SPECIFICATIONS

1.0 GENERAL REQUIREMENTS

1.1 Definitions

These definitions refer to the Specification, Drawings, Conditions of Contract and Bill of Quantities for this Contract only.

'Ancillary Works' means all appliances or things of whatsoever nature required to be installed or constructed on under in or through the Site and which are to remain on Site and become the property of the Engineer in accordance with the Contract upon the issue of a Certificate of Completion in respect of the Site operations or section or part thereof as the case may be.

'Equipment' means any appliances or things of whatsoever nature required temporarily for carrying out the Site Operations but does not include anything which forms part of the Ancillary Works.

'Test' or 'Bore Hole' or 'Exploratory Hole' means any kind of hole made to explore ground conditions or for any other reason whatsoever.

'Laboratory Testing' means the testing operations and processes necessary for the preparation of the Report to be carried out in accordance with the Contract at a laboratory approved by the Engineer on samples and cores obtained during the Site Operations and strictly in accordance with specifications.

'Report' or 'Factual Report' means the report to be prepared and submitted in accordance with the Contract.

'Appendix' means the lists of Site Operations, Laboratory Testing and other requirements referred to in the Specification.

'Site Operations' means all the work of every kind including Ancillary works required to be carried out on under in or through the Site in accordance with the Contract.

1.2 Works

Scope of works are specified in Drawings No. to and Bill Of Quantities.

1.3 Programme to be furnished

Immediately on the acceptance of his Tender, the Contractor shall submit to the Engineer for his approval a programme showing the order of procedure and method on which the Contractor intends to supply, use or construct as the case may be. The submission and approval by the Engineer of such programme or particulars shall not relieve the Contractor of his duties or responsibilities under the Contract.

If at anytime it should appear to the Engineer that the actual progress of Works does not conform to the approved programme, the Contractor shall produce at the request of the Engineer a revised programme showing the modifications to the approved programme necessary to ensure completion of the whole works within the time for completion provided for the Contract.

1.4 References Used in the Specification

The following references are used in the Specification :-

MS 2038 : 2006 : Code of Practice for Site Investigation
MS 1056 : 2005 : Method of Test for Soils for Civil Engineering Purposes

1.5 Setting Out And Taking Levels

The Engineer shall provide the Contractor with adequate bench marks, permanent ground markers and/or other information sufficient for the Contractor to set out the whole of the site Operations in accordance with Clause 14 of the Conditions of Contract.

The Contractor shall establish the position of each Exploratory Hole, and shall confirm the position of each Exploratory Hole with the Engineer prior to commencing any Site Operations at that location.

Reduced levels shall be measured by the Contractor for all locations of Exploratory Holes or test locations. The temporary bench marks used shall follow those given in the original site plan if the bench marks are given. Otherwise they shall be based on permanent features on site. Under no circumstances shall reduced levels be given by interpolating lines on the site plan.

1.6 Supply of Equipment, Materials and Labour

The Contractor shall supply and provide all the Equipment, labour and materials necessary for execution of the Works and Ancillary Works including the supervision thereof, transport to or from the Site and in and about the works and other things of every kind required for the construction, completion and maintenance of the works.

1.7 Watching and Lighting

The Contractor shall in connection with the works provide and maintain all lights, guards, fencing and watching when and where necessary or required by the Engineer or by any competent statutory bodies or other authority for the protection of the works or for the safety and convenience of the public or others.

1.8 Traffic Safety and Control (Traffic Safety Measures)

(a) The Contractor shall provide, erect and maintain such traffic signs, warning lamps, barriers and traffic control signals and such other measures as may be necessitated by the construction of the Works in accordance with the requirements of the relevant Traffic Signs and Regulations of PLUS, JKR's Arahan Teknik (Jalan 12C/85) "Manual on Traffic Control Devices, Temporary Signs and Work Zones Control" and any amendments thereof. Where the circumstances of any particular case are not covered by the recommendations the Contractor shall submit proposals for dealing with such situations to the Engineer for approval. Compliance with this Clause shall not relieve the Contractor of any of his other obligations and liabilities under the Contract and under the relevant provisions of the Highway Acts.

(b) The Contractor shall take into account information about particular localities contained in

the Contract drawings when planning the traffic safety measures.

(c) The Contractor shall, after consultation with any statutory or other authority concerned, submit to the Engineer for his approval a programme based on such consultation showing the scheme of traffic management he proposes for carrying out the works before commencing any which affects the use of the public road and thereafter furnish such further details and information as necessitated by the Works or as the Engineer may require.

(d) The Contractor shall not commence any work which affects the public road until all traffic safety measures necessitated by the work are fully operational.

(e) The traffic signs, warning lamps, barriers and traffic control signals shall be in accordance with the requirements of the relevant Traffic Signs Regulations current at the date of the execution of the Work.

(f) Traffic signs shall comply with . JKR/ARAHAN TEKNIK and road danger lamps with . JKR/ARAHAN TEKNIK, except that the flashing rate for flashing lamps shall be within the range 120 - 150 flashes per minute. The minimum luminous intensity of the lamps shall be 0.5 candela for steady lamps, 1.0 candela for ripple lamps at their peak, and 1.5 candela for flashing lamps at their peak.

(g) The Contractor shall keep clean and legible at all times all traffic signs, warning lamps, barrier and traffic control signals and he shall position, re-position, cover or remove them as necessitated by the progress of the Works.

(h) **Maintenance of Traffic Flows and Control of Traffic**

One lane must be maintained at all times during the period of contract. The Contractor shall limit his working such that the overall length of any continuous or nearby continuous section of lane closure shall not exceed 150m.

Any work involving the reduction in the number of traffic lanes, particularly on heavily trafficked commuter routes, should not take place between the hours of 0730 and 0830 & 1700 and 1830 without the express permission of the Engineer.

(i) **Temporary Traffic Signs**

The Contractor shall at all times take full and sufficient precaution to ensure the safety of all traffic through and around the work site and of traffic that is diverted by the works.

To this end, the Contractor shall erect and maintain on site and a prescribed points on the approaches to the site all traffic signs necessary for the direction and control of traffic. The sizes of all such signs and lettering and the wording thereon shall be approved by the Engineer before the erection. Construction and excavations shall be sign posted and during periods of darkness, flood lighted to the approval of the Engineer.

Temporary traffic signs shall comply with the requirements of the Manual on Traffic control Devices, Traffic Signs and Work Zones Control. JKR/ARAHAN TEKNIK (Jalan) 2C/65 and Arahan Teknik Lembaga Lebuhraya Malaysia.

1.9 Facilities for other Contractors

The Contractor in accordance with the requirements of the Engineer shall not obstruct and afford all reasonable access to any other contractors employed by the engineer and their workmen and for the workmen of the Engineer and of any other properly authorized authorities or statutory

bodies who may be employed in the execution on or near the site of any work not included in the Contract or of any contract which the Engineer may enter in connection with or ancillary to the Works.

1.10 Temporary Access

The Contractor shall provide all temporary roads and gangways required for the execution of the Works. He shall provide at all times during the progress of the works proper means of access with ladders, gangways, boats, etc. and the necessary attendance for inspection of the Works by the Engineer or his Representative as directed.

1.11 Workmen's Accommodation

The contractor shall be responsible for the proper housing at site for his labour force to the satisfaction of the relevant Health Authorities. Alternatively, the Contractor may provide proper accommodation off site.

1.12 Water supply

The Contractor shall provide water required in connection with works, including the supply and fixing of all fittings, maintenance of the supply, payment of all fees, removal of all fittings and making good all disturbances after completion of the Works.

1.13 Electrical Power Supply

Should the Contractor require any electricity supply he shall make his own arrangements with the authority concerned, comply with all safety regulations and pay all fees in connection with the installation and supply.

1.14 Storage Facilities

The Contractor shall provide facilities for the storage and protection of soil, rock and water samples. These facilities shall provide protection at all times from temperatures in excess of 35 degrees Centigrade and from wetting or drying out due to weather exposure.

1.15 Removal of Improper Plant, etc.

The Engineer shall during the course of the works have the power to order in writing from time to time :-

(a) the removal from the site of any plant not conforming to the requirements of the Specification, and the replacement of such plant at the Contractor's own cost.

(b) the dismissal from the site of any technician, supervisor, plant operator, or any workmen of the Contractor found incapable or refusing to follow the proper procedure of work as specified, and replacement of such workmen at the Contractor's own cost.

1.16 Damage to Overhead and Underground Mains and Services

Particular care should be taken to avoid damages to electricity mains, water mains, telephone lines, sewerage mains, gas mains and the like.

The Contractor is fully responsible to ascertain the positions of all mains or services in the vicinity of the Exploratory Hole. He shall be fully responsible for any damage and for claims for consequential damages.

The Engineer shall be immediately informed if any of the original locations of the Exploratory Holes coincide with the positions of the mains or services. It will be the Engineer's responsibility to change the locations of the affected boreholes or other tests.

1.17 Clearance of Site on Completion

As soon as the investigation work is completed, all test pits, boreholes, etc. shall be backfilled to the satisfaction of the Engineer. On completion, the Contractor shall remove from site all plants, surplus materials, condemned equipment, temporary works and rubbish of any kind, and leave the site and clean and tidy to the satisfaction of the Engineer.

1.18 Care of Works

From the commencement to the completion of the works, the Contractor shall take full responsibility for the care thereof and in case any damage, loss or injury shall happen to the works from any causes whatsoever shall at his own cost repair and make good the same so that at completion the Works shall be in good order and condition and in conformity in every respect with the requirements of the Contract and the Engineer's instructions.

1.19 Laboratory Testing Facilities

The Contractor shall carry out the Laboratory Testing at his own testing laboratories. If the testing facilities of other laboratories are to be made use of, the Contractor shall submit in writing the names of the proposed laboratories to the Engineer for approval as required by Clause 27 of the Conditions of Contract.

1.20 Independent Testing by Engineer

Independent laboratory testing may be carried out by the Engineer and for this purpose the Engineer reserves the right to instruct the Contractor to send samples to an Independent laboratory for testing. Unless otherwise specified, all costs associated with these instructions shall be borne by the employer.

1.21 Exploratory Bore Hole/Test Location Markers

The positions of Exploratory Bore Holes/Test Locations or as instructed by the Engineer carried out on land shall be permanently marked by markers immediately after their completion. Each marker shall comprise a 610 mm long steel rod of 20 mm diameter which shall be cast into not less than 0.03 cubic meters of concrete at surface level with their tops carefully squared. The Exploratory Hole number shall be clearly inscribed in the fresh concrete. The steel rod shall be painted white.

1.22 Photographs

The Contractor shall supply colour photographs of rock cores, soil samples, trial pits or such portion of the Works in progress as may be directed by the Engineer from time to time. The camera to be used is approved Digital Camera having image quality of at least 5 megapixel. Proofs shall be supplied to the Engineer within seven (7) days of the photographs being taken in the form of three images per high quality digital printing paper of A4 size and each image shall be described. All such pictures shall be presented in Tiff or JEPG format on a Compact Disk and each such disk shall include list describing each photograph. No pictures may be supplied to any person or persons except with the authority of the Engineer. Where videos of the works are available, these will be presented in MPEG I or MPEG II format on a Compact Disk.

1.23 Engineer's Transport

Where so specifically required, the Contractor shall provide plain coloured transport for the exclusive use of the Employer for any purpose in connection with the Site Operations. The vehicles shall be delivered and maintained in good roadworthy condition. They shall be licensed and insured for use on the public highway and shall have comprehensive insurance cover for any qualified driver authorized by the Employer together with any authorized passengers and the carriage of goods or samples. The Contractor shall provide fuel, oil and maintenance in conformity with the vehicle manufacturer's recommendation and shall clean the vehicles inside and outside as required. A suitable replacement shall be provided for any vehicle out of service for more than 24 hours. When drivers are to be provided with the vehicles they shall be duly licensed.

1.23 Contractor's Professional Attendance on Site

The Contractor shall provide an engineer or engineering geologist of experience full time on site during the site who shall be responsible for the whole of site operations and approved by the Engineer, which approval may be withdrawn at any time, and who shall be responsible for the technical direction and output of the whole of the investigation. Such person will be contractor’s representative on site and will be required to ensure quality work, compliance with Specification and taking site instructions from the Engineer's Representatives. Where more than one plant is operating on site, each plant shall have trained operator answerable to the contractor’s representative. Such operator will have adequate experience and be capable of logging samples according to specified standards and keeping records of all observations.

1.24 Particular Contract Requirements

The Works shall be carried out following the particular requirements set out in the contract.

1.25 Submission of Reports

On completion of the Works, the Contractor shall submit Factual Report as specified below:
FACTUAL REPORT shall consist of true and faithful reporting of all findings, equipment and material used and test results obtained, codes of practice followed and any variations thereof.

2.0 BOREHOLES

2.1 Percussion Boring

2.1.1 **Scope**

Percussion boring, where required, shall be carried out at locations shown on the Drawings or as instructed by the Engineer and shall comprise the formation of a borehole using a cable percussion rig and attachments such as shell, clay cutter, chisel and sinker bar. Method employed for advancing of boreholes using percussion boring must be to the approval of the engineer

2.1.2 **Borehole and Casing Diameter**

The minimum diameter of boring or internal diameter of casing shall be 150mm. Where boring are of such depth that the advancement of a casing becomes impracticable or where hard strata and obstructions are likely to be met, the Contractor shall bore or provide casings of sufficient diameter to complete the work.

2.1.3 **Use of Clay Cutters**

Clay cutters shall not be used for advancing the boring in soils where they will cause excessive disturbance in soil volume which is to be sampled. Where clay cutters are permitted they shall be of a pattern approved by the Engineer, and the combined weight of clay cutter and any sinker bar shall not exceed 150 kg.

2.1.4 **Use of Shell and Casing**

Care shall be taken at all times to avoid disturbing or loosening of the soil or loss of ground. When using a shell and casing in order to keep disturbance of the ground to a minimum, the Contractor shall operate the equipment in such a way as to allow the shell to proceed before the casing only the minimum distance necessary to advance the boring. When using a shell in granular soils beneath the water table the diameter of the shell shall be 25mm less than the diameter of the casing.

2.1.5 **Addition of Water to Boring**

The Contractor shall not add water during boring unless boring in dry granular soils or in very stiff clays. For conditions where the addition of water is permitted, the Contractor shall use the minimum amount of water necessary for advancing the boring. When water is added to assist with the works the Contractor shall record the depths through which water was added. Where boring reveal saturated soft soils or artesian or sub-artesian ground water in granular soils, the Contractor shall immediately add and maintain a head of water during boring and sampling in order to counteract the disturbance caused by the removal of overburden or inflow of ground water.

2.1.6 **Hard Strata and Obstructions**

In boring where hard strata or obstructions are encountered the Contractor shall continue boring using a chisel or similar approved tool for a minimum time of 1 hour in an attempt to penetrate the hard strata or obstructions. Upon completion of the above requirement the Contractor shall consult with the Engineer who shall instruct the Contractor either to continue chiseling or to change to a different method of boring or to terminate the borehole.

2.2 Rotary Boring

2.2.1 **Scope**

Rotary boring shall be carried out at locations shown on the Drawings or as instructed by the Engineer and shall comprise the formation of a borehole by the rotary action of a drill bit, with cuttings washed to the ground surface by drilling fluid pumped down the drilling rod**.** Boreholes shall not be advanced by either surging action of the casing, by the chopping or twisting action of bits via the rods. Unless otherwise specified, all reference to boring in this contract will be deemed to be rotary boring.

2.2.2 **Borehole and Casing Diameter**

The diameter of boreholes casing shall be such that the requirements of rotary boring, sampling and field testing are satisfied.

2.2.3 **Casing and Support of Borehole Sides**

Casing shall be used to the full depth of the boreholes at all times unless otherwise permitted by the Engineer. Other methods of stabilization of the borehole may be used subject to the prior approval of the Engineer of the procedure used. In any case, casing shall be used when there is doubt as to the effectiveness of the method of stabilization proposed or practiced.

2.2.4 **Heaving of the Bottom of the Borehole**

To prevent heave and disturbance of the soil at the bottom of the borehole, the level of drilling fluid in the borehole must at all times be equal to or higher than the elevation of the ground water. This condition shall be strictly observed in formations consisting of sand or coarse silt, or in operations involving undisturbed sampling and in-situ testing. In very soft ground or when instructed by the Engineer, the Contractor shall use heavy drilling fluid in addition to full depth of casing to stabilize the borehole.

2.3 ADVANCING THE BOREHOLE

2.3.1 Borehole

Advancing of the borehole will carried out using compatible drill rods with suitable drill bits and casing or where permitted, proper drilling fluids. In every case, advancing of the borehole will be such that the disturbance to and contamination of the soil(s) immediately below the borehole will be kept to minimum. Any method of advancing borehole other than that described in 2.0, 2.1 and 2.2. will require prior written approval of the engineer.

2.3.2 Drilling Medium

Any drilling medium other than clear water will only be used with prior approval of the Engineer. Where water is used as drilling medium, re-circulated water will only be used where water is extremely difficult to obtain and only with prior approval of the Engineer. Generally any medium that affects, in the opinion of the Engineer, the proper identification of soil strata's will not be acceptable.

2.3.3 Water Jetting

Water Jetting is a method of advancing borehole using pipe or casing alone. Advance of borehole is achieved by rotating and surging of casing and usage of water at high pressures. Water Jetting shall be carried only at locations shown on the Drawings or as instructed by the Engineer and shall comprise of forming a hole in the ground either over land or over water by water jetting to bedrock. No samples or tests will be permitted in any hole created using water jetting without the previous approval of the Engineer. Samples obtained from boreholes created by water jetting, disturbed or otherwise will clearly state the method of boring as water jetting.

2.4 Rotary Core Drilling

2.4.1 Scope

Rotary core drilling shall be carried out at locations shown on the Drawings or as directed by the Engineer. Drilling shall be carried out in accordance with good practice and detailed in ASTM D 211.3 or similar approved standard. Drilling shall consist of obtaining core samples of the full depth of the strata being penetrated. Should the Contractor fail to ensure that drilling and sampling is undertaken as specified or instructed then he may be liable to re-drill all or part of a borehole at his own expense should the Engineer so direct.

2.4.2 Core Barrels Types

In residual soils and highly weathered rock rotary drilling shall be carried out using Mazier type triple tube retractable core barrels producing a core of not less than 50mm diameter (N size). The detachable inner liner shall be used to transport and store the sample.

When drilling competent and relatively unweathered rock conventional triple and double tube barrels shall be used. The latter type shall be confined to good rock without a significant presence of fractures and only swivel-type designs shall be acceptable. The triple tube system is preferred. When using these non-retractable core barrels the minimum core diameter shall be 45mm.

2.4.3 Drilling Methods

The methods and equipment used shall be such that

(a) The soils encountered and the levels of strata boundaries can be accurately identified.
(b) Truly representative disturbed and undisturbed samples can be recovered from any depth in the borehole, and
(c) All in-situ tests referred to in the Specifications can be undertaken and field installations incorporated at any depth in the borehole.

Drilling shall be carried out in such a manner and using such sizes of rods and bits including any required modification to the drill bit, such that the maximum amount of core is recovered. This requires close surveillance of drilling fluid, drilling pressures, lengths of runs and all other factors relevant to the nature of the material being drilled.

The core barrel shall be withdrawn and the core removed as often as may be necessary to secure the maximum possible amount of core.

Coring runs shall be limited to a maximum length of 1.5m. When less than 95% of the core is recovered from a run the length of the following run shall be reduced by 50% unless otherwise directed by the Engineer. If less than 50% recovery is achieved the following run shall not exceed 0.5m until full recovery is achieved from two consecutive runs.

The core barrel shall be removed from the borehole immediately if blocking of the bit or grinding of the core is apparent regardless of the length of run which has been made.

The Contractor shall in general use no drilling lubricants in the borehole other than clean water, air or air with an approved drilling foam additive. Additives shall only be used in the flushing medium upon approval by the Engineer. No adapters allowing use of different rod sizes than that required as compatible with sampling and borehole sizes will be allowed without prior approval of the engineer and only in extreme cases.

2.4.4 Core Barrels, Casing and Drill Rods.

Details of the manufacturers and the specifications of all core barrels and of proposed tungsten carbide and diamond core bits shall be given. The Contractor shall supply section drawings of the barrels and bits he proposes to use. He shall submit also manufacturer's brochures illustrating the type of equipment he proposes to use. The use of equipment without such information shall not be allowed. The core barrels shall be of approved, manufacture and, unless otherwise approved by the Engineer, all accessories and spare parts shall be as supplied or recommended by the manufacturer. Substitute core barrels and bits, locally manufactured or not, are proposed to be used contractor shall ensure that these are not sub-standard and such usage will only be with the prior approval of the engineer. The Contractor shall provide sufficient numbers of core barrels and accessories in order to carry out the scheduled work without delay. Each core barrel shall be provided with the full range of bit types to cope with the various ground conditions encountered at the site. Spares for each bit type shall be available for use on site without causing any delay to drilling operations. An adequate supply of short, medium and long plain retractor shoes shall be available for use with Mazier type triple tube retractable core barrels. All core barrels shall be equipped with sediment catcher tubes. The tube shall have the same external diameter as the core barrel, and its length shall be approximately 0.75m. The upper end shall be tapered with the upper edge curved slightly inwards to prevent fouling the side of the borehole on withdrawal of the core barrel. Triple tube core barrels shall be equipped with built in ball check pistons to ensure that the core is not subjected to water flushing when extracting the inner barrel containing the core.

Casing shall be used to prevent collapse of the sides of the hole. The size of casing and drill rods shall be appropriate for the size of core barrel in use. All casing and drill rods shall be straight and in good condition, and shall be cleaned thoroughly before use to ensure that all scale, dirt, and other loose material are removed. All drill rods shall be of standard lengths (eg. 3.0, 1.5, 0.75m). Short lengths of drill rod and casing shall be available to enable continuous coring to be carried out.

2.4.5 Drilling Rigs and Ancillary Equipment

Drilling rigs shall be of the hydraulic feed type with sufficient horsepower and capacity to drive a rotary tool tipped with diamonds or tungsten carbide in the sizes and to the depths specified. The rigs shall be such that they are capable of applying to the drilling bit a working hydraulic thrust of the order of 10 kN to 15 kN. The weight of the drilling rig shall be compatible with the maximum hydraulic thrust required without movement of the rig. If the weight of the rig is insufficient to prevent movement, the base of the rig shall be securely anchored down or loaded. The rigs shall also be fitted with a tachometer and a hydraulic feed pressure gauge, both of appropriate scales. A rigid rod, clearly graduated in 10mm increments shall be permanently attached to and parallel with the hydraulic feed rams, to provide a means of measuring penetration and estimating penetration rates. Where the flushing medium is water, a centrifugal or reciprocating pump shall be provided equipped with a gear box and capable of delivering up to 2 liter/sec. The pump shall incorporate a `surge' bottle to reduce fluctuations in water pressure and the suction hose shall be fitted with a suitable filter at all times. A full by-pass system shall be provided and attached to the drilling rig allowing the operator full control of water flow from zero to maximum pump delivery rate. A pressure gauge, in full working order, capable of operating in the range 0 kN/m^2 to 2000 kN/m^2 shall be directly fitted into the water supply line on the `downstream' side of the by-pass valve. Where the flushing medium in use is air with foam additive an air compressor capable of producing $2m^3$/min to $5m^3$/min with a working pressure up to 700 kN/m^2 shall be provided. A by-pass system similar to that required for water flush and a pressure gauge of appropriate scale shall also be provided.

To inject liquid foam mixture into the flushing air-stream an air-driven drum pump or other approved system shall be provided. The pump shall be equipped with a pressure balancer, a pressure limiting valve, an on/off control valve with the facility for regulating the flow of liquid foam mixture up to a maximum of 0.1 litre/sec. Details of the proposed foam additive and mixes shall be submitted to the Engineer for approval and the use of a foam stabilizer shall not be permitted unless this has been agreed with the Engineer. The Contractor shall ensure that the proposed foam is either fully biodegradable or water soluble and make arrangements for the collection and removal or dispersal of the foam returns when required. The Contractor shall provide recent certified calibration for all gauges and measuring equipment used. Calibration shall have taken place within three months of intended use.

2.4.6 **Record of drilling equipment**

On the daily record sheet the driller shall record the type of core barrel used and the type of coring bit used. This information shall be recorded for each core run.

2.4.7 **Extraction of Cores**

Core shall be extracted from double tube core barrels using a hydraulic or similar approved extruder. The extruder shall apply a continuous pressure to one end of the core whilst the barrel is in a horizontal position. Drilling shall not be allowed to commence unless a suitable approved extruder is available on site. No standing time shall be approved by the Engineer in respect of delays resulting from this requirement. Cores from triple tube barrels with continuous inner liners shall be carefully removed from the core barrel, sealed and labeled as specified. Cores from split-tube triple tube core barrels shall be carefully removed from the core barrels using hydraulic pressure and be carefully transferred into split plastic tubes of the same internal diameter as the split inner tubes. The Engineer may instruct certain core lengths to be sealed in aluminium foil and waxed before sealing inside the plastic tube. Where air/foam is used as the flushing medium a water supply with complete by-pass shall also be available and used for the extrusion of the split inner tubes from the core barrel. Under no circumstances shall air pressure be used for the extrusion of cores. The Contractor shall submit a detailed method statement explaining how the core shall be extracted from the core barrel. The works shall not proceed until this method statement has been agreed with the Engineer.

2.4.8 **Core Boxes, Packing and Labeling of Cores**

Core boxes shall be constructed of sound materials such as timber, galvanized steel or reinforced plastic with a lid having secure fastenings. Handles shall be attached to the core box for lifting. Core boxes shall not contain more than 50 kg of core. The height of the core boxes shall be compatible with the diameter of the core to be stored in them. The standard core box as shown in Fig. 2.1 shall be used. As the core is extruded it shall be arranged in the box in proper sequence starting with the shallowest core on the left side nearest the hinge and then working along the slat and subsequently outwards towards the clasp. Slats shall be positioned and secured such that the core is restrained from movement. Wooden partition blocks not less than 25mm in thickness shall be placed at the beginning and end of each box and at the end of each core run. These blocks shall be marked with the depth below ground level in waterproof marking in numbers at least 20mm high and facing the box lid. Each core box shall be marked in English identifying the site locality, borehole number, core box number, depths, and date. Core losses shall be shown by wooden blocks or polystyrene of a square cross-section to fill the core space and of a length equal to the core lost. Until the boxes containing the cores are transported from the site they shall be neatly stored at the borehole locations in such a manner that inspection of the cores can easily be made. The boxes shall be stored under cover and protected from the weather. All core boxes shall be carefully transported to avoid damage and disturbance to the contents. Unexamined core samples contained within plastic lining tubes and waxed samples retained for testing shall be stiffened with laths of wood and wrapped carefully with foam sheeting to minimize disturbance during transportation. All core, boxes and samples shall be delivered to Contractor's store and shall remain the property of the Engineer.

2.4.9 **Core Recovery Ratio (CRR), Rock Quality Designation (RQD) and Fracture Index (FI).**

The Core Recovery Ratio (CRR), Rock Quality Designation (RQD) and the Fracture Index (FI) as described below shall be reported for each core run. Good quality core is defined as intact core having a fully circular circumference. The CRR shall mean the ratio of the total length of the good quality core over the drilling run expressed to the nearest 5%. The RQD is the percentage of the total length of good quality cores each exceeding 100mm in length over the drilling run, expressed to the nearest 5%. Any length of core containing breaks caused during drilling or handling shall be considered as solid when computing the RQD. The FI shall mean the number of naturally occurring fractures per meter run of core. Care shall be exercised to ensure that fractures caused during drilling or extraction of the core from the core barrel or liner are not included in the assessment of FI.

2.5 Hand Auger Boring

2.5.1 **Scope**

Hand auger boring shall be carried out at locations shown on the Drawings or as instructed by the Engineer in accordance with ASTM D 1452 or similar approved standard and shall consist of the formation of a borehole by hand auguring techniques.

2.5.2 **Equipment and Diameter of Boreholes**

The auger stem shall be of a design such that an open-tube or thin-walled sampler can be fitted at the auger end and undisturbed samples may be taken. The minimum diameter of hand auger boring shall be 100mm and casing shall not be required.

2.5.3 **Depth of Hand Auger Boring**

The hand auger holes shall be stopped when the sides of the hole starts to collapse or when the resistance to augering is so great that the auger cannot be advanced with the force of two healthy workers of average Malaysian Physique.

2.6 Backfilling of Boreholes

Exploratory holes shall be backfilled as soon as practicable after the hole is completed, unless otherwise directed by the Engineer. The Contractor shall backfill and compact all exploratory holes in such manner and using such materials that no subsequent depression is formed at the ground surface due to settlement of the backfill.

3.0 GROUND WATER

3.1 Ground Water Observations

3.1.1 **Measurement accuracy**

The observation of ground water level for all types of boreholes shall be made with a tape, rod, rule or dipmeter that permits measurements with an accuracy of plus or minus 25mm.

3.1.2 **First encounter**

For boreholes advanced without use of drilling fluid (including water) and when water is first encountered, the depth from ground level to point of entry shall be recorded and exploratory hole

operations stopped. The depth from ground level to water shall then be recorded at 5 minutes intervals until no further rise is observed.

However, if at the end of the period of 20 minutes the water level is still rising, unless otherwise instructed by the Engineer, this shall be recorded together with the depth to water below ground level and exploratory hole shall then be continued.

If casing is used and this forms a seal against the entry of ground water, the Contractor shall record the depth at which no further entry or only insignificant infiltration of water occurred. Where applicable every effort shall be made to seal off each water strike.

Where ground water occurs as a slow seepage into the exploratory hole, the point of entry of the seepage shall be recorded and water levels monitored as specified above.

3.1.3 **Subsequent encounter**

When further changes in water levels occur such as when lower water tables are found after upper water tables have been sealed off by the casing, they shall be recorded as in 3.1.2 above.

3.1.4 **Beginnings and end of shift**

For all types of cased boreholes, before a day's work is completed the casing shall be pulled up by about 0.3m and left in such a position overnight. The groundwater level shall be recorded as the last operation of the day and the first operation on the following day's boring. The recordings shall be repeated daily while boring for that particular borehole is in progress. The casing shall be capped overnight by the Contractor in such a way as to prevent the entry of rainwater and surface water but allow a free passage of air into the casing.

In a hand auger hole the groundwater level shall be recorded immediately the hole is completed and early in the following morning. For the purpose of such groundwater level observations, holes shall be suitably covered and protected from the entry of rainwater and surface water once they are completed. If the sides of the hole have collapsed over night, the "apparent" depth of the hole shall be recorded. At least one observation of the groundwater level and the "apparent" depth of auger hole, if applicable, is necessary for all hand auger holes.

3.2 Standpipe

3.2.1 **Scope**

Standpipe shall be installed in boreholes at locations shown on the Drawings or as instructed by the Engineer. The final details of any installation will be decided by the Engineer and will be dependent upon the actual subsoil and ground water conditions found. The installation shall be generally as shown in Fig. 3.1.

3.2.2 **UPVC Tubing**

50mm φ UPVC pipe slotted as shown in the Fig. 3.1 shall be installed with approved filter fabric wrapped around the whole slotted end.

3.2.3 **Grouting**

A grout of cement and bentonite in the proportions of 1:4 shall be used as indicated on Fig. 3.1. If water in the exploratory hole is contaminated by grout it shall be replaced by clean water, the method being to the approval of the Engineer.

3.2.4 **Sand Filter**

The sand filter surround to the slotted tubing shall be clean sand with particles sizes not greater than 1200 microns and not less than 210 microns the volume of the sand filter placed shall be

recorded. The Contractor's arrangements shall ensure that no sand adheres to the soil to the sides of the unlined borehole. Where there is water in the borehole the Contractor shall allow sufficient time for all the sand to settle.

3.2.5 **Surface installation**

The top of the UPVC tubing shall be covered by a plastic cap or similar as approved by the Engineer. An air vent shall be provided as shown on Fig. 3.1. Arrangement to protect the top of the UPVC tubing shall consist of a loose fitting cap and hook. The top end shall be set in concrete as shown on Fig. 3.1.

3.2.6 **Water levels**

The ground water level shall be recorded immediately before and after installation of the standpipe. Before readings are commenced the standpipe shall be filled with slightly warm water and its correct functioning demonstrated to the Engineer. Each installation shall be clearly and permanently labeled with a metal stamp or tag giving the exploratory hole/test number. During the site operations the Contractor shall record the ground water level in standpipe as instructed by the Engineer.

3.2.7 **Checking of Installation**

The correct installation and functioning of all standpipe installations shall be confirmed immediately following their completion.

(a) The Contractor shall ensure that there are no obstructions in the riser tube.

(b) The Contractor shall ensure that the tip is located to within 0.1m of the required depth and that the tip has not been displaced as a result of removing the borehole casing.

(c) The Contractor shall flush the system and top up the riser tube with clean water and measure and record the fall in the head of water for a period not exceeding 30 mins.

3.2.8 **Maintenance and Protection**

The Contractor shall ensure that proper maintenance and protection be provided for the installation throughout the monitoring period so that correct readings are obtained.

4.0 SAMPLING

4.1 Extent and Frequency of Sampling

4.1.1 **General requirements**

Method and frequency of sampling shall depend on the purpose or nature of structure for which the borehole is required. All sampling is to be carried out strictly in accordance with relevant standards and good geotechnical engineering practice.

4.2 Disturbed Sampling

4.2.1 **Small disturbed samples**

Small disturbed samples may be obtained by any means provided that the soil sample obtained is representative and unchanged in its constituent components. Samplers with flap retainer or

basket retainer or other attachment may be necessary for cohesionless soils.

Small disturbed samples shall be not less than 1.0 kg. These samples shall be immediately wrapped in thin plastic sheets such that soil structure remains intact, the sample shall be wrapped again and then placed in a plastic bag and sealed adequately to avoid moisture losses. The samples shall then be placed in appropriate container for transporting to the laboratory or location designated by the Engineer or his representative.

4.2.2 **Bulk disturbed samples**

Bulk disturbed samples shall be obtained from the cutting tools during percussion boring. The samples shall be collected over a depth interval of 1.0m or less and shall weigh not less than 30 kg.

4.3 Undisturbed Sampling

4.3.1 **Preparation for sampling**

Before taking an "undisturbed" sample the bottom of the exploratory hole shall be carefully cleared of loose material and where a casing is being used the sample shall be taken below the bottom of this casing. The depth to the bottom of the casing shall be recorded on the borehole logs. When an uncompleted hole is left overnight or for any other substantial period of time, no samples shall be taken until the hole has been advanced by a minimum of 300mm from the previous depth.

In soft soils a head of water shall be maintained in the casing to minimize heave in the borehole.

4.3.2 **Sampling tubes**

All tubes used for undisturbed sampling shall be of light alloy, stainless steel or with an equivalent surface plating for corrosion protection and shall be clear and free of all surface irregularities including projecting weld seams, burrs and dents. Sample tubes that are corroded or susceptible to corrosion or have non-machined cutting edges or have seams shall not be used. The cutting edges, area ratios and inside clearances shall be as specified in the following clauses.

4.3.3 **Open-tube sampling**

Open-tube drive samples shall generally be taken in stiff to hard cohesive soils in cable percussion boring using open-tube sampler and equipment as described in MS 2038 : 2006 . The sampler shall have diameter compatible with size of the borehole or casing diameter and a minimum length of 450mm. Inside of the casing shall be clean, smooth and without seams or obstruction of any kind. The cutting shoes shall be clean, sharp and without burred edges. The cutting edge taper shall not exceed 20 degrees. Area ratio shall be less than 25% with an inside clearance of 1% to 2%. The number of blows, weight of drop hammer, height of drop and length driven shall be recorded when cable percussion boring is used.

4.3.4 **Thin-walled sampling**

Thin-walled samples shall generally be taken in soft to firm soils using equipment and procedures as described in ASTM D 1587. Minimum outside diameter of the tube shall be compatible with size of bore hole or casing adopted or the size approved by the engineer and nominal length of the tube shall be 600 mm or the length approved by the engineer. Wall thickness shall be between 1.5mm and 2.0mm with an inside clearance of 0.5 % to 1.0%. Inside of the tube shall be smooth without burrs or seams, cutting edge shall be properly machined. The area ratio shall be 10% nominally. The tube shall be pushed into the base of the borehole by a continuous thrust and steady motion without driving, impact or twisting. The drilling rig or boring plant used shall be capable of exerting a static thrust of 10 kN on the sampler.

4.3.5 **Piston sampling**

For detailed investigation of soft cohesive soils, stationary piston sampling equipment shall be used unless otherwise specified. Minimum outside diameter of the tube shall be compatible with size of boring or casing adopted or the size approved by the engineer and nominal length of the tube shall be 1000mm or the length approved by the engineer. Wall thickness shall be between 1.5mm and 2.0mm. The sampling tube shall be stainless steel and shall have smooth surfaces. The area ratio shall be 10% nominally. The cutting edge shall be machined and taper angle shall be between 6 degrees and 10 degrees and the inside clearance ratio shall be 0% to 0.5%, inside of the tube shall be smooth without burrs or seams. When drilling has advanced to the required sampling depth the base of the borehole shall be cleaned thoroughly to ensure there is no debris at the bottom of the borehole. The assembled piston sampler shall be lowered down the borehole taking great care that the sampler does not come into contact with the borehole casing. Once the piston sampler reaches the base of the borehole the depth of the sampler must be checked against the prior measured depth of the borehole. If these measurements are not exactly the same it is likely that debris has accumulated at the base of the borehole. If such a condition exists the sampler shall be removed and the borehole shall be cleared out again.

Provided the sampler has reached the clean base of the borehole the sampler shall be held tight by the drilling rods to ensure that the weight of the sampler together with the drill string does not rest on the soil to be sampled. The piston shall then be unlocked from the sampler body by twisting the central piston rod. The piston rod shall then be attached to the tower, mast or tripod of the drilling machine. A considerable tensile force can develop in the piston rod. The swivel, adjustable turnbuckle and chain shall be chosen to withstand a force equivalent to the jacking load capability of the drilling equipment. The turnbuckle shall be adjusted to ensure that all play and backlash has been taken up. The piston rod shall be marked in a convenient manner to measure any settlement of the piston during sampling. Prior to advancing the sampler the length of advance shall be determined and the drill rods marked accordingly. The advance length shall be approximately 90% of the effective internal length of the sampling tube.

The advance of the sampler shall be made in one fast continuous movement. The rate of penetration of the sampler shall be of the order of 200 mm/s. The actual advance length of the sampler shall be measured in a conventional way and the amount of advance shall be recorded on the drilling logs. The settlement, if any, of the fixed piston shall be measured and recorded on the drilling logs. A waiting period of at least 5 minutes shall elapse before the complete sampler is removed from the borehole. The sampler shall be lifted without rotation. After withdrawal of the sampler from the borehole the sample and tube shall be removed from the sampler. The air vent screws shall be removed from the sampler. The air vent screws shall be removed to ensure that there is not any vacuum created as the sampler head and sample tube are separated. Prior to the execution of piston sampling on site the Contractor shall submit details of the equipment he proposes to use and he shall submit a copy of the instruction on piston sampling that shall be given to the drillers.

4.3.6 **Recovery and preservation of undisturbed samples**

(a) Following the sampling procedure of Clause 4.3.5 a rubber cap shall be placed on the lower end of the sampling tube containing the cutting edge. This will prevent damage to the cutting edge itself.

(b) From the other end of the sampling tube about 40mm of material shall be carefully removed. The material shall be retained in a screw top clear plastic container or plastic bags and sealed.

(c) The inside of the tube from its open end to the surface of the undisturbed sample shall be cleared of all soil debris using special cleaning tools.

(d) A circular piece of paper having the same diameter as the inside of the sampling tube shall be placed on top of the sample. This paper is to minimize wax impregnation.

(e) Melted non-shrinking microcrystalline wax shall be poured onto the paper disc to a thickness of about 10mm.

(f) Once the wax is nearly solid a neoprene disc having the same diameter as the inside of the tube shall be gently pressed into the wax to ensure the wax makes a good seal with the wall of the sampler.

(g) Another 10mm thickness of wax shall be poured onto the neoprene disc, once hardened a final 30mm thickness of wax shall be poured onto the sample.

(h) Once the wax has hardened moist sand, saw dust, or soil shall be placed on the waxed sample to fill completely the sampling tube.

(i) A rubber cap shall then be placed on the end of the sample tube and its edge sealed against the outside of the sample tube with adhesive vinyl tape.

(j) The tube shall be inverted carefully and steps (b) to (i) repeated for the cutting shoe end of the tube.

(k) The sample tube shall be labeled in accordance with clause 4.6.

(l) Until the samples are removed from the site they shall be placed in protective boxes in a dry place and under cover to the requirements of Clause 1.14.

4.3.7 **Unsuccessful sampling**

Where an attempt to take an undisturbed sample fails the bore hole shall be cleaned out for the full depth to which the sampling tube has been driven and the recovered soil saved as a disturbed sample. A fresh attempt shall then be made from the level of the base of the failed attempt. Should this second attempt prove unsuccessful, the Contractor shall adopt other means of sampling as agreed with the Engineer.

4.4 Ground Water Sampling

Ground water samples shall be taken in accordance with MS 2038 : 2006 on each occasion that ground water is encountered during boring. In percussion boring where water has not been added and in hand auger boring ground water samples shall be taken as soon as practicable after ground water is encountered. In all types of boring where water is added ground water samples should be collected when directed by the Engineer, by first removing all water from the borehole by pumping or bailing, then taking a ground water sample from the water which collects by seepage. Where above is not possible due to shallow water table or soils ingressing into borehole, a hand auger hole should be put down near to bore hole for water sampling purposes. Approximately 1.0 litre of water should be collected and stored in a clear inert plastic bottle, rinsing the bottle three times with the water being sampled before filling. The ground water sample shall sensibly fill the bottle which shall be sealed with a water-tight screw cap.

4.5 Surface Water Sampling

Water samples shall be taken from streams, ditches or standing water as directed by the Engineer. The samples taken shall be representative of the water in the source. Collection and storage of the water samples shall be as for ground water samples as described in Clause 4.4.

4.6 Labelling of Samples

All samples shall be labelled immediately after being taken from the Exploratory Hole or surface water. The label shall be clearly and indelibly marked and shall show all the necessary information about the sample, including the following:-

- Contract title, reference number and job number
- date of sampling
- Exploratory Hole reference number (for surface water, give relevant details)
- sample reference number
- depth of sample (including top and bottom of sample)

The following legend shall be used for the Exploratory Hole and sample reference numbers:-

Percussion boring	PH
Rotary boring	BH
Auger boring	HA
Trial pits	TP
Mazier core sample	MS
Rotary core sample	C
Stationary piston undisturbed sample	UP
Thin-walled tube undisturbed sample	UT
Open-tube undisturbed sample	UD
Small disturbed sample	DS
Sample from SPT spoon	SPT
Bulk disturbed sample	DB
Ground water sample	WG
Surface water sample	WS

The label shall be securely fixed onto the outside of the sample tube, jar or bag. The outside of the sample tube, jar or bag shall also be clearly and indelibly marked with the same information as the label.

4.7 Storage, Protection and Transportation of Samples

The Contractor shall store all samples in an orderly fashion at site in protective boxes in a dry place and under cover to the requirements of Clause 1.14 until they are dispatched to the designated laboratories or as directed by the Engineer.

The thin-walled, stationary piston and Mazier type undisturbed samples shall be stored, protected and transported with utmost care to avoid disturbance to the samples. They shall be placed and transported in approved shipping containers.

The shipping container shall be constructed such that they are padded throughout with rubber foam and contain partitions to stop the sampler tubes from moving in any direction during transporting to the laboratory. The rubber foam lining shall have a minimum uncompressed thickness of 100mm.

The container shall be capable of accommodating a minimum of three undisturbed samples and shall be of strong construction with carrying handles. Prior to the commencement of site work the Contractor shall submit a sample of the shipping container for approval.

During transportation all undisturbed samples shall be protected in the same manner as during storage on site.

The contractor shall describe the methods of sample transport in his final report.

4.8 Provision of Record Samples

The Contractor shall take 150gm of representative soil sample from each undisturbed, bulk disturbed and split spoon sample collected. These samples shall be known as "record samples" and shall be delivered as directed by the Engineer. The Contract Title and reference number, borehole number, sample reference number and the depth of sample shall be marked on a card fixed to the outside of the jar. The "record samples" from a project shall be stored in a crate with the Contract Title and reference and the year and month of investigation clearly and indelibly marked on the crate. These samples shall be delivered at the same time as submission of the preliminary records.

4.9 Retention and Disposal of Samples

All samples shall be kept for a period of not less than three months after submission of the approved report and shall be discarded after that time only on the instructions of the Engineer. The Engineer may request that certain of the samples be retained either by the Contractor.

5.0 INSPECTION PITS AND TRIAL PITS (TRENCHING)

5.1 Inspection Pits and Precautions for Underground Services

The Contractor shall start all Exploratory Holes located within the boundaries of public highways and elsewhere where the presence of underground services is expected by means of a hand excavated inspection pit not less than 0.5 sq.m. in plan and not more than 1.5m deep. Hand operated power tools may be used to assist excavation where hard strata such as road pavements cannot be broken out without the use of such tools. Exploratory Holes shall not begin until the presence or otherwise of all such services has been established. The position depths and dimensions of all services encountered shall be measured and recorded in the daily Journal, and strata recorded as set out in Clause 8.1.1.

5.2 Trenches for Examining and Sampling Soils

5.2.1 **Scope**

Trenches shall be excavated at locations shown on the Drawings or as instructed by the Engineer.

5.2.2 **Excavation Methods and In-situ Tests**

The Contractor shall excavate trenches by hand or machine to permit in situ examination of soil, soil sampling and in situ testing as required. The plan area of any trenches shall be about 6m x 1.8m and depth of excavation shall be at least 1.0m below top of pile cap. In-situ density tests using sand replacement method **(Test 15, MS 1056 : 2005)** shall be carried out on the embankment fill at ½m intervals or as directed.

5.2.3 **Support to Pit Sides and Safety**

The Contractor shall adequately support the sides of pits and trenches at all times to protect anyone entering and working in the hole. The supports shall be placed so as to minimize interference with the taking of samples or inspection of the faces. The Contractor shall take all necessary safety checks, including checking for noxious or toxic gases or materials, or radioactive materials.

Unsupported trial pits shall be excavated by machine to depths as stated in the Contract. The purpose of these pits is for visual examination from ground level only, and access below 1.5m

depth is not required.

5.2.4 **Ground Water**

The Contractor shall keep inspection pits and trial pits free of surface run-off water. Ground water shall be controlled by pumping or other means to permit continuous exploration insofar as the rate of inflow of water does not make control difficult.

5.3 Sampling from Trial Pits

5.3.1 **Small disturbed samples**

Small disturbed samples of not less than 1 kg shall be taken at each change in soil type, change in consistency or as instructed by the Engineer. They shall be placed immediately in air-tight containers which they should sensibly fill.

5.3.2 **Tube Sampling in Trial Pits**

As directed by the Engineer, open tube undisturbed samples shall be taken in trial pits using U100 samplers using approved thin-walled sampler tubes as described in MS 2038 : 2006 .

Prior to sampling in trial pits, the area over-lying the soil to be samples shall be cleared by the Contractor of all material which has altered from its natural condition in order to expose soil in its natural condition.

Horizontal and vertical samples shall be taken by jacking in the sampler with a hydraulic jack. On completion of jacking the sampling tube shall be rotated one half turn before withdrawal.

5.3.3 **Bulk disturbed samples**

Bulk disturbed samples of not less than 30 kg shall be collected over a depth interval of 0.5m at specified depths or as instructed by the Engineer. The samples collected shall be representative of the zone from which they have been taken.

In association with the bulk sampling, two separate samples of not less than 0.2kg each shall be taken for natural moisture content determination and shall be collected, preserved and stored as disturbed samples in accordance with Clause 4.2.1.

5.4 Backfilling

The inspection pits and trial pits shall be backfilled as soon as practicable after they have been completed. The Contractor shall backfill and compact the pits with the excavated materials in such a manner that no subsequent depression is formed at the ground surface due to settlement of the backfill.

6.0 FIELD TESTING

6.1 Standard Penetration Test (SPT)

6.1.1 **Scope**

The Standard Penetration Test (SPT) shall be carried out in boreholes at intervals given in the Specification or where indicated by the Engineer in accordance with Method 3.3 MS 1056 : 2005 : Part 9. The SPT shall consist of driving a split spoon sampler in a standard manner and obtaining

a disturbed sample of the soil penetrated.

6.1.2 **Equipment and sample recovery**

Equipment and procedures shall follow the requirements of MS 1056 : 2005. The driving assembly used shall be a self-tripping hammer of an approved design which permits a free drop of the hammer. All threaded connections between the split spoon sampler and the anvil shall be tightened using pipe wrenches. The recovered sample shall be preserved, labeled and stored as required for "small disturbed samples" in Clause 4.2.1. If no sample is recovered in the split spoon sampler a small disturbed sample shall be recovered from the position of the test.

6.1.3 **Procedure**

All SPTs shall consist of both a seating drive followed by a test drive, including cases where high penetration resistances are encountered. The procedure for carrying out all tests shall be as follows :-

Seating drive : number of blows for first 150mm penetration. If 75 blows are required before 150mm penetration is reached, then record penetration for 50 blows and terminate test drive.

Test drive : number of blows for further 300mm penetration. If 75 blows are required before 300mm penetration is reached, then record penetration for 75 blows and terminate test drive.

6.1.4 **Use of solid cone**

When tests are performed in soils containing boulders or cobbles, or in weathered rocks of high resistance, and when agreed by the Engineer, the split barrel sampler may be replaced by a solid 60 degree cone. In this case, a small disturbed sample shall be recovered from the position of the test.

6.2 Field Vane Shear Test in Borehole

6.2.1. **Scope**

The field vane test shall be carried out in boreholes at intervals given in the specification or where indicated by the Engineer in accordance with Method 4.4 : MS 1056 : 2005 : Part 9 and shall comprise the measurement of peak and residual vane shear strength and obtaining a disturbed sample of the soil tested.

6.2.2. **Equipment**

The equipment shall follow the requirements of MS 1056 : 2005. The torque head shall be of a type such that torque is applied through a worm and pinion mechanism. Minimum vane diameter shall be 50mm. For tests in soft clays minimum vane diameter shall be 65mm.

6.2.3 **Calibration and tolerances**

The instrument used for the measurement of torque shall be checked and calibrated as required by MS 1056 : 2005. The maximum period between calibration and use on site shall be 3 months. Calibration certificates from an approved standards agency shall be given to the Engineer in his office and a copy made available at site for the Engineer's retention before the start of testing. Testing shall not start until the specified calibration certificates are received by the Engineer. Calibration shall be repeated after completion of the site works. Permitted tolerances on vane dimensions shall be plus or minus 0.5mm due to either manufacture or wear. However, the actual vane dimensions shall be measured at the start of works to an accuracy of plus or minus 0.1mm, and these actual dimensions shall be used in calculations. The vane dimensions shall be

checked at the end of the works. Permitted tolerance on the torque head measurements shall be plus or minus 5% of the measured value.

6.2.4 **Procedure**

The field vane test shall be carried out in accordance with MS 1056 :2005, with the following additional requirements

(a) Before starting the test, the torque head measuring instrument shall be firmly secured against rotation and vertical movement with respect to ground level.

(b) During the execution of the test a period of 5 minutes shall be allowed to elapse between pushing the vane to its final depth and commencing rotation.

(c) The torque head measuring instrument shall be zeroed before being placed over the upper extension tube.

(d) During testing the vane shall be rotated at a rate of 6 degrees/min. and readings of torque shall be recorded every 2 degrees rotation of the torque head. In stiffer materials which reach failure in less than 10 degrees rotation, readings shall be taken every 1 degree.

(e) The procedure for remoulding shall follow the requirements of MS 2038 : 2006 .

(f) For both peak and remoulded tests, rotation of the vane shall be terminated when the soil has conclusively sheared or when the readings are either constant or falling for at least 20 degrees of rotation. The time to failure is generally 2 minutes to 5 minutes except in very soft clays where it may be as much as 10 minutes to 15 minutes.

(g) The full operation of the field vane shall include the taking of a representative small disturbed sample from the same level as the test.

(h) On completion of all vane tests in any one borehole the vane head assembly shall be stripped down, cleaned and lubricated following the manufacturer's instructions.

6.3 Permeability Testing in Boreholes

6.3.1 **Scope**

Permeability testing shall be carried out in boreholes as indicated by the Engineer in accordance with MS 2038 : 2006 and shall consist of falling or rising head tests.

6.3.2 **Equipment and procedure**

The borehole shall be cleaned out before carrying out a permeability test and the casing raised to expose a length of borehole wall equal to approximately two times the borehole diameter. For materials which are likely to collapse if unsupported a suitable filter material shall be placed in the base of the borehole to support the uncased part.

For falling head tests the water level in the borehole shall be raised by adding water to a level agreed by the Engineer. It may be necessary to raise the water level above the ground surface and sufficient length of casing shall be provided to project above ground level.

For rising head tests, the water level in the borehole shall first be lowered by bailing to a level agreed by the Engineer.

The water level shall be recorded at 10 second intervals during the early stages of the test and at less frequent intervals in the latter stages in order that a representative record of the fall or rise in the water level relative to time can be obtained.

The level of the natural ground water table shall be established at the time of testing.

In cases where the stratum being tested may be partially saturated, the initial part of the test may be repeated a number of times until a repeatable result is obtained.

6.4 Deep Sounding Test (Mechanical)

6.4.1 **Scope**

The deep sounding test (mechanical) (also known as the "Dutch Cone Penetration Test") shall be carried out at locations shown on the Drawings or as indicated by the Engineer using a mechanical friction cone in accordance with ASTM D 3441 and shall comprise the measurement of cone resistance and local friction.

6.4.2 **Equipment**

The equipment shall follow the requirements of ASTM D 3441 with the additional requirement that the cone shall have a tapered mantle similar to the mantle cone. A friction reducer shall be used for all tests.

The Contractor shall have two load cells available, each equipped with two pressure gauges capable of measuring the following ranges of equivalent cone resistance :-

- medium load cell: 0 to 1.6 MPa and 0 to 25 MPa;
- heavy load cell : 0 to 10 MPa and 0 to 100 MPa.

The Contractor shall use the load cell and gauges most suitable for the soils penetrated. If necessary during a test the load cells shall be changed to suit the type of material penetrated. Alternative arrangement of load cells and pressure gauges may be used with the Engineer's approval provided that they give similar ranges of sensitivity to those specified above. Cones with an electric measuring and recording mechanism shall only be used with the prior approval of the Engineer.

The capacity of the jacking equipment and the amount of available reaction shall be as instructed by the Engineer. At locations as instructed by the Engineer, available reaction shall be increased by the use of kentledge or anchors.

Guides shall be provided for the part of the sounding rods protruding above the soil and for the rod length exposed in water in order to prevent buckling.

6.4.3 **Calibration and tolerances**

Calibration of the load cells shall be carried out no more than 6 months before the start of site work. The calibration certificate shall consist of a graph or listing of figures in which loads or pressures measured by the load cells are compared to loads or pressures measured by a standard load cell from an approved standards agency. The Engineer shall be provided with two copies of the calibration certificate before the commencement of site work.

Permitted tolerances on equipment dimensions shall be as given in ASTM D 3441. Permitted tolerances on loadcells shall be plus or minus 5% of the measured value.

6.4.4 **Procedure**

The penetrometer jacking equipment shall be set up on a firm and level platform. If stones, hardcore or similar material are present at or just below ground level, then a small starter hole shall be formed through this material at the test location.

Before starting each test the cone, sounding tubes and inner rods shall be thoroughly cleaned of all oil, grease and soil particles. The cone shall be extended and compressed several times in a reservoir of water until the telescopic action is smooth and requires little force. If the cone has a tendency to stick or jam, or if there is noticeable play or looseness between the different parts of the cone, then the cone shall not be used.

The mechanical cone shall be advanced into the ground at a rate of 20mm/s, ensuring that the sounding rods are vertical and taking the required sets of readings every 200mm. As testing proceeds, the space between the inner rod and the outer sounding tube shall be kept full of water. Penetration shall be continued until the safe working limits of the equipment as determined by the Contractor are reached. The Engineer may require that the test be terminated before the safe working limits of the equipment as determined by the Contractor are reached.

If during testing the inner rod fails to return to the correct position after the outer sounding tubes have been advanced to a measurement depth, then a note shall be made on the record sheet against the affected measurements. If the inner rod fails to return to the correct position during five consecutive readings, then the test shall be temporarily terminated and the cone extracted from the ground, inspected, cleaned and if necessary replaced. The cone shall then be readvanced directly to the depth of temporary termination and the test continued.

6.5 Deep Sounding Test (Piezocone)

6.5.1 **Scope**

The deep sounding test (piezocone) (also known as the "piezocone test") shall be carried out at locations shown on the Drawings or as indicated by the Engineer using an electric cone in accordance with ASTM D 3441. The cone shall incorporate a filter and transducer for the instantaneous measurement of pore water pressure and the test shall comprise the measurement of cone resistance, local friction and pore water pressure.

6.5.2 **Equipment**

The equipment used shall be that designed for this method of testing. Equipment shall follow the requirements of ASTM D 3441 with the following additional requirements :

(a) The type of cone used shall be suitable for the testing of soils from very soft to firm clay, peats and organic clays to sands.

(b) The filter used to measure pore water pressure shall be located between the cone and the friction sleeve. The filter shall be of the same external diameter as the friction sleeve, and shall be to the approval of the Engineer. The filter shall be saturated in a deaired silicon oil or similar approved liquid and the same liquid shall be used to fill the space within the cone between the filter and the pore pressure transducer. The use of ceramic filter elements and/or water as the saturating liquid will not be permitted unless approved by the Engineer. A new filter shall be used for each test and shall be fitted onto the cone within a reservoir or the same liquid used to saturate the filter.

(c) An inclinometer shall be incorporated in the piezocone capable of measuring the inclination of the cone from the vertical.

(d) The penetration test jacking equipment shall be capable of 10 tonne hydraulic capacity with an available reaction of 4 tonne. The Contractor shall make arrangements to ensure that testing is carried out to a sufficient depth.

(e) Monitoring and recording equipment shall be capable of providing the following records of the measured parameters during the execution of the test :

- a continuous or quasi-continuous record of all measured parameters stored on

digital magnetic tape of similar media device to be used for eventual production of the final plots;

- an instantaneous pen plot or graphical display of at least three measured parameters, cone resistance, local friction and pore water pressure.

- a hard copy of measured numerical parameters recorded at intervals of 100mm or less.

The equipment shall have the capability of reading to the following minimum values:-

- cone 0.01 MPa
- local friction 0.1 kPa
- pore water pressure 1 kPa
- inclination 1 degree

The recording equipment shall be housed in a weatherproof cabin.

(f) A friction reducer shall be used for all tests.

6.5.3 **Calibration and tolerances**

The cone and measurement system shall be calibrated for use in a range of soil types from very soft to firm clays, peats, and organic cohesive soils to sands. The Engineer shall be provided with two copies of the calibration certificates before or at the commencement of site work. The calibration certificate shall consist of a graph or listing of figures in which loads or pressures recorded by the piezocone measurement system are compared to loads or pressures measured by a standard load cell or pressure measuring device from an approved standards agency. Calibration shall be carried out no more than 3 months before the start of site work.

The Contractor shall have available on site throughout the duration of the site work a calibration load cell suitable for on-site use to enable gross error checks to be carried out.

Permitted tolerances on equipment dimensions shall be as given in ASTM D 3441. Permitted tolerances on load and pressure monitoring devices shall be plus or minus 5% of the measured value.

6.5.4 **Procedure for penetration test**

The penetration test jacking equipment shall be set up on a firm and level platform at locations indicated by the Engineer. If stones, hardcore or similar material are present at or just below ground level, then a small starter hole shall be formed through this material at the test location.

The piezocones shall be advanced into the ground at a rate of 20mm/s, ensuring that the sounding tubes are vertical. Contractor shall ensure that this rate of penetration is maintained for the full depth of the test. Data shall be recorded using the specified recording equipment. Penetration shall be continued until the safe working limits of the equipment as determined by the Contractor are reached. These safe working limits shall be agreed with the Engineer prior to the commencement of site works. The Engineer may require that the test be terminated before the safe working limits of the equipment as determined by the Contractor are reached.

6.5.5 **Procedure for dissipation test**

At locations and depths to be decided by the Engineer, penetration of the piezocone shall be stopped and excess pore water pressure shall be allowed to dissipate. During these periods loading on the sounding tubes shall be removed. Dissipation of excess pore pressure shall be recorded on a time scale.

In addition to any graphical plots, numerical values of pore water pressure shall be recorded at

least at the following times after ceasing penetration : 0, 0.5, 1, 1.5, 2, 3, 4, 6, 8, 10, 15, 20, 25, 30, 35, 40, 50, 60 minutes. It is expected that a one hour period of dissipation will generally be sufficient, but this period may be altered by the Engineer to suit the ground conditions encountered.

6.6 Piezometer

6.6.1 **Scope**

Piezometers shall be installed at locations shown on the drawings or as instructed by the Engineer. The final details of any piezometer installation will be decided by the Engineer and will depend upon the actual subsoil and ground conditions found and the supplier's recommendations. The piezometer shall be either vibrating wire type or pneumatic type for the measurement of pore pressure.

6.6.2 **Vibrating Wire Type Piezometer**

6.6.2.1 **Piezometer tip and cable**

The piezometer tip shall incorporate a filter and transducer for the measurement of pore pressure. The piezometer tip shall consist of a Porous ceramic element or other suitable element with average pore diameter of 1 micron. The ceramic element should be soaked in boiled water for 24 hours prior to installation. Cables should be laid in continuous lengths without any joints. The joints between the tips and cables shall be wrapped with approved corrosion resisting tape. Cables should be placed loosely to allow for settlements or lateral displacements.

6.6.2.2 **Grouting**

A grout of cement and bentonite in the proportions of 1:4 shall be used. Bentonite should be made in the form of pellets to seal.

6.6.2.3 **Sand Filter**

The sand filter surround to the porous element shall be clean and fall wholly between the limits of grading 1200 and 210 microns and the volume of the sand filter shall be recorded.

The Contractor's arrangement shall ensure that no sand adheres to the soils in the sides of the unlined boreholes. The Contractor shall allow sufficient time for all the sand to settle. The piezometer tip shall be placed in the hole and the remaining sand filter shall then be added as described above. The above procedure could be repeated for all other elevations of piezometer installations.

6.6.2.4 **Surface installation**

All necessary steps has to be taken to take care of the exposed parts of the cable from damaging, by the Contractor. Before installing it has to be sent to the Engineer for approval.

6.6.3 **Pneumatic Piezometer**

6.6.3.1 **Piezometer tip and tubing**

The piezometer tip shall comprise a porous element integral with a diaphragm transducer, installed either in a borehole or by pushing to shallow depths in soft soil. Twin nylon tubes in polythene sheath covering, connect the transducer to a terminal panel or readout unit. The piezometer tip is soaked in water for at least 24 hours before connecting to the twin tubing.

For lower pressures up to 350m head of water and tube lengths up to 500m, pneumatic readout with either a Bourdou tube or digital display shall be used. For high pressures, up to 2000m head

of water or for tube lengths greater than 500m hydraulic readout shall be used.

6.6.3.2 **Sand Filter**

The sand filter surround to the porous element shall be coarse, clean and fall wholly between the limits of grading 1200 and 210 microns and the volume of sand filter shall be recorded. Filter sand is poured and tamped until tip is covered by at least 150mm.

6.6.3.3 **Grouting**

A plug to prevent entry of grout into the sand filter is placed in the form of balls of stiff bentonite or bentonite granules dropped through the water and tamped into place. Backfilling is completed to ground surface with an impervious grout, generally a bentonite-cement mix placed through a tremie pipe which is positioned above the bentonite plug and withdrawn as grouting proceeds.

6.6.3.4 **Installation**

The hole, diameter 75-150mm, is driven in soils using shell and auger and in rocks with rotary water flush drilling. Air flush and consequent entrapment of air in the ground should be avoided. The sides of the hole in the vicinity of the piezometer tip should be free from mud-cake and debris; the hole should be flushed clean before installation of the piezometer tip. If the hole requires casing, this is withdrawn to keep pace with the installing operation.

Coarse, clean sand filter material is placed through water tot he proposed base of the piezometer tip, and is compacted. The piezometer tip, soaked in water for at least 24 hours, is connected tot he twin tubing and inserted in the borehole using placing tubes. Further filter sand is poured and tamped until the tip is covered by at least 150mm.

The piezometer tubes must be protected from mechanical damage. They may be run in protective conduits or cast into concrete. The tubes should be looped where they cross an interface and at joints.

6.6.4 **Pressure head readings**

The pressure head level shall be recorded immediately after the installation of the piezometer. Before readings are commenced, the correct functioning is demonstrated to the Engineer. Each piezometer shall be clearly and permanently labelled with a metal stamp or tag giving the borehole location number. During the site operation, the Contractor shall record the pressure head levels as instructed by the Engineer.

6.6.5 **Maintenance and Protection**

The Contractor shall ensure at all times throughout the monitoring period that proper maintenance and protection be given to the installations and surface terminals on site so that correct measurements are obtained.

6.7 Inclinometer and Extensometer

6.7.1 **Scope**

The inclinometer and extensometer tests shall be carried out at borehole locations and depths given on the Drawings or as instructed by the Engineer. This shall be done to study the settlement and lateral movement of the embankment foundations. The installation details shall be in accordance with the manufacture's recommendations and as directed by the Engineer.

6.7.2 **Calibration and tolerance**

The inclinometer and Extensometer shall be calibrated for use and copies of the calibration

certificates shall be provided before or at the commencement of work at the site to the Engineer. It shall consist of a graph or listing of figures. Calibration shall not be carried out more than 3 months before the start of the site work.

The diameter ratio of the borehole and the tubing shall be between 10 to 15%.

6.7.3 **Procedure**

The inclinometer and extensometer shall be installed in the boreholes as instructed by the Engineer. The rotary drilling shall be carried out until a hard strata and the inclinometer tubing's tip should be tied to that, and the subsequent tubes are fixed on that. Before installation, the orientation of keyways must be established and if possible maintained throughout the installation. The tubing is lowered in a pre-grout borehole and they are jointed with the next. A hydrostatic head is maintained with clean water to stop the grout from entering through a joint. During the extraction of the casing the orientation of the tube shall be checked after each length is pulled. The horizontal displacement of the ground below the embankment is measured using the inclinometer at 0.5m intervals with depth for the whole compressible clay strata. On the other hand, the vertical displacements or settlements in the clay strata is measured by the use of magnetic targets placed at 1.5m depth intervals on the outside of the inclinometer tubing. Monitoring of the readings during the site operations and subsequent period shall be as instructed by the Engineer.

6.7.4 **Maintenance and Protection**

The Contractor shall ensure at all times throughout the monitoring period that proper maintenance and protection be given to the installations and surface terminals on site so that correct measurements are obtained.

6.8 Pressuremeter

6.8.1 **Scope**

The pressuremeter test shall be carried out at location shown on the drawing or as instructed by the Engineer. It shall be carried out to find Parameters Limit pressure PL, Deformation Modulus E and insitu horizontal stresses.

6.8.2 **Equipment**

(a) The type of standard metallic probe covers will allow testing in majority of soils from very soft to hard clays, fills, embankments, organic clays to sands. However, self boring type pressuremeter is required for very soft, sensitive clays.

(b) The equipment shall have the capability of reading
- up to 20 to 25 bars pressure in soils
- up to 50 to 70 bars in rocks

6.8.3 **Calibration**

In a pressuremeter testing instrument accuracy is always important to obtain the corrected pressure-volume curve, or pressure-radius curve. Therefore, the instrument has to be calibrated for each borehole or as instructed by the Engineer. Calibration for Pressure losses 'Probe Calibration' shall be done by inflating the Pressuremeter in air. Calibration dates and method or calibration shall be given to the Engineer from time to time.

6.8.4 **Installation and Procedures**

During the drilling care shall be taken for least disturbance of the borehole. Boring shall be carried out with bentonite slurry. Contractor shall take all necessary steps to ensure borehole

from collapsing. All other types of problems considering different type of soils the Contractor shall use the Standard methods in practice with prior approval from the Engineer. The corrected pressure-volume curve shall be plotted on the site immediately after the test and a copy shall be submitted to the Engineer.

When the volume variation for a pressure increment of 1 bar, becomes less than 0.5cu.m, the volumetric shunt must be used, magnifying 50 times the sensitivity of the volume readings.

The test is standardized and should be carried out with ten equal loading increments upto the point of failure. Readings of deformation with respect to time are taken for each pressure increment of 15 sec., 30 sec., and one minute after the application of this increment.

6.9 Penetration Field Vane Shear Test

6.9.1 **Scope**

The penetration field vane test shall be carried out at locations and intervals given on the Drawings or as instructed by the Engineer in accordance with Method 4.4 : MS 1056 : 2005 : Part 9 and shall comprise the measurement of peak and residual vane shear strength without the use of a borehole.

6.9.2 **Equipment**

The equipment shall be in accordance with MS 1056 : 2005 with the following additional requirements :

(a) The vane test apparatus shall be Geonor penetration type or similar approved which shall be capable of penetration to the maximum depth indicated on the Drawings or instructed by the engineer.

(b) Two sizes of vane shall be available for different ranges of shear strength measurement as follows :-

Vane size 55 x 110mm for the measurement of undrained shear strength between 50 to 100 kPa

Vane size 65 x 130mm for the measurement of undrained shear strength between 0 to 60 kPa.

(c) The reaction and capacity of the jacking equipment shall be sufficient to reach the maximum depth required.

(d) Bearings shall be provided every 3.0m between the outer tube and inner rod of the vane test apparatus.

6.9.3 **Calibration and tolerances**

The instrument used for the measurement of torque shall be checked and calibrated as required by MS 1056 : 2005. The maximum period between calibration and use on site shall be 3 months. Calibration certificates from an approved standards agency shall be given to the Engineer and a copy made available at site for the Engineer's retention before the start of testing. Testing shall not start until the specified calibration certificates are received by the Engineer. Calibration shall be repeated after completion of the site works.

Permitted tolerances on vane dimensions shall be plus or minus 0.5mm due to either manufacture or wear. However the actual vane dimensions shall be measured at the start of works to an accuracy of plus or minus 0.1mm, and these actual dimensions shall be used in calculations. The vane dimensions shall be checked at the end of the works. Permitted tolerance on the torque

head measurements shall be plus or minus 5% of the measured value.

6.9.4 **Procedure**

The field vane test shall be carried out in accordance with MS 1056 : 2005, with the following additional requirements

(a) Once the vane within the protecting shoe reaches the required level before pushing the vane to the final test depth, the upper extension tube shall be firmly secured against rotation and vertical movement with respect to ground level.

(b) During the execution of the test a period of 5 minutes shall be allowed to elapse between pushing the vane to its final depth and commencing rotation.

(c) The torque head measuring instrument shall be zeroed before being placed over the upper extension tube.

(d) During testing the vane shall be rotated at a rate of 6 degrees/min. and readings of torque shall be recorded every 2 degree rotation of the torque head. In stiffer materials which reach failure in less than 10 degree rotation, readings shall be taken every 1 degree.

(e) The procedure for remoulding shall follow the requirements of MS 2038 : 2006 .

(f) For both peak and remoulded tests, rotation of the vane shall be terminated when the soil has conclusively sheared or when the readings are either constant or falling for at least 20 degrees of rotation. The time to failure is generally 2 minutes to 5 minutess except in very soft clays where it may be as much as 10 minutes to 15 minutes.

(g) On completion of a test, the vane shall be withdrawn back into the protecting shoe, then advanced to the next test depth.

(h) On completion of all vane tests in any one borehole the vane head assembly shall be stripped down, cleaned and lubricated following the manufacturer's instructions.

6.10 Penetration Piston Sampling

6.10.1 **Scope**

The penetration piston sampling shall be carried out at locations shown on the Drawings or as directed by the Engineer and shall comprise the taking of undisturbed samples using stationary piston sampler with sampler pushed into the ground with jacking equipment without the use of a borehole.

6.10.2 **Equipment and Procedure**

The stationary piston sampling equipment and procedures shall be in accordance with MS 2038 : 2006 and Clause 4.3.5 of the Specification with the following additional requirements :

(a) The jacking equipment shall have 2.5 tonne minimum capacity with an available reaction sufficient to allow full mobilization of the jack capacity.

(b) The penetration jacking equipment shall be set up on a firm and level platform. If stones, hardcore or similar material are present at or just below ground level, then a small starter hole, shall be formed through this material at the test location.

6.11 JKR or Mackintosh Probes

6.11.1 **Scope**

The JKR or Mackintosh Probe shall be carried out at locations shown in the Drawings or as indicated by the Engineer and shall consist of driving a standard probe into the ground and recording the resistance to penetration.

6.11.2 **Equipment**

The apparatus used shall be the standard JKR Probe or the Mackintosh Probe.

The probing rig shall consist of a stable frame for driving the extension rods and cone vertically, with a guide to provide lateral support for that part of the extension rods protruding above the soil or exposed in water, the means of handling and operating the driving device and a means of extracting the rods and cone. The guide shall be such that not more than 1.2m or rod is unsupported at any one time and if the driving device is not separately provided with a guide then not more than 0.6m of rod shall be unsupported where the blow count is in excess of 15 blows per 300mm.

6.11.3 **Procedure**

The probing rig shall be erected so that the deviation from the vertical of the first extension rod shall not be greater than 2%. Maximum deviation from the vertical of the extension rods during driving shall be 5%.

The driving shall be as continuous as possible but in no case shall interruptions longer than 5 minutes be allowed unless recorded on the journal. The hammer shall be raised in such a way as not to carry it more or less than the defined height above the driving head. The cone shall be driven at a rate of between 15 to 30 blows per minute, and the number of blows shall be recorded for each 300mm increment of penetration.

The probing shall be stopped when the resistance has reached 400 blows/300mm penetration unless otherwise directed by the Engineer.

7.0 LABORATORY TESTING

7.1 Schedule of Laboratory Testing

The Engineer will decide the laboratory test required and will provide the Contractor with one or more Schedules of Laboratory Tests. It may be necessary to specify additional testing after the results of the original testing are available. The Contractor shall therefore ensure that the portions of samples remaining after extraction of test specimens are properly resealed and stored. Testing schedules will not be prepared until the Engineer has received the relevant preliminary records as detailed in Clause 8.3. The Contractor shall inform the Engineer within 7 working days from the receipt of the testing schedule if the sample is not adequate for all the tests specified.

7.2 Units to be used

The units used shall be in S.I. The measured accuracy required shall follow that in the testing standards.

7.3 Testing Standards

The relevant testing standards and the additional testing requirements for all the tests shall be as specified in clause 1.4.

7.4 Information Required

In addition to the information required by the relevant specified standards, additional information as listed in Table 7.1 shall be submitted with the results of all the tests referred to in the Specification and Bill of Quantities. When strength tests have been scheduled on samples of residual soils the contractor shall describe in detail and before testing any surface features of the material i.e sandy pockets, relict joints, mineral lineation, foliation, Fe staining, veins, fossils and stress relief cracks.

8.0 REPORTING

8.1 Information to be Submitted

8.1.1 General information for all Exploratory Holes. Soundings and Penetration Tests

The following general information where appropriate shall be submitted on record sheets of all Exploratory Holes and any other tests or installations, soundings and field tests in daily journals, preliminary records and the final Report.

(a) Contract Title and Reference Number
(b) Contractor's Name
(c) Exploratory Hole, sounding, or field test reference number, location (coordinates and chainage and offset) and diameter or size
(d) Dates of exploration referred to the depth at the end of each working day or shift.
(e) Equipment used
(f) Details of services or drains located
(g) Data on the stability of the Exploratory Hole and details of casing/shoring used related to progress.

8.2 Daily Journals

The Contractor shall prepare for each Exploratory Hole, Sounding and field test, a daily Journal which shall be of a form to be approved by the Engineer. The Journals for each Exploratory Hole Sounding and field test shall be submitted to the Engineer at the beginning of the next working day following the day to which they refer. The journal shall contain the information required in Clause 8.1 where relevant.

8.3 Preliminary Records of Exploratory Holes, Soundings and Field Tests

The Contractor shall prepare preliminary records which shall be submitted to the Engineer in duplicate within 7 working days of the completion of each Exploratory Hole, Sounding and field tests to which they refer and shall contain the information required in Clause 8.1 where relevant.

8.4 Preliminary Laboratory Test Results

The information to be submitted shall be as given in Clause 7.4. In addition a single copy of each laboratory test result sheet shall be submitted together with any calculations carried out.

8.5 Final Report

The Final Report shall consist of a **factual** report on the Soils Investigation authenticated by the Contractor's own Professional Engineer as described under Clause 25 of the Instruction to Tenderers. The Report shall be bound in loose leafed hard backed multiple ring binders with not more than 50mm thickness of pages in each volume, or as otherwise directed by the Engineer. The cover of the report shall highlight the Engineer, the title of the project, the contractor and the duration dates of the field works (in that order). The Final Report shall contain the following information :

(a) A brief factual description of the works, stating the aim and scope of the Works, code of practice adopted, the numbers and types of Exploratory Holes, Soundings and field tests, duration and time of year, weather conditions encountered, a brief description of the Site Operations and List of laboratory tests including testing standards used.

(b) A brief description of equipment and procedures used for forming Exploratory Holes, Soundings and carrying out field tests.

(c) Records of Exploratory Holes, Soundings and field test including all the information required in Clause 8.1 where relevant. The records shall include all the information presented in the preliminary records updated as necessary based on laboratory test results and further examination of samples.

(d) Standpipe and piezometer records, including relevant permeability test results.

(e) All laboratory test records and results.

(f) Summary sheets of all test results.

(g) Site plans showing locations of all Exploratory Holes, Soundings, other tests and areas covered by the Soils Investigation, including the Scale and North sign.

(h) All soil description presented shall take into account laboratory test results strictly in accordance with latest MS 1056 : 2005 or relevant Malaysian Code of Practice

8.6 Approval of Final Report

Two draft copies of the final Report shall be submitted to the Engineer for approval before submission of the Final Report. The Contractor shall allow two weeks in his Programme for the Engineer to grant this approval and he shall include amendments, if any, as required by the Engineer, in the Final Report. The number of copies of the Final Report to be submitted shall be in accordance with the Bill of Quantities.