SECTION 6: INCIDENTAL CONSTRUCTION

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SECTION 6.01 CONCRETE KERBS, GUTTERS, SIDEWALKS AND PAVED MEDIANS

6.01.1 SCOPE

The works covered in this Section consists of furnishing materials and construction of concrete kerbs, gutters, kerb-and-gutter combinations and concrete paving to sidewalks and medians, using in-situ or precast concrete as and where shown on the Drawings.

6.01.2 MATERIALS AND PRECAST MANUFACTURE

A. Concrete

Portland cement concrete shall be Class 210/20 for all in-situ and precast concrete, except for base course and backing concrete which shall be Class 110/25. All concrete shall conform to the relevant requirements of Section 5.01: Concrete Mixes and Testing and shall be produced by commercial ready-mix plant approved by the Engineer.

B. Mortar

Mortar shall consist of cement and fine aggregate having the same proportions as used in the concrete construction and shall conform to all relevant requirements of Section 5.01: Concrete Mixes and Testing.

C. Reinforcement

Reinforcing steel shall conform to the requirements of Section 5.03: Steel Reinforcement.

D. Precast Concrete Units

D.1 All precast units shall be manufactured to the dimensions shown on the Drawings. Manufacturing tolerances shall be 3 mm in any one dimension. End and edge faces shall be perpendicular to the base.

D.2 Each precast kerb or gutter unit shall normally be 0.5 m in length and this length shall be reduced to 0.25 m or as directed, where units are to be installed along curves of less than 10 m radius.

D.3 For horizontal curves of radius less than 10 metres, kerb and gutter units shall be manufactured to the radius shown and in such circumstances straight elements or portions of straight elements shall not be used. Bullnoses and curved faces shall be of constant radius with a smooth transition from a radius to a plain face.

D.4 Unless shown otherwise on the Drawings, precast concrete tiles (paving slabs) shall be 400 mm by 400 mm by 40 mm thickness with a 5 mm edge bevel. The tile face shall be grooved in squares of a size agreed by the Engineer as appropriate to the tile dimensions. Colouring of the top layer, where required, shall be achieved using mineral oxides.

D.5 Surfaces of precast units that will be exposed to view after installation shall be true and even, with a dense finish of uniform texture and colour, free from cracks, holes, fins, staining or other blemishes or defects. Units failing to meet these requirements shall be rejected. Surfaces that will not be exposed to view after installation shall have all fins and irregular projections removed and all cavities, minor honeycombing and other defects made good with mortar after the units have been saturated with water for at least 3 hours.

D.6 Precast units shall be cast upside down in approved steel moulds under conditions of controlled temperature and humidity. The units shall be steam cured or any other method approved by the Engineer until the concrete attains the full specified 28-day strength.

D.7 The Contractor shall submit for approval, samples of each of the proposed units together with the manufacturer's certificates and details of the method of manufacture and materials to be used. The Engineer's approval of the samples shall not be considered final and the Engineer shall reject any precast units delivered to the Site, which do not meet the required standards.

D.8 Testing of Tiles

The following tests shall be carried out on sidewalk tiles to ascertain their suitability for the work.

(i) Flexural Strength

(ii) Abrasion Resistance

The first test shall be carried out on four samples taking as the final result the average of the most homogeneous results of the four. The abrasion resistance test shall be carried out on two samples, the results of which shall be averaged.

(i) Flexural Strength

This test shall be carried out by placing the tile on two knife edge supports, with edges rounded with a radius of one cm, arranged parallel to the side of the tile and ten cm apart. The load is gradually transmitted to the tile top surface along the centreline by a third knife edge arranged parallel to the other two.

The unit maximum bending stress (Flexural Strength) equals $15Phb^2$ where "P" is the total breaking load in kilograms, "b" is the width of the tile in centimetres, "h" the thickness of the tile in centimetres.

The minimum value for Flexural Strength shall be 30 kg/sq. cm minimum.

(ii) Abrasion Resistance

This test is carried out with a machine composed of a horizontal cast-iron disc, rotating about its vertical central axis at uniform speed; a horizontal diametrical cross-piece by which two samples are pressed on the disc, at such a distance from the centre of the disc, that the relative speed with respect to the disc, is one metre per second; a second horizontal diametrical cross-piece orthogonal to the first, which carries at either end appropriate devices to let the moistened abrasive flow on the track; two pairs of conveniently arranged brushes to guide the abrasive that tends to escape under the samples.

The samples, pressed against the disc, rotate by means of a special mechanical device, around their own vertical central axis, at the rate of one turn of the specimen for 50 turns of the disc. Carborundum grit sufficiently coated with liquid mineral oil with an Engler viscosity of between five and seven at 50^{o}C shall be used as an abrasive. The grit shall pass sieve No. 60 and be retained on sieve No. 100. Consumption of carborundum and oil shall be approximately 20 and 12 grams respectively per minute.

The square sample, with a surface area of 50 sq. cm shall be pressed against the disc by a total weight of 15 kg (unit pressure of 0.3 kg/sq. cm). The test shall be carried out with a distance run of the grinding wheel of 500 meters. For materials with a surface wearing layer different from the rest of the tile, the distance run shall be such that the disc does not penetrate into the lower layer.

The thickness of the layer abraded in mm with a pressure of 0.3 kg/sq. cm for a distance run of 1000 meters is taken as the abrasion factor. This factor is determined by assuming that the consumption is proportional to the distance run.

The limit acceptance value for the Abrasion Factor shall be 12mm maximum.

E. Preformed Expansion Joint Filler

Preformed expansion joint filler shall conform to AASHTO M 33.

F. Epoxy Adhesive

Epoxy adhesive (for use in attaching precast units to existing concrete pavement surfaces) shall conform to the relevant requirements of Section 6.10: Raised Pavement Markers.

G. Ducts

Ducts (if required under sidewalks or medians) shall consist of uPVC plastic pipe conforming to ASTM D 2750, Type II. If jacking is required, duct shall be galvanized steel tube approved by the Engineer.

H. Bedding

Bedding material shall conform to the relevant requirements of Section 3.02: Granular Sub-Base Courses for Class A or Class B Granular Material.

6.01.3 CONSTRUCTION AND INSTALLATION

A. Cast In-Situ Curbs and Gutters

A.1 The subgrade shall be excavated to the grades and sections shown on the Drawings. If the section is not indicated, the width to be excavated shall be 300 mm each side of the outside edges of the kerb or gutter. The subgrade shall be of approved uniform density. The subgrade shall be excavated to a minimum depth of 150 mm below base level and the material replaced with bedding material which shall be compacted to at least 95% AASHTO T180 maximum density. All foundations shall be rolled or compacted to provide a smooth surface and shall be approved before placing concrete.

A.2 For stationary side form construction forms for kerbs and gutters shall be of a proprietary steel type. All forms shall be sufficiently strong and rigid and securely staked and braced to obtain a finish in accordance with the dimensions, lines and grades required. Forms shall be cleaned and oiled before each use. Forms shall be removed as soon as practicable after concreting, provided no damage results to the kerb or gutter and not until at least 24 hours after completion of concreting.

A.3 For slip-form construction, kerbs or gutters shall be constructed by use of either slip-form or extrusion equipment. The completed kerb or gutter shall be true to shape, grade, and line and the concrete shall be compacted and of the required surface texture.

A.4 Concrete shall be placed upon the previously prepared and moistened subgrade and compacted with an internal vibrator. The surface shall be shaped by use of a steel screed to produce the section shown on the Drawings. The edges shall be rounded with preformed shuttering to form the required radius, which, if not shown otherwise on the Drawings, shall be 5 mm.

A.5 Contraction and construction joints of the required types shall be constructed at the intervals and locations shown on the Drawings. Adjacent to flexible base or surface courses, weaker plane contraction joints in curbs or gutters shall be constructed by sawing through the kerb to a depth of not less than 30 mm below the surface of the gutter, by inserting a suitable removable metal template in the fresh concrete or by other methods if approved before construction by the Engineer. Sealing of joints shall not be required unless shown on the Drawings.

A.6 Exposed surfaces shall be finished to the full width with a trowel and edger. The top face of kerbs or gutters shall receive a light brush finish. Forms for the roadway face of kerbs and the top surface of gutters shall be removed not less than 24 hours after the concrete has been placed. Finishing of the surfaces shall then be carried out provided the alignment tolerances and other requirements have been met.

A.7 Tolerances on tangential sections of kerbs and gutters shall be tested using a 4 m straightedge. The finished surface of concrete shall not deviate from the straightedge between any 2 contact points by more than 5 mm. Curved sections shall be true to the specified radius plus or minus 5 mm and all joints shall be flush and neat in appearance.

A.8 All fins and irregular projections shall be removed and cavities produced by form ties and all other small holes, honeycomb spots, broken corners or edges and other defects shall be rectified. After saturating with water for a period of not less than 3 hours, the surfaces shall be carefully pointed and made true with mortar. All construction and expansion joints shall be left carefully tooled and free of all mortar and concrete. Joint filler shall be left exposed for its full length with clean and true edges. The resulting surfaces shall be true and uniform.

A.9 A rubbed finish shall then be carried out to surfaces, which are to be exposed to view after completion of construction. Before rubbing, the concrete shall be kept saturated with water for at least 3 hours. Sufficient time shall have elapsed before the wetting down to allow the mortar used in the pointing of holes and defects to set. Surfaces shall be rubbed with a medium carborundum stone, using mortar on its face. Rubbing shall remove all remaining form marks, projections and irregularities and result in a uniform surface. The final finish shall involve rubbing with a fine carborundum stone and water until the entire surface is of a smooth texture and uniform colour. After the surface has dried, loose powder shall be removed and the surface shall be left clean and free from unacceptable flaws or imperfections.

A.10 Kerbs and gutters shall be moist cured until stripped and finished, and then membrane cured in accordance with the relevant requirements of Section 5.02: Concrete Handling, Placing and Curing. Curing compound shall be applied immediately following completion of the rubbed finish.

A.11 The area adjacent to completed and accepted kerbs and gutters shall be backfilled with approved material to their top edges or to the elevations shown on the Drawings. Backfill shall be placed and compacted to 95% AASHTO T180 maximum density.

B. Precast Concrete Kerbs and Gutters

B.1 Subgrade for the concrete base shall be constructed as for in-situ kerbs and gutters.

B.2 Forms for the concrete base shall be wood or steel. All forms shall be sufficiently strong and rigid and securely staked and braced to obtain a finished product correct to the dimensions, lines and grade required. Forms shall be cleaned and oiled before each use. If approved beforehand by the Engineer, forms for the concrete base may be omitted and the concrete placed directly against undisturbed excavated faces.

B.3 Base concrete shall be placed, compacted and shaped to the sections shown on the Drawings. Concrete shall be compacted to the satisfaction of the Engineer with an internal type vibrator or by manual means. Edges shall be rounded if necessary by the use of wood moulding or by the use of an edger as applicable. The concrete base shall be finished to a true and even surface with a wood float. Concrete shall be membrane or water cured for at least seven days before precast units are placed thereon.

B.4 Precast units shall be soaked in water immediately before installation. Units shall be set accurately in position in mortar on the concrete base. Joints between precast units shall not be mortared unless otherwise shown on the Drawings. Units shall be closely spaced and expansion joints provided every 10 metres.

B.5 Where kerbs or gutters are installed on existing concrete pavement using epoxy resin adhesive, the installation procedures shall conform to those specified for raised pavement markers in Section 6.10: Pavement Markings for Traffic.

B.6 After kerbs have been installed concrete backing shall be placed as shown on the Drawings. Pavement courses shall not be laid against curbs until the concrete backing has been membrane or water cured for at least 14 days.

B.7 The tolerances on the alignment of completed precast units shall be as specified for in-situ concrete construction.

B.8 Backfilling shall be carried out as specified for in- situ kerbs and gutters.

C. In Situ Concrete Paving

C.1 Excavation shall be carried out to the required depth and to a width that shall permit the installation and bracing of the forms. The foundation shall be shaped and compacted to an even surface conforming to the sections shown on the Drawings. All soft and yielding material shall be removed and replaced with suitable fill material.

C.2 Bedding material shall be placed in layers not exceeding 100 mm in depth and each layer shall be compacted to 95% AASHTO T180 maximum density. The total bedding course thickness shall be as shown on the Drawings, or if not shown, 100 mm minimum thickness.

C.3 Forms shall be of steel or wood and shall extend for the full depth of the concrete. All forms shall be straight, free from warping and of sufficient strength to resist the pressure of the concrete without displacement. Bracing and staking of forms shall be such that the forms remain in both horizontal and vertical alignment until their removal. All forms shall be cleaned and oiled before concrete is placed.

C.4 The formation shall be thoroughly moistened immediately prior to the placing of concrete. Concrete shall be deposited in one course without segregation and shall be compacted by vibrators. The surface shall be finished with a wooden float and light brooming. No plastering of the surface shall be permitted. All outside edges of the tiles and all joints shall be edged with a 5 mm radius edging tool.

C.5 Forms shall only be removed when there is no risk of damage to the concrete and at least 24 hours after completion of concreting.

C.6 The smoothness of paved areas shall be tested using a 4 m straightedge. The finished surface of concrete shall not deviate from the straightedge between any two contact points by more than 5 mm. Sections of defective paving shall be removed and replaced as directed by the Engineer at the Contractor's expense.

C.7 Expansion joints shall be of the dimensions specified and shall be filled with approved, premolded expansion joint filler. The area being paved shall be divided into sections by weakened plane joints formed by a jointing tool or other methods acceptable to the Engineer. Joints shall extend into the concrete 0.20 to 0.25 times the depth and shall be approximately 3 mm wide. Joints shall match as nearly as possible adjacent joints in curb or pavements. Weakened plane joints may be sawn in lieu of forming with a jointing tool.

C.8 Construction joints shall be formed around all appurtenances such as manholes or utility poles, extending into and through the sidewalk or median. Premolded expansion joint filler of 10 mm thickness shall be installed in these joints. Expansion joint filler of the thickness indicated shall be installed between concrete construction and any adjacent fixed structures such as walls, buildings or bridges. The expansion joint material shall extend for the full depth of the concrete.

C.9 Concrete shall be cured by membrane curing in accordance with the requirements of Section 5.02: Concrete Handling, Placing and Curing.

D. Precast Concrete Tiles (Paving Slabs)

D.1 Excavation and placing of bedding material shall be as specified for in-situ concrete paving. The surface of the completed bedding shall be dampened and base course concrete placed and finished to the thickness as shown on the Drawings or, if not shown, 40 mm minimum thickness.

D.2 Base course concrete shall be water or membrane cured as specified for in situ concrete paving, for a period of not less than 7 days before placing precast tiles.

D.3 Immediately prior to tile laying, the concrete base course shall be dampened and the concrete tiles shall be immersed in water. Tiles shall then be laid true to line and grade on a 10 mm to 20 mm thickness of mortar. Joints shall be 3 mm wide.

D.4 The tolerance on smoothness of precast concrete tiled areas and removal and replacement of defective tiling shall be as specified for in situ concrete paving.

D.5 Tiles shall be cleaned 24 to 36 hours after laying and joints shall be mortared using a plasticizer in the mortar to improve workability and to enable the mortar to be readily smoothed and finished. As soon as the mortar has partially set, all mortar material shall be raked from the top 3 mm depth of the joint, using a grooving tool to produce a smooth circular section.

D.6 When the mortar is sufficiently set, the surface shall be sprinkled with water and covered with plastic or nylon sheets during the curing period. The sheets shall be left in place until final hardening of the mortar or as directed by the Engineer. All foreign matter, wood, concrete, mortar lumps, etc., shall then be removed and the surface cleaned of staining, discolouration and other blemishes.

D.7 In cases where tiles are required to be cut at the boundaries of tiled areas, or due to the presence of obstacles, poles, hydrants, etc., or in the construction of the driveways or side roads, the Contractor shall cut the tiles or substitute in situ concrete of at least the same quality as the tile concrete. The Engineer shall decide, after trials, on the method to be adopted. Cutting of tiles or substitution of in-situ concrete shall be kept to a minimum. The Contractor shall complete the areas using uncut precast tiles to the maximum extent practicable.

D.8 The method of construction and sequence of operations for areas constructed using precast tiles shall be the same as for areas constructed using in situ concrete. The Contractor shall ensure that the final appearance of such surfaces, regardless of the method of construction, is substantially the same for all types of construction.

D.9 Where a sidewalk crosses the entrance to a shop or a house, etc., which is higher than the sidewalk, the Contractor shall construct steps, formed by a curb and a complete or partial tile. Steps shall be backfilled with concrete of the same quality as specified for concrete base course.

D.10 Steps shall be constructed wherever the difference in elevation between the entrance and the sidewalk is more than 250 mm. The Contractor shall submit for approval, prior to commencing any sidewalk construction, a list of locations where steps are required, together with design details for their construction.

6.01.4 MEASUREMENT

A. Precast Concrete Kerbs and Gutters shall be measured by the linear metre of each type furnished, constructed or installed, completed, and accepted. Measurements shall be taken on the front face of concrete curbs or on the flow line of gutters as appropriate and shall include measurement of concrete kerbs required for steps.

B. Precast Concrete Edge Kerb and In Situ Concrete Edge Curb shall be measured by the linear metre of each type furnished, constructed or installed, completed and accepted.

C. Precast Concrete Tiling shall be measured by the square metre of the plan area of each type furnished, constructed or installed, completed, and accepted.

D. Excavation, backfilling, bedding, concrete base course, concrete backing, construction in and around obstacles, poles, manholes, flower beds, cutting and shaping of tiles on curves, jointing, and finishing at walls and fences, etc., shall not be separately measured for direct payment, but shall be considered as subsidiary work; the costs of which will be deemed to be included in the Contract Prices for the Pay Items.

SECTION 6.07 MAINTENANCE OF TRAFFIC AND DETOURS

6.07.1 SCOPE

A. The work covered in this section includes the supply of all materials, construction of detour roads, bridges and culverts where necessary and installing, operating and maintaining all required temporary lighting, signing, signals, pavement marking, barriers and other safety measures for the maintenance of vehicular and pedestrian traffic through and around the Site of the Works during the Contract Period. These works also include the removal of all unwanted temporary detour items and facilities at the end of the Contract and other work as directed by the Engineer.

6.07.2 MAINTENANCE AND PROTECTION OF TRAFFIC

A. General Procedures

A.1 The Contractor shall ensure the free movement of vehicular and pedestrian traffic and shall maintain all highways including temporary detours and accesses in a clear and safe condition free from obstructions. Adequate access to the Site shall be maintained at all times to ensure that traffic on existing roads is not impeded unnecessarily by traffic turning into the Site.

A.2 In order to facilitate movement of traffic through or around construction and when and wherever required by the Engineer, the Contractor shall furnish, erect and maintain signs, traffic barricades and other facilities necessary for safe and efficient direction and handling of traffic at specified locations in or around the Site to the satisfaction and approval of the Engineer.

A.3 The Contractor shall, if detailed on the Drawings or instructed by the Engineer, provide flashing signal lights by night and provide sturdy barricades for the protection of workmen engaged on traffic control.

A.4 Where required by the Contract Documents or the Engineer, the Contractor shall provide, erect, operate and maintain temporary traffic signals of the 3-colour type. Signals shall be capable of both automatic and manual operation as required. The timing device of any automatic traffic signal shall be accurate to within plus or minus two seconds.

A.5 Manually operated "stop-go" signs shall only be used if approved by the Engineer.

A.6 Traffic signals, when used, shall be sited on the nearside of the travelled way in positions which shall be clearly visible to on-coming drivers for a distance consistent with safe stopping. Appropriate advance warning signs shall be provided and maintained in a clean condition.

A.7 The Contractor shall, whenever necessary, provide flagmen at specified locations with the sole task of directing traffic through or around the Site and shall provide and erect within or near the Site any warning or directional signs the Engineer may require.

A.8 All barriers, traffic signs, signals and other such devices shall be erected, maintained and removed when necessary, as directed by the Engineer.

B. One-Way Traffic Operation

B.1 Whenever it becomes necessary to operate one-way traffic along any stretch of road in or around the Site, the Contractor shall, for the purpose of maintaining traffic, provide a detour with a traffic lane of not less than 3.5 m wide and shall keep it open to traffic. If construction work is proceeding at more than one location, the Contractor shall carry out his work so as to cause minimum obstruction and delay to traffic and shall be responsible for control of traffic using such detour lanes.

B.2 At locations where traffic is handled along single lane sections and whenever required by the Engineer, movement of the Contractor's equipment from one part of the Site to another shall be in accordance with the traffic regulations and by agreement with the concerned Authorities. Material spilt as a result of hauling operations along or across the highway shall be removed forthwith by the Contractor, failing which the Engineer shall arrange for its removal by others, at the Contractor's expense.

C. Half Width Construction of Highway

C.1 Where, in the opinion of the Engineer, construction of a detour is inappropriate, new construction shall be limited to half the highway width at a time.

C.2 Details of half width stretches and the timing of construction of each shall be included in the Contractor's Programme for execution of the Works.

C.3 Half width construction shall be kept to the minimum length possible.

6.07.3 DETOUR CONSTRUCTION AND MAINTENENCE

A. The Contractor shall submit to the Engineer for approval, details of the layout, pavement construction, drainage, lighting, signing and marking of any detours, which he proposes. He shall give the Engineer at least 7 day’s notice of such proposals.

B. The standard of construction of each temporary detour shall be adequate in all respects for the class of traffic that will use it. Any utilities located below the detour shall be properly protected. The width of any detour shall be not less than that of the existing highway (including sidewalks), which it replaces unless otherwise provided for. The minimum width shall be 10.5 m.

C. Detours shall be properly drained at all times.

D. The standard of lighting levels and uniformity for each detour shall be at least equivalent to that existing on the highway. In addition to lighting of detours, the Contractor shall provide and maintain illumination of all temporary traffic signs during the hours of darkness.

E. All detours shall be signed, marked and furnished with traffic signals conforming to the requirements of the CDR Safety, Health and Environmental Regulations and LIBNOR "Signalisation et Equipments de la Route", and as shown on the Drawings.

F Any obstruction associated with detours, including ramps, variations of lane widths, siting of warning signs, etc., shall be marked by the use of cones, flashing beacons and warning lamps, appropriate to the location concerned.

G. Detours shall be constructed in advance of the affected works.

H. The Contractor shall monitor and maintain detours, providing 24 hour cover to ensure that all signs, lighting and barriers are in place and functioning and that the road surfaces and rights of way are maintained at all times. He shall liaise with the emergency services in order to provide emergency call out facilities to effect repairs in the event of accidents.

I. Before any detour is opened to traffic, the Contractor shall obtain approval from the Engineer. The diversion of traffic on the day on which the detour is initially put into operation shall be carried out with the assistance and coordination of the Police Department.

6.07.4 REMOVAL OF DETOURS

A. General

A.1 The Contractor shall ensure the free movement of vehicular traffic prior to the removal of any temporary detour road.

A.2 Removal of temporary detours shall be carried out at times determined by the Engineer during construction and at the end of the Contract.

B. Detours Outside of the Right of Way

B.1 Unwanted pavement furnished for temporary detours outside the right of way shall be removed. Unsurfaced areas shall be backfilled and graded to levels to match the surrounding lands.

B.2 Grassed areas disturbed by the works shall be restored to their former condition after removing the temporary detours.

B.3 All facilities furnished for temporary detours, including barricades, barriers, traffic signs, flashing signal lights and unwanted lighting devices, shall be removed at the end of the Contract as directed by the Engineer.

C. Detours Inside the Right of Way

C.1 The Contractor shall arrange for the removal of all unwanted temporary detour items and facilities furnished inside the right of way at times approved by the Engineer and in line with the approved phased construction scheme.

6.07.5 MEASUREMENT

Works required for the construction of detours shown on the Drawings or ordered by the Engineer shall be measured and paid for in accordance with the applicable sections of the Specification and the pay items set for such works in the Bill of Quantities. Works required for the construction and removal of the detour but not listed in the Bill of Quantities shall not be measured for direct payment but shall be considered as subsidiary works the cost of which will be deemed to be included in the Contract prices for pay items.

SECTION 6.08 HIGHWAY SIGNING

6.08.1 SCOPE

A. The work covered in this Section consists of furnishing and installing all road signs complete with footings, bases, posts, and all other parts and appurtenances necessary for installation in accordance with this Specification and Drawings and as directed by the Engineer.

B. This section also covers furnishing and installing permanent regulatory overhead signs mounted on steel structures.

6.08.2 PRODUCTS

A. The Contractor shall submit a written request to the Engineer for approval of all traffic sign materials, giving makes, types and specification details, including samples of complete traffic signs, to be used in the Works.

B. The Contractor shall obtain approval of all sign materials before ordering any traffic signs.

6.08.3 MATERIALS

A. Concrete Bases (for Road Signs)

Sign base dimensions shall be as shown on the Drawings. Concrete shall be in accordance with the requirements of Section 5.01: Concrete, Materials and Testing using a 25 mm maximum aggregate size. The quality shall be that of reinforced concrete.

B. Reinforcement

Reinforcing steel shall conform to the relevant requirements of Section 5.03: Steel Reinforcement.

C. Bolts

Bolts, nuts and washers shall be of stainless steel conforming to ASTM A-276 chroming-nickel grade with a minimum yield strength of 2400 kg/cm^2.

D. Ordinary and Break-Away Posts (for Road Signs)

D1. Posts shall be manufactured from one of the following materials:

- Steel in the form of structural hollow sections or rolled steel joists hot-dip galvanized after fabrication. The weight of the zinc-coating shall be a minimum of 450 g/m^2.
- Aluminium in the form of drawn tubes complying with grades 6063 – TF or 6082 – TF of BS EN 573 or bars or extruded tubes or sections complying with grades 6063 – TF or 6082 – TF of BS 1474:1987

D2 . Posts shall have dimensions and thicknesses as shown and detailed on the Drawings The top of posts shall be closed or capped with a PVC cap.

E. Sign Plates

E1. Sign plates shall be constructed from one or more of the following materials: -

- Sheet aluminium and sheet aluminium alloy of minimum thickness 3.0 mm for flat plate (non bent edge) signs or 2.5 mm for bent- edged stiffened signs
- Extruded aluminium and extruded plank sections complying with grades HE-9TF, HE9-TE or HE 30-TF of BS 1474:1987. Planks shall have a maximum length of 4 m. 15 cm and 20cm wide planks shall have a minimum thickness of 2mm and 25 cm and 30 cm wide planks shall have a minimum thickness of 2.5 cm.

E2. All overhead sign plates and other signs with a face area of over 2 square metres shall be constructed from extruded aluminium in accordance with D2 above.

E3. Sign plates shall be non-porous, smooth, flat, rigid, weatherproof and shall not rust or deteriorate. They shall be cut and smoothed so that there are no sharp edges. The corners shall be rounded off to a minimum radius of 30 mm for road signs and 100 mm for overhead signs. Any trademark or other printing shall be carefully removed with a lacquer thinner.

6.08.4 SIGN SHEETING AND SIGN FACE CONSTRUCTION

A. The sign faces shall be made with wide angle reflective high intensity sheeting which shall be processed onto the plate. The manufacturer's trademark or name and sheeting grade shall be clearly shown as a non-removable built-in mark on the sheeting. Sheeting material shall be accompanied by a certificate of compliance listing its detailed specifications and identifying the standards to which it complies.

B. The base of the sign shall be of white, blue, green or yellow wide angle high intensity reflective sheeting or as described in the foregoing paragraphs. The particular sign message shall be as indicated on the Drawings or instructed by the Engineer.

C. Prior to the application of reflective film, the signs shall be cleaned and wax free. They shall be degreased by vapour or by alkaline immersion and etched by scrubbing with abrasive cleaners, such as medium fine steel wool. They shall be rinsed thoroughly and dried with hot air before applying any reflective material.

D. The sheeting shall be cut by a band saw or power guillotine. The cutting tool shall be clean and sharp. The sheeting shall be cut from face side and held securely during cutting to avoid shattering and edge chipping.

E. The sheeting after application to the sign base shall not come off the edges nor shall it peel off nor warp. The surface shall be smooth, flat and free from any bubbles, pimples, edge chipping or edge shattering. It shall be washable and weatherproof.

F. The sheeting of different reflective colours shall have a life of 10 years after application to the face of the sign.

G. This life of 10 years shall be the outdoor at-site life during which period it shall not fade in colour or its reflectivity, nor shall it deteriorate in any way.

H. The back face of the sign plate shall be treated and painted to the colour specified in the Drawings or by the Engineer so that the life of the two faces remains the same.

6.08.5 LETTERING

A. Sign lettering shall be in clear open letters of the English language, and in "Al-Naskh" script in Arabic language.

B. The Contractor shall comply with lettering scripts and dimensions as described in the LIBNOR Standard "Signalisation et Equipments de la Route" published by the Committee of Lebanese Norms.

6.08.6 LOCATION OF SIGNS

A. Signs shall be located as shown on the Drawings. These locations are subject to field adjustments by the Engineer. No sign shall be erected prior to the Engineer's final approval of the location.

6.08.7 EXISTING SIGNS

A. Where shown on the Drawings or ordered by the Engineer, the existing signs and, if so indicated, the sign structure shall be replaced or removed by the Contractor. Prior to any work, and immediately after the site submission, the Contractor shall prepare within two weeks a detailed inventory of existing erected signs showing their location, type, material, and physical condition. The Engineer shall revise and examine this inventory in order to determine whether existing signs shall be removed, relocated or replaced, either partially or entirely.

6.08.8 SIGN REMOVAL

A. Where shown on the Drawings or ordered by the Engineer, existing signs shall be removed by the Contractor. Where indicated, the Contractor shall remove concrete pedestals to a minimum of 15 cm below finished grade and backfill the hole to the satisfaction of the Engineer. Where the existing sign post is located within a sidewalk area, the Contractor shall remove the post and finish the area so as to make the sidewalk continuous. Signs plates, posts and metal structural members shall remain the property of the owner and shall be stockpiled, as specified by the Engineer, at the location designated by the owner. The Contractor shall dismantle all signs to leave them in a reusable condition.

6.08.9 SIGN REPLACEMENT

A. Where shown on the Drawings or ordered by the Engineer after his revision of the existing sign messages or layouts, the Contractor shall remove and reinstall sections or all of the existing sign or furnish and install new message components. Prior to installing the revised sign, the Contractor shall thoroughly clean the sign face and plug all existing rivet holes with aluminium blind rivets painted the same colour as the sign background. Modifications to the sign shall be completed during the same day in which work is commenced and while the sign is in place. All new materials necessary to accomplish this work shall be the same type and size as the existing components, and it shall be the Contractor's responsibility to verify such component type and size. Materials damaged by the Contractor shall be replaced at his own expense. Existing materials not reinstalled shall become the property of the owner and shall be removed from the project as directed by the Engineer.

6.08.10 SIGN RELOCATION

Where shown on the Drawings or as directed by the Engineer, the existing signs and the sign structures shall be relocated by the Contractor. Where the existing sign structure is mounted on concrete pedestals, the Contractor shall remove the pedestal to a minimum of 15 cm below finished grade, and backfill the remaining hole with material similar to that surrounding the hole. At the new sign location the Contractor shall provide the necessary materials, labour and hardware to erect and provide an operable unit to the satisfaction of the Engineer. All materials damaged by the Contractor shall be replaced at his own expense.

6.08.11 ERECTION OF SIGNS

A. All signs shall be mounted approximately at right angles to the direction of, and facing, the traffic they are intended to serve.

B. To get maximum effectiveness from reflecting sheeting, the sign shall be properly located and should be faced 3 degrees away from the road.

C. To avoid specular glare, the sign face shall be tilted back two or three degrees.

D. Signs shall be installed at the locations and in accordance with details shown on the drawings and in accordance with the approved samples and materials.

E. All sign components shall withstand a wind load of 150 kg per square metre of sign surface without permanent deformation. Sign plates not exceeding 1 m in width shall be supported on single posts. Sign plates exceeding 1 m in width shall be supported on double posts, with or without bracing.

F. Sign plates shall be attached to the posts with stiffeners, bolts, and screws which shall be painted in the same colour as the corresponding area of the sign plate.

G. For single post- mounted signs a locking pin shall be incorporated into the sign plate attachment system to prevent rotation of the sign plate around the axis of the post.

H. The exact location of the sign shall be designated by the Engineer.

I. Holes for posts shall be provided to a depth permitting the installation of the post and the base to the depth indicated on the Drawings or required by the Engineer. All loose material shall be removed from excavation and bearing surface of footings and the excavation shall be cleaned and cut to an even surface prior to the placement of concrete base. Approved backfill material shall be used. The adjacent surface shall be neatly graded and compacted.

6.08.12 GUARANTEE BY CONTRACTOR

A. All signs shall be guaranteed by the Contractor against any defect in material and workmanship for a period of 1 year from the date of completion of the Works under the Contract. If any defect should arise due to material or workmanship, it shall be rectified by the Contractor at his own expense.

B. If such a defect is rectified by other than the Contractor in accordance with the Employer’s instructions, the expense of such rectification shall be deducted from any monies due to the Contractor under the Contract.

C. Reflectivity of the signs shall be tested prior to the issue of the Certificate of Completion and again prior to the Issue of the Defects Liability Certificate. They shall also be assessed at any other time during the Defects Liability Period to ensure conformance with the manufacturers' specifications. The Contractor shall provide assistance in terms of traffic management provision and support labour, testing equipment and materials for the duration of testing when requested by the Engineer.

6.08.13 MEASUREMENT

A. Small signs (triangular, circular and rectangular signs up to 1 square metre in surface plate area) shall be measured by the number of such signs furnished and installed (excluding sign post supports) and accepted.

B. Rectangular and Trapezoidal Signs over 1 square metre in surface plate area and intended for ground mounting, shall be measured by the square metre of surface area furnished, installed (excluding sign post supports) and accepted. Each sign area shall be measured to the nearest 0.01 square metre.

C. Rectangular signs intended for mounting on overhead support structures, shall be measured by the square metre of surface area furnished, installed (including sign stiffening but excluding sign support brackets) and accepted. Each sign area shall be measured to the nearest 0.01 square metre.

D. Multiple Post Sign Support Assemblies and Breakaway Multiple Post Sign Support Assemblies shall be measured by the number of each type of such assemblies furnished, installed and accepted.

E. Overhead Sign Support Structures (sign gantries and cantilever) shall be measured by the number of each type and size of such structures furnished, installed (including sign support brackets but excluding sign panels and stiffening) and accepted.

F. Removal and stockpiling of existing signs shall be measured by the number of signs and supports dismantled and transported to a location specified in the Contract or instructed by the Engineer. The rate shall include covering or disposal off site of the post foundations and reinstatement of the post foundation excavation all as specified in the Drawings or instructed by the Engineer.

G. Relocation of existing signs shall be measured by the number of signs and supports re-erected at the location specified in the Contract or instructed by the Engineer. The rate shall include dismantling the sign from its original location, transportation and temporary storage, covering or disposal off site of the existing post foundations and reinstatement of the post foundation excavation as specified in the Drawings or by the Engineer, repairs to and rehabilitation of the existing sign plate, posts and mountings, replacement of defective components, the volume of concrete specified in bases installed and accepted and all equipment, labour, tools and incidentals necessary to complete the item.

H. Illumination of signs shall be measured separately as prescribed in Section 7.09: Sign Illumination.

I. Excavation, backfilling, concrete, reinforcement and other ancillary items shall not be measured for direct payment, but shall be considered as subsidiary work, the costs of which will be deemed to be included in the Contract prices for the Pay Items.

SECTION 6.09 ROADWAY MARKINGS

6.09.1 SCOPE

A. The work covered in this Section consists of the furnishing and application of traffic markings to highway pavements for the guidance, control and safety of vehicular and pedestrian traffic.

B. White and yellow painted markings shall include centrelines, lane lines, border (edge) lines, pedestrian crossing lines, stop lines, chevron striping (at gore areas), directional arrows, lettering, and symbols using the following materials as appropriate and as shown on the Drawings.

- Thermoplastic Reflectorized Paint (TRP)
- Reflectorized Cold Paint (RCP)
- Preformed Reflectorized Thermoplastic Film

C. Cold paint applications shall be used for the following, or as indicated on the Drawings:

- For all markings on roads with slow moving traffic (design speed less than 30 kph).
- For markings on existing road pavements over one year old
- On roads in areas over 1200 metres above sea level, that are regularly snow-ploughed in winter.
- For temporary road markings
- For yellow painted curbs adjacent to the pavement edge where parking is prohibited.
- On bituminous speed bumps

D. Preformed, reflectorized, thermoplastic film shall be used where appropriate and as shown on the Drawings or as instructed by the Engineer.

6.09.2 MATERIALS

6.09.2.1 Thermoplastic Reflectorized Paint (TRP)

A. TRP shall consist of a homogenous mixture of thermoplastic binder, white or yellow pigment, glass reflectorizing spheres and filler that is to be applied to the pavement in a molten state by mechanical means. Upon cooling to normal pavement temperature, this material shall produce an adherent, reflectorized paint line of specified thickness capable of resisting deformation.

B. White and yellow TRP shall conform to AASHTO M-249, except where stated otherwise in paragraphs C to D below.

C. For thin lines (1.2 mm thick or less) the minimum TiO_2 content of the mix shall be 10%. For other lines and markings with thicknesses over 1.2mm the minimum TiO_2 content shall be 6%. In either case, daylight luminescence immediately after application shall be 75% minimum.

D. Pre-mixed glass spheres shall occupy a minimum of 30% by weight of the TRP for thin lines (1.2 mm thick or less) and 20% for thick lines. In any case night time retroreflectivity shall be at one year of age not less than 150 mcd/ lux sq. m. mixture and shall conform with the following requirements: -

D1. Crushing Resistance: An 18 kg dead weight for No. 20 to No. 30 mesh spheres shall be the average resistance when tested in accordance with ASTM D-1213.

D2. Roundness: A minimum of 75% shall be true spheres when tested in accordance with ASTM D-1155. Not less than 70% of the spheres of each sieve size shall be free from imperfections of all types, including film, scratches, pits, clusters, and opaqueness.

D3 . Index of Refraction: The spheres mixed into the material shall have a minimum index of refraction of 1.65 when tested by the liquid immersion method at 25 degrees C, and the spheres automatically applied to the surface of the TRP line shall have a minimum index of refraction of 1.5.

D4. Gradation: When tested in accordance with ASTM D-1214, the spheres used in the TRP shall have the following gradation:

Standard Sieve Size	**% Passing by Weight**
1.70 mm (No. 12)	100
0.180 mm (No. 80)	0 – 5

D5. Chemical Resistance: The glass spheres shall withstand immersion in water and acids without noticeable corrosion or etching, and shall not be darkened or otherwise decomposed by sulphides. A 3 to 5 gm sample shall be placed in each of 3 glass beakers or porcelain dishes, one covered with distilled water, the second with a 3 N solution of sulphuric acid and the third with a solution of 50% sodium sulphide, 48% distilled water and 2% aerosol 1B or similar wetting agent. No darkening, hazing, or other evidence of instability shall be noticeable in the glass spheres when examined microscopically, after one hour immersion.

D6. Silica Content: The silica content (SiO2) of the spheres shall be 60% plus or minus 5% when tested in accordance with Federal Test Method 141a.

6.09.2.2 Cold Paint

A. Traffic Paint shall consist of a ready mixture of binder, white or yellow pigment, and filler specifically compounded for cold application and adhesion to finished paved areas. Paint shall be reflectorized by adding reflective spheres before the film dries or sets, using drop-on or pressurized methods.

B. Reflectorized white and yellow cold applied traffic paint shall conform to AASHTO M-248, Type F. The surface application of glass spheres shall conform to AASHTO M 247, Type I.

6.09.2.3 Preformed Thermoplastic Reflectorized Film

A. Preformed thermoplastic reflectorized film shall be homogenous, extruded prefabricated white or yellow, of the specified shape and capable of being affixed to bituminous or cement concrete surfaces. It shall contain reflective glass spheres uniformly distributed and bonded to the top surface of the material. The film shall be weather resistant and shall not show any appreciable fading, lifting, shrinkage, significant tearing, roll back or other signs of poor adhesion throughout its design life.

B. The thermoplastic film without adhesive shall be a minimum of 1.5 mm thick.

C. The film as supplied shall be of good appearance, free from cracks and discolorations and the edges shall be clean cut and well defined. It may be supplied complete with a precoated factory-applied, pressure sensitive adhesive backing with a protective release paper or with separate adhesives as recommended by the manufacturer.

D. The adhesive shall allow the plastic film to be repositioned on the pavement surface to which it is to be applied before permanently fixing it in its final position.

E. The preformed thermoplastic film shall consist of the following: -

	Minimum % by Weight
Polymeric resins and plasticizers	20
Pigments	30
Reflective glass spheres	20

F. The pigments shall be selected and blended to provide a white or yellow marking film which conforms to standard highway colours throughout the design life of the film.

G. The plastic film shall be sufficiently flexible so that a temperature of 26 – 28^{o}C an unmounted piece of material (without adhesive and paper backing) 75 mm by 150 mm, may be bent over a 25mm mandrel until the end faces are parallel and 25 mm apart without showing any fracture lines in the uppermost surface.

H. The plastic film (without adhesive and paper backing) shall have a minimum tensile strength of 0.6 kg/ sq. cm when a specimen 150 mm by 25mm is tested in accordance with the requirements of ASTM D 638. The rate of pull of the test shall be 6 mm/ minute. The test shall be conducted at a temperature of 21 – 27^{o}C. The elongation shall be no greater than 75%.

I. A 150 mm long by 25 mm wide section of the plastic film (without adhesive and paper backing) shall support a dead weight load of 1.8 kg for not less than 5 minutes at a temperature of 21 – 27°C.

J. The plastic film shall have a maximum loss in weight of 0.25 grammes in 500 revolutions when abraded according to Federal Test Method Standard No. 141, Method 6192, using H-18 calibrated wheels with a 1,000 gram load on each wheel.

6.09.3 APPLICATION AND INSTALLATION

A. Equipment for Marking

A1. The equipment used for pavement marking shall consist of truck-mounted units, motorized equipment or manually operated equipment, depending on the type of markings required. The truck-mounted or motorized unit for centrelines, lane lines, and edge lines shall consist of a mobile, self-contained unit carrying its own material and capable of operating at a maximum speed of 10 km/h while applying paint. The hand application equipment shall be sufficiently manoeuvrable to install centrelines, lane lines, edge lines, gore striping, turn lines, crosswalks, stop lines, kerb lines, arrows and legends.

A2. Spraying equipment shall be capable of satisfactorily applying the paint under pressure with a uniformity of feed through nozzles spraying directly on the pavement. Each paint tank shall be equipped with cut-off valves which will enable broken (skip) lines to be sprayed automatically. Each nozzle shall have a mechanical bead dispenser that will operate simultaneously with the spray nozzle and distribute the beads in a uniform pattern at the rate specified. Each nozzle shall also be equipped with suitable line guides and shall provide a method for cleaning the surface of dust just prior to paint application.

A3. The spray machine for application of reflectorized paint lines and other markings shall have an attachment to accurately regulate the rate of application and a tachometer or other approved device to ensure uniform paint application at the designated rate. It shall be adjustable to ensure the painting of one or two adjacent lines simultaneously along the centreline. The paint shall be properly agitated while in operation.

A4 . Equipment for application of thermoplastic reflectorized paint lines and other markings shall deposit the plastic material in a hot molten state on the pavement, italicising either an extrusion or spray method. Equipment shall be capable of providing continuous mixing and agitation of the material which will be maintained at the correct application temperature. The use of direct flame heat shall not be permitted.

A5. An automatic glass sphere dispenser with a synchronized automatic cut-off shall be attached to the applicator machine. The dispenser shall utilize pressure type spray guns which will embed the spheres into the surface to at least 0.5 times the sphere diameter. The dispenser shall also be equipped with an automatic cut-off synchronized with the cut-off of the thermoplastic material.

A6. Hand equipment shall be used only for painted markings, including arrows, pedestrian crossings, stop lines symbols, legends, kerb lines and short sections of linear markings where the use of motorised equipment is not practical. The hand equipment shall be capable of holding a minimum of 25 kg and not more than 100 kg of molten material unless otherwise agreed with the Engineer.

A7. Pre-melting equipment shall provide for continuous mixing and indirect oil jacket heating of the material. Heating by direct flame shall not be permitted. The heating equipment shall be of such capacity to maintain the thermoplastic at the required temperatures as specified by the supplier. It shall be thermostatically controlled and fitted with safety devices ensuring combustion cut-off in case of defects.

A8. Equipment for the application of thermoplastic shall have a material tank to the specification in A7 above. Spray application equipment shall have a pressurised tank and shall be fitted with a low pressure spray system. All spray lines and appurtenances leading from the heated pressure tank to the spray nozzle shall be fully insulated or suitably heated to allow the heated material to leave the spray gun at a minimum temperature of 225^{o}C. Spray equipment shall have a low pressure spray system and screed equipment shall allow continuous control of line thickness regardless of speed. All spray lines and appurtenances leading from the heated pressure tank to the spray nozzle shall be fully insulated and/ or suitably heated to allow the heated material to leave the spray gun at the required temperature. Screed and spray line laying equipment shall be designed to simultaneously apply reflective glass beads in synchronisation with the thermoplastic material.

A.9 Preformed reflectorized thermoplastic film for traffic markings shall be applied by manual or machine methods consistent with the type of markings and with the approval of the Engineer.

B. Setting Out and Pavement Preparation

B1. The Contractor shall set out all control points necessary for locating paint lines and markings. On irregular widths of highway, the locations of border (edge) lines shall be adjusted to provide a smooth alignment on the pavement surface. The locations of all painted markings and each location for raised pavement markers and studs shall be accurately established and shall be subject to approval by the Engineer before application and installation commence. Markers and studs shall not be located over longitudinal or transverse pavement joints.

B2 . The area of highway surface on which markings are to be applied shall be free of dirt, existing paint lines if directed, curing compound, grease, oil, moisture, loose or unsound layers, and any other material which could adversely affect the bond. The area shall be thoroughly cleaned (by sweeping and air blasting as necessary) to the satisfaction of the Engineer before proceeding with painting.

B3. Pavement marking shall not proceed when there is moisture on the pavement surface or the air is misty, or the surface temperature of the pavement is below 10°C; or when wind or other conditions may cause a film of dust to be deposited

on the surface, or in other conditions that, in the opinion of the Engineer, could displace, damage, or adversely affect the bonding of the material to the pavement surface. Any markings damaged due to water or rain or suffering from lack of adhesion through any cause shall be removed and replaced at the Contractor's expense.

C. Thermoplastic Reflectorized Paint (TRP) Application

C1. To ensure optimum adhesion, the thermoplastic paint shall be applied in a molten state within the temperature range recommended by the manufacturer.

C2 Thermoplastic painted markings may be applied by screed or spray to the following minimum thicknesses or as specified on the Drawings. Unless stated on the Drawings or elsewhere in the Contract Documents, the Engineer shall confirm the bi-directional daily traffic figures.

Method of Application	**Bi- Directional Daily Traffic (PCU per Day)**		
	<20000	**20000-60000**	**60000>**
Screed	2mm	2.5mm	3mm
Spray*	2mm	2.5mm	3mm

* In two or more applications

C3. The completed lines shall have a continuous and uniform cross-section, and shall have clean, sharp edges. The width of paint line specified shall be applied in one application.

C4. Reflective beads shall be applied before the thermoplastic material has set by the automatic glass sphere dispenser attached to the painting machine. The sphere dispenser shall embed at least 65% the sphere diameter into the surface. The application rate of spheres shall be a minimum of 0.3 kg/sq. m.

D. Cold Paint Application

D1. Cold paint shall be applied in 2 passes with a minimum of six weeks between each pass.

D2. A glass sphere top dressing shall be applied to the both paint applications immediately after it has been placed by the automatic glass sphere dispenser attached to the painting machine. The sphere dispenser shall embed at least 65% of the sphere diameter into the surface. The application rate of spheres shall be a minimum of 0.3 kg/sq. m.

D3. The markings shall be protected for a minimum of 20 minutes (or longer if necessary according to the manufacturer's recommendations) to allow for drying and curing of the paint.

E. Kerb Paint Application

E1. The paint shall be sprayed to cover entirely the kerbstone between the pavement edge and tile edge (25 to 35 cm width depending on the existing condition of the kerb). Areas adjacent to those to be painted shall be protected and covered during paint application. The surface of the kerbstone shall be free of dirt, grease, oil, moisture loose or unsound layers and any other material which could adversely affect the bond or the colour. The area shall be thoroughly cleaned to the satisfaction of the Engineer before proceeding with painting.

F. Protection of Markings

F1. Immediately following the application of paint lines and other markings on pavements open to traffic, traffic cones or other approved devices shall be placed alongside or over the paint at intervals not exceeding 10 metres and shall remain in place until the paint has dried.

F2. Traffic shall be prevented from crossing wet paint lines and the Contractor shall use sufficient numbers of flagmen, barricades, or other protection, particularly at crossings, to prevent traffic from crossing wet paint. Sections of paint which have been damaged by traffic before the paint has cured, shall be repaired and the pavement outside the painted area cleaned at the Contractor's expense.

F3. Temporary barricades and signs as specified, or required by the Engineer, shall be erected at the beginning and end of the highway section on which the Contractor proposes to apply paint markings or install markers or studs. On completion, the temporary barricades and cones shall be moved ahead to the next section. Barricades and cones shall not be left in place overnight. The equipment shall be operated that it will be unnecessary for public traffic to cross the newly placed material behind the equipment in order to safely pass the equipment.

F4. Protective and traffic warning devices shall be approved by the Engineer before any placement.

G. Tolerances and Finish

G1. A tolerance of 12 mm over or 3 mm under the specified line width shall be allowed, provided the variation is gradual and does not detract from the general finished appearance of the line. Segments of broken line may vary up to 30 mm from the specified length. Segments shall be square at each end without mist or distortion. Deviations from the control line of up to 25 mm on tangents and 50 mm on curves shall be accepted, provided the deviation does not increase or decrease at a rate of more than 15 mm in 10 m. Lines that do not meet these tolerances shall be removed and replaced at the Contractor's expense.

G2. When it is necessary to remove paint, this shall be carried out using a method satisfactory to the Engineer and shall not damage the underlying pavement surface. When it is necessary to correct a deviation which exceeds the permissible tolerance in alignment, the affected length of line shall be removed plus an additional 5 metres in each direction, and a new line painted.

G3. All pavement markings shall maintain a minimum retro-reflectivity of 100 millicandellas up to the end of the defects liability period following completion of the final application of paint.

6.09.4 SAMPLING AND TESTING

A. All material shall be shipped to the job site in undamaged, sealed original packaging, clearly identifying each material by name, colour, manufacturer, batch number and date of manufacture. All material shall be accompanied by certified test results verifying compliance with all specified physical and chemical requirements conforming to latest versions of AASHTO M-247, M-248 and M-249. The Contractor shall be fully responsible for providing all materials conforming to the required specifications.

B. All paint products and other materials designated by the Engineer shall be available for testing. Sampling shall be performed by the Contractor in the presence of the Engineer. Materials shall be sampled in their original containers and the containers resealed as approved by the Engineer. All samples shall be packaged for shipment as approved by the Engineer. Samples shall be transported to an independent laboratory as directed and approved by the Engineer. Paint materials shall not be used until approved by the Engineer.

C. If instructed by the Engineer, the Contractor shall install, at his own expense, at a designated test site, strips of samples of materials proposed for all types of pavement markings for verification and testing for compliance with the Specifications.

D. The following road stripe and marking characteristics shall be tested prior to the issue of the Certificate of Completion and again prior to the Issue of the Defects Liability Certificate. They may also be assessed at any other time during the period from the application of test markings to the end of the defects liability period:

- Reflection in daylight or under road lighting
- Retroreflection under vehicle headlamp illumination
- Colour (luminance and/or chromaticity)
- Skid resistance

E. The Contractor shall provide assistance in terms of traffic management provision and support labour, testing equipment and materials for the duration of testing as and when requested by the Engineer.

6.09.5 GUARANTEE BY CONTRACTOR

A. All marking and painting shall be guaranteed by the Contractor against any defect in material, workmanship, performance during the whole defect liability period. If any defect should arise due to material or workmanship, it shall be rectified by the Contractor at his own expense.

B. If such a defect is rectified by other than the Contractor the expense of such rectification shall be deducted from any monies due on this Contract.

C. The Contractor shall furnish copies of manufacturers' warranties and guarantees.

6.09.6 TYPES OF PAVEMENT MARKINGS

A. Continuous White Line (Type MR1)
A continuous longitudinal white line 20 cm wide

B. Continuous White Line (Type MR1-A)
A continuous longitudinal white line 15 cm wide.

C. Emergency Stop Lane Line (Type MR1´)
A broken longitudinal white line 20cm wide. The broken or "skip" pattern shall be based on 48.0 m unit consisting of 36 m line and 12 m gap.

D. Continuous Yellow Line (Type MR2 and MR2-A)
A continuous longitudinal yellow line, 20 cm wide.

E. Continuous Double Yellow Line (Type MR2-2)
Two continuous longitudinal yellow lines, each 20 cm wide, separated by a 10 cm space.

F. Broken White Line (Type MR3)
A broken longitudinal white line, 15 cm wide. The broken or "skip" pattern shall be based on 6 m unit consisting of 4m line and 2 m gap.

G. Broken White Line (Type MR3')
A broken longitudinal white line, 25 cm wide. The broken or "skip" pattern shall be based on a 5.33 m unit consisting of 4m line and 1.33 m gap.

H. Broken White Line (Type MR3A)
As Mr3 but with a width of 12 cm.

I. Broken White Line (Type MR3'-A)
As Mr3 but with a width of 20 cm.

J. Double Broken White Line (Type MR3A – 3A)
Two broken longitudinal yellow lines, each 12 cm wide and 10 cm apart. The broken or "skip" pattern shall be based on 6 m unit consisting of 4m line and 2 m gap.

K Broken White Line (Type MR3'- B)
A broken longitudinal white line, 20 cm wide. The broken or "skip" pattern shall be based on a 4 m unit consisting of 3 m line and 1 m gap.

L. Broken White Line (Type MR4)
A broken longitudinal white line, 15 cm wide. The broken or "skip" pattern shall be based on a 16 m unit consisting of 4m line and 12 m gap.

M. Broken White Line (Type MR5)

A broken longitudinal white line, 12 cm wide. The broken or "skip" pattern shall be based on a 12 m unit consisting of 3 m line and 9 m gap.

N. Broken White Line (Type MR5-A)
A broken longitudinal white line, 20 cm wide. The broken or "skip" pattern shall be based on a 6 m unit consisting of a 1.5m line and 4.5 m gap.

O. Broken White Line (Type MR5 - 5)
Two broken longitudinal yellow lines, each 12 cm wide. The broken or "skip" pattern shall be based on a 12 m unit consisting of 3 m line and 9 m gap.

P. Broken White Line (Type MR6)
A broken white line, 20 cm wide. The broken or "skip" pattern shall be based on a 6 m unit consisting of 3 m line and 3 m gap.

Q. Broken White Line (Type MR6 - A)
A broken longitudinal white line, 25 cm wide. The broken or "skip" pattern shall be based on an 8 m unit consisting of 4 m line and 4 m gap.

R. White "Stop" Line (Type MR7)
A transverse solid white line, 50 cm wide.

S. Broken White "Give Way" Line (Type MR8)
A transverse broken white line, 40 cm wide. The broken or "skip" pattern shall be based on a 1 m unit, consisting of a 0.5 m line and a 0.5 m gap.

T. Broken White Line (Type MR9)
A transverse broken white line, 15 cm wide used transversely to delineate the stopping point at traffic signals. The broken or "skip" pattern shall be based on a 1 m unit, consisting of a 0.5 m line and a 0.5 m gap.

U. Broken White Line (Type MR9 -A)
A transverse broken white line, 10 cm wide used at junctions, crossroads and roundabouts. The broken or "skip" pattern shall be based on a 1 m unit, consisting of a 0.5 m line and a 0.5 m gap.

V. Continuous White Line (Type MR10)
A continuous longitudinal white line 12 cm wide.

W. Continuous Double Yellow Line (Type MR10 -10)
Two continuous yellow lines, each 12 cm wide, separated by a 10 cm space.

X. Continuous Mixed Yellow Line (Type MR10 – 3A)
Two longitudinal yellow lines, both 12 cm wide, one continuous and the other based on a 4.5 m unit , consisting of a 3 m line and a 1.5 m gap.

Y. Continuous Yellow Line (Type MR11)
A continuous longitudinal yellow line 12 cm wide. SOLID WHITE line, 40 cm wide unless noted otherwise in the Drawings.

Z. Continuous White Line (Type MR12)
A continuous longitudinal white line 25 cm wide.

AA. Traffic Arrow
A white marking conforming to details shown on the Drawings.

BB. Pedestrian Crossing
50 cm x 300 or 400 cm white lines, with 50 cm gaps between them, as shown on the drawings.

CC. Gore Stripes {Chevrons}
A solid white line, 50 cm wide, used to delineate turn lanes from through lanes, for traffic islands, and for hash marks, and shall be as shown on the Drawings.

6.09.7 MEASUREMENT

Painted Pavement Lines and Painted and Preformed Film Markings shall be measured by the square metre of painted area furnished for each application, applied, cured and accepted.

Painted Kerbstones shall be measured by the linear metre of kerb painted, cured and accepted.

SECTION 6.11 SPEED BUMPS AND RUMBLE STRIPS

6.11.1 SCOPE

Thee work covered in this section includes furnishing materials for and The construction of speed bumps, concrete rumble strips, ceramic marker rumble strips and scored shoulder rumble strips at the locations shown on the Drawings.

6.11.2 MATERIALS

A. Tack Coat
Liquid asphalt for tack coat shall be rapid curing type cutback grades RC-250 or RC-3000 as directed, and shall conform to the relevant requirements of Section 4.02: Bituminous Prime and Tack Coats.

B. Bituminous Mix
The bituminous mix for speed bumps shall conform to the relevant requirements of Section 4.03: Bituminous Binder and Wearing Courses for a wearing course mix unless otherwise shown on the Drawings.

C. Concrete
Unless otherwise shown on the Drawings, Portland cement concrete, for concrete rumble strips shall be Class 210/20 and shall conform to the relevant requirements of Section 5.01: Concrete Mixes and Testing.

D. Reinforcement
Steel mesh for concrete rumble strips shall be of the sizes shown on the Drawings and shall conform to the relevant requirements of Section 5.03: Steel Reinforcement.

E. Ceramic Raised Pavement Markers
Ceramic raised pavement markers for rumble strips shall be of the size shown on the Drawings. Ceramic markers and the epoxy adhesives shall conform to the relevant requirements of Section 6.10: Raised Pavement Markers.

F. Reflective Paint
White reflectorized paint (RP) used to distinguish the speed bumps shall conform to the relevant requirements of Section 6.09: Roadway Markings.

6.11.3 CONSTRUCTION AND INSTALLATION

A. Speed Bumps

A.1 Prior to the application of the tack coat, the bituminous surface shall be cleaned free of all dirt, dust and other foreign substances which, in the opinion of the Engineer, would prevent proper bonding of the tack coat.

A.2 Immediately after the surface has been cleaned and approved by the Engineer the tack coat shall be applied by pressure distributor, or by hand-spraying

equipment which shall achieve a uniform mist type coverage without blotches or streaks. The rate of application shall be between 0.2 and 0.3 litres per square metre unless otherwise required by the Engineer.

A.3 When the tack coat has set and has been approved by the Engineer, the Contractor shall place the speed bump form in position. The hot bituminous mix shall be placed in the forms and consolidated by hand flush with the top of the form.

A.4 After the bituminous mix has been placed in the form and consolidated, the form shall be carefully lifted and removed and rolling operations shall commence. Rolling shall be performed with a suitable type of pneumatic roller initially travelling parallel to the roadway centreline and finally at right angles to the centreline until the speed bump is compacted to the required cross section. The height of speed bumps above the pavement surface shall not exceed 100mm.

A.5 The finished surface of the speed bump shall be painted with white reflectorized paint in accordance with the relevant requirements of Section 6.09 - Roadway Markings.

B. Concrete Rumble Strips

B.1 Concrete rumble strips shall be installed after completion of the bituminous wearing course. Locations shall be marked as shown on the Drawings or as ordered by the Engineer. Saw cutting shall be performed to a minimum depth of 200 mm. Underlying subgrade or base material shall be compacted to 100% AASHTO TI80 maximum density and moistened immediately prior to placing of concrete.

B.2 Concrete shall be placed, vibrated and screeded in accordance with the relevant requirements of Section 5.05: Concrete Pavement. Machine placing and finishing is not required. The installation shall be checked with a full width straightedge before texturing.

B.3 Immediately after initial texturing, the rumble texture shall be achieved using a template which shall produce the size, shape and pattern of scalloped depressions shown on the Drawings. Depression moulds shall be vibrated or forced into the surface of the fresh concrete. The template shall form uniform depressions 20 mm to 30 mm deep, and 75 mm between peaks.

B.4 Moulds shall be withdrawn on completion without damaging the edges of the depression. The Contractor shall periodically check the top surface of the concrete with a straightedge and ensure the template is not displacing the concrete.

B.5 Concrete edges shall be properly finished and the concrete shall be cured in accordance with the relevant requirements of Section 5.02: Concrete Handling, Placing and Curing. If a curing compound is approved for use, additional care shall be taken to ensure that all vertical surfaces of depressions are adequately coated.

C. Ceramic Marker Rumble Strips

Raised ceramic pavement markers for rumble strips shall be installed in the appropriate geometric patterns as shown on the Drawings and in accordance with the relevant requirements of Section 6.10: Raised Pavement Markers.

D. Scored Shoulder Rumble Strips

D.1 Scored shoulder rumble strips shall consist of a series of depressions as shown on the Drawings, extending transversely across the paved shoulder, except for a 300 mm strip adjacent to the travelled way and a 300 mm strip at the outside edge. Each depression shall be the shape of a semi-circular cylinder of 25 mm diameter. Depressions shall be 10 mm to 15 mm deep and spaced 0.2 m or 0.25 m apart longitudinally.

D.2 Scored shoulder rumble strips shall be installed to the required dimensions using a specially constructed steel wheel roller with ridges added to the roller drive drum of the length, spacing, and cross section appropriate to the required scoring.

D.3 Rolling of the depressions shall be performed in lieu of, or immediately following, breakdown rolling of the bituminous shoulder material. The Contractor shall select the weight and sequence of rollers to achieve the required depressions and the required density of the finished pavement.

D.4 The required minimum density of the bituminous course used for the shoulders shall be compatible with the construction of the scored shoulder rumble strips.

6.11.4 MEASUREMENT

A. Bituminous Speed Bumps, Concrete Rumble Strips, and Scored Shoulder Rumble Strips shall be measured by the square metre of each type constructed, completed, and accepted.

B. Ceramic Marker Rumble Strips shall be measured by the number of ceramic raised pavement markers; furnished, installed, completed, and accepted.

C. Unless shown as Pay Items in the Bills of Quantities, all other Works prescribed in this Section shall not be measured for direct payment, but shall be considered as subsidiary works the costs of which will be deemed to be included in the Contract prices for Pay Items.

SECTION 6.13: STEEL GUARDRAILS AND CONCRETE SAFETY BARRIERS

6.13.1 SCOPE

The work covered in this Section consists of the furnishing, construction and erection of steel guardrails, concrete barriers, impact attenuators and glare screens as and where shown on the Drawings.

6.13.2 MATERIALS

A. Metal Beam Guardrail

A.1 The Contractor shall construct all guard rails complete with posts as shown on the Drawings, in accordance with these specifications and in conformity with the lines and grades as directed by the Engineer. The Contractor shall submit to the Engineer for his review and approval shop drawings complete with all details of the type of corrugated steel beams and rails he proposes to use on this project.

A.2 Rail elements and backup plates for W-Beam rail shall conform to AASHTO M180, Class A type 2 galvanized. Rail elements for triple corrugated beam rails used in **Guard Rail Energy Absorbing Terminal** (**G.R.E.A.T**.) proprietary impact attenuators shall conform to AASHTO M180, Class B, Type 2 galvanized. Rail element joints shall be fabricated to lap by not less than 300 mm and be bolted.

A.3 Galvanized beam elements and end sections shall be marked at the point of fabrication with the manufacturer's name or trademark, gauge or thickness and with the coating date or coating lot reference. Each reference shall be readily identified. The identification markings shall be placed where they will not be obscured by posts or laps after erection. No markings, except die stamping approved by the Engineer, shall be placed on the traffic face of the beam. Marking materials used shall resist obliteration during handling.

A.4 All galvanized materials for guardrail shall be carefully handled to avoid damage to surfaces. Any galvanized material on which the smelter coating has been bruised or broken shall be rejected or repaired by a method approved by the Engineer.

A.5 The Contractor shall furnish the Engineer with the manufacturer's certification (Certificates of Guarantee) in triplicate, which states that the materials supplied conform to the requirements of these Specifications. The certification shall include, or have attached, specific results of laboratory tests for specified physical and chemical properties as determined from representative samples of the material which verify conformance to the specifications. The Engineer shall check at random weights and characteristics of guard rail elements for correct conformance. This testing shall be at the expense of the Contractor.

A.6 Rail metal shall withstand a cold bend without cracking of 180 degrees around a mandrel of a diameter equal to 2.5 times the thickness of the sheet metal plate.
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A.7 Rail elements to be erected on a radius of 45 m or less shall be shaped in the shop. The radius of curvature shall be stencilled on the back of each section of rail.

A.8 Rail elements shall be designed to be spliced at intervals not exceeding 4 metres and such splices shall be made at posts, unless otherwise shown on the Drawings.

B. Box Beam Guardrail

B.1 Box beam guardrails shall be hot-formed welded and seamless carbon steel structural tube or cold-formed welded. Posts, splice tongues and plates shall conform to ASTM A 36. Rails shall conform to ASTM A 500, Grade A or B, or ASTM A 501.

B.2 Mill transverse welds shall not be permitted on rail sections. Longitudinal welds shall be made by the resistance, gas shielded arc, submerged arc or plasma arc welding processes and shall be sound, free from defects and shall not be repaired. The welded joint in cold and hot-formed welded rails shall have a minimum tensile strength specified for the railing when subjected to the tensile strap test specified in ASTM E8M (metric).

B.3 Rail sections for tangent runs shall be not less than 6 metres in length. Rail splices shall be a minimum of 400 mm from the centreline of any post.

C. Wire Rope

C.1 Wire rope for cable guardrail, cable guardrail anchor terminals and metal beam guardrail anchor terminals shall conform to AASHTO M 30, Type II, Class A. Equivalent galvanized wire rope with a minimum breaking strength of 19,400 kg shall be acceptable, if approved by the Engineer.

C.2 Wire rope restraining cable for G.R.E.A.T. Hi-Dro and Hi-Dri impact attenuators shall be minimum 22 mm nominal diameter galvanized wire rope conforming to ASTM A 603, Class A.

C.3 Pull-out and secondary cable for Hi-Dro and Hi-Dri impact attenuators shall be minimum 9.5 mm nominal diameter galvanized wire rope conforming to ASTM A 603, Class A.

D. Pedestrian Guardrail

Pedestrian Guardrail shall be welded structural hot dipped galvanized steel complying with the requirements of AASHTO M 232 (ASTM A 153) zinc coating (hot dip) on iron and steel hardware.

E. Posts and Miscellaneous Hardware

E.1 Unless otherwise shown on the Drawings, all steel posts, plates, angles, channels, brackets and anchor assembly units shall conform to ASTM A 36. Cold rolled post sections shall conform to ASTM A 446, Grade B.

E.2 The swaged fittings for anchor terminals shall be machined from hot-rolled carbon steel conforming to ASTM A 576, Grade 1035 and shall be annealed using a method suitable for cold swaging. A lock pinhole shall be drilled through the swage fitting head to accommodate a 7 mm, plated, spring steel pin to retain the stud in the correct position. The stud shall be steel conforming to ASTM A 449. Prior to galvanizing, a 10 mm slot for the locking pin shall be milled into the stud end. The swaged fitting, stud and nut shall develop the full breaking strength of the wire cable.

E.3 Anchor rod eyes shall be hot forged or formed with full penetration welds. After fabrication, anchor rods with eyes that have been formed with any part of the eye below 870 ^{o}C during the forming operation or with eyes that have been closed by welding shall be thermally stress relieved prior to galvanizing. The completed anchor rod, after galvanizing, shall develop a strength of 23,000 kilograms.

E.4 Clevises shall be drop forged galvanized steel and shall develop the full specified breaking strength of the wire cable.

E.5 The concrete insert assembly for Type 4 anchor terminals (beams of corrosion resistant steel - AASHTO M180) shall be fabricated as shown on the Drawings. Ferrules shall be steel conforming to ASTM A 108, Grade 12 L 14. Inserts shall be tapped to the dimensional requirements specified in ASTM A 563 for nuts receiving galvanized bolts. Insert assembly wires shall conform to ASTM A 510, Grade 1030, and have a minimum tensile strength of 686 MN/m^2 (7,000 kg/cm^2). Welded attachments of wires to ferrules shall develop the full tensile strength of the wire.

E.6 Turnbuckles shall be steel of commercial quality and shall have a minimum breaking strength of 1,500 kilograms. Turnbuckles shall be galvanized in accordance with ASTM A 153. Compensating and non-compensating cable ends shall be cast steel conforming to ASTM A 27 or malleable iron conforming to the requirements of ASTM A 47M (metric). Compensating devices shall have spring constants of 8,000 kg/m plus or minus 500 kg/m and permit a travel of 150 mm plus or minus 25 mm. All elements shall be galvanized.

E.7 Cable connecting hardware shall develop the full strength of the wire rope. At all locations where the cable is connected to a cable end with a wedge type connection, one wire of the wire rope shall be crimped over the base of the wedge to hold the cable firmly in place.

E.8 Restraining chains for G.R.E.A.T. impact attenuators shall be 12 mm nominal size and shall conform to ASTM A 413, Grade 28.

F. Glare Screens

F.1 Glare screen fabric shall be chain link mesh conforming to ASTM A 491 or ASTM A 392. Mesh sizes and wire diameters shall be as specified on the Drawings.

F.2 Posts shall be galvanized steel pipe conforming to ASTM A 153 and of the diameter shown on the Drawings. Posts shall be furnished with galvanized watertight caps.

F.3 Tension wire shall conform to ASTM A 641M (metric)- Class 1, Hard Temper, with a minimum diameter of 4.5 mm.

F.4 Tension cable shall conform to ASTM A 474 or A 475, 6 mm minimum diameter, high strength grade.

F.5 All hardware shall be typical of the types shown on the Drawings and shall be galvanized in accordance with ASTM A 153.

F.6 If shown on the Drawings, the fence fabric, posts and all exposed galvanized hardware shall be coated with a minimum 0.25 mm coating of bonded PVC. PVC shall be applied by the thermal extrusion process and shall withstand a minimum exposure of 1,500 hr at 62^{o}C without any deterioration when tested in accordance with ASTM D 1499.

F.7 Slats, when required, shall be either wood or plastic and of the dimensions shown on the Drawings. Wood slats shall be treated with a suitable preservative.

F.8 Plastic slats shall be tubular polyethylene, colour pigmented material consisting of high density polyethylene and colour pigments designed to retard ultraviolet penetration. The material shall have a minimum wall thickness of 0.7 mm and shall remain flexible without distortion and without becoming brittle through a temperature range of 0^{o}C to 60^{o}C.

F.9 Plastic slats shall be retained in place by means of U-shaped retainer members at the bottom and top of the glare screen. Retainer members shall be of the same material as the slats.

F.10 Samples for the colour of plastic slats shall be submitted for approval before use.

G. Bolts, Nuts, and Other Fittings

G.1 All bolts shall conform to ASTM A 307, except those designated on the Drawings as high strength, which shall conform to ASTM A 325 or A 449.

G.2 All nuts shall conform to ASTM A 563, Grade A or better, except those designated on the Drawings as high strength, which shall conform to ASTM A 563, Grade C or better.

H. Galvanizing

H.1 All of the exposed materials for guardrails, guardrail anchor terminals, impact attenuators, glare screens and delineators which consist of steel or iron shall be galvanized after fabrication unless otherwise specified. Whenever a galvanizing requirement is not included in the Specifications, it shall be in accordance with ASTM A 123 or ASTM A 153 as appropriate.

H.2 All components shall be fabricated and galvanized for installation without additional drilling, cutting or welding. When field modifications are approved by the Engineer or when minor damage to the galvanized coating occurs, the exposed surface shall be repaired by thoroughly cleaning and applying 2 applications of zinc dust-zinc oxide primer, as specified in Section 6.06: Painting of Structures.

I. Concrete

I.1 All concrete shall conform to the relevant requirements of Section 5.01: Concrete Mixes and Testing.

I.2 Unless otherwise shown on the Drawings classes of concrete shall be as follows:

- Concrete for post supports, buried footings and anchors shall be Class 170/60.
- Concrete for New Jersey concrete barriers and terminal sections shall be Class 360/20.
- All other concrete shall be Class 210/20.

J. Reinforcement

Reinforcing steel shall be of the size and type shown on the Drawings and shall conform to the requirements of Section 5.03: Steel Reinforcement.

K. Other Materials

Other materials shall be as shown on the Drawings. Special materials for impact attenuators shall be as specified by the manufacturer.

6.13.3 CONSTRUCTION AND INSTALLATION

A. Metal Beam and Cable Guardrail

A.1 Guardrail of the kind and type shown on the Drawings shall be constructed at the locations shown thereon and as determined by the Engineer.

A.2 All posts shall be set vertically in holes with the designated diameters and in the positions shown on the Drawings. Post holes shall be backfilled with cement mortar or concrete tamped into place as shown on the Drawings and when required by the Engineer.

A.3 Steel rail sections shall be cut, punched and/or drilled in the shop prior to galvanizing. Special detail holes shall only be cut in the field when necessary and if approved by the Engineer.

A.4 All nicks, gouges and scratches in the galvanized surface of the railing shall be painted with a high zinc content paint. The railing and posts shall be painted as described in Section 6.06: Painting of Structures.

A.5 Posts shall be installed by driving plumb to the required elevations or set in concrete, as shown on the Drawings.

A.6 If ground conditions are such that pilot holes are necessary to prevent damage to posts during driving, all space around steel posts after driving shall be filled with dry sand or fine gravel.

A.7 When posts are set in concrete, the concrete shall be placed against the face of the excavation unless otherwise approved by the Engineer.

A.8 Continuous lengths of rail or cable shall be installed and alignment checked and adjusted before final tightening of bolts. Unless otherwise specified, bolted connections shall be torqued to between 6 and 7 kg-m. Lapped rails shall be installed with the exposed ends away from the stream of traffic.

B. Pedestrian Guardrails

B.1 All prefabricated or ready-assembled pedestrian guardrails shall be welded in accordance with Section 5.16: Structural Steelwork and Metal Components

B.2 When directed by the Engineer and before fabrication has commenced, welding procedure trials shall be carried out using representative samples of materials to be used in the work.

B.3 During guardrail erection all members shall be securely held in their positions until the post fixings have gained sufficient strength to withstand the design load required. The assessment of the strength of the post fixing shall be subject to the Engineer's agreement. Finished guardrails shall be true to line throughout their length.

B.4 The rails and posts of pedestrian guardrails shall be closed sections presenting no visible seam welds or exposed bolt heads. The exact shape of the posts and rails shall be in accordance with the Drawings and to the approval of the Engineer.

C. Guardrail Anchor Terminals

C.1 Guardrail anchor terminals shall be installed as and where shown on the Drawings.

C.2 Posts, anchors and footings shall be driven or installed in concrete as required. Concrete shall be placed against the excavated earth unless otherwise approved by the Engineer.

C.3 Bolted connections shall be torqued as for guardrail bolts.

C.4 Cable guardrail end assemblies shall be attached to the breakaway anchor angle and turnbuckles tightened to provide the spring compression as shown on the Drawings. Backfill above the tops of concrete anchor footings shall not be placed before cables are tensioned. Cables shall be uniformly tensioned prior to bending tabs on end post caps.

D. New Jersey Concrete Barriers and Terminal Sections.

D.1 Concrete barriers shall present a smooth, continuous, uniform appearance in their final position, conforming to the horizontal and vertical lines shown on the Drawings and shall be free of lumps, sags, or other irregularities. The top and exposed faces of the barrier shall not vary by more than 6 millimetres between any 2 contact points when tested with a 4 metre straightedge laid on the surfaces.

D.2 Concrete barriers may be precast, cast in situ with fixed forms, or extruded with slip forms. Concrete barriers constructed by casting in situ using fixed forms, shall conform to the relevant requirements of Section 5.06: Reinforced Concrete Structures.

D.3 Unless otherwise shown on the Drawings, traverse expansion joints of 10 mm thick premolded filler shall be provided in all cast in-situ concrete barriers at a spacing not exceeding 15 metres centre to centre.

D.4 If concrete barriers are constructed using an extrusion machine or other similar type equipment, the concrete shall be thoroughly compacted and the exposed surfaces shall conform to the relevant requirements of Section 5.06: Reinforced Concrete Structures and as specified herein.

D.5 The Contractor shall furnish evidence of successful operation of the proposed extrusion machine or other equipment, by constructing a trial section of barrier or by other evidence acceptable to the Engineer.

D.6 Concrete shall be fed to the extrusion machine at a uniform rate. The machine shall be operated under sufficient uniform restraint to forward motion to produce a thoroughly consolidated mass of concrete free from surface pitting larger than 20 mm in diameter and requiring no further finishing. The concrete shall be of such consistency that, after extrusion, it will maintain the shape of the barrier without support. The grade for the top of the concrete barrier shall be indicated by an approved offset guide line.

D.7 The forming portion of the extrusion machine shall be readily adjustable vertically during the forward motion of the machine to conform to the predetermined grade line. A grade line gauge or pointer shall be attached to the machine so that a continual comparison can be made between the barrier being placed and other established grade lines as indicated by the offset guide line. Other means of controlling barrier grades may be approved by the Engineer.

D.8 Expansion joints shall be constructed in the extruded concrete by sawing through the barrier section to its full depth. If sawing is carried out before the concrete has hardened, the adjacent portions of the barrier shall be firmly supported with close fitting shields. When sawing is carried out after the application of curing compound, the exposed faces of the barrier in the vicinity of the joint shall be treated with curing compound after sawing the joint.

D.9 If stationary forms for concrete barriers are used, they shall be removed as soon as possible after the concrete has set sufficiently to maintain the shape of the barrier without support. The surface shall be free from pits larger than 20 mm in diameter and shall be given a final soft brush finish with strokes parallel to the line of the barriers. Finishing with a brush application of grout shall not be permitted.

D.10 Concrete surfaces shall be finished as necessary to produce smooth, even surfaces of uniform texture and appearance, free of bulges, depressions and other imperfections. The use of power sanders, carborundum stones or disks may be required to remove bulges or other imperfections.

D.11 Exposed surface of concrete barriers shall be cured by membrane curing as specified in Section 5.02: Concrete Handling, Placing and Curing.

E. Impact Attenuators

Impact attenuators shall be installed as and where shown on the Drawings and in accordance with the manufacturer's recommendations and instructions. A copy of these recommendations and instructions shall be submitted to the Engineer upon delivery of the impact attenuator materials and before any installation commences.

F. Glare Screens

F.1 Glare screen fabric shall be placed on the face of the posts designated by the Engineer. On curves, the fabric shall be placed on the face of the posts on the outside of curves.

F.2 The fabric shall be stretched taut and securely fastened to posts as shown on the Drawings. Fabric shall be cut and attached independently at all pull and brace posts. Rolls of wire fabric shall be joined by weaving a single strand into the end of the rolls to form a continuous mesh between pull posts.

6.13.4 TESTING

A. Copies of all Certificates of Guarantee and test reports for all manufactured items shall be submitted to the Engineer.

B. Precast and in-situ concrete in foundations, New Jersey barriers and terminal sections shall be sampled and tested in accordance with Section 5.01: Concrete Mixes and Testing.

C. The Engineer may request additional sample materials for testing for strength, galvanizing, or other parameters.

D. Post fixing tests shall be carried out in accordance with manufacturer's recommendations, detailed on the Drawings or as instructed by the Engineer.

6.13.5 MEASUREMENT

A. Steel Guardrail, New Jersey Concrete Barrier and Glare Screen shall be measured by the linear meter furnished, installed completed and accepted. Measurements shall be based on the dimensions as shown on the Drawings. Terminal and Transition Sections shall not be measured for direct payment, but shall be considered as subsidiary Works the costs of which will be deemed to be included in the Contract prices for Pay Items.

B. Impact Attenuators shall be measured by the unit of each type furnished, constructed or installed, completed and accepted.

C. Excavation, backfilling, concrete footings, anchors, lifting device, dowel bars and other ancillary items, shall not be measured for direct payment, but shall be considered as subsidiary work; the costs of which will be deemed to be included in the Contract prices for Pay Items.

SECTION 6.15: SITE INVESTIGATION

6.15.1 SCOPE

The work covered in this Section consists of the organization and execution of a site investigation survey, the testing and analysis of samples and the production of a comprehensive site investigation report.

6.15.2 PARTICULAR REQUIREMENTS

A. Type of Investigation and Report Required: A geotechnical investigation and report giving a full description of subsurface conditions, results of in situ and laboratory testing and recommendations. A detailed description of the surface conditions and features within the site shall be provided.

B. Description of The Site: The Contractor is responsible for his own interpretation of the geological site conditions within the project region.

C. Boreholes: Boreholes shall be drilled to the required depth specified by the Engineer on site. If rock is encountered, continuous coring shall be carried for a minimum of 7.5 m into good quality rock or as directed by the Engineer. Good quality rock is defined as rock with rock quality designation (RQD) value more than 75% for a core run of 1.0 m and a core recovery of not less than 90%.

D. Test Pits: Test pits shall be excavated to the required dimensions specified by and in the presence of the Engineer on site. Samples shall be taken for analysis and testing as directed by the Engineer.

E. In Situ Tests: Standard Penetration Tests are to undertaken in boreholes and test pits at the frequency or locations directed by the Engineer .

F. Laboratory Tests: The following tests shall be carried out as frequently as required, subject to the Engineer's approval, to describe adequately the natural variability in the soil deposit moisture content.

- Sieve analysis for granular materials.
- Mechanical analysis by sedimentation for fine materials.
- Dry and bulk densities of cemented and cohesive soil.
- Plasticity indices.
- Specific gravity.
- Chemical analysis of soil and ground water.
- Calcium carbonate content of soil or rock.
- Unconfined compression tests on cohesive soils.
- Unconsolidated undrained triaxial compression tests on cohesive soils.
- Consolidated undrained triaxial compression tests on cohesive soils.
- Consolidated drained direct shear (or triaxial) compression tests on cohesive soils.
- One dimensional consolidation tests on cohesive soils.
- Uniaxial compression tests on rock cores.
- Point load index of rock samples.

G. Responsibility: The Contractor is responsible for:

- The true and proper setting out of boreholes, test pits and test locations in relation to permanent reference points or bench marks.
- Accuracy of levels of boreholes and test pits.
- Accuracy of depth records to given bench marks on or near the site.
- Accuracy of his observations generally and for his reports on the observations.
- Accuracy of his calculations and interpretation.

H. Quality Assurance – Codes And Standards: The Contractor shall comply with provisions of following codes, specifications, and standards, except where more stringent requirements are shown or specified: BS EN ISO 14688-1:2002, BS EN ISO 14688-2: 2004, BS EN ISO 14689-1: 2003, BS EN ISO 22476-2: 2005 and BS EN ISO 22476-3: 2005.

I. Quality Assurance – Responsibility: When calculations, interpretations and recommendations are made the Contractor shall provide the names, qualifications and details of experience of those responsible and their position within the Contractor's organization.

J. Quality Assurance – Supervision: The Contractor's representative for the Site Investigation shall be a soils engineer, engineering geologist, or geotechnical engineer fully experienced in site investigation work. This specialist shall be on site full time for the duration of the site investigation readily available to attend to both the site investigation operatives and the Engineer.

K. Project Conditions – Services And Structures: Prior to excavation or drilling, where underground services or structures are believed to exist in the immediate vicinity of a borehole position or test pit, exploratory pits shall be excavated to such a depth to ensure that all underground services and structures are uncovered. The location of services and structures shall be clearly identified and sufficient clearance allowed for in a no-drilling zone to avoid damage.

L. Project Conditions – Pollution: The Contractor shall take sufficient measures to prevent fouling of the atmosphere, any river, stream, watercourse or sewer as a result of his activities. Provision shall be made for discharge or disposal from the work or temporary work of water waste products and spoil however arising. Methods of disposal shall be to the satisfaction of the Engineer and of any other authority or person having an interest in any land or watercourse over or in which water and waste products may be discharged. The requirements of this clause shall not limit any of the Contractor's statutory obligations or liabilities.

M. Position of Boreholes: The Contractor shall reference positions of boreholes and standpipes as installed from features of the site and record their co-ordinates in the Investigation Report.

N. Obtaining and Storing Samples: Methods of sampling and subsequent handling, labelling and storage of samples shall be in accordance with the applicable procedures described BS EN 14688-1:2002.

O. Submittals – Daily Borehole Records: daily borehole records shall be submitted to the Engineer not later than noon on the following day.

P. Daily Test Pit Records shall be submitted to the Engineer not later than noon on the following day.

Q. Daily Reports shall include weather conditions, work progress, difficulties and any oilier significant event.

R. Programme Of Laboratory Testing: A programme of laboratory testing shall be submitted to the Engineer for approval within 48 hours after completion of drilling and sampling for each borehole.

S. Geological Maps: The Contractor shall submit a detailed engineering geological map showing surface deposits whether naturally occurring or man-made at a scale agreed by the Engineer.

T. Draft Report: Two copies of the Draft Report in English including all the requirements detailed in Clause 6.15.3 below shall be submitted to the Engineer for approval at least six days before the end of the Contract Period. The Engineer shall inform the Contractor of any corrections or amendments within three working days of receipt of the draft.

U. Final Report: Four bound copies and one unbound copy of the accepted report, describing the work shall be produced in A4 size and shall contain the following factual information:

- Exploratory borehole records.
- In situ test records.
- Plots of all laboratory and in situ test results against depth.
- Laboratory test records and summaries.
- Plans with location of exploratory holes.
- Plan showing surface deposits/rock outcrops, fill, geologic features (Engineering Geological map).
- Bearing capacity, settlements and recommendations for slopes and foundations (type, level).
- Schedule of contents.
- Independently bound appendix of colour photographs of all rock cores, test pits and trenches and any oilier features relevant to the text and observations.
- Geological cross section(s) of the site.
- Sections through the boreholes showing the interpreted geological conditions.
- A description of the work undertaken with notes on any special situations or conditions relative to the work recommendations for foundation design and construction.
- Detailed design calculations and methods.

Soft copies using Excel version 5.0 or a later version shall be submitted in CD Rom format which shall include:

- All laboratory testing, in tabular and graphical form
- Summary tables of the laboratory testing results
- Soil and rock classification.

Soft copies of boreholes and test pit logs shall be submitted in Excel or other program acceptable to the Engineer. The soft copy of the text of the report shall be submitted in Microsoft Word Version 6.0 or a later version.

6.15.3 BORING AND SAMPLING

A. Boring Method

A.1 Boreholes shall be supported with casing as necessary to prevent collapse of the sides. Bentonite may be used subject to the approval of the Engineer as long as it does not interfere with sampling of soil or in-situ testing.

A.2 The contractor shall take all necessary measures to ensure that groundwater levels over the site are not affected by the borehole works and precautions shall be taken to prevent surface water entering boreholes.

A.3 Boring in soil shall be to a minimum diameter of 112 mm, unless otherwise directed by the Engineer, and undertaken either by shell and auger (cable percussion), wash boring or rotary power hollow stem auger methods to enable samples of at least 100 mm diameter to be obtained using open or piston samplers. Other drilling methods shall only be used if approved by the Engineer.

A.4 Unless otherwise specified for in-situ tests in boreholes, cores of not less than 76 mm diameter shall be obtained when drilling in rock by rotary coring methods.

A.5 Use of rotary percussion methods of drilling (down the hole hammer) or wash boring shall only be allowed with the approval of the Engineer.

A.6 Drilling fluid shall be fresh water or a mixture of water and bentonite if it is agreed with the Engineer that it is necessary to keep borehole sides stable. Use of sea water, air or air entrained foam or other fluids shall only be allowed with the approval of the Engineer and when it is the only means to obtain good quality samples.

A.7 When drilling over water, the Contractor shall provide a stable platform such as a stand up barge or floating platform and drill boreholes through guide pipes spanning between the working platform and the water bed. The design of staging, towers and platforms shall take into account fluctuating water levels due to tides, waves and swell conditions. Such construction shall be sufficiently strong for boring operations to resist waves, tidal flow and other currents and floating debris. Due consideration shall be given to safety requirements, navigational warnings and regulations of governmental departments and other authorities. Necessary readings of water levels and tidal gauges shall be made to enable sea bed elevations at locations of over-water boreholes to be referred to chart datum and elevations of various strata to be determined accurately.

A.8 If an obstruction is encountered which prevents further progress in boring by shell and auger or rotary power auguring, the Contractor shall attempt to break through the obstruction by chiselling. If the size or composition of the obstruction is such that little or no progress is made by chiselling, the Contractor shall inform the Engineer and if instructed and agreed, rotary coring methods shall be used to drill through and obtain cores of the obstruction of not less than 76 mm diameter.

A.9 If boring shows that the obstruction is bedrock, rotary core drilling shall be continued to the depth and diameter required by the Engineer to prove continuity and the engineering characteristics of formation.

A.10 If the boring shows that the obstruction is a boulder, ledge of rock or other object underlain by soil, the Contactor shall inform and agree with the Engineer the use of one of the following courses of action:

- Chisel out the cored borehole through the obstruction sufficient to allow shell and auger boring, in situ sampling and testing to continue below the obstruction
- Continue boring by rotary core drilling to the required depth and diameter of borehole and agree with the Engineer as to whether or not it is necessary to obtain undisturbed samples of soils in a nearby borehole at levels beneath the obstruction.
- Abandon the borehole and drill another one nearby to obtain the necessary samples.

B. Groundwater Observations

B.1 When groundwater is encountered in a borehole, the Contractor shall immediately cease boring and observe and record any movement in level of groundwater after half an hour. A standpipe or piezometer shall be installed on completion of borehole if specified or instructed by the Engineer.

B.2 In deeper aquifers the Contractor shall observe and record changes in water level, making records of groundwater levels, referring to the datum used for the work.

B.3 If casing is used and this forms a seal against entry of groundwater, the Contractor shall record the depth at which no further entry or only insignificant infiltration of water occurs.

B.4 If it is necessary to add water to the borehole to facilitate boring, it shall be used sparingly and shall not prevent accurate observation of groundwater conditions in the borehole.

B.5 The Contractor shall install standpipes in boreholes to the number and depths required by the Engineer. Standpipes shall comprise a rigid polyvinyl chloride or galvanized iron pipe of 45 mm minimum diameter, having at its lower end an approved porous filter element or perforated for a length of at least 500 mm. The filter or bottom of pipe shall have a surround of sand of a graded sand and gravel mix to prevent entry of soil particles into the pipe. A layer of the graded mix shall be placed in the bottom of the borehole prior to lowering the stand-pipe and before withdrawing the borehole casing. A screwed cap to the top of the standpipe, not less than 150 mm below ground level shall be provided. The cap shall be protected with a short length of 150 mm diameter pipe set vertically with the upper end covered by a paving slab set flush with the ground surface.

B.6 When instructed by the Engineer, the contractor shall fill the borehole above the filter with a layer of bentonite -cement grout. A plug of stiff bentonite shall be dropped into the borehole and carefully tamped into place, followed the pumped bentonite - cement grout to fill the borehole to a level of at least 0.5 metres above the filter or as instructed by the Engineer. A plug of bentonite-cement of a stiff plastic consistency shall be carefully tamped into place below the level of the standpipe to form a seal against the upward flow of groundwater into the standpipe from a deeper aquifer, if instructed by the Engineer..

Daily readings of water levels in all standpipes shall be taken. The frequency and duration of the readings shall be directed by the Engineer.

C. Soil Sampling

C.1 Undisturbed soil samples shall be obtained in all cohesive soils and mixed soils having sufficient cohesion at one metre depth intervals. The 200 mm of soil immediately above the level of soil to be sampled shall be removed without the casing being lowered. Boreholes shall be carefully cleaned before sampling.

C.2 Undisturbed samples shall be taken in seamless sampling tubes of not less than 100 mm internal diameter and 450 mm long designed so that samples can be sent to the laboratory without removal. The area ratio of sampling tubes shall be less than 15%.

C.3 The undisturbed sampling tool shall be lined with a coating of oil inside and out. The tool shall be sunk into the soil by jacking or, when this is not possible, by careful hammer driving. Care shall be taken when driving the tool to prevent soil becoming compressed in the sampler. Double tube or piston samplers shall be used if these prove to be the only means of obtaining acceptable samples. In soft clays particular care shall be taken to avoid disturbance to samples. In hard clays or cemented soils a Denison sampler or similar equipment approved by the Engineer shall be used.

C.4 Immediately after taking undisturbed samples from the boreholes a 25 mm thick layer from each end shall be removed and the ends sealed with a thick coating of paraffin wax or other wax approved by the Engineer. The 25 mm thick layers shall be transferred and stored in an airtight container for classification testing. The samples shall be sent to the laboratory suitably packed to prevent damage or disturbance. The samples shall be numbered and labelled so that all samples can be identified giving borehole, soil stratum, depth and date.

C.5 Standard penetration tests shall be undertaken as specified by the Engineer to recover a disturbed sample of soil at intervals of not more than one metre in the top five metres and at intervals of 1.5 metres or at the change of each strata thereafter.

C.6 Where undisturbed soil samples and standard penetration test samples are not obtained, disturbed samples of soils shall be recovered from boring tools. Disturbed samples shall be obtained at such spacing to ensure that samples from borehole either in the form of undisturbed samples, standard penetration test samples or disturbed samples are obtained for every 1 metre depth bored. The minimum weight of disturbed samples shall be as specified in BS EN ISO 14688.

C.7 Where bulk soil samples are required for compaction tests, the minimum weight of sample shall be 50 kg, unless otherwise instructed by the Engineer.

D. Coring

D.1 Continuous cores of all cemented material shall be extracted carefully to obtain a good recovery of weakly cemented material. The core barrel shall be fitted with a coring bit most suited to the formations being drilled and which yields the best recovery.

D.2 For coring in marl or other material that may be sensitive to water, compressed air shall be used as drilling fluid to obtain good samples.

D.3 Coring runs shall be limited to not more than 2 metres. If the core recovery is less than 80% the run shall be reduced until an acceptable recovery for subsurface conditions is obtained, as approved by the Engineer.

E. Rock Sampling

E.1 Where boreholes are drilled using rotary coring methods, rock cores of not less than 76 mm diameter shall be extracted, unless otherwise directed by the Engineer. After being brought to the surface cores shall be removed from the core barrel by methods designed to cause the least possible further disturbance.

E.2 Where split inner core barrels are not in use, cores shall be extracted core by steadily applied pressure. Extraction by hammering the barrel or explosive extrusion under high air or water pressures shall not be permitted. After extrusion cores shall be placed in a purpose made core box.

E.3 Cores shall be safely preserved, photographed and logged.

E.4 Core storage boxes be of sound, robust, watertight construction able to withstand the weight of cores and any full boxes which may subsequently be placed on them. They shall be purpose made to hold the size of core being obtained tightly and to be placed in rows separated by wooden slats. Boxes shall have strong metal hinged lids fitted with padlocks, hasps and staples for closing and end ropes for handling. The top and bottom of boxes shall be reinforced by cross straps to aid stacking and retrieval. Boxes shall be constructed of wood, marine plywood or other material approved by the Engineer.

E.5 Cores shall be laid in the core box with the shallowest core to the left and the deepest to the right. The highest core sample shall be placed nearest to the lid hinge. Boxes shall be identified inside and outside by the site name, borehole number, core box number, depth of top and bottom of core, the Contractor's name and the date. This information shall be either painted on box or stamped on metal labels waxed and nailed to the box.

E.6 The depth of the top and bottom of the total core and separate core runs shall be painted on blocks of wood or other material approved by the Engineer made to fit between dividing slots.

E.7 In order that zones of core loss can be readily identified wooden dowels cut to appropriate lengths and suitably identified shall be inserted either by the sections where loss occurred or at the base of the core runs.

E.8 Sections of core which are weak and friable, formed of rocks or soils which are likely to dry out or otherwise alter in nature with time shall be sealed with aluminium foil and subsequently covered with wax before placing in core box.

E.9 All cores shall be photographed as soon as possible after extraction. Photographs shall be free from distortion and shall include a scale and colour chart. All boxes shall be clearly labelled and show the depth to the top and bottom of each core run. Photographs and representative soil and core samples such as SPT or core shall be taken after extraction and prior to placing in plastic bags or core boxes. The samples shall be clearly labelled as described above.

E.10 Samples of soil and cores of rock shall be carefully transported from the site to the testing laboratory.

F. Soil and Rock Description

All soil and rock descriptions shall be in accordance with BS 5930:1999.

G. Groundwater Sampling

Samples of groundwater shall be taken as soon as sufficient water has entered the borehole after boring has reached groundwater level.

G.1 If water has been added to borehole before reaching groundwater level, all water in the borehole shall be extracted and uncontaminated groundwater allowed to seep back into the borehole before a sample is taken.

G.2 Where the groundwater is sealed off by a borehole casing and a lower aquifer is encountered a sample of water shall be taken from this and any succeeding aquifers.

G.3 Samples of groundwater shall be at least 500 ml in volume and placed in clean jars or bottles already rinsed with the water to be sampled, labelled and stored as described in BS 5930:1999.

6.15.4 COMPLETION AND BACKFILLING OF BOREHOLES

A. Backfilling of boreholes shall only commence after approval to proceed is given by the Engineer. Backfilling shall consist of soil placed in the borehole in layers, each successive layer being tamped by boring tools.

B. Backfilling shall be completed as the borehole casing is withdrawn.

C. When instructed by the Engineer boreholes shall be backfilled with concrete having a cement content of not less than 250 kg/m^3.

D. When instructed by the Engineer boreholes shall be backfilled with a bentonite /cement mix of an approved consistency.

E. When instructed by the Engineer boreholes shall be plugged where they might otherwise penetrate an artesian basin and lead to contamination of water in an aquifer.

F. Where boreholes are to be backfilled in areas of present or future underground water supplies the Contractor shall obtain advice from water authority concerned on the particular measures required to prevent pollution.

6.15.5 BOREHOLE RECORDS

A. The Contractor shall supply to the Engineer with a journal of each day's boring not later than noon on the following working day.

B. Where boring is to be completed by shell and auger or rotary power auger the journal shall state:

- Job name.
- Dates and times of boring.
- Borehole number.
- Ground level at position of boring.
- Type of plant used and method of boring.
- Diameter of boring.
- Diameter and depth of casings.
- All water levels encountered including measurements of fluctuation of adjacent tidal waters, lakes or rivers.
- Depths at which groundwater was sealed off.
- Level at which groundwater was standing at commencement and termination of working day (where a boring is on land but is near tidal waters the level of those waters is to be recorded at intervals throughout the day).
- Level at which water, if any, was added to borehole.
- Levels of water in standpipes.
- Depths of the base of each stratum from ground level and a preliminary description of the stratum.
- Records of in-situ tests made and instrumentation installed.
- Time taken for chiselling through obstructions and the weight of chisel.
- Other relevant remarks.

C. Where boring is to be completed by rotary coring methods the journal shall state:

- Job name.
- Date and times of boring.
- Borehole number.
- Ground level at position of boring.
- Type of plant used and method of operation including details of type of flushing.
- Type of core barrel and bit.
- Depths of holes at start and end of each working day or shift as relevant
- Depth of start and finish of each core run.
- Core diameter and changes in core size.
- State of bit.
- Time to drill each core run.
- Character and proportion of each flush return.
- Level at which groundwater was standing at commencement and termination of the working day (where a boring is on land but is near tidal waters the water level shall be recorded at intervals throughout the day).
- Depths of base of each stratum from ground level and preliminary description of strata.
- Total core recovery (TCR) defined as percentage of the rock recovered during a single core run, with information as to the possible location of core loss.
- Rock Quality Designation (RQD) of each run (RQD is the ratio expressed as a percentage of aggregate length of core pieces over 100mm in a run divided by the length of run).
- Solid core recovery defined as percentage of the full diameter core recovered during a single core run.
- Fracture Index defined as the number of fractures per unit metre.
- Details of in-situ tests and instrumentation installed
- Other relevant remarks.

D. Where boring is conducted on marine craft remarks shall also include:

- The level to which borehole data are to be referred.
- Time and height of high and low water at a tide gauge and tidal heights at intervals as directed by the Engineer.
- Time and height of water levels at borehole position at intervals as directed by the Engineer.
- Details of movement of water levels within borehole in relation to fluctuation of water levels at borehole locations.
- Detailed records of delays due to reasons other than failure of boring equipment (e.g. craft dragging anchors, mist, shipping movements and broken drilling tubes).
- Detailed records of movements, vibration and oscillation of drilling tubes
- Detailed records of bowing of drilling tubes because of waves, tidal currents etc.

E. After completion of all soil tests and visual examination of all samples in the laboratory, the Contractor shall prepare final borehole logs to include grid or topographical references and details similar to those in borehole records but corrected in the light of all information finally available and with descriptions by a qualified soils engineer or engineering geologist.

F. Where cores have been obtained by rotary drilling methods the final borehole logs shall state in addition to information given in borehole records:

- The condition of each core run in terms of percentage recovery and rock quality designation, i.e. percentage of solid core recovered in pieces longer than 100 mm.
- Definition of each rock type, its altered state and relative strength; details of natural discontinuities and rock structure and the nature of joint or fracture infilling.

G. The Engineer shall examine the borehole logs and shall, if he considers it necessary, instruct changes in the number, location and depth of boreholes. The Contractor shall not be entitled to modify his unit prices as a result of such changes.

6.15.6 IN-SITU TESTING

Standard Penetration Test

A. The Standard Penetration Test shall be performed at 1.0 metre intervals in the top 5 metres and at intervals of 1.5 metres and at the change of each stratum thereafter. If gravelly soil is encountered the standard penetration tool shall be fitted with a cone at its tip and the test carried out as normal. The standard penetration test sampler shall have an internal diameter of 35mm and an external diameter of 50 mm and shall be driven with a 63.5 kg hammer dropped through 0.76 metres. The hammer shall be dropped using a free-drop trigger release mechanism allowing control of the 0.76 metre drop. The bottom of the casing, if used, shall be stopped at test level, the borehole cleaned down to bottom of the casing and testing to start from that level down. Casings shall not be lowered during execution of the Standard Penetration Test.

B. The Standard Penetration Test shall be performed in accordance with BS EN ISO 22476-3:2005. Notwithstanding all precautions specified to avoid carrying out test in loosened soil, if there is good reason to believe that unrealistically low results are being obtained or soil flows into the borehole preventing testing being carried out, the Contractor shall report the matter to the Engineer and obtain his instruction regarding whether an alternative test is to be undertaken.

6.15.7 LABORATORY TESTING

A. The programme of laboratory testing shall be oriented towards obtaining data pertinent to the work. The programme and type of laboratory testing shall be submitted by the Contractor to the Engineer for approval.

B. Laboratory tests on soils shall be carried out in accordance with BS EN ISO 14688 or an approved equivalent where applicable and with the agreement of the Engineer.

C. The Contractor shall submit a report on laboratory tests containing the data required by the Specification for each test.

D. The Moisture Content Determination shall be expressed as a percentage of the dry weight of the soil to two significant figures.

E. The Sieve Analysis submittals shall include:

- The cumulative percentage by weight of soil passing test sieves after wet sieving and drying, plotted on a particle size analysis diagram
- The weight of samples tested.

F. The Particle Size Analysis By Sedimentation submittals shall include::

- The cumulative percentages as for sieve analysis plus percentage less than 0.2 mm, 0.006 mm and 0.002 mm plotted on a particle size analysis sheet.
- The loss of pretreatment to the nearest 1%.
- The weight of the sample tested.

G. The Density Test submittals shall include the bulk density and maximum and minimum density tests to be reported in Mg/m^3 to two decimal places

H. Plasticity Indices test submittals shall include::

- The history of the sample, i.e. the natural state, air dried or oven dried.
- The method used to obtain results.
- The percentage of material passing the ASTM sieve no. 40.
- The liquid limit expressed to the nearest 1%
- The plastic limit expressed to the nearest 1%
- The Plasticity Index.

I. The Unconsolidated Undrained Triaxial Compression Test: submittals shall include::

- The method used
- Whether the specimens were undisturbed or remoulded and the method of specimen preparation.
- The depth and orientation of specimen within the original sample.
- Initial and final dimensions of test specimens (mm).
- Descriptions of samples
- The bulk density (mg/m^3) to two decimal places.
- The natural moisture content to the nearest 1%.
- The cell pressure (kN/m^2).
- The rate of compressive strain to the nearest 1%.
- The thickness and type of membrane used and the correction applied.
- The maximum principal stress difference (kN/m^2).
- Time to failure.
- Deviator stress/strain curves.
- Mohr's Circle diagram for each set of three tests and the shear strength parameters.
- Orientation of the specimen with respect to the vertical.
- Sample description.
- Plasticity Index.
- Sketches to show modes of failure of specimens.

J. The Consolidated Undrained Triaxial Compression Test: submittals shall include::

- The method used
- Whether specimens were undisturbed or remoulded and the method of specimen preparation.
- Depth and orientation of the specimen within the original sample.
- Initial and final dimensions of test specimens (mm).
- Bulk density (Mg/m^3) to two decimal places.
- A description of each sample.
- Whether side drains were fitted.
- Method of saturation and the pore pressure and value of pore pressure coefficient B at the end of saturation.
- Cell pressure, back pressure pore pressure dissipation at the end of consolidation.
- Pore pressure and percentage pore pressure dissipation at the end of the consolidation phase.
- A plot of volume change, cm^3 (or volumetric strain) versus the square root of time for the consolidation phase.
- Rate of axial displacement applied to the specimen (mm/min or %/hr).
- Pore pressure and effective stress at the start of the compression stage.
- The failure criterion adopted.
- Axial strain, deviator stress, pore pressure and effective major and minor principal stresses at failure.
- Effective principle stress ratio at failure.
- A sketch of the specimen after testing, indicating mode of failure.
- Details and magnitude of corrections applied.
- Final density and moisture contents.
- Curves of deviator stress versus axial strain.
- Curves of pore pressure versus axial strain.
- Curves of effective principle stress ratio versus axial strain.
- Elastic modulus
- Mohr's Circle for each set of three tests and effective and the total shear strength parameters.

K. The Consolidated Drained Triaxial Compression Test samples shall be drained during shear and the rate of shearing is to be such that no excess pore pressure is generated during the shearing. The submittals shall include::

- The method used.
- Specific gravity.
- Initial water content.
- Final water content.
- Initial thickness.
- Final thickness.
- Specimen thickness change.
- Whether undisturbed or remoulded specimens and the method of specimen preparation.
- Depth and orientation of specimen within the original sample.
- Initial and final dimensions of test specimens (mm).
- Bulk density (Mg/m^3) to two decimal places.
- Description of sample.
- Description of types of shear devices (including whether side drains are fitted).
- Method of saturation and pore pressure and value of pore pressure coefficient B at the end of saturation.
- Cell pressure, back pressure pore pressure dissipation at the end of the consolidation.
- Pore pressure and percent pore pressure dissipation at the end of the consolidation phase.
- Plot of volume change, cm^3 (or volumetric strain) versus the square root of time for consolidation phase.
- Rate of axial displacement applied to the specimen (mm/min or %/hr)
- Pore pressure and effective stress at the start of the compression stage
- Failure criterion adopted.
- Axial strain, deviator stress, pore pressure and effective major and minor principal stresses at failure.
- Effective principle stress ratio at failure.
- A sketch of the specimen after test, indicating mode of failure.
- Details and magnitude of corrections applied.
- Final density and moisture content
- Curve of deviator stress versus axial strain.
- Curve of pore pressure versus axial strain.
- Curve of effective principle stress ratio versus axial strain
- Elastic modulus.
- Mohr's Circles for each set of three tests and effective shear strength parameters.

L. The Consolidated Drained Direct Shear Compression Test submittals shall include:

- The method used.
- Specific gravity.
- Initial water content.
- Final water content.
- Initial thickness.
- Final thickness.
- Specimen thickness change.
- Whether undisturbed or remoulded specimens, and the method of specimen preparation.
- Depth and orientation of specimen within original sample.
- Initial and final dimensions of test specimens (mm).
- Bulk density (Mg/m^3) to two decimal places.
- Description of sample.
- Description of type of shear device.
- Specific gravity.
- Initial water content.
- Final water content.
- Initial thickness.
- Final thickness.
- Specimen thickness change.
- Void ratio.
- Normal stress shear displacement.
- Shear resistance value.
- A plot of the maximum shear stress verses normal stress for each sample.
- A plot of the shear stress and specimen thickness change verses shear displacement.
- If any departure from procedure outline was performed (such as special loading sequence or wetting etc).

M. The Unconfined Compression Test on Soil submittals shall include:

- The method used:
- Dimensions of specimen (mm)
- Bulk density (Mg/m^3)
- Moisture content to nearest 1%.
- Compressive strength to the nearest 2 kN/m^2 for values up to 50 kN/m^2, to the nearest 5 kN/m^2 for values of 50-100 kN/m^2 and to the nearest 10 kN/m^2 for values over 100 kN/m^2
- Shear strength (kN/m^2) to two decimal places.

N. Consolidation Test submittals shall include:

- The method used:
- Initial and final thickness of specimen to nearest 0.002 mm.
- Initial moisture content.
- Initial bulk density (Mg/m^3) to two decimal places.
- Specific gravity of soil particles.
- Graph of the voids ratio versus the logarithm of applied effective stress.
- Graph of compression (mm) versus the square root of time or logarithm of time (min).
- Coefficient of compressibility (m^2/MN) for a minimum of four pressure increments including at least one pressure greater than the pressure increment from expected loading.
- Compression ratios and the coefficient of consolidation (m^2/year) for a minimum of four pressure increments including at least one pressure greater than the pressure increment from expected loading.
- Orientation of the specimen with respect to the vertical
- A detailed description of the specimen.

O. Specific Gravity of Soil Particles test submittals shall include:

- The method used:
- The specific gravity of soil particles to the nearest 0.01.

P. For the Sulphate Content of Soil test, the Contractor shall submit the water soluble sulphate content of soil expressed as the percentage of sulphur trioxide or in grams per litre when determined from a 1:1 aqueous extract.

Q. For the Calcium Carbonate Content of Soil test, the Contractor shall submit the calcium carbonate content to nearest 1% by weight of the original direct sample.

R. For the pH Value of Soil the Contractor shall submit the pH values accurate to 0.1.

S. For the Chloride Content of Groundwater the Contractor shall submit the concentration expressed in mg/1.

T. For the Sulphate Content of Groundwater: the Contractor shall submit the sulphate content of groundwater expressed as parts per million.

U. For the Chloride Content of Groundwater: the Contractor shall submit the chloride content of groundwater expressed as parts per million.

V. For the pH Value of Groundwater the Contractor shall submit pH values accurate to 0.1.

W. The Uniaxial Compression Test for Rock submittals shall include:

- Physical descriptions of samples including rock types, location and orientation of apparent weakness planes, bedding planes, large inclusions or homogeneities.
- Dimensions of specimens (mm).
- General indication of moisture condition of samples at time of test.
- Type and location of failures.
- Uniaxial compressive strengths to the nearest 50 kN/m^2.

X. Point Load Test submittals shall include point load strengths corrected to that of a 50 mm core to the nearest 50 kN/m^2, raw data, dimensions of specimens, correction procedures and correlations used to deduce the unconfined compression strengths.

Y. The standards and equipment used for other laboratory tests required shall be agreed with the Engineer as well as the procedures and results to be submitted.

6.15.8 MEASUREMENT

A. GENERAL

Unless otherwise stated in Bill of Quantities or herein, the costs of the following are deemed to be included with the work, as applicable. Rates and prices inserted by the Contractor against the work items in the Bill of Quantities, shall be deemed to cover such costs:

- Labour and all costs in connection therewith.
- Materials, products, goods, supplies, consumables and all costs in connection therewith.
- Contractor's equipment, including but not limited to: plant, machinery, tools, vehicles and all costs in connection therewith.
- Temporary works and all cost in connection therewith, including but not limited to: installing, maintaining, adapting, clearing away and making good as necessary.
- Work at any location or depth.
- Work in small, isolated quantities.
- Protection of all work.
- Protection of all existing structures, utilities, site improvements, trees and vegetation, features, pavements and other facilities on and adjacent to the site, which are to remain upon completion of the work.
- All other enabling tasks, associated and subsidiary components and items of work, which are indicated or reasonably inferred from the Drawings and/or the Specification, and which are necessary to perform and complete the work described.
- Establishment costs, overhead charges and profit.
- On-site and off-site supervision and management.

- Site administration and security.
- Insurances, bonds and guarantees.
- Water for the works
- Lighting and power for the works.
- Temporary access, hard standings, crossings and the like.
- Temporary fencing, hoardings, screens, foot-ways and the like.
- Giving notices and making applications, including the payment of fees and charges in connection therewith.
- Safety, health and welfare of workpeople.
- Compliance with traffic regulations.
- Maintenance of public and private roads, services and adjoining property.
- Control of noise and pollution, prevention of fire and compliance with all other statutory and general obligations.
- Clearance and removal from the site of all Contractor's rubbish, debris and surplus excavated material, and upon completion of the Works, the reinstatement and restoration of the site to its original condition.
- Providing equipment for testing.
- Preparation and submittal of reports, drawings, records, certificates, notices, proposals, designs, details, calculations and other information and data required by the Specification.
- Compliance with all other requirements, provisions, responsibilities and obligations contained in the Contract Documents.

B. SUBSURFACE INVESTIGATION

B.1 Mobilization

B.1.1 If there is no separate rate for Mobilization in the Bill of Quantities either for on-shore and off-shore works then the associated costs are deemed to be included in the rates for the other associated work items. Rates and prices inserted by the Contractor against the work items in the Bill of Quantities shall be deemed to cover for such work.

B.1.2 The rate for Mobilization, if included in the Bill of Quantities, is deemed to include:

- Bringing to and providing on-site all Contractor's equipment, accommodation, messing facilities and temporary works materials necessary to undertake the works.
- Carrying out enabling tasks and providing all temporary works and services necessary to commence, perform and complete the Works.
- Demobilizing the site upon completion of the Works, including but not limited to: removing from site all Contractor's Equipment and temporary works materials, clearing and removing from the site all Contractor's rubbish, debris and surplus excavated material, and reinstating and restoring the site to the original condition.

B.2 Drilling and Coring

B.2.1 Drilling and coring boreholes items shall be measured in metres. Drilled lengths are measured from the top to the bottom, along the axis of the relevant borehole. The top of the borehole is the natural ground or the sea bed.

B.2.2 Work is deemed to include:

- Accessing borehole locations.
- Setting out borehole locations and providing coordinates.
- Excavating exploratory pits to determine the existence or otherwise of any underground services, utilities or structures at, or in the vicinity of borehole locations.
- Backfilling exploratory pits.
- Erecting drilling rig and equipment at borehole locations, including but not limited to: assembling, maintaining and adapting as necessary; dismantling upon completion and moving from location to location as required.
- In-situ testing (refer to Clause 6.15.6)
- Drilling or coring vertical or inclined boreholes.
- Providing temporary support for sides of boreholes.
- Drilling through any material (except rock), including artificial obstructions.
- Coring through rock.
- Taking both disturbed and undisturbed soil samples and photographs.
- Taking continuous core samples.
- Observing ground water levels and taking ground water samples, carrying out standard penetration, and pocket penetrometer tests, backfilling boreholes upon completion of the work, providing daily records and borehole logs.
- Installing standpipe equipment, materials, filters, screens and instruments, etc., and maintaining for as long as is necessary.
- Monitoring water levels at intervals as directed
- Taking water samples as directed.
- On completion of the work, reinstatement of the borehole working area and access routes thereto, to the original condition and to the satisfaction of the Engineer.

B.3 Test Pits

B.3.1 Excavation of test pits is measured per number excavated. The dimensions of the excavation shall be measured from the top surface to the base of the excavation as specified on the Drawings, indicated in the Bill of Quantities or instructed by the Engineer. The top surface is the natural ground level. Additional excavation in test pits due to overbreak of rock or other reason shall not be paid for separately and the costs shall be deemed to be included in the rate for excavation.

B.3.2 Work is deemed to include:

- Accessing test pit locations.
- Setting out test pit locations and providing coordinates.
- Excavation to the depths and dimensions specified.
- Over- excavation and overbreak
- Providing temporary support for the sides of the excavations.
- Excavation though rock using cutting and breaking tools as necessary
- Taking measures to protect services uncovered through excavation, including temporary supports, repairs and reinstatement to the satisfaction of the service provider
- Taking both disturbed and undisturbed soil samples and photographs.
- Dewatering of excavation
- Carrying out standard penetration, and pocket penetrometer tests
- Backfilling excavations upon completion of the work
- Providing daily records and test pit logs.
- Monitoring water levels at intervals as directed
- Taking water samples as directed.
- On completion of the work, reinstatement of the test pit working area and access routes thereto, to the original condition and to the satisfaction of the Engineer

B.4 Laboratory Testing

B.4.1 Laboratory testing includes mechanical and chemical tests. These tests are enumerated, and the types are listed below:

Mechanical Tests

(1) Sieve analysis (including moisture content determination)

(2) Particle size analysis by sedimentation for fine materials (including moisture content determination)

(3) Specific gravity /density testing

(4) Plasticity indices

(5) Unconsolidated undrained triaxial compression tests on cohesive soils

(6) Consolidated undrained triaxial compression tests on cohesive soils

(7) Consolidated drained triaxial compression tests on cohesive soils

(8) Consolidated drained direct shear compression tests on cohesive soils

(9) Unconfined compression tests on soils

(10) One dimensional consolidation tests on cohesive soils

(11) Uniaxial compression tests on rock cores, including bulk density, moisture content, and Young's Modulus determination

(12) Point load index of rock samples

(13) Optimum moisture content

Chemical Tests (Analysis of Soils and Groundwater)

(14) Sulphate content

(15) Chloride content

(16) PH value

(17) Calcium carbonate content of soil or rock

B.4.2 Work is deemed to include:

- Moving test equipment from location to location as required.
- Setting up test equipment, carrying out tests and recording the data.
- Providing the data.
- Handling, packing, protecting and transporting soil, rock and water samples to the laboratory.
- Carrying out specified tests in accordance with an approved programme.
- Reporting of tests results.

B.4.3 Laboratory tests shall be measured by number of the aforementioned listed tests, completed as directed submitted and accepted.

B.5 Report

B.5.1 Work is deemed to include the preparation and submittal of a complete and full report document(s), incorporating drawings, records, results, certificates all other information and data required by the Specification; including but not necessarily limited to:

- Reporting of all excavation and drilling and of on site and laboratory testing.
- Borehole logs.
- Production of engineering geological maps and cross-sections.
- Bearing capacity, settlements and recommendations for slopes and foundations (type, level).
- Providing hard and soft copies as specified.
- Photographs.

B.5.2 Preparation and submittal of each report shall be measured per item, incorporating all the draft and final copies specified or as instructed by the Engineer.