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2 BOREHOLES

2.1 GENERAL

2.1.1 Scope

1 Advancement of boreholes by percussion boring, auger boring, and rotary drilling.

2 Related Sections and Parts are as follows:

This Section

Part 1 .....General

Section 4, ...Foundations and Retaining Structures
Section 6, ...Roadworks
Section 8, ...Drainage Works
Section 12, ...Earthworks Related to Buildings

2.1.2 References

1 The following standards and other documents are referred to in this Part:

ASTM D420 ..... Site Characterization for Engineering, Design, and Construction Purposes

ASTM D2488 ..... Standard Practice for Description and Identification of Soils (Visual-Manual Procedures)

BS 5930 ..... Code of practice for ground investigations

EN 1997-2..... Eurocode 7 - Geotechnical design - Part 2: Ground investigation and testing

Engineering Group of the Geological Society Working Party Report The logging of rock cores for engineering purposes (1970).

2.2 BOREHOLES GENERALLY

2.2.1 Method and Diameter

1 The method of advancement and the diameter of a borehole shall be such that the boring can be completed and logged to the designated depth, and samples of the designated diameter can be obtained, in-situ testing carried out and instrumentation installed.

2 The following methods may be employed for advancement of a borehole unless otherwise designated:

(a) Percussion boring.

(b) Auger boring (If hollow stem augering is proposed, the Contractor shall satisfy the Employer that the SPT values obtained are not effected by disturbance of the soil by the auger head, or the presence of material within the hollow stem.).

(c) Rotary drilling.

2.2.2 Addition of Water to the Borehole

1 Jetting with water shall not be used to assist the advance of the borehole, except where approved by the Engineer. Where the borehole penetrates below the water table and disturbance of the soils is likely, a positive hydraulic head shall be maintained in the borehole.

2.2.3 Backfilling

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1 The Contractor shall backfill boreholes in such a manner as to minimise subsequent depression at the ground surface due to settlement of the backfill. In some circumstances, grout or special infilling may be required by the Engineer. Where artesian or other water conditions make normal backfilling impracticable, the Contractor shall consult and agree with the Engineer a procedure for sealing the borehole.

2.3 PERCUSSION BORING

2.3.1 Hard Stratum or Obstruction in Percussion Boring

1 In a borehole where percussion boring is employed and a hard stratum or obstruction is encountered, the Contractor shall employ chiselling techniques for a period of up to 1 h. Should this not penetrate through the hard stratum or obstruction the Contractor shall inform the Engineer, who may instruct the use of one or more of the following:

(a) continuation of chiselling techniques

(b) rotary or other approved drilling until the stratum is penetrated

(c) abandonment of the borehole.

2.4 AUGER BORING

2.4.1 Hand Auger

1 Hand auger boring may be appropriate in suitable self-supporting strata.

2.4.2 Continuous Flight Auger Boring

1 Where continuous flight auger boring is used, it shall be carried out under the full-time supervision of a person meeting the requirements of Part 1 Clause 1.5 Paragraph 5 Item (c) who shall produce, as boring proceeds, a record of the material and groundwater encountered.

2.4.3 Hollow Stem Flight Auger

1 Where hollow stem flight auger boring is used, the equipment used shall be such as to bore and recover samples as designated. Sampling shall be carried out through the hollow stem.

2.5 ROTARY DRILLING

2.5.1 General

1 Rotary drilling may be required for the recovery of cores, or for the advancement of a hole in rock, with or without core recovery.

2.5.2 Drilling Fluid

1 The drilling fluid shall normally be clean water, air or air mist. However, with the approval of the Engineer, drilling muds, additives or foam may be used.

2 The loss of drilling fluid during the advancement of a boring can be indicative of the presence of open joints, fracture zones or voids in the rock mass being drilled. Therefore, the volumes of fluid losses and the intervals over which they occur should be recorded. For example, "no fluid loss" means that no fluid was lost except through spillage and filling the hole. "Partial fluid loss" means that a return was achieved, but the amount of return was significantly less than the amount being pumped in. "Complete water loss" means that no fluid returned to the surface during the pumping operation. A combination of opinions from the field personnel and the driller on this matter will result in the best estimate

2.5.3 Rotary Drilling with Core Recovery

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1 Unless otherwise designated rotary core drilling shall be carried out by a double or triple tube coring system incorporating a removable inner liner or split tube. The triple tube system may be affected by use of a double tube barrel with an approved semi-rigid liner.

2 Rotary core drilling shall produce cores of not less than the designated diameter throughout the core length. Care shall be exercised in the drilling so as to optimise core recovery.

The drilling rate should be monitored and recorded on the boring log in the units of minutes per 0.3 m (1 ft). Only time spent advancing the boring should be used to determine the drilling rate.

3 The first drill run in each hole shall not exceed 1 m in length. Subsequent drill runs shall not normally exceed 3 m in length and the core barrel shall be removed from the drill hole as often as is required to obtain the best possible core recovery or alternatively the core samples shall be retrieved by means of wireline. The Engineer may designate in-situ testing between drill runs.

4 Removal of cores and labelling of liners shall be carried out as follows:

(a) All operations entailed in recovering the cores from the ground after completion of drilling shall be carried out in a manner such as to minimise disturbance to the cores.

(b) Core barrels or inner tube in case of wireline shall be held horizontally while the innermost liner containing the core is removed without vibration and in a manner to prevent disturbance to the core. The core should be rigidly supported at all times while it is being extruded and during subsequent handling, and the liner containing the core must not be allowed to flex

(c) Immediately after removing the liner the top and bottom shall be marked in indelible ink. The ends of liners shall be capped and sealed using adhesive tape. Liners shall be cut to the length of the enclosed core. Alternatively, should a metallic split tube be used, the samples shall be placed in half cut PVC pipes sealed with the second half after core samples description with marking of the core run on the PVC tube and the core box.

(d) Where the length of core recovered from any single core run is such that it cannot be accommodated in one channel of the core box, the liner shall be cut to coincide, if possible, with existing fractures. The liner either side of the cut shall be marked 'cut' and the ends capped as above.

(e) Each section of liner shall be marked with the contract title, exploratory hole reference number, date and the depths of the top and bottom of the drill run.

(f) Core obtained without a liner and that from within the core catcher but not inside the liner shall be wrapped in two layers of plastic cling film and labelled to indicate the depth and exploratory hole reference number.

5 Core boxes, packing, labelling, storing shall be carried out as follows:

(a) Core boxes shall be soundly constructed and fitted with stout carrying handles, fastenings and hinged lids. The total weight of the cores and box shall together not exceed 60 kg.

(b) Cores shall be rigidly and securely packed at the site of drilling and during all subsequent handling and storage the cores shall remain packed unless required for examination or testing. Cores shall be placed in the box, in their liners where used, with the shallowest core to the top left hand corner, the top being considered adjacent to the hinged section. Cores from the core catcher shall also be placed in the core boxes at the correct relative depth.

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(c) Depth shall be indicated on the core box by durable markers at the beginning and end of each drill run. Rigid core spacers shall be used to indicate missing lengths. The contract title, exploratory hole reference number and the depth of coring contained in each bore shall be clearly indicated in indelible ink inside, on top and on the right-hand end of the box and on the inside of the box lid.

(d) Core boxes containing core shall be kept horizontal and moved and handled with care at all times. Cores shall be protected from direct sunlight. At the end of each day's work, core boxes shall be stored secure from interference and protected from the weather.

6 Cores shall be prepared for examination as follows:

(a) Cores shall be prepared for examination by the removal of sealing materials and splitting of liners in such a way as not to damage the cores. Plastic liners shall be cut lengthways such that at least half the core circumference is exposed. If half PVC is used, care should be taken while removing and replacing the split half.

(b) Before examination of the core, the Contractor shall photograph the cores. The time between beginning preparation and the examination of the prepared and photographed cores shall be minimised to prevent loss of moisture from the core samples.

(c) Cores shall be examined and described on site by a person meeting the requirements of Part 1 Clause 1.5 Paragraph 5 Item (c) in accordance with BS 5930 or ASTM D 2488 and the recommendations of the Engineering Group of the Geological Society Working Party Report The logging of rock cores for engineering purpose (1970).

7 The total core recovery (TCR) is the length of the total amount of rock core recovered from a core run, and the recovery ratio is the ratio of the length of core recovered to the total length of the core drilled on a given run, expressed as either a fraction or a percentage. On the other hand, solid core recovery (SCR) is the length of core recovered as solid cylinder (i.e., core with a full circumference) expressed as a percentage of the length of the core run. Core length should be measured along the core centerline. When the recovery is less than the length of the core run, the non-recovered section should be assumed to be at the end of the run unless there is reason to suspect otherwise (e.g., weathered zone, drop of rods, plugging during drilling, loss of fluid, and rolled or recut pieces of core). Non-recovery should be marked as NCR (no core recovery) on the boring log, and entries should not be made for bedding, fracturing, or weathering in that interval.

8 The RQD is a modified core recovery percentage in which the lengths of all pieces of sound core over 100 mm (4 in) long are summed and divided by the length of the core run. The correct procedure for measuring RQD is illustrated in the below Figure. The RQD is an index of rock quality in that problematic rock that is highly weathered, soft, fractured, sheared, and jointed typically yields lower RQD values. Thus, RQD is simply a measurement of the percentage of "good" rock recovered from an interval of a borehole.

9 The total number of natural fractures per unit length of core recorded for each core run or for lithological units where appropriate and expressed as fractures per meter.

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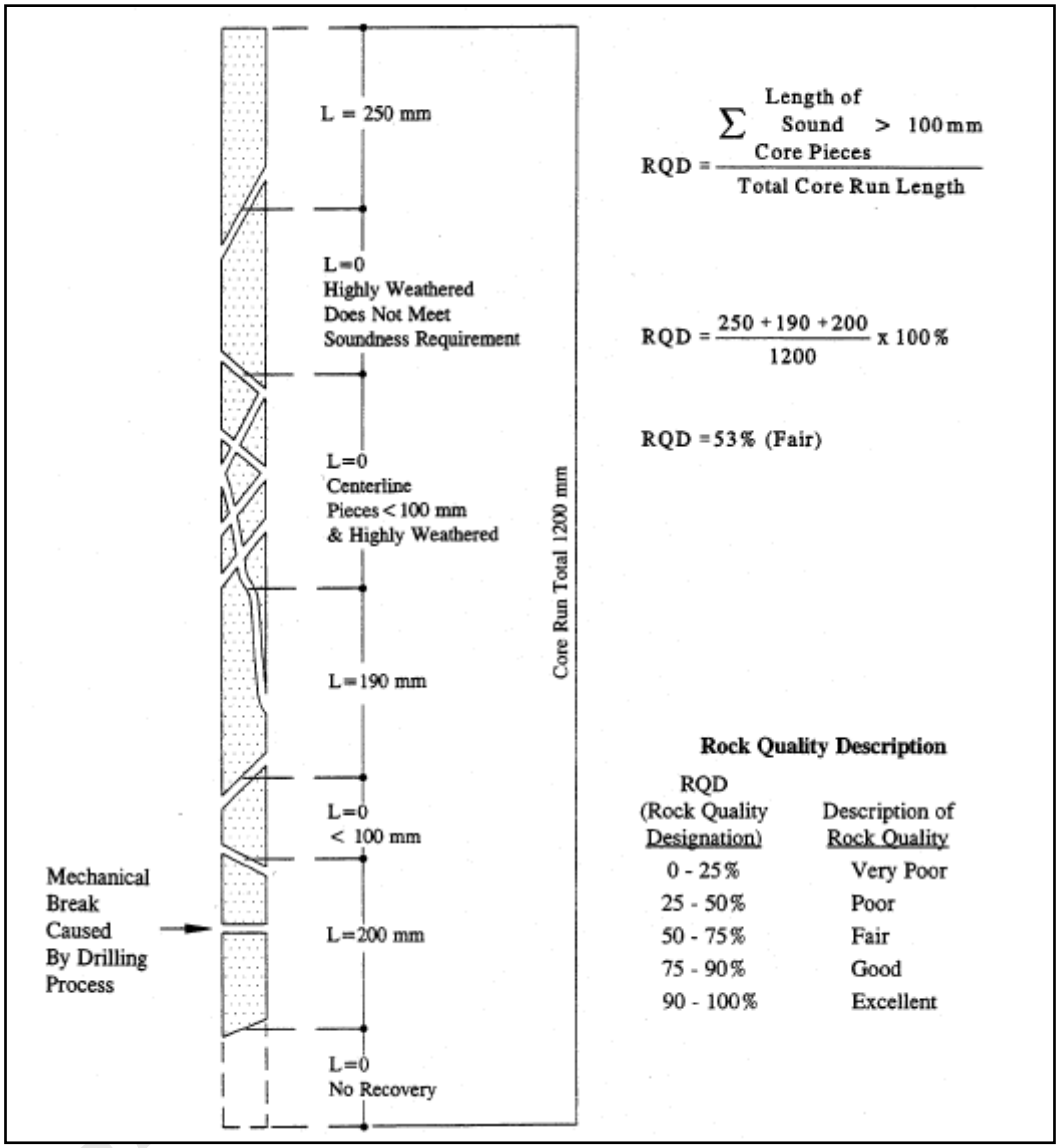

TCR= ∑ Length of Core Pieces

Total Core Run Length

SCR= ∑ Length of Solid Core Pieces

Total Core Run Length

F.I. = Number of Fractures to length of core run per linear meter.

10 When the examination of the cores has been completed, the Contractor may be required to retain separately designated core sub-samples for possible laboratory testing. The Contractor shall cut the liner and cap and seal the core sub-samples in such a way as to prevent loss of moisture and sample disturbance. They shall be clearly labelled so that the location, depth and origin of the sub-samples can be readily identified. Cores in their liners remaining after the designated sub-samples have been removed shall be end-capped and resealed and replaced in the original core box location. Rigid spacers shall be placed in the spaces in the cores boxes previously occupied by the core sub-samples to prevent movement of adjacent cores and these shall be labelled identically to the core sub-samples that they replace. The core sub-samples shall be retained in separate core boxes clearly marked to indicate the origin of the cores contained within.

11 The Contractor shall protect all cores and transport them including loading and unloading to

(a) The Contractor's premises.

(b) For a number of selected cores, to the designated address.

12 After submittal of the approved final report, the Contractor shall retain cores, other than those delivered to the designated address, for a period of time required by the Engineer. The Engineer's written permission shall be obtained before disposal of the cores, but the required retention period will normally not exceed three months.

2.5.4 Rotary Drilling without Core Recovery

1 Rotary blind bit or rotary percussive drilling may be used to advance a hole. The hole diameter shall be as designated.

2 When used for the purpose of locating mineral seams, mineworkings, adits, shafts, other cavities or anomalous conditions, drilling shall be under the full-time supervision of a person meeting the requirements of Part 1 Clause 1.5 Paragraph 5 Item (c). As drilling proceeds a systematic record shall be made of the drilling methods, rate of penetration, loss of flushing medium, the material penetrated and any cavities or broken ground encountered.

2.5.5 Backfilling

1 Except where otherwise designated, the Contractor shall backfill rotary drill holes with clean, well graded aggregate. The aggregate size and gradation shall be approved by the Engineer. Under special circumstances grout may be required to backfill the holes. The grout shall consist of equal portions by weight of ordinary Portland cement and bentonite mixed by machine or hand to a uniform colour and consistency before placing, with a moisture content not greater than 250 %. The grout shall be introduced at the bottom of the hole by means of a tremie pipe, which shall be raised but kept below the grout surface as the filling proceeds.

2 Where artesian water conditions or voids make normal grouting impracticable, the Contractor shall consult and agree with the Engineer a procedure for sealing the drill hole.

2.5.6 Photographs

1 In addition to the requirements of Part 1, the Contractor shall photograph cores where required in a fresh condition before logging and ensure that the following criteria are fulfilled:

(a) A graduated scale in centimetres is provided.

(b) Labels and markers are clearly legible in the photograph.

(c) A clearly legible reference board identifying the project title, exploratory hole number, date, and depth of drill runs shall be included in each photograph.

(d) Core boxes are evenly and consistently lit.

(e) The length of the core box in each photograph fills the frame.

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(f) The focal plane of the camera and the plane of the core box are parallel.

(g) The camera is placed in the same position with respect to the core box in every photograph.

(h) The resolution of the camera is not less than 8Mpixels.

(i) The photograph taken should be in focus along all the core samples length.

2.6 BOREHOLES OVERWATER

1 When boreholes are required overwater the method of drilling and sampling shall comply in general with the other requirements given in this Section, with the exception of backfilling.

2 Overwater boreholes shall be undertaken by the use of overwater staging, work over platform (WOP) jack-up vessels, anchored floating vessels or any other methods agreed with the Engineer.

3 Control of the elevation related to the borehole/seabed surface or varying stratums shall be related to the top of the casing installed. Anchored floating vessels will keep a constant record of tidal movement between the vessel and the fixed casing elevation and make any allowances necessary.

4 Boring or drilling operations will cease when the wave height exceeds the designated maximum value relating to standing time due to inclement weather, if this item is applicable to the Contract under the contract specific documentation.

5 An accurate method of measuring wave height from trough to crest will be installed on the drilling vessel or platform and calibrated and approved by the Engineer before beginning drilling operations.

6 All overwater operations will comply with all local government regulations related to such work and will also comply fully with any Safety of Lives at Sea (SOLAS) regulations in force at the time.

END OF PART

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