant, or a water-jet system.

Excavation inside caisson compartments shall, unless otherwise specified herein, comply with the provisions of CLAUSE 6105.

In multi-compartmented caissons, the excavation in any one compartment shall not be taken deeper than 0.6m below that in any other compartment, except where necessary for correcting deviations.

Cutting edges shall be frequently inspected or probed to locate obstacles, which shall be removed immediately.

The Contractor shall supply all grabs, pumps, diving gear and other equipment required for sinking and founding all caissons and shall allow the Engineer to use the diving suit and equipment for inspection purposes.

The Contractor shall employ a competent diver to carry out work under water and shall make provision in the rates bid for the respective items for this cost.

Where the caisson strikes a hard inclined layer and work has to be carried out below the cutting edge, such work shall be measured and paid for under the relevant items of CLAUSE 6118, and, where no applicable items exist, such work shall be paid for as extra work.

Should the Contractor wish to apply the pneumatic caisson method (with a compressed air chamber) for construction, he/she shall furnish the Engineer with full details of the equipment and method to be used for approval.

(c) Founding

The material at the founding level, if sloping and/or irregular, shall in so far as is possible be cut to as nearly level a surface as possible until the entire cutting edge is evenly and firmly supported on the material. Subject to the approval of the Engineer, blasting may be used for this purpose. If blasting should be resorted to, only light charges may be used and the caisson shall be protected against damage by suitable cushioning being provided.

Should the sloping surface be of hard rock which cannot be cut or broken by any safe and feasible means, the foundation shall be built up by means of a solid wedge of concrete which fills the entire space between the bedrock surface and the horizontal plane through the cutting edge. This concrete shall be of the same class as that specified on the Drawings or in the Bill of Quantities for the concrete seal.

The rock or hard material on which the structure is to be founded shall be completely uncovered. The founding surface shall be cleared of all loose material before inspection by the Engineer immediately prior to casting the concrete seal.

No concrete shall be placed in the wedge or the seal before the Engineer has inspected and approved the foundation. For this purpose the Contractor shall adequately dewater the caisson to enable the Engineer to conduct the inspection.
In the event of a caisson not being vertical or in its correct position when it has reached the required depth, or in the event of a caisson being cracked during the sinking process, the Contractor shall at his/her own cost carry out the necessary remedial work to the satisfaction of the Engineer.

(d) Data

The Contractor shall provide the Engineer with a complete record of the types of material excavated during sinking, together with the level at which each type of the material was found. In addition, a log showing the rate of sinking shall be kept by the Contractor and furnished to the Engineer.

(e) Filling the caissons

(i) Concrete seal
The seal shall be constructed of mass concrete of the class specified and shall be placed in accordance with the dimensions and levels shown on the Drawings or as prescribed by the Engineer.

If this seal cannot be placed in the dry and has to be placed under water, the method of placing this concrete shall be approved by the Engineer. The Contractor shall cease placing the concrete under water when sufficient concrete has been placed to seal the foundation effectively.

After the concrete has been placed, the concrete seal and the head of water over it shall remain undisturbed for a period of at least seven days after which the caisson shall be dewatered by pumping for inspection. If more water is still leaking into the caisson, the process of sealing as specified herein shall be continued until the water level within the caisson does not rise at a rate exceeding 10 mm per hour.

The relevant requirements of SUBCLAUSE 6114(a) shall apply for placing the concrete under water. For concrete placed under water by methods other than by tremie, the cement content shall be 20% more than the quantity required for ordinary concrete of the same mix but shall be not less than 450 kg/m^3 of concrete.

(ii) Filling
Subsequent to inspection of the caisson compartments above the concrete seal, the compartments shall be filled with sand. The sand shall be sufficiently wetted to obviate bulking.

The first 2 m of filling above the concrete seal shall be lowered gently into position. The sand may then be poured from the top and compacted sufficiently to prevent settlement while the cover slab concrete is being placed.

The top of the sand fill within the caisson shall be finished off to the level specified below the underside of the caisson cover slab.

(f) Stripping

Where the walls of the caisson have been overbuilt, the concrete shall be stripped to the required level without damage being done to the concrete below the cut-off level. The longitudinal reinforcement of the caisson shall project above the cut-off level by a distance of at least 40 times the bar diameter.

(g) Concrete blinding below the caisson cover slabs

A concrete blinding of the specified thickness and class of concrete shall be provided to the level shown on the Drawings over the area covered by the cover slab, including the area within the caissons on top of the sand filling, except where the underside of the cover slab is being formed with formwork.

(h) Environmental considerations

Water quality and marine life shall not be adversely affected in any way during operations.

Where adverse impacts have been indicated in the Environmental Impact Assessment Report, the Contractor shall carry out such measures as required to mitigate and minimise negative impacts to the water quality and marine life.

The Engineer shall approve all methods that the Contractor proposes according to the Environmental Impact Assessment Report.

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ITEM		UNIT
61.01	ADDITIONAL FOUNDATION INVESTIGATIONS:	PROVISIONAL SUM

A provisional sum shall be provided in the Bill of Quantities to cover the cost of this work.

The work authorised by the Engineer shall be paid for in accordance with the provisions of CLAUSE 1209 of these Specifications.

ITEM	UNIT
61.02 EXCAVATION:	
(a) COMMON EXCAVATION IN SOFT MATERIAL SITUATED WITHIN THE FOLLOWING SUCCESSIVE DEPTH RANGES:	
(i) 0 m UP TO 2 m	CUBIC METRE (m^3)
(ii) 2 m UP TO 4 m	CUBIC METRE (m^3)
(iii) FURTHER INCREMENTS OF 2 m	CUBIC METRE (m^3)
(b) EXTRA-OVER SUB-ITEM 61.02(a) FOR EXCAVATION IN ROCK IRRESPECTIVE OF DEPTH	CUBIC METRE (m^3)

The limits for the successive depth ranges shall be measured down from the surface levels described in SECTION 6100 to the founding level agreed on.

In the case of excavations that are required for diverting, channelling or widening watercourses, the successive depth ranges for those portions of the excavations that are within 5 m of a concrete structure shall be measured from the surface levels agreed on to the invert level of the channel or watercourse.

The unit of measurement shall be the cubic metre of material, measured in the original position before excavation. The quantity of excavation for each depth range shall be calculated from the neat outlines of the base or floor and the depth of excavation completed within each range.

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

At the concrete faces for which formwork has to be provided, additional excavation shall be measured to 0.5 m outside the concrete perimeter to make provision for a working space.

Where foundation fill is constructed in an excavation, the quantity of excavated material measured for payment shall be the material excavated between the average ground level, as described in SUBCLAUSE 6105(b), and the founding level, from a prism with vertical sides, as described in CLAUSE 6109 or as prescribed by the Engineer.

In no case shall any of the following excavations be included in the measurement for payment:

(i) The volume of excavation in excess of the above mentioned limits.

(ii) The volume included within the excavated road prism, contiguous channels, ditches, etc, for which payment is provided elsewhere in the Specifications.

The bid rates shall include full compensation for excavation in each class of material, the spoiling or stockpiling of materials, the hauling of excavated material for the free haul distance as defined in SUBCLAUSE 1602(c), any additional excavation the Contractor may require for additional working space outside the authorised limits, trimming and cleaning the bottoms and sides of excavations, and strutting, shoring and safeguarding the excavations.

If after a foundation excavation has been completed, cleaned and trimmed ready for concrete blinding, the Engineer orders further excavations to be made on account of changed dimensions and/or founding conditions, an extra over payment (SUB ITEM 61.02(c)) on the additional excavation measured for payment shall be payable in full compensation for any incidentals to the Contractor over and above the normal excavation costs.

ITEM	UNIT
61.03 ACCESS AND DRAINAGE:	
(a) ACCESS	LUMP SUM

The bid lump sum shall include full compensation for providing access which, inter alia, shall include constructing temporary banks, artificial islands and/or cofferdams; their protection, safeguarding and maintenance; draining and keeping dry the working areas; draining the excavations within the access; and any incidentals in respect of work to be done below standing water.

75% of the lump sum will be paid when the access has been constructed. The remaining 25% will be paid after the access has been removed.

(b) DRAINAGE, WHERE NO LUMP SUM ACCESS HAS BEEN PROVIDED	LUMP SUM

Payment will be made for this work by way of a lump sum for each structure or series of structures appearing separately in the Bill of Quantities. The lump sum shall be paid on a pro rata basis as the work progresses.

The bid lump sum shall include full compensation for draining by pumping or in any other way and for any other work necessary for keeping the excavation dry or for working in the dry.

ITEM	UNIT
61.04 BACKFILL TO EXCAVATIONS UTILISING:	
(a) MATERIAL FROM THE EXCAVATIONS	CUBIC METRE (m^3)
(b) IMPORTED MATERIAL	CUBIC METRE (m^3)
(c) SOIL CEMENT	CUBIC METRE (m^3)

The unit of measurement shall be the cubic metre of backfill material measured in the excavation, excluding the volume occupied by the structure. The quantity measured shall be calculated from within the neat outlines defined for the excavation under ITEM 61.02 and the height to which the backfilling is constructed. The volume occupied by the structure shall be subtracted when calculating the volume of backfilling.

The height shall be determined by the upper surface of the road prism or the reference ground surface (SUBCLAUSE 6105(b)), whichever is the lower.

The bid rates shall include full compensation for furnishing and placing all materials within the entire excavation, transporting the material and preparing, processing, shaping, watering, mixing and compaction of the material to the specified densities.

No overhaul shall be paid.

ITEM		UNIT
61.05	FOUNDATION FILL CONSISTING OF:	
(a)	ROCK FILL	CUBIC METRE (m^3)
(b)	CRUSHED STONE FILL	CUBIC METRE (m^3)
(c)	COMPACTED GRANULAR MATERIAL	CUBIC METRE (m^3)
(d)	MASS CONCRETE (CLASS INDICATED)	CUBIC METRE (m^3)
(e)	CONCRETE BLINDING (THICKNESS AND CLASS OF CONCRETE INDICATED)	CUBIC METRE (m^3)

The unit of measurement shall be the cubic metre of approved material placed and compacted below the bases as specified or where directed by the Engineer.

The quantity of foundation fill to be measured for payment shall be the material contained within the prism specified in CLAUSE 6109 or shall otherwise be the quantity to the outlines shown on the Drawings or as directed by the Engineer.

The bid rates shall include full compensation for procuring, furnishing, transporting, placing and compaction of the material.

No overhaul shall be paid.

ITEM		UNIT
61.06	ESTABLISHMENT ON THE SITE FOR THE DRILLING OF HOLES (TYPE OF DRILLING INDICATED)	LUMP SUM

The bid lump sum shall include full compensation for establishment on the site, moving to individual bridge positions and the subsequent removal of all special equipment for drilling the holes and additional equipment for carrying out operations, the cost of which does not vary with the actual amount of work to be done.

This work will be paid for by way of a lump sum, 75% of which will become payable when all the equipment is on the site and the first hole has been drilled. The remaining 25% will become payable after all the holes have been drilled and the equipment has been removed from the site.

ITEM		UNIT
61.07	DRILLING OF HOLES (DIAMETER AND TYPE OF DRILLING INDICATED)	METRE (m)

The unit of measurement shall be the metre of hole drilled.

The bid rate shall include full compensation for drilling and clearing the holes as specified, equipment moving and setting up in position, drilling and clearing the holes as specified. Where no provision has been made for payment in the Bill of Quantities under ITEM 61.09, the bid rate shall also include full compensation for work falling under that item.

ITEM		UNIT
61.08	GROUTING (TYPE OF GROUT AND FOR WHICH PURPOSE IT IS REQUIRED INDICATED)	KILOGRAM (kg)

The unit of measurement for grouting shall be the kilogram of cement or proprietary brand of grout mix as may be applicable used in the grouting operation.

The bid rate shall include full compensation for providing the equipment and all the material, and mixing and pumping the grout into the prepared holes in accordance with the instructions of the Engineer, and also for the water-pressure tests.

ITEM		UNIT
61.09	DOWEL BARS (TYPE, DIAMETER AND LENGTH OF DOWEL BARS TOGETHER WITH TYPE OF GROUT, INDICATED)	KILOGRAM (kg)

The unit of measurement for the dowel bars shall be the kilogram of bars provided and secured in position. The bid rate shall include full compensation for supplying all the material and positioning and grouting the dowel bars as specified.

ITEM		UNIT
61.10	FOUNDATION LINING (TYPE OF MATERIAL AND THICKNESS INDICATED)	SQUARE METRE (m^2)

The unit of measurement for foundation lining shall be the square metre of concrete surface lined.

The bid rate shall include full compensation for procuring, furnishing, lapping and placing all material and for all labour and incidentals required for completing the work as specified.

ITEM		UNIT
61.11	ESTABLISHMENT ON THE SITE FOR PILING	LUMP SUM

The bid lump sum shall include full compensation for generally levelling the piling site, establishing on the site and subsequently removing all structural platforms, rafts, and all special equipment for foundation piling and for carrying out operations, the cost of which does not vary with the actual amount of piling done.

This work will be paid for by way of a lump sum, 50% of which will become payable when all equipment is on the site and the first pile has been installed. The second instalment of 25% of the lump sum will be payable after half the total number of piles have been installed, and the final instalment of 25% after all the piles have been completed and the equipment has been removed from the site.

ITEM		UNIT
61.12	MOVING TO, AND SETTING UP THE EQUIPMENT AT EACH POSITION FOR INSTALLING THE PILES	NUMBER (no)

The unit of measurement shall be the number of positions to which the installation equipment has to be moved and set up in position. The quantity measured shall be the number of piles installed plus the number of piles redriven on the instruction of the Engineer, plus any piles provided in addition for load tests, which do not form part of a specific pile group.

ITEM	UNIT
61.13 AUGERED OR BORED HOLES FOR PILES WITH A DIAMETER OF (DIAMETER INDICATED) THROUGH MATERIAL SITUATED WITHIN THE FOLLOWING SUCCESSIVE DEPTH RANGES:	
(a) AUGERED HOLES:	
(i) 0 m UP TO 10 m	METRE (m)
(ii) EXCEEDING 10 m, UP TO 15 m	METRE (m)
(iii) FURTHER INCREMENTS OF 5 m	METRE (m)
(b) BORED HOLES:	
(i) 0 m UP TO 10 m	METRE (m)
(ii) EXCEEDING 10 m, UP TO 15 m	METRE (m)
(iii) FURTHER INCREMENTS OF 5 m	METRE (m)

The limits for the successive depth ranges shall be measured down from the average ground surface (SUBCLAUSE 6113(h)) to the agreed founding level (CLAUSE 6106).

The unit of measurement shall be the metre of hole, including the depth of the bulbous base formed, as may be applicable. The depth of the bulbous base shall be deemed to be equal to the diameter of a sphere, the volume of which shall be equal to the quantity of compacted concrete in the bulbous base.

Irrespective of the total depth of the hole, the quantity within each depth range shall be measured and paid for separately.

The bid rates for forming augered holes shall include full compensation for augering and disposing of surplus material resulting from the hole having been formed.

The bid rates for forming bored holes shall include full compensation for boring, supplying, installing and extracting the driven temporary casing as well as for disposing of surplus material resulting from the hole having been formed.

ITEM	UNIT
61.14 DRIVING THE TEMPORARY CASING FOR DRIVEN DISPLACEMENT PILING SYSTEMS FOR FORMING HOLES FOR PILES WITH A DIAMETER OF (DIAMETER INDICATED) THROUGH MATERIAL SITUATED WITHIN THE FOLLOWING SUCCESSIVE DEPTH RANGES:	
(a) 0 m UP TO 10 m	METRE (m)
(b) EXCEEDING 10m, UP TO 15 m	METRE (m)
(c) FURTHER INCREMENTS OF 5 m	METRE (m)

The limits for the successive depth ranges shall be measured down from the average ground surface to the agreed founding level (CLAUSE 6106).

The unit of measurement shall be the metre of hole plus the depth of bulbous base formed as may be applicable. The depth of the bulbous base shall be deemed to be equal to the diameter of a sphere, the volume of which shall be equal to the quantity of compacted concrete in the bulbous base. Irrespective of the total depth of the hole, the quantity within each depth range shall be measured and paid for separately. The bid rates shall include full compensation for supplying, driving and subsequently extracting the temporary casing.

ITEM	UNIT
61.15 MANUFACTURING, SUPPLYING AND DELIVERING PREFABRICATED PILES (TYPE AND SIZE INDICATED).	METRE (m)

The unit of measurement shall be the metre of accepted prefabricated pile delivered on the site in accordance with the Engineer's written instructions.

The bid rate shall include full compensation for supplying all the materials, manufacturing, transporting and delivering to the point of use and handling the prefabricated piles.

ITEM	UNIT
61.16 INSTALLATION OF PREFABRICATED PILES (TYPE AND SIZE INDICATED) THROUGH MATERIAL SITUATED WITHIN THE FOLLOWING SUCCESSIVE DEPTH RANGES:	
(a) 0 m UP TO 10 m	METRE (m)
(b) EXCEEDING 10 m, UP TO 15 m	METRE (m)
(c) FURTHER INCREMENTS OF 5 m	METRE (m)

The limits for the successive depth ranges shall be measured down from the average ground surface to the founding depth agreed on (CLAUSE 6106).

The unit of measurement shall be the metre of prefabricated pile installed. That part of the prefabricated pile projecting above the average ground surface shall not be measured and paid for.

Irrespective of the total length of pile installed, the quantity installed within each depth range shall be measured and paid for separately.

The bid rates shall include full compensation for hoisting and driving the pile.

ITEM	UNIT
61.17 EXTRA OVER ITEM 61.16, IRRESPECTIVE OF THE DEPTH TO FORM AUGERED AND BORED PILE HOLES THROUGH IDENTIFIED OBSTRUCTIONS CONSISTING OF:	
(a) COARSE GRAVEL WITH A MAXIMUM CONTENT OF LESS THAN (MAXIMUM PERCENTAGE INDICATED)	METRE (m)
(b) BOULDERS (DESCRIPTION OF AND MAXIMUM SIZE INDICATED)	METRE (m)
(c) ROCK FORMATION (DESCRIPTION AND CLASS OF ROCK INDICATED)	METRE (m)

The unit of measurement shall be the metre of pile hole formed through the identified obstruction, measured from the depth at which the identified obstruction is encountered to the depth at which normal auger drilling or boring can be resumed or another type of identified obstruction is encountered.

The bid rates shall include full compensation for all additional work and incidentals required for forming the pile hole through the identified obstruction.

Where obstructions other than those provided for in ITEM 61.19 can be identified, they shall be described on the Drawings and/or in the Special Specifications. Provision therefor shall be made in the Bill of Quantities under extensions to ITEM 61.19.

ITEM	UNIT
61.18 FORMING AUGERED AND BORED PILE HOLES THROUGH UNIDENTIFIED OBSTRUCTIONS	PROVISIONAL SUM

A provisional sum shall be allowed in the Bill of Quantities for covering the cost of this work.

Payment for the work authorised by the Engineer shall be in accordance with the provisions of the Conditions of Contract.

ITEM	UNIT
61.19 DRIVING TEMPORARY CASINGS FOR DRIVEN DISPLACEMENT PILING SYSTEMS OR INSTALLING PREFABRICATED PILES THROUGH IDENTIFIED OR UNIDENTIFIED OBSTRUCTIONS	PROVISIONAL SUM

A provisional sum shall be allowed in the Bill of Quantities for covering the cost of this work.

The method of payment for the work authorised by the Engineer shall be in accordance with the provisions of the Conditions of Contract.

ITEM	UNIT
61.20 EXTRA OVER ITEMS 61.16, 61.17 AND 61.19 FOR RAKING PILES:	
(a) HOLES FOR PILES OF (DIAMETER AND RAKE INDICATED)	METRE (m)
(b) TEMPORARY CASING FOR DRIVEN DISPLACEMENT PILE SYSTEMS (DIAMETER AND RAKE INDICATED)	METRE (m)
(c) PREFABRICATED PILES (TYPE, SIZE AND RATE INDICATED)	METRE (m)

The bid rates shall include full compensation for all additional work and incidentals for forming the pile holes or for driving and later extracting the temporary casing, or for installing prefabricated piles to the rake shown.

ITEM	UNIT
61.21 FORMING UNDERREAMS FOR PILES OF (DIAMETER INDICATED)	NUMBER (no)

The unit of measurement shall be the number of pile holes underreamed. The bid rate shall include full compensation for all work to be done in forming the underreams, but shall exclude the concrete work.

ITEM	UNIT
61.22 FORMING THE BULBOUS BASES FOR PILES OF (DIAMETER INDICATED)	NUMBER (no)

The unit of measurement shall be the number of bulbous bases formed.

The bid rate shall include full compensation for all work to be done in forming the bulbous bases but shall exclude the concrete work.

ITEM	UNIT
61.23 SOCKETING PILES INTO ROCK FORMATION (CLASS OF ROCK AND LENGTH OF SOCKET INDICATED)	NUMBER (no)

The unit of measurement shall be the number of sockets, the length of which shall be not less than the specified length, formed in rock, the hardness of which shall be not less than that of the specified class of rock.

The bid rate shall include full compensation for all work to be done for socketing into the rock formation.

ITEM	UNIT
61.24 INSTALLING AND REMOVING TEMPORARY CASINGS IN AUGERED HOLES FOR PILES OF (DIAMETER INDICATED)	METRE (m)

The unit of measurement shall be the metre of temporary casing installed as directed by the Engineer or shown on the Drawings. Only the installed temporary casing below the average ground surface (SUBCLAUSE 6113(h)) shall be measured for payment.

The bid rate shall include full compensation for supplying, installing and removing the temporary casings.

ITEM	UNIT
61.25 INSTALLING PERMANENT PILE CASING FOR PILES OF (DIAMETER INDICATED)	METRE (m)

The unit of measurement shall be the metre of permanent casing installed as instructed by the Engineer or shown on the Drawings. The bid rate shall include full compensation for supplying and installing permanent pile casing.

ITEM	UNIT
61.26 STEEL REINFORCEMENT IN CAST IN SITU PILES:	
(a) MILD-STEEL BARS	TONNE (t)
(b) HIGH-YIELD-STRESS-STEEL BARS (TYPE INDICATED)	TONNE (t)

The unit of measurement for steel bars shall be the tonne of reinforcement in place in accordance with the Drawings or as authorised.
Ties and other steel used for keeping the reinforcing steel in position shall be measured as steel reinforcing under the appropriate SUBITEM.

The bid rates shall include full compensation for supplying, delivering, cutting, bending, welding, trial welds, placing and fixing the steel reinforcing, including all tying wires, spacers and waste.

ITEM	UNIT
61.27 CAST IN SITU CONCRETE IN PILES, UNDERREAMS, BULBOUS BASES AND SOCKETS (CLASS OF CONCRETE INDICATED)	CUBIC METRE (m^3)

The unit of measurement shall be the cubic metre of concrete placed in the cast in situ piles underreams, bulbous bases and sockets. The quantity shall be calculated from the nominal pile diameter and length of pile from the founding level to the specified cutting-off

level, plus the additional quantity of concrete in the underream and bulbous base as may be relevant.

The bid rate shall include full compensation for supplying and storing all material, providing all equipment, mixing, transporting, placing and compacting the concrete, curing the concrete and repairing defective concrete. Payment shall distinguish between the different classes of concrete.

ITEM		UNIT
61.28	EXTRA OVER ITEM 61.30 FOR CONCRETE CAST UNDER WATER	CUBIC METRE (m^3)

The unit of measurement shall be the cubic metre of concrete cast under water, the quantity being calculated as for ITEM 61.30.

The bid rate shall include full compensation for all additional work, incidentals and extra cement required for placing the concrete under water.

ITEM		UNIT
61.32	SPLICING/COUPLING PREFABRICATED PILES FOR LENGTHENING(SIZE OF PILE INDICATED)	NUMBER (no)

The unit of measurement shall be the number of splices/couplings in prefabricated piles for each size of pile. The bid rate shall include full compensation for all work required for splicing/coupling the piles in accordance with the Specifications.

ITEM		UNIT
61.30	STRIPPING/CUTTING THE PILE HEADS (TYPE AND DIAMETER/SIZE OF PILE INDICATED)	NUMBER (no)

The unit of measurement shall be the number of heads of each type and diameter/size of pile stripped/cut.

The bid rate shall include full compensation for providing all tools and stripping/cutting the pile heads.

ITEM		UNIT
61.31	ESTABLISHMENT ON THE SITE FOR THE LOAD TESTING OF PILES	LUMP SUM

The bid lump sum shall include full compensation for the establishment on the site and subsequently removing all the special equipment required for conducting the load tests on piles. This cost does not vary with the number of load tests to be conducted.

Payment for this work shall be made by way of a lump sum, 100% of which will be paid after the testing assembly has been completely assembled and the first load test has been started.

ITEM		UNIT
61.32	LOAD TESTS ON PILES (COMPRESSION/TENSION TEST, DIAMETER/ SIZE, SPECIFIED WORKING LOAD INDICATED)	NUMBER (no)

The unit of measurement shall be the number of load tests conducted on the instruction of the Engineer, for each specified working load.

Test piles, but not anchor piles and anchors, shall be measured as specified above for permanent piles. Anchor piles and anchors shall be deemed to form part of the testing equipment under this item.

The bid rate shall include full compensation for installing the anchor piles and anchors where necessary; conducting load tests, and processing and submitting the results.

ITEM		UNIT
61.33	ESTABLISHMENT ON THE SITE FOR CORE DRILLING	LUMP SUM

The bid lump sum shall include full compensation for the establishment on the site and subsequently removing all the equipment required for conducting the core drilling. This cost does not vary with the quantity of work to be done. This work shall be paid for by way of a lump sum, 100% of which will be payable when the equipment has been set up at the first location and drilling has started.

ITEM		UNIT
61.34	MOVING THE EQUIPMENT TO AND ASSEMBLING IT AT EACH LOCATION WHERE CORES ARE TO BE DRILLED	NUMBER (no)

The unit of measurement shall be the number of locations to which the core-drilling equipment is to be moved and at which it has to be assembled.

The bid rate shall include full compensation for the cost of moving and assembling the equipment.

ITEM		UNIT
61.35	DRILLING THE CORES (DIAMETER INDICATED) IN:	
(a)	CONCRETE	METRE (m)
(b)	FOUNDING FORMATION:	
	(i) IRRESPECTIVE OF HARDNESS	METRE (m)
	(ii) WITH A HARDNESS OF (HARDNESS INDICATED)	METRE (m)

The unit of measurement shall be the metre of hole drilled. The bid rate shall include full compensation for drilling, recovering and packing the cores, keeping the drilling records, providing core boxes, providing and installing the casings, and backfilling the holes with grout.

ITEM		UNIT
61.36	FORMWORK FOR CAISSONS (CLASS OF FINISH INDICATED)	SQUARE METRE (m^2)

The unit of measurement shall be the square metre of formwork, and only the area of formwork in contact with the finished face of the concrete shall be measured. Formwork for construction joints shall be measured for payment under Class F1 surface finish but shall be measured only for construction joints shown on the Drawings or as prescribed by the Engineer.

The bid rate shall include full compensation for supplying all the materials, erecting the falsework and formwork, constructing the forms, forming the grooves, fillets, chamfers, stopends for construction joints, treating the forms, all accessories, and stripping and removing the formwork after completion of the work. Payment for formwork shall be made only after the

formwork has been stripped and the surface finish approved.

ITEM	UNIT
61.37 STEEL REINFORCEMENT FOR CAISSONS:	
(a) MILD-STEEL BARS	TONNE (t)
(b) HIGH-YIELD-STRESS-STEEL BARS (TYPE INDICATED)	TONNE (t)

The unit of measurement for steel bars shall be the tonne of reinforcement in place in accordance with the Drawings or as may have been authorised.

Ties and other steel used for positioning the reinforcing steel shall be measured as steel reinforcing under the appropriate SUBITEM.

The bid rates shall include full compensation for supplying, delivering, cutting, bending, welding, trial welding joints, placing and fixing the steel, including all tying wire, spacers and waste.

ITEM	UNIT
61.38 CAST IN SITU CONCRETE IN CAISSONS AND CONCRETE SEALS (CLASS OF CONCRETE INDICATED)	CUBIC METRE (m^3)

The unit of measurement for cast in situ concrete shall be the cubic metre of concrete in place. Concrete quantities in the caissons shall be calculated from the dimensions shown on the Drawings or authorised by the Engineer, and the length of the caisson from the founding level to the specified cut-off level. The quantity of concrete in the concrete seal shall be calculated in accordance with the dimensions shown on the Drawings or authorised by the Engineer.

The bid rate shall include full compensation for procuring and furnishing all the materials, storing the material, providing all equipment, mixing, transporting, placing and compacting the concrete, all sealing, curing the concrete and repairing defective concrete. Payment shall distinguish between the different classes of concrete.

ITEM	UNIT
61.39 CUTTING EDGE FOR (DIAMETER/SIZE INDICATED) CAISSONS	NUMBER (no)

The unit of measurement shall be the number of caissons provided with cutting edges, irrespective of the material they have been constructed of.

The bid rate shall include full compensation for manufacturing, supplying, delivering and installing the complete cutting edge as well as for joining the cutting edge to the caisson unit. Where the cutting edge is of concrete and forms part of the bottom element, the bid rate shall include full compensation for all additional work required for completing the element.

ITEM	UNIT
61.40 SINKING (DIAMETER/SIZE INDICATED) CAISSONS THROUGH MATERIAL SITUATED WITHIN THE FOLLOWING SUCCESSIVE DEPTH RANGES:	
(a) 0 m UP TO 5 m	METRE (m)
(b) EXCEEDING 5 m AND UP TO 10 m	METRE (m)
(c) FURTHER INCREMENTS OF 5 m	METRE (m)

The limits of the successive depth ranges shall be measured down from the firm horizontal base (SUBCLAUSE 6117(b)) to the agreed founding level (CLAUSE 6106).

The unit of measurement shall be the metre of caisson sunk.

Irrespective of the length of caisson sunk, the quantity for each depth range shall be measured and paid for separately.

The bid rates shall include full compensation for locating and holding in position, dewatering, pumping, kentledge and lubricating the sides of the caisson, and for all work in connection with the sinking of the caisson which is not paid for elsewhere.

ITEM	UNIT
61.41 EXCAVATION FOR CAISSONS:	
(a) EXCAVATING SOFT MATERIAL SITUATED WITHIN THE FOLLOWING SUCCESSIVE DEPTH RANGES:	
(i) 0 m UP TO 2 m	CUBIC METRE (m^3)
(ii) EXCEEDING 2 m, UP TO 4 m	CUBIC METRE (m^3)
(iii) FURTHER INCREMENTS OF 2 m DEPTHS	CUBIC METRE (m^3)
(b) EXTRA OVER SUBITEM 61.44(a) FOR EXCAVATION IN ROCK MATERIAL IRRESPECTIVE OF DEPTH	CUBIC METRE (m^3)

The limits for the successive depth ranges shall be measured down from the firm horizontal base (SUBCLAUSE 6117(b)) to the excavated level inside the caisson.

The unit of measurement shall be the cubic metre of material, measured in the original position before excavation. The quantity of excavation for each depth range shall be calculated from the gross area of the caisson in plan and the depth of excavation completed within each depth range.

Irrespective of the total depth of excavation, the quantity of material within each depth range shall be measured and paid for separately. The bid rates shall include full compensation for excavation in the classified material, spoiling or stockpiling the material, hauling the excavated material for the free haul distance according to SUBCLAUSE 1602(c), trimming the bottom of the excavation, dewatering, pumping and removing the material leaking into the caisson before sealing.

ITEM	UNIT
61.42 FILLING THE CAISSONS	CUBIC METRE (m^3)

The unit of measurement shall be the cubic metre of sand placed above the concrete seal in the caisson compartments.

The bid rate shall include full compensation for supplying and placing the sand, transporting the material and compaction of the material as specified.

No overhaul shall be paid.

ITEM	UNIT
61.43 STRIPPING THE (SIZE OF CAISSON INDICATED) CAISSON HEADS	NUMBER (no)

The unit of measurement shall be the number of caissons of each size stripped.

The bid rate shall include full compensation for cutting away, trimming and disposing of the concrete removed.

ITEM	UNIT
61.44 NUCLEAR INTEGRITY TESTING ON BORED PILES:	
(a) CONSTRUCTING 5 m LONG CALIBRATION PILES OF (INDICATE DIAMETER)	NUMBER (no)
(b) INSTALLING 65 mm INTERNAL DIAMETER STEEL DUCTS IN THE PILES	METRE (m)
(c) PERFORMING INTEGRITY TESTS USING:	
(i) THE NUCLEAR METHOD	NUMBER (no)
(ii) THE NEUTRON METHOD	NUMBER (no)

The unit of measurement for SUBITEM (a) shall be the number of calibration piles constructed. The unit of measurement for SUBITEM (b) shall be the metre of 65 mm internal diameter steel duct installed. The unit of measurement for SUBITEM (c) shall be the number of integrity tests performed by each method.

The bid rates shall include full compensation for procuring and furnishing all materials, equipment, labour and incidentals for forming the bored holes, constructing the calibration piles, installing the steel ducts, and performing the prescribed integrity tests, complete as specified.

SERIES 6000: STRUCTURES

SECTION 6200: FALSEWORK, FORMWORK AND CONCRETE FINISH

CONTENTS:

6201 SCOPE

This Section covers the design, supply, erection and removal of all falsework and formwork used in the construction of permanent work. This Section also describes the classes of surface finishes on formed and unformed concrete surfaces.

6202 MATERIALS

(a) General

The materials used in the construction of falsework and formwork shall be suitable for the purpose for which they are required and be of such quality as to produce the specified standard of work. The type, grade and condition of the material shall be subject to the Engineer's approval.

(b) Falsework

The timber, structural steel and scaffolding used shall be free from defects that may prejudice the stability of the falsework. The jacks, devices, clamps and fittings shall all be in a good working order and of adequate design and strength.

(c) Formwork

(i) Tongue-and-groove boarding
Tongue and-groove boarding shall be of suitably dried timber which will not warp, distort or cause discolouration of the concrete. The widths of the boards shall be as specified on the Drawings or in the Bill of Quantities or as prescribed by the Engineer. Boards shall be supplied in lengths not shorter than 3 m.

(ii) Steel forms to exposed surfaces
For classes F2 and F3 surface finish the individual panels shall be assembled sufficiently rigidly and so clamped as not to deform or kick during handling or under the pressure of the wet concrete.

The surfaces of forms which are to be in contact with the concrete shall be clean, free from deposits or adhering matter, ridges or spatter which will impart irregularities and blemishes to the concrete surface, and shall also be free from indentations and warps.

(iii) Void formers
Void formers used in permanent work shall be subject to the approval of the Engineer.

Where void formers of a special design are required, details thereof will be specified.

Void formers shall be manufactured from material which will not leak, tear or be damaged during the course of construction and shall be of such tight construction as to prevent undue loss of the mortar component of the concrete through leakage. The units shall be sufficiently rigid so as not to deform during handling or under the pressure of the wet concrete.

For mild-steel spiral-lock-formed void formers, the metal thickness shall be as follows, unless otherwise specified:

(1) Unbraced void formers
0.6 mm for diameters of up to 600 mm.
0.8 mm for diameters exceeding 600 mm and up to 800 mm.
1.0 mm for diameters exceeding 800 mm and up to 1000 mm.

(2) Braced void formers
0.6 mm for diameters of up to 800 mm.
0.8 mm for diameters exceeding 800 mm and up to 1000 mm.
1.0 mm for diameters exceeding 1000 mm and up to 1200 mm.
1.2 mm for diameters exceeding 1200 mm.

The thickness specified for braced void formers shall apply to formers internally braced with timber or equivalent braces. The braces shall be at spacing not exceeding 2 m and not further than 1.0 m from the end of each unit. Timber cross braces shall consist of members with cross-sectional dimensions of at least 50 mm x 50 mm.

All hollow void-former units shall be provided with a 12 mm diameter drainage hole at each end.

(iv) Chamfer and recess fillets
Timber fillets used for forming chamfers and recesses on exposed surfaces shall be made from new material unless otherwise authorised.

(v) Jack rods for sliding formwork
The jack rods, base plates and couplers shall be strong enough to carry the design load under all operating conditions without buckling, distorting or causing damage to the concrete. Jack rods which are to remain permanently embedded in the concrete shall comply with the requirements of CLAUSES 6303 and 6305. Under no circumstances shall bent rods be used in the work.

The jack rods used shall have a diameter of at least 25 mm.

6203 GENERAL

Notwithstanding approval given by the Engineer for the design and drawings prepared by the Contractor for the falsework and formwork, and the acceptance of the falsework and formwork as constructed, the Contractor shall be solely responsible for the safety and adequacy of the falsework and formwork and shall indemnify and keep indemnified the Employer and Engineer against any losses, claims or damage to persons or property whatsoever which may arise out of or in consequence of the design, construction, use and maintenance of the falsework and formwork and against all claims, demands, proceedings, damages, costs, charges and

expenses whatsoever in respect thereof or in relation thereto.

For Works on, over, under or adjacent to any railway line which is controlled by a Rail Authority, the Contractor shall comply, inter alia, with the requirements for the preparation and submission of drawings for falsework and formwork, and the submission of certificates for the proper construction thereof, all in accordance with the relevant Rail Authority Specification.

After having constructed the falsework and formwork, and prior to placing the reinforcing steel and/or the concrete, the Contractor shall inspect the falsework and formwork. Dimensions shall be checked, unevenness of surface shall be corrected, and special attention paid to the adequacy and tightness of all bolts, ties and bracings as well as to the soundness of the foundations.

The Contractor shall give the Engineer at least 24 hours notice of his/her intention to place the concrete to enable the Engineer to inspect all aspects of the completed work. However, before notifying the Engineer, the Contractor shall satisfy himself/herself that the work complies in all respects with the Specifications.

Concrete sections with dimensions smaller than 200 mm shall not be formed with sliding formwork unless authorised by the Engineer.

6204 DESIGN

(a) General
The Contractor's design and drawings of the falsework and formwork shall comply amongst others with all statutory requirements.

The Engineer may require the Contractor to submit to him/her for consideration and approval the design and drawings of the falsework and formwork for any structure. The Contractor shall submit his/her design criteria and calculations and detail drawings of the falsework and formwork to the Engineer at least 14 days before the Engineer's approval is required.

(b) Falsework
The Contractor shall make his/her own assessment of the allowable bearing pressure on the foundation material and shall design the footings and falsework to prevent overloading, differential settlement and unacceptable overall settlement. In assessing the allowable bearing pressure, due account shall be taken of the effect of wetting on the foundation material.

In designing the falsework, cognisance shall also be taken of the redistribution of load that may occur on account of the effect of temperature, wind force, the prestressing of curved and skewed structures, stage construction, flooding and debris.

Particular attention shall be given to providing transverse and diagonal bracing as well as rib stiffeners on cross bearers.

(c) Formwork

(i) General
Formwork shall be so designed as to be sufficiently rigid to ensure that the specified dimensional tolerances can be achieved under the combined action of self-weight, dead load and imposed loads as well as the additional loads resulting from the rate of concreting, the layer thickness of the concrete cast in one operation and the method of placing and compaction.

(ii) Sliding formwork
The Contractor shall be responsible for the design of the sliding formwork. Prior to fabrication or bringing the sliding formwork and any additional equipment to the site, the Contractor shall submit drawings of the complete sliding- formwork assembly to the Engineer for approval. The drawings shall show full details of the forms, jacking frames, access ladders, hanging platforms, safety rails and curing skirts as well as details of the jacks and jack layouts.

The Contractor shall be required to submit to the Engineer, before slide casting commences, an instruction manual in which the sliding techniques, jacking procedure, methods of keeping the formwork level, the procedure to be adopted to prevent bonding of the concrete to the forms and a method for releasing the forms in the event of bonding, the instrumentation and monitoring of the slide casting and correcting for verticality, twisting and levelness are described in detail.

The formwork panels shall be inclined to give a small taper, the forms being slightly wider at the bottom than at the top.

The taper shall be so designed as to produce specified concrete thickness at the mid-lift level of the form.

The spacing of the jacks with their jack rods shall be so designed that the dead load of the sliding-formwork assembly, the frictional load, and the weight of materials, personnel and equipment will be evenly distributed and within the design capacity of the jacks used.

6205 CONSTRUCTION

(a) Falsework
Falsework shall be erected in accordance with the approved drawings incorporating such modifications as required by the Engineer.

The Contractor shall take precautions to prevent deterioration of the foundations during the course of construction.

The falsework shall incorporate features that will permit adjustment to the alignment of the formwork to counter the expected settlement and deflection under load.

(b) Formwork

(i) General
The formwork for bridge decks shall be erected to levels calculated from the information given on the plans for road works and bridges. The levels shall be adapted to make provision for the specified precamber as well as for the expected deflection and settlement of the fully loaded falsework and formwork. The levels shall be set out and checked at intervals not exceeding 2.5 m.

For constructing the formwork, the Contractor may, subject to the provisions of CLAUSE 6202, use any material suitable for and compatible with the class of surface finish and dimensional tolerances specified for the particular member.

Formwork shall be sufficiently rigid to maintain the forms in their correct position, shape and profile and shall be of such tight construction that the concrete

can be placed and compacted without undue loss or leakage of the mortar component of the concrete.

The joints between contiguous formwork elements shall be of a tight fit and, where necessary, the joints shall be caulked, taped or packed with a sealing gasket, all at no extra payment. Paper, cloth or similar material shall not be used for this purpose.

The formwork construction shall permit accurate erection and easy stripping without shock, disturbance or damage to the cast concrete. Where necessary, the formwork assembly shall permit the removal or release of side forms independently of the soffit forms.

Metal supports, ties, hangers and accessories embedded in the concrete shall be removed to a depth of not less than the cover specified for the reinforcement. No wire ties shall be used. The resultant voids shall be filled.

All external corners shall be chamfered by fillet strips being fixed into the corners of the formwork to form 25 mm x 25 mm chamfers. Re-entrant angles need not be chamfered unless specified.

Where polystyrene or similar material, susceptible to damage is used, it shall be lined with a hard surface on the side to be concreted. The hard material shall be sufficiently resilient to ensure that the required quality of work can be achieved.

Where it is specified, all formwork ties shall be provided with recoverable truncated cones between sleeve ends and formwork faces to ensure that sleeve ends are not exposed on concrete surfaces. The cones shall have a minimum depth of 15 mm. The resultant voids shall be filled.

(ii) Formwork to enclosed surfaces
The formwork and boards shall be so arranged as to form a uniform and regular pattern in line with and perpendicular to the main axis of the member, unless otherwise approved or directed by the Engineer.

Joints between contiguous members shall, after caulking, taping or sealing, be treated to prevent blemishes, stains and undue marks from being imparted to the concrete surface.

Bolt and tie positions shall be so arranged that they conform to the symmetry of the formwork panels or boards. Bolt and rivet heads which will be in contact with the formed surface shall be of the countersunk type and shall be treated to prevent marks from forming on the concrete surface.

The formwork at construction joints shall be braced to prevent steps from forming in the concrete surfaces at the joints between successive stages of construction. Where moulding or recess strips are specified, they shall be neatly butted or mitred.

(iii) Formwork for open joints
The requirements for formwork for open joints shall, unless otherwise specified, apply only to cases where the distance between opposite concrete surfaces is equal to or less than 150 mm.

Formwork for open joints shall be constructed to produce a Class F1 surface finish to concealed surfaces or a Class F2 or F3 surface finish corresponding to the in-plane surface finish of the bordering concrete surfaces. The material used and construction of the formwork shall permit its complete removal to form the open joint.

No solvent shall be used to remove formwork unless approved by the Engineer.

(iv) Openings and wall chases
Openings and wall chases shall be provided only where indicated on the Drawings or as authorised by the Engineer. Frames for openings shall be rigid and firmly secured in position to prevent their moving. Temporary holes shall be so formed that they will not create an irregular pattern in relation to the rest of the exposed, formed concrete surface.

(v) Sliding formwork

(1) Constructional equipment
Unless otherwise specified in the Special Specifications, hoisting equipment for sliding formwork, which operates stepwise with upward movements of between 10 mm and 100 mm will be acceptable. However, the use of linked hydraulic or pneumatic jacks is preferable, which are reversible and driven by an electrically operated pump, and which can hoist at a steady rate. The jacks shall have independent controls for regulating verticality and levelness. The jacking system shall ensure that the sliding-formwork assembly can be hoisted evenly.

The use of hoisting systems which operate without jack rods shall be subject to the approval of the Engineer.

All equipment shall be thoroughly tested and inspected before installation and shall be maintained in a good working order throughout the entire sliding operation.

The Contractor shall keep adequate back-up, equipment and quantities of materials on the site to ensure that the slide casting can proceed without interruption.

(2) Instrumentation and monitoring
The Contractor shall supply and install suitable instrumentation on the sliding platform and foundations and against the sides of the structure for monitoring the height, verticality, levelness and twisting, at regular distances. The equipment used, its utilisation and the frequency of recording any readings shall be approved by the Engineer. The Contractor shall be responsible for all monitoring work and shall ensure that records of all readings and measurements taken are filed systematically and are at all times available to the Engineer and the person in control of the sliding operation.

Unless otherwise specified, the verticality of the structure shall be controlled with laser alignment apparatus or optical plummets and the levelness of the sliding forms with a water-level system with reference control points placed at strategic locations.

Height and verticality shall be monitored at intervals not exceeding four hours. The readings shall be plotted immediately on graphs. When the structure is more than 10 mm out of vertical, the Engineer shall be notified immediately.

(3) Supervision
During the entire period of the sliding operation a competent person who is fully acquainted with the sliding technique and the Contractor's methods of construction shall be in attendance on the sliding platform and in control of the sliding operations.

(4) Construction
The jacking frame shall be constructed with adequate clearance between the underside of the cross members and top of the formwork to allow the horizontal reinforcement and embedded items to be correctly installed. A control procedure shall be agreed on by the Contractor and the Engineer to ensure that all the reinforcement is placed. At all times there shall be horizontal reinforcement above the level of the top of the formwork panel.

Guides shall be provided to ensure that the vertical reinforcement can be correctly placed and the specified concrete cover over the reinforcement maintained.

Where the jack rods are to be recovered, adequate precautions shall be taken in respect of their removal without damage being caused to the concrete.

Where jack rods occur at openings or wall chases, adequate lateral support shall be provided to prevent their buckling. Equipment and material shall be so distributed on the working platforms that the load will be evenly distributed over the jacks.

Guard plates shall be provided at the tops of the forms to the outside walls to prevent the concrete from falling down the outside.

The framework, forms and platforms shall be regularly cleared and the accumulation thereon of redundant concrete prevented.

The Contractor shall take all precautions to prevent contamination of the concrete by leaking oil or other causes.

(5) The sliding process
The Contractor shall give the Engineer 24 hours' notice of his/her intention to commence with slide casting. Permission to commence with the sliding shall not be given by the Engineer before the sliding-formwork assembly is fully operative and the complete stock of all materials required for the slide casting as well as back-up and equipment are on the site.

The Contractor shall ensure that the rate of sliding is such that the concrete at the bottom of the formwork has obtained sufficient strength to support itself and all loads which may be placed on the concrete at the time, and that the concrete does not adhere to the sides of the forms.

The slide-casting operation shall be continuous, without any interruptions, until the full height of the structure has been reached, and shall be geared and organised so as to maintain an average rate of sliding of 350 mm per hour.

(6) Interruptions
When the sliding operations are delayed for more than 45 minutes, the Contractor shall prevent adhesion of the setting concrete to the formwork panels by easing the forms or moving them slightly every 10 minutes, or alternatively, where reversible jacks are used, by lowering the forms by 10 mm to 25 mm. Wherever interruptions occur, emergency construction joints shall be formed and treated in accordance with CLAUSE 6408. Before concreting is restarted, the form shall be adjusted to fit snugly onto the hardened concrete so as to prevent steps from being formed on the exposed concrete surface. When slide casting is recommenced, care shall be taken to prevent the fresh concrete from being lifted off from the old concrete.

(vi) Void formers
Void formers shall be secured in position at regular intervals to prevent displacement and distortion during concreting. The void formers shall be supported on precast concrete blocks or rigid welded steel cradles, all subject to approval by the Engineer. The ties securing the void formers shall be attached to the formwork and cross bearers of the falsework. The void formers shall not be tied to or supported on the reinforcement.

Fibre-cement plates shall be supported so that the plate spans in the direction parallel to the orientation of the fibres. Asbestos is a banned and dangerous substance; as such asbestos fibres shall NOT be used.

(vii) Preparing the formwork
The surfaces of forms which are to be in contact with fresh (wet) concrete shall be treated to ensure non-adhesion of the concrete to the forms and easy release from the concrete during the stripping of the formwork.

Release agents shall be applied strictly in accordance with the manufacturer's instructions, and every precaution shall be taken to avoid the contamination of the reinforcement prestressing tendons and anchorages. In the selection of release agents, due regard shall be given to the necessity for maintaining a uniform colour and appearance throughout on the exposed concrete surfaces.

Before the concrete is placed, all dirt and foreign matter shall be removed from the forms and the forms shall be thoroughly wetted with water.

6206 REMOVAL OF FALSEWORK AND FORMWORK

Falsework and formwork shall not be removed before the concrete has attained sufficient strength to support its own weight and any loads which may be imposed on it. This condition shall be assumed to require the formwork to remain in place after the concrete has been placed, for the appropriate minimum period of time given in TABLES 6206/1 to 6206/3, unless the Contractor can prove, to the satisfaction of the Engineer, that shorter periods are sufficient to fulfil this condition. In such case the formwork may be removed after the shorter periods of time agreed on by the Engineer.

Formwork shall be removed only with the permission of the Engineer. The work of striking after the receipt of such permission shall be carried out under the personal supervision of a competent foreman.

Where the Engineer considers the Contractor's proposals for the removal of formwork to be premature either on account of the weather or for any other reasons he may order the Contractor to delay such removal and the Contractor shall have no claim for delay in consequence thereof.

TABLE 6206/1
REMOVING FALSEWORK AND FRAMEWORK - NORMAL COMMON CEMENTS

Falsework and formwork for:	Days	
	Normal weather	Cold weather
Beam sides, walls and unloaded columns	1	1.5
Soffits of slabs and beams		
– Spans up to 3 m	4	7
– Spans 3 m to 6 m	10	17
– Spans 6 m to 12 m	14	24
– Spans over 12 m	21	30

TABLE 6206/2
REMOVING FALSEWORK AND FRAMEWORK - RAPID HARDENING COMMON CEMENTS

Falsework and formwork for:	Days	
	Normal weather	Cold *) weather
Beam sides, walls and unloaded columns	0.5	1
Soffits of slabs and beams		
– Spans up to 3 m	2	4
– Spans 3 m to 6 m	5	10
– Spans 6 m to 12 m	10	18
– Spans over 12 m	18	28
*) Shorter periods may be used for sections thicker than 300 mm on approval of the Engineer.		

TABLE 6206/3
*REMOVING FALSEWORK AND FRAMEWORK – CEMENTS WITH MORE THAN 15% BLAST FURNACE SLAG OR FLY ASH**

Falsework and formwork for:	Days	
	Normal weather	Cold weather
Beam sides, walls and unloaded columns	2	4
Soffits of slabs and beams		
– Spans up to 3 m	6	10
– Spans 3 m to 6 m	14	24
– Spans 6 m to 12 m	21	28
– Spans over 12 m	28	36

* Also applicable to 50/50 mixture of Portland cement and milled granulated blast furnace slag.

Falsework and formwork shall be carefully removed without exposing the cast concrete to damage, disturbance or shock.

Weather may be regarded as being 'normal" when atmospheric temperatures adjacent to the concrete, as measured by a maximum-and-minimum thermometer, do not fall below 15°C, and as "cold" when temperatures, similarly measured, fall below 5°C. When the minimum temperatures fall between these values, the length of the period after which the formwork may be removed, shall be between the periods specified for normal and cold weather.

Any period during which the temperature remains below 2°C shall be disregarded in calculating the minimum time which shall elapse before the forms are removed.
On continuously reinforced concrete structures the falsework and supporting formwork shall not be removed before the concrete of the last pour has reached the appropriate minimum age given in TABLE 6206/1 or the appropriate minimum strength. Where the structure is constructed in stages, the falsework and supporting formwork shall be removed as specified or authorised.

On prestressed-concrete structures the falsework and supporting formwork shall be removed after the full prestressing force relating to the particular stage of construction has been applied, unless otherwise specified or authorised.

6207 FORMED SURFACES, CLASSES OF FINISH

(a) General
In addition to complying with the tolerances specified in CLAUSE 6803, the surface finish on formed concrete surfaces shall also comply with the following requirements.

(b) Class F1 surface finish
After repair work has been done to surface defects in accordance with SUBCLAUSE 6208(b), no further treatment of the as-stripped finish will be required. This finish is required on concealed formed surfaces.

Surfaces that in the final stage will be covered with backfill shall have a finish of Class F1.

(c) Class F2 surface finish
This finish shall be equivalent to that obtained from the use of square-edged timber panels and boards wrought to the correct thickness, or shutter boards or steel forms arranged in a regular pattern. This finish is intended to be left as struck but surface defects shall be remedied in accordance with SUBCLAUSE 6208(b).

Although minor surface blemishes and slight discolouration will be permitted, large blemishes and severe stains and discolouration shall be repaired where so directed by the Engineer. This surface finish is intended for exposed formed surfaces that cannot readily be seen by the general public as in the case of culverts, remote structures and structures to which access is restricted.

(d) Class F3 surface finish
This finish shall be that obtained by first producing a Class F2 surface finish with joint marks which form an approved regular pattern to fit in with the appearance of the structure. All projections shall then be removed, irregularities repaired and the surface rubbed or treated to form a smooth finish of uniform texture, appearance and colour. This surface finish is required on all exposed formed surfaces unless a Class F2 finish is specified.

Unless specified to the contrary, steel forms may be used to form surfaces with a Class F3 surface finish.

(e) Board surface finish
This finish shall be that obtained by using tongue-and-groove timber boarding arranged in an approved regular pattern. The finish is intended to be left as struck but surface defects shall be remedied in accordance with SUBCLAUSE 6208(b) and large fins trimmed where directed by the Engineer.

(f) Protecting the surfaces
The Contractor shall ensure that all concrete surfaces are protected from rust marks, spillage and stains of all kinds and other damage during construction.

6208 REMEDIAL TREATMENT OF FORMED SURFACES

(a) General
Agreement shall be reached between the Engineer and the Contractor regarding any remedial treatment to be given after the surfaces have been inspected immediately after the formwork has been removed; the treatment shall be carried out without delay by the Contractor at his/her expense. No surfaces may be treated before inspection by the Engineer. Any concrete which is found to have been treated before inspection by the Engineer, shall be rejected.

(b) Repairs to surface defects
Surface defects such as small areas of honeycombing, cavities produced by form ties, large isolated blow-holes, broken corner edges, etc, shall be repaired with mortar having a cement and sand ratio equal to that of the concrete being repaired.

For the repair of large or deep areas of honeycombing and defects, special approved methods and techniques, such as pneumatically applied mortar pressure grouting, epoxy bonding agents, etc, may be used.

Where, in the opinion of the Engineer, the extent of the honeycombing or defects is of such a degree that doubt exists about the effectiveness of repair work, the Contractor shall at his/her own cost perform a load test in accordance with SUBCLAUSE 6414(b) to prove that the structural safety of the repaired member has not been prejudiced failing which, the structure shall be rebuilt in part or in full at the Contractor's cost.

Where the concrete has been damaged by adhesion to the formwork panel, the cracked and loose concrete shall be removed; or where the fresh concrete has lifted off at construction joints, the crack shall be scraped out immediately on both sides of the wall to a depth of at least 50 mm. The cavities so formed shall then be repaired as described above.

(c) Rubbing the surfaces
If the finish of exposed formed surfaces does not comply with the requirements for uniformity of texture, appearance and colour, the Contractor shall, when so instructed by the Engineer, rub down the exposed surfaces of the entire structure or of any part of it as specified below.

The surface shall be saturated with water for at least one hour. Initial rubbing shall be done with a medium-coarse carborundum stone, where a small amount of mortar, having a sand and cement ratio equal to that of the concrete being repaired is used on the surface. Rubbing shall be continued until all form marks, projections and irregularities have been removed and a uniform surface has been obtained. The paste produced by the rubbing shall be left in place. The final rubbing shall be carried out with a fine carborundum stone and water. This rubbing shall continue until the entire surface is of a smooth, even texture and is uniform in colour. The surface shall then be washed with a brush to remove surplus paste and powder.

Where the concrete surfaces formed by sliding formwork require treatment to achieve the surface finish specified for the member, the concrete shall, as soon as the surfaces under the formwork are exposed, be floated with rubber- lined floats to the desired finish.

6209 UNFORMED SURFACES: CLASSES OF FINISH

(a) Class U1 surface finish (rough)
This surface finish is required on those portions of bridge decks or culvert decks which are to receive bituminous or concrete surfacing or which are to be covered by backfilling material.

Where the placing and compacting of the concrete have been completed as specified in CLAUSE 6407, the top surface shall be screeded off with a template to the required cross-section and tamped with a tamping board to compact the surface thoroughly and to bring mortar to the surface, so as to leave the surface slightly rough but generally at the required elevation.

(b) Class U2 surface finish (floated)
This surface finish is required on sidewalks, the tops of wing walls and retaining walls, exposed concrete shoulders and unsurfaced areas on bridge decks, and the inverts of box culverts.

The surface shall first be given a Class U1 surface finish and after the concrete has hardened sufficiently, it shall be wood-floated to a uniform surface free from trowel marks. For non-skid surfaces such as on sidewalks, bridge decks and exposed culverts, the surface shall then be given a broom finish. The corrugations so produced shall be approximately 1.0 mm deep, uniform in appearance and width and shall be perpendicular to the centre line of the pavement.

(c) Class U3 surface finish (smoothly finished)
This surface finish shall be required at bearing areas and the tops of concrete railings, exposed upper surfaces of floor slabs and upper surfaces in contact with water. The surface shall first be given a Class U1 surface finish, and after the concrete has hardened sufficiently, it shall be floated with a steel float to a smooth surface to within the dimensional tolerances specified in SUBCLAUSE 6803(h).

Rubbing with carborundum stone after the concrete has hardened shall be allowed but under no circumstances will plastering of the surface be permitted.

6210 MEASUREMENT AND PAYMENT

ITEM	UNIT
62.01 FORMWORK TO PROVIDE (CLASS OF FINISH INDICATED AS F1, F2, F3 OR BOARD) SURFACE FINISH TO (DESCRIPTION OF MEMBER TO WHICH APPLICABLE)	SQUARE METRE (m^2)

ITEM	UNIT
62.02 VERTICAL FORMWORK TO PROVIDE (CLASS OF FINISH INDICATED AS F1, F2, F3 OR BOARD) SURFACE FINISH TO (DESCRIPTION OF MEMBER TO WHICH APPLICABLE)	SQUARE METRE (m^2)

ITEM	UNIT
62.03 HORIZONTAL FORMWORK TO PROVIDE (CLASS OF FINISH INDICATED AS F1, F2, F3 OR BOARD) SURFACE FINISH TO (DESCRIPTION OF MEMBER TO WHICH APPLICABLE)	SQUARE METRE (m^2)

ITEM		UNIT
62.04	INCLINED FORMWORK TO PROVIDE (CLASS OF FINISH INDICATED AS F1, F2, F3 OR BOARD) SURFACE FINISH TO (DESCRIPTION OF MEMBER TO WHICH APPLICABLE)	SQUARE METRE (m^2)

The unit of measurement shall be the square metre, and only the actual area of formwork in contact with the finished face of the concrete shall be measured. Formwork for the different classes of finish shall be measured separately. Formwork for construction joints shall be measured for payment under Class F1 surface finish, but only formwork for mandatory construction joints shall be measured for payment.

The bid rates shall include full compensation for procuring and furnishing all materials required, erecting the falsework and formwork, constructing the forms, forming the grooves, fillets, chamfers and stop-ends for construction joints, treating and preparing the forms, all bolts, nuts, ties, struts and stays, stripping and removing the formwork after completion of the work, all labour, equipment and incidentals, and rubbing and surface treatment. Payment of 80% of the amount due for formwork will be made when the formwork has been removed, and payment of the remaining 20% will be made on approval of the concrete surface finish.

Note: Vertical and horizontal formwork shall be the formwork of which inclination of the finishing surface in relation to the horizontal level shall be larger and smaller than 40° respectively. Inclined formwork shall be the formwork described as such in the Bill of Quantities.

ITEM		UNIT
62.05	PERMANENT FORMWORK (DESCRIPTION OF MEMBER TO WHICH APPLICABLE)	SQUARE METRE (m^2)

The unit of measurement shall be the square metre of concrete area formed with permanent formwork.

The bid rates shall include full compensation for procuring and furnishing all the materials required, installing the formwork, and labour, equipment and incidentals.

ITEM		UNIT
62.06	FORMWORK TO FORM OPEN JOINTS (DESCRIPTION OF MEMBER TO WHICH APPLICABLE, AND LOCATION)	SQUARE METRE (m^2)

The unit of measurement shall be the square metre of concrete area formed.

Surfaces formed prior to the construction of the final surface for completing the joint, shall be measured under ITEMS 62.01, 62.02, 62.03 or 62.04, as may be applicable.

The bid rate shall include full compensation for procuring and furnishing all the materials required, constructing the formwork and subsequently removing all the material within the joint space, as well as labour, equipment and incidentals. Payment for formwork to open joints shall be made only after the forms and filler material have been completely removed and approval of the surface finish has been obtained.

ITEM		UNIT
62.07	ESTABLISHMENT ON THE SITE FOR SLIDING FORMWORK OPERATIONS	LUMP SUM

The bid lump sum shall include full compensation for the establishment on the site and the subsequent removal of the complete sliding-formwork assembly, special equipment, and incidentals for the sliding work, the cost of which does not vary with the actual amount of sliding work done.

This work will be paid for by way of a lump sum, 75% of which will become payable when the sliding-formwork assembly and equipment have been fully installed at the first structural member on the site, and the remaining 25% will become payable after all sliding work has been completed and the said items have been removed from the site.

ITEM		UNIT
62.08	TRANSPORTING TO AND SETTING UP THE SLIDING FORMWORK ASSEMBLY AT (DESCRIPTION OF EACH STRUCTURE)	NUMBER (no)

The unit of measurement shall be the number of structures to which the complete sliding-formwork assembly has to be transported and set up in position ready to be commissioned.

The bid rate shall include full compensation for all costs involved in dismantling, transporting and erecting of the complete sliding-formwork assembly.

ITEM		UNIT
62.09	FORMING THE CONCRETE BY SLIDING FORMWORK FOR (DESCRIPTION OF EACH STRUCTURE AND CLASS OF SURFACE FINISH TO EXPOSED SURFACES INDICATED)	METRE (m)

The unit of measurement shall be the metre height of each structure formed by sliding formwork. The quantity measured shall be the actual height of each structure formed by the sliding technique.

The bid rate shall include full compensation for sliding, instrumentation and monitoring, the maintenance of the complete sliding-formwork assembly and equipment, supplying, installing and recovering the jack rods, floating, repairing and treating the concrete surfaces, forming the emergency construction joints, and all labour, equipment and incidentals.

SERIES 6000: STRUCTURES

SECTION 6300: STEEL REINFORCEMENT FOR STRUCTURES

CONTENTS:

6301 SCOPE

This Section covers the furnishing, inspection, testing, certification and placing of reinforcing steel in concrete structures.

6302 MATERIALS

(a) Steel bars

Steel reinforcing bars shall comply with the requirements of US 155:1995, BS 4449:1997 or equivalent on the approval of the Engineer unless otherwise noted on the Drawings. For each consignment of steel reinforcement delivered on the site, the Contractor shall submit a certificate issued by a recognised testing authority to confirm that the steel complies with the specified requirements.

(b) Welded steel fabric

Welded steel fabric shall comply with the requirements of AASHTO M55 or equivalent on approval of the Engineer. The grade of wire shall be W4 in accordance with AASHTO M32 or equivalent on approval of the Engineer unless otherwise noted on the Drawings. The grid shall be 100 mm x 100 mm unless otherwise noted on the Drawings.

(c) Mechanical couplers

All mechanical couplers used shall be subject to the approval of the Engineer. The tensile properties determined on a test sample which consists of reinforcing bars butt-jointed by a mechanical coupler shall comply with requirements as given in the Special Specifications.

(d) Definitions

For this Section 6300, the following definitions shall apply:

(i) Bar
A steel product of plain or deformed cross section.

(ii) Hot rolled deformed bar
A bar that has been so shaped during hot rolling that it conforms to either geometrical or the performance test classification given in SUBCLAUSE 6304 (e).

(iii) Cold worked deformed bar
A bar that has been cold worked to conform to the property requirements of BS 4449:1997 and that conforms to either the geometrical or performance test classification given in SUBCLAUSE 6304 (e).

(iv) Nominal size
The diameter of a circle with an area equal to the effective cross sectional area of the bar.

(v) Batch
Any quantity of bars of one size and grade, whether in coils or bundles, produced by one manufacturer or supplier, presented for examination at any one time.

(vi) Characteristic strength
The value of yield strength having a prescribed probability of not being attained in a hypothetical unlimited test series. The characteristic value is the lower limit of the one sided statistical tolerance interval at which there is a 90% probability (i.e. $1 - \alpha = 0.90$) that 95% ($p = 0.95$) of the values are at or above this lower limit. This definition refers to the long term quality level of production.

6303 STORING THE MATERIALS

Reinforcing steel shall be stacked off the ground and, in aggressive environments, shall be stored under cover. It shall be protected at all times from contamination and corrosion.

6304 INSPECTION, TESTING AND CERTIFICATION OF CARBON STEEL BARS FOR THE REINFORCEMENT OF CONCRETE

(a) Manufacturer's inspection

(i) General
All units of continuous production shall be tested according to 6304 (a) (ii) below.

(ii) Selection of test specimens
The unit of production from which test specimens shall be selected shall be the cast.

Test specimens shall be either at least 600 mm long or 20 times the nominal size, whichever is the greater. The rate of testing shall be:

- for casts of 100 t or less: three tensile tests and one rebend test;
- for casts greater than 100 t: three tensile tests and one rebend test for the first 100 t, and an additional tensile test for each full (or part over) 30 t remaining.

(iii) Condition of test specimens
The tensile and rebend tests shall be carried out on straight bars in the delivery or accelerated aged condition. Bars with nominal diameter of 40 mm or less shall not be machined.

(iv) Tensile test
The tensile strength, yield strength and elongation at fracture A_5 shall be determined by the methods described in BS EN 10002-1. The upper yield strength R_{eH} shall be determined for steel showing a defined yield point. If this is not applicable, and at the discretion of the manufacturer, the 0.2% proof strength $R_{p0.2}$ shall be determined, using an extensometer calibrated to class 2 of BS EN 10002-4, using a strain rate corresponding to a rate of loading not exceeding 10 N/mm^2 per second approaching the yield strength.

At the option of the manufacturer, for routine testing, the percentage total strain may be determined as an alternative to 0.2% proof stress. This is the stress on the specimen, derived from the load, corresponding to an increase in percentage total strain as specified in Table 6304/1 below. The strain may be measured by the extensometer in any convenient gauge length.

The 0.2% proof stress shall be used in cases of dispute.

TABLE 6304/1
ALLOWABLE PERCENTAGE TOTAL STRAIN

Percentage total strain	
Steel grade	Total strain (%)
250	0.33
460	0.43

For elongation values, the test results shall be regarded as valid, irrespective of the position of the fracture, provided that the minimum elongation specified in Table 6304/2 has been obtained.

TABLE 6304/2
TENSILE PROPERTIES OF CARBON STEEL BARS FOR THE REINFORCEMENT OF CONCRETE

Grade	Yield strength (Re) **1)** N/mm^2	Stress ratio (R_m/R_e) **2)** (min)	Elongation at fracture A_5 (min) %	Total elongation at maximum force (A_{gt}) (min) **3)** %
250	250	1.15	22	-
460A **4)**	460	1.05	12	2.5
460B **4)**	460	1.08	14	5

1) For routine testing, the yield strength shall be considered a minimum value. For determination of long term quality level, the values given shall be for characteristic strength.
2) R_m is the tensile strength.
3) The total elongation at maximum force shall be measured and recorded and available for inspection, but values obtained below the minimum values specified shall not be a cause for non-conformity with BS 4449:1997. A_{gt} shall be determined in accordance with ISO 10606.
4) Ductility classes A and B are designated ductility classes N and H respectively in DD ENV 1992-1-1:1992.

Where the minimum elongation is not obtained, the sample shall be deemed not to comply with BS 4449:1997, except in the following cases, where the test results shall be considered invalid:

- if the distance between the fracture and the nearer gauge mark is less than one third of the gauge length; or
- if the relevant end of the gauge used for measuring the elongation is 2d or less from the face of the machine grips.

The cross sectional area for bars of uniform section to be used for calculation of stresses is calculated using the formula:

$$A = \frac{M}{0.00785L}$$

where

M is the mass of the bar (kg);
L is the length of the bar (m);
A is the cross sectional area (mm^2).

The precision for the measurement of mass and length shall be ±0.5% and the bar length shall not be less than 0.5 m.

(v) Evaluation of tensile test results
All tensile test results shall conform to Table 6304/2 above.

(vi) Rebend test

(1) Sequence of operations
The rebend test specimens shall be subjected to the following:

- The specimen shall be bent through an angle of 45°, using a former of diameter specified in Table 6304/3 at a temperature between 5°C and 30°C so as to produce a continuous and uniform bending deformation (curvature) at every section of the bend. The result shall be conducted either:
  - On a bending machine in which the test specimen is supported by plain smooth surfaces or rolls that do not resist longitudinal movement of the piece; or
  - On a three-point hydraulic bending machine.

TABLE 6304/3
REBEND TEST FORMERS FOR TESTING OF CARBON STEEL BARS FOR THE REINFORCEMENT OF CONCRETE

Rebend test formers		
Grade	Nominal size (mm)	Diameter of former
250	All sizes	2d
460	d ≤ 16 d > 16	5d

- The test machine shall be serviceable and able to impart a constant load to the specimen, and shall be without impact effect. The maximum bending rate shall be 3 r/min or equivalent.
- The test specimen shall be heated to 100°C and maintained at this temperature for at least 30 minutes.
- The test specimen shall be allowed to cool to a temperature between 5°C and 30°C, and partially re-straightened by a steadily applied force, through at least 23°, on the bending machine used above.

(2) Failure in relation to rib damage
In the event of a specimen failing the rebend test, if there is any damage to the ribs caused by carrying out the initial bending, the test shall be considered invalid, and shall be repeated on another specimen.

Damage to the ribs may be avoided by inserting an aluminium sheet between the specimen and the former. The aluminium sheet shall have a maximum thickness of 6 mm.

(vii) Cross sectional area and mass
The cross sectional areas for the preferred sizes of bars shall conform to the values in Table 6304/4, while the tolerances shall conform to the values in Table 6303/5.

TABLE 6304/4
CROSS SECTIONAL AREA AND MASS OF CARBON STEEL BARS FOR THE REINFORCEMENT OF CONCRETE

Nominal size (mm)	Cross sectional area (mm^2)	Mass per metre run (kg)
6*	28.3	0.222
8	50.3	0.395
10	78.5	0.616
12	113.1	0.888
16	201.1	1.579
20	314.2	2.466
25	490.9	3.854
32	804.2	6.313
40	1256.6	9.864
50*	1963.5	15.413
* This is a non-preferred size		

TABLE 6304/5
TOLERANCE ON MASS OF CARBON STEEL BARS FOR THE REINFORCEMENT OF CONCRETE

Nominal size	Tolerance on mass per metre run (%)
6	±9
8 and 10	±6.5
12 and over	±4.5

(viii) Chemistry

The chemical composition of steel based on the cast analysis, shall be in accordance with Table 6304/6.

Bars of both grades shall have a carbon equivalent value, based on cast analysis, not exceeding the maximum values given in Table 6303/6.

The following formula shall be used to calculate the carbon equivalent value, where the chemical symbols represent the percentages of each element:

Carbon equivalent value =

C + Mn/6 + [Cr + Mo + V]/5 + [Ni +Cu]/15

In cases of dispute, the appropriate methods of test given in BS 6200-3:2002 shall be used.

TABLE 6304/6
CHEMICAL COMPOSITION OF STEEL GRADES: CAST ANALYSIS

Element	Grade 250 % (max.)	Grade 460 % (max.)
Carbon	0.25	0.25
Sulphur	0.060	0.050
Phosphorus	0.060	0.050
Nitrogen	0.012	0.012
Note 1: The maximum value for nitrogen does not apply if the chemical composition shows a minimum aluminium content of 0.020%, or if sufficient other nitrogen binding elements are present. Note 2: Nitrogen content is not normally given on a release certificate.		

Table 6304/7 gives the maximum values of the carbon equivalent values.

TABLE 6304/7
MAXIMUM CARBON EQUIVALENT VALUES: CAST ANALYSIS

Grade	Maximum carbon equivalent value (%)
250	0.42
460	0.51

(ix) Product analysis and permitted deviations

The maximum deviations on product analysis from the values specified for cast analysis (see Table 6304/6 and 6304/7) shall be as given in Table 6304/8.

TABLE 6304/8
MAXIMUM DEVIATIONS IN CHEMICAL COMPOSITION ON PRODUCT ANALYSIS

Element	Deviation above the specified maximum given in Table 6304/5 and 6 (%)
Carbon	0.02
Sulphur	0.005
Phosphorus	0.005
Total nitrogen	0.001
Carbon equivalent value	0.03
Note: The product analysis may vary from the cast analysis due to chemical heterogeneity arising during the casting and solidification process.	

Samples for product analysis shall be taken in accordance with the appropriate method of BS 6200-3:2002.

During product analysis, any bar that falls outside the maximum deviation limits for the composition range of a specified element, given in Table 6403/8, shall be deemed not to conform to BS 4449:1997.

If during product analysis, a single sample falls outside the maximum deviation limits for the composition range of a specified element, given in Table 6403/8, further samples shall be selected for analysis from the remainder of the batch as follows:

(a) at least two samples from the same cast for delivered masses up to 5 t;
(b) at least five samples from the same cast for delivered masses up to 20 t;
(c) at least eight samples from the same cast for delivered masses over 20 t.

If any of the further samples analyzed fall outside the maximum deviation limits for any element, the batch shall be deemed not to conform to BS 4449:1997.

(b) Material covered by a third party product certification scheme

(i) Consistency of production

To determine the production consistency of the manufacturer, the long term quality level shall be regularly assessed. However, no conclusion regarding product conformity to BS 4449:1997 shall be made on the basis of this assessment.

(ii) Determination of long term quality level

(1) Extent of testing

The yield strength results obtained on all casts shall be collated either every three months or after at least 200 results have been obtained. The results shall be used to determine the long term quality level.

(2) Evaluation

The average yield strength *m* shall satisfy the following:

$$m \geq cv + k\sigma$$

where

cv is the characteristic strength (N/mm^2);
k is the acceptability index (see Table 6304/9);
σ is the standard deviation of the population.

TABLE 6304/9
ACCEPTABILITY INDEX k AS A FUNCTION OF THE NUMBER OF TEST RESULTS n (FOR A RELIABLE PASS RATE OF 5% (PASS = 0.95) AT A PROBABILITY OF 90% (1 – α = 0.90))

n	***k***
5	3.40
6	3.09
7	2.89
8	2.75
9	2.65
10	2.57
11	2.50
12	2.45
13	2.40
14	2.36
15	2.33
16	2.30
17	2.27
18	2.25
19	2.23
20	2.21
30	2.08
40	2.01
50	1.97
60	1.93
70	1.90
80	1.89
90	1.87
100	1.86
150	1.82
200	1.79
250	1.78
300	1.77
400	1.75
500	1.74
1000	1.71
∞	1.64

(3) Test Certificates

- Certificate of Conformity
  A certificate of product conformity to BS 4449:1997 shall be issued when requested by the Engineer.

The certificate shall state:

- That the product materials conform to BS 4449:1997, and have undergone the tests specified in BS 4449:1997, at the specified frequency;
- The address at which the records of the tests are available for inspection.

The certificate shall include the approval number issued by the certifying authority.

- Manufacturer's statement of results
  In the case of products delivered to a supplier, the manufacturer shall provide the following information:

- The cast number and cast analysis, including all specified elements and elements used for the calculation of the carbon equivalent value;
- The results of the tensile and rebend tests, including the effective cross sectional area;
- For deformed bars, the rolled on mill mark.

The information shall include the approval number of the certifying authority.

(c) Material not covered by a third party product certification scheme

(i) General

Material not covered by a third party product certification scheme shall be assessed by acceptance tests on each batch. Sampling and testing shall be carried out by an independent organization at the producer's works or in the Contractor's yard.

(ii) Extent of sampling and testing

For testing purposes, the batch shall be divided into test units each with a maximum mass of 100 t. Each test unit shall comprise of products of the same steel grade and nominal diameter of the same cast. The manufacturer shall certify that all products in the test unit originate from the same cast.

Test specimens shall be taken from each test unit as follows:

(a) fifteen specimens (or if appropriate, 60 specimens – see also Subclause 6304 (c) (iv) (a) 2.), from different bars, for testing as specified in SUBCLAUSE 6304 (c) (iii) (a) and (b).
(b) two test specimens, from different bars, for testing in accordance with SUBCLAUSE 6304 (c) (iii) (c).

Preparation of test specimens shall be carried out as described in SUBCLAUSE 6304 (a).

(iii) Properties to be tested

Specimens selected in accordance with SUBCLAUSE 6304 (c) (ii) shall be tested for the following:

(a) inspection by variables
1. tensile strength R_m;
2. yield strength R_e;
3. elongation after fracture A_5;
4. total elongation at maximum force A_{gt} (for grade 460A and 460B).

(b) inspection by attributes
1. behavior in the rebend test;
2. deviations from the nominal cross section;
3. bond test.

(c) chemical composition according to the product analysis

(d) fatigue properties: grade 460

The fatigue properties of grade 460 steels shall be determined for each size and defined bar shape in the batch. Sampling and testing shall be carried out in accordance with Subclause 6304 (d).

All elements listed in SUBCLAUSE 6304 (a) (viii) and the carbon equivalent shall be determined.

The test procedures shall be as described in SUBCLAUSE 6304 (a).

(iv) Evaluation of results

(a) Inspection of variables
Inspection of variables shall be carried out as follows:

(1) The following shall be determined for the characteristic strength when testing for properties listed in SUBCLAUSE 6304 (c) (iii).
- All individual values for characteristic strength *cv* for the 15 test specimens;
- The mean value for the characteristic strength m_{15} (for $n = 15$);
- The standard deviation S_{15} (for $n = 15$).

The test unit shall be deemed to conform to BS 4449:1997 if all individual values of R_m/R_e and the elongation at fracture A5 exceed values specified in Table 6304/2, and the following condition is fulfilled by the characteristic strength:

$$m_{15} - 2.33 \times S_{15} \geq cv$$

(2) If the condition for the characteristic strength stated above is not fulfilled, a secondary calculation (the acceptability index *k*) shall be determined, where:

$$k = \frac{m_{15} - cv}{S_{15}}$$

If $k \geq 2$, testing shall continue. Forty-five further test specimens shall be taken and tested from different bars in the same test unit, so that a total of 60 test results are available ($n = 60$).

The test unit shall be deemed to conform to BS 4449:1997 if all individual values of R_m/R_e and the elongation at fracture A5 exceed values specified in Table 6403/2, and the following condition is fulfilled by the characteristic strength (1.93 is the value for the acceptability index *k* for $n = 60$, in accordance with SUBCLAUSE 6403 (c)):

$$m_{60} - 1.93 \times S_{60} \geq cv$$

(b) Inspection by attributes
Inspection by attributes shall be carried out as follows. When testing the properties listed in Subclause 6304 (c) (iii) (b), either:

a) all the results determined on the 15 test specimens shall conform to BS 4449:1997; or
b) if a maximum of two of the 15 results do not conform to BS 4449:1997, 45 further test specimens shall be taken and tested from different bars in the test unit, making 60 test results available. The unit shall be deemed to conform to BS 4449:1997 if no more than two of the 60 test specimens fail the tests.

(c) Fatigue properties
The batch shall be deemed to conform to BS 4449:1997 if it conforms to SUBCLAUSE 6304 (d).

(iv) Test report
A test report shall be produced containing the following data:

- the place of manufacture of the reinforcing steels;
- the nominal diameter of the steel;
- the grade of the steel;
- the making of the steel;
- the cast number;
- the date of testing;
- the mass of the test unit;
- the individual test results for all the properties specified in SUBCLAUSE 6304 (c) (iii).

(d) Method of test for fatigue properties of deformed bars

(i) Fatigue testing
The fatigue properties for each defined bar shape and process route shall be established at an applicable testing laboratory, initially by testing three sizes selected from the top, middle and bottom of the product size range. Products representing the full size range shall be tested on the basis of a tree year cycle.

Testing shall be carried out on bars in the commercially straight condition. The bars shall endure 5×10^6 cycles of stress at he applicable stress range for the size of the bar, given in Table 6304/10.

TABLE 6304/10
TEST STRESS RANGES FOR NOMINAL BAR SIZES

Bar size (mm)	Stress range (N/mm^2)
Up to and including 16	200
Over 16 up to and including 20	185
Over 20 up to and including 25	170
Over 25 up to and including 32	160
Over 32 up to and including 40	150

(ii) Sampling
Bars shall be grouped into batches of 50, all manufactured at the same time, and of the same size and type. The bars shall not exhibit isolated defects that are not characteristic of the product. Test specimens shall be cut from the bars selected at random, and shall have a minimum length of 30*d* and a minimum free length of 10*d*, where *d* in the nominal diameter of the specimen. Each test unit shall comprise five test specimens.

(iii) Test procedure
Specimens shall be tested in air under axial tensile loading, using tapered grips and a suitable gripping medium. The stress ratio shall be 0.2 and the frequency not exceed 120 Hz. A sine wave form shall be used. Testing shall be carried out under load control and stresses shall be calculated on the nominal area.

The tests shall be considered invalid if a specimen fails the test due to a defect unique to the specimen, or occurs in an area adjacent to the testing machine grips.

(iv) Retests
- the batch shall be deemed to conform to BS 4449:1997 if all five specimens endure 5×10^6 cycles of stress.
- If two or more specimens fail to endure 5×10^6 cycles, and the test is valid (see SUBCLAUSE 6304 (d) (iii)), the batch shall be deemed not to conform to BS 4449:1997 and shall be rejected.
- If one specimen fails the test, a further five test specimens shall be selected from the same batch. If one or more of these specimens fails, the batch shall be deemed not to conform to BS 4449:1997 and shall be rejected.

(e) Bond classification of deformed bars

(i) General
Deformed bars shall be classified either as type 1 or type 2 as follows. Either:

a) in accordance with their surface shape, as specified in Subclause 6304 (ii); or
b) for bars that do not conform to the surface bond classification scheme of SUBCLAUSE 6304 (ii), in accordance with SUBCLAUSE 6304 (iii).

(ii) Bond classification by surface shape
Bond classification by surface shape shall be as follows:

Type 1 Either a plain square twisted bar or a plain chamfered square twisted bar, with a pitch of twist not greater than 14 times the nominal size.

Type 2 A bar with transverse ribs of a substantially uniform spacing not greater than 0.8φ for as-rolled deformed bars or 1.2φ for cold twisted bars; having a mean area of ribs (per unit length), above the core of the bar projected on a plane normal to the axis of the bar, of not less than 0.15φ mm^2/mm, where φ is the nominal bar size in millimetres.

(iii) Bond classification by performance
The performance tests described in BS 4449:1997, Annex D shall be conducted at an appropriate laboratory. The bond classification established at the laboratory and given on the test report shall be regarded as final.

6305 BENDING THE REINFORCING STEEL

Reinforcement shall be cut or cut and bent to the dimensions shown on the bending schedules and in accordance with BS 8666:2000 or BS EN ISO 4066:2000 or as prescribed by the Engineer.

No flame-cutting of high-tensile steel bars shall be permitted except when authorised.

All bars with less than 32 mm in diameter shall be bent cold and bending shall be done slowly, a steady, even pressure being exerted without jerking or impact.

If approved, the hot bending of bars of at least 32 mm in diameter will be permitted, provided that the bars do not depend on cold working for their strength. When hot bending is approved, the bars shall be heated slowly to a cherry-red heat (not exceeding 840°C) and shall be allowed to cool slowly in air after bending. Quenching with water shall not be permitted.

Already bent reinforcing bars shall not be re-bent at the same spot without authorisation.

6306 SURFACE CONDITION

When the concrete is placed around the reinforcing steel and/or dowels, the reinforcing steel and/or dowels shall be clean, free from mud, oil, grease, paint, loose rust, concrete droppings, loose mill scale or any other substance which could have an adverse chemical effect on the steel or concrete, or which could reduce the strength of bond.

6307 PLACING AND FIXING

Reinforcement shall be positioned as shown on the Drawings and shall be firmly secured in position within the tolerance given in SUBCLAUSE 6803(f) by being tied with 1.6 mm or 1.25 mm diameter annealed wire or by suitable clips being used, or, where authorised, by tack welding. Any cover and spacer blocks required to support the reinforcement shall be as small as may be consistent with their use and shall be of an approved material and design.

The concrete cover over the projecting ends of ties or clamps shall comply with the specifications for concrete cover over reinforcement detailed in TABLE 6306/1 at the end of the Section.

Where protruding bars are exposed to the elements for a long period, the bars shall be adequately protected against corrosion and damage and shall be properly cleaned before being permanently encased in concrete.

In members which are formed with sliding formwork, spacer ladders for placing and fixing the wall reinforcement shall be used at spacings indicated on the Drawings or as prescribed by the Engineer. The spacer ladders shall consist of two bars 3.7 m in length with ties 4 mm in diameter welded to them to resemble a ladder. The ties shall be spaced at multiples of the horizontal bar spacing in the wall, and shall be used to secure the horizontal reinforcement. The laps in the horizontal reinforcement shall be staggered to ensure that no part of two laps in any four consecutive layers lie in the same vertical plane.

6308 COVER AND SUPPORTS

The term "cover" in this context shall mean the minimum thickness of concrete between the surface of the reinforcement and the face of the concrete.

The minimum cover shall be as shown on the Drawings. Where no cover is indicated, the minimum cover provided shall be at least equal to the appropriate values shown in TABLE 6308/1 at the end of the Section.

The cover shall be increased by the expected depth of any surface treatment, e.g. when concrete is bush hammered or when rebates are provided.

Additional cover as prescribed by the Engineer shall be provided if porous aggregates are used.

The cover blocks or spacers required for ensuring that the specified cover is obtained shall be of a material, shape and design acceptable to the Engineer.

Concrete spacer blocks shall be made with 5 mm maximum sized aggregate and shall be of the same strength and material source as those of the surrounding concrete. The blocks shall be formed in specially manufactured moulds and the concrete compacted on a vibratory table, and cured under water for a period of at least 14 days, all to the satisfaction of the Engineer.

Ties cast into spacer blocks shall not extend deeper into the spacer block than half the depth of the spacer block.

The Contractor shall provide stools as shown on the Drawings, or where they are not detailed on the Drawings, wherever the Engineer requires them to be installed. The stools shall be suitably robust, and fixed securely so that they can not swivel or move. The stools shall have sufficient strength to perform the required functions, taking into account amongst others temporary loads such as the weight of workmen and wet concrete, and forces caused by vibrators and other methods of compacting the concrete.

6309 LAPS AND JOINTS

Laps, joints, splices and mechanical couplings shall be applied only by the specified methods and at the positions shown on the Drawings or as authorised.

6310 WELDING

Reinforcement shall be welded only where shown on the Drawings or as authorised.

Flash butt welding shall be done only with the combination of flashing, heating, upsetting and annealing to the satisfaction of the Engineer, and only those machines which control this cycle of operations automatically shall be used.

Metal-arc welding of reinforcement shall be done in accordance with BS EN 1011-1:1998 and BS EN 1011-2:2001, and with the recommendations of the reinforcement manufacturers, subject to approval by the Engineer and the satisfactory performance of trial joints. Hot-rolled high-yield-stress steel shall be preheated to between 240°C and 280°C and only low-hydrogen electrodes may be used.

Trial welding joints shall be made on the site in circumstances similar to those which will govern during the making of production welding joints by the person who will be responsible for the production welding joints.

Other methods of welding e.g. resistance welding, may be used subject to approval by the Engineer and to their satisfactory performance in trial joints.

Welded joints shall be full-strength welds and their strength shall be assessed by destruction tests on samples selected by the Engineer.

6311 MEASUREMENT AND PAYMENT

ITEM	UNIT
63.01 STEEL REINFORCEMENT FOR:	
(a) (DESCRIPTION OF PORTION OF STRUCTURE TO WHICH APPLICABLE):	
(i) MILD STEEL BARS	TONNE (t)
(ii) HIGH-YIELD-STRESS-STEEL BARS (TYPE INDICATED)	TONNE (t)
(iii) WELDED STEEL FABRIC	TONNE (t)
(b) ETC FOR OTHER STRUCTURES OR PARTS OF STRUCTURES	TONNE (t)

The unit of measurement for steel bars shall be the tonne of reinforcing steel in place in accordance with the Drawings or as authorised.

The unit of measurement for welded steel fabric shall be the tonne of welded steel fabric in place, the quantity of which shall be calculated from the area of the mesh used in accordance with the Drawings or as authorised.

Ties, stools and other steel used for positioning the reinforcing steel shall be measured as steel reinforcement under the appropriate SUBITEM.

The bid rates shall include full compensation for supplying, delivering, cutting, bending, welding, trial weld joints, placing and fixing the steel reinforcement, including all tying wire, spacers and waste.

TABLE 6308/1
MINIMUM CONCRETE COVER OVER REINFORCEMENT

Condition of exposure	Description of members/surface to which the cover applies	Min cover (mm)				
		Class of concrete				
		20	25	30	40	50
1. MODERATE: Concrete surfaces above ground level and protected against alternately wet and dry conditions caused by water and rain	1.1 Surfaces protected by the superstructure, viz. the sides of beams and the undersides of slabs and other surfaces not likely to be moistened by condensation	50	45	40	35	25
	1.2 Surfaces protected by a waterproof cover or permanent formwork not likely to be subjected to weathering or corrosion	50	45	40	35	25
	1.3 Enclosed surfaces	50	45	40	35	25
	1.4 Structures/members permanently submerged	50	45	40	35	25
	1.5 Railway structures:					
	(i) Surfaces of precast elements not in contact with soil	NA	NA	NA	30	30
	(ii) Surfaces protected by permanent formwork not likely to be subjected to weathering or corrosion	NA	30	30	30	30
	(iii) Surfaces in contact with ballast	NA	55	50	50	45
	(iv) All other surfaces	NA	50	40	40	35
2. SEVERE: Concrete surfaces exposed to heavy rain and alternating wet and dry conditions	2.1 All exposed surfaces	NA	50	45	40	35
	2.2 Surfaces on which condensation takes place	NA	50	45	40	35
	2.3 Surfaces in contact with soil	NA	50	45	40	35
	2.4 Surfaces permanently under running water	NA	50	45	40	35
	2.5 Railway structures:					
	(i) Surfaces of precast elements not in contact with soil	NA	NA	NA	30	30
	(ii) Surfaces protected by permanent formwork not likely to be subjected to weathering or corrosion	NA	30	30	30	30
	(iii) Surfaces in contact with ballast	NA	55	50	50	45
	(iv) All other surfaces	NA	50	40	40	35
	2.6 Cast in situ piles:					
	(i) Wet cast against casing	50	50	50	50	50
	(ii) Wet cast against soil	75	75	75	75	75
	(iii) Dry cast against soil	75	75	75	75	75
3. VERY SEVERE: Concrete surfaces exposed to aggressive water or a saline atmosphere	3.1 Surfaces in rivers polluted by industries	NA	NA	NA	60	50
	3.2 Cast in situ piles, wet cast against casings	NA	NA	NA	80	80
4. EXTREME: Concrete surfaces exposed to the abrasive action of very aggressive water	4.1 Surfaces in contact with industrially polluted water	NA	NA	NA	65	65
	4.2 Surfaces in contact with marshy conditions	NA	NA	NA	65	55

SERIES 6000: STRUCTURES

SECTION 6400: CONCRETE FOR STRUCTURES

CONTENTS:

6401 SCOPE

This Section covers the manufacture, transport, placing and testing of concrete used in the Works where plain, reinforced or prestressed concrete is specified.

6402 MATERIALS

(a) Cement

Cement used for concrete shall be any of the following:

(i) Cements complying with the requirements of US 310-1:2001 (CEM I or II), BS EN 197-1:2000, AASHTO M85-98 or equivalent standard on approval of the Engineer.

(ii) Sulphate-resistant cement conforming to the requirements of BS 4027:1996, but only where shown on the Drawings or instructed by the Engineer.

(iii) Blast-furnace cement may be used if specified in the Special Specifications, and shall comply with the requirements of US 310-1:2001 (CEM III), AASHTO M240-97 or equivalent standard on approval of the Engineer.

In prestressed concrete members or units the use of blast-furnace cement will not be permitted.

The type of cement to be used for different concrete members shall be set out in the Special Specifications.

(b) Aggregates

Both coarse aggregate (stone) and fine aggregate (sand) shall comply with the requirements of BS EN 1367-4:2002 or equivalent, subject to the following:

(i) The drying shrinkage of both the fine and coarse aggregate when tested in accordance with BS EN 1367:2002 or equivalent shall not exceed the following limits:

(1) For use in prestressed concrete, concrete bridge decks and slender columns the shrinkage of both fine and coarse aggregate shall not exceed 130% of that of the reference aggregate.

(2) For use in other reinforced concrete members the shrinkage of the fine aggregate shall not exceed 175%, and that of the coarse aggregate 150% of that of the reference aggregate.

(3) For use in mass concrete substructures and unreinforced concrete head walls and wing walls, the shrinkage of both the fine and coarse aggregate shall not exceed 200% of that of the reference aggregate.

Where there is any doubt about the shrinkage characteristics of aggregates, the Contractor shall submit a certificate by an approved laboratory which gives the shrinkage characteristics of the aggregate.

The drying shrinkage of concrete samples made from each of the required three concrete mixtures for preparing the compressive-strength and flexural-strength samples shall not exceed 0.04%.

(ii) The flakiness index of the stone as specified in BS 812-105.1:1989 shall not exceed 35%.

(iii) Aggregates shall not contain any deleterious amounts of organic materials such as grass, timber or similar materials and shall be free from clay, shale, pyrites and all other impurities.

(iv) Where there is any danger of a particular combination of aggregate and cement giving rise to a harmful alkali-aggregate reaction, the particular combination shall be tested in accordance with BS 812-123:1999, and, where the result points to such reaction, either the aggregate or the cement or both shall be replaced so that an acceptable combination may be obtained.

(v) The fineness modulus of the fine aggregate shall not vary by more than ± 0.2 from the approved modulus.

(vi) The coarse part of aggregate shall be roughly cubical in shape and free from excess flat and/or elongated particles.

(c) Boulders

Boulders used in concrete shall comply with the following

(i) The boulders shall be clean, durable and inert.

(ii) The aggregate crushing value may not exceed 25%.

(iii) The weight of each boulder shall be between 15 kg and 55 kg.

(iv) No dimension of any boulder shall be less than 150 mm or exceed 500 mm.

(d) Water

Water for use in mixing concrete and mortar and for curing and related purposes shall be obtained from a source approved by the Engineer and shall comply with the requirements of BS EN 1008:2002.

Water shall be clean, fresh and free from detrimental concentrations of acids, alkalis, salts, sugar and other organic or chemical substances that could impair the durability and strength of the concrete or the imbedded steel. The Contractor shall prove the suitability of the water by way of tests conducted by an approved laboratory. For reinforced and prestressed concrete the

chloride content of the mixing water shall not exceed 500 mg/l when tested in accordance with BS 6068-2.37:1990, SANS 5202/ SABS SM 202 or equivalent.

(e) Admixtures
Admixtures shall not be used in concrete without the approval of the Engineer who may require that tests be conducted before the admixtures be used to prove their suitability. Admixtures, if their use is allowed, shall comply with the following requirements:

(i) Admixtures shall be used only in liquid form and shall be batched in solution in the mixing water by a mechanical batcher capable of dispensing the admixture in quantities accurate to within 5% of the required quantity.

(ii) All admixtures shall comply with the requirements of ASTM C-494 or AASHTO M-194 and shall be of an approved brand and type.

(iii) Air entraining agents shall comply with the requirements of ASTM C-260 or AASHTO M-154.

(iv) Admixtures shall not contain any chlorides.

(f) Curing agents
Curing agents shall be tested in accordance with ASTM C-156 and shall comply with the requirements of ASTM C-309, except that the loss of water within 72 hours shall not exceed 0.40 kg/m^2. Only approved curing agents shall be used.

Curing agents shall be clear or pigmented as specified or required by the Engineer. A certificate from an approved testing laboratory stating that the curing compound complies with the specified requirements shall be submitted to the Engineer.

Irrespective of the above specifications being met, the curing compound shall be the type that can be applied to a wet surface without loss of stability or impairment of its water retention properties.

6403 STORING THE MATERIALS

(a) Cement
Cement stored on the site shall be kept under cover which provides adequate protection against moisture and other factors which may promote deterioration of the cement.

If more than one type of cement is to be used in the Works, the storage space shall be suitably subdivided to the satisfaction of the Engineer and great care shall be exercised to ensure that different types of cement do not come into contact with each other. The Engineer shall be furnished with the means of identifying the various consignments of cement delivered.

When the cement is supplied in bags, the bags shall be closely and neatly stacked to a height not exceeding 12 bags and arranged so that they will not be in contact with the ground or the walls and can be used in the order in which they were delivered to the site.

Cement shall not be kept in a temporary store except where it is necessary for the efficient organisation of the mixing station, and only when the prior approval of the Engineer has been obtained.

Where silos are used for the storage of cement, each silo shall be completely separate and fitted with a filter or an approved alternative method of dust control. Each filter or dust control system shall be of sufficient size to allow delivery of cement to be maintained at a specified pressure and shall be maintained to prevent undue emission of dust to prevent interference with weighing accuracy by build up of pressure. Cement drawn for use from silos shall be measured by weight and not by volume.

Cement shall not be kept in storage for longer than eight weeks without the Engineer's permission, and different brands and/or types of the same brand of cement shall be stored separately.

(b) Aggregates
Aggregates of different nominal sizes shall be stored separately and in such a manner as to avoid segregation occurring. Intermixing of different materials and contamination by foreign matter shall be avoided. Aggregates exposed to a saline environment shall be covered to protect them from salt contamination.

Where concrete is batched on site, the aggregates shall be stored in bins with a 3 m wide concrete apron slab constructed around the outer edge of the aggregate stockpile area, to prevent contamination during the process of tipping and removing the aggregate. The aggregates shall be tipped on the concrete apron slab. The storage bin shall have a concrete floor of 150 mm thickness.

The Contractor may be required to carry out on Site supplementary processing and/or effective washing of aggregates where in the opinion of the Engineer such action is necessary to ensure that all aggregates comply fully with the requirements of this Specification at the time when concrete materials are batched and mixed. Methods used for processing and washing aggregates shall be subject to the approval of the Engineer.

(c) Storage capacity
The storage capacity provided and the quantity of material stored (whether cement, aggregates or water) shall be sufficient to ensure that no interruptions to the progress of the work will be occasioned by the lack of any materials.

(d) Deteriorated material
Deteriorated or contaminated or otherwise damaged material shall not be used in concrete. Such material shall be removed from the site without delay.

6404 CONCRETE QUALITY

(a) General
Concrete shall comply with the requirements for strength concrete or prescribed-mix concrete, as specified in SUBCLAUSES 6404(b) and (c).

The total alkaline content (Na_20 equivalent) of the concrete shall be limited taking into account the degree of reactivity as specified in SUBCLAUSE 6402(b).

(b) Strength concrete
The Contractor shall be responsible for the design of the concrete mix and for the proportions of the constituent materials necessary for producing concrete which complies with the requirements specified below for each class of concrete.

The class of concrete is indicated by the characteristic 28-day cube crushing strength in MPa and the maximum size of coarse aggregate in the mix.

E.g. **CLASS 30/38** concrete means concrete with a characteristic cube crushing strength of 30 MPa after 28 days and a maximum sized coarse aggregate of 38 mm.

The aggregate size shall be selected in accordance with US 101:2000, BS 882:1992 and BS EN 12620:2002, SANS 1083 or equivalent.

Characteristic strength shall be defined as that value of the cube strength below which not more than 5% of the results of all possible cube strength measurements of the specified concrete are expected to fall.

The characteristic cube crushing strength of strength concrete shall be of any strength from 15 MPa, in increments of 5 MPa, up to 60 MPa, as indicated on the Drawings or in the Bill of Quantities or as may be prescribed by the Engineer. The strengths preferred are 15, 20, 25, 30, 40, 50 and 60 MPa.

The cement content for any class of concrete shall not exceed 500 kg per cubic metre of concrete.

Where for reasons of durability or other considerations, concrete is designated by the prefix "W".

E.g. **CLASS W30/19**, such designations shall denote concrete having a cement content not less than and a water:cement ratio not exceeding the limits given in the Special Specifications.

In such cases, characteristic cube compressive strengths should be:

(i) the specified 28-day characteristic cube compressive strength, or

(ii) a characteristic cube compressive strength corresponding to the designated maximum water:cement ratio, or

(iii) a characteristic cube compressive strength corresponding to the designated cement content.

Before starting with any concrete work on the site, the Contractor shall submit, for approval, samples of the constituent materials of the concrete and a statement of the mix proportions that he/she proposes to use for each class of concrete indicated in the Bill of Quantities.

Where any change occurs in the material sources, the aggregate sizes, or any other components of the concrete, the above procedure shall be repeated.

The samples submitted shall be accompanied by evidence that they comply with the requirements for the various materials specified. The statement regarding the mix proportions shall be accompanied by evidence establishing that concrete made from the materials in the proposed proportions will have the specified properties.

Evidence shall be in the form of:

(i) a statement regarding the test results, which shall be furnished by an approved laboratory; or

(ii) an authoritative report on previous use of and experience in regard to the material.

The actual mix proportions used as well as any changes thereto shall be subject to the Engineer's approval, but such approval shall not in any way relieve the Contractor of his/her responsibility for producing concrete with the specified properties.

The Contractor is cautioned that the quality of cement may vary from consignment to consignment so as to necessitate adjustments in the cement content of mixes. In order to ensure a uniform quality of concrete, the Contractor shall obtain from the manufacturer the data regarding the relevant cement quality for each consignment with a view to ascertaining the required adjustment in the cement content. This information shall be submitted to the Engineer.

(c) Bleeding
The concrete shall be so proportioned with suitable materials that bleeding is not excessive.

(d) Consistency and workability
The concrete shall be of suitable workability for the nature of the work to be executed without the excessive use of water so that it can be readily compacted into the corners of the formwork and around the reinforcement, tendons and ducts without the material segregating. The maximum free water:cement ratio under any circumstances is 0.5.

Slump measurements obtained in accordance with the test method described in BS EN 12350-2:2000 on concrete used in the Works shall fall within the ranges specified in TABLE 6404/1.

TABLE 6404/1
SLUMP VALUES

Type of construction	Slump (mm) *)	
	Max	Min
Prestressed concrete	75	25
Concrete nosings and pre-fabricated units	75	50
Mass concrete	100	25
Reinforced concrete footings, cast in situ piles (except dry-cast piles), slabs, beams and columns	125	50

***)** Where high-frequency vibrators are used, the values shall be reduced by one-third.

(e) Sulphate content
The total water-soluble sulphate content of the concrete mix, expressed as SO_3, shall not exceed 4% (m/m) of the cementitious binder content of the mix. The sulphate content shall be calculated as the total from the various constituents of the mix using the following test methods:

- Cementitious binder : - BS 1881-124:1998 or equivalent
- Aggregates : - BS 882:1992 or BS EN 12620:2002 or equivalent
- Water : - BS 6068-2.39:1991 or ISO 9280:1990 or equivalent

(f) Pumped concrete
Where pumping of the concrete is approved by the Engineer, the concrete mix to be pumped shall be so designed that:

(i) settlement will not exceed 125 mm;

(ii) graded aggregate and suitable admixtures be used, wherever necessary, with a view to improving the pumpability of the mix; and

(iii) its shrinkage capacity shall not be excessively higher than that of ordinary concrete mixes.

(g) Concrete classification
Concrete for use in the Works shall comply with the requirements of BS EN 206-1:2000. It shall be classified as shown in Table 6404/2 herein. The class of concrete is denoted by the 28-day characteristic strength and the

nominal maximum aggregate size. Characteristic strength shall be defined as that value of the cube strength below which not more than 5% of the results of all possible cube strength measurements of the specified concrete are expected to fall.

The class of concrete to be used in each part of the Works shall be as stated in the Bill of Quantities or on the Drawings.

TABLE 6404/2
CLASSES OF CONCRETE

Class of concrete	Type of construction	Minimum cement content / m^3		Minimum strength	
		Sulphate resisting (kg)	Common Cements (kg)	Characteristic (MPa)	Mean (MPa)
30/14	All precast work	390	360	30	45
25/20	Normal RC structures	360	330	25	40
20/40	Pipeline protection; benching in manholes and chambers; blinding concrete; mass concrete structures	270	290	20	35
7/40	Kerb foundation or haunch; filling to overbreak	270	290	7	11.6

Notes:

1. The values in column 5 may be adjusted subject to compliance with the requirements given in SUBCLAUSES 6404(b) and (c).

2. The maximum free water/cement ratio is 0.5.

6405 MEASURING THE MATERIALS

(a) Cement
Where cement is supplied in standard bags, the bags shall be -ascertained to contain 50 kg. All cement taken from bulk-storage containers and from partly used bags shall be batched by weight, accurate to within 3% of the required weight.

(b) Water
The mixing water for each batch shall be measured, either by weight or by volume, accurate to within 3% of the required quantity. The quantity of water added to the mix shall be adjusted to make allowance for moisture in the aggregates.

(c) Aggregates
All aggregates for strength concrete shall be measured separately by weight, except as otherwise provided in this Clause, accurate to within 3% of the required quantity.

Aggregates for strength concrete may be volume batched subject to the approval of the Engineer, and on condition that the quantity of cement is increased, at the Contractor's own expense, by 25 kg/m^3 of concrete, over and above the quantity which would have been necessary were the aggregate to have been batched by weight.

Aggregates for prescribed-mix concrete as specified in SUBCLAUSE 6404(c) may be measured separately by volume. Batching boxes for volume batching shall be filled without any tamping, ramming or consolidating the material (other than that occurring naturally during the filling of the container), and shall be screeded off level with their topmost edges.

Any adjustment to the volume shall be made by supplementary containers of a suitable size being used. Adjustments to the volume, by the incomplete filling of batching boxes to marks on their inside faces will not be permitted.

Fine aggregate shall be tested for bulking at the beginning of and halfway through each concreting shift, and adjustment shall be made to the batch volume to give the true volume required.

The measurement of cement in gauge boxes will not be permitted, and volume batching shall be so planned as to use full bags of cement.

6406 MIXING

(a) General
Mixing the material for concrete shall be conducted by an experienced operator. Unless otherwise authorised, mixing shall be carried out in a mechanical batch-mixer of an approved type which will be capable of producing a uniform distribution of ingredients throughout the batch.

(b) Charging the mixer
The sequence of charging the ingredients shall be subject to approval by the Engineer, and, unless otherwise instructed, the same sequence of charging the ingredients shall be maintained.
The volume of the mixed material by batch shall not exceed the volume recommended by the manufacturer of the mixer.

(c) Mixing and discharging
The period of mixing shall be measured from the time when all the materials are in the drum until the commencement of discharge.

Concrete shall be mixed in a batch type mixer manufactured in accordance with BS 1305:1974 and to the approval of the Engineer. Mixing for each batch shall continue until there is uniform distribution of the materials and uniformity of colour and consistency of the concrete. Admixtures for which approval in writing has been given by the Engineer shall be introduced into concrete by means of automatic dosing equipment. Such equipment shall feed a fixed quantity of admixture into the mixing water before the latter is discharged into the mixer and shall be subject to the approval of the Engineer.

The mixing period for the materials shall be 90 seconds and may be reduced only if the Engineer is satisfied that the reduced mixing time will produce concrete with the same strength and uniformity as concrete mixed for 90 seconds. The reduced mixing time, however, shall be not less than 50 seconds or the manufacturer's recommended mixing time whichever is the longer. A suitable timing device shall be attached to the mixer to ensure that the minimum mixing time for the materials has been complied with.

The first batch to be run when starting with a clean mixer shall contain only 2/3 of the required quantity of

coarse aggregate to make provision for "coating" the mixer drum. Discharge shall be so carried out that no segregation of the materials will occur in the mix. The mixer shall be emptied completely before it is recharged with fresh materials.

The Contractor shall take particular care to ensure that the mixer drum is washed and cleaned out immediately following the completion of each concreting operation or when changing a mix using a different type of cement.

Under certain conditions the Engineer may sanction hand mixing, in which case the concrete shall be made on a flat watertight platform or suitable area. The cement and aggregate shall be spread in thin layers and mixed dry until a uniform colour is obtained. Water shall be added and the mixture turned over at least three times or until the concrete is of uniform colour and consistency throughout.

(d) Maintaining and cleaning the mixer
If the mixer has stopped running for a period in excess of 30 minutes, it shall be thoroughly cleaned-out particular attention being given to the removal of any build-up of materials in the drum, in the loader, and around the blades or paddles. Worn or bent blades and paddles shall be replaced.

Before any concrete is mixed, the inner surfaces of the mixer shall be cleaned and all hardened concrete removed.

(e) Standby mixer
When sections are cast where it is important for the casting to continue without interruption, a standby mixer shall be held in readiness to run on 15 minutes notice should the stock mixers break down.

(f) Ready-mixed concrete
Where ready-mixed concrete is delivered at the site, the requirements of BS 5328 or BS EN 206-1:2000 or equivalent shall have priority over the requirements specified in this Section should inconsistencies occur.

6407 TRANSPORTING, PLACING AND COMPACTING

(a) General
Concrete shall be handled from the place of mixing to the place of final deposit as rapidly as practicable by means that will prevent segregation or loss of any ingredient. Wherever practicable, concrete shall be emptied from a mixer directly into the skip which shall then be transported to the place of final deposit and the concrete shall be discharged as close as possible to its final position to avoid rehandling or flowing.

Should the Contractor propose to use concrete pumps for the transporting and placing of concrete he shall submit full details of the equipment and operating techniques he proposes to use for the approval of the Engineer.

Where concrete is conveyed by chuting or pumping, the equipment used shall be designed to ensure continuous and unimpeded flow in the chute or pipe. The delivery end of the chute or pipe shall be thoroughly flushed with water before and after each working period and shall be kept clean. Water used for this purpose shall be discharged away from any permanent works.

Concrete shall not be placed in any part of the Works until the Engineer's approval has been given. If concreting is not started within 24 hours of approval having been given, approval shall again be obtained from the Engineer.

Concreting operations shall be carried out only during daylight hours unless proper lighting arrangements have been made and the lights are in working order before mixing of the concrete commences. Workmen shall not be allowed to work double shifts and the Contractor shall provide a fresh team for night shifts.

Sufficient material to afford full production to a concrete pour shall be available at the place of work prior to the commencement of concreting.
Placing and compacting the concrete shall at all times be under the direct supervision of an experienced concrete supervisor.

Once the casting of concrete has begun, it shall be carried out in a continuous process between construction joints. Concrete shall be placed within 60 minutes from the start of mixing. These times may be extended by the Engineer where a retarding admixture has been used. All excavations and other contact surfaces of an absorbent nature such as timber formwork shall be damp but no standing water shall be permitted to remain on these surfaces. The formwork shall be clean on the inside.

Water quality, freshwater life or any other sensitive environment shall not be adversely affected in any way.

(b) Placing
Whenever possible, concrete shall be deposited vertically into its final position. Unless otherwise agreed by the Engineer on the basis of satisfactory site trials, concrete shall not be dropped into place from a height exceeding 1 metre. Where chutes are used, their length and slope shall be such as not to cause segregation, and suitable spouts and baffles shall be provided at the lower end to minimise segregation. The displacement of concrete by vibration instead of by direct placing is not permitted.

Care shall be taken when casting bridge decks of a substantial thickness to avoid layering of the concrete, and the entire thickness shall be placed in one pass. Fresh concrete shall not be placed against concrete which has been in position for more than 30 minutes unless a construction joint has been formed or unless a retarding additive has been used in the concrete.

The pumping of concrete shall be subject to approval by the Engineer. Aluminium pipes shall not be used for this purpose.

In plain concrete with a thickness of not less than 300 mm, boulders may, if approved, be included to displace concrete for up to 20% of the total volume, provided that:

(i) the boulders are spread evenly throughout the concrete;

(ii) no boulder laid shall have a dimension exceeding one third of the smallest dimension of the concrete in any plane, and

(iii) each boulder is surrounded by at least 75 mm of concrete.

(c) Placing under water
Placing under water shall be allowed only in exceptional circumstances where it is not feasible to dewater the location before the concrete is placed. No concrete shall be placed in running water.

Underwater concrete shall be placed by means of tremies. Full details of the method proposed by the Contractor shall be submitted in advance for approval. Placing by skip or pipeline will also be considered under certain circumstances as approved by the Engineer.

During concreting by tremie, the pipe shall be kept filled with concrete at all times to prevent air and water from entering the tremie. When the tremie is charged, an approved sliding plug shall be used. Once concreting has begun by tremie, the discharge end of the tremie shall be kept well below the surface of the concrete. Should this seal be broken, the tremie shall be lifted and plugged before concreting is recommenced. Distribution of concrete by lateral movement of the tremie will not be permitted.

The concrete mix to be placed underwater shall be specially designed and approved for this purpose to ensure good flowability, plasticity and cohesion. Increased sand and cement contents over those of normal mixes will usually be required.

(d) Compaction
The Contractor shall regard compacting of concrete as work of fundamental importance, the object of which is to produce a watertight concrete of maximum density and strength.

Concrete shall be fully compacted by approved means during and immediately after placing. It shall be thoroughly worked against the formwork, around reinforcement bars, tendons, ducts and embedded fittings and into corners to form a solid mass free from voids.

The concrete shall be free from honeycombing and planes of weakness, and successive layers of the same lift shall be thoroughly bonded together.

Unless otherwise permitted by the Engineer, concrete shall be compacted by means of vibrators of an approved design. Internal vibrators shall be capable of producing not less than 10000 cycles per minute and external vibrators not less than 3000 cycles per minute. A sufficient number of vibrators shall be used to handle the maximum rate of concrete production with an allowance for breakdowns and spares.

Vibration shall be applied by experienced labourers, and over-vibration resulting in segregation, surface water and leakage shall be avoided. Contact with reinforcement and formwork shall, in so far as is practicable, be avoided when internal vibrators are used. Concrete shall not be subjected to disturbance by vibration within 4 to 24 hours of it having been compacted.

Concrete that has partially set before placing shall not be used and shall be removed from site.

Whenever vibration is applied externally, the design of the formwork and positioning of vibrators shall be such as to ensure efficient compaction and avoidance of surface blemishes.

Special attention shall be given to the compaction of concrete in the anchorage zones and behind the anchor plates and in all places where high concentrations of reinforcing steel or cables occur.

Where the placing and compaction of concrete is difficult, a mix containing smaller sized aggregate may be used but only with the approval of the Engineer and after a mix containing such aggregate has been designed and tested.

When placing concrete against horizontal or inclined elements of waterstops, the latter shall be lifted and the concrete placed and compacted to a level slightly higher than the underside of the waterstop before releasing the waterstop to ensure complete compaction of the concrete around the waterstop.

(e) Requirements in respect of sliding formwork
Where sliding formwork is used, the following additional requirements shall apply:

(i) The Contractor shall take all the necessary measures to ensure the continuity of operations. All the necessary lighting and standby equipment for mixing, hoisting, placing and compacting shall be provided and all the materials required for completing each structure shall be ready on the site before casting commences.

(ii) Concrete shall be cast in uniform layers in the formwork so that the level of the top surface of the concrete differs by no more than 250 mm between any two points in the formwork. In addition, the top level of the concrete shall never be so low down in the formwork as will cause structural instability in the formwork. The working platform shall be kept clean and no concrete which has dried out in part may be swept into the formwork.

(iii) The concrete shall be compacted during and immediately after placing. Care shall be taken not to damage or disturb previously placed concrete. To ensure the proper bonding of successive layers not more than one hour shall elapse between the placing of successive layers except where an approved admixture has been applied, in which case the delay may be amended in consideration of such circumstances.

(iv) The slump of concrete may be up to 150 mm should the approved method of sliding so require.

6408 CONSTRUCTION JOINTS

(a) General
The Contractor shall submit for approval by the Engineer his proposals for the position of construction joints having due regard to any that may be shown in the drawings.

Concreting shall be carried out continuously up to the construction joints shown on the working drawings or as approved, except that if, because of an emergency (such as breakdown of the mixing equipment or the occurrence of unsuitable weather), concreting has to be interrupted, a construction joint shall be formed at the place of stoppage and in the manner which will least impair the durability, appearance, and proper functioning of the concrete.

Unless otherwise shown on the Drawings, the exact position of horizontal construction joints shall be marked on the framework by means of grout checks in order to obtain truly horizontal joints.

Joint lines shall be clean, true and regular and, wherever possible, arranged to coincide with features of the finished work.

Stub columns, stub walls and stays on footings shall be cast integrally with the footings and not afterwards, even where another class of concrete is being used.

In all cases vertical stop boards of a form to be approved by the Engineer shall be provided at the end of each section of work which is to be concreted in one operation, and the concrete shall be thoroughly consolidated against these stop boards.

(b) Preparing the surfaces
When the concrete has set and while it is still green, the surface film and all loose material shall be removed without disturbing the aggregate, by means of a water

jet assisted by light brushing to expose the aggregate and leave a sound, irregular surface. Where this is not possible, the surface film shall be removed after the concrete has hardened, by mechanical means appropriate to the degree of hardness of the concrete so as to expose the aggregate and leave a sound, irregular surface. The roughened surface shall be washed with clean water to remove all laitance, dirt and loose particles.
Surface retarding agents may be used only with the approval of the Engineer.

(c) Placing fresh concrete at construction joints
Where fresh concrete is placed the same day as that on which the construction joint was formed, the fresh concrete shall be cast directly against the face of the construction joint.

When concreting recommences a day or more after the construction joint has been formed, the following procedure shall be followed:

(i) The construction joint shall be kept constantly wet for a period of at least six hours. The surface shall be in a saturated, surface dry condition when concreting has to recommence.

(ii) Any dirt, excess water and loose particles shall be removed prior to re-concreting being started.

(iii) For horizontal construction joints a 25 mm thick concrete layer of the same grade of concrete made richer by reducing the coarse aggregate content by 25% shall be placed on the joint plane immediately before concreting.

(iv) For vertical construction joints the fresh concrete shall be placed against a surface prepared in accordance with SUBCLAUSE 6408(b), which is in a saturated, surface-dry condition.

Epoxy resins specially designed for bonding old concrete to new shall be used at construction joints where so specified. The preparation of the construction joint surface and the application of the epoxy resin shall be strictly in accordance with the manufacturer's recommendations and the Engineer's instructions. The actual brand and type of resin used shall be subject to the Engineer's approval.

6409 CURING AND PROTECTING

Formwork shall be retained in position for the appropriate times given in CLAUSE 6206, and as soon as may be practicable, all exposed concrete surfaces shall be protected from loss of moisture by one or more of the following methods:

(a) Method 1
Retaining formwork in place for the full curing period.

(b) Method 2
Ponding the exposed surfaces with water, except where atmospheric temperatures are low, i.e. less than 5°C.

(c) Method 3
Covering it with sand or mats made from a moisture-retaining material, and keeping the covering constantly wet.

(d) Method 4
Constantly spraying the entire area of the exposed surfaces with water (only on surfaces where sand cover or ponding is impossible).

(e) Method 5
Covering with a waterproof or plastic sheeting firmly anchored at the edges.

(f) Method 6
Using an approved curing compound applied in accordance with the manufacturer's instructions, except that, where the surface has to be subsequently waterproofed, coated or gunited, this method may not be used.

(g) Method 7
Steam curing the concrete (precast units).

(h) General
The method of curing adopted shall be subject to the Engineer's approval and shall not cause staining, contamination, or marring of the surface of the concrete.

The curing period shall be continuous for at least seven days for concrete made with common cements, and at least 10 days if Portland blast-furnace cement or a 50/50 mixture of Portland cement and ground granulated blast-furnace slag is used. When the temperature of concrete falls below 5°C, these minimum curing periods shall be extended by the period during which the temperature of the concrete was below 5°C.

When sliding formwork is used, the concrete shall be protected against the weather and rapid drying out by means of a 4 m wide skirt attached to the lower perimeter of the formwork and hanging over the working platform. The skirt shall consist of hessian in the dry seasons and of canvas or other suitable material inthe wet seasons. The skirt shall be weighted at the bottom to prevent it flapping in windy conditions.
The concrete shall be cured by means of a fog spray to keep it wet constantly for the periods stated above or until a curing compound is applied. Wetting the concrete by spraying shall be by means of a fixed spraybar along the full length of the sliding formwork. The spraybar shall be connected to a suitable high-pressure water supply. Wetting shall be discontinued when the ambient air temperature drops below 5°C, and care shall be taken by the Contractor to ensure that the water will not erode the surface of the fresh concrete.

6410 ADVERSE WEATHER CONDITIONS

(a) Cold weather
Concrete shall not be placed during falling temperatures when the ambient air temperature falls below 7°C or during rising temperatures when the ambient air temperature is below 3°C. When concrete is placed at air temperatures below 5°C the concrete temperature shall not be below 10°C, for which purpose heating of the water and/or the aggregate shall be permitted. The Contractor shall make all the necessary arrangements for heating the material. Heated water and aggregate shall first be mixed and the cement shall then be added only while the temperature is below 30°C.

The temperature of placed concrete shall not be allowed to fall below 5°C until the concrete has attained a strength of at least 5 MPa, and the Contractor shall be responsible for all protective measures necessary to this end. All concrete damaged by casting at temperatures less than 5°C shall be removed and replaced by the Contractor at this own expense.

The Contractor shall provide a thermometer suitable for measuring the temperature of aggregates, and a maximum and minimum thermometer, which shall be hung in a position, indicated by the Engineer.

(b) Hot weather

When the ambient air temperature exceeds 30°C during concreting, the Contractor shall take measures to control the temperature of the concrete ingredients so that the temperature of the placed concrete will not exceed 30°C unless otherwise determined by the Engineer. Such measures include spraying aggregate stockpiles with water to promote cooling down by evaporation and, where feasible, shading the stockpiles and the area where concreting is carried out. Curing shall commence immediately after concrete has been placed to prevent an excessive loss of moisture.

Formwork shall be shaded from direct exposure to the sun both prior to the placement of concrete and during its setting. The Contractor shall take appropriate measures to ensure that reinforcement in and projecting from the section to be concreted is maintained at the lowest temperatures practicable.

(c) Precautionary measures for using sliding formwork

During sliding operations in cold weather, the water only, or the water and the aggregate, shall be heated to ensure that the concrete temperature will not drop below 10°C until it has attained a strength of 5 MPa.

During cold weather the rate of sliding shall be suitably decreased to ensure sufficient strength in the concrete which leaves the bottom of the formwork.

6411 PIPES AND CONDUITS

No pipes and conduits other than those shown on the Drawings shall be embedded in the concrete without the Engineer's approval. The clear space between such pipes or between such pipes and any reinforcing steel shall be at least 40 mm or the maximum size of the aggregate plus 5 mm, whichever is the greater. The thickness of the concrete cover over pipes and fittings shall be at least 25 mm.

The ends of all ferrules used for bracing formwork shall be neatly finished off to the details shown on the Drawings. Where no details are given on the Drawings, ferrules shall be cut back to a depth of at least the specified cover, and the holes shall be filled in with mortar and finished off flush with the concrete surface.

6412 APPLIED LOADING

No load shall be applied to any part of a structure until the specified curing period has expired, after which applied loading shall be allowed only when approved by the Engineer. The Engineer's decision will be based on the type of load to be applied, the age of the concrete, the magnitude of stress induced and the propping of the structure. No structure shall be opened to traffic until test cubes made from the concrete in all parts of the structure have attained the specified minimum 28-day compressive strength.

The Contractor shall not permit backfilling around any structure incorporating a ground or floor slab before that slab has been cast and properly cured and the concrete has attained its specified 28-day strength.

6413 PRECAST CONCRETE

This Clause applies to all reinforced and prestressed concrete members other than precast concrete piles, culverts and pipes in so far as they are dealt with separately elsewhere in these Specifications.

All precast members shall be manufactured in accordance with the requirements specified for cast in situ members in so far as these requirements are relevant. In addition, the following shall apply:

(a) The Contractor shall take all necessary safety and precautionary measures during the handling and erection of precast members and for ensuring the stability of members as positioned and prior to their being cast in.

(b) Where precast concrete members have not been manufactured on the site, the manufacturer shall keep and make available to the Engineer complete records of all the concrete mixes and strength tests pertaining to the members cast. The Contractor shall notify the Engineer in advance of the dates on which members are to be cast so that arrangements for inspecting and testing the precast members can be made.

Precast concrete units shall not be moved or transported from the place of casting until they are properly cured and the concrete has achieved its specified 28-day strength.

(c) For the purposes of identification, all members shall be marked with paint in neat lettering with the member number shown on the Drawings or as agreed on and an identification number relating to the manufacturing records. Letters etc shall be so positioned as not to be visible when the structural member is placed in its final position in the completed structure.

(d) All precast members which have been chipped, cracked, warped or otherwise damaged to the extent that such damage will, in the opinion of the Engineer, prejudice the appearance, function or structural integrity of the members shall be rejected or, where so allowed, repaired to the satisfaction of the Engineer.

6414 QUALITY OF WORKMANSHIP AND MATERIALS

(a) Criteria for compliance with the requirements

Routine inspection and quality control will be done by the Engineer as specified in SECTION 7200. The criteria for compliance with the requirements specified for 28-day characteristic compressive strength shall be as specified in CLAUSE 7205 for full acceptance, and as specified in CLAUSE 7207 for conditional acceptance. The re-submission of concrete lots on the basis of cores for full or conditional acceptance shall not be allowed. The Contractor's attention is drawn to CLAUSE 7208. If the Engineer is satisfied that the requirements of the Contractor's process control have been met, the Engineer may decide at his/her discretion to use the Contractor's test results in the evaluation of the concrete.

(b) Procedure in the event of non-compliance with the requirements

Any lot represented by test cubes failing to comply with the criteria specified for the characteristic strength shall be rejected, or the Engineer may at his/her discretion allow the following tests to be conducted in order to decide whether the concrete may be left in position at further reduced payment:

(i) The Engineer may allow the elements or units concerned to be cured for an additional period not exceeding 56 days. Thereafter the Contractor shall drill cores in accordance with BS EN 206-1:2000 or BS 5328 or equivalent, and the Engineer will evaluate these cores in accordance with BS 8110-1:1997 or equivalent.

(ii) Where the Engineer so directs, full-scale load tests shall be conducted in accordance with BS 8110-1:1997 or equivalent to determine whether any particular structure or member can be left in position. The cost of such tests shall be for the

Contractor's account regardless of the outcome of the tests.

In all cases where concrete has been supplied which fails to comply with the strength requirements, the Contractor shall immediately take the required remedial action by changing the mix proportions to obtain the required strength.

(c) Tests ordered by the Engineer
Where the routine testing of concrete cubes is not conducted on the site by the Engineer, he/she may order the Contractor to have the concrete cubes, which have been made by the Engineer, tested at an approved testing laboratory, in which case no separate payment will be made for such tests.

6415 DEMOLITION AND REMOVAL OF EXISTING CONCRETE

Where partial demolition is required for extension work to existing structures the first three paragraphs of CLAUSE 2214 shall apply. In addition the following shall apply:

(a) The Contractor shall take great care to ensure that the reinforcement required to tie in the extension work is not cut off or damaged in the demolition process. Where reinforcement has been cut off, or where in the opinion of the Engineer, the reinforcement has been damaged to such an extent that it will not adequately perform its function, the Contractor shall, at his/her own expense, install dowel bars of the same diameter as the bar cut off or damaged, all to the satisfaction of the Engineer.

(b) Only hand operated breaking equipment shall be used for the demolition of concrete where extension work is required.

6416 MEASUREMENT AND PAYMENT

ITEM		UNIT
64.01	CAST IN SITU CONCRETE:	
(a)	(CLASS OF CONCRETE AND PART OF STRUCTURE OR USE INDICATED)	CUBIC METRE (m^3)
(b)	DITTO FOR OTHER CLASSES OF CONCRETE AND OTHER USES OR PARTS OF THE STRUCTURE	CUBIC METRE (m^3)

The unit of measurement for cast in situ concrete shall be the cubic metre of concrete in place. Quantities shall be calculated from the dimensions shown on the Drawings or as authorised. No deduction in volume measured for payment shall be made for the volume of any reinforcing steel, inserts and pipes or conduits under 150 mm in diameter embedded in the concrete.

The bid rate shall include full compensation for procuring and furnishing all the materials, storing the materials, providing all equipment, mixing, transporting, placing and compacting the concrete, forming the inserts, construction joints (except mandatory construction joints) and contraction joints, curing and protecting the concrete, repairing defective surfaces, and finishing the concrete surfaces as specified. Payment shall distinguish between the different classes of concrete.

ITEM		UNIT
64.02	MANUFACTURING PRECAST CONCRETE MEMBERS (DESCRIPTION OF MEMBER WITH REFERENCE TO DRAWING)	NUMBER (no)

The unit of measurement shall be the number of complete members or elements of each type and size in position in the Works.

The bid rate for each precast member shall include full compensation for concrete work, formwork, reinforcing steel and prestressing as required for manufacturing the member complete, excluding only prestressing in connection with in situ concrete cast subsequent to the placing of the precast members for which prestressing payment is separately provided elsewhere in the Bill of Quantities.

ITEM		UNIT
64.03	TRANSPORTING AND ERECTING PRECAST CONCRETE MEMBERS (DESCRIPTION OF MEMBER AND APPROXIMATE MASS TO BE GIVEN)	NUMBER (no)

The unit of measurement shall be the number of precast concrete members of each type and size placed into position.

The bid rate for each precast member shall include full compensation for all work, costs and equipment required for transporting, erecting and placing into position the precast concrete members.

ITEM		UNIT
64.04	EPOXY BONDING OF NEW CONCRETE SURFACES TO OLD	SQUARE METRE (m^2)

The unit of measurement shall be the square metre of new concrete surface bonded to old by means of an approved epoxy bonding agent as set out in the Specifications. The bid rate shall include full compensation for preparing the surfaces, furnishing and applying the bonding agent and for chamfering the concrete on visible joints, complete as shown on the Drawings.

ITEM		UNIT
64.05	EXTRA OVER ITEM 64.01 OR 64.02 FOR THE USE OF SULPHATE-RESISTANT CEMENT IN CONCRETE	CUBIC METRE (m^3)

The unit of measurement shall be the cubic metre of concrete manufactured with sulphate-resistant cement and placed in accordance with the details on the Drawings, or as instructed by the Engineer.

The bid rate shall be extra over each of the relevant rates for which sulphate resistant cement is used.

ITEM		UNIT
64.06	DEMOLISHING EXISTING CONCRETE:	
(a)	PLAIN CONCRETE (MEMBER INDICATED)	CUBIC METRE (m^3)
(b)	REINFORCED CONCRETE (MEMBER INDICATED)	CUBIC METRE (m^3)

The unit of measurement shall be the cubic metre of plain or reinforced concrete demolished for each member or portion thereof scheduled separately in the Bill of Quantities.

The bid rate shall include full compensation for all labour and equipment required to demolish the existing concrete and disposal of the product of the demolition to an approved disposal site.

The bid rate shall also include full compensation for any necessary measures to ensure no debris falls into watercourses and for any debris that has fallen into watercourses to be recovered.

SERIES 6000: STRUCTURES

SECTION 6500: PRESTRESSING

CONTENTS:

6501 SCOPE

This Section covers the materials, equipment and work required for prestressing structural concrete members.

6502 DEFINITIONS

The following definitions shall apply to these Specifications:

(a) Anchorage
Anchorage is the device comprising all the components and materials required for retaining the force in a tensioned tendon and to transmit this force to the concrete of the structure.

(b) Anchorage reinforcement
Anchorage reinforcement is the spiral and other reinforcement which forms part of the anchorage and is required for strengthening the anchorage and/or assisting in transmitting the tendon force to the concrete.

(c) Bursting reinforcement
Bursting reinforcement is the reinforcing steel required in and adjacent to the anchorage zones to resist the tensile stresses induced in the concrete by the anchorage(s).

(d) Cable
Cable is the tendon, together with the anchorage, sheathing and all fittings.

(e) Characteristic strength
Characteristic strength of prestressing steel is the manufacturer's guaranteed tensile strength below which no more than 5% of the test results in a statistical population shall fall.

(f) Duct
Duct is the void formed to house the tendon(s) and may be formed by coring, or by using sheaths or by way of extractable cores.

(g) Prestress
Prestress is the stress induced in concrete by tensioned tendons.

(h) Prestressed concrete
Prestressed concrete is structural concrete in which effective internal stresses are induced by means of tensioned tendons.

(i) Pre-tensioned concrete
Pre-tensioned concrete is prestressed concrete where the tendon is tensioned before the concrete has been cast.

(j) Post-tensioned concrete
Post-tensioned concrete is prestressed concrete where the tendon is tensioned after the concrete has hardened.

(k) Pull-in
Pull-in is the elastic shortening of the tendon caused by relative movement between the anchorage or coupler components on account of seating and gripping action during or immediately after transfer.

(l) Release
Release is the specified elastic shortening of the tendon at the anchorage achieved before or during transfer.

(m) Sheath
Sheath is the tube or casing enclosing the tendon and which temporarily or permanently allows a relative movement between the tendon and the surrounding concrete.

(n) Tendon
Tendon is the prestressing steel consisting of the bar, wire or strand individually placed, or of bars, wires or strands placed in a duct, all of which are tensioned to impart prestress to a concrete member.

(o) Tensioning
Tensioning is the action of inducing and regulating the force in a tendon by means of tensioning and measuring equipment.

(p) Transfer
Transfer in the case of post-tensioned concrete is the action of transferring the tensioning force from the tensioning equipment (jack) to the anchorage.

Transfer in the case of pre-tensioned concrete is the action of transferring the force in the tensioned tendon(s) to the concrete.

(q) Bond breaker
Bond breaker is the coating or sheath placed on a tendon to prevent it from bonding to the surrounding concrete.

(r) Coupler
Coupler is the device comprising all components required to join two tendons.

(s) Deflector
Deflector is the device used to deflect a tendon alignment within a structural element.

(t) Transmission length
Transmission length is the tendon length required to transmit via bond stresses the full force in the tendon to the concrete.

(u) Precamber
Precamber is the allowance made into formwork to accommodate the slightly convex shape of a horizontal prestressed member.

6503 MATERIALS

(a) General
All materials and prestressing systems used in the prestressing of structural concrete members shall be subject to approval by the Engineer.

(b) Prestressing steel

(i) General
The Contractor shall keep proper records of all material analyses and test certificates for the batches of prestressing steel used in the Works. Where required by the Engineer, the Contractor shall produce certificates from recognised testing authorities certifying compliance of the prestressing steel with the specified requirements.

Where prestressing steel is available in weld-free lengths (production lengths) and lengths containing welds (standard lengths), the batches delivered at the site shall be clearly labelled for identification purposes.

Under no circumstances shall prestressing steel after manufacture be subjected to heat treatment other than provided for in the Specifications.

(ii) Bars
Cold-worked high-tensile alloy steel bars for prestressed concrete shall comply at least with the requirements of BS 4486:1980.

The type of prestressing steel shall be indicated in accordance with the requirements of CLAUSE 4.2 of BS 4486:1980 e.g. BS 4486-RR-32-1230 for 32 mm diameter double-ridged bar with a characteristic strength of 1230 MPa.

(iii) Wires and seven-wire steel strand
Steel wire and seven-wire steel strand for prestressed concrete shall comply at least with the requirements of BS 5896:1980.

The type of prestressing steel shall be indicated in accordance with the requirements of CLAUSES 14 and 20 of BS 5896:1980 for wire and strands respectively, e.g.:

(1) BS 5896/2 wire 1770-7-PE-relax 1 for a 7 mm diameter plain wire of Class 1 relaxation with a characteristic strength of 1770 MPa; and

(2) BS 5896/3 superstrand 1860-12.9-relax 2 for a 12.9 mm diameter superstrand of Class 2 relaxation with a characteristic strength of 1860 MPa.

(iv) Straightness
Prestressing bars delivered at the site shall be straight. Only small adjustments for straightness may be made, which shall be done by hand on the site at a temperature above 5°C and under the supervision of the Engineer. Where heating of the bars is required, this shall be by means of steam or hot water. Bars bent in the threaded portion shall not be used.

Prestressing wire and strand shall be supplied in coils with a sufficiently large diameter to ensure that the wire and strand will reel off straight.

(v) Surface condition
Prestressing steel shall be clean, free from faults or defects, and without any harmful films and matter which may impair adhesion to the grout or concrete. A film of rust is not necessarily harmful and may improve the bond. It may, however, increase the friction between the tendon and duct. The depth of imperfections or pits on the surface of prestressing steel shall not exceed 0.1 mm for wire with a diameter up to and including 8 mm, or 0.2 mm for bars or wire with a diameter exceeding 8 mm.

Tendons may be cleaned by wire brushing or by passing through a pressure box containing carborundum powder. Solvent solutions shall not be used for cleaning without the approval of the Engineer.

Prestressing steel shall be delivered at the site suitably protected against damage and corrosion. Such protection or the use of a corrosion inhibitor, where allowed by the Engineer, shall not have any deleterious effect on the steel or concrete or impair the bond between the two.

(vi) Galvanising
Galvanised prestressing steel shall not be used unless specified. Under no circumstances shall prestressing steel be subjected to galvanising after manufacture.

(vii) Welds
Prestressing steel used in structural prestressed concrete shall be weld-free. Where the steel is supplied in standard lengths, the welds shall be cut out and delivered to the Engineer.

(c) Anchorages and couplers
Anchorages and couplers to be used in prestressed concrete shall comply with the requirements of BS 4447:1973 and shall be of a proved and approved type, constructed from durable material completely free from imperfections and shall not damage, distort or kink the prestressing steel in a manner that will result in ultimate tensile strength reduction. They shall resist, without failure and/or excessive deformation or relaxation of the force in the tendons, the full ultimate tensile strength of the tendons. The characteristic value for anchorages and couplers, determined in accordance with BS 4447:1973, shall not be less than 90%.

The anchorages shall effectively distribute the force in the tendon to the structural member, and the resulting local stresses and strains in the member shall be so limited as to prevent damage. Unless otherwise approved by the Engineer, all anchorages and couplers shall be provided with anchorage reinforcement.

Wedges and the insides of barrels or cones shall be clean to allow the free movement and seating of the wedges inside the taper.

The threads of bars, nuts, anchorages and couplers shall be suitably protected against damage and corrosion. The protection shall be removed at the last moment and the threads properly lubricated before use.

(d) Sheaths
Sheaths shall be grout-tight and of such material and configuration that bond forces can be transferred from the grout to the surrounding concrete. The properties of the sheath material shall be such that no corrosion attack of the prestressing steel will be induced. The sheath shall be sufficiently flexible to accept the required curvature without kinking, and strong enough to retain its cross-section and alignment and to resist damage on account of handling, transporting, tying and contact with vibrators during concreting. Unless otherwise approved by the Engineer the thickness of the metal of steel sheaths shall not be less than 0.4 mm.

Metal sheathing shall be delivered at the site suitably protected against damage and corrosion. At the time of incorporation into the structural member, the sheathing shall be free from loose mill scale, loose rust, lubricants and harmful matter.

Galvanised sheathing shall not be used unless specified.

Unless otherwise specified, the internal diameter of the sheath shall be at least 10 mm greater than the diameter of the tendon. For vertical tendons and where tendons are to be drawn into cast-in sheaths, the cross-sectional duct area shall be at least three times the cross-sectional area of the tendon.

(e) Cable supports
Supports of reinforcing steel or structural steel suitably braced to prevent buckling under load shall be used to support the cables. The cable saddles shall be rigid and secured in position by welding or by equivalent mechanical means to resist both gravitational and buoyancy forces.

Normal web reinforcement shall not be utilised to support cables.

Saddles for external cables shall be of special design and material to ensure low friction and to prevent the tendon or parts thereof from grooving the surface. The saddle plates shall be curved to the requisite radius to prevent the tendon or part thereof from bearing on the end of the plate and shall incorporate features to ensure that individual bars, wires and strands are seated separately.

(f) Tendon spacers
Tendon spacers used inside the ducts to separate individual bars, wires or strands of the tendon shall be of a proven and approved type and manufactured from material which will not induce corrosion of the prestressing steel.

(g) Grout

(i) Materials
In addition to the requirements of SUBCLAUSE 6402(d), water shall not contain more than 500 mg of chloride ions per litre of water.

Only common cements which comply with the requirements of US 310-1:2001/EAS 18-1, BS EN 197-1:2000 or equivalent shall be used. The temperature of the cement shall be less than 40°C, and the cement shall be stored in accordance with the requirements of SUBCLAUSE 6403(a).

Fine aggregate shall consist of siliceous granules, finely ground limestones, trass or very fine sand. The aggregate used shall pass through a 0.600 mm sieve. The use of fine aggregate shall be subject to the approval of the Engineer and shall be restricted to grout for ducts with a diameter exceeding 150 mm. The aggregate content in the grout shall not exceed 30% of the weight of the cement.

The use of admixtures shall be subject to tests having shown that their use improves the properties of the grout, e.g. by increasing workability, reducing bleeding, entraining air, or expanding the grout. Admixtures shall be free from any product liable to damage the steel or the grout itself, such as halides, nitrates, sulphides, sulphates, etc. The quantity of admixture to be used shall be in accordance with the manufacturer's instructions.

(ii) Properties of the grout
The mixed grout shall have the following properties:

(1) The chloride ions content shall not exceed 750 mg/litre.

(2) The viscosity of the grout measured in accordance with SUBCLAUSE 7111(b) for horizontal cables shall be 500 to 2 500 cP and for vertical cables 400 to 1 500 cP. The viscosity of the grout, 20 minutes after mixing, shall not exceed 2500 cP and 1 500 cP for horizontal and vertical cables respectively.

(3) Bleeding at 20°C measured in accordance with SUBCLAUSE 7112 shall not exceed 2% by volume three hours after the grout has been mixed, and the maximum bleeding shall not exceed 4%. In addition, the separated (bleed) water must be reabsorbed after 24 hours.

(4) The compressive strength of 100 mm cubes made of the grout and cured in a moist atmosphere for the first 24 hours and then in water at 20°C shall exceed 20 MPa at seven days.

(h) Protecting agents for unbonded tendons
The material used for permanent protection of unbonded tendons shall have the following properties:

(i) It shall remain free from cracks and shall not become brittle or fluid within the temperature range of -20°C to 70°C.

(ii) It shall be chemically stable and the Engineer shall approve its properties.

(iii) It shall be non-reactive with the surrounding materials, i.e. concrete, tendons, wrapping or sheathing.

(iv) It shall be non-corrosive or corrosion-inhibiting.

(v) It shall be impervious to moisture.

(vi) It shall be sufficiently tough to withstand the abrasion caused when a tendon, precoated with the material, is drawn into the sheath.

(vii) It shall have no appreciable shrinkage or excessive volume increase.

(viii) It shall have a suitable viscosity at ambient temperature or require only moderate preheating to permit injection.

(i) Testing
Prestressing steel, anchorages and couplers, and grout shall be tested in accordance with the requirements of SUBCLAUSE 7111(b). Testing shall be carried out at the frequencies as directed by the Engineer.

6504 EQUIPMENT

(a) General
All equipment used shall be in a good working order and properly maintained.

(b) Tensioning and measuring equipment
Tensioning and measuring equipment shall be such that the tendon force can be established to an accuracy of ±2% during any stage of the tensioning operation.

Unless otherwise authorised by the Engineer, the tensioning equipment shall be power driven and capable of gradually applying a controlled total force without inducing dangerous secondary stresses in the tendon, anchorage or concrete.

The force in the tendon during tensioning shall be measured by a direct-reading dynamometer or obtained direct from pressure gauges fitted in the hydraulic system to determine the pressure in the jacks.

Pressure gauges shall have concentric scale dials which comply with the requirements of BS EN 837-1:1998. The dials shall not be less than 150 mm in

diameter and the gauges shall be used within the range of 50 to 90% of their full capacity at maximum service pressure.

When pressure gauges not using glycerine are used, a snubber or similar device shall be fitted to protect the gauge against any sudden release of pressure. Provision shall also be made for T-connections for the attachment, when required, for supplementary control gauges.

Only self-sealing connections shall be used in the hydraulic circuit. Where the pressure input pipe is connected to the jack, a pipe rupture valve shall be installed in the circuit.

Tensioning equipment shall be calibrated before the tensioning operation and thereafter at frequent intervals, as directed by the Engineer, with a master gauge or proving ring, and the Engineer shall be furnished with a calibration chart. The load-measuring devices shall be calibrated to an accuracy of $\pm$2%.

The extension of tendons shall be measured to an accuracy of $\pm$2% or $\pm$2 mm, whichever is the more accurate, and pull-in and release to an accuracy of $\pm$2 mm.

(c) Grouting equipment

(i) Mixer
Mechanically operated mixers used shall be of a type capable of producing high local turbulence while imparting only a slow motion to the body of the grout.

The mixer shall be equipped with a screen with openings not exceeding 1.0 mm and shall be capable of consistently producing grout with a colloidal consistency.

(ii) Agitator
Where the capacity of the mixer is insufficient to fill the duct completely with grout, an agitator shall be used.

Mechanical agitators used shall be capable of maintaining the colloidal condition of the grout fill during the storing and injection processes. The grout shall be delivered at the structure from the agitator, and the system shall make provision for re-circulating the grout from the pump back to the agitator.

(iii) Injection equipment
The pump shall be of the positive displacement type (piston, screw or similar type), capable of exerting a constant pressure of at least 10 bars on completely grouted cables and shall incorporate a safety device for preventing the build-up of pressure above 20 bars. The pump shall be fitted with a pressure gauge and a valve which can be locked-off without loss of pressure in the cable.

The pump shall be capable of delivering grout at a speed that will produce a speed of the grout in the cable of between 6 and 12 m/minute.

All connections in the pipes and between the pipe and the cable shall be airtight. Only bayonet, threaded, or similar types of connectors shall be used.

6505 TECHNICAL DATA

The following technical data for pre-tensioned and post-tensioned structural members required for the Contract will be furnished on the Drawings:

(a) Tendon alignment
A diagram showing the alignment of each tendon or group of tendons in both the horizontal and vertical planes, together with the horizontal and vertical co-ordinates, and curve equations of the centroid of the tendon(s), as may be relevant.

(b) Tendon system
The design shall be based on the system shown on the Drawings, but the Contractor may use any suitable system which will meet all the specified requirements, subject to approval by the Engineer.

(c) Tensioning the tendons
Full particulars regarding the partial tensioning of the tendons, the stage during which the tendons shall be tensioned, and the sequence of tensioning to be followed.

(d) Tensioning force
The maximum tensioning force and the effective force at the live anchorages, after transfer, as well as the corresponding stress level in the prestressing steel, for each tendon or group of tendons. The forces will be given in MN units, and the stress levels will be expressed as a percentage of the characteristic strength.

(e) Extension
The extension per tendon or group of tendons under the maximum tensioning force, together with the modulus of elasticity (E) on which it has been based. The release to be attained at each live anchorage as well as the pull-in for which provision has been made.

The Contractor shall show on his/her drawings the expected extension based on the actual modulus of elasticity of the strand as well as the expected wedge pull-in and any provision for shimming.

(f) Prestressing losses in tendons
The losses allowed for in the design from the causes listed below will be given as follows:

(i) Friction loss
The formula used for determining the tendon/duct friction loss together with the values adopted for the friction coefficient (μ) caused by curvature, and the wobble factor (k) caused by unintentional variation from the specified alignment.

(ii) Elastic deformation of concrete
The elastic factor, which, when multiplied by the compressive stress in the concrete adjacent to the tendon, will give the loss caused by the deformation of the concrete.

(iii) Creep of the concrete
The creep factor, which, when multiplied by the compressive stress in the concrete adjacent to the tendon, will give the loss caused by the creep of the concrete.

(iv) Shrinkage of the concrete
The stress loss in MPa caused by the shrinkage of the concrete.

(v) Relaxation of prestressing steel
The stress loss in MPa at a stress level of 70% of the characteristic strength of the prestressing steel caused by the relaxation of the prestressing steel.

(g) Anchorages
The positions where loop or fan-type dead-end anchorage may be used.

(h) Bursting reinforcement
The bursting reinforcement for the prestressing system on which the design is based.

(i) Precamber
The precamber at intervals not exceeding 0.25 times the span length.

(j) Compressive strength of the concrete during transfer
The compressive strength to be attained by the concrete in the relevant member before transfer may be effected.

6506 PRESTRESSING SYSTEM

The use of all prestressing systems will be subject to approval by the Engineer. Bidders are advised to obtain approval for the prestressing system they intend using, prior to submitting their bids.

Within one month of the bid having been awarded, or within a period agreed on with the Engineer, the Contractor shall submit full details regarding the prestressing system(s), materials and equipment he/she intends using, as well as regarding the methods he/she proposes to adopt in the prestressing and related operations.

The Engineer, at his/her own discretion, may call for further information in the form of detailed drawings, proof of successful previous use, performance certificates from an approved independent testing authority, and calculations substantiating the adequacy of the system. The Contractor shall furnish such information within two weeks of being called upon to do so or within a period agreed on with the Engineer. If, after investigating all the information, the Engineer is not satisfied that the prestressing of the structural member can be carried out satisfactorily with the prestressing system offered by the Contractor, the Engineer reserves the right to order the Contractor to use any system which is suited to the work and which is readily available to the Contractor.

Only minor alterations to the concrete dimensions shown on the Drawings will be considered in order to accommodate the prestressing system finally selected. Major alterations occasioned by the prestressing system offered by the Contractor and which is at variance with the tendon system specified in SUBCLAUSE 6505(b) shall be treated as alternative designs and shall be dealt with as specified in CLAUSE 1212.

6507 DRAWINGS PREPARED BY THE CONTRACTOR

All drawings prepared by the Contractor and submitted to the Engineer for consideration shall comply with the requirements of CLAUSE 1221.

The Contractor shall submit to the Engineer at least two months before he/she intends commencing with the prestressing work, drawings detailing the layout and alignment for the individual tendons, the cable supports, modifications to the bursting and other reinforcement, anchorage recesses, tensioning sequence, tensioning loads and extensions, as well as requirements for controlling the tensioning operations. For the prestressing system finally selected, the technical data which are at variance with the information given on the Drawings shall be shown on the Drawings. Each tendon shall be separately numbered for identification.

Where required, the Contractor shall submit calculations in respect of the variation of the tendon force along the length of the tendon, the expected extension and the bursting forces.

After approval by the Engineer of the Drawings and calculations prepared by the Contractor, no departure shall be permitted from the forces, stresses and extensions shown thereon, without authorisation by the Engineer.

The prestressing work shall not be commenced before the relevant drawings have been accepted by the Engineer. The Contractor shall make full allowance in his/her bid rates for all costs in connection with the furnishing of information, making calculations, and preparing and submitting the Drawings. However, no allowance need be made for the cost of checking, undertaken by the Engineer, of drawings and calculations for work which does not qualify as an alternative design.

Alternative designs shall comply with the requirements of CLAUSE 1212 and the relevant provisions of this Section.

6508 PRECASTING

(a) Casting yard on the site
Subject to approval by the Engineer, precast work may be done at any location selected by the Contractor.

Before the casting yard is established, the Contractor shall submit plans to the Engineer which demarcate the site and detail the layout of the Works, together with a flow diagram of the construction stages and storage.

(b) Manufacture off the site
The Contractor shall notify the Engineer in advance of the dates when tensioning of tendons, casting of members and transfer, will be undertaken.

Within seven days of transfer, the Contractor shall submit to the Engineer a certificate giving the tendon force(s) and extension(s) attained as well as records of the cube crushing strength and age of concrete at transfer.

Test results relating to all aspects of the work shall be sent to the Engineer immediately upon their becoming available.

Where the Engineer requires tests to be conducted on completed members, no member to which the tests relate shall be dispatched to the site until the tests have been satisfactorily completed and the members accepted by the Engineer.

(c) Manufacture
Before work is commenced, details of the manufacture and phasing of the work shall be submitted to the Engineer for approval. After approval, no changes shall be made to the methods or systems, without approval by the Engineer.

The Contractor shall ensure that the specified precamber is incorporated in the formwork. The magnitude of the precamber shown on the Drawings shall be subject to variation depending on the Contractor's construction programme; and the Contractor shall, before manufacture, ascertain in writing from the Engineer, the increase or decrease in precamber. This procedure shall also apply to the cases where no precamber has been specified.

Lifting and supporting the precast members shall be made only at the points marked and provided on the members.

Precast members which have not been fully tensioned or fully stage extensioned or which have ungrouted tensioned tendons shall not be handled without authorisation by the Engineer.

Where members with ungrouted tensioned tendons are handled, control shall be exercised to guard against possible slip of the tendon at the anchorage.

Prestressed precast concrete members shall also comply with the requirements of CLAUSE 6413.

6509 PRE-TENSIONING

During the period between tensioning and transfer, the force in the tendon shall be fully maintained by some positive means. At transfer, detensioning shall take place slowly to minimise any shock which could adversely affect the transmission length of the tendon.

In the long-line method of pre-tensioning, sufficient locator plates shall be distributed throughout the length of the bed to ensure that the straight tendons are maintained in their proper position during concreting. Where a number of units are manufactured in line, they shall be free to slide in the direction of their length so as to permit transfer of the tendon force to the concrete along the entire line.

In the individual-mould system, the moulds shall be sufficiently rigid to provide the reaction to the tendon force without distortion.

Where possible, the mechanism for holding down or holding up deflected tendons shall ensure that the part in contact with the tendon will be free to move in the line of the tendon so that friction losses are eliminated. If, however, a system is used which develops a frictional force, this force shall be determined by test and due allowance made thereof.

For single tendons, the deflector in contact with the tendon shall have a radius of not less than 5 times the tendon diameter for wire, or 10 times the tendon diameter for a strand, and the total angle of deflection shall not exceed 15".

Transfer of the tendon force to the concrete shall be effected in conjunction with the release of hold-down and hold-up forces in accordance with an approved method.

Transfer shall not be effected until compressive-strength tests on the concrete show that the concrete of the particular member has attained a compressive strength of at least the compressive strength shown on the Drawings. The transmission length is affected by the concrete strength, and the necessary modification for the concrete strength at transfer shall be made in conjunction with the Engineer.

The tendons shall be cut off flush with the end of the member and the exposed ends covered with a heavy coat of approved bituminous material or epoxy resin. The cutting of the prestressing steel shall be performed with a high-speed abrasive cutting wheel. Flame cutting will not be permitted.

6510 POST-TENSIONING

(a) Storage, handling and protection

During storage, transit and construction and after installation, the sheaths, prestressing steel, anchorages and couplers shall be protected against corrosion, damage or permanent deformation. The manner and extent of protection required will depend on the environmental factors and the length of time before permanent corrosion protection is applied, and shall be to the satisfaction of the Engineer. Under severe corrosive conditions in damp and wet areas and under aggressive conditions, the materials shall be stored in weatherproof sheds. All materials shall be stored clear of the ground and while in storage shall not be enclosed to the weather.

When prestressing steel has been stored for a prolonged period and there is evidence of its deterioration, the Contractor may be called on to prove by tests that the quality of the steel has not been significantly impaired and that the prestressing steel still complies with the provisions of these Specifications.

Suitable protection shall be provided to the threaded ends of bars.

After fabrication, the cable ends shall be covered with protective wrapping to prevent the ingress of moisture into the duct.

When the tendon is to be left untensioned for a prolonged period after installation, precautions shall be taken to protect the tendon against corrosion. Corrosion inhibitors, oils or similar materials used as lubrication or to provide temporary protection shall be such that they can be completely removed before permanent protection is effected.

(b) Fabrication

All cutting of prestressing steel shall be performed with a high-speed abrasive cutting wheel or by a method approved by the Engineer. Flame cutting will not be permitted.

Care shall be taken to prevent the prestressing steel or anchorages from coming into contact with splashes from flame-cutting or welding processes in the vicinity.

Where possible, all bars, wires or strands tensioned in one operation shall be taken from the same parcel of prestressing steel. The tendon or cable shall be labelled to show the tendon or cable number, as well as identify from which parcel the steel has been taken.

Where bars, wires or strands in a tendon are not tensioned simultaneously, tendon spacers shall be used in accordance with the recommendations for the prestressing system or, in the absence thereof, as directed by the Engineer.

Cables shall be fitted at both ends with pipes with a diameter of at least 10 mm for the injection of grout or protection agents. The ends of the injection pipes shall be fitted with a clamp, valve or device capable of withstanding a pressure of at least 15 bars without loss of grout or protection agent.

Vent pipes with a diameter of at least 25 mm shall be provided in the duct at every high point, change of sheath cross-section and at such intermediate positions as may be shown on the Drawings or required by the Engineer. The vent pipes shall extend to at least 500 mm above the concrete and shall comply with the requirements for injection pipes.

Connections to, and joints in sheaths shall be made grout-tight by using special sheathing couplings and taping. With bonded cables, the length of taping shall not exceed six sheath diameters. Where over sleeves are used, equal overlaps shall be provided over each length of sheathing. Joints in adjacent sheaths shall be spaced at least 300 mm apart.

(c) Installation

The installation of tendons shall not commence until the requirements of CLAUSE 6507 have been complied with.

The cable, sheath or extractable core shall be accurately installed to the specified alignment and securely held in position both vertically and horizontally at intervals appropriate to its rigidity so as not to be displaced during concreting, either by the weight of the concrete or by buoyancy. The spacing of the cable supports shall furthermore ensure that the tendon can be installed to a smooth alignment without kinks and within the tolerance specified in SUBCLAUSE 6803(g). Cable sheaths shall be supported and held in position by means of separate reinforcing steel supports with a diameter of not less than 16 mm. The transverse bars must be welded to the vertical bars or must rest on lugs welded to the vertical bars. The spacing of the vertical supports shall not exceed 1.0 m

Extractable cores shall not be coated with release agent unless approved by the Engineer.

Unless otherwise shown on the Drawings, the alignment of the tendon within a distance of 1.0 m from the live anchorage and/or coupler shall be straight. The tendon axis shall be set perpendicular to the bearing surface of its anchorage and firmly secured in position so as not to move during concreting. External anchorages shall be seated on a thin mortar bedding to bear evenly on the concrete bearing surface, and the tendon axis shall be perpendicular to the bearing surface of the anchorage.

Unless otherwise shown on the Drawings, the minimum concrete cover over the outside surface of the sheath or cable support shall comply with the requirements of CLAUSE 6307, except that, for sheaths, the cover shall not be less than 50 mm.

The spacing of cables will depend on the size of the cable and shall be such that the concrete can be properly placed and compacted.

Immediately before concreting, the Contractor shall inspect the sheaths for grout-tightness and shall seal all damaged and suspect sections.

External tendons shall be installed to the same standards and accuracy specified herein for internal tendons. The tendons shall be temporarily supported at regular intervals along the straight length between saddles. The supports shall consist of rigidly constructed frames secured to the concrete face.

(d) Concrete strength

Full tensioning of all or some of the tendons shall not commence until the compressive-strength of the concrete is 35 MPa or the strength shown on the Drawings, whichever is the greater.

The compressive strength of the concrete shall be determined from cubes manufactured and tested in accordance with SUBCLAUSE 7106(a) which have been cured under the same conditions as the structural member which is to be prestressed. The number of concrete cubes required for this purpose shall be as agreed on with the Engineer.

Where initially all or some of the tendons are to be partially tensioned, tensioning shall not commence before the concrete has attained the compressive strength indicated on the Drawings.

(e) Tensioning

(i) Preparation

Within two hours of the concrete having been placed, the Contractor shall demonstrate that sheaths are free from obstructions, that extractable cores can be removed and, where the design permits, that all tendons are free to move in the ducts. All water in the ducts shall then be expelled with compressed air and the cables/ducts sealed until tensioning takes place.

Before tensioning is commenced, the side forms and other restraining elements shall be released or removed to give the structural member the freedom to deform under the induced force.

(ii) Tensioning sequence

The sequence of tensioning to be followed shall be as shown on the Drawings and/or on drawings prepared by the Contractor in terms of CLAUSE 6507. The Contractor shall make allowance in his/her bid rates for all incidentals which he/she may have to incur as a result of having to tension fully only some of the tendons at any one stage or instant. Where partial tensioning of tendons is required, the work shall be executed in accordance with the details on the Drawings or as specified. The Contractor shall, in his/her bid rates, make provision for all incidentals he/she may have to incur as a result of having to tension partially only some of or all the tendons at any one stage or instant.

(iii) Assembling the equipment, and safety precautions

The tensioning and measuring equipment shall be assembled for tensioning in exactly the same way as they are assembled for calibration.

The Contractor shall take all the necessary safety precautions to prevent accidents caused by the malfunctioning or failure of any part of the equipment or material and shall accept full responsibility for injury sustained by persons or damage to property resulting therefrom.

(iv) Friction

The Engineer may require the Contractor to perform friction tests on designated tendons and to revise the relevant theoretical extensions to compensate for the discrepancy between the values adopted in the design and the test results. Payment for these tests shall be made under ITEM 71.01.

Where applicable, allowance shall be made in the tensioning force to compensate for friction loss in the jack and in the anchorage.

(v) Tensioning

Tensioning shall be carried out under the supervision of a technician skilled in the use of the prestressing system and equipment and the methods of tensioning to be adopted.

Tensioning shall not be commenced before the Engineer has been advised of each tensioning operation and has given his/her approval for the work to be started.

The technician and operators shall be supplied with a schedule listing the sequence of tensioning the various tendons and a tensioning record sheet showing the theoretical gauge readings, jacking forces, extensions, release and pull-in for each tensioning operation. The record sheet shall furthermore provide room for entering the corresponding information recorded and observations made during tensioning. A graph of the tensioning force and/or gauge reading versus theoretical extensions shall, where required, be appended to the record sheet and the actual extensions measured for each load increment shall be plotted on the graph. Copies of the completed record sheets and graphs shall be submitted to the Engineer within 24 hours of each tensioning operation having been completed.

The Contractor shall note that the extensions shall be regarded as an indirect measurement of the tensioning force and shall serve as a control on the tensioning force applied.

The protruding ends of all bars, wires and strands shall be clearly marked for the accurate measurement of extension, release and pull-in.

Before tensioning is commenced on external tendons, a small load shall be applied to each tendon, commencing with the uppermost tendon. The force shall be sufficient to take up all slack and prevent entanglement of the tendons.

The jacking force shall be increased to approximately 5% to 10% of the final jacking force to take up the tendon slack and to determine the zero position for measuring the extension and to check the gripping devices and the position and alignment of the jacks. The load shall then be increased gradually to the full specified tensioning force while intermediate gauge readings and extensions are recorded at regular intervals.

The final stage of tensioning shall be deemed to have been satisfactorily accomplished when all the following requirements have been complied with:

(1) The tendons have been tensioned to the required force.

(2) The measured extension on individual tendons is within ±6% of the theoretical extensions.

(3) The average variation between the measured and theoretical extensions of all the tendons in a structural member is less than ±3%.

(4) The release and/or pull-in is within ±2 mm of the theoretical values.

Where the above conditions are not met individually and collectively, the Contractor shall immediately advise the Engineer and obtain a ruling as to the procedure to be followed.

In the event of the tendon friction being too high, the Contractor may, subject to approval by the Engineer, inject an approved lubricant into the sheath after first having detensioned the tendon.

The cost of the remedial and corrective measures and of the release and retensioning of tendons, which have been occasioned by failure of the operations to meet the above requirements shall be for the Contractor's account.

After the tensioning has been accepted by the Engineer, the Contractor may cut off the tendons behind the anchorage as described in SUBCLAUSE 6510(b).

(f) Permanent protection and bonding of tendons

(i) General
After tensioning, all tendons shall receive permanent protection against mechanical damage and corrosion.

Internal tendons shall be protected and bonded to the structural member by cement grout or, when permitted by the Engineer, by sand-cement grout. Where bond is not important, protection may be effected by the use of bitumen, petroleum-based compounds, epoxy resins, plastics and similar products, all complying with the requirements of SUBCLAUSE 6503(h) and subject to approval by the Engineer.

Tendons located outside the structural section (i.e. external tendons) shall be encased with a dense concrete, dense mortar or material sufficiently stable and hard, all subject to approval by the Engineer. The encasement shall be of the thickness shown on the Drawings. Where bonding of the tendon to the structural concrete is required, this shall be achieved by bonding the concrete encasement to the structure with reinforcing steel as detailed on the Drawings.

Protection and bonding of the tendons shall be effected within seven days of the final tensioning of the tendons, or as specified on the Drawings, but shall not take place without the prior approval of the Engineer having been obtained.

After the permanent protection or bonding has been completed the anchorages shall be encased in concrete or grout which shall be bonded to the old concrete with epoxy resin designed for this purpose, or shall be completely coated with a corrosion-resistant material. The protection provided shall in all cases prevent the ingress of water or aggressive agents.

(ii) Preparation of ducts
Before permanent protection and/or bonding of tendons is effected, the following precautions shall be taken:

(1) The cables shall be checked for blockages by water or compressed air being injected.

(2) Unlined ducts which are to be filled with grout shall be flushed with water to wet the concrete.

(3) Temporary protection or lubricants which are incompatible with the permanent protection or bonding, shall be removed by flushing the duct with water or an inert solution, or by any suitable approved method.

(4) On completion of the above, any excess fluid shall be expelled from the ducts by means of compressed air or shall be displaced by the protecting agent or grout, as may be relevant.

(5) Any blockages, leakages or factors which in any way may affect the permanent protection or bonding shall immediately be reported to the Engineer.

(iii) Mixing

(1) Protecting agents
The mixing of protecting agents shall be strictly in accordance with the manufacturer's instructions.

(2) Grout
The aggregate, if used, and the cement shall be measured by weight, and the water by weight or by volume.

The water:cement ratio by weight shall be as low as possible within the range between 0.36 to 0.45, and shall be consistent with the fluidity requirements of SUBCLAUSE 6503(g).

Where an admixture is used, it shall be dissolved in a part of the mixing water before it is added to the grout.

Mixing shall be commenced by two-thirds of the cement being added to the greater part of the mixing water, and, if used, an additive predissolved in part of the mixing water, and finally the remainder of the cement. Mixing shall continue for not longer than four minutes after which the grout shall be continually agitated at slow speed throughout the injection operation.

Where aggregate is used in the grout mix, the word "cement" in the preceding paragraph shall be replaced by the term "cement/aggregate component".

(iv) Injection

(1) General
The injection of permanent protecting agents or grout shall not commence before approval has been granted that the work may start.

Before injection commences all air shall be expelled from the injection equipment and hoses and all connections checked for airtightness.

Injection shall take place from the anchorage or coupler, whichever is situated at the lower end of the cable. Grout injection shall proceed without any interruption until the cable has been completely filled and closed off.

(2) Protecting agents
The injection of protecting agents shall be strictly in accordance with the instructions, and with the equipment specified by the manufacturer.

(3) Grout
Immediately after mixing, and also during injection, the fluidity of the grout shall be tested at regular intervals in accordance with SUBCLAUSE 6503(g)(i).

Injection shall be continuous at a rate of 6 to 12 m per minute. As soon as grout with the original consistency flows from the intermediate vent pipes they shall be successively closed. Injection shall continue until the grout flowing from the vent at the free end is of the same consistency as that of the injected grout. At this stage the vent shall be closed and the final pressure or a pressure of 5 bars, whichever is the greater, shall have been maintained on the grout column for five minutes before the valve at the injection end is closed.

All vents shall be kept closed and supported vertically until the grout has finally settled. On vertical cables, a riser pipe with funnel shall be fitted to the top anchor to ensure that the separated water migrates upwards and will not remain in the cable.

If an expanding agent is used in the grout mix, the air vents shall be re-opened after grouting to release any separated water, and shall then again be closed.

Unless a retarder is used in the grout mix, the grout not used within 60 minutes of mixing shall be discarded.

During the course of grouting, 100 mm cubes shall be made for testing in accordance with SUBCLAUSE 6503(g)(i). Whilst the grout is being poured into the cube mould, the sides of the mould shall be slightly tapped to permit any entrapped air to escape.

Precautions shall be taken not to discharge the escaping grout onto railway lines, public roads, water courses or private property.

If a blockage occurs during the course of grouting, the grouting shall be stopped before the maximum grouting pressure is reached. The duct shall then be flushed out immediately and the blockage cleared.

Grouting shall not be carried out during very cold weather when the ambient air temperature drops below 5°C. Care shall be taken that the ducts are completely free from frost or ice before grouting commences after frosty weather.

6511 LOSS OF PRESTRESS

Any structural member which has lost all or part of its prestress through the failure or malfunctioning of any part of the prestressing component may be rejected by the Engineer and shall be removed from the Works unless approved remedial measures have been successfully carried out on the member. No payment will be made in respect of such remedial work or loss suffered by the Contractor in this regard.

6512 MEASUREMENT AND PAYMENT

ITEM	UNIT
65.01 PRESTRESSING TENDONS:	
(a) LONGITUDINAL TENDONS	MEGANEWTON - METRE (MN-m)
(b) TRANSVERSE TENDONS	MEGANEWTON - METRE (MN-m)
(c) VERTICAL TENDONS	MEGANEWTON - METRE (MN-m)

The unit of measurement shall be the MegaNewton-metre which is calculated as the product of the characteristic strength in MegaPascals of the prestressing steel, the cross-sectional area of the tendon in square metres and the length of the tendon in metres between the faces of the anchorages. In the case of fan and loop anchorages the "length of the tendon" shall include the length of tendon forming the loop or fan.

The bid rates shall include full compensation for preparing and submitting the Drawings, supplying, storing, handling and protecting all materials (excluding anchorages and couplers), fabricating, supporting and installing the cables; lubricating, permanently protecting and bonding the tendons, for the using of all the equipment, as well as for all work and incidentals required for completing the work as specified.

ITEM	UNIT
65.02 ANCHORAGES AND COUPLERS:	
(a) END ANCHORAGE AT JACKING	MEGANEWTON (MN)
(b) ANCHORAGE AT DEAD END	MEGANEWTON (MN)
(c) COUPLER AT JACKING END	MEGANEWTON (MN)
(d) COUPLER AT DEAD END	MEGANEWTON (MN)

The unit of measurement shall be the MegaNewton which is calculated as the product of the characteristic

strength in MegaPascals of the prestressing steel and the cross-sectional area of the tendon in square metres, effectively anchored or coupled.

The bid rates shall include full compensation for supplying, storing, handling, fabricating and protecting the complete anchorage or coupler assembly, anchorage reinforcing, constructing the recesses for the anchorage or coupler, tensioning, anchoring and/or coupling, trimming the tendon ends, using all the equipment, as well as for all work and incidentals required for completing the work as specified.

The coupler shall include the complete assembly consisting of the anchorage built into the first-stage construction and the part coupled to it.

The bid rate for loop or fan anchorages shall exclude the cost of the length of tendon forming the loop or fan.

ITEM		UNIT
65.03	EXTRA OVER ITEM 65.02 FOR PARTIALLY TENSIONING THE TENDONS	MEGANEWTON (MN)

The unit of measurement shall be the MegaNewton, which is calculated as for ITEM 65.02.

The bid rate shall include full compensation for the use of all equipment, as well as for all work and incidentals required for tensioning and anchoring the tendons to the specified partial force.

SERIES 6000: STRUCTURES

SECTION 6600: NO-FINES CONCRETE; JOINTS; BEARINGS; PARAPETS AND DRAINAGE FOR STRUCTURES

CONTENTS:

6601 SCOPE

This Section covers:

- the manufacture and placing of no-fines concrete used in the Works;
- the supply and installation of all permanent joints which will permit relative movement between contiguous structural members;
- the construction, supply and installation of bearings for structures;
- the construction of parapets, railings and sidewalks on structures;
- the construction and/or installation of drainage works such as weep holes, drainage pipes and gulleys, no-fines concrete blocks, filter lining and concrete channelling;

6602 NO-FINES CONCRETE

(a) Materials

Cement, aggregate and water shall comply with the requirements of CLAUSE 6402.

Each size of aggregate shall be a single size aggregate graded in accordance with US 101:2000 or BS EN 12620:2002, BS 882:1992 or equivalent.

(b) Classes of no-fines concrete

No-fines concrete shall be classified by the prefix NF and the size of aggregate to be used. E.g. CLASS NF 19 means a no fines concrete with a 19.0 mm nominal size aggregate.

The volume of aggregate per 50 kg of cement for each class of concrete shall be as detailed in TABLE 6602/1.

TABLE 6602/1
VOLUMES OF AGGREGATE

Class of cement	Aggregate per 50 kg
NF38	0.33 m^3
NF19	0.30 m^3
NF13	0.27 m^3

(c) Batching and mixing

Cement shall be measured by weight or in full packets of 50 kg each and aggregate shall be measured by volume in approved measuring boxes or barrows.

The aggregate shall be moist or wetted before the cement is added. Where drum mixers are used, about 20% of the water shall be poured into the drum before the aggregate and cement are loaded. The mixing time in the drum shall be about 45 to 50 seconds.

The quantity of water added shall be just sufficient to form a smooth grout which will adhere to and completely coat each and every particle of aggregate, and which is just wet enough to ensure that, at points of contact of aggregate, the grout will run together to form a small fillet to bond the aggregate together. The mix shall contain no more than 20 litres of water for every 50 kg of cement.

Mixing shall be done in an approved batch-type mechanical mixer, but small quantities may be hand mixed.

(d) Placing

No-fines concrete shall be placed in accordance with the procedure approved by the Engineer. It shall be placed in its final position within 15 minutes of having been mixed.

The concrete shall be worked sufficiently to ensure that it will completely fill the space to be concreted and that adjacent aggregate particles are in contact with one another. Excessive tamping shall be avoided and the concrete shall not in any circumstances be vibrated.

(e) Protection

All no-fines concrete shall be protected from the elements' and loss of moisture. Protection against loss of moisture shall be accomplished by one or more of the following methods:

(i) Retaining formwork in place.

(ii) Covering enclosed surfaces with sacking or other approved material kept continuously wet.

(iii) Covering enclosed surfaces with plastic sheeting.

No-fines concrete placed during cold weather shall be adequately protected against frost for at least three days.

6603 JOINTS IN STRUCTURES

(a) Materials

(i) General

All materials used in forming, constructing and sealing permanent joints as well as all proprietary or custom-built expansion-joint assemblies shall be subject to the approval of the Engineer.

When required by the Engineer, the Contractor shall submit test certificates issued by an approved, independent testing authority to confirm that the respective materials comply with the specified requirements, or a certificate by the patent holder or designer certifying that the manufactured item complies in all respects with relevant product specifications.

(ii) Joint filler

Joint filler shall consist of sheets or strips of the following materials complying with the requirements of the relevant specifications listed:

(1) Bitumen-impregnated fibreboard and bitumen impregnated corkboard - US Federal Specification HH-F-341 F or AASHTO Specification M-213.

(2) Resin-impregnated corkboard - US Federal Specification HH-F-341F.

(3) Flexible foams of expanded polyethylene, polyurethane, PVC or polypropylene – AASHTO Specification M-153.

(4) Rigid foams of expanded polyethylene, polyurethane or polystyrene - BS 4840:1985 or BS 3837:1986 Parts 1 and 2.

Other joint filler materials may be used if approved by the Engineer after he/she has been furnished with full specifications and information by the Contractor.

(iii) Sealants
Thermoplastic hot-poured sealants shall comply with the requirements of US Federal Specification SS-S-1401 B, BS 2499:1993 or AASHTO Specification M-173. The sealants shall be of the rubberised bituminous type containing a minimum of 20% natural or synthetic rubber.

Thermoplastic cold-applied sealants shall comply with the requirements of BS 5212-1:1990 or US Federal Specification SS-S-156. The sealant shall be of the rubberised bituminous type containing a minimum of 20% natural or synthetic rubber.

Thermosetting chemically curing sealants shall comply with the requirements of ASTM C-920 or BS 4254:1983.

The final IRHD (International Rubber Hardness Degree) hardness of the sealant shall be 20$\pm$5.

Silicone sealants shall comply with the requirements of the Special Specifications.

Other sealants may be used if approved by the Engineer after he/she has been furnished with full information and specifications by the Contractor.

(iv) Waterstops
Waterstops shall be of natural rubber or flexible PVC and of the type specified or shown on the Drawings.

Natural-rubber waterstops shall comply with the requirements of BS 6213:2000.

Flexible PVC rubber waterstops shall comply with the requirements of BS 2571:1990.

(v) Accessory material

(1) Primers
Where a primer is to be used in conjunction with the sealant, it shall be of the prescribed proprietary material.

(2) Bond breakers
Polyethylene tape coated paper, metal foil or similar material may be used where bond breakers are required.

(3) Backup material
Backup material shall consist of a compressible material of correct width and shape to ensure that, after installation, it will be in approximately 50% compression and the sealant can be formed to the specified depth.
Backup materials shall be compatible with the sealant used. Material containing bitumen or solvents shall not be used with thermosetting chemically curing sealants.

(vi) Cover plates

(1) Steel cover plates shall be of
- Grade 43A steel which complies with the requirements of BS EN 10113:1993, BS EN 10155:1993, or
- Grade 300W steel which complies with the requirements of BS EN 10113:1993, BS EN 10155:1993 or equivalent.

(2) Galvanising shall comply with the requirements of BS EN ISO 1461:1999 and BS EN 10240:1998 or equivalent.

(3) Anchor bolts shall be of stainless steel Grade 302 S.21, which complies with the requirements of BS EN 10083 (various dates)/BS EN 10088:1995 or equivalent.

(b) Filled and unfilled joints

(i) General
Wherever polystyrene or similar material susceptible to damage is used for forming joints, it shall be lined with a hard surface on the side to be concreted. The hard surface shall be sufficiently resilient to ensure that the joint and surfaces can be formed free from defects.

(ii) Filled joints
Filled joints shall be accurately formed to the dimensions shown and with the filler material specified on the Drawings. The filler shall be secured in position such that it will not be displaced during concreting or thereafter if the filler is to remain permanently in the joint.

Where the removal of the filter is required, it shall be done prior to the installation of the proprietary joint.

(iii) Unfilled joints
Unfilled joints shall be accurately formed to the dimensions given on the Drawings and all external corners chamfered or rounded for at least 5 mm. The concrete face against which the fresh concrete is placed shall be treated in good time with an approved bond breaker.

(c) Concrete nosings
Concrete nosings forming the edges of expansion joints shall be constructed as follows:

(i) After the concrete in the structural member has hardened sufficiently, the protruding ends of the reinforcing steel shall be bent flat onto the concrete surface of the formed recess.

(ii) Before the asphalt surfacing is laid, the recess shall be filled with well-compacted crusher run, sand or weak mortar. The Contractor shall ensure that the concrete surfaces of the recess and the reinforcing steel are not contaminated with bituminous agents. The asphalt surfacing shall then be laid continuously over the joint.

(iii) The asphalt surfacing shall be cut with a diamond saw blade to correspond to the width of the nosing and all material shall be removed from the nosing recess. The concrete surfaces of the recess shall then be roughened to expose the aggregate and leave sound, irregular surfaces. The reinforcing steel shall then be bent, fixed and placed as shown on the Drawings.

(iv) The prepared concrete surfaces of the recesses shall be treated with an approved epoxy-resin adhesive, immediately before the concrete nosings are cast. Opposite concrete nosings, separated by a joint filler strip, shall be cast simultaneously in

accordance with SUBCLAUSE 6408(c), and compacted with a vibrator. The nosing shall be screeded flush with the premix surfacing and be given a Class U2 surface finish.

(v) Curing shall be in accordance with CLAUSE 6409(f), Method 6.

(vi) After three days, the gap between the nosings shall be enlarged to the requisite dimensions by cutting both sides with parallel diamond saw blades. The depth of the saw cut shall be such that a ledge is formed along the lower edge of the cut on which the sealer unit can be supported.

(vii) The exposed corners of the nosings shall be ground to a 10 mm chamfer.

(viii) After the joint has been sealed, the wearing surface of the nosings shall be treated with a bituminous primer to the satisfaction of the Engineer.

Unless otherwise specified, traffic shall not be permitted to pass over the joint before the concrete in the nosing has achieved its specified 28-day strength.

Unless otherwise indicated on the Drawings, the concrete used in the construction of the nosings shall be Class 40/13 and shall have a slump of not less than 50 mm and not exceeding 75 mm.

Concrete nosings shall be constructed under the direct supervision of experienced and skilled personnel.

(d) Plug type expansion joints

Plug type expansion joint systems, shall be constructed in accordance with the details on the Drawings and the specifications and instructions of the licences.

(e) Sealing the joints

(i) General
Sealed joints shall be made watertight over the full length of the joint, including the full height of the kerbing, unless otherwise prescribed in the Special Specifications. Unless a waterstop is equipped with an effective watertight interlocking system for joining sections, all joints in waterstops shall be bonded or fused to have a tensile strength of at least 50% of that of the unjointed material. At intersections and abrupt changes of direction, waterstops shall be jointed with prefabricated junction pieces.

Restrictions on joint width and on the temperature at the time of installing the sealant or seal will be shown on the Drawings. In the absence of such restrictions on the Drawings, and unless otherwise specified, installation shall be carried out only within the temperature range between 5°C and 30°C.

(ii) Preparing the joints
Where required, joints shall be sawn at a suitable time so as to avoid edge spalling or ravelling.

After the temporary filler material has been removed or the excess concrete has been broken out, the inside faces of the joint shall be wirebrushed or sand-blasted to remove all laitance and contaminants. The joint shall then be cleaned and blown out with compressed air to remove all traces of dust. Solvents shall not be used for removing contaminants from the concrete and porous surfaces.

The Contractor shall ensure that primers are applied only to surfaces which are absolutely dry. The primer shall be applied strictly in accordance with the manufacturer's instructions. Unless otherwise specified, the primer shall be applied within the temperature range of 10°C and 40°C, and the sealant shall be applied after the curing period of the primer and within the period when the primer remains active.

(iii) Sealants
Sealants shall be applied strictly in accordance with the manufacturer's instructions by a person skilled in the use of the particular type of sealant. Trapping of air and the forming of voids in the sealant shall be avoided. The sealant shall be finished to a neat appearance to the specified depth.

Thermoplastic hot-poured sealants shall not be poured into the joints when the temperature of the joint is below 10°C. The safe heating temperature shall not exceed the specified pouring temperature by more than 10°C.

Two-part thermosetting chemically curing sealants shall not be applied after expiry of the specified pot-life period which commences once the base and activator of the sealant have been combined.

(iv) Waterstops
Waterstops shall be securely and accurately located in position so that they will not be displaced or deformed during construction.

(f) Proprietary expansion joints

(i) General
The use of any type of expansion joint shall be subject to approval. Bidders shall obtain approval for the type of expansion joint they intend using prior to submitting their bids.

(ii) Dimensions
The Contractor shall note the overall dimensions of the expansion joints and the limiting dimensions of that portion of the concrete structure which is to accommodate the joints. No alterations to the concrete which will be visible in the final structure or major re-arrangement of the prestressing anchorages will be permitted in order to accommodate joints of excessive size.

All joints to be installed skew shall be accurately dimensioned to ensure compliance with the requirements of SUBCLAUSE 6603(g).

Unless otherwise specified, proprietary expansion joints shall include the complete expansion-joint assembly, traversing the entire roadway, kerbs, sidewalks and median, and shall include the coping and parapet cover plates as well as the drainage system to drain the expansion joint.

(iii) Design and manufacture
The expansion joint shall be designed to withstand the movements, displacements and rotations specified on the Drawings in conjunction with the loads described in the code of practice adopted for the design of the structure without exceeding in any member the requirement for serviceability limit state. Any strengthening of the supporting member required to resist forces imparted by the joint to the structure shall be for the Contractor's account.

The specified movements, displacements and rotations shall be withstood without the efficacy or riding quality of the joint being impaired.

The joint shall be vibration free, resistant to mechanical wear and other forms of abrasion, and shall resist corrosion. It shall have good riding characteristics, shall be highly skid resistant, silent, and of watertight construction or have provision for the disposal of water, debris or grit collecting in the joint. It shall be of a construction that will facilitate easy inspection, maintenance and repair.

Apart from stainless steel, all steel surfaces shall be prepared in accordance with the requirements of SUBCLAUSE 6907(b) and sprayed with a galvanising coat which complies with the requirements of BS EN ISO 14713:1999 or equivalent for Zn 150 coverage. All enclosed surfaces sprayed with zinc shall, within four hours, be covered with a sealant suitable for use with the zinc and the subsequent layer. Two coats of chlorinated rubber paint with a combined dry-coat thickness of not less than 150 μm shall then be applied. They shall be of two different colours.

Prior to manufacture of the joints, the Contractor shall submit for approval detail drawings in accordance with the requirements of CLAUSE 1221 of each expansion joint. The expansion joints delivered at the site shall be suitably marked to show clearly the sequence and position of installation.

(g) Installing the expansion joints

Proprietary expansion joints shall be installed by approved specialist subcontractors only. Installed proprietary expansion joints shall have a 15 year written guarantee. No expansion joint or part thereof shall be installed prior to the construction of the final surfacing.

The expansion joint shall form an even surface with the road surface on either side and the deviation across and along the expansion joint shall comply with the requirements of SUBCLAUSE 3405(e) and SUBCLAUSE 3405(f) for surface regularity measured by a 3 m straight-edge.

On completion of the installation of the proprietary expansion joints, the Contractor shall submit to the Engineer a certificate from the manufacturer or supplier of the joints, certifying acceptance of the installation, only if the manufacturer installed the joints. Notwithstanding the issuing of such certificate, it shall not relieve the Contractor of his/her responsibility under the Contract. No separate payment will be made for the inspection of the joints and the issuing of the certificate by the manufacturer or supplier. It will be regarded as an obligation of the Contractor to be covered by the contract prices paid for joints.

6604 BEARINGS FOR STRUCTURES

(a) Materials

(i) General
When requested by the Engineer, the Contractor shall submit test certificates from an approved, independent testing authority to show that the respective materials comply with the specified requirements, or a certificate from the patent holder or designer certifying that the manufactured item complies in all respects with relevant product specifications.

Unless otherwise specified, all the materials used for manufacturing the bearings shall comply with the requirements of BS 5400:1983 Part 9.2.

(ii) Roofing felt

Roofing felt shall be 3-ply and comply with the requirements of BS 8217:1994 or equivalent for Type 1 roofing felt.

(iii) Elastomer
The elastomer used in the manufacture of bearings shall be natural rubber or synthetic rubber.

Natural rubber shall comply with the requirements of BS 1154:2003 for specified IRHD hardness.

Synthetic rubber shall comply with the requirements of BS 2752:2003 for specified IRHD hardness.

(iv) Stainless steel plate
The texture of the sliding surface of stainless steel plate used in conjunction with PTFE to form low-friction sliding surfaces shall be equal to or better than 0.2 μm Ra in accordance with the requirements of BS 1134:1988 Parts 1 and 2.

(v) Stainless steel dowels and bolts
Stainless steel used for the manufacture of dowels and anchor bolts shall comply with the requirements of BS EN 10088 for Steel 316S16.

(vi) Mortar
Mortar beddings for seating the bearings shall be composed of an approved sand and either cement or epoxy resin, or may consist of an approved proprietary mortar. The mortar shall comply with the following strength requirements:

(1) Sand-cement mortar
The 7-day compressive strength of 150 mm cubes made from the mortar and cured in a moist atmosphere for the first 24 hours and afterwards in water at 20°C shall be not less than 1.5 times the average contact stress under the bearing or 15 MPa, whichever is the greater.

(2) Sand-epoxy resin mortar.
The cured compressive cube strength of the mortar shall be not less than two times the average contact stress under the bearing, or 20 MPa, whichever is the greater.

(3) Proprietary mortar
The strength requirements for proprietary mortars shall be in accordance with either SUBCLAUSE 6604(a)(vi)(1) or (2) as may be relevant.

(b) Concrete hinges

Concrete hinges shall be constructed in accordance with the details shown on the Drawings.

Construction joints shall not be formed in the throat area. Where a joint is necessary, it shall be formed as a recess below the throat, level with the top reinforcement mat. The width of the recess shall be slightly greater than that of the throat.

Care shall be taken to eliminate the formation of shrinkage cracks within the throat.

During construction, adequate bracing and support shall be provided to the satisfaction of the Engineer to prevent rotation in the throat from the time of casting to completion of the structure incorporating the hinge. During the course of construction the hinge shall not be subjected to conditions which will induce tensile stresses in the throat area. Upon completion of the structural members incorporating the hinge, the space around the throat shall be filled and sealed with an approved compressible material.

(c) Roofing felt
Roofing felt used as bearing strips shall consist of at least three layers.

Where lubricated linings are specified, the roofing felt shall be saturated with motor oil and then liberally dusted with graphite powder before it is laid on the bearing surface.

(d) Elastomeric bearings

(i) Technical data
The following technical data for the elastomeric bearings will be supplied on the Drawings, and shall also be supplied on drawings prepared by the Contractor for submission to the Engineer:

(1) Design loads and deformations
The critical design-load combinations and co-existing rotations and horizontal displacements for each bearing or each group of identical bearings.

(2) Size and construction of bearing
The size and construction of the bearing shall be designated by:

L x B x n(t)

where:

L = length of bearing in the transverse direction, in mm
B = width of bearing in the span direction, in mm
n = number of elastomer layers.
t = thickness of individual elastomer layers, in mm

The steel plates shall be encased in a 3 mm thick elastomer layer.

(3) Hardness and type of elastomer
The IRHD hardness and type of elastomer, i.e. natural or synthetic rubber, from which the specified bearings are to be manufactured.

(4) Identification
Each bearing shall be identified by a number.

(ii) Alternative bearings
Where alternative bearings are offered by the Contractor, they shall be designed in accordance with the requirements of BS 5400:1983 Part 9.1 for the loadings and deformations shown on the Drawings.

Where a bearing consisting of a type of rubber is offered which differs from that which is specified, the bearing shall be redesigned to make provision for the variation in hardness and/or type of rubber.

(iii) Inspection and testing
On completion of the manufacture of the bearings, the Contractor shall submit bearings selected by the Engineer, or specially manufactured bearings to serve as samples as authorised by the Engineer, to an independent testing authority for testing.

The testing facilities of the manufacturer or supplier may be used if so approved and on condition that the tests are conducted in the presence of the Engineer.

The Engineer shall determine which tests are to be conducted, and the tests shall comply with the appropriate requirements of SUBCLAUSE 7111(a). Payment will be made under ITEM 71.01 for these tests, for bearings damaged, and for sample bearings.

Copies of test results and certificates for the above mentioned tests shall be submitted by the Contractor to the Engineer in good time to enable the Engineer to assess the information before the bearings are installed.

The dimensional tolerances for the bearings shall comply with the requirements of SUBCLAUSE 6803(h).

Before the bearings are dispatched to the site of the Works, each bearing, with the exception of large bearings as provided for in the Special Specifications shall be subjected simultaneously to a vertical load equal to 150% of the maximum design load, and to a shear distortion equal to 150% of the maximum design value. The bearings shall be visually inspected for defects by the Engineer or his/her nominee and shall not at any stage under this test show any cracks visible to the naked eye or any other defects. The cost of this testing shall be included in the rate bid for ITEM 71.01.

The Engineer may instruct that one bearing of each consignment shall be cut open, at the Contractor's expense, with a view to a visual assessment of the bonding and the thickness of layers.

(e) Proprietary bearings

(i) General
This Clause covers custom-built bearings and bearings manufactured under licence, except elastomeric bearings. Combined bearings, consisting of an assembly of an elastomeric bearing in conjunction with a low-friction sliding or mechanical component shall fall under this Clause.

The bidder may base his/her bid on any bearing which complies with the specified requirements, provided that the efficacy of the bearing has been verified by tests and successful previous use. Evidence hereof as well as information on the durability and suitability of the bearings for the specified use shall be submitted to the Engineer for consideration.

Details of the product guarantee shall be submitted with the bid.

(ii) Drawings and approval
Prior to manufacturing the bearings, the Contractor or his/her nominee shall submit the following information to the Engineer for consideration:

(1) The manufacturer's specification containing detailed information on the design standards, materials, manufacture and technical data.

(2) Drawings complying with the provision in CLAUSE 1221 showing the bearing construction and installation details.

(3) Friction properties based on actual tests conducted on the relevant materials.

(iii) Technical requirements
The following technical requirements will be supplied on the Drawings, and shall also be supplied on the Drawings prepared by the Contractor for submission to the Engineer:

(1) Design loads and movement
The maximum and minimum vertical loads and co-existing horizontal loads as well as the

maximum horizontal load and co-existing vertical load. The maximum values in each direction of the reversible and irreversible movements and the rotation about each axis.

(2) Identification
Identification of each bearing by a number, data on the degree of freedom of movement (fixed, multi-directional or unidirectional bearings) and the type of bearing (spherical, elastomer-pot, etc) shall appear on each bearing.

(iv) Design
The bearings shall be designed in accordance with the requirements and recommendations of BS 5400:1983 Part 9.1. The following shall also be complied with:

(1) The average pressure on the area of the elastomer shall not exceed 25 MPa under the serviceability Limit State, unless otherwise prescribed by the Engineer.

(2) The maximum average contact stress and maximum edge stress on the concrete or mortar bedding shall not exceed 0.5 and 0.6 times the 28-day cube characteristic compressive strength under the serviceability Limit State respectively, unless otherwise prescribed by the Engineer.

(3) The bearing pad shall be of dimensions as will fit into the space allowed for its installation. Major alterations to the contiguous members will not be permitted.

(v) Construction
Unless otherwise specified, the following shall be complied with:

(1) The thickness of the elastomer disc shall be not less than 0.066 times its diameter.

(2) Approved lubricants only shall be used on the PTFE sliding surfaces.

(3) The bearing shall be provided with tight-fitting seals to prevent the ingress of dust or deleterious matter onto the moving parts. The seals shall be of an approved type and sufficiently durable to last in excess of 50 years.

(4) The assembled bearing shall be supplied with welded or bolted lugs or straps, temporarily securing the moving parts firmly in position to ensure that no undesirable relative movement occurs before or during construction.

(5) The bearing shall be recessed into adaptor plates or be of such construction as to facilitate removal of the bearing from the installed position without damage to any part of the bearing or the surrounding material after the relevant structural member has been raised by 15 mm or the distance specified.

(6) Anchors and holding-down bolts shall be of the specified material.

(7) Corrosion protection of all exposed steel surfaces, with the exception of the stainless-steel sliding plate, shall involve the following treatment:

- Preparing the surfaces by abrasive blasting to a finish equal to the Sa3 finish of BS EN ISO 8501-1:2001, BS 7079-A1:1989, Swedish Standard SIS 05 59 00 or equivalent.
- Spraying the surfaces with zinc to comply with the requirements of AASHTO M32-97 or equivalent on approval of the Engineer for Type Zn 150 surfacing.
- Coating the zinc-sprayed surfaces within four hours with a sealer compatible with the zinc and the subsequent coats of paint.
- Applying a coat of chlorinated rubber paint with a minimum of 75 μm of dry-film thickness and of a colour which differs from that of the final coat of paint.
- Applying a final coat of chlorinated rubber paint with a minimum of 75 μm of dry-film thickness and of dark grey colour.
- Surfaces in contact with concrete shall be sprayed with zinc so that it complies with the requirements of AASHTO M32-97 or equivalent on approval of the Engineer for Type Zn 150 surfacing.

(vi) Inspection and testing
The Engineer may require tests to be conducted to verify compliance of the bearing with the specifications and/or its satisfactory performance under the design loads. Payment for this testing will be made under ITEM 71.01.

Test certificates of all the tests conducted shall be submitted to the Engineer.

The Contractor shall give the Engineer at least seven days notice prior to final assembly of the bearings to enable the Engineer to inspect the bearings at the factory.

Under no circumstances shall bearings be taken apart and reassembled on the site, except where it is an unavoidable feature of the installation procedure, in which case the dismantling, installation and reassembly shall be under the supervision of qualified personnel.

Rehabilitation, modification and repair work to bearings shall be carried out only in the factory or in an approved engineering Works.

(f) Dowels and guides
Where dowels and guides are used in conjunction with bearings they shall not complicate or prevent the removal of the bearings.

(g) Storage and handling
The bearings shall at all times be stored under cover and clear of the ground, away from sunlight, heat, oils and chemicals deleterious to the bearings. The bearings shall not be stacked in a manner or on a surface which will cause distortion of the bearings.

The bearings shall be handled with care to ensure that they are not subjected to impact loads or any other conditions which may be harmful.

(h) Installation
The concrete surfaces of elements required to receive bearings shall comply with the requirements of SUBCLAUSE 6209(c). Plastering of the surface will not under any circumstances be permitted.

Before the mortar bedding is constructed, the concrete surface shall be chipped back to expose the aggregate and leave a sound irregular surface. Bonding of the mortar bedding to the concrete surface shall be in accordance with the manufacturer's recommendations and the Engineer's instructions.

Unless otherwise shown on the Drawings, the bearings shall be installed on a horizontal plane and shall be in full contact with the concrete and bedding surfaces.

To accommodate soffit irregularities and camber in the case of precast members, the member shall be lowered onto a mortar skim on top of the bearing. The member shall then be propped until the mortar skim has hardened into a wedge.

The bearings shall be accurately installed to the specified level, alignment and orientation, all within the construction tolerances set out in SUBCLAUSE 6803(h) and the details shown on the Drawings.

Where the bearing has long sliding plates, the latter shall be rigidly supported to prevent their being distorted under the weight of the wet concrete and the construction loads. Before the bearing is incorporated into the structure, it shall be cleaned to remove all deleterious substances and adhering matter, after which it shall be wrapped in polyethylene sheeting and so sealed as to prevent the ingress of mortar and/or slush onto the bearing during the course of construction.

After installation, the polyethylene wrapping shall be removed, the bearing and the space around the bearing thoroughly cleaned and the lugs removed as prescribed by the Engineer.

On completion of installation of proprietary bearings, the Contractor shall submit to the Engineer a certificate from the manufacturer or supplier of the bearings certifying acceptance of the installation, only if the manufacturer installed the bearings. The issuing of such a certificate shall not relieve the Contractor of his/her responsibility under this Contract. No separate payment will be made for the inspection of the bearings by the manufacturer or supplier and the issuing of the certificate.

6605 PARAPETS, RAILINGS AND SIDEWALKS

(a) Materials

(i) Concrete
All concrete work shall be carried out in accordance with the requirements of SECTIONS 6200, 6300, 6400 and CLAUSE 6603.

(ii) Structural steel
Structural steel work shall comply with the provisions of SUBCLAUSE 6702(a).

(iii) Mortar
Mortar shall comply with the requirements of SUBCLAUSE 6604(a)(vi).

(b) Concrete parapets

Concrete parapets shall be either cast in situ or precast or a combination of the two as shown on the Drawings. Where possible, precast elements shall be placed with the unformed surface downwards or outwards.
Concrete parapets shall be constructed after the removal of the falsework and the completion of the prestressing but not before the bridge deck has been accurately measured so as to determine the final lines and levels.

Service ducts in parapets and blocks shall be fixed and cast into position in accordance with the requirements of CLAUSE 6411 and the details shown on the Drawings.

The pipes and fittings to be used for the construction of the ducting shall be rigid PVC pipes and fittings with flexible rubber joints which comply with the requirements of BS 4346-1:1969 or equivalent. Duct ends shall be provided with suitable conical wooden stoppers to prevent dirt, concrete, etc, from entering the ducts. Two strands of 2.5 mm diameter galvanised steel wire shall be threaded through each duct. The strands shall extend 2 m beyond each end and be wedged firmly into position with the wooden stoppers. Inspection eyes for the ducts shall be constructed in accordance with the details shown on the Drawings.

No separate payment will be made for service ducts in parapets and end blocks and the rates bid for the parapets and end blocks shall include full compensation for the provision and installation of service ducts complete with stoppers, draw wire and inspection eyes.

(c) Steel railings

All steelwork shall be manufactured in accordance with the requirements of SECTION 6700.

A mortar bed, not less than 10 mm in thickness, shall be provided below all steel base plates over the full dimensions of the plate. The sides of the beds shall be neatly chamfered at 45°. All open spaces between the bolt and the sides of the holes in the base plate shall be filled with an approved sealant.

Steelwork which is to be cast or grouted into concrete shall be completely painted to a distance of 75 mm in the concrete or grout, and shall be cleaned of all loose rust, mill scale, oil or other material which may impair the bond between the concrete and steel.

All steelwork shall be painted in the shop and on site in accordance with the provisions of SECTION 6900. Surfaces which will be inaccessible after erection of the units shall be painted before erection commences. If called for on the Drawings or in the Bill of Quantities, steelwork shall be galvanised and painted. Galvanising shall be done after fabrication, in accordance with BS EN ISO 1461:1999 or equivalent for Type A1 articles.

(d) Numbers for structures

(i) Number plates
Number plates shall be fixed in the positions and according to the method of fixing shown on the Drawings.

(ii) Painted numbers
The surface onto which the numbers are to be painted shall be prepared in accordance with the requirements of SUBCLAUSE 6909(a). The background shall be of at least two coats of the prescribed paint. The letters and figures shall be in accordance with the details given on the Drawings and shall be written at the prescribed positions with a template.

(iii) Numbers shaped in concrete
Bridge numbers shall be placed and shaped in accordance with the requirements shown on the Drawings. The minimum concrete cover over the steel reinforcement behind the numbers shall not be less than the prescribed cover for the structural member in question.

(e) Concrete sidewalks

After completion of the prestressing (if any) and the removal of the formwork, the sidewalks and kerbing shall be constructed, but not before the bridge deck has been accurately surveyed to establish final lines and levels.

The previously cast bridge deck area shall be prepared as specified in CLAUSE 6408 to receive the sidewalk concrete.

Forms shall be accurately set to the final lines and levels and shall be firmly held in position during the placing of the concrete. Stops at the ends of sections shall be accurately placed to ensure that joints between adjacent sections will be truly perpendicular to the surface of the concrete and at right angles to the edge of the road or to the skew angle of the deck at the expansion joint.

After removal of the forms, the enclosed surfaces of the kerbs and copings shall be rubbed and finished in accordance with the requirements of SUBCLAUSES 6208(a), 6208(c) and 6209(b). All edges shall be rounded to a radius of 20 mm unless otherwise shown on the Drawings.

(f) Concrete surface finish requirements
All formed concrete surfaces shall have a Class F3 surface finish as specified in SUBCLAUSE 6207(d) and all unformed concrete surfaces shall have a Class U2 surface finish in accordance with SUBCLAUSE 6209(b).

(g) Transition blocks
Transition blocks shall be constructed in accordance with the details shown on the Drawings.

(h) Nose endings
Nose endings of balustrades shall be constructed in accordance with the details on the Drawings.

6606 DRAINAGE FOR STRUCTURES

(a) Weep holes, drainage pipes and channelling
Weep holes shall not be placed within 40 mm of any reinforcement and shall be carefully cleaned and kept clean. Drainage pipes shall be of the material prescribed on the Drawings, and the interior surface shall, on completion, be smooth and clean.

Cast in situ concrete channelling shall be provided next to the kerbing if shown on the Drawings and according to the details provided. Concrete work shall be carried out in accordance with the provisions of SECTION 6400 and channelling shall be given a Class U3 surface finish as specified in SUBCLAUSE 6209(c). The channelling shall be bonded to the bridge deck concrete in accordance with the provisions of CLAUSE 6408.

(b) No-fines concrete blocks
Blocks shall be of the class of prescribed no-fines concrete and to the required dimensions and shall be placed in advance of backfilling.

No-fines concrete shall comply with the requirements of CLAUSE 6602.

(c) Synthetic-fibre filter fabric
Synthetic-fibre filter fabric shall be of the type and grade shown on the Drawings or specified in the Special Specifications. Filter fabric shall be placed as shown on the Drawings and shall be protected against sunlight and mechanical damage during storage and installation.

The fabric shall comply with the requirements of SUBCLAUSE 2104(a).

(d) Crushed stone in drainage strips behind walls
The crushed stone used in drainage strips shall comply with the requirements for 20 mm nominal size stone. The crushed stone shall be wrapped in synthetic-fibre geotextile and placed in accordance with the details shown on the Drawings or as instructed by the Engineer.

The fabric shall comply with the requirements of SUBCLAUSE 2104(a).

6607 MEASUREMENT AND PAYMENT

ITEM		UNIT
66.01	CAST IN SITU NO-FINES CONCRETE	CUBIC METRE (m^3)

The provisions of CLAUSE 6416 ITEM 64.01 shall apply with changes as required.

ITEM		UNIT
66.02	PRECAST NO-FINES CONCRETE UNITS (CLASS OF CONCRETE AND DESCRIPTION OF UNIT)	NUMBER (no)

The unit of measurement shall be the number of complete units of each size and type in position in the Works.

The bid rate for each precast concrete unit shall include full compensation for providing all the materials, labour, equipment and formwork required for manufacturing the unit complete as shown on the Drawings and for transporting and placing the unit in position.

ITEM		UNIT
66.03	PROPRIETARY EXPANSION JOINTS:	
(a)	PRIME COST SUM ALLOWED FOR PURCHASING AND TAKING DELIVERY OF EXPANSION JOINTS	PRIME COST SUM
(b)	PERCENTAGE ON PRIME COST SUM FOR CHARGES AND PROFIT	PER CENT (%)

A Prime Cost Sum shall be allowed for payment for actual costs of purchasing and taking delivery of proprietary expansion joints. A percentage on the prime cost sum shall cover the Contractor's charges and profit for purchase and delivery of the joints.

ITEM		UNIT
66.04	INSTALLATION OF PROPRIETARY EXPANSION JOINTS:	
(a)	(DESCRIPTION OF JOINT MEASURED PER METRE)	METRE (m)
(b)	(DESCRIPTION OF JOINT MEASURED BY NUMBER)	NUMBER (no)

The unit of measurement shall be either the metre of complete joint of each type installed or the number of complete joints of each type installed. The bid rates shall include full compensation for supplying all materials not covered under ITEM 66.03, transporting, handling and storing, and all labour, equipment, shaping the recesses, and incidentals required for installing the expansion joint complete in accordance with instructions. Separate payment shall not be made for supplying and/or installing the seal in proprietary expansion joints or the seal between concrete or synthetic nosings.

The cost of forming the open joint(s) shall not be included in the rates bid for ITEM 66.04 as payment for this work shall be made under ITEM 62.06.

The bid rate shall be final and binding, irrespective of the type or make of joint finally installed.

ITEM		UNIT
66.05	EXPANSION JOINTS:	
(a)	(DESCRIPTION OF JOINT MEASURED PER METRE)	METRE (m)
(b)	(DESCRIPTION OF JOINT MEASURED BY NUMBER)	NUMBER (no)

The unit of measurement shall be the metre of complete expansion joint of each type installed or the number of completed joints of each type installed.

The bid rates shall include full compensation for supplying all the materials, manufacturing the expansion joint, transporting, handling and storing, and all labour equipment, shaping the recesses, and incidentals required for installing the expansion joint complete in accordance with instructions. Separate payment shall not be made for supplying and/or installing the seal in proprietary expansion joints or the seal between concrete or synthetic nosings.

The cost of forming the open joint(s) shall not be included in the rates bid for ITEM 66.05 as payment for this work shall be made under ITEM 62.06.

ITEM		UNIT
66.06	FILLED JOINTS:	
(a)	(DESCRIPTION OF AND THICKNESS OF JOINT FILLER FOR JOINTS MEASURED PER SQUARE METRE)	SQUARE METRE (m^2)
(b)	(DESCRIPTION OF AND THICKNESS OF JOINT FILLER FOR JOINTS MEASURED PER METRE)	METRE (m)

The unit of measurement shall be the square metre of filled joint calculated from the surface area of the joint. Where the filled joint is 150 mm or less in depth, the unit of measurement shall be the metre of filled joints measured along the joint centre line. Concrete surfaces formed prior to the construction of the final surface for completing the filled joint shall be measured under ITEMS 62.01, 62.02, 62.03 or 62.04, as may be applicable.

The bid rates shall include full compensation for supplying and installing the joint filler and all materials not covered under ITEM 66.08, and for all labour and incidentals required for completing the filled joint as prescribed.

ITEM		UNIT
66.07	UNFILLED JOINTS:	
(a)	(DESCRIPTION OF JOINT FOR JOINTS MEASURED PER SQUARE METRE)	SQUARE METRE (m^2)
(b)	(DESCRIPTION OF JOINT FOR JOINTS MEASURED PER LINEAR METRE)	METRE (m)

The unit of measurement shall be the square metre of unfilled joint, calculated in accordance with the joint area. Where, however, the depth of the joint is 150 mm or less, the unit of measurement shall be the metre of unfilled joint measured along the joint centre line. Concrete areas formed before the final surface is constructed to complete the unfilled joint, shall be measured under ITEMS 62.01, 62.02, 62.03 or 62.04, as may be applicable.

The bid rates shall include full compensation for providing and applying the bond breaker and all materials not paid for under ITEM 66.08, also for the labour and incidentals required for completing the unfilled joint as prescribed.

ITEM		UNIT
66.08	SEALING JOINTS WITH:	
(a)	SEALANT (DESCRIPTION OF JOINT, SEALANT AND SIZE)	METRE (m)
(b)	SEAL (DESCRIPTION OF JOINT, SEALANT AND SIZE)	METRE (m)
(c)	WATERSTOP (DESCRIPTION OF JOINT, WATERSTOP AND SIZE)	METRE (m)

The unit of measurement shall be the metre of sealant, seal or waterstop of each type installed.

The bid rates shall include full compensation for supplying all materials, forming or cutting the concrete to the required shape and size, all labour, equipment and incidentals required for sealing the joint complete in accordance with the prescriptions, and for all waste materials.

ITEM		UNIT
66.09	PROPRIETARY BEARINGS:	
(a)	PRIME COST SUM ALLOWED FOR PURCHASING AND TAKING DELIVERY OF BEARINGS	PRIME COST SUM
(b)	PERCENTAGE ON PRIME COST SUM FOR CHARGES AND PROFIT	PERCENTAGE (%)

A Prime Cost Sum shall be allowed for payment for actual costs of purchasing and taking delivery of proprietary bearings, complete with anchor bolts and/or dowels. A percentage on the prime cost sum shall cover the Contractor's charges and profit for purchase and delivery of the bearings.

ITEM		UNIT
66.10	INSTALLING THE PROPRIETARY BEARINGS (DESCRIPTION OF EACH TYPE, AND STATE CLASS)	NUMBER (no)

The unit of measurement shall be the number of complete bearings of each type and class installed.

The bid rate shall include full compensation for supplying all the materials not covered under ITEM 66.09, constructing the bedding, transporting, handling and storing, and all labour, equipment and incidentals required for installing the bearings complete as detailed.

The bid rate shall be final and binding, irrespective of the type or make of bearing finally installed.

ITEM		UNIT
66.11	BEARINGS (DESCRIPTION OF EACH TYPE AND CLASS)	NUMBER (no)

The unit of measurement shall be the number of complete bearings of each type and class installed.

The bid rate shall include full compensation for supplying all the materials, including anchor bolts and/or dowels, constructing the bedding, manufacturing the bearings, transporting, handling and storing, and all labour, equipment and incidentals required for installing the bearings complete as detailed.

ITEM		UNIT
66.12	CONCRETE HINGES:	
(a)	(DESCRIPTION OF HINGE MEASURED PER METRE)	METRE (m)
(b)	(DESCRIPTION OF HINGE MEASURED BY NUMBER)	NUMBER (no)

The unit of measurement shall be either the metre of complete hinge of each type manufactured and installed or the number of complete hinges of each type manufactured and installed.

The bid rates shall include full compensation for supplying all materials, including formwork, manufacturing the hinges, transporting, handling and storing, sealing the hinges, and all labour, equipment and incidentals required for installing the hinges complete as detailed.

ITEM		UNIT
66.13	BEARING STRIPS (DESCRIPTION OF THE MATERIAL AND NUMBER OF LAYERS)	SQUARE METRE (m^2)

The unit of measurement shall be the square metre of bearing area lined with the specified material irrespective of the number of layers placed.

The bid rate shall include full compensation for supplying all the materials, transporting, handling and storing, and all labour and incidentals required for installing the bearing strips complete as detailed.

ITEM		UNIT
66.14	DOWELS/GUIDES (DESCRIPTION OF EACH TYPE)	NUMBER (no)

The unit of measurement shall be the number of dowels/guides of each type installed.

The bid rate shall include full compensation for supplying all materials, including anchor bolts, manufacturing the dowels/guides, transporting, handling and storing, and all labour, equipment and incidentals required for installing the dowels/guides complete as detailed.

ITEM		UNIT
66.15	CONCRETE PARAPETS	METRE (m)

The unit of measurement for concrete parapets shall be the metre of concrete parapet complete in accordance with the Drawings. Concrete parapets shall include all work above the top level of the sidewalks or, where not placed on a sidewalk, above the top of the bridge deck concrete, wingwalls or retaining walls and shall also include any kerbing and coping forming an integral part of the concrete parapet.

The bid rate for concrete parapets shall include full compensation for all concrete, formwork, service ducts, drawing wires and accessories. The rates will exclude only the cost of reinforcing steel as this will be measured and paid for under ITEM 63.01.

ITEM		UNIT
66.16	STEEL RAILINGS (TYPE DESCRIBED)	METRE (m)

The unit of measurement for steel railings shall be the metre of railing complete in accordance with the Drawings.

The bid rate for steel railings shall include full compensation for all steelwork and corrosion protection, including fastenings, anchor bolts, mortar bedding, etc, as may be required for erecting the railings.

ITEM		UNIT
66.17	END BLOCKS	NUMBER (no)

The unit of measurement of bridge end blocks shall be the number of end blocks constructed complete in accordance with the Drawings.

The bid rate shall include full compensation for all materials, labour, equipment, and other incidentals required for constructing the end blocks complete as specified, excluding only reinforcing steel.

ITEM		UNIT
66.18	NUMBERS FOR STRUCTURES:	
(a)	NUMBER PLATES	NUMBER (no)
(b)	PAINTED NUMBERS	NUMBER (no)
(c)	NUMBERS FORMED IN CONCRETE	NUMBER (no)

The unit of measurement shall be either the number of bridge number plates provided and installed, or the number of complete numbers painted on the structures, or the number of complete numbers formed in concrete. A bridge number may consist of a combination of letters and digits; e.g. B1533.

The bid rates shall include full compensation for providing and installing either the number plates, or preparing the surface and painting the numbers, or forming the numbers in concrete, and for all material, labour and equipment required in this connection.

ITEM		UNIT
66.19	DRAINAGE PIPES AND WEEP HOLES:	
(a)	DRAINAGE PIPES: ·	
	(i) (TYPE AND SIZE INDICATED)	METRE (m)
	(ii) (TYPE AND SIZE INDICATED)	NUMBER (no)
(b)	WEEP HOLES:	
	(i) (TYPE AND SIZE INDICATED)	METRE (m)
	(ii) (TYPE AND SIZE INDICATED)	NUMBER (no)

The unit of measurement shall be either the metre of pipe/weep hole or the number of pipes/weep holes of each type and size of pipe/weep hole completed.

The bid rates shall include full compensation for supplying all the materials, manufacturing and installing the pipes and making weep holes.

ITEM		UNIT
66.20	DRAINAGE GULLEYS DESCRIPTION OF EACH TYPE GIVEN)	NUMBER (no)

The unit of measurement shall be the number of drainage gulleys of each type installed.

The bid rate shall include full compensation for providing all the material and manufacturing and installing the drainage inlets.

ITEM		UNIT
66.21	SYNTHETIC-FIBRE FILTER FABRIC (TYPE INDICATED AND DESCRIPTION)	SQUARE METRE (m^2)

The unit of measurement shall be the square metre of filter fabric installed as specified, including the specified overlap.

The bid rate shall include full compensation for supplying, cutting, lapping and installing the filter fabric, and for waste material.

ITEM		UNIT
66.22	CONCRETE CHANNELLING (SIZE INDICATED)	METRE (m)

The unit of measurement shall be the metre of completed concrete channelling of each size constructed.

The bid rate shall include full compensation for providing all the material, all labour equipment and expenses required for completing the work.

ITEM		UNIT
66.23	CRUSHED STONE IN DRAINAGE STRIPS	CUBIC METRE (m^3)

The unit of measurement shall be the cubic metre of crushed stone placed in position as specified, in accordance with the details shown on the Drawings or instructed by the Engineer.

The bid rate shall include full compensation for procuring, furnishing and placing the crushed stone, and for wrapping it in synthetic-fibre geotextile as specified. The geotextile will be measured for payment under ITEM 66.21.

ITEM		UNIT
66.24	NOSE ENDINGS OF BALUSTRADES	NUMBER (no)

The unit of measurement shall be the number of nose endings constructed complete in accordance with the details shown on the Drawings.

The bid rate shall include full compensation for all labour, equipment and materials required, for filling the recesses with concrete or nosing material, 20 mm x 20 mm plastijoint seal between the end block and the transition block, steel cover plate complete with anchor bolts, and all incidentals required for constructing the nose endings complete.

ITEM		UNIT
66.25	CONCRETE TRANSITION BLOCKS (LENGTH INDICATED)	NUMBER (no)

The unit of measurement shall be the number of each size of concrete transition block constructed complete in accordance with the details shown on the Drawings.

The bid rate shall include full compensation for all labour, equipment, materials and all incidentals required for constructing the transition blocks.

SERIES 6000: STRUCTURES

SECTION 6700: STRUCTURAL STEELWORK

CONTENTS:

6701 SCOPE

This Section covers the manufacture, transport and erection of structural steelwork for minor structures, e.g. overhead road-sign structures. It does not apply to major steel structures such as steel bridges, which will be covered in the Special Specifications where work of this nature is required.

6702 MATERIALS

(a) Structural steel
Structural steel shall comply with the following requirements:

- Mild steel: BS 7613:1994/BS 7668:1994/BS EN 10029:1991/BS EN 10113:1993/BS EN 10115:1993/BS EN 10210-1:1994 or equivalents.
- High-yield stress steel: BS 7613:1994/BS 7668:1994/BS EN 10029:1991/BS EN 10113:1993/BS EN 10115:1993/BS EN 10210-1:1994 or equivalents.

The dimensions and properties of rolled steel sections shall comply with the prescriptions given in the structural steel tables issued by the British Standards Institution or equivalent.

(b) Steel tubes
Steel tubes shall comply with the requirements of BS EN 39:2001 or equivalent.

(c) Bolts, nuts and washers
Ordinary bolts and nuts shall be bolts and nuts used for transferring forces by tensile stress, compressive stress and shear stress without any friction-grip action being considered. Ordinary bolts and nuts shall comply with BS 3692:2001 or BS 325:1947 or equivalent. Washers for ordinary bolts and nuts shall comply with the requirements of BS EN 2138:2000 or equivalent.

High-strength friction-grip bolts, nuts and washers shall comply with the requirements of BS 4395-2:1969 or equivalent.

Other approved friction-grip fasteners equal to the above may be used.

(d) Rivets
Mild-steel rivets shall comply with the requirements of BS 1109:1943 or equivalent. High-tensile rivets shall be so manufactured that they can be driven and their heads formed satisfactorily without the physical properties of the steel being impaired.

(e) Welding consumables
Welding electrodes shall comply with the requirements of SABS 455 or equivalent.

The quality, handling and storage of all consumables shall be so as to achieve the desirable properties of the weld metal.

The welding consumables used shall be appropriate to produce weld metal which will yield all the weld-metal test specimens as specified in BS 709:1983 having both minimum yield and minimum tensile strengths not less than those of the parent metal.

(f) Test certificates
The Contractor shall submit test certificates, as required by the Engineer, of the structural steel and anchor bolts that will be used.

6703 CODES OF PRACTICE

The design, where undertaken by the Contractor, of all work shall comply with the requirements of BS 5950:2000 Parts 1 to 9 or equivalent.

6704 SHOP DETAILS

Where shop details have not been furnished on the Drawings, the Contractor shall prepare his/her own shop details in accordance with the provisions of CLAUSE 1221. Shop details shall be approved and signed by the Engineer prior to the fabrication of any items.

6705 FABRICATION AND ASSEMBLY

(a) General
All structural steel both before and after fabrication shall be within the tolerances specified in SUBCLAUSE 6803(j) and shall be flat, straight (unless required to be formed to another shape) and free from twists.

(b) Marking the steel
At all stages of fabrication, all structural steel other than Grade 43A steel shall be clearly marked by grade by means of a suitable marking system.

(c) Cutting
Steel shall be cut by sawing, shearing with shears, cropping, or flame-cutting.

Edges shall be free from any defects or distortions and all burrs, notches and similar defects shall be removed.

All structural welds shall be full-strength joints.

(d) Holes for fasteners
Holes for fasteners shall not be formed by flame cutting. Holes in light members not thicker than 12 mm or the diameter of the hole, whichever is the smaller, may be punched.

Holes for fasteners of up to 25 mm in diameter shall not be more than 2 mm larger than the diameter of the fastener and holes for larger fasteners not more than 3 mm larger than the diameter of the fastener.

Holes for friction-grip fasteners shall be in accordance with BS 4604-2:1970 or equivalent.

All burrs shall be removed from holes before assembly.

(e) Joints in compression
The abutting surfaces of joints dependent on contact for the transmission of load shall be accurately prepared so

that the full area intended for bearing will be in contact as specified in SUBCLAUSE 6803(j).

(f) Hollow sections
Unless protection against corrosion is provided by other means, the interior of any hollow section shall be sealed to prevent the ingress of moisture. Where a sealed hollow member is holed for a fastener or pin, precautionary measures shall be taken to prevent the ingress of water to the interior of the member. Vent holes for galvanising shall be sealed after galvanising has been completed.

(g) Alignment of holes
All matching holes for fasteners or pins shall be accurately aligned so that the fasteners can be inserted freely through the assembled members in a direction at right angles to the faces in contact. Drifting for aligning the holes shall not distort the metal or enlarge the holes.

(h) Welding
Welding shall be done in accordance with the requirements of BS EN 1011:1998.

The welding techniques shall be such as to avoid undue distortion and to minimise shrinking stresses.

All slag shall be removed.

Where required for certain welding:

(i) The manufacturer shall hold a valid welding-procedures certificate in accordance with BS EN 288-1:1992 or equivalent for Grade B welding joints, and the welding shall be done by a welder qualified in accordance with BS EN 287:1992 or equivalent;

(ii) Or, the welder shall hold a valid certificate of competency in accordance with BS 4872-1:1982 or equivalent for the specified type of welding.

(i) Bolting
The jointed parts shall be firmly drawn together. Where necessary, tapering washers shall be used for each bolt head and nut to transfer the compressive stress over its full surface. Where bolt holes have greater than normal clearance, washers shall be placed under the bolt heads and nuts.

The length of each bolt shall be such that, after tightening, at least one full thread projects through the nut on the outside and at least one full thread (in addition to the thread run-out) remains clear between the nut and the bolt head.

(j) Friction-grip fastening
The use of friction-grip bolts shall be in accordance with BS 4604-2:1970 or equivalent. Where use is made of equivalent types of friction-grip fasteners, they shall comply with the requirements of BS 4604-2:1970 or equivalent for equivalent fasteners and shall be installed in accordance with the appropriate requirements of BS 4604-2:1970 or equivalent.

(k) Riveting
Wherever possible, riveting shall be done with pneumatic equipment.

Riveted units shall have all parts firmly drawn together and aligned before riveting. Every rivet shall, when driven, completely fill the hole and shall have a well-formed head or, if countersunk, fill the countersink completely.

All loose, eccentric-headed, badly formed, burnt or otherwise defective rivets shall be cut out and replaced.

(l) Trimming
All fabricated steel work shall be neatly trimmed so as not to show any sharp edges. Acute angles shall be rounded off to a radius of at least 1.0 mm.

(m) Corrosion prevention

(i) Painting
Before removal from the place of manufacture the steelwork shall be painted as specified in SECTION 6900.

Where the finishing coats are to be applied on the site, the shop painting shall include the application of an undercoat as specified in SECTION 6900.

Galvanised steel shall not be painted unless painting is specifically called for in the specifications.

(ii) Sprayed metal coatings
Where the sprayed metal coating of steel surfaces is called for, it shall be done in accordance with the requirements of BS EN ISO 14713:1999 or equivalent. The type of metal used shall be as specified, and, unless otherwise specified, the metal coating shall comply with the requirements of Type Al 150 or Type Zn 150.

(iii) Galvanising
Where the galvanising of structural steelwork is required, the members shall be hot-dip galvanised. Structural steel members shall be given an 85 μm coating or such other thickness as may be specified, in accordance with BS EN ISO 1461:1999 or equivalent and sheet steel and strip a Class M coating in accordance with BS EN 10147:2000 or equivalent.

All nuts, bolts, screws and threaded articles shall be hot-dipped galvanised in accordance with the appropriate requirements of BS EN ISO 1461:1999 or equivalent for Type C1 or Type C2 articles.

Cut ends and small damaged areas shall be repaired by the application of a zinc-rich paint or by zinc spraying.

(n) Built-up sections
In addition to the requirements of SECTION 6700, built-up sections shall be produced in accordance with Drawings and Special Specifications to the Engineer's approval.

6706 ERECTION

(a) General
Where specified, details of the method of erection shall be submitted to the Engineer for approval.

All structural steel shall be stored, transported, handled and erected so as not to subject it to undue stress or damage.

Erection over traffic is not permitted, and a temporary diversion for traffic shall be provided.

Provision for traffic accommodation will be paid for in accordance with the appropriate items under SECTION 1500.

(b) Safety during erection
During the erection of a structure, the steelwork shall be bolted, braced or otherwise secured so as to make adequate provision for all erection loads.

(c) Alignment
Each part of a structure shall be aligned as soon as possible after erection. Members shall not be permanently connected until sufficiently large members of the structure have been aligned, plumbed, levelled, and temporarily secured to prevent their displacement during the erection or alignment of the remainder of the structure.

(d) Corrections
Drift pins, jacking equipment and the like shall not be used for bringing improperly fabricated members into place. A moderate degree of cutting and reaming may be done to correct minor misfits if, in the opinion of the Engineer, this will not be detrimental to the appearance or strength of the structure. The burning of holes will not be permitted without written approval.

(e) Repairs to painting and site painting
Repairs to painting and site painting shall be effected in accordance with the provisions of CLAUSE 6907.

(f) Grouting
The grout shall be poured under and around the base plates of columns after the steelwork has been finally checked for alignment and height, and after the approval of the Engineer has been obtained to proceed with the grouting. The column base plates shall be supported by the top and bottom nuts and by steel wedges. The area under the steel shall be thoroughly cleaned and shall be dust and oil-free, and the concrete shall be thoroughly rinsed with water to leave the surface clean and moist.

The grout shall be an approved non-shrinking, pourable, cementitious grout. The grout shall be prepared and applied strictly in accordance with the manufacturer's recommendations and the Engineer's directives.

Leak-proof formwork shall be used for the pourable grout, and all corners shall be chamfered. The surface finish shall be Class F2 and Class U2 as applicable.

6707 TESTING

(a) Testing by the Engineer
The Engineer may nominate a testing authority to inspect the Works and to conduct such tests as he/she may deem to be necessary to test compliance with the specifications. Where required, test samples of welds shall be prepared by the Contractor, free of charge.

Payment for these tests shall be made under ITEM 71.01.

(b) Process control
Welds shall be regularly inspected and tested by the Contractor in terms of his/her obligations in regard to process control, as described in CLAUSE 1205. This shall include visual inspection of welds to ensure that no undercutting, uneven lengths, porosity, or evidence of cracking occurs and that full fusion of the metals has been achieved. In doubtful areas, cores containing weld metal and adjacent parent material shall, if so required by the Engineer, be cut out, polished and examined and the hole repaired.

At least 30% of the welds shall be examined by ultrasonic or radiographic means. If more than 5% of the examined welds show unsatisfactory results, additional examinations covering all welds shall be performed. Certificates of the examination confirming that the steel plates and welds comply with the requirements of SABS 044 Part III or equivalent shall be submitted to the Engineer.

The cost of testing shall be deemed to be included in the rate bid for ITEM 67.01 Structural steel.

6708 MEASUREMENT AND PAYMENT

ITEM	UNIT
67.01 STRUCTURAL STEEL:	
(a) (STRUCTURE/ARTICLE DESCRIBED)	TONNE (t)
(b) (STRUCTURE/ARTICLE DESCRIBED)	METRE (m)
(c) (STRUCTURE/ARTICLE DESCRIBED)	NUMBER (no)

The unit of measurement shall be either the tonne or the metre of erected permanent steel structures or articles, or the number of erected permanent steel structures or articles. Where the unit of measurement is the tonne the weight of the steel waste caused by punching, drilling, sheared edges, milling or planning, or metal cut-outs shall not be deducted, and the weight of rivets, bolts, nuts, washers, welding fillets or temporary bracing shall not be added. In computing the weight of steel, the nominal weight per unit of length or area will be used and tolerances and other permissible deviations will be ignored.

The bid rates shall include full compensation for preparing shop details where not provided on the Drawings, the supply of all the required materials, fabrication, process control, loading, transporting to the site, off-loading, and erecting. It shall also include full compensation for all nuts, bolts, washers, rivets, cutting, waste, and any temporary bracing necessary for transporting and erecting.

The bid rate shall also include full compensation for supplying and pouring the specified grout under and around the base plates of steel columns, for procuring and supplying all the necessary labour, equipment, tools and materials, as well as waste, formwork for the grout, and finishing to obtain the required surface finish for the grout under and around base plates of steel columns.

ITEM	UNIT
67.02 ANCHOR BOLTS:	
(a) (DESCRIPTION OF EACH ASSEMBLY, AND GRADE/TYPE OF STEEL, DIAMETER AND LENGTH INDICATED)	KILOGRAM (kg)
(b) (DESCRIPTION OF EACH ASSEMBLY, AND GRADE/TYPE OF STEEL, DIAMETER AND LENGTH INDICATED)	NUMBER (no)

The unit of measurement shall be either the kilogram of installed anchor-bolt assemblies or the number of installed anchor-bolt assemblies.

The bid rates shall include full compensation for the materials, fabrication, handling, transporting and installing the anchor-bolt assemblies, including corrosion protection.

ITEM	UNIT
67.03 CORROSION PROTECTION:	
(a) SPRAYED-ON METAL:	
(i) (TYPE OF METAL AND THICKNESS OR TYPE SYMBOL OF COATING INDICATED)	TONNE (t)
(ii) (TYPE OF METAL AND THICKNESS OR TYPE SYMBOL	METRE (m)

OF COATING INDICATED)

(iii) (TYPE OF METAL AND THICKNESS OR TYPE SYMBOL OF COATING INDICATED) NUMBER (no)

(b) HOT-DIP GALVANISING:

(i) (TYPE OF METAL AND THICKNESS OR TYPE SYMBOL OF ZINC COAT INDICATED) TONNE (t)

(ii) (TYPE OF METAL AND THICKNESS OR TYPE SYMBOL OF ZINC COAT INDICATED) METRE (m)

(iii) (TYPE OF METAL AND THICKNESS OR TYPE SYMBOL OF ZINC COAT INDICATED) NUMBER (no)

The unit of measurement shall be either a tonne or a metre of steel structures or articles protected against corrosion, or the number of steel structures or articles protected against corrosion. The quantities are calculated as specified in ITEM 67.01.

The bid rates shall be extra over the rates for ITEM 67.01 and shall include full compensation for applying the specified corrosion protection, including surface preparation, materials, labour, tools, equipment and all incidentals required.

Note:
Payment for painting shall be made under ITEM 69.01.

SERIES 6000: STRUCTURES

SECTION 6800: CONSTRUCTION TOLERANCES FOR STRUCTURES

CONTENTS:

6801 SCOPE

This Section covers the requirements in regard to the construction tolerances applicable to the various structures and structural members.

6802 DEFINITIONS

Except where otherwise specified, the following aspects of construction to which tolerances apply shall have the meanings attributed to them below:

(a) Position
The position of a structure or structural member shall be the horizontal position of its centre line(s) and/or centre point(s) in relation to the overall layout of the Works as shown on the Drawings.

(b) Alignment
The alignment of a structure or structural member shall be the alignment of its centre line(s) in relation to the overall layout of the Works as shown on the Drawings. Deviation from true alignment shall be measured in degrees of an arc.

(c) Leading and cross-sectional dimensions
The leading and cross-sectional dimensions of a structure or structural member shall be the dimensions relating to width, length, height, thickness, etc, which collectively determine its shape, and are shown on the Drawings. Dimensional tolerances not relating to leading or cross-sectional dimensions shall be shown on the Drawings.

(d) Levels
The level of any structure or structural member shall be the level of the upper or lower surface, as may be relevant, with reference to an established datum-level on the site.

(e) Surface regularity
Surface regularity is the shape of a surface with reference to a 3 m straight-edge (or template in the case of curved surfaces) placed on the surface.

The tolerance for surface regularity is expressed as a distance by which the surface tested may deviate from a straight-edge (or template in the case of curved surfaces) held against the surface.

6803 TOLERANCES

The tolerances given below shall be the maximum permissible deviations from the specified dimensions, levels, alignment, positions, etc, shown on the Drawings of the structures or structural members.

(a) Foundations, footings, pile capping slabs, columns, walls, piers, abutments, bridge and culvert superstructures
The tolerances are given in TABLES 6803/1, 6803/2, 6803/3, 6803/4 and 6803/5.

TABLE 6803/1
TOLERANCES OF PILE FOUNDATIONS

Position:	
0.167 times the diameter of the pile, or 100 mm, whichever shall be the greater	
External dimensions:	
Prefabricated piles	+25 mm -5 mm
Cast in situ piles	plus-tolerance not specified, minus-tolerance 0 mm
Pile-head level:	Average level of trimmed cut pile head ±25 mm
Verticality or rake	1.5°
Straightness:	
For precast piles the permissible maximum deviation from straight is 5 mm for piles up to 3 m in length and 1.0 mm more for each additional metre of pile length.	

TABLE 6803/2
TOLERANCES OF CAISSONS

Position of top of caisson:	
10% of the smallest outer dimension of the caisson, measured in plan.	
Verticality:	
1.5°	
Dimensions:	
Wall thickness	+25 mm -5 mm
Outer dimension of circular, rectangular or square cross-section	±25 mm
Level: Upper level of trimmed/cut caisson head:	
Maximum deviation of average level	±25 mm
Maximum deviation of any individual level	±50 mm
Foundation fill:	
Average level of top of fill	±25 mm

TABLE 6803/3
TOLERANCES OF FOOTINGS, PILE CAPPINGS, CAISSON COVER SLABS ETC

Position:	
15 mm	
Alignment:	
Individual members	5°
Members as they collectively determine the alignment of the structure as a whole	1 minute
Dimensions:	
Leading dimensions in plan	±25 mm
Thickness	+25 mm -15 mm
Levels:	
Average level of slabs, footings, etc	±25 mm

TABLE 6803/4
TOLERANCES OF COLUMNS, WALLS, PIERS, ABUTMENTS, ETC

Position:	
10 mm	
Alignment:	
Walls, piers, abutments and column groups	2 minutes
Dimensions:	
Leading dimensions of walls, piers and abutments	±25 mm
Thickness of walls, piers and abutments and cross-sectional dimensions of columns:	
Plus-tolerance	25 mm
Minus-tolerance	3% of the specified dimensions within the range of 5 mm to 25 mm
Levels:	
Levels: Average level of finished or trimmed/cut columns, piers, walls, abutments, etc	±10 mm
Verticality:	
Using ordinary formwork	1 in 400. Maximum 25 mm
Using sliding formwork	1 in 200. Maximum 50 mm
Surface regularity:	
Using ordinary formwork	3 mm
Using sliding formwork 1 in 200.	6 mm

TABLE 6803/5
TOLERANCES OF BRIDGE AND CULVERT SUPERSTRUCTURES

Position:	
10 mm	
Alignment:	
Superstructure as a whole	1 minute
Dimensions:	
Leading dimensions in plan	±25 mm
Thickness of slabs, width and depth of beams:	
Plus tolerance	15 mm
Minus tolerance	3% of the specified dimensions within the range of 5 mm to 15 mm
Surface regularity:	
All surfaces other than upper surface of deck	3 mm
Bridge and culvert decks, surface tolerances:	
The tolerances specified in CLAUSE 3405 for the base in respect of level, grade, cross-section and surface regularity shall apply. Surface regularity shall be tested by straight-edge.	

(b) Precast beams
The following tolerances shall apply to precast beams in addition to the requirements stated in SUBCLAUSE 6803(d) for the superstructure.

The width of the gap between contiguous beams shall not exceed twice the width of the specified nominal gap shown on the Drawings or the width of the nominal gap plus 40 mm, whichever is the less, and the overall width between the outermost beams of the bridge deck shall be within 40 mm of the specified width.

STRAIGHTNESS OR BOW: The deviation from the prescribed line measured on the overall length of the beam shall not exceed the following:

(i) In the horizontal plane:
0.5 mm per metre length of the beam within the tolerance range of 6 mm to 15 mm.

(ii) In the vertical plane:
(1) I-beams: 2 mm per metre length of the beam within the tolerance range of 6 mm to 20 mm.
(2) Other beams: 1.0 mm per metre length of the beam within the tolerance range of 3 mm to 20 mm.

CAMBER: The soffits of adjacent beams when placed side by side on the bridge deck shall not at any place differ by more than 2 mm per metre length of the beam within the tolerance range of 6 mm to 20 mm.

THE LENGTHS OF PRECAST BEAMS: Before stressing, the length shall be ±0.1% of the total length within the tolerance range of ±5 mm to 20 mm.

SURFACE REGULARITY: 6 mm

(c) Reinforcing steel
Except for the requirements given below, no tolerances are given for the placing and fixing of reinforcing steel. The steel, however, shall be neatly and accurately fixed in a manner which is consistent with proper workmanship and the structural integrity of the structural member. Specifically the following requirements shall apply:

(i) Tension steel
The actual position of tension steel shall not deviate from the true position by a distance which would reduce the effective lever arm by more than 2% of the overall depth of the member, or 10 mm, whichever is the greater.

(ii) Concrete cover
The concrete cover on reinforcing steel shall nowhere be less than the specified cover.

(iii) Spacing between bars
The spacing between closely spaced parallel bars, especially in beams and columns, shall, unless otherwise specified, be not less than the maximum size of the aggregate used in the concrete.

(iv) Bending of reinforcement
The requirements of BS 8666:2000 or equivalent regarding dimensional tolerances for cutting and bending of the reinforcing steel shall apply, with the proviso that the other requirements set out in this Clause shall be complied with even if the tolerances in BS 8666:2000 or equivalent are not exceeded.

(d) Prestressing
Sheaths for prestressing tendons shall be placed and maintained in position within the following tolerances:

(i) In the direction of the width of the member:
For members of up to 200 mm in depth: ±20 mm
For members exceeding 200 mm in depth: ±10 mm

(ii) In the direction of the depth of the member:
For members of up to 200 mm in depth:
±0.025 x depth

For members exceeding 200 mm in depth:
±0.01 x depth within the tolerance range of ±5 mm to ±25 mm.

(e) Bearings

Bearings for structures shall be installed to within 5 mm of the position shown on the Drawings and to within 2 mm of the required level.

Dimensional tolerances for elastomeric bearings shall comply with the requirements of BS 5400:1983 Part 9.2.

(f) Miscellaneous

(i) Chamfers
Fillets used for forming chamfers shall be within a tolerance of 1.0 mm in cross-sectional dimensions, and the actual chamfer on the concrete shall not vary by more than 3 mm from the specified dimensions.

(ii) Kerbs, copings, sidewalks, bridge railings, parapets, etc
The members shall be constructed within a tolerance of ±5 mm for all dimensions. The alignment shall not deviate from the true alignment by more than 10 mm in any place, nor shall the alignment deviate by more than 5 mm from the true alignment over any length of 5 m.

(g) Fabrication and assembly tolerances for structural steel

(i) General
The fabrication and assembly tolerances on all dimensions for structural steel shall be ±2 mm. Holes for connections shall be drilled/punched and aligned as specified in SUBCLAUSES 6705(d) and (g) respectively.

(ii) Cross-section
The tolerances on cross-sectional dimensions of rolled sections shall be as specified in the Design Tables according to Eurocode 3 or equivalent.

(iii) Straightness
A structural member before erection shall not deviate from straightness (or the specified shape) by more than the following:

For compression members and beams, one-thousandth of the length between points which are laterally restrained. For other members, one five hundredth of the overall length, but not exceeding 25 mm.

(iv) Length
The length of a member shall not deviate from its prescribed length by more than the following:

For compression members faced at both ends for bearing, ±1.0 mm

For other members: +0 mm and -4 mm

For such members as trusses and lattice girders, the above tolerances shall apply to the members as a whole. The lengths of component parts shall be such that the structural member can be properly assembled with the required accuracy.

(v) Bearing surfaces
Where two steel surfaces are required to be in contact for transferring compressive forces, the maximum clearance between the bearing surfaces shall not exceed 1.0mm when the members in contact are aligned.

(vi) Accuracy of erection
Steelwork shall not be out of plumb over any vertical distance by more than 5 mm or one thousandth of the distance, whichever is the greater.

(h) Fabricating and construction tolerances for reinforced-earth structures

(i) Individual concrete panels:
Surface regularity:
- When tested with a 1.5 m straight-edge, the deviation shall not exceed 5mm.
- Leading dimensions ±5 mm

(ii) Completed walls:
Surface regularity:
- When tested with a 3 m straight-edge, the deviation shall not exceed 20 mm.
- No point of the structure shall be out of position vertically by more than 10 mm per metre height of the structure, with a maximum of 50 mm.

6804 MEASUREMENT AND PAYMENT

No separate measurement and payment shall be made to the Contractor for complying with the requirements of this Section.

SERIES 6000: STRUCTURES

SECTION 6900: PAINTING

CONTENTS:

6901 SCOPE

This Section covers the painting of structural steel, guardrails, overhead road sign supports and other structures according to the requirements of the various Sections of these Specifications where painting is called for.

6902 MATERIAL

Paints shall comply with the requirements of the following Specifications:

(a) Primers

(i) Zinc-chromate primers for steel:
BS 4652:1995 or equivalent
(ii) Wash primer (metal etch primer):
SABS 723 or equivalent
(iii) Calcium-plumbate primer:
BS 3698:1964 or equivalent
(iv) Two-pack Zinc-rich epoxy primer:
SABS 926 or equivalent

(b) Undercoat
BS 7664:2000 or equivalent

(c) Finishing coats
(i) Decorative enamel for interior and exterior:
SABS 630 or equivalent
(ii) High-gloss paint:
SABS 684 (Type A) or equivalent
(iii) Micaceous iron-ore-pigmented paint:
SABS 684 or equivalent
(iv) Baking enamels:
SABS 783 or equivalent
(v) Emulsion paint for exterior use (polyacrylic):
SABS 634 or equivalent
(vi) Chloro-rubber paint:
SABS 1413 or equivalent
(vii) Bituminous aluminium paint:
SABS 802 or equivalent

(d) Other
(i) Epoxy-tar paints:
SABS 801 (Type I) or equivalent
(ii) Bonding liquid for concrete surfaces:
CKS 564 or equivalent
(iii) Bituminous-emulsion paint shall consist of a stable bituminous emulsion with a minimum of 45% of bitumen and about 5% of approved fibre.

6903 GENERAL

All paint shall be obtained only from suppliers approved by the Engineer. Unless otherwise agreed by the Engineer, all paints forming part of any one paint system shall be obtained form the same source. Paints shall be supplied in sealed containers of not more than 5 litres capacity and shall be used in strict rotation. Unless otherwise agreed by the Engineer samples of paint of not less than 2 litres capacity shall be submitted for testing to the Engineer or his nominated testing authority.

Paint shall be stored on site under cover and in conditions as recommended by the manufacturers.

Paint shall be stored in such a manner that each batch can be issued for use in the order of delivery.

A separate store shall be provided for cleaning solvents used for brush or other cleaning purposes. Cleaning solvents shall not be stored where paint or paint thinners are stored or where paint is prepared for application.

Paints with a limited safe shelf life shall not be used after the period stated in the manufacturer's data sheets.

Inflammable material shall be stored in accordance with the appropriate regulations.

Flat and gloss paints shall not be boxed up together and skinned ullages shall be discarded.

No paint shall be applied to surfaces containing physically adhering contaminants such as oil, grease, dirt, marking material, water-soluble salts, wax, paint and temporary protectives, or to surfaces containing chemically bonded contaminants such as rust, mill scale, slag and flux.

All surfaces which are to be painted shall be dry. Unless otherwise stated, subsequent coats of paints shall be applied over dry paint surfaces.

All traces of soluble salts and corrosive airborne contaminants shall be thoroughly washed from the surface prior to painting, and the surface shall be dried and painted immediately afterwards.

Where surfaces are to be welded, unless otherwise specified, no paint shall be applied within 75 mm of the weld position.

After the welding has been completed, the welds and adjacent parent metal shall be completely deslagged, and the surfaces shall then be inspected and approved by the Engineer. All spatter shall be removed prior to the surfaces being painted. The weld area shall be abrasive-blasted and/or ground and all contaminants such as flux shall be removed prior to the surface being painted.

Surfaces which are to rest on concrete or other floors shall receive all the prescribed coats of paint prior to the member being erected.

Damaged paint areas shall be cleaned, rust spots removed and the surface primed again so that the patch painting covers the damaged areas and extends over a strip of 20 mm beyond each damaged area.

Where the shop coat is allowed to age for a few months before the next layer of paint is applied, light sanding with sandpaper or rubbing with steel wool and scrubbing with clean water with a bristle brush shall be carried out.

Steel to be embedded in concrete shall be entirely painted to a distance of 50 mm within the concrete, measured from the concrete outer surface.

All epoxy coating shall be carried out by a specialist firm or contractor approved by the Engineer. With its quotation the specialist firm shall be required to submit a letter of guarantee that the product it proposes to supply when applied in accordance with this specification and any additional specifications which shall be quoted by the firm will withstand the environmental service conditions to be encountered. The Contractor shall quote the guarantee period in number of years from time of application of the coating.

The paint manufacturer's instructions shall be strictly adhered to.

Painted steel members shall be stacked so as to be off the ground.

Friction-grip surfaces shall not be painted but shall be treated in accordance with the Special Specifications.

Implementation of the manufacturer's recommendations concerning health and safety aspects of paints approved by the Engineer for use on the works shall be mandatory under this contract.

6904 APPLYING THE PAINT

Unless otherwise specified, paint may be applied either by brush, spray or roller method, or by any combination of these three methods.

Where brushes are used, they shall have sufficient body and length of bristle for spreading the paint in a uniform coat. Paint shall be evenly spread and thoroughly brushed out. If brush marks are visible, it will be considered that the paint has been improperly applied, and the paint will not be accepted.

On all surfaces which are inaccessible to painting by regular painting equipment, the paint shall be applied by bottle brushes, sheepskin daubers, or by any other acceptable method so as to render the required coating of paint.

If spray methods are used, the operator shall be thoroughly experienced. Runs, sags, thin areas in the paint coat, skips, or where air bubbles have formed or the paint has delaminated, shall be considered as being unsatisfactory, and the Contractor will be required to repaint the surface by brush.

A water trap and an air-regulating valve acceptable to the Engineer shall be furnished and installed on the equipment used for spray-painting.

Mechanical mixers shall be used for mixing paint properly when no ready-mixed paints are used. Prior to application, the paint shall be remixed for a sufficient length of time to mix the pigment and vehicle thoroughly. Paint shall be constantly kept well stirred to keep the pigments in suspension during its application. All skins in the paint shall be removed by screening. If it cannot be removed effectively, the paint and paintwork already completed may be condemned at the discretion of the Engineer.

No thinners or cleaners shall be employed other than those recommended by the paint manufacturer and to the Engineer's approval.

Paint shall not be applied when the temperature of the surface to be painted is less than 3°C above dew point or when the temperature of the steel is below 5°C or above 35°C, unless otherwise prescribed by the Engineer.

Paint shall not be applied in fog or mist, when it is raining or when rain is expected, or when the relative humidity is above 90%.

6905 PROTECTING THE WORKS DURING PAINTING OPERATIONS

All necessary precautions shall be taken by the Contractor before the commencement of any painting activities to ensure that no damage or disfigurement of any kind is caused thereby to any part of the works. If in the opinion of the Engineer the precautions taken are inadequate the Contractor shall at his/her own expense make all such improvements as the Engineer directs.

The Contractor shall protect all parts of the structure against disfigurement by spatters, splashes and/or smirches of paint or of paint materials. The Contractor shall be responsible for any damage to or paint on or contamination to vehicles, persons or property, including plants and animals, as a result of his/her operations, and he/she will be required to provide protective measures at his/her own cost to prevent such damage.

Any unsightly paint stains shall be removed by the Contractor at his/her own cost.

If passing traffic creates sufficient dust to harm or spoil the appearance of painted surfaces, the Contractor shall sprinkle the adjacent roads and shoulders with water at his/her own cost, for a sufficient distance on each side of the location where the painting is being done, to keep the dust away from freshly painted surfaces. The Contractor shall at his/her own cost, also furnish and post DRIVE SLOWLY signs and take other necessary precautions to prevent dust and dirt from adhering onto freshly painted surfaces.

6906 PREPARING SURFACES FOR PAINTING

The Contractor shall regard the preparation of surfaces to be painted as a work of fundamental importance the object of which is to ensure the production of sound, clean, smooth and dry surfaces. The preparation shall have no detrimental effect on the sub-strata to be painted nor shall it be prejudicial to subsequent painting operations.

In addition to the specific processes described below and/or in the manufacturer's instructions and specifications all surfaces shall be cleaned free from all dirt, grease, oil or other deleterious matter both before the application of primer and between subsequent successive coats of paint.

All surfaces prepared and made ready for painting shall be to a standard approved by the Engineer before painting work is begun.

6907 PAINTING STRUCTURAL STEEL

(a) General

This Section includes the painting of steel guardrail posts, steel road sign supports and steel sign face frames, where required.

The surface preparation, priming and application of an undercoat shall be carried out under cover at the fabricator's works. Where possible, all painting shall be done at the fabricator's works but, where this is not feasible, the Engineer may permit the application of the

finishing coats on the site, in which case an undercoat shall be applied at the fabricator's works prior to the members being despatched to the Works.

Unless otherwise specified, the protection described in SUBCLAUSES 6907(c), (d) and (e) shall be applied to all steelwork. Corrosion protection of steelwork exposed to aggressive or severe conditions shall comply with the requirements of the Special Specifications.

(b) Surface preparation

(i) New structures
After all cutting, drilling, welding and punching have been completed, it shall be ascertained that all sharp edges have been uniformly rounded off and smoothed down. All physically adhering contaminants shall be removed and the surface shall then be abrasive-blasted to Sa 2½ finish in accordance with the BS EN ISO 8501-1:2001, BS 7079-A1:1989 "second quality" or equivalent. The profile limit of the surface finish shall be between 30 μm and 60 μm. The abrasive-blasting profile shall be measured in accordance with BS EN ISO 8503-3:1995, BS 7079-C3:1989 or equivalent and shall comply with BS EN ISO 8503-1:1995, BS 7079-C1:1989 or equivalent.

No abrasive-blasting shall be done during rainy weather or when corrosive air conditions prevail.

Unless the application of a primer follows within four hours of abrasive blasting and before any oxidation of the prepared surface takes place, the abrasive-blasted surface shall immediately after abrasive blasting be given one coat of a wash primer.

(ii) Existing structures
The surface preparation of existing structures shall be carried out on site in accordance with BS EN ISO 8504-1:2001, BS 7079-D1:2000 or equivalent.

(c) Primer
The prepared surface shall be given two coats of a zinc-chromate primer in accordance with BS 4652:1995 or equivalent. The first coat shall be applied within 12 hours in the case of wash-primed surfaces and within four hours, but before any oxidation of the surface takes place, in the case of abrasive-blasted surfaces that have not been wash-primed. A fast-drying zinc chromate in accordance with BS 4652:1995 or equivalent, may be used as primer. In all cases the dry-film thickness shall not be less than 30 μm per coat.

When steel has to be welded after the primer has been applied, the steel shall be left unpainted for a distance of 75 mm from the weld joint unless a weldable type of paint has been used. The welds shall be treated in accordance with the instructions of CLAUSES 6903 and 6907.

(d) Undercoat
Where the finishing coats are to be applied on the site, the primed surfaces shall be given one coat of a universal undercoat with a suitable colour in the fabricator's shop before despatch. The undercoat shall be applied as soon as the prime coat has dried sufficiently. The dry-film thickness shall not be less than 25 μm.

(e) Finishing coat
Two finishing coats of high-gloss structural paint (BS EN ISO 12944:1998 or equivalent) of the specified colour shall be applied to leave a dry-film thickness of not less than 25 μm per coat.
Where the finishing coats are applied on the site, the undercoat shall be lightly sanded and the members washed and cleaned of all contaminants. The first finishing coat shall be applied as soon as the structural members are dry.

Where specified in the Special Specifications, the second finishing coat shall consist of a micaceous iron-ore-pigmented structural paint of the specified colour to a dry-film thickness of not less than 30 μm. Unless otherwise specified, the second finishing coat shall be applied within 48 hours of the application of the first finishing coat.

The dry-film thickness of the total paint system shall not be less than 110 μm when no undercoat is used and not less than 135 μm when an undercoat is used. Where the second finishing coat is an iron-ore-pigmented paint, these thicknesses shall be increased by 5 μm.

(f) Mating surfaces
When mating surfaces are brought together, both surfaces shall already have been covered with all the specified coats of paint, but, where this is impossible, each surface shall be given a copious coating of primer and the surfaces drawn up while the paint is still wet.

(g) Back-to-back members and areas not easily accessible
Back-to-back members and areas not easily accessible shall be fully coated with all the specified coats of paint up to and including the finishing coats before erection.

(h) Damaged areas
Damaged areas shall be treated as follows:

Sand down to bright metal and clean. Spot prime with two coats and sand down lightly when hard. Rinse off with water and allow to dry. Apply two finishing coats.

(i) Structural steel to be embedded below ground
Those parts of structural-steel members to be embedded in soil and all bases to a height of 500 mm shall be given two coats of an epoxy-tar prime instead of the zinc-chromate prime specified for other surfaces.

(j) Epoxy coating work generally
In addition to the general requirements of this specification the following conditions shall apply wherever epoxy coating work is being carried out:-

(1) The work shall be illuminated to the satisfaction of the Engineer.

(2) Forced draught ventilation to the approval of the Engineer shall be used wherever required for the needs of personnel or for drying out surfaces.

(3) Operatives shall work in pairs.

The Contractor shall demonstrate all his methods, equipment and materials before any work commences. Sample areas of substrate shall be prepared and coated as required by the Engineer and for his approval.

There shall be strict control of surface cleanliness between primer and epoxy coating and between coats of the same. Vacuum removal of dust and sand shall be employed and contamination shall be removed as specified in appropriate preparation clauses herein. Where dirt or dust has become trapped in the painted surface it shall be removed with suitable abrasive paper. The surface being painted shall be free of visible moisture throughout these operations.

The paint shall be applied only to clean dry primed or previously coated surfaces. Any thick runs or collections of paint shall be removed before they harden.

Not less than two coats shall be applied over the primer by airless spray; not less than 3 by brush.

Each coat shall be distinctly different in colour from the primer or previous coat. The colour of the final coat shall be as required by the Engineer.

Each coat shall be seen to have completely covered the preceding coat without "misses" or pinholes or any areas visibly low in thickness. A high voltage pin-hole detector shall also be used to determine the integrity of the coats.

The coat manufacturer shall stipulate primer and epoxy recoat intervals for all curing temperatures likely to be encountered and these shall be adopted with a maximum tolerance of +4 hours. Where this is exceeded, the surfaces to be recoated shall first be suitably abraded to remove gloss and give a good key.

6908 PAINTING GUARDRAILS

(a) General
This Section covers the painting of guardrails, should it be prescribed. The painting of steel guardrail posts is covered in SUBCLAUSE 6907.

(b) Surface preparation and priming
All dirt, loose mill scale and loose corrosion products shall be removed by hand or power tools and all rust and mill scale by pickling, after which the surface shall be rinsed. A neutralising rinse shall also be applied, or the surface shall be phosphated.

(c) Priming
Apply two coats of zinc-chromate primer to a dry-film thickness of not less than 20 μm per coat.

After the prime coats have hardened, the guard rails may be transported to the site.

(d) Storage on the site
The primed guardrails shall be stored off the ground under cover and protected against rain and weather until erection. Guardrails shall be stacked individually and not nested so as to prevent corrosion during storage. The finishing coats shall be applied as soon as possible and the primed surfaces shall not be allowed to corrode as a result of prolonged exposure to the weather. Any guardrails showing signs of rust before the application of the finishing coats shall be rubbed down with steel wool or fine sandpaper until all rust is removed, and it shall then be recoated with a zinc-chromate primer.

(e) Finishing
Before the first finishing coat is applied, the guard rails shall be thoroughly washed down to remove all traces of salt and/or other air-borne corrosive materials and all dirt or other contaminants.

As soon as the rinsed guard rails are dry, a finishing coat of aluminium paint or a white high-gloss enamel in accordance with BS 7664:2000 or equivalent shall be applied to a dry-film thickness of not less than 25 μm. Within 48 hours this shall be followed by a second coat as described before.

The guard rails shall preferably be given both finishing coats before erection, but, where this is impossible, the Engineer may permit the finishing coats to be applied after the guard rails have been erected, provided that all mating surfaces and spots which are not easily accessible are painted with the finishing coats before the guard rails are erected.

The total dry-film thickness of all coats of the paint shall not be less than 90 μm. All damaged spots shall be treated as specified in SUBCLAUSE 6907(h).

6909 PAINTING CONCRETE

(a) Surface preparation
The surface of the concrete to be painted shall be cleaned of all dust, loose particles, laitance, impurities and other deleterious materials, and then washed and allowed to dry.

Unless the surface is to be covered with a bituminous paint, all cracks, holes and cavities shall be filled with grout or an acrylic filler.

(b) Sealing and priming
The surface shall be sealed with an approved clear sealer which complies with CKS 564 or equivalent and then primed with a primer consisting of an undercoat diluted to 50%.

(c) Undercoat and finishing
An undercoat shall be applied after priming, followed by two finishing coats of the prescribed paint.

(d) Bituminous paint
The surface shall be prepared in accordance with the requirements of SUBCLAUSE 6909(a). Before it dries out, a primer shall be applied in accordance with the instructions of the fabricator of the bituminous paint.

After the primer has been applied, two coats of bituminous paint shall be applied at the rate of 0.75 litre/m^2/coat. No paint coat shall be applied unless the previous coat has dried out completely, and no paint shall be applied to the paintwork for so long as any moisture occurs on the surface.

6910 PAINTING GALVANISED SURFACES

Galvanised surfaces shall be painted as specified in this Section for steel surfaces, except that the surface preparation and priming shall be as follows:

(a) Surface preparation
Dirt and other adherent contaminating matter shall be removed from galvanised surfaces by brushing with wire or stiff bristle brushes or by other methods approved by the Engineer. Cleaning shall not damage the galvanising. Oil or grease shall be removed from galvanised surfaces by the application of an emulsion cleaner. Any zinc corrosion products remaining shall be removed by washing with sweet water and scrubbing with hard bristle brushes.

After being cleaned and degreased all galvanised surfaces shall be etched with T-wash as described in BS EN ISO 12944:1998. If any surface fails to turn black the cleaning degreasing and etching processes shall be repeated.

(b) Priming
Two coats of calcium-plumbate primer shall be applied to a dry-film thickness of at least 25 μm.

The undercoat shall follow within one week of the primer.

6911 PAINTING OF ROAD SIGNS

The painting of ungalvanised steel road signs, supports, and sign face frames shall be carried out as specified for structural steel in CLAUSE 6907.

The painting of galvanised steel road signs, supports and sign face frames shall be carried out as specified in CLAUSES 6906 and 6907.

The back of all road sign faces shall be painted grey.

6912 PAINTING OF TIMBER

(a) Surface Preparation
All dirt, peeling or cracking paint and other foreign matter shall be removed by wire brushing, scraping, approved wax-free flushable paint remover, or other approved means immediately prior to painting.

The moisture content of the timber shall not be more than 20% at the time of applying the first coat.

All cracks, shakes or scars shall be filled with putty, flush to the surface, before painting.

The surfaces shall then be washed with G1 cleaner or an equivalent and allowed to dry.

(b) Primer
One coat of wood primer shall be applied.

(c) Finishing
Two coats of high gloss enamel shall be applied in the specified colour. They shall be of two different colours.

6913 MEASURING PAINT THICKNESS

The dry-film thickness of paint shall be determined in accordance with BS 3900-C5:1997, BS EN ISO 2808:2001 or equivalent.

At least 90% of all thickness measurements shall comply with the minimum specified requirements. The thickness shall not in any case be less than 70% of the specified thickness.

6914 MEASUREMENT AND PAYMENT

ITEM	UNIT
69.01 PAINTING:	
(a) (DESCRIBE STRUCTURE/ARTICLE)	SQUARE METRE (m^2)
(b) (DESCRIBE STRUCTURE/ARTICLE)	NUMBER (no)
(c) (DESCRIBE STRUCTURE/ARTICLE)	METRE (m)
(d) (DESCRIBE STRUCTURE/ARTICLE)	TONNE (t)

The unit of measurement for SUBITEM (a) shall be the square metre of surface painted. Only the surface covered by the final finishing coat shall be measured.

The unit of measurement may also be the number of structures or articles painted, or a metre length of the structures or articles painted, or a tonne of the structures or articles painted; the quantities shall be calculated as specified in SECTION 6700 for ITEM 67.01.

The bid rates shall include full compensation for surface preparation, applying all the coats of paint, repairing any damaged surfaces, and all materials and equipment necessary for completing the work.

SERIES 7000

TOLERANCES, TESTING AND QUALITY CONTROL

CONTENTS OF THE GENERAL SPECIFICATIONS:

SERIES 7000: TOLERANCES, TESTING AND QUALITY CONTROL

SECTION 7100: TESTING OF MATERIALS AND WORKMANSHIP

CONTENTS:

7101 SCOPE

This SECTION covers the tests and methods of testing which are required for the selection and control of the materials and for control of workmanship, trials and construction control testing.

During the progress of the Work tests shall be conducted on materials and workmanship to ensure compliance with the requirements of the Specifications.

The Contractor's attention is drawn to the provisions of Clause 1205 in regard to his/her obligations to conduct tests on regular basis for check of compliance with specification requirements. The intensity of control and of tests to be conducted by the Contractor is not specified but shall be adequate to ensure that proper control is being exercised. This process-control shall be detailed in a quality control management system to be prepared by the Contractor.

7102 MATERIALS GENERALLY

All materials shall conform to the requirements of the Contract, the Drawings and the Specifications.

All materials shall be of approved manufacture and origin and the best quality of their respective kinds. Unless otherwise specified such materials shall be new (as compared to used or reprocessed).

No materials of any description shall be used without the prior sanction of the Engineer and any materials condemned as unsuitable for use in the Works shall be removed immediately from the Site by and without recompense to the Contractor.

7103 GENERAL SPECIFICATIONS

Where in the Specifications tests on materials, tests on completed Works and construction control tests are called for or implied, they shall be carried out according to the test methods listed in Section 7502 (a), unless the test in question is not covered within this Section. When a particular test is not covered by the referred standard, then the method shall be to an equivalent standard called for in the contract documents or as directed by the Engineer.

Materials shall comply with, the requirements of the current edition of Specifications issued by the Uganda National Bureau of Standards (US), American Association of State Highway and Transportation Officials (AASHTO) or American Society for Testing Materials (ASTM) or British Standard (BS), or European Standards (BS EN) or where applicable, an equivalent Specification called for in the contract documents or as directed by the Engineer.

Other equivalent national standard specifications may only be substituted for the above at the sole discretion of the Engineer.

7104 MATERIALS TESTING AND ACCEPTANCE

As soon as possible after the Contract has been awarded, the Contractor shall submit to the Engineer complete statements as to the origin, composition and manufacture of all materials to be used in the Works together with a list of the suppliers from whom he proposes to purchase these materials.

Prior to delivery of materials to the job site, the Contractor shall submit certified test reports and samples to the Engineer of all materials proposed for use in the Works, whether from an outside supplier or whether supplied by the Contractor from his own resources. The certification(s) shall show the appropriate test(s) for each material, the test results, and a statement that the material meets the specification requirement. The Engineer's approval shall be received prior to any materials being delivered in bulk to the works.

The Engineer may request further samples for testing, prior to and during construction to verify the quality of the materials and to ensure conformance with the applicable specifications. The Contractor shall provide all samples free of charge.

All equipment to be used in testing shall be calibrated at the start of the project, and at regular intervals throughout the project period as approved by the Engineer.

The Contractor shall test samples as specified from each quarry location and borrow pit proposed for use in the Works. The particular tests to be carried out will be determined by the function for which the Contractor proposes to use the material in the Works, as necessary to show compliance to these Specifications. The results of these tests shall be submitted to the Engineer for approval at least 14 days before the quarry or borrow pit is required for use. Should any quarry or borrow pit prove to be unsuitable, the Contractor shall investigate further sites until suitable materials are found and approved.

The Contractor’s programme shall allow sufficient time for materials testing and no claim for delays or extra costs arising out of this will be accepted.

All materials supplied for use in the Works shall conform within specified tolerances, to the quality of the

approved samples, which will be retained at the Engineer's office until the completion of the Contract.

Where a material has been specified by a manufacturer's trade name, the product of another manufacturer will be accepted provided that, in the opinion of the Engineer, it is in all respects of an equivalent or higher quality.

7105 LABORATORY FOR THE ENGINEER

The Contractor shall facilitate independent testing by the Engineer as he may deem necessary in accordance with SECTION 1410.

7106 TESTING BY THE CONTRACTOR

The Contractor shall provide, use and maintain on the site throughout the period of execution of the works a suitable laboratory and adequate equipment operated by competent staff for carrying out tests required for the selection and control of the quality of materials and for the control of workmanship in accordance with this specification, in accordance with SECTION 1410. The contractor shall assume that tests will be required on all materials used in the works and on all finished work.

The Contractor shall carry out all necessary tests and shall report to the Engineer the results of such tests before submitting materials and finished work to the Engineer for approval. In appropriate circumstances, tests may be carried out at the place of manufacture.

7107 ACCEPTANCE STANDARDS OR MATERIALS

All materials used in or upon the works shall comply with this Specification and the Special Specification and shall be acceptable to the Engineer. Where so specified, the material shall comply with the US specification named or with an alternative national specification on the approval of the Engineer.

Similarly, where a material has been specified by manufacturer's trade name, the product of another manufacturer will be acceptable provided it is in all respects of equivalent or higher quality and provided that the Engineer's approval has been obtained.

Samples of all materials proposed to be used shall be submitted to the Engineer and shall, where required, be tested prior to the material being delivered in bulk upon the works.

7108 THE COST OF TESTING

(a) Process control

The cost of testing undertaken by the Contractor in terms of his obligations under CLAUSE 1205 for purposes of process control, including the taking of samples, reinstating where samples have been taken, and all testing equipment, labour, materials, etc, shall be included in the rates bid for the various items of work supplied and will not be paid for separately.

(b) Producing certificates

Where the properties of materials or manufactured products are required in these Specifications to comply with specified specifications published by a Standards Authority approved by the Engineer, the Contractor shall produce, when called upon to do so, certificates from the manufacturer confirming that the materials or products supplied comply with the relevant specifications. All costs of providing such certificates shall be borne by the Contractor.

(c) Testing materials and products covered by certificates

The Engineer shall be entitled to take samples of, and order tests to be made on, products and materials in respect of which certificates of compliance may be required. The Contractor shall only be paid at the appropriate rates if the costs of such tests are itemised in the Bill of Quantities.

7109 TAKING AND SUBMITTING SAMPLES

(a) General

Where the Contractor is required in these Specifications to submit samples of materials or mixtures to the Engineer for approval prior to their being used in the Works, the use of these materials or mixtures without the Engineer's written approval shall constitute default on the part of the Contractor, who shall be liable for the consequence of such default. All samples shall be submitted in sufficient time for proper testing.

The Engineer's approval of any materials or mixtures shall in no way relieve the Contractor of his obligation to provide materials, mixtures and workmanship which comply with the Specifications.

All samples for testing shall be taken from the road after completion of work on the particular layer to be tested except as specified elsewhere in these Specifications. Where specified or required by the Engineer, stratified random sampling methods, as defined in SUBCLAUSES 7203(b) and 7204(b), shall be followed. For the testing of layer work stratified random sampling methods shall be used for obtaining all the sample portions and for determining the locations of in situ test sites.

The method of taking samples shall be as specified in the appropriate sampling and testing methods listed in SECTION 7502 (a) or similar approved by the Engineer.

The Engineer shall have full access to the Works for the purpose of taking samples. The Contractor shall render any assistance necessary for taking the samples and shall be responsible for the reinstatement of pavement layers or other structures at the positions where the samples have been taken. Full compensation for rendering assistance with sampling and for reinstatement where samples have been taken shall be included in the rates tendered for the various items of work tested, and no additional payment will be made in this respect.

(b) Sampling frequency

Samples shall be taken for laboratory testing for each new material encountered, or when there is a significant change in material properties in the opinion of the Engineer.

The minimum sampling frequencies shall be as given in TABLE 7109/1. Samples for tests that are not mentioned in TABLE 7109/1, but for which there are material requirements in these Specifications, shall be taken as required by the Engineer.

7110 TESTING METHODS

All tests shall be conducted in accordance with the standard methods specified in the Specifications. Other equivalent national standard specifications may only substitute the prescribed test method at the sole discretion of the Engineer.

Where in the Specifications tests on materials, tests on completed Works and construction control tests are called for or implied, they shall be carried out according to test methods listed in SECTION 7502 (a), unless the test in question is not covered within this Section. When

a particular test is not listed in SECTION 7502 (a), then the method shall be an equivalent standard called for in the contract documents or as directed by the Engineer.
In addition to the above standard methods of testing, equivalent standard specifications or test methods of other bodies may be used in these specifications if approved by the Engineer.

In all cases the latest amendment or revision current at the closing date of the tender is implied when reference is made to one of the above standards in the Specification.

The Contractor shall have on the Site all the relevant standards required for the work he is to undertake under the Contract. The Engineer shall be provided a copy of such standards.

TABLE 7109/1
SAMPLING FREQUENCIES

Layer and nominal class of material	Tests to be carried out *1)*	Sampling frequency, minimum			
Roadbed	CBR	1	sample per	10000	m^2
	MDD, PI, grading	1	sample per	5000	m^2
Earthworks fill using soils: (G3)	CBR, PI, grading	1	sample per	2000	m^3
	MDD	1	sample per	1000	m^3
Backfill to culverts and structures	CBR, PI, grading	1	sample per	500	m^3
	MDD	1	sample per	200	m^3
Improved subgrade (G7, G15) or Gravel wearing course (GW)	CBR, PI, grading	1	sample per	10000	m^2
	MDD	1	sample per	5000	m^2
Subbase: (G30, G45)	CBR, incl. swell, grading	1	sample per	5000	m^2
	MDD, PI, LL, LS	1	sample per	5000	m^2
Subbase: (CM, C0.7, C1.0)	UCS, PI	1	sample per	5000	m^2
	MDD	1	sample per	5000	m^2
Base course: (G60, G80)	CBR, PI, grading	1	sample per	5000	m^2
	MDD	1	sample per	2500	m^2
Base course: (C1.0, C1.5)	UCS, PI	1	sample per	5000	m^2
	MDD	1	sample per	2500	m^2
Base course using crushed aggregate: (CRS)	LS, grading	1	sample per	5000	m^2
	MDD	1	sample per	2500	m^2
Base course using crushed aggregate: (CRR)	LL, LS, grading, flakiness	1	sample per	5000	m^2
	MDD, TFV, CBR	1	sample per	10000	m^2
Base course of a bituminous mix or asphalt concrete surfacing	Extraction, grading	1	sample per	10000	m^2
	Marshall test / Gyratory Compaction Test	1	sample per	5000	m^2
Surface treatments	TFV	1	sample per	20000	m^2
	Grading, flakiness	1	sample per	5000	m^2
	Tray Test 2	1	sampler per	500	m^2
The referred tests shall be carried out in accordance with standards test methods indicated in the special specifications or other standards approved by the Engineer. Tray test shall be performed for both bitumen spraying rate and chipping spreading rate.					

It is emphasised that the Atterberg limits of soil fines shall be measured according to the British Standard (BS) procedures and utilise BS equipment. Other laboratory test procedures and equipment do not give comparable results and shall not be used unless proper correlation to BS has been carried out to the satisfaction of the Engineer.

All CBR testing shall be carried out using the three point method as described in SECTION 7502 (a) or other approved at the discretion of the Engineer. All CBR tests relate to material compacted to the dry density obtained using the compaction test as specified in the respective CLAUSES for material requirements. The CBR testing shall be carried out at moisture content as specified in the respective Clauses for material requirements.

7111 TESTING CEMENTITIOUS BINDERS AND CONCRETE

(a) Testing aggregates for concrete
Aggregates shall be regularly tested by the Contractor at a frequency to the satisfaction of the Engineer as part of the Contractor's process control as they are being manufactured or brought onto the site and used or taken to stockpile.

The appropriate test methods shall be those included under the respective CLAUSES of the Specifications, or any other relevant tests prescribed by the Engineer.

Accelerated tests shall be carried out to determine the potential alkali reactivity of aggregates where this is considered appropriate by the Engineer.

(b) Test for cementitious- binder content
The test method used for determining the cementitious binder content of soils, gravels or crushed stone mixed with a chemical stabilising agent shall be determined by the Engineer and may be any test method currently recognised by the Engineer as being acceptable.

Where the cementitious binder content is determined, due allowance shall be made for the presence in the un-stabilised material of naturally occurring MgO or CaO which affects the result of such tests. If the standard deviation of the natural CaO plus MgO content of the untreated material exceeds 0.35% any determination of the cementitious- binder content shall be ignored.

Sample holes shall be randomly (as defined in SUBCLAUSES 7203(b) and 7204(b)) spaced transversely as well as longitudinally over the area to be tested, or as directed by the Engineer, and if the material is road – mixed, samples shall be taken from the top and bottom of each hole. The minimum number of samples per test shall be 10.

(c) Canvas patch test for the spreading rate of cementitious binder
The following method shall be used for determining the spreading rate of a chemical stabilising agent where bulk distributors are used.

At least 10 clean canvas patches, each measuring 1.0 m x 1.0 m shall be placed flat on the road in selected positions in relation to the bulk distributor's track. After the stabilising agent has been spread by the bulk distributor, the canvas patches shall be carefully lifted and all the material on the patches transferred to a container and weighed. The total mass of stabilising agent on each patch is then recorded and the average rate of application determined. Instead of canvas patches, flat metal trays may be used for collecting the stabilising agent.

(d) Test for mix uniformity in chemically stabilised layers
Where required by the Engineer, the Contractor shall determine the mix uniformity in chemically stabilised layers by means of unconfined compressive strength tests, using an approved method.

The Contractor shall without delay make the necessary arrangements to take samples in accordance with the requirements in the method used.

(e) Test for initial consumption of lime
The objective of the gravel ICL test is the control of the pH in lime and cement stabilised soil in order to allow the possible formation of cement minerals, calcium silica hydrate in particular, and for proper modification to take place. It is recommended that the stabiliser to be used during construction (or the nearest equivalent) should be used to carry out this test.

(f) Determining the compressive strength
The procedure for sampling and manufacturing, storing, curing and testing test cubes shall be in accordance with appropriate tests in SECTION 7502 (a).

Where specified in the Special Specifications, the compaction of concrete specimens in the moulds by means of a vibrating table shall be obligatory. In such case the method of compaction shall be as follows:

(i) Plastic concrete
Fill the mould halfway and vibrate it and spade it on all four sides with a suitable trowel to remove air bubbles. Stop the vibration as soon as a wet sheen appears on the surface. Fill the mould and repeat the procedure, but stop when again a wet sheet appears on the surface.

(ii) Stiff Concrete
The same procedure is followed, except that the mould is filled in three to four steps instead of in two. The vibration is stopped for each layer when a wet sheen appears.

(g) Consistency
The test method described in shall apply in regard to the slump test.

(h) Air content
The air content of the freshly mixed concrete shall be tested by the method given in BS 1881, Part 106 or equivalent. Air content tests shall be conducted on the same samples of concrete from which cubes were made for the 28 – day compressive strength tests.

(i) Drilling and testing the cores
Where sections of concrete which have failed to comply with the Specifications are required to be further investigated by extracting and testing concrete cores, 100 mm or 150 mm cores shall be drilled and tested. The sampling and testing procedure to be followed shall be in accordance with the publication Concrete Core Testing for Strength – Concrete Society Technical Report No.11, published by the Concrete Society of Great Britain.

The instructions of this report shall be followed for determining the "estimated potential strength", which shall be compared with the 28 days cube strength specified for each type of concrete. Corrections to the actual core strength to allow for excess voids, included steel and the length :diameter ratio of cores shall be as stated in this publication, and the correction for curing shall be determined by the Engineer in accordance with this publication and such other information as he may deem to be appropriate.

The Engineer's decision regarding the degree to which the concrete, which is represented by the cores tested as described above, complies with the requirements and also regarding the properties and suitability of the concrete, shall be final and binding.

7112 TESTING SOILS, GRAVEL AND CRUSHED AGGREGATE FOR EARTHWORKS AND PAVEMENT LAYERS

Specimens of soils, gravel and crushed stone materials in earthworks and pavement layers shall be taken in accordance with CLAUSE 7104, and subjected to tests as prescribed for each respective layer in the relevant sections of SERIES 3000 and in accordance with the relevant provisions of SECTIONS 7100 AND 7200.

7113 TESTING BITUMINOUS BINDERS AND MIXES

Specimens and samples of materials and pavement layers shall be taken as provided for in the present SECTION 7100 and as prescribed in the relevant sections of SERIES 4000.

The Engineer shall be entitled to order the Contractor to have material tested by an approved laboratory for compliance with all of the requirements specified, and the results of such tests shall be submitted directly to the Engineer by the testing laboratory with copies, if requested, to the Contractor.

The cost of such tests shall be borne as specified in CLAUSE 7108.

7114 FIELD DENSITY TESTING

(a) General
All earthwork and pavement layers and backfill to drainage works and structures will be subject to construction control testing by the Engineer, and the Contractor must allow for any disturbance or delays to the sequence of his operations occasioned by such control testing.

The contractor shall request, in writing, the Engineer's approval for each layer of each section of earthworks and pavement construction and backfill to drainage works and structures. Such requests shall be made only when the Contractor is fully satisfied that the section of the work concerned is in the condition required by this Specification. Such requests shall be accompanied by the test results required in accordance with this Specification.

The Engineer shall thereupon without undue delay inspect the section for any visible wet spots, laminations, heaving material (visible during compaction or on proof rolling), segregation, and for the uniformity of the mixing and compaction. Providing the visual aspects are satisfactory, the Engineer shall test the section of the works submitted and inform the Contractor in writing of the results of the tests at the same time accepting or rejecting the section or layer concerned.

Work on layers shall in no circumstances commence until the preceding layer has been approved and accepted by the Engineer in writing. The Contractor is wholly responsible for protecting and maintaining the condition of the work which has been submitted for approval.

Should any layer be left unprotected for more than 24 hours subsequent to approval the Contractor shall request re-approval of the layer and the layer will again be subject to proof rolling, construction control testing, and tolerance checks in accordance with this Specification.

Notwithstanding the Engineer's approval of a layer, the Contractor shall be responsible for making good any subsequent damage doe to traffic, ingress of water or any other reason and should any damage occur the layer will again be subject to proof rolling, construction control testing and tolerance checks in accordance with this Specification.

(b) Testing frequency
The minimum testing frequencies shall be as given in TABLE 7114/1.

TABLE 7114/1
TESTING FREQUENCIES FOR FIELD DENSITY TESTING

Layer and nominal class of material	Frequency, minimum	Absolute minimum
Roadbed	1 test per 1000 m^2	3 tests per section and 1 test per 50m
Earthworks fill using soils: (G3)	1 test per 200 m^3	3 per section per layer
Backfill to culverts and structures	2 tests per 10 m^3	2 per section
Fill or improved subgrade layers using dump rock: (DR)	Method specification	
Improved subgrade layers using gravel/soils: (G7, G15)	1 test per 1000 m^2	4 per section per layer
Gravel wearing course used on gravel roads: (GW)	1 test per 1000 m^2	4 per section
Subbase: (G30, G45, CM, C 0.7, C 1.0)	1 test per 750 m^2	5 per section
Base course: (G60, G80, CRS, CRR)	1 test per 500 m^2	6 per section
Base course of bituminous mix: (BEMIX, FBMIX, DBM40, DBM30, 37.5, 25.0 Nominal mixes)	1 test per 500 m^2	6 per section
Asphalt concrete surfacing (AC20, AC14, AC10, 19.0, 12.5, 9.5 Nominal mixes)	1 test per 400 m^2	6 per section

(c) Testing methods
If a nuclear method is used for determining density and moisture content, tests will be done at least at the same frequency required when using the sand replacement method but at each nuclear densometer test location, the average of two readings taken at positions rotated by 180° shall be used. A check/comparison test using the sand replacement method shall be carried out as required by the Engineer.

Initial calibration of the nuclear testing equipment shall be done by carrying out at least fifty tests in parallel with the sand replacement method for each different material encountered.

When starting to use a new material source, or whenever there is a change of material type, a calibration shall be carried out in accordance with the manufacturer's guidelines or as required by the Engineer to establish a moisture correction and any correction of density required. Check tests will be used to update the initial calibration of the nuclear density testing equipment.

(d) Field density requirements
The required field densities for each material type shall be as shown in TABLE 7114/2. The values shown are nominal values, or lower specification limits, to which an assessment of the results shall be applied in accordance with SECTION 7200.

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TABLE 7114/2
MINIMUM FIELD DENSITY, NOMINAL VALUES

Layer and nominal class of material	**Field density, Lower Specification Limit**
Roadbed (after removal of topsoil etc.)	Depends on the depth below formation, reference is made to TABLE 3606/1
Backfill to culverts and structures	To be the same as adjacent layers at the same level, not less than 93% BS-Heavy
Fill or improved subgrade layers using dump rock: (DR)	Method specification
Earthworks fill using soils: (G3) (more than 300mm below formation level)	90% of BS-Heavy
Lower improved subgrade layers using gravel/soils: (G7)	93% of BS-Heavy
Upper improved subgrade layers using gravel/soils: (G15)	95% of BS-Heavy
Gravel wearing course used on gravel roads: (GW)	95% of BS-Heavy
Subbase of natural gravel: (G30, G45)	95% of BS-Heavy
Subbase of cemented material: (CM, C0.7, C1.0)	95% of BS-Heavy
Base course of natural gravel: (G60, G80)	98% of BS-Heavy
Base course of cemented material: (C1.0, C1.5)	97% of BS-Heavy
Base course of crushed aggregate: CRS	98% of BS-Heavy
Base course of crushed aggregate: CRR	102% of BS-Heavy
Base course of cold bituminous mix: (BEMIX, FBMIX)	96% of Marshall density, or method specifications ***1)***
Base course of hot bituminous mix: (DBM40, DBM30)	Method specification) ***1)***
Base course of hot bituminous mix: (37.5, 25.0 Nominal mixes)	93.5 % of max. theoretical density of mix (G_{mm})
Asphalt concrete surfacing: (AC20, AC14, AC10)	96% of Marshall density (75 blows at each face)
Asphalt concrete surfacing: (19.0, 12.5, 9.5 Nominal mixes)	93.5 % of max. theoretical density of mix (G_{mm})
1) Marshall density cannot be used on coarse bituminous material types, i.e. with nominal aggregate size 30 mm or larger. Whether or not Marshall compaction can be applied for a specific type of cold bituminous mix shall be decided by the Engineer.	

7115 TESTS OF SURFACE REGULARITY, LEVELS AND LAYER THICKNESS

(a) General

(i) Straight edge measurements, normal conditions
Measurements of surface regularity shall be carried out with a 3 m straight edge having sharp right angled corners at the bottom, and shall be placed on the road at any angle to the centreline as directed by the Engineer. Measurements shall be carried out by measuring the largest deviation from true surface along the straightedge.

Using the rolling straight edge for measuring surface irregularities, the apparatus and testing method for this shall be in accordance with testing Method ST3 of TMH6 of South Africa.

(ii) Straight edge measurements, severe conditions
Where surface irregularities are measured on a surface with a coarse surface texture in the opinion of the Engineer, such as grooved concrete pavements, crushed aggregate pavement layers, natural gravel base course, asphalt with rolled in such chipping, seals and other like surface, the following procedure shall be followed:

A metal wedge of 100 mm in length and 50 mm in width shall be constructed with a taper of 7.5 horizontal to 1.0 vertical and tapering to a feather edge (50 mm wide). Parallel lines spaced at 7.5 mm intervals shall be engraved on the sloping face and numbered to indicate the positions where the wedge is 1.0 mm, 2.0 mm, etc, thick.

(iii) Horizontal tolerances
At no point shall the distance between the centre-line and the edge of the top of a layer be less than that detailed or more than 150 mm in excess of that detailed.

(iv) Shoulders
Shoulders shall be constructed to the same thickness, level, crossfall and surface regularity requirements as for the adjacent pavement layers, except otherwise as stated in the other contract documents.

(b) Surface regularity, straight edge measurements
The required surface regularity, measured with a 3 m straight edge at any angle in relation to the centreline, shall be within the limits shown in TABLE 7115/1.

(c) Surface levels
The maximum deviation in levels shall be as shown in TABLE 7115/2.

TABLE 7115/1
SURFACE REGULARITY, MEASUREMENTS WITH 3 METRE STRAIGHT EDGE

Layer	Maximum straight edge deviation (mm)
Bituminous wearing course	6
Bituminous binder course	7
Base course	7
Gravel wearing course	15
Subbase	30

TABLE 7115/2
SURFACE LEVELS

Layer and material class	Maximum deviation in levels (mm)			
	High (+)		Low (-)	
	H_{90} value ***1)***	Absolute max H_{max} value	H_{90} value ***1)***	Absolute max H_{max} value
Base course, when followed by a seal only	10	15	10	15
Base course, when followed by AC surfacing	NIL	NIL	10	20
Subbase	NIL	NIL	25	35
Formation	NIL	NIL	50	75
Gravel wearing course	15	30	15	20
1) H_{90} is the limit within which 90% of the measurements shall fall when assessing 50 or more measurements against the specified level at the respective locations the measurements were taken.				

(d) Surface crossfall
The maximum deviation in longitudinal slope or crossfall shall be as shown in TABLE 7115/3. The values shown are nominal values to which an assessment of the results shall be applied in accordance with SECTION 7200.

TABLE 7115/3
SURFACE CROSSFALL

Layer	Maximum crossfall deviation ± (%)
Bituminous wearing course	0.25
Base course	0.25
Subbase	0.50
Formation	0.50
Gravel wearing course	0.50

(e) Layer thickness
The final compacted layer thickness measured by excavating trial pits or core drilling shall not deviate more from the specified thickness than the maximum deviations shown in TABLE 7115/4. The measurements shall be taken at locations as directed by the Engineer at intervals not less frequent than 25 metres and a lot size shall be at least 20 measurements.

TABLE 7115/4
LAYER THICKNESS

Layer	Maximum deviation in layer thickness (mm)	
	T_{90} value ***1)***	Absolute max T_{max} value
Bituminous wearing course	5	10
Bituminous base course (not PM materials)	10	15
Base course, aggregate or natural gravel	10	20
Subbase	15	25
Improved subgrade layers	20	35
Gravel wearing course	15	25
1) T_{90} is the value with which 90% of the measurements shall comply when assessing 20 or more measurements against the specified layer thickness.		

7116 LABORATORY TRIALS AND SITE TRIALS

(a) Laboratory trials
Laboratory trials shall be carried out by the Contractor and the Engineer on earthwork and pavement materials which are to be used in the works in their natural state to establish a relationship between their specified end product requirements and properties which can be readily determined in the field for construction control purposes.

Laboratory trial mixes and site trials for bituminous mixes shall be carried out in accordance with the requirements of SERIES 4000 of this Specification.

For mixed materials the composition which meets the specified requirements and is accepted by the Engineer shall then be used in the site trials to establish that all specified requirements of the completed pavement course can be achieved.

The Laboratory trials on mixed materials shall be undertaken, and the Contractor's proposals based thereon submitted to the Engineer, at least two weeks before the Contractor proposes to use the mixed material in the site trials.

(b) Site trials
The Contractor shall prepare a Trial Section Programme for the approval of the Engineer detailing all sequences of the proposed trial section. In addition to the items listed further below, at least the following, where appropriate, shall be included:
- date and time, location, sketch of location and type of layer to be placed;
- preparation of surface;
- rate of application;
- frequency of testing (test trays, cores, density measurements, gradation, etc);
- type and number of equipment to be used;
- roller pattern;
- joint construction methods.

The plan for the proposed trial section shall be forwarded to the Engineer for approval not less than two working days before the planned trial. Attention shall be given to joint construction methods, limitation of longitudinal and transversal joints and handling of materials.

Full scale laying and compaction site trials shall be carried out by the Contractor on all earthwork and pavement materials proposed for the works using the constructional plant and methods proposed by the Contractor for constructing the works. The trials shall be carried out with the agreement, and in the presence of the Engineer.

The trials shall be carried out to enable the Contractor to demonstrate the suitability of his mixing and compaction equipment to provide and compact the material to the specified density and to confirm that the other specified requirements of the completed earthwork or pavement layer can be achieved.

Each trial area shall be at least 100 metres long and to the full construction width and shall be laid to the specified depth for the material. It may form part of the works provided it complies with this Specification. Any areas which do not comply with this Specification shall be removed and a new trial shall be laid.

The Contractor shall allow in his programme for conducting site trials and for carrying out the appropriate tests on them. The trial on each pavement layer shall be undertaken at least 21 days ahead of the Contractor proposing to commence full scale work on that layer.

The Contractor shall compact each section of trial over the range of compactive effort the Contractor is proposing and if appropriate, the following data shall be recorded for each level of compactive effort at each site trial:

(i) The composition and grading of the material before the site trial.

(ii) The composition and grading of the material including the cement, lime or bitumen content.

(iii) The moisture content at the time of compaction and the optimum moisture content for the specified compaction.

(iv) The type, size, tyre pressure, frequency of vibration and the number of passes of the compaction equipment.

(v) The maximum dry density or target density as appropriate measured on a sample before and at intervals through the site trials.

(vi) The density achieved.

(vii) The compacted thickness of the layer.

(viii) Any other relevant information as directed by the Engineer.

At least eight sets of tests shall be made by the Contractor and the Engineer on each 100 metres of trial for each level of compactive effort and provided all eight sets of results over the range of compactive effort proposed by the Contractor meet the specified requirements for the material the site trial shall be deemed successful. The above data recorded in the trial shall become the agreed basis on which the particular material shall be provided and processed to achieve the specified requirements.

The Contractor shall not proceed with the placing of the layer tried in the trial section until the methods, materials and procedures established in the trials have been approved. Such approval shall be based on a detailed trial section report prepared by the Contractor including all observations and test results. Should the trial fail, the Contractor shall perform additional trials at his own cost until a trial and the trial section report has been approved by the Engineer.

If during the execution of the works, the construction control tests indicate that the requirements for a material are not being consistently achieved, then work on that layer shall stop until the cause is investigated by the Contractor. Such investigation may include, effect of using other compaction methods, further laboratory and site trials on the material to determine a revised set of data as above which, when agreed, shall be the basis on which all subsequent material will be provided and processed to achieve the specified requirements.

Agreement by the Engineer to a set of data recorded in a site trial shall not relieve the Contractor of any responsibility to comply with the requirements of this Specification and the Special Specification.

7117 TESTS ON STRUCTURES

(a) Test on elastomeric bearings
Tests on elastomeric bearings shall be conducted in accordance with BS 5400 Part 9.2: 1983 and the bearings shall comply with the test requirements specified in the said specification.

(b) Prestressed concrete

(i) General
Where so directed by the Engineer the contractor shall make arrangements for samples of the materials he intends to use in the Works to be tested by an Independent testing authority. The cost of testing prestressing steel, anchorage assemblies and couplings shall be included in his rates.

Material represented by samples which do not comply with the specified requirements shall be removed and replaced with suitable material.

(ii) Anchorage's and couplers
Anchorage's and couplers shall be tested in accordance with the requirements of CLAUSE 6503. The anchorages and couplers shall be assembled in accordance with their practical application on the site where all components necessary for anchoring shall be used, but excluding the ducts.

(iii) Prestressing steel
Prestressing steel shall be tested in accordance with the requirements of CLAUSE 6503. Should any test piece fail to comply with the requirements specified for the prestressing steel, the material represented by that sample shall be replaced with materials conforming to the specifications if further testing confirms that they do not comply with the specifications.

(iv) Grout
The fluidity of grout shall be measured with a flow cone, immersion apparatus or viscometer. The instrument shall be accurately calibrated in a laboratory so that the specified viscosity of grout can be controlled satisfactorily.

The readings obtained during grouting shall be compared with the times determined in the laboratory for grouts of the specified viscosities.

The bleeding of grout shall be measured in a metal or glass container with an internal diameter of approximately 100 mm and a height of approximately 120 mm. The grout and water levels in the container shall be controlled with a metal bridge into which two adjustable studs A and B are secured.

The procedure for determining the bleeding of grout shall be as follows:

Studs A and B in the metal bridge shall be adjusted and locked so that the distance from the lower tips of studs to the bottom of the container will be approximately 100 mm and 107 mm respectively. The volume V_a and V_b for the container at the respective levels of the stud settings shall then be determined to the nearest millilitre.

The container shall be filled with freshly mixed grout to a level where the grout will just touch the tip of stud A which points downwards. The bridge shall then be removed and the container tightly sealed to prevent evaporation. The container shall then be stored at 20°C and kept free from vibrations for the entire duration of the test.

Three hours after the grout has been mixed, the container shall be opened and the free (bleed) water poured off. The bridge shall be placed over the container with tip of stud B pointing downwards and water poured onto the grout with measuring apparatus until the water level touches the tip of stud B. The volume of water added shall be determined to the nearest millilitre.

(c) Load test on foundation piles
The head of the test pile shall be exposed for checking position and slope. Where necessary, the head shall be cut further back so as to expose a full bond length of main reinforcing steel, and a suitable pile head slab for applying an axial load to the pile shall be cast. As an alternative, the head may be cut at right angles and the load applied directly to the pile.

The test load shall be applied to the top of the pile with a hydraulic jack. Where more than one jack is used for applying the load, all the jacks in the circuit shall be activated by the same pumping unit. The jack (s) shall be placed so as to ensure that the load is applied axially.

The applied load shall be calculated in accordance with the hydraulic pressure which is being monitored by two pressure meters in the circuit. The pressure meter shall be calibrated in divisions not exceeding 2% of the maximum pressure applied, and the range of the metres shall not exceed 150% of the maximum pressure. The jack(s) and meters shall be calibrated by an approved testing laboratory not more than four weeks before the test will commence.

The deflection of the pile head shall be measured with two scale rulers and two dial extensometers. The scale rulers shall be fixed to the pile and placed on both sides of the pile on a diameter line and the dial extensometers shall be similarly placed but on a diameter line at right angles to that in which the scale rulers have been mounted.

Level measurements shall be taken on the scale rulers and reduced as a level mark to a similar scale ruler placed at a distance from the test pile. All three scale rulers shall be calibrated in millimetres and the level – indicating instrument shall be capable of taking readings to 0.5 mm, and approximate readings of up to 0.1 mm.

The dial extensometers shall have a range of 50 mm and shall be marked in 0.1 mm divisions to enable measurements to 0.05 mm to be taken. The plungers of the extensometer shall rest on a machined metal or glass surface.

The extensometer shall be supported by one or more beams kept in the shade. The supports for the beams shall be so placed as to limit the effect of earth movements around the test pile on the deflection readings.

The test load shall be applied in increments of 20% of the specified working load to a maximum test load equal to twice the specified working load or the ultimate test load whichever is the smaller.

A load increment may not be applied before the subsidence or the rate has stabilised at a rate of not more than 0.10 mm in 20 minutes under the load applied.

After the load loading has been completed, the maximum test load shall be maintained until the movement is less than 0.2 mm within a period of 24 hours. The load shall be removed in decrements of 20%

of the specified working load at intervals of not less than 20 minutes.

After the loading has been removed, the readings on both meters registering the movement of the pile shall be recorded accurately to 0.1 mm at intervals of 5.10 and 20 minutes and then every 30 minutes until the load is changed. The final recovery shall be recorded 24 hours after the maximum test load has been removed.

During the test, the pile shall be loaded with up to 100% of the specified working load and the load shall then be removed. It shall then be loaded to the maximum test load after which the test load shall be removed.

7118 MEASUREMENT AND PAYMENT

Payment for the Engineer's laboratory shall be in accordance with SECTION 1400.

ITEM	UNIT
71.01 SPECIAL TESTS REQUESTED BY THE ENGINEER	
(a) TESTS	PROVISIONAL SUM
(b) CONTRACTOR'S OVERHEAD AND PROFIT	%

The actual costs of special tests requested by the Engineer shall be reimbursed from the provisional sum entered in the Bill of Quantities for such tests. The Contractor's overhead and profit associated with arranging and paying for the tests shall be covered by a percentage on the actual costs.

SERIES 7000: TOLERANCES, TESTING AND QUALITY CONTROL

SECTION 7200: QUALITY CONTROL

CONTENTS:

7201 SCOPE

This Section describes the scheme used for determining, by means of tests and measurements and by applying statistical judgement plans, whether certain specified requirements in regard to the properties of materials and workmanship are being complied with.

It also covers the requirements in regard to the control to be exercised by the Contractor for monitoring the quality of his work and materials and the routine tests and inspections to be carried out by the Engineer.

7202 JUDGEMENT PLANS: GENERAL

Certain requirements and nominal limit values are laid down in the Specifications in regard to the properties of materials and workmanship to be supplied. Tests shall be conducted and measurements taken for controlling the relevant properties of the workmanship and materials supplied, and the results of such tests and measurements shall be assessed on the basis of the prescribed criteria for compliance with the specified requirements.

Wherever possible, acceptance criteria shall be determined by way of statistical principles described in this Section. Wherever statistical acceptance criteria are deemed inappropriate in the opinion of the Engineer, a specified minimum requirement shall be fully complied with.

Despite acceptance of those properties judged by these statistical methods, the materials or work submitted will be rejected when other properties (which are not controlled by statistical methods) fail to comply with the requirements of the Specifications, or where there are other causes for rejection such as obviously defective workmanship or excessively variable properties, visible signs of poor workmanship, and similar considerations which constitute sufficient grounds for rejecting the work without any further testing in the opinion of the Engineer.

The Engineer shall be entitled to assess separately any specified portion of a lot if, in his opinion, it exhibits significant deviations as compared with the remainder of the lot.

7203 DEFINITIONS

The limit values will depend on the sample sizes and may be a lower limit L, an upper limit or double limits.

For the purposes of this SECTION the following words and symbols shall have the following meanings:

(a) Lot
A lot is a sizeable portion of work or quantity of material which is assessed as a unit for the purpose of quality control, and selected to represent material or work produced by essentially the same process and from essentially the same materials.

(b) Random Sample
Random samples are test measurements at separate test positions or on separate sample portions obtained from the lot in an unbiased manner.

(c) Nominal value or specification limit
This is the limit value of the property of any material outside which not more than a specified percentage of the population of values representing an acceptable material is allowed to lie. The nominal value may be a single lower limit or a single upper limit or a double limit consisting of a lower limit and an upper limit.

(d) Acceptance limit for sample mean
This is the limit value of a product property within which the sample mean shall lie for a product to be acceptable.

(e) Acceptance limits for individual test values
These are the limit values of a product property within which the sample values representing a product shall lie for the product to be acceptable.

(f) Conditional acceptance
This is the acceptance of a lot at conditions that specific rectification measures are taken and carried through to completion to the satisfaction of the Engineer before the lot can be approved in the permanent Works and certified for payment. Conditional acceptance shall be subject to the provisions of CLAUSE 7202.

(g) Outliers
Where, in a sample, one or more test results differ significantly from the other values obtained, this difference could be ascribed to an assignable cause if so deemed by the Engineer, in which case such test result shall be regarded as an outlier and disregarded when assessing the lot.

7204 GENERAL REQUIREMENTS

(a) Determining the lot size

(i) Road-construction layers
The lot size shall be a section compacted in one process where essentially the same materials and construction equipment have been used.

Where production is on a continuous basis, a lot shall normally mean the product of one day's work and shall not exceed the product of two full days' work. However, a lot of any smaller size may be ordered by the Engineer where:

(1) The properties under investigation exhibit abnormal local variation within the normal lot size.
(2) An area is obviously of a different quality than the rest;
(3) The rate of production is very high.

(ii) Concrete
The lot size shall be determined by the Engineer, with due regard being given to the size and the type of structure in which the concrete is placed, the specific portion of the structure, and the total quantity of concrete placed in a day. The lot sizes in

concrete structures could therefore vary considerably, and, particularly in the case of small structures, it could be necessary to combine samples of the same grade of concrete from different structures at the discretion of the Engineer, provided that the concrete has been obtained from the same concrete plant and has been cast in the same period.

(iii) Other
In certain cases, as for example in material stockpiles, others where the definition of a lot in accordance with this Section does not apply directly in the opinion of the Engineer, the Engineer will determine lot sizes in accordance with circumstances pertaining to each case.

(b) Random sampling
When any lot is tested, whether a normally sized lot or an isolated section that clearly exhibits an abnormal variation of the properties under consideration, all samples shall be taken in a random pattern.

For this purpose use shall be made of tables of random numbers according to standard instructions approved by the Engineer.

(c) Sample Sizes
For purposes of acceptance control, the Engineer will determine sample size, i.e. the number of values to be assessed in a lot.

(d) Outliers
Test results shall be scanned for possible outliers. Where there is reason to believe that a test result may be erroneous, it shall, if possible, be re-examined by further testing, and, if there is reasonable evidence to suggest that the test result is erroneous, it shall be regarded as an outlier, rejected and replaced with a fresh result.

Where reinvestigation of a test result is not possible, the procedure described below shall be used for identifying outliers:

Calculate the value of T_o from

$$T_0 = \frac{abs(X_0 - X_n)}{S_n}$$

Where X_n and S_n are the arithmetic mean and the sample standard deviation respectively, and X_o is the value of the test differing most from the mean.

Compare the value of T_o with the value of T for the applicable value of n from TABLE 7204/1.

If T_o is greater than T, then X_o is an outlier.

Every outlier shall be disregarded and replaced by another random test value. The sample mean and the sample standard deviation shall then be recalculated. If an outlier cannot be replaced, the sample mean and the standard deviation shall be calculated using the remaining test results. The final number of test results used in the assessment, after the elimination of outliers, shall never be less than three.

(e) Resubmission
Where a lot has been accepted conditionally, or has been rejected, the Engineer may agree to its resubmission for approval if it has been rectified to the satisfaction of the Engineer. In such case a fresh sample shall be taken, and a fresh (second) set of test values determined.

The first and second sets of test values shall then be compared with each other to determine whether their properties differ significantly.

Where in the opinion of the Engineer a significant difference does occur, the submission of the lot shall be regarded as a first submission and assessed as such, and only the second set of test values shall then be used for this purpose.

TABLE 7204/1
VALUES OF T FOR DIFFERENT SAMPLE SIZES

Number of observations n	Critical value T
1	
2	
3	
4	1.46
5	1.67
6	1.82
7	1.94
8	2.03
9	2.11
10	2.18
11	2.23
12	2.29
13	2.33
14	2.37
15	2.41
16	2.44
17	2.47
18	2.5
19	2.53
20	2.56

7205 PROCEDURES AND ACCEPTANCE LIMITS

(a) General
The statistical judgement procedures described below shall apply to the corresponding product properties for the purpose of acceptance control. Outliers shall be identified, disregarded, and, if possible, replaced at the discretion of the Engineer.

(b) Straight edge measurements
Six straightedge measurements shall be taken in the longitudinal direction and six measurements shall be taken in the transversal direction every 25 m along the road or as otherwise directed by the Engineer. The measurements shall be taken at offsets as agreed with the Engineer. All measurements taken shall fall within the limits given in TABLE 7115/1 including the requirement for surface dressing.

(c) Surface levels
At least 5 points across road shall be taken every 25 m. The levels shall be taken at the centreline, at the edge of the carriageway and at the edge of the shoulders or as directed by the Engineer. The levels may be taken at shorter intervals than 25 m, see CLAUSE 7303.

At least 50, but preferably more, levels shall be determined for each lot of completed work The lot will be considered to comply with the requirements in respect of surface levels if, before any repair work is undertaken, at least 90% of the level measurements show a deviation from the specified levels which is

smaller than the tolerance specified in TABLE 7115/2 and no measurements fall outside the maximum allowed deviation H_{max}.

Isolated spots, where the surface levels deviate by more than the appropriate tolerance of the specified levels shall be repaired to bring the deviation to within the tolerance.

(d) Crossfall and longitudinal slope
All measurements of crossfall and longitudinal slope as directed by the Engineer shall fall within the limits given in TABLE 7115/3.

Isolated spots, where the crossfall and longitudinal slope deviate by more than the appropriate tolerance of the specified crossfall shall be repaired to bring the deviation to within the tolerance.

(e) Layer thickness
At least 20, but preferably more, layer thickness shall be determined in accordance with a stratified random pattern (as defined in SUBCLAUSES 7203(b) and 7204(b)) for each lot of completed layer work. Layer thickness may not be determined by means of level measurements, but shall be measured by core drilling of excavation of sample pits at locations approved by the Engineer.

The lot will be considered to comply with the requirements for layer thickness if both the following conditions are fulfilled:
- at least 90% of all the thickness measurements taken before any thickness repairs are made are equal to or greater than the specified nominal thickness, minus the T_{90} tolerance specified in TABLE 7115/4.
- the mean layer thickness of the lot is not less than the specified nominal thickness

(f) Relative compaction of earthworks and pavement layers
At least the following number of relative density determinations shall be taken in a random pattern (as defined in SUBCLAUSES 7203(b) and 7204(b)) on each section or as directed by the Engineer and assessed as a lot:
- Roadbed, fill: 3 tests
- Improved subgrade layers, gravel wearing course: 4 tests
- Subbase: 5 tests
- Base course, binder course, surfacings: 6 tests

After outliers have been examined and replaced as directed by the Engineer, compliance with the specified density requirements shall be determined by the statistical method specified below unless a fixed minimum average value and/or absolute minimum value has been specified for the compaction elsewhere in these Specifications.

The lot will be considered to comply with the requirements for field density if the following conditions are fulfilled:

(1) For a lower limit specification, LL_s

$X_n > LL_s + S_n*K$

Accept the lot if the sample mean satisfies the expression, otherwise reject the lot.

(2) For an upper limit specification, UL_s

$X_n < UL_s - S_n*K$

Accept the lot if the sample mean satisfies the expression, otherwise reject the lot.

(3) For a double limit specification, LL_s and UL_s

$LL_s + S_n*K < X_n < UL_s - S_n*K$

Accept the lot if the sample mean satisfies the expression, otherwise reject the lot.

where

X_n is the arithmetic mean of a set of n test results constituting the sample.

S_n is the sample standard deviation defined by:

$$S_n = \left(\frac{\sum x^2 - n(x_n)^2}{n - 1} \right)^{0.5}$$

where

X is the value of an individual sample portion, i.e. an individual test result or measurement.

n is the number of sample portions, i.e. the number of individual test results or measurements.

K is a statistical constant defined by

$$K = \frac{t}{\sqrt{n}}$$

where

t is the Student's t.

The value of K is dependent on the number of sample portions in the sample and the acceptance criteria.

The value of K reflecting 90% control limit for the sample mean is given in TABLE 7205/1.

TABLE 7205/1:
VALUES OF STUDENT'S-T AND K FOR DIFFERENT SAMPLE SIZES

n	Student's-t	$K = \frac{t}{\sqrt{n}}$
3	1.89	1.09
4	1.64	0.82
5	1.53	0.68
6	1.48	0.60
7	1.44	0.54
8	1.42	0.50
9	1.40	0.47
10	1.38	0.44
11	1.37	0.41
12	1.36	0.39
13	1.36	0.38
14	1.35	0.36
15	1.34	0.35
16	1.34	0.34
17	1.34	0.32
18	1.33	0.31
19	1.33	0.31

(g) Cementitious binder content of cemented layers

(i) Method

(1) Take 50 samples according to a random pattern (as defined in SUBCLAUSES 7203(b) and 7204(b)) and determine their cementitious binder content.
(2) Examine the results for outliers and replace them if any in the opinion of the Engineer.

(ii) Analysis
The lot will be considered to comply with the requirements for cementitious binder content if the following conditions are both fulfilled:

(1) The mean cementitious-binder content shall be not less than 91% of the specified binder content.
(2) The cementitious binder content in not more than 12 of the 50 samples may be lower than 70% of the specified binder content.

(h) Concrete cube compressive strength, 28-day

(i) Method
Take at least the minimum number of samples as given in Table 7205/3 according to a random pattern (as defined in SUBCLAUSES 7203(b) and 7204(b)) and make test cubes. Test them for cube compressive strength after 28 days.

TABLE 7205/3
MINIMUM NUMBER OF TESTS OF STRUCTURAL CONCRETE FOR COMPRESSION STRENGTH

Volume of lot (m^3)	Minimum number of tests in lot *1)*
0 – 20	4
21 – 40	6
41 – 70	9
71 – 100	12
101 – 150	14
> 150	16
1) Each test consists of the average value of a set of three cubes.	

(ii) Analysis
Examine the results for outliers and disregard as required in the opinion of the Engineer. The results are then assessed according to the criteria set out below. A lot will comply with the requirements for the characteristic strength denoted **X,** if it meets the following requirements by using the acceptance factors **A** and **B** given in TABLE 7205/4:

- Mean value: minimum (**X** + **A**)
- Single test value: minimum (**X** - **B**)

TABLE 7205/4
ACCEPTANCE FACTORS FOR STRENGTH OF STRUCTURAL CONCRETE

Number of tests in lot	Acceptance factors for strength of structural concrete	
	A (MPa)	**B** (MPa)
3	2.7	3.9
4	2.7	4.2
5	2.6	4.5
6	2.5	4.7
7	2.4	4.9
8	2.3	5.0
9	2.2	5.2
10	2.1	5.3
11	1.9	5.4
12	1.7	5.5
13	1.4	5.6
14	1.1	5.7
15	0.5	5.8

7206 CONDITIONAL ACCEPTANCE

(a) General
Where a lot is rejected under a statistical judgement, plan described in this Section, but the test results are such that the lot complies with the requirements for conditional acceptance specified in this Clause, the Engineer may accept the lot conditionally. The Engineer shall then apply a number of conditions for rectification of the layer at his own discretion for the product to be approved and certified for payment. Conditional acceptance shall be the sole discretion of the Engineer and is not an option that may be exercised by the Contractor or a right he may claim.

The Contractor shall have the option to remove and reinstate completely at his own cost conditionally accepted work with work which complies with the requirements.

(b) Application
Conditional acceptance may be applied in respect of the properties of structures as shown in TABLE 7206/1.

(c) Criteria
Properties to which conditional acceptance may apply in accordance with this Section shall comply with the following criteria. Two requirements shall always apply to the acceptance, one in relation to the sample mean and one in relation to individual tests value. A lot may be conditionally accepted when it complies with one of the two requirements for acceptance according to the statistical judgement., but not with the other.

TABLE 7206/1
PROPERTIES TO WHICH CONDITIONAL ACCEPTANCE MAY APPLY

Property	Structure
Relative compaction	– Bituminous base course or surfacing – Cemented layers – Plant mixed, paver laid layers
Bituminous binder content	Layers of bituminous mixes
Cementitious binder content	Cemented layers
28-day cube strength	All structural concrete (excepting concrete pavements
Levels	Earthworks and pavement layers
Layer thickness	Earthworks and pavement layers

(d) Resubmission
Where a lot has been accepted conditionally or has been rejected, the Engineer may agree to its resubmission for approval if it has been reworked and the Engineer is satisfied that a proper attempt was made to improve the properties that were unacceptable. A fresh sample shall be taken, and a fresh (second) set of test values determined. The first and second sets of test values shall then be compared with each other to determine whether their properties differ significantly. Where in the opinion of the Engineer a significant difference does occur, the resubmission of the lot shall be regarded as a first submission and assessed as such.

7207 ROUTINE TESTS AND INSPECTION BY THE ENGINEER

The Engineer will at regular intervals inspect and test materials and completed work for compliance with the specified requirements, and, where applicable the various specified judgement plans will be applied. The testing frequencies and sample and lot sizes for routine testing shall be at the Engineer's discretion.

All sections of completed work shall be submitted to the Engineer for routine inspection and testing, and the Contractor shall not cover up or construct any work on top of sections of completed work before being advised by the Engineer of the outcome of his tests and inspection. The Contractor shall arrange the submission of work for testing in a manner as will afford the Engineer reasonable opportunity for inspecting and testing.

7208 PROCESS CONTROL BY THE CONTRACTOR

The requirements of Clause 1205 shall apply in respect of the Contractor's obligation to institute and implement a control system for monitoring the quality of the work and materials supplied.

For continuous concrete and asphalt-production processes, the Engineer may order the Contractor to augment the above control system by introducing a process-control system for monitoring the various properties to be controlled. The specific system to be applied shall be subject to the Engineer's approval.

The Contractor shall take immediate steps to rectify any deviation from the specified requirements indicated by his process-control system, and the Engineer shall have the right to inspect and be given all details of tests and testing procedures in order to satisfy himself that the Contractor is implementing adequate process-control system.

7209 MEASUREMENT AND PAYMENT

No separate measurement or payments apply to this Section.

SERIES 7000: TOLERANCES, TESTING AND QUALITY CONTROL

SECTION 7300: SETTING OUT AND TOLERANCES

CONTENTS:

7301 SCOPE

This Section covers the procedures for setting out and gives the limits for geometric tolerances for earthworks and layer work.

7302 GENERAL

The Engineer will provide sufficient basic survey information to enable the contractor to set out the works and the Contractor shall be responsible for setting out all necessary reference points and for the maintenance thereof.

The Contractor shall satisfy himself as to the accuracy in line, level and dimension of the basic survey and setting out details provided and should the Contractor discover any error in the information provided by the Engineer, he should at once notify the Engineer. If the information is confirmed to be in error the Engineer will issue amended drawings or instructions regarding the correction of the error.

Prior to commencing construction, the Contractor shall establish the road reserve boundary posts, or if no boundary posts are instructed, then the Contractor shall establish reference points to define the road reserve at 100 m intervals on both sides.

The Contractor shall establish temporary benchmarks along the road at intervals not exceeding 200 m and shall provide the Engineer with a schedule of their levels and locations.

The Contractor shall not remove, damage, alter or destroy in any way plot beacons or survey beacons. Should the Contractor consider that any beacon will be interfered with by the works he shall notify the Engineer who, if he considers necessary, will make arrangements for the removal and replacement of the beacon.

If the Contractor removes or disturbs a beacon without permission of the Engineer, he shall be liable for the full cost of its replacement and any legal consequences thereof.

7303 DETAILED SETTING OUT

The Contractor shall set out the line and level of the works at intervals of not more than 25 m or such lesser intervals as are required to construct the Works to the tolerances specified in this Specification. Reference pegs and batter rails clearly and indelibly marked with all the relevant information shall be provided clear of the road and at right angles to it from which the centreline, level and batter slope can be directly established at any time. These shall be maintained by the Contractor for as long as they are needed to check the work.

After completion of the setting out and site clearance the Contractor shall take ground cross sections at intervals of 25 m along the road centreline and along the centreline of all culverts and structures. These shall be plotted to a natural scale of 1:100 on a stable transparent material or other approved material and a copy of the plot submitted to the Engineer for agreement. If the Contractor fails to take requisite levels, levels determined by the Engineer shall be taken as correct.

The Contractor shall programme for a period of 30 days between submitting the ground cross sections and being issued with final road, culvert and structure levels. A minimum 5 km section of road shall be submitted, but where the Contractor submits cross sections for more than 10 km of road within the same 30 day period the initial 30 days shall be extended by 30 days for each additional 10 km or part thereof. Final road, culvert or structure levels will be determined by the Engineer and may be different from the levels shown on the Drawings.

On receipt of the final road levels the Contractor shall mark up the details on the transparencies and the original and one print of the cross-sections shall be provided free of charge by the Contractor for the Engineer.

On completion of the earthworks but before starting formation or pavement layers the Contractor shall establish steel pins at a constant offset to the edges of the carriageway shoulders. The offset may however vary between sections in cut and those in fill. The steel pins will be clearly and indelibly marked with all the relevant information necessary to directly establish the centreline and level at any point across the carriageway by using either boning rods or a string line.

The interval between pins shall not be more that 12.5 m and the pins shall be maintained by the Contractor for as long as they are needed by the Engineer to check the work.

7304 TOLERANCES

(a) General
In addition to the requirements set out in this Clause attention is drawn to the requirements of CLAUSE 7115 which shall all be fulfilled.

(b) Horizontal alignments
Horizontal alignments shall be determined from the centreline of the pavement surface as constructed, and all other parallel alignments shall be corrected within a tolerance of ±13 mm therefrom.

(c) Thickness of pavement layers
The thickness of any pavement layer as specified or ordered by the Engineer, measured at five points in any length of 100 m, shall meet the requirements given in TABLE 7115/4.

(d) Surface levels of payment layers and formation
The level measured at any point on the surface of a pavement layer or the formation level shall not deviate from the corresponding level calculated from the Drawings by more than the tolerances shown in TABLE 7115/2.

For checking compliance with TABLE 7115/2 measurements of surface levels will be taken at points to be selected by the Engineer at 12.5 m centres longitudinally and at 2 m centres transversely. At junctions, the grid point spacing shall be determined by the Engineer.

(e) Surface regularity
The surface regularity of pavement layers and the formation shall be tested at points decided by the Engineer with a rigid, steel straightedge 3 m long placed at any angle to the centreline of the road. The maximum allowable deviation of the surface below the straightedge shall be as given in TABLE 7115/1.

In addition the longitudinal slope or transverse crossfall shall not deviate from that shown on the Drawings by more than the tolerances given in TABLE 7115/3.

(f) Shoulders
Shoulders shall be constructed to the same thickness, level and surface regularity requirements as for the adjacent pavement layers.

(g) Cutting and embankment slopes
In the final trimmed slope of cuttings a tolerance of +0.25 will be permitted, i.e. if a slope of 1 in 2 is specified, the acceptable slope shall be not steeper than 1 in 2 or slacker than 1 in 2.25

In the final trimmed slopes of embankments, a tolerance of +0.25 will be permitted, i.e. if the specified slope is 1 in 2, the acceptable slope shall be not steeper than 1 in 2 or slacker than 1 in 2.25.

(h) Width of cuttings and embankments
The tolerance permitted in the width of the bottom of cuttings shall be 200 mm between the centreline of the road and the toe of the cutting slope.

The width of embankments measured as the horizontal distance from the centreline of the road to the top of the embankment shall not be less than that shown on the Drawing or more than that shown on the Drawings plus 0.25 m.

(i) Depth of side drains
The depth of side drains measured as the vertical height difference from the centreline of the finished pavement and the invert of the side drain shall not be less than that shown on the Drawings nor more than that shown on the Drawings plus 0.15 m.

7305 MEASUREMENT AND PAYMENT

No separate payment shall be made for work described in this Section.

Notwithstanding the provisions in this Specification, measurement and payment for earthworks and pavement works shall be made on the basis of the net cross-section Drawings or as ordered by the Engineer and no additional payment shall be made in respect of variation within or without the specified tolerances.

SERIES 7000: TOLERANCES, TESTING AND QUALITY CONTROL

SECTION 7400: RECTIFICATION OF EARTHWORKS AND PAVEMENT LAYERS OUTSIDE PERMITTED GEOMETRIC TOLERANCES

CONTENTS:

7401 SCOPE

This Section sets out the methods for rectification of earthworks and pavement layers constructed outside permitted geometric tolerances. Where any tolerances in SECTION 7300 are exceeded, the Contractor shall determine the full extent of the area which is out of tolerance and shall make good the surface of the pavement course, earthworks or formation in the manner described below.

7402 RECTIFICATION MEASURES

(a) Earthworks excluding improved subgrade layers

Where a cutting slope is steeper, and an embankment slope is slacker, than the specified slope then the slope shall be trimmed to the specified slope. Where a cutting slope in slacker, and an embankment slope is steeper, than the specified slope then the slope shall be benched and fill material placed and compacted and the slope shall be trimmed all in accordance with requirements of SERIES 3000 and any other relevant part of this Specification.

Where the width of a cutting is less than, and the width of an embankment more than, the specified width then the cutting or embankment shall be trimmed to the specified width. Where the width of a cutting is more than, and the width of an embankment is less than, the specified width then the embankment or cutting shall be benched and fill material placed and compacted and the slopes shall be trimmed all in accordance with the requirements of this Specification.

Where the depth of a side drain is less than that specified the side drain shall be trimmed to the specified depth. Where the depth of a side drain is more than specified the side drain shall be backfilled with fill material compacted to a dry density of at least 90% MDD of BS-Heavy up to the specified depth.

Where the results of the construction control tests are less than that specified the full depth of the layer shall be reworked to specification. The area treated shall be the whole section submitted for approval or, following a retest, a length of at least 50 m both sides of each test and retest failure or such area to be determined by the Engineer as necessary to obtain compliance with this Specification.

(b) Improved subgrade layers

Where the levels or widths are out of tolerance then the full depth of the layer shall be reworked to specification. The area treated shall be at least 12.5 m long and 3 m wide or such area to be determined by the Engineer as necessary to obtain compliance with this Specification.

Where the results of the construction control tests are less than that specified the full depth of the layer shall be reworked to specification. The area treated shall be the whole section submitted for approval or following a retest a length of at least 50 m both sides of each test and retest, failure.

(c) Base course and subbase

Where the levels or widths are out of tolerance and the courses consist of unbound (i.e. natural or graded stone) material, the full depth of the material shall be reworked to specification. The area treated shall be at least 30 m long and 3 m wide or such area to the determined by the Engineer as necessary to obtain compliance with this Specification.

Where the courses consist of cement or lime treated material or lean concrete the full depth of the layer shall be removed from the pavement and replaced to specification. The area treated shall be at least 5m long and the full width of the paving laid in one operation. If areas are corrected within 7 days of laying no construction traffic or compaction plant shall use the surrounding satisfactory areas during that period.

For bituminous bases the full depth of layer shall be removed and replaced with fresh material laid and compacted to specification. Any area so treated shall be at least 5 m long and the full width of the paving laid in one operation.

Where the results of the construction control tests for any of the base or subbase materials are less than that specified, the full depth of the layer shall be reworked to specification in case of unbound material and removed and replaced to specification in case of cemented and bituminous materials. The area treated shall be the whole section submitted for approval or, following a retest, such area to be determined by the Engineer as necessary to obtain compliance with the Specification.

(d) Asphalt concrete surfacing

Where the levels or widths are out of tolerance the full depth of the layer shall be removed and replaced with fresh material laid and compacted to specification. The area rectified shall be the full width of the paving laid in one operation and at least 15 m long.

Where the results of the construction control tests for the wearing course are less than that specified the full depth of the layer shall be removed and replaced to specification. The area treated shall be the whole section submitted for approval or, following a retest, such area to be determined by the Engineer as necessary to obtain compliance with the Specification.

7403 MEASUREMENT AND PAYMENT

No additional payment will be made for work described in this Section.

SERIES 7000: TOLERANCES, TESTING AND QUALITY CONTROL

SECTION 7500: SPECIFICATIONS AND TEST METHODS

CONTENTS:

7501 INSTITUTIONS

- Central Materials Laboratory (CML) of Ministry of Works, Housing and Communications, Uganda.
- Uganda National Bureau of Standards (UNBS)
- American Association of State Highway and Transport Officials (AASHTO)
- American Society for Testing and Materials (ASTM)
- British Standards Institute (BS)
- European Standards (BS EN)
- Deutshe Ingineur Norme (DIN)
- South African Bureau of Standards (SABS)
- Southern African Bitumen and Tar Association (SABITA)
- Swedish Standard (SIS)
- International Standards Organisation (ISO)

7502 STANDARDS AND TEST METHODS

(a) Test methods

(i) Tests on Soils and Gravel:

Name of Test	Standard Test Method
Moisture Content	BS 1377: Part 2: 1990
Liquid Limit (Cone Penetrometer)	BS 1377: Part 2: 1990
Plastic Limit & Plasticity Index	BS 1377: Part 2: 1990
Linear Shrinkage	BS 1377: Part 2: 1990
Particle Density Determination – Pycnometer	BS 1377: Part 2: 1990
Particle Density Determination	BS 7755-5.3/ISO 11508
Bulk Density for undisturbed samples	BS 1377: Part 2: 1990
Determination of dry bulk density	ISO 11272: 1998
Particle Size Distribution	BS 1377: Part 2: 1990
Particle Size Distribution - Hydrometer Method	BS 1377: Part 2: 1990
Compaction Test - BS Light and BS Heavy	BS 1377: Part 4: 1990
Unsoaked CBR Test - One Point Method	BS 1377: Part 4: 1990
Unsoaked CBR Test - Three Point Method	BS 1377: Part 4: 1990
Soaked CBR Test - One point method	BS 1377: Part 4: 1990
Soaked CBR Test - Three Point Method	BS 1377: Part 4: 1990
Consolidation Test - Oedometer	BS 1377: Part 5: 1990
Triaxial Test	BS 1377: Part 7: 1990
Shear Box Test	BS 1377: Part 7: 1990
Permeability Test - Constant Head	BS 1377: Part 5: 1990
Organic Content - Ignition Loss Method	BS 1377: Part 3: 1990
Crumb Test	BS 1377: Part 5: 1990
pH Value (pH meter)	BS 1377: Part 3: 1990
Sulphate carbonate content	BS 1377: Part 3
Chloride content	BS 1377: Part 2
Durability test	BS 1377: Part 5
Field density	BS 1377: Part 9
In situ tests: sand replacement, CBR testing, vane shear strength, cone penetrometer and plate bearing test	BS 1377: Part 9
Determination of water retention characteristics	BS 7755-5.5
Sampling, sample preparation and tests on materials before stabilisation	BS 1924: Part 1
Preparation of Stabilised Samples for UCS	BS1924:Part 2:1990
Compaction Test and UCS of Stabilised Materials	BS1924:Part 2:1990
Initial Consumption of Lime - ICL	US 288:2001 or BS 1924:Part 2:1990
Quicklime, hydrated lime and natural calcium carbonate-methods of physical testing	BS 6463 : Part 103

(ii) Tests on Aggregates

Name of Test	Standard Test Method
Guide to sampling and testing aggregates	BS 812: Part 101 and BS 5835
Methods of sampling	US 145:2000 or BS 812: Part 102
Determination of physical properties	US 146:2000
Moisture content of aggregates	BS 812: Part 109:1990 and BS 5835
Relative density	BS EN 1097-3: Part 3: 1998
Determination of loose bulk density and air voids	BS EN 1097-3: Part 3: 1998

Name of Test	Standard Test Method
Water absorption	BS EN 1097-3: Part 3: 1998
Determination of voids of dry compacted filler	BS EN 1097-4: Part 4: 1999
Determination of resistance to wear by abrasion from studded tyres – Nordic test	BS EN 1097-9: Part 9: 1999
Sieve tests on aggregates	BS 812: Part 103.1: 1985
Flakiness Index (FI)	BS EN 933-3: 1997
Elongation Index	BS 812: Section 105.2:1990
Average Least Dimension (ALD)	US 144:2000 or BS EN 933-3: 1997
Particle Shape Index	US 144:2000 or BS EN 933-4: Part 4
Aggregate Crushing Value (ACV)	BS 812: Part 110: 1990
Ten Percent Fines Value (TFV)	BS 812: Part 111: 1990
Aggregate Impact Value (AIV) - Standard	BS 812: Part 112: 1990
Aggregate Impact Value (AIV) - Modified	BS 812: Part 112: 1990
Los Angeles Abrasion Test (LAA)	ASTM C535-89 and BS 812: Part 113
Polished Stone Value	BS 812: Part 114
Determination of percentage of crushed & broken surfaces in coarse aggregate particles	BS EN 933-5: Part 5: 1998
Determination of shell content - percentage shells in coarse aggregate	BS EN 933-7: Part 7
Assessment of fines – Grading of fillers (Airjet filing)	BS EN 933-10: 2001
Determination of grading requirements	BS 882
Determination of resistance to wear (mico-Deval)	BS EN 1097-1: Part 1: 1998
Determination of resistance to fragmentation	BS EN 1097-2: Part 2: 1998
Sodium Soundness Test (SSS)	ASTM C88-90
Sulphate Content	BS 812: Part 118
Magnesium Sulphate test	BS EN 1367-2: Part 2
“Sonnenbrand” boiling test	BS EN 1367-3: Part 3
Determination of Drying and Shrinkage	BS EN 1367-4: Part 4
Aggregate Soundness	BS 812: Part 121
Alkali-Silica Reactivity	BS 812: Part 123: 1999
Tests for filler aggregates used in bituminous mixes – Delta ring and ball	BS EN 13179-1: Part 1: 2000
Tests for filler aggregates used in bituminous mixes – Bitumen number	BS EN 13179-1: Part 2: 2000

(ii) Tests on Concrete

Name of Test	Standard Test Method
TESTING CEMENT	
Determination of strength	US 100-1/ EAS 148-1: Part 1
Chemical analysis of cement	US 100-2 / EAS 148-2: Part 2
Determination of standard consistency, setting time and soundness	US 100-3 / EAS 148-3: Part 3
Determination of chloride, carbon dioxide and alkali content	US 100-4 / EAS 148-8: Part 4
Pozzolanicity test for pozzolanic cements soundness	US 100-5:2001 / EAS 148-5: Part 5
Determination of fineness	US 100-6:2001 / EAS 148-6: Part 6
Methods of taking and preparing samples of cement	US 100-7:2001 / EAS 148-7
TESTING FRESH CONCRETE	
Sampling	BS EN 12350-1: Part 1: 2000
Slump Test	BS 1881: Part 102: 1983
Vebe test	BS EN 12350-3: Part 3
Making of Concrete Test Cubes	BS 1881: Part 108: 1983
Concrete Cube Strength	BS 1881: Part 116: 1983
Degree of Compactibility	BS EN 12350-4: Part 4: 2000
Flow Table test	BS EN 12350-5: Part 5
Determination of density	BS EN 12350-6: Part 6: 2000
Air Content	BS 1881: Part 106: 1983
Measuring fibre content in fresh glass fibre reinforced concrete	BS EN 1170-2: Part 2
TESTING HARDENED CONCRETE	
Shape, dimensions and other requirements for specimens and moulds	BS EN 12390-1: Part 1: 2000
Making and curing specimens for strength tests	BS EN 12390-2: Part 2: 2000
Compressive strength of test specimens	BS EN 12390-3: Part 3: 2002 BS 1881: Part 116: 1983
Flexural strength of test specimens	BS EN 12390-5: Part 5: 2000
Tensile splitting strength of test specimens	BS EN 12390-6: Part 6: 2000
Density of hardened concrete	BS EN 12390-7: Part 7: 2000
Depth of penetration of water under pressure	BS EN 12390-8: Part 8: 2000
Cored specimens – taking, examining and testing in compression	BS EN 12504-1: Part 2: 2000
Method of normal curing of test specimens	BS 1881: Part 111: 1983
Method for testing cement in a reference concrete	BS 1881: Part 131: 1983

(iv) Tests on Asphalt and Bituminous Materials

Name of Test	**Standard Test Method**
Sampling Bituminous mixes	BS 598: Part 100
Preconditioning of bitumen samples prior to mixing or testing	NPRA 014 Test 14.511
Density of Bituminous Binders	ASTM D70-97
Flash and Fire Point by Cleveland Open Cup	ASTM D92-90
Thin-Film Oven Test (TFOT)	ASTM D1754-87
Rotating Thin-Film Oven Test (RTFOT)	AASHTO T 240
Penetration of Bituminous Materials	ASTM D5-86 or BS 2000: Part 49
Softening Point Test	ASTM D36-70 or BS 2000: Part 58
Ductility	ASTM D113-86
Viscosity Determination using the Brookfield Thermosel Apparatus	ASTM D4402-91 or BS 2000: Part 72
Kinematic Viscosity of Asphalts	AASHTO T 201 or ASTM D 2170
Viscosity of Asphalts by Vacuum capillary Viscometer	AASHTO T 202 or ASTM D 2171
Density and Water Absorption of Aggregates Retrieved on a 4.75 mm Sieve	ASTM C127-88
Density and Water Absorption of Aggregates Passing the 4.75 mm Sieve	ASTM C128-88
Calibration of Glass Pycnometers (0.5-1 litre)	NPRA 014 Test 14.5922
Mixing of Test Specimens; Hot Bituminous Mixes	NPRA 014 Test 14.5532
Determination of Maximum Theoretical Density of Asphalt Mixes	ASTM D2041-95 and D4469-85
and Absorption of Binder into Aggregates	
Bulk Density of Saturated Surface Dry Asphalt Mix Samples	ASTM D2726-96
Bulk Density of Paraffin-Coated Asphalt Mix Samples	ASTM D1188-89
Bulk Density of Asphalt Mix Samples, Calliper Measurements	NPRA 014 test 14.5622
Calculation of Void Content in Bituminous Mixes	ASTM D3203 and AASHTO pp19-93
Marshall Test	ASTM D1559-89
Marshall Mix Design	ASTM D1559-89
Refusal Density Mix Design	TRL Overseas Road Note 31, Appendix D: 1990
Methods of test of the design of wearing course asphalt	BS 598: Part 107
Methods for the determination of the condition of binder on coated chippings and for the measurement of the rate of spread of coated chippings	BS 598: Part 108
Methods for the measurement of temperature of bituminous mixtures	BS 598: Part 109
Temperature Measurement	BS EN 12697 – 13: Part 13: 2000
Methods of test for the determination of density and compaction	BS 598: Part 104
Indirect Tensile Strength Test	ASTM D3967 and NPRA 014 Test 14.554
Determination of Binder Content and Aggregate Grading by Extraction	ASTM D2172-88, Method B BS EN 12697 – 1: Part 1: 2000
Bitumen Recovery : rotary evaporator soluble binder content	BS EN 12697 – 3: Part 3: 2000
Bitumen Recovery : fractionating column	BS EN 12697 – 4: 2000
Water Content	BS EN 12697 – 27: Part 14: 2000
Sampling	BS EN 12697 – 27: Part 27: 2001
Distillation of cut back asphalt (bituminous) products	BS 2000: Part 27
Frass breaking point of bitumen	BS 2000: Part 80
Methods of testing plastics	BS 2782: Part 3
Resin compositions-method for preparation of test specimens	BS 6319: Part 1
Raw and vulcanised rubber-chemical tests	BS 7164: Various dates
Plastics/rubber – Polymer dispersions and rubber lattices- Determination of residual monomers and other organic components by capillary chromatography	BS ISO 13741: 1998
Plastics and Liquid epoxy resins- Determination of tendency to crystallise	BS ISO 4895: 1997
Effect of Water on Bituminous Coated Aggregates, Boiling Test	ASTM D3625-96

(b) Uganda National Bureau of Standards (UNBS)

US 100	Cement - methods of testing
US 101: 2000	Aggregates from natural sources for concrete
US 104: 1993	Pozzolanas for use with lime
US 144: 2000	Aggregates-particle size and particle shape determination
US 145: 2000	Aggregates-methods of sampling
US 146: 2000	Aggregates-determination of physical properties
US 288: 2001	Lime for soil stabilisation
US 290: 2001	Glossary terms used in lime products
US 310: 2001	Compositions, specifications, conformity criteria and evaluation for common cements
US 320: 2001	Cement-Definition of terminologies
US 401: 1993	Reflective sheeting materials for traffic control signs

(c) American Association of State Highway and Transport Officials (AASHTO)

M – 85	Ordinary Portland cement
M – 140	Bituminous prime coat
M – 153	Joint filler
M – 154	Air entraining agents.
M – 173	Thermoplastic hot poured sealant
M – 194	Concrete Admixtures
M – 213	Joint filler
M – 216	Road lime
M – 240	Portland blast furnace cement
T – 87	Atterberg limits test method
T – 89	Atterberg limits test method
T – 90	Atterberg limits test method
T – 132	Sealant tests
T – 180	Maximum dry density test method

(d) American Society for Testing and Materials (ASTM)

A – 252-68	Pile castings
C – 156	Curing agents
C – 260	Air entraining agents
C – 309	Curing agents
C – 494	Concrete admixtures
C – 719	Sealant tests
C – 920	Thermosetting chemically cured sealant
C – 227-90	Test method for alkali reactivity of aggregates
D – 36	Bitumen tests (Softening point)
D – 244	Bitumen tests (binder content test)
D – 1557	Maximum dry density tests
D – 4402	Bitumen tests (dynamic viscosity)

(e) British Standards Institute (BS)

BS – 4	Structural steel hot rolled sections
BS – 63	Road aggregates
BS – 76	Tars
BS – 162	Working under power lines
BS – 146	Portland blast furnace cement with strength properties outside the scope of BS EN 197
BS – 410	Test sieves for particle analysis
Bs – 434	Bitumen road emulsions
BS – 594	Hot rolled asphalt
BS – 470	Aluminium plate
BS – 709	Welding
BS – 812	Fillers for asphalt
BS – 873	Traffic signs, road studs and bollards
BS – 881	VEBE test BS - 915 High alumina cement
BS – 970	Stainless steel
BS – 1134	Stainless steel plate
BS – 1154	Natural rubber
BS – 1474	Aluminium sections
BS – 1707	Hot binder distributors for road surface dressing
BS – 1721	Fire extinguishers
BS – 1780	Pressure gauges
BS – 2499	Hot applied joint sealants
BS – 2752	Synthetic rubber
BS – 2994	Cold rolled steel sections
BS – 3262	Hot applied thermoplastic road marking materials
BS – 3662	Plastic road marking paint
BS – 3690	Specification of bitumens for road purposes
BS – 3837	Joint filler (rigid foams)
BS – 3892	Pulverised fuel ash
BS – 3921	Clay bricks
BS – 4246	Low heat Portland blast-furnace cement
BS – 4254	Joint sealant
BS – 4360	Structural steel
BS – 4447	Anchorages and couplers
BS – 4486	High tensile alloy steel bars
BS – 4840	Joint filler (rigid foams)
BS – 4987	Coated macadams for roads and other paved areas
BS – 5047	Polymised types of butadiene rubber (BR)
BS – 5075	Concrete admixtures
BS – 5268	Timber
BS – 5135	Welding
BS – 5212	Cold applied joint sealants
BS – 5328	Specifying concrete
Bs – 5273	Dense tar surfacing
BS – 5400	Bridge bearings
BS – 5750	Quality systems
BS – 5896	Steel wire
BS – 5911	Precast concrete pipes
BS – 5930	Site investigation
BS – 6031	Earthworks
BS – 6044	Rubber lattices
BS – 6088	Glass beads
BS – 6089	Concrete strength in existing structures
BS – 6543	Recycling
BS – 6572	Specification for High Density Polyethylene (HDPE) pipes
BS – 6588	Portland pulverised fuel ash cements
BS – 6610	Pozzolanic pulverised fuel ash cement
BS – 6677	Clay and calcium silicate paver for flexible pavements
BS – 6699	Ground granulated blast-furnace slag for use with Portland cement
BS – 6717	Precast concrete paving blocks
BS – 7263	Precast concrete kerbs, edgings, channels and quadrants
Bs – 7373	Preparation of specifications
BS – 7533	Pavement design-clay or concrete pavers
BS – 7583	Portland and Limestone cement
BS – 7755	Soil quality
BS – 7850	Total Quality Management
BS – 7903	Selection and use of gully trops and manholes
BS – 8000	Code of practice for concrete work
BS – 8004	Code of practice for foundations
BS – 8006	Strengthened / reinforced soils and other fills
BS – 8110	Structural use of concrete

(f) Standard Coordination Specification (CKS)

CKS – 82	Steel sections
CKS – 176	Corrugated metal culverts
CKS – 191	Retro-reflective materials
CKS – 192	Retro-reflective road marking paint
CKS – 388	Natural rubber water stops
CKS – 389	PVC rubber water stops
CKS – 437	Corrugated metal culverts
CKS – 564	Bonding liquid for concrete surfaces
CKS – 592	Barbed tape concertina wire

(g) Deutshe Ingineur Norme (DIN)

DIN – 52013	Bitumen tests (ductility and elastic recovery)

(h) South African Bureau of Standards (SABS)

SABS – 044	Welding procedures
SABS – 064	Abrasive blasting
SABS – 094	Holes for friction grip fasteners
SABS – 0100	Concrete cores
SABS – 0142	Electrical installations
SABS – 0162	Design of work/codes of practice
SABS – 05	Timber treatment
SABS – 82	Steel reinforcing bars
SABS – 92	Roofing felt (bridge bearings)
SABS – 113	pH test (Water)
SABS – 134	Paint
SABS – 135	Bolts and nuts
SABS – 136	Bolts and nuts
SABS – 141	Paint thickness test
SABS – 202	Chloride content (Water)
SABS – 212	Sulphate content (Water)
SABS – 213	Total dissolved solids (Water)
SABS – 227	Bricks
SABS – 307	Penetration grade bitumen
SABS – 308	Prime
SABS – 309	Bitumen emulsion
SABS – 435	Rivets
SABS – 455	Welding electrodes
SABS – 457	Timber Posts
SABS – 471	Ordinary Portland Cement
SABS – 533	Pipes
SABS – 538	Timber treatment
SABS – 539	Timber treatment
SABS – 548	Bitumen emulsion
SABS – 558	Manhole covers
SABS – 626	Portland blast-furnace cement
SABS – 630	Finishing coats (paint)
SABS – 634	Finishing coats (paint)
SABS – 657	Steel tubes
SABS – 673	Timber treatment
SABS – 675	Wire
SABS – 677	Pipes
SABS – 679	Primer (paint)
SABS – 681	Undercoat (paint)
SABS – 684	Finishing coats (paint)
SABS – 723	Primer (paint)
SABS – 731	Road marking paint
SABS – 741	Sulphate content (cementitious binders)
SABS – 748	Prime
SABS – 1519	Paint
SABS – 1555	Delineation signs
SABS – 1580	Wire mesh
SABS – 749	Prime
SABS – 754	Timber posts
SABS – 763	Galvanishing
SABS – 772	Abrasive blasting
SABS – 783	Finishing coats (paint)
SABS – 791	Pipes
SABS – 801	Epoxy tar paint
SABS – 802	Finishing coats (paint)
SABS – 821	Road Lime
SABS – 831	Rapid hardening cement (OPC15)
SABS – 836	Aggregate test
SABS – 837	Sugar Content (Water)
SABS – 838	Sand equivalent test
SABS – 841	Alkali carbonates and bicarbonates (water)
SABS – 844	Relative density tests
SABS – 845	Compacted bulk density
SABS – 848	Polished stone value tests
SABS – 850	Sulphate content (aggregates)
SABS – 855	Free water content (aggregates)
SABS – 856	Bulking of fine aggregates
SABS – 862	Slump (concrete)
SABS – 864	Flexure strength test (concrete)
SABS – 865	Compression strength (Concrete cores)
SABS – 878	Ready mix concrete
SABS – 912	Primer (paint)
SABS – 920	Steel reinforcing bars
SABS – 921	Pipes
SABS – 926	Zinc rich epoxy
SABS – 927	Kerbing
SABS – 934	Galvanising
SABS – 967	Rubber joints for pipes
SABS – 986	Culverts
SABS – 1024	Welded steel fabric
SABS – 1058	Paving blocks
SABS – 1077	Joint sealant
SABS – 1083	Aggregate
SABS – 1085	Sand
SABS – 1091	Paint
SABS – 1143	Steel bolts and nuts
SABS – 1149	Washers
SABS – 1223	Pipes
SABS – 1260	Prime
SABS – 1282	Friction grip nuts and bolts
SABS – 1350	Guardrails
SABS – 1373	Diamond mesh
SABS – 1391	Galvanising
SABS – 1413	Finishing coats (paint)
SABS – 1431	Structure steel
SABS – 1442	Road Studs
SABS – 1500	Electrical installations

(i) Technical Methods for Highways (TMH), South Africa

TMH – 1	Standard methods of testing road construction material
TMH – 5	Sampling methods for road construction materials
TMH – 6	Special methods for testing roads

(j) International Standards Organisation

ISO / R – 161	Specification for High Density Polyethylene (HDPE) pipes
BS ISO 8349	Road vehicles-measurement of road friction by direct liquid injection method

(k) European Standards

BS EN 124	Concrete-Specification, performance, production and conformity
BS EN 125	Gully and manhole tops-loading, design and dimensions
BS EN 197	Cement-Composition, specifications, conformity criteria and conformity evaluation
BS EN 206	Concrete-guidance to specifier/specification for the constituent materials and concrete
BS EN 410-2	Test sieves
BS EN 512	Fibre-cement products, pressure pipes and joints
BS EN 1423	Road marking materials-glass beads, antiskid aggregates and mixtures of the two
BS EN 1424	Road marking performance for road users and premix glass beads
BS EN 1456-1	UPVC pipes
BS EN 1463	Road marking materials - Retro reflective road studs
BS EN 1824	Road trials
BS EN 1871	Physical properties for paint, thermoplastic and cold plastic
EN – 10113	Structural steel
EN – 10155	Structural steel
BS EN 1916	Precast concrete pipes
BS EN 12271	Surface dressing
BS EN 12591	Specification for pavement grade bitumens
BS EN 12597	Bitumen and bituminous binders-terminology
BS EN 12889	Trench less construction and testing of drains and sewers
BS EN 13055-1	Lightweight aggregates for concrete

BS EN 13249	Geotextiles-characteristics required fro use in construction of roads and other trafficked areas
BS EN 13251	Geotextiles-characteristics required for use in earthworks, foundations and retaining structures
BS EN 13252	Geotextiles-characteristics required for use in drainage systems
BS EN ISO 10320	Geotextiles-Identification on site

7503 ADDRESSES

The Ugandan, AASHTO, ASTM, BS, BS EN, ISO, CKS, DIN, SABS, SIS and US Federal specification and test method documents referred to in this document can be obtained from the following sources:

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