29.21 Field Trial

Field trials shall be undertaken to assess the adequacy of the trench drain design and stability of the cladding layer for the dredged sand fill embankments during periods of flooding and rapid drawdown. These trials shall be completed prior to the construction of trench drains in the highway embankments.

The field trial shall comprise a test section of completed embankment not less than 30 m in length. Water retaining enclosure bunds shall be constructed to the same height as the test embankment 15 m from the toe of the embankment as shown on the Drawings. The layout shall be to the approval of the Engineer.

The Contractor shall ensure the stability and water retaining ability of the enclosure bunt for the duration of the trials.

Standpipe piezometers shall be installed at locations and depths as shown on the Drawings to the approval of the Engineer.

The Contractor shall provide water pumps of sufficient capacity to maintain water levels and to control rate of rise and fall within the bunds. Maximum rate of rise and fall of water levels shall be of the order of 400mm/day. A maximum water level of 1.5 in below the crest level of the embankment will be required.

Water level gauge posts graduated in meter and centimeter divisions shall be located on both sides of the embankment at positions approved by the Engineer.

The sequence of filling, maintaining levels and drawdown of water within the enclosed area shall be carried out as directed by the Engineer.

29.22 Embankment Protection

Embankments formed of dredged sand shall be protected from scour and erosion by a layer of cladding material as specified in Article 29.12 of approximately 540mm finished thickness giving a horizontal layer width of 1.2m. This material shall be spread in layers not exceeding 200mm loose thickness and compacted by means of suitable size equipment to a density of **95 per cent of the maximum dry density** as determined by AASHTO T99 (Standard Compaction). Care shall be taken to ensure that the drainage paths of trench drains do not become blocked.

29.23 Capping Layer Material

Embankments formed of local borrow material shall be finished with a layer of improved subgrade material complying with Article 35.2 of the thickness and dimensions shown on the Drawings. Note that the thickness may be adjusted by the Engineer depending on the actual CBR strength of the local borrow material used.

29.24 Earthworks to be Kept Free of Water

The Contractor shall arrange for the rapid dispersal of water shed on to the earthworks or completed formation during construction, or which enters the earthworks from any source. Adequate means for trapping silt and sand shall be provided on temporary systems. The arrangements shall be made in respect of all earthworks including excavations whether for pipe trenches, foundations or cuttings.

The Contractor shall provide where necessary temporary water courses, ditches, drains, pumping or other means of maintaining the earthworks free from water.

Such provision shall include carrying out the work of forming the embankments in such a manner that their surfaces have at all times a sufficient minimum crossfall and., where practicable a sufficient longitudinal gradient to enable them to shed water without forming erosion channels and prevent ponding.

29.25 Grassing

The Contractor shall without delay, following completion of the earthwork to be grassed, carry out grassing measures in accordance with this Article at the following locations as and where directed by the Engineer:

- on the batters of all embankments;
- on shoulders of minor intersecting roads and within large traffic islands unless otherwise shown on the Drawings; and
- elsewhere as directed by the Engineer which may include erodible batters of excavation and disposal areas.

On the completion of the Contract, areas which the Engineer may have specified or directed to be grassed shall have a thick uniform mat of grass which is well established without bare patches and free from areas of erosion.

All grassing shall be carried out to the satisfaction of the Engineer and where the Engineer considers that the grassed areas do not comply sufficiently with the requirements of this Article he will direct that additional grassing measures be taken to bring the area up to an acceptable standard.

The grassing measures shall be carried out by topsoil placement which consists of distributing topsoil where specified and directed by sprigging with individual rooted approved grasses or by sowing approved seeds and fertilizing areas where topsoil has been placed. The areas covered with topsoil shall be scarified at the time of initial sowing followed by initial watering.

Alternative methods of achieving the provision and protection of grassed areas will be

acceptable if preferred by the Contractor including:

- by straw mulching which consists of the application of a surface protection of 450 bales of straw per hectare held in place by black wire netting or sprayed down with cold asphalt of an approved brand at the rate of 0.25 liters per square meter of 1:1 aqueous asphalt emulsion;
- by mechanical and biological means of soil stabilization which consists of the application of jute or plastic mesh;
- by placing of grass sods as described in Article 29.26.
- by any other methods approved by the Engineer.

On completion of grassing specified above the Contractor shall maintain, fertilize and water the grassed areas. Any areas subsequently killed or damaged before completion of the Contract shall be restored re-grassed and watered by the Contractor.

29.26 Turfing with Sods

29.26.1 Description

This work shall consist of furnishing and laying of the live sod of perennial turf forming grass on hard shoulders, turfed shoulders, embankment slopes, verge or other locations shown on the Drawing or as directed by the Engineer. Unless otherwise instructed by the Engineer, the work shall be taken up as soon as possible following construction of the embankment, hard shoulder and turfed shoulder etc.

29.26.2 Materials

The sod shall consist of dense, well-rooted growth of permanent and desirable grasses, indigenous to the locality where it is to be used, and shall be practically free from weeds or other undesirable matter. At the time the sod is cut, the grass on the sod shall have a length of approximately 50mm and the sod shall have been freed of debris.

Thickness of the sod shall be as uniform as possible, with some 40-80mm or so of soil covering the grass roots depending on the nature of the sod, so that practically all the dense root system of the grasses is retained in the sod strip. The sods shall be cut in rectangular strips of uniform width, not less than about 250 mm x 300 mm in size but not so large that it is inconvenient to handle and transport these without damage. During wet weather, the sod shall be allowed to dry sufficiently to prevent rearing during handling and during dry weather shall be watered before lifting to ensure its vitality and prevent the dropping of the soil in handling.

29.26.3 Preparation of the Earthbed

The area to be sodded shall have been previously constructed to the required slope and cross

section. Soil on the area shall be loosened, freed of all stones larger than 50 mm size, sticks, stumps and any undesirable foreign matter, and brought to a reasonably fine granular texture to a depth of not less than 25mm for receiving the sod.

Where required top soil shall be spread over the slops. Prior to placing the top soil the slope shall be scarified to the depths shown on the Drawings or as directed by the Engineer. The top soil shall be spread to a depth which after settlement will provide the required nominal depth shown on the Drawings. Spreading shall not be done when the ground is excessively wet.

29.26.4 Placing the Sods

The prepared sod bed shall be moistened to the loosened depth, if not already sufficiently moist, and the sod shall be placed thereon within approximately 24 hours after the same has been cut. Each sod strip shall be laid edge to edge and such that the joints caused by abutting ends are staggered. Every strip, after it is snugly placed against the strips already in position, shall be lightly tamped with suitable wooden or metal tampers so as to eliminate air pockets and to press it into the underlying soil.

On side slopes steeper than 2 to 1, the laying of sods shall be started from bottom to upwards.

At points where water may flow over a sodded area, the upper edges of the sod strips shall be turned into the soil below the adjacent area and a layer of earth placed over this followed by its thorough compaction.

29.26.5 Staking the Sods

Where the side slope is 2 to 1 or steeper and the distance along the slope is more than 2 meters, the sods shall be staked with pegs or nails spaced approximately 500 to 1000mm along the longitudinal axis of the sod strips. Stakes shall be driven approximately plumb through the sods to be almost flush with them.

29.26.6 Top Dressing

After the sods have been laid in position, the surface shall be cleaned of loose sod, excess soil and other foreign material. Thereafter a thin layer of top soil shall be scattered over the surface of top dressing and the area thoroughly moistened by sprinkling with water.

29.26.7 Water and Maintenance

The sods shall be watered by the Contractor for a period of at least four weeks after laying. Watering shall be so done as to avoid erosion and prevent damage to sodded areas by wheels of water tanks.

The Contractor shall erect necessary warning signs and barriers, repair or replace sodded areas failing to show uniform growth of grass or damaged by his operations and shall otherwise maintain the sod at his cost until final acceptance. If necessary the Contractor may apply fertilizer to achieve the required standard.

29.27 Subgrade Preparation

In areas where pavements are to be constructed on embankments formed by others, sub-grade preparation shall be carried out prior to the start of any pavement works.

Such preparation will include removal of any protective surface layer, testing to determine the in-situ densities in the as built embankment, excavation and replacement of the upper layers including compaction as necessary to ensure compliance with the requirements of this Specification.

29.28 Preparation and Surface Treatment of Formation

Preparation and surface treatment of the formation shall be carried out only after completion of any specified subgrade preparation and unless otherwise agreed by the Engineer immediately prior to laying the lowest layer of the pavement.

The formation shall, after reinstatement of any soft areas, be well cleaned and free from mud and all extraneous material, including wind blown material.

Should the subgrade become cracked and hardened before laying the sub-base it shall be scarified, moistened and thoroughly compacted.

In no case shall any sub-base be placed on loose or wet subgrade. Final subgrade preparation shall not be commenced without the prior approval of the Engineer.

29.29 Testing

Testing shall be carried out to demonstrate the compliance of the completed works with the requirements of this Specification. The frequency of testing shall be as required by the Engineer and shall be not less than indicated in **Table 29.2**.

Table 29.2 Testing of Earthworks

	Description	Test	Frequency
(a)	**Borrow Pits and other Borrow Areas**		
(i)	Classification Tests :		
	Liquid Limit	AASHTO T 89	
	Plastic Limit	AASHTO T 90	1 set/500 m^3
	Plastic Index	AASHTO T 90	
	Particle Size Distribution	AASHTO T 88	
(ii)	Compaction Characteristics :		
	Local borrow :		
	Dry Density Moisture Content	AASHTO T 99	3 sets/1000m^3
	Dredged Sand Fill :		
	Dry Density Moisture Content	AASHTO T 99	3 sets/500 m^3
(b)	**General Fill Areas**		
	Site Compaction Trials:	Test as ordered by the Engineer.	
	In Situ Dry Density	AASHTO T 191	1 per 500 m^3
(c)	**Upper Layers of Fill**		
	Laboratory CBR (soaked 4 days)	AASHTO T 193	1 per 1000 m^3
	In Situ Dry Density	AASHTO T 191	1 per 200 m^3
(d)	**Cladding Layers**		
(i)	Classification Tests :		
	Liquid Limit	AASHTO T 89	
	Plastic Limit	AASHTO T 90	1 set/500 m^3
	Plastic Index	AASHTO T 90	
	Sieve Analysis	AASHTO T 88	
(ii)	Compaction Characteristics :		
	Max. Dry Density/ Moisture Content	AASHTO T 99	1 per 500 m^3
(iii)	In Situ Dry Density	AASHTO T 89 AASHTO T 191	1 per 200 m^3
(iv)	Stability Test	As ordered by the Engineer	
(e)	**Trench Drains to Dredged Sand Embankment**		
(i)	Filter Fabrics	Off site testing as ordered by the Engineer	
(iii)	Drainage Material		
	Particle Size Distribution	AASHTO T 27	1 per 500 m^3

SECTION 30
DRAINAGE AND SERVICE DUCTS

30.1 Types of Pipe

30.1.1 General

a) Where the term drain is used in this section it shall be deemed to include the terms sewers and piped culverts.

b) Unless otherwise described in the Contract, three types of pipe shall be used within any individual drain length between manholes, catch pits or culvert head walls,

c) The Contractor may provide different pipes and bed to that which are described in the Contract, subject to the Engineer being satisfied that the hydraulic design and strength of the proposed pipes, together with its support and back fill, are equally effective as those described in the Contract and that the pipes will not be injuriously affected by either the adjacent ground or the effluent to be carried.

30.1.2 Reinforced Concrete Pipes for Drainage

a) Reinforced concrete pipes for drainage shall conform to the provisions of AASHTO M170-74 "Reinforced concrete culvert, storm drain and sewer pipe". They shall conform to the design requirements for Class IV reinforced concrete pipes.

b) Acceptance shall be on the basis of plant load-bearing tests, material tests and inspection of manufactured pipe for visual defects and imperfections.

The strength test requirements under the three edge bearing test (AASHTO T33-72) for Class IV pipes shall be:

D-load to produce a 0.25 mm crack – 95.8N/m per mm dia of pipe.
D-load to produce ultimate load – 144.0 N/m per mm dia of pipe.

c) The pipes shall be provided with flexible joints of the spigot and socket type conforming to the provisions of AASHTO M198-74 "Joints for circular concrete and sewer pipe using rubber gaskets".

d) Modified pipe designs on the basis of AASHTO M242-73 "Reinforced concrete D-load culvert, storm drain, and sewer pipe" will be accepted provided the D-load criteria in Sub-Clause (b) above are met.

e) Acceptance of pipe by load testing :

1) Acceptance of design shall be on the basis of para 9.1 AASHTO M242-73.
2) Acceptance by lot shall be on the basis of para 10 AASHTO M242-73.

30.1.3 Pipes for Service Ducts

a) Pipes for service ducts shall have a smooth internal bore without any sharp edge to the ends of pipes. They shall be 100mm internal dia unless otherwise specified in the Contract and comply with Table 1.

Table 1 Pipes for Ducts

Material	Standard	Additional Specification
Vitrified clay	BS 65	Plain ended, self-aligning flexible sleeve jointed with internal ends reduced to 3mm minimum
Unplasticised Polyvinylchlorine (UPVC)	BS 3505 (Class B) or BS 4660 or BS 5481	When pipes to BS 3505 (Class B) are used, joints shall comply with BS 4346.

b) Each duct shall be fitted with pigmented, stranded polypropylene or other approved draw rope of 5.3 kN breaking load, the ends of which shall be made fast and clearly marked. The ends of a duct shall be sealed by stoppers immediately it has been laid.

30.2 Excavation for Pipe Lines and Drainage Structures

a) The sides of pits and trenches shall be adequately supported at all times. Except where described in the Contract, they shall not be battered within 0.3 m of the top of the pipe. The width of the vertical section of the trench should not be more than the outside dia of the pipe plus 0.6 m.

b) Material excavated from trenches shall be set aside for back fill, unless considered unsuitable by the Engineer.

c) Soft spots rock or boulders in the bottom of drainage excavations shall be removed and the resulting void immediately back filled with granular sub-base material Article 35.3 of this specifications or pipe bedding material Article 30.3.

d) The Contractor shall make good at his own expense with one of the materials described in Sub-Clause (c) as directed by the Engineer:

i) any additional excavation at or below the bottom of drainage trenches if the Contractor allows the trench bottom to become soft or otherwise unsuitable for construction of the pipeline;

ii) any excavation greater than the net volume required for the drainage works below the upper level of any pipe surround as described in the Contract.

30.3 Bedding Laying and Surrounding of Pipes

a) Immediately following the excavation of the trench the pipes shall be laid and jointed on the pipe bed. Pipes shall be laid so that each one is in contact with the bed throughout the length of its barrel. In the case of socketed or sleeve jointed pipes the bed shall be cut away and removed at each socket or sleeve to give clearance of at least 50mm so the socket or sleeve does not bear upon the bed.

b) Pipe bedding and haunching or surrounding material shall comply with the following:

i) For pipes on beds described in the Contract as Types B F S & K the granular bedding material:

- Shall consist of crushed rock, overburnt brick or sand with a magnesium soundness (ASTM C88-76 (5 cycles)) not greater than 18%:

- Shall have a Ten Percent Fines Value not less than 50.

- Shall have a soluble sulphate content of less than 1.9 gm of sulphate (as SO_3) per liter when treated in accordance with test 10 of BS 1377, except that the water to soil ratio shall be 2:1;

- Shall comply with one of the following requirements of Table 30.2.

ii) For pipes on beds described as Types A and L the concrete cradle or surround shall be of concrete class 20/20 complying with the requirements of Section 8. Back filling shall not be carried out before the concrete has cured.

c) Selected back fill shall be suitable material to Article 29.2 which is easily compacted and free from lumps of cohesive soil larger than 75mm and stones larger than 37.5mm.. The soluble sulphate content shall not exceed 1.9gm of sulphate (as SO_3) per liter when tested in accordance with Test 10 of BS 1377 except that the water soil ratio shall be 2:1.

d) The bedding, haunching and surrounding of the pipes shall be carried out immediately after jointing. The haunching and surround shall be brought up equally on both sides of the pipe ensuring that it is in contact with the underside of the pipe barrel and be carefully compacted in layers not exceeding 150mm thickness ensuring full compaction next to the trench walls. Pipes shall be maintained to line and level during bedding, surrounding and haunching operations. The surround for rigid pipes may be bedding material or selected back fill unless otherwise described in the Contract and shall be taken to a height of 300 mm above the top of the pipe barrel. The surround for flexible pipes shall be pipe bedding material and shall extend 150mm above the top of the pipe barrel.

Table 30.2: Granular Materials for Pipe Bedding

Nominal (Pipe dia)	Grading to BS 822		Other Granular Materials	
mm Size	Single size mm	Graded mm	Maximum Factor Art. 30.4	
Not exceeding 140	10	-	0.15 max.	10mm
Exceeding 140 not exceeding 400	10,14 or 20	20-5 14-5	0.15max.	20mm
Exceeding 400	12,14,20 or 40	14 to 5 20 to 5 40 to 5	0.15max.	40mm

30.4 Test for Compaction Factor Value of Bedding Material

a) The following apparatus shall be used:

i) Open ended cylinder 250mm long and 145 to 160mm internal diameter;

ii) Metal rammer with striking face 40mm diameter and a total mass. 1 kg.

b) On each occasion that bedding material is being used, a representative sample of the material shall be prepared with a moisture content equal to that of the material that is to be used. The cylinder shall be placed on a firm flat surface and filled with the material by pouring from a minimum height. No additional compaction shall be given to the material in the cylinder. The material shall be struck off level with the top of cylinder and the surplus material removed. The cylinder shall then be lifted clear of its contents and placed on a fresh area of the flat surface.

c) The material shall be quartered and each quarter successively replaced in the cylinder and vigorously tamped with the rammer until no further compaction is observed.

d) The distance of the level of the material below the top of the cylinder shall be measured and divided by the cylinder height to obtain the compaction factor value.

30.5 Jointing of Pipes

a) Joints in surface water drains and pipe culverts shall be water tight. Ducts need not have water tight joints.

b) Water tight joints for surface water drains and culverts shall be flexible joints of the spigot and socket type with a deformable ring held between pipe spigots and sockets and shall be jointed in accordance with the manufacturers recommendations.

c) Where a concrete bed, cradle or surround is used with rigid pipes having flexible joints a compressible board or a preformed joint filler as approved by the Engineer shall be placed in contact with the end of a socket at a flexible pipe joint and shall extend through the full thickness of any concrete in contact with the pipe. Such joints in the concrete bed, cradle or surround shall be at intervals not exceeding 5 meters, except where the joints in the pipe exceed 5m when they shall be at each pipe joint.

d) Joints for pipes in service ducts shall comply with the appropriate British Standard and with the following:

   i) Pipes for ducts shall be jointed so that no silt, grit, grout or concrete surround is able to enter the duct. Pipes with push fit joints shall have a register to ensure that the pipe is fully pushed into the joint.

   ii) Joints in pipes to ES 3505 shall comply with ES 4346 Part 2.

30.6 Backfilling of Trenches

a) Backfilling shall be undertaken immediately after the required operations preceding have been completed following inspection by the Engineer. The excavated material where judged suitable by the Engineer shall be deposited in layers not exceeding 150mm deep and compacted as specified in clause Article 29.15. Care should be taken to compact the material evenly without dislodging or damaging pipes. Power rammers shall not to be used within 300mm of any part of the pipe or joint.

b) Where the Contractor allows stock piled material, which on excavation was accepted by the Engineer as acceptable for back fill to trench excavation, to become unsuitable when required, he shall, at his own expense, run the material to waste and replace with acceptable material.

c) Except in carriageways or other paved areas, or as described in the Contract, back fill for trenches shall be brought up to ground level. Where top soil is at the surface on the line of the trench the back fill shall include a layer of top soil of the same thickness and quality as the surrounding ground. For trenches in carriageway or other paved areas the back fill shall be brought up to formation level, or subformation level where capping is required, or such lower level as described in the Contract.

d) Where trenches have been excavated through pavement materials the back-fill above subgrade level shall consist of the same types of pavement material, compacted to the same densities, as those required for the pavement layers.

30.7 Pipes in Embankments

Where pipes in embankments or in other areas of fill are permitted in the Contract to be constructed other than in trench the fill shall be brought up to and over them equally on both sides. The fill shall be deposited in even layers and shall not be heaped above the pipe.

Spreading on compaction shall be carried out evenly without dislodging, distorting or damaging the pipe. Power rammers shall not to be used within 300mm of a pipe or joint.

30.8 Cable Ducts and Markers

a) Trenches for cable ducts, unless otherwise described in the Contract or ordered by the Engineer, shall be excavated to such levels that the top of the duct will be 900 mm below finished pavement level or 200 mm below bottom of sub-base level, whichever is the greater. Ducts shall extend 300 mm beyond the edge of the road pavement, the paved shoulder or behind the kerb lane.

b) Excavation, backfilling, bedding, laying, surrounding and jointing of ducts shall be carried out as described in Article 30.2, 30.3, 30.5, 30.6 and 30.7 above.

c) Duct markers shall be of bronze, brass or aluminium 150mm square set on a ground spike 100mm long or have lugs attached to enable them to be set in the concrete face of a kerb or pavement. They shall be planted at each end of a duct or set in a kerb or pavement above the end of the duct. The flange shall indicate:

Electric cable duct
depth .... mm
or
Telephone cable duct
depth.... mm
or

Other similar wording as directed embossed, engraved or impressed on its surface.

30.9 Drainage Adjacent to Culvert Wing Walls and Headwalls

Permeable backing shall be provided behind culvert wing walls as shown on the Drawings. This shall consist of Class 1 bricks laid in stretcher bond with dry joints on a Class 20/20 mass concrete base with half-round channel cast in. To prevent migration of soil through the drain the bricks shall be covered with a suitable filter fabric membrane as specified in Article 29.17.

A gravel drain shall be provided, as shown on the Drawings, adjacent to the culvert head wall, returning along the wingwall and discharging into the permeable backing. Drainage material shall comply with the requirements of Article 29.

30.10 Testing

a) All drains or service ducts less than 350 mm dia diameter shall be checked, by drawing through each completed length of pipe, a wooden mandrel of dia 10% less than that of the duct.

SECTION 31
ROAD MARKINGS

31.1 Road Marking Materials for Asphaltic Concrete Surfaces

The road marking materials shall consist of white or yellow (as indicated on the Drawings) tropical grade thermoplastic material, reflectorized with ballotini, and shall all conform to the requirements of BS 3262 as amended below:

a) Softening point: Clause 10.1 of BS 3262. The softening point shall be not less than 95°C.

b) Flow resistance: Appendix F of BS 3262. The percentage decrease in the height of the cone of tropical formulation material shall be measured after 48 hrs at 40°C.

31.2 Application of Road Markings

Road markings shall be applied in accordance with the manufacturer's recommendations and BS 3262 as continuous or intermittent lines, letters, arrows, figures or symbols of the types and colors and dimensions indicated on the Drawings, or as otherwise directed by the Engineer. The thermoplastic materials complying with BS 3262 shall be laid to the following thicknesses:

a) Screed markings 4mm ± 1mm
b) Sprayed markings 2mm ± 0.5mm

These thicknesses specified are exclusive of surface applied ballotini. The method of thickness measurement shall be in accordance with Appendix H of BS 3262.

The Contractor shall state the maximum safe heating temperature, the temperature range of the apparatus and the method of laying to be used.

The thermoplastic markings shall be screed or spray applied incorporating ballotini and also have a surface application of ballotini applied evenly at the rate of 400-500 g/m^2.

Road marking materials shall only be applied to surfaces which are clean and dry. Markings shall be free from raggedness at their edges and shall be uniform and free from streaks. Carriageway lane and edge lines shall be laid by approved mechanical means to a regular alignment.

31.3 Trial Areas for Road Markings

The Contractor shall undertake trial areas of a representative sample of the road markings to demonstrate the suitability of his proposed method and plant and the competence of his operatives to the satisfaction of the Engineer.

SECTION 32
TRAFEIC SIGNS

32.1 General

Exact details of the traffic signs are shown on the Drawings and Schedules. They shall comprise:

a) Non-illuminated signs;
b) Externally illuminated signs.

All signs, posts and auxiliary equipment shall be of the permanent type and shall comply with BS 873, except as specified herein.

To avoid electrical interaction and subsequent deterioration where different materials are used, care shall be taken by the use of suitable interface washers. Clamps, fixing bolts, screws and washers shall be of stainless steel. Neoprene or nylon washers shall be used for tightening onto plastic surfaces.

Surfaces shall be hard and free from blemishes, runs, drips and crazing. External areas of the signs other than sign faces shall be provided with an anti-dazzle grey color finish.

Unless otherwise indicated on the Drawings, all informatory and directional signs shall be post-mounted to give a clear height below the bottom edge of the sign plate or face of 1.0m to adjacent road level or 2.1m above footpath level where one exists. All regulatory and warning signs shall be post-mounted to give a clear height below the bottom edge of the sign plate or face of 2.1m to adjacent road level.

All signs shall be provided with bracings and supports, as necessary, to withstand a design wind speed of 50 m/s. Signs mounted on single posts shall incorporate locking arrangements to prevent rotation. Post stiffenings and fixings shall not project outside the sign plate except for supporting the lanterns for externally illuminated signs.

32.2 Externally Illuminated Sign Plates

Sign plates shall be constructed of:

a) Galvanized sheet steel, in compliance with BS 1449, of minimum thickness 1.25mm, or

b) Sheet aluminium, complying with BS 1470 type SIC-4, HS30 T.F, NS3-6 or NS4-86, of minimum thickness 3.0mm

Horizontal and vertical stiffening frames shall be provided at the rear of the plate where the vertical or horizontal dimensions exceed 0.8m or the total area exceeds 0.8 m^2.

Where galvanized sheet steel sign plates are used all cut edges and edges of holes shall be coated with a zinc rich paint. Aluminium sign plates shall be anodized.

Rivets shall be finished flush with the sign face and all hollow rivets shall be filled.

The sign plates shall be paint coated with a minimum of one coat primer, one undercoat and two finishing coats before the application of symbols and characters.

Symbols and characters may be painted or applied by cut out plastic film, edge sealed in accordance with manufacturer's instructions.

The entire face shall be covered with non-reflective plastic sheeting fixed with heat activated or pressure sensitive adhesive applied in accordance with the manufacturer's instructions.

The sheeting shall preferably be applied in one piece but where joints are necessary they shall be overlapped. The overlap shall be in a downward direction and not less than 6mm. Vertical joints shall not be used. Following the application of the plastic sheeting, the entire face and edges of the sign plate shall be given a coat of clear lacquer applied as recommended by the manufacturer of the sheeting material.

32.3 Non-Illuminated Sign Plates

Non-illuminated sign plates shall be in accordance with Article 32.2 except that symbols, characters and background as appropriate shall be formed in water proof plastic film which embodies glass beads giving the required color in accordance with the requirements of Table 1 of BS 873: Part 6. After application the sign shall be edge sealed and coated with clear lacquer.

32.4 Lanterns for Externally Illuminated Signs

Externally illuminated signs shall be provided with bracket mounted lanterns giving downward illumination. Bracket arms shall be galvanized tubular steel and shall have an outreach of suitable dimensions to give illumination over the sign face. They shall be so arranged that the bottom edges of the lanterns do not project below the top edges of the signs and do not obscure any part of the signs.

The lanterns shall accommodate the lamps as specified together with control gear and shall be totally enclosed. The lanterns and ballast gear shall comply with the requirements of Section 36.

Electrical equipment and internal wiring at illuminated traffic signs shall comply with the requirements of Section 36.

32.5 Posts

Posts supporting signs shall be of tubular steel construction of not less than 75mm diameter and shall be galvanized. They shall be provided with an adequate length of foundation root for burying into the ground or supports as detailed in the Drawings. The Contractor shall include for all temporary supports and guides as may be necessary and for erection on any

prepared foundations. The outside and inside of the posts buried below ground shall be bitumen covered carried to a height of 200mm above ground level. All other external surfaces of the posts shall be finished in non-reflective grey to match the rear faces of the signs and sign frames.

Regulatory and warning signs shall be mounted on one post and directional and informatory signs shall be mounted on a minimum of two posts.

Sign posts and their foundations shall be designed for the following conditions:

a) Temperature Range $0^{o}C$ to $50^{o}C$
b) Wind Speed from any direction 50 m/s
c) Relative Humidity 100%

The factor of safety against overturning shall be not less than 1.5 under working conditions and the maximum deflection shall not exceed 1/40th of the height measured from the center of the sign to ground level for single post mounted signs and 1/80th of the same height for signs provided with two or more posts.

For externally illuminated signs a base compartment in the post shall be provided and the access door shall be weatherproof with a tamperproof locking device standard on all signs. Twelve door keys shall be handed over to the Engineer on completion of the Contract. Where two or more posts are provided, for uniformity of appearance, a dummy compartment shall be fitted to the other or outer-most post. An earthing terminal shall be provided within the base compartment comprising a 25mm long 10mm diameter (minimum) set screw with two washers and locknuts. A suitable sized hole shall be provided in the foundation root for the incoming loop-in cables. The edges of the hole shall be chamfered and rounded and shall be machined prior to galvanizing.

Each post shall be provided with a top cap to prevent the ingress of rain.

32.6 Approval of Traffic Signs

At least 60 days before the erection of any road sign the Contractor shall supply to the Engineer detailed drawings, load and stress calculations and samples of the different signs and fittings for the Engineer's approval.

SECTION 33
SOILS INVESTIGATION

33.1 General

33.1.1 Objective of Investigation

The Contractor shall carry out a soil investigation to obtain information with respect to ground conditions which in conjunction with the trial piling programme will enable the Engineer to finalize the toe levels of pile for the bridges. The soil investigation will also provide subsurface information in the road embankment section. The investigation shall consist of on-land and over-water borings (with sampling and standard penetration tests) in soil to as deep as El.- 120m PWD, and installation of standpipe piezometers to depths of up to 15m, together with laboratory testing of recovered samples. A report in English giving all the information obtained from the investigation shall be provided.

33.1.2 Scope

The soil investigation required by the Contract shall comprise the following:

a) Boreholes at the locations and elevations (or depths) shown in the Schedule of Soil Investigation Borings specified herein in Attachment A. Standard Penetration Tests and sampling shall be carried out and standpipe piezometers installed as specified in this Section;

b) laboratory testing of samples at the Engineer's laboratory on site and at independent laboratories off site as directed by the Engineer;

c) depending on the outcome of the investigation described above, any further investigation as deemed necessary by the Engineer in order to achieve the objective stated in Article 33.1.1.

Additional borings and tests may be proposed by the Contractor to suit his method of working and carried out with the approval of the Engineer. These borings and tests shall not be considered as required by the Contract, and shall be performed at the Contractor's expense.

33.1.3 Standards and Codes

The standards and codes of practice which shall apply shall be the latest version current at the time of tender of the following:

BS 5930: Code of Practice for Site Investigations;

BS 1377: Methods of Test for Soils for Civil Engineering Purposes.

33.1.4 Positioning and Leveling

The Contractor shall securely mark with a steel pin set in a concrete block the on-land borehole locations to allow leveling and shall establish levels thereon to the satisfaction of the Engineer. For over-water borehole locations the Contractor shall determine levels of river bottom and water level with respect to temporary on-land bench marks, approved by the Engineer. The position of over-water borehole locations shall be referenced by the Contractor to a nearby permanent on-land survey station to be provided by the Contractor to enable each borehole position to be located to the accuracy specified herein,

33.1.5 Measurement of Depth

All depths of samples, tests and changes of strata shall be measured to an accuracy of 25mm.

33.1.6 Method Statements

The Contractor shall submit to the Engineer full details of his proposed method of working plant and equipment. A tender vessel shall be in constant attendance during the over-water work.

a) Type and manufacture of rigs and all equipment;

b) Barges, anchorages and tug vessels;

c) Number and functions of crew;

d) Anticipated duration of daily set-up and close down periods and duration of working day;

e) Qualifications and experience of personnel to carry out soil investigation operations;

f) Type(s) of proposed drilling fluid(s);

g) Weather river conditions and various combinations thereof which would in the Contractor's opinion force;

   i) an abandonment of drilling operations, or

   ii) an abandonment of positioning operations.

33.1.7 Contractor's Superintendence

The work on site shall be carried out under the superintendence of a qualified and experienced Senior Geotechnical Engineer or Engineering Geologist. He shall be capable of competently logging the strata encountered considering both available knowledge of the regional geology and any correlation between boreholes and with the penetration testing. He shall direct immediate production of the field logs for the investigation, and the subsequent production of draft and final logs after the approval of the Engineer. He shall be fully conversant with the theory and techniques of the in-situ testing covered by this specification. He shall maintain close liaison with the Engineer.

Each boring operation shall have in attendance on it, for a minimum of 50% of its operating time, a qualified engineer or geologist. They shall always be present during special sampling and in-situ testing operations and shall be capable of producing the borehole logs and directing the crews in matters of techniques so as to ensure that the highest quality of sampling and testing is achieved.

The Contractor shall provide full curricula vitae of the staff he proposes to employ on supervision these works, including the qualifications of each member of staff listed

33.1.8 Mobilization

The Contractor shall mobilize for the soil investigation works to suit his construction programme. In his construction programme he shall allow four weeks between the submission of the final Soil Investigation Report and receipt of the Engineer's decision as to whether the results require an adjustment to the pile depths shown on the Drawings.

33.1.9 Plant and Equipment

The Contractor shall provide full details of his proposed plant, equipment, personnel and methods for the investigation in sufficient time to obtain the Engineer's approval before mobilization. The term equipment as used herein shall include all equipment and appliances necessary to carry out the soil investigation as specified and shown on the Drawings.

Plant and equipment shall be in good operating condition and well maintained throughout the investigation.

33.1.10 Failure to Complete Boring/Insitu Testing

Should any borehole location be lost or abandoned by the Contractor before the required depth has been reached or required tests have been carried out, then the Contractor shall repeat the boring as close as practicable to the original site to recover the lost depth and continue until the required data have been obtained.

33.1.11 Changes to Location and Quantities of Investigation

The Engineer may vary the quantity, location and depth of any boring and the sequence or quantity of in-situ testing and sampling depending on the actual ground conditions or obstacles encountered.

33.1.12 Confidentiality

The Contractor shall keep all log books, records and samples in safe custody and shall not allow any person not duly authorized by the Engineer to have access thereto. The Contractor shall not disclose any information relating to the Contract to any person not authorized by the Engineer.

33.2 Not Used

33.3 Boring

33.3.1 Equipment and Methods

The equipment shall be suitable for borings to depths below El.-120m PWD in generally granular soils. It shall provide immediate indication of cohesive layers within the depth penetrated. Within the borings Standard Penetration Testing (SPT), small and bulk disturbed sampling and 'undisturbed' thin-walled tube (Shelby) sampling shall be carried out as appropriate to the full depth.

Before boring of each hole commences the Contractor shall obtain the consent of the Engineer to the equipment and methods he proposes to use. After commencing a borehole the Contractor shall not change his methods of boring without the consent of the Engineer.

33.3.2 Borehole Position

The Contractor shall establish each on-land borehole to within 0.5m and each over-water borehole to within 2m of the positions required by the Engineer. He shall make and record accurately such measurements as may be necessary to enable each borehole to be located.

33.3.3 Borehole Diameter

The minimum starting diameter of the borehole shall be sufficient to allow the proposed borings to be completed with a minimum diameter of 100mm.

Should any boring prove abortive because of the Contractor's failure to begin boring with a sufficiently large diameter then the Contractor shall be required to re-bore at his own expense.

33.3.4 Water Levels in Boreholes

The Contractor shall at all times during boring maintain the water level in the borehole at or above standing water level or river level, whichever is the higher. During all operations the driller shall raise the tools from the boreholes slowly in order to minimize the effects of suction or disturbance. An exception to this requirement will occur if rising head permeability tests are instructed.

33.3.5 Completion of Boreholes

No casing shall be withdrawn until the Engineer has given his consent for the termination of the borehole.

33.3.6 Protection of Boreholes

On-land boreholes not attended at any time shall be covered with a steel plate, together with such other measures as are necessary to prevent loss of the borehole.

33.3.7 Backfilling of Boreholes

The Contractor shall thoroughly backfill all boreholes with arisings tamped lightly in place throughout the bore depth or a bentonite-cement grout if preferred to prevent formation of voids.

33.3.8 Water Level Measurement

Water levels in the borehole and river levels shall be recorded at the beginning and end of each shift and before and after any pause in operations longer than 30 minutes, together with the time elapsed since water was last added to the boring, the depth of the borehole and any casing, and the time of day.

33.3.9 Contractor's Instructions

A copy of the Contractor's "Instructions to Drillers" shall be given to the Engineer before site work commences.

33.4 In-situ Testing

33.4.1 Standard Penetration Tests

Standard Penetration Tests shall be carried out in accordance with BS 1377 test 19 using an automatic trip hammer. The Engineer may from time to time require the driving shoe to be replaced by a solid 60° cone, which shall be used in any event in gravelly strata. The depth of each test shall be determined by measuring the rods. In the event that the penetration resistance, N, is less than 10, the Engineer may require the borehole to be cleaned out and another test carried out immediately.

Small disturbed samples removed from the Standard Penetration Test split spoon sampler shall be taken in accordance with BS 5930. For tests carried out using a solid cone bulk disturbed samples shall be taken from the test zone.

33.4.2 Frequency of Standard Penetration Tests

Unless otherwise instructed by the Engineer a standard penetration test shall be carried out at the top of each stratum and thereafter at 2-meter intervals through the full thickness of the stratum. In clayey strata an SPT test shall be carried out immediately after the first undisturbed sampling operation and thereafter following the recovery of alternate undisturbed samples.

33.4.3 Permeability Tests

The Contractor shall carry out variable head tests in boreholes as instructed by the Engineer. The Contractor shall obtain the agreement of the Engineer that the results are acceptable before proceeding further.

In falling head tests the water level in the hole shall be raised by adding water to a level

above the piezometric surface with a sufficient length of casing provided to project above ground or river level if required. Casing joints shall be watertight.

In rising head tests, the water level in each hole shall be lowered by bailing to a level agreed by the Engineer.

The water levels shall be recorded such that a representative record of the fall or rise in the water level relative to time can be obtained.

The general test procedure and methods of analysis of the results shall be as detailed in BS 5930.

33.4.4 Information to be Submitted

The information to be submitted by the Contractor is as follows:

a) Standard Penetration Test:

i) hole location and number;
ii) ground level;
iii) soil profile;
iv) type of test;
v) ground water table before test;
vi) diameter of hole;
vii) depth of base of hole;
viii) depth to base of casing;
ix) level of water at start and end of test;
x) the number of blows for each of the first and second 75mm of penetration, (the seating blows);
xi) the number of blows for four further penetrations of 75mm, or the penetration produced by 100 blows.

b) Variable Head Permeability Test:

i) to ix) as for a) above;

x) graphical plot of results;
xi) value of coefficient of permeability of material tested together with calculations.

33.5 Sampling

33.5.1 Preparation for Sampling

Before sampling in a borehole, the bottom of the boring shall be carefully cleaned of loose or disturbed material and where a casing is being used the sample shall be taken below the bottom of the casing.

33.5.2 Small Disturbed Samples

Small disturbed samples about 0.7 kg shall be in accordance with BS 5930. They shall be placed immediately in airtight non-corrodible containers which they shall sensibly fill.

33.5.3 Bulk Disturbed Sample

Bulk disturbed samples at least 12 kg in weight shall be taken in granular strata in accordance with BS 5930 (1981). They shall be representative of the zone from which they have been taken and the following sampling procedure shall be used. Within the limits of the zone being sampled all the recovered soil shall be placed on a suitable tray, care being taken to retain the fines of water bearing granular soils. The soil shall be mixed by shovel and quartered until the required amount of soil is obtained.

33.5.4 Thin Wall Undisturbed (Shelby) Samples

Thin wall 'undisturbed' Shelby type tube samples shall be taken in all clay layers encountered using sample tubes having a minimum diameter of 70mm and a length of 450mm with an area ratio of about 10%. The tubes shall be pushed into the strata using a smooth continuous operation or carefully driven. Details of the method of taking the samples proposed by the Contractor shall be submitted in accordance with Article 33.1.6. On removal from the boreholes the samples shall immediately be sealed with microcrystalline wax to preserve their natural moisture content and in such a manner as to prevent the sealant from entering any natural voids which may be present in the samples. All undisturbed tube samples shall be transported and stored in an upright position at all times.

33.5.5 Unsuccessful Undisturbed Sampling

Where an attempt to take an "undisturbed" sample is not successful, the boring shall be cleaned out for the full depth to which the sampling tube has been driven and the recovered soil saved as a disturbed sample. The Engineer may then require a fresh attempt to be made from the level of the base of the unsuccessful attempt. A Standard Penetration Test shall be carried out, either after the first or second sampling attempt as agreed with the Engineer.

33.5.6 Frequency of Sampling

Undisturbed sampling shall be carried out at the top of all clayey strata encountered, and at 1.5m intervals thereafter through the clayey zone, or as otherwise directed by the Engineer on site.

33.5.7 Care of Samples

No samples shall remain in the open for more than one hour. All samples shall be protected at all times from temperatures above 35°C.

33.5.8 Sample Store

The Contractor shall, at a location to be agreed with the Engineer, provide and maintain for the period of the site works a secure lockable building for use as a sample store of minimum dimensions 5m by 6m with a hardstanding for the parking of three vehicles within a protective fence. The store shall have power, lighting, a water supply and drainage, and a bench for use in the examination of samples together with an extruder for use with the thin wailed 'Shelby' tubes and a maximum and minimum thermometer. On completion of the works the Contractor shall dismantle and remove the building with its foundations and services and reinstate the area to leave it level and clean, and clear of all material not natural to the site.

33.5.9 (Not Used)

33.5.10 Labeling of Samples

Labeling shall he in duplicate with indelible ink on durable labels with one label placed within the container and one firmly fixed to the outside of sample containers. All samples shall be labeled immediately after being taken. Each label shall include the following information:

a) site location reference;

b) the date of sampling;

c) the borehole number;

d) the depth of the top and bottom of the sample;

e) the type of sample.

33.5.11 Transport and Retention of Samples

The Contractor shall be responsible for proper preparation, storage and transportation of samples and shall replace at his own expense samples required for the works that are lost or damaged.

On completion of each stage of the Investigation or as otherwise instructed by the Engineer the Contractor shall transport required samples from the sample store to designated locations in Dhaka.

33.6 Instrumentation

33.6.1 Installation of Stand Pipe Piezometer

Standpipe piezometer shall be installed in such boreholes and at such depths as directed by the Engineer. Not more than one piezometer will be required in a borehole. Standpipe piezometers shall not be installed in boreholes supported by means of drilling mud.

33.6.2 Stand Pipe Details

Standpipes shall be of PVC or similar plastic tubing of not less than 19mm internal bore. All joints shall be properly formed with threaded collars and shall be sealed with approved plastic cement to be watertight.

A porous element (Casagrande pot) which shall be soaked in clean water for at least 24 hours prior to installation shall be attached to the bottom of each standpipe and shall be surrounded by approved saturated clean sand which shall extend either a minimum of 1500mm above and 1500mm below the porous element or for the full depth of the borehole to within 3m of ground level. The Engineer may direct gravel to be used in some situations. Watertight seals shall be formed above and below the sand or gravel except where the standpipe is installed at the base of a borehole, in which case the lower seal shall be omitted. The standpipe shall be surrounded by a 600mm cube of concrete flush with the ground surface into which shall be set a suitable cap and cover to seal and protect the top of the standpipe. The Engineer may instruct that the porous element is replaced with a slotted standpipe.

33.6.3 Water Seal

Bentonite pellets shall be dropped down the borehole to produce a minimum thickness of a 2.0m seal. The seal shall be allowed to set for at least two hours or as directed by the Engineer prior to any further construction. After installation of the standpipes and the watertight seals the boreholes shall be backfilled with a bentonite/cement grout. Complete details of the as-built piezometer in the form of a diagram shall be submitted to the Engineer not more than one working day after completion of the installation.

33.6.4 Stand Pipe Reading

Readings of the water leave in each standpipe shall be made at daily intervals after their installation for a period not exceeding 7 days as directed by the Engineer. The water level measurements shall be given to the Engineer within 24 hours of the readings being made. The Contractor shall supply for the use of the Engineer as required an approved portable graduated electric water level dip-meter (with minimum 30m cable) complete with reeling spool for the duration of the works.

33.7 Records and Progress Reports

33.7.1 Daily Reports

Daily field reports in duplicate shall be submitted to the Engineer before noon of the following day. The reports shall give fill details of his operations on site including staff, plant and equipment, boring and testing progress, causes of delays, variations, sequences and depths of strata encountered, samples taken and in-situ tests carried out.

33.7.2 Weekly Reports

The Contractor shall submit a weekly progress report in duplicate to the Engineer during the progress of the investigation detailing any changes to his proposed sequence or method of

working to carry out the soil investigation.

33.7.3 Logging of Boreholes

All boreholes shall be logged by a qualified and experienced Geotechnical Engineer or Engineering Geologist as the boring proceeds.

33.7.4 Preliminary Borehole Logs

Preliminary borehole logs to a vertical scale of 1:50 shall be supplied to the Engineer in duplicate as soon as possible after each boring has been completed and in any event not more than two working days after completion of each borehole. The classification and description of the strata shall be in accordance with BS 5930. The logs shall be checked by the superintending Senior Geotechnical Engineer/Engineering Geologist before being submitted to the Engineer.

33.7.5 Final Logs

Final borehole logs (scale 1:50) shall be submitted in duplicate to the Engineer 4 weeks after approval of the preliminary log by the Engineer.

33.7.6 Format of Borehole Logs

The Contractor shall obtain the consent of the Engineer to the proposed format of borehole logs before site work commences.

33.7.7 (Not Used)

33.7.8 Information to be Submitted

The information to be submitted by the Contractor on the borehole logs is as follows:

All boring logs:

a) Contract details, client and contractor

b) Borehole number, date and times of commencement and completion of boring

c) Location, site, co-ordinates and ground level

d) Boring/drilling technique, type of plant

e) Flush method and character and proportion of flush return

f) Boring diameter, casing diameter and progress

g) Ground water levels and levels and rates of inflow of water strikes

h) Depths and thickness of each stratum

i) Geotechnical description-color, in-situ strength and structure, weathered state, alteration state, minor lithological characteristics and additional descriptive terms including the

presence of mica, soil name (in capitals), other terms indicating special engineering characteristics

j) Ancillary geological information

k) Sample depths and types

l) In-situ test depths and results

m) Instrumentation depths and types

n) Symbolic log

o) River level at or near site of test at start and finish of each shift

p) Additional information required by the Engineer

For over water locations

Where boring is carried out over water the relevant remarks in the above lists shall also include:

q) Time and height of river water levels at intervals as directed by the Engineer. Details of movement of water levels within the borehole related to fluctuation of river levels at the borehole location;

r) Detailed records of delays caused other than by failure of boring equipment, e.g. craft dragging anchors, weather, shipping movements, etc.;

s) Detailed records of the movement, vibration and oscillation of drilling tubes;

t) Detailed records of the bowing of drilling tubes because of waves, currents, etc.;

u) Details of weather and water conditions (waves, currents, etc.).

33.8 Reporting

33.8.1 Final Report

The Contractor shall prepare a Final Report in English on the boring, sampling, in-situ testing and site laboratory testing for the Soil Investigation. The standard size of the report, all borehole logs, site laboratory tests and drawings (folded) shall be A4.

33.8.2 Contents of Final Report

The Final Report shall include location plans (Scale 1:1000) showing positions of boreholes, borehole logs, in-situ test results, details of ground conditions, details of boring and in-situ test methods, water level observations in boreholes and standpipes and description of all equipment used during the investigations. The extent of information submitted on in-situ tests shall be in accordance with the requirements set out in Articles 33.4.4 and 33.7.7. Laboratory tests and results shall be reported as described in the applicable Standards.

33.8.3 Submission

Four copies of the complete draft of the Final Report shall be submitted to the Engineer for review and comment. Ten copies of the approved Final Report shall be submitted to the Engineer two weeks after the issue of comments on the draft reports by the Engineer.

33.8.4 Negatives

After approval and submission of the Final Reports, the Contractor shall give the Engineer a copy of the report on computer diskette together with negatives of any photographs to enable the Engineer to reproduce additional copies of the report.

Attachment A

SCHEDULE OF SOIL INVESTIGATION BORINGS

Notes :

1. All borings shall be located on centerline of bridge or roadway, unless otherwise shown.

2. Additional borings shall be performed when directed by the Engineer. The locations and depths of these additional borings will be determined by the Engineer.

3. Additional borings and tests may be proposed by the Contractor to suit his method of working, and carried out with the approval of the Engineer. These borings and tests shall not be considered as required by the Contract, and shall be performed at the Contractor's expense.