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## 1 GENERAL

### 1.1 INTRODUCTION

#### 1.1.1 Scope

- 1 General requirements and information for the execution of ground investigations.
- 2 The purpose of QCS is to provide as a general technical guide for acceptable construction work practices in the State of Qatar, considering this; any addition for technology, material, specification, standard that are not mentioned in this section or their modification, shall be subject to approval as stated in the introduction of QCS (00-02)
- 3 Related Sections are as follows:  
  
Section 1 ..... General  
Section 2 ..... Quality Assurance and Quality Control  
Section 4 ..... Foundations and Retaining Structures  
Section 6 ..... Roadworks  
Section 8 ..... Drainage Works  
Section 12 ..... Earthworks Related to Buildings

#### 1.1.2 References

- 1 The following standards and other documents are referred to in this Part:  
  
AASHTO M145 .....Standard Specification for Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes  
  
ASTM D420.....Site Characterization for Engineering, Design, and Construction Purposes  
  
ASTM D2487.....Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)  
  
ASTM D2488.....Standard Practice for Description and Identification of Soils (Visual-Manual Procedures)  
  
ASTM D5434.....Standard Guide for Field Logging of Subsurface Explorations of Soil and Rock  
  
ASTM D7012.....Standard Test Methods for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens under Varying States of Stress and Temperatures  
  
BS 5930 .....Code of practice for ground investigations  
  
EN 1997-2 .....Eurocode 7 - Geotechnical design - Part 2: Ground investigation and testing  
  
ISO 14688-1.....Geotechnical investigation and testing — Identification and classification of soil — Part 1: Identification and description  
  
ISO 14689 .....Geotechnical investigation and testing — Identification, description and classification of rock  
  
Deere D. U. et al., Design of surface and near-surface construction in rock. Proc. 8th US symposium on rock mechanics. AIME, New York, 1967  
  
Code of Practice and Specifications for Road Openings in the Highway issued by the Government.

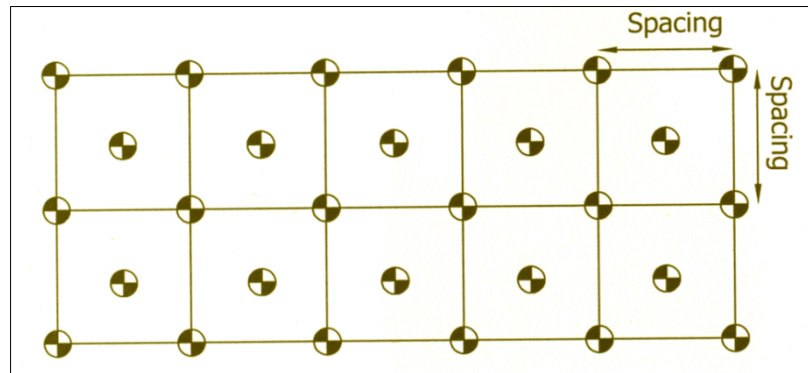
### 1.1.3 Definitions

- 1 **Topsoil:** the surface layer of earth that contains organic material and can also support vegetation.
- 2 **Soil:** earthen material not classified herein as topsoil or hard stratum.
- 3 **Hard stratum and obstruction:** The words 'hard stratum' and 'obstruction' shall mean natural or artificial material, including rock, which cannot be penetrated except by the use of chiseling techniques, rotary drilling, blasting or powered breaking tools. The term 'hard stratum' shall apply during boring, where it is shown that condition (1) or condition (2) below are fulfilled, provided that the boring rig involved is in good working order and is fully manned:
  - (a) Condition (1) 100 mm diameter undisturbed sample tubes cannot be driven more than 300 mm
  - (b) Condition (2) a standard penetration resistance test shows a resistance in excess of 35 blows/75 mm.
- 4 **Fill:** deposits or embankments which have been formed by persons, as distinct from geological agencies.
- 5 **Exploratory Hole/Trench/Excavation:** any boring, pit trench, ditch or shaft formed for the purpose of ground investigation.
- 6 **Boring:** hole in earth, excavated by either percussion or auger equipment.
- 7 **Drilling:** any hole in rock, excavated by rotary equipment.
- 8 **Borehole:** exploratory hole excavated by boring or drilling techniques.

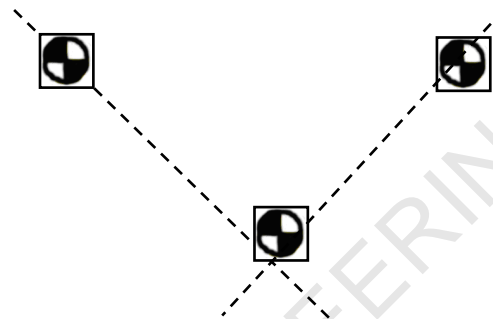
## 1.2 SUBMITTALS

### 1.2.1 Programme of Works

- 1 The Geotechnical Investigation Contractor shall prepare a programme of works for the investigation which will give a detailed schedule showing proposed time schedule for all aspect of the work, details of all plant and equipment to be used in addition to a list of personnel who will work on the project.
- 2 Boreholes layout for Buildings
  - (a) The boreholes layout for the open areas of the proposed construction sites should generally be as below sketch with the spacing as mentioned in Section 2.



- (b) The boreholes layout for the proposed construction site should provide information on the soil strata in at least in two perpendicular planes as shown below with the spacing as mentioned in Section 2.



### 3 Boreholes layout for Roads

- (a) The boreholes layout for the proposed roads should be in a staggered order to provide information on the soil strata in different planes with the spacing as mentioned in Section 2. The details for the borehole locations and spacing can be found in the latest version of the Qatar Highway Design Manual (QHDM) Volume 2 Part 15: Ground Investigation and Aspects of Geotechnical Design Guide.

#### 1.2.2 Preliminary Logs

- 1 The Geotechnical Investigation Contractor shall prepare a preliminary log of each exploratory hole. For trial pits and trenches, a trial pit or trench map showing each face of the pit or trench shall be provided, as appropriate. Preliminary logs shall be submitted to the Engineer in duplicate within seven working days of completion of the explorations to which they refer to, and shall contain the information required for the exploratory hole logs.
- 2 Geotechnical Investigation Contractor activities shall fully comply with Ministry of Environment and Climate Change (MECC) and/or Ministry of Municipality (MM) requirements and/or those of other Government Departments, Ministries and Statutory Organizations.
- 3 The Geotechnical Investigation Contractor shall obtain all necessary work permits and security permits prior to commencement of Geotechnical investigation of the site.
- 4 The investigation shall provide detailed information on the nature of the sub-strata, superficial deposits and ground water table at the site together with general recommendations for designing foundations and earthworks, new road pavements, culverts, retaining walls, etc.
- 5 The geotechnical investigation Exploratory Boreholes shall be spaced as mentioned in Section 2.
- 6 The geotechnical investigation Exploratory Boreholes depths shall be as mentioned in Table 1.1.

**Table 1.1: Minimum Depth of Boreholes**

No of floors	Depth of Boreholes (m)
3 or Less	6
4	8
5	9
6	10
7	12
8	13
>8	$3S^{0.7}$

**Notes:**

- The depth of boreholes is measured from foundation level.
- S** is the number of floors.
- For structures small in plan area, exploration should be made at a minimum of three points, unless other reliable information is available in the immediate vicinity. Where a structure consists of a number of adjacent units, one exploration point per unit may suffice.
- For piles the depth of Boreholes is at least below the depth of pile tip by 5m or 5D (D is the diameter of the pile at the toe) whichever is greater.
- For roads, the depth of Boreholes shall be greater than 2m below the proposed formation Level.
- For trenches, pipeline and Tunnels, the depth of Boreholes shall be the larger value of:
  - 2m below the inverted level;
  - 1.5width of excavation.
  - 2D (D=Diameter or equivalent diameter of the tunnel/underground structure).

**1.2.3 Exploratory Hole Logs**

- The exploratory hole logs shall be prepared and presented to a suitable vertical scale. The logs shall include all the information that follows, such information having been updated as necessary in the light of laboratory testing and further examination of samples and cores.
- Information for exploratory hole logs:

	Rotary Borehole	Drilling	Pit and Trench	Static and Dynamic Probing
All the designated information	√	√	√	√
National grid co-ordinates	√	√	√	√
Ground level related to the datum	√	√	√	√
Elevation of each stratum referred to the datum	√	√	√	(√)
Description of each stratum in accordance with BS 5930 and initials of person who carried out the logging (and responsible Supervisor if under training)	√	√	√	(√)

	Rotary Borehole	Drilling	Pit and Trench	Static and Dynamic Probing
Details of groundwater observations	√	√	√	(√)
Symbolic legend of strata in accordance with BS 5930	√	√	√	(√)
Core recovery as percentage of each core run		√		
Rock Quality Designation, RQD (Deere et al. 1967)		√		

Note: √ means information required; (√) means information required if applicable.

#### 1.2.4 Preliminary Laboratory Test Results

- 1 Laboratory test results shall be submitted to the Engineer in batches at the completion of each week's testing. Legible photocopies of work sheets are acceptable. The minimum Laboratory Tests are mentioned in Part 6, (6.3.1)

#### 1.2.5 Soil Description and Soil Classification

- 1 Soil description is based on visual examination of retrieved soil samples in accordance to applicable standards (ASTM D2488, BS 5930, ISO 14688-1).
- 2 The soil's description should include as a minimum:
  - (a) Color description.
  - (b) Apparent consistency (for fine-grained soils) or density adjective (for coarse-grained soils).
  - (c) Water content condition adjective (e.g., dry, damp, moist, wet).
  - (d) Minor soil type name with "y" added if fine-grained minor component is less than 30 percent but greater than 12 percent or coarse-grained minor component is 30 percent or more.
  - (e) Descriptive adjective for main soil type.
  - (f) Particle-size distribution adjective for gravel and sand.
  - (g) Plasticity adjective and soil texture (silty or clayey) for inorganic and organic silts or clays.
  - (h) Main soil type name (all capital letters).
  - (i) Descriptive adjective "with" for the fine-grained minor soil type if 5 to 12 percent or for the coarse grained minor soil type if less than 30 percent but 15 percent or more (note some practices use the descriptive adjectives "some" and "trace" for minor components).
  - (j) Descriptive term for minor type(s) of soil.
- 3 Soil classification is based on actual laboratory tests performed on extracted representative samples and in accordance with applicable standards (ASTM D2487, BS 5930, AASHTO M145, ISO 14688-1).
- 4 The soil description and soil classification should always follow one coherent standard from site investigation to laboratory testing, leading to the soil description and soil classification. It is not allowed to mix standards, in order to avoid mismatching results.

### 1.2.6 Rock Description and Classification

- 1 Rock description is based on visual examination of retrieved rock samples in accordance to applicable standards (ASTM D5434, BS 5930, ISO 14689).
- 2 The rock description should always follow one coherent standard from site investigation to laboratory testing, leading to the rock description. It is not allowed to mix standards, in order to avoid mismatching results, unless a gap in a particular standard allows for such use (i.e. BS does not have a test method for compressive strength on intact rock core samples, which allows the use of either ISRM or ASTM D7012).
- 3 The rock's lithologic description should include as a minimum the following items:
  - (a) Rock type (Igneous, Sedimentary or Metamorphic)/name (Limestone, Dolomite...etc.).
  - (b) Color.
  - (c) Grain size and shape.
  - (d) Fabric / Texture.
  - (e) Structure (stratification / foliation).
  - (f) Mineral composition.
  - (g) Weathering and alteration.
  - (h) Strength.
  - (i) Hardness.
  - (j) Discontinuities (Spacing, Type, Conditions).
  - (k) Fracture.
- 4 Rock Classification at the present time, there is no common unified system for classifying rock. However, as guidelines the International Society of Rock Mechanics (ISRM) (1981) standards and the Bureau of Reclamation (2001) standards or other equivalent standards can be used.

### 1.2.7 Digital Data

- 1 Data from the investigation shall be provided in digital form to the approval of the Engineer.

### 1.2.8 Form of Report

- 1 The report shall comprise of a factual or interpretative or both types of reports as required by the Employer or Engineer. Reports shall begin with a cover page showing the name of the Contract and the names of the Employer, Engineer and Geotechnical Investigation Contractor. Report pages shall be numbered consecutively.
- 2 Upon completion of the field investigation and laboratory testing program, the geotechnical engineer will compile, evaluate, and interpret the data and perform engineering analyses for the design of foundations, cuts, embankments, and other required facilities. Additionally, the geotechnical engineer will be responsible for producing a report that presents the subsurface information obtained from the site investigations and provides specific technical recommendations. The below figure is the minimum hidings to be available for developing a geotechnical report.

3 The factual report shall contain, as a minimum, the following information:

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4 The interpretative report shall contain the following information:

- (a) A written appraisal of the ground and water conditions.
- (b) Analysis and recommendations as designated.

When so designated, the Geotechnical Investigation Contractor shall supply the calculations and analyses on which recommendations are based.

#### 1.2.9 Approval of Report

1 A draft copy of the factual report and the interpretative report shall be submitted to the Engineer for approval before submission of the final report.

### 1.3 QUALITY ASSURANCE

1 Only Geotechnical Investigation Contractors holding a current approval certificate from Qatar General Organization for Standardization (Qatar Standards- QS) shall be permitted to carry out ground investigations.

2 The work shall be carried out in accordance with the relevant British Standards or equivalent.

3 Where specifically designated, all work shall be carried out in accordance with a quality management system established in accordance with Section 2 Quality Assurance and Quality Control of the QCS. Records to indicate compliance with quality management shall be made available to the Engineer on request.

4 The Geotechnical Investigation Contractor shall provide full time professional attendance on site. The professional attendant shall be approved by the Engineer, and shall be responsible for the technical direction of all fieldwork.

5 The Geotechnical Investigation Contractor's geotechnical and environmental personnel employed on the Contract shall be competent to undertake the work required. Categories of personnel who may be required by the Contract are as follows:

- (a) Technician.
- (b) Graduate Engineer/Geologist/Environmental Scientist.
- (c) Graduate Engineer/Geologist/Environmental Scientist with at least three years of relevant experience since graduation.
- (d) Professional Engineer/Geologist/Environmental Scientist with at least five years of relevant experience.
- (e) Professional Engineer/Geologist/Environmental Specialist with at least ten years of relevant experience.

6 All drillers employed on the Contract shall be experienced and competent in percussion or auger boring or rotary drilling, to the complete satisfaction of the Engineer. One competent drilling supervisor per site shall be permanently on the Site during borehole operations.

7 Rock cores from geotechnical explorations should be stored in structurally sound core boxes. Cores should be handled carefully during transfer from barrel to box to preserve mating across fractures and fracture-filling materials. Breaks in core that occur during or after the core is transferred to the core box should be refitted and marked across the fracture trace to indicate a mechanical break. Breaks made to fit the core into the core box and breaks made to examine an inner core surface should be marked as such. These deliberate breaks should be avoided unless absolutely necessary. Cores should be placed in the boxes from left to right, top to bottom. The depths of the top and bottom of the core and each noticeable gap in the formation should be marked by a clearly labelled rigid spacer block.

## **1.4 GENERAL PROJECT/SITE CONDITIONS**

### **1.4.1 General**

- 1 Geotechnical Investigation Contractor shall only use access routes to and between exploration sites that are approved by the Engineer.
- 2 Where the presence of underground services is likely, exploratory holes shall be started by means of a hand excavated inspection pit.
- 3 In addition to any designated notice, at least one working day's notice of the intended time of entry shall be given to the land owner and occupier of the exploration site.
- 4 All work shall be carried out with the least possible damage to the Site and its environs.
- 5 All barriers breached or otherwise disturbed during the execution of site operations shall be immediately repaired or replaced to the same standard.
- 6 Working hours shall be restricted to those designated.
- 7 Daily allocation sheets detailing the work carried out shall be submitted in duplicate at the end of each day's work.

### **1.4.2 Working Areas**

- 1 Operations shall be confined to the minimum area of ground required for the Works. Unless otherwise designated, on completion of each exploration all equipment, surplus material and rubbish of every kind shall be cleared away and removed from the Site. Damage to land or property in the vicinity of the exploratory hole and on access routes shall be made good. The whole of the Site and any ancillary works shall be left in a clean and tidy condition.

### **1.4.3 Turf and Topsoil**

- 1 Turf and topsoil shall be stripped from the site of each exploration and stockpiled for future replacement. Vegetation and topsoil adjacent to the exploration which may be damaged by the operations shall either be removed and stockpiled as above, or otherwise protected from damage. After completion of the exploration all topsoil shall be replaced, and the Site restored to its original condition.

### **1.4.4 Paved Areas**

- 1 Pavement from paved areas (other than paving slabs and blocks) shall be broken out to the minimum extent necessary for each exploration. After completion of the exploration and backfill of the excavation, the disturbed subgrade shall be compacted, and the paving replaced.
- 2 Restoration of highway pavement shall be in accordance with the current Code of Practice and Specification for Road Openings in the Highway issued by the Government.

### **1.4.5 Paving Slabs and Blocks**

- 1 Paving slabs and blocks shall be removed from the Site, as required for each exploration, and stored for reuse.
- 2 Contiguous paving slabs and blocks which are liable to be damaged by the operations shall either be removed and stored as above or otherwise protected from damage.
- 3 After completion of the exploration and backfill of the excavation, the disturbed subgrade shall be compacted, and the paving slabs and blocks relaid.

### **1.4.6 Claims for Damage**

- 1 Any damage or claim for compensation for damage by owners or occupiers of the Site, shall be reported to the Engineer.

**1.4.7 Geotechnical and Environmental Personnel**

- 1 In addition to the provision of the designated personnel by the Geotechnical Investigation Contractor, the Engineer may specifically require the services of geotechnical and environmental personnel for advice, assistance or preparation of interpretative reports. The form of interpretative reports shall be agreed with the Engineer. Details of the qualifications and experience of the personnel shall be supplied to the Engineer.

**1.4.8 Location of Exploratory Holes**

- 1 The location of each exploratory hole shall be measured from an approved grid co-ordinate system, and shall be accurate to within 1 m, and the position recorded on a plan as designated.

**1.4.9 Ground Elevation of Exploratory Holes**

- 1 The elevation of the ground at each exploratory hole shall be established, on the basis of the Qatar National Datum unless otherwise designated or approved by the Engineer, to the nearest 0.05 m.

**1.4.10 Exploratory Work**

- 1 The location and depth of each exploratory hole shall be as designated. The Engineer may, after consultation with the Geotechnical Investigation Contractor, vary the location and depth of any exploratory hole and the sequence or quantity of in-situ testing depending on the actual ground conditions encountered. When the position of an exploratory hole has been varied, the Geotechnical Investigation Contractor shall take all necessary measurements and shall inform the Engineer of the revised co-ordinates and ground elevation or other measurements required to locate the exploratory hole.

**1.4.11 Methods of Investigation**

- 1 The Engineer will have the option to require any of the following methods of investigation. These options will comprise, but not necessarily be limited to, the following:
- (a) Desk study.
  - (b) Geological mapping.
  - (c) Topographic survey.
  - (d) Aerial photographs.
- or any other methods described in this Section.

**1.4.12 Safety and Management**

- 1 The Geotechnical Investigation Contractor shall submit detailed Job Hazard Analysis (JHA) to all site activities including but not limited to potential hazard, who/what might be harmed, control/ recovery measure, responsible person...etc.
- 2 The presence and nature of known areas of hazardous or contaminated ground are designated, based on available records. If evidence of further hazardous or contaminated ground is encountered, the Geotechnical Investigation Contractor shall immediately so inform the Engineer. If required by the Engineer, the Geotechnical Investigation Contractor's work plan shall be revised appropriately to take into account the nature and level of contamination encountered. Where contaminated land is present or suspected the Geotechnical Investigation Contractor shall take the appropriate health and safety precautions as directed by the Engineer and where appropriate by the Civil Defence Department of the Government. Care shall be taken to avoid contaminating the egress from the Site.

3 A method statement indicating the safety procedures to be followed during the investigation of hazardous or contaminated ground shall be provided by the Geotechnical Investigation Contractor before beginning the investigation in the hazardous or contaminated ground.

4 Traffic safety and management measures shall be provided, in accordance with the provisions of traffic control of Section 1, General. Where the circumstances of any particular case are not designated, proposals for dealing with such situations shall be submitted to the Engineer for approval.

#### **1.4.13 Anomalous Conditions**

1 Where anomalous or unexpected features are revealed, the Geotechnical Investigation Contractor shall immediately inform the Engineer.

#### **1.4.14 Surface Water Control**

1 Surface water or other water shall be prevented from entering the exploratory hole, except as permitted by the Engineer.

#### **1.4.15 Photographs**

1 Colour photographs shall be taken and supplied by the Geotechnical Investigation Contractor as designated. Each photograph shall clearly show all necessary details and shall have its scale identified.

2 A single gloss colour print (size 150 mm by 100 mm) copy of each photograph shall be submitted to the Engineer for his approval, within seven working days of the photography. In the event that the photographs are of a quality unacceptable to the Engineer, they shall be retaken.

3 On acceptance of the quality of the photograph, two complete sets of prints of all the photographs shall be presented, annotated and submitted in bound volumes, together with the original photograph digital format with the factual report.

4 Particular requirements for photographs of cores and pits and trenches are given in Parts 3 and 4.

#### **1.4.16 Facilities for the Engineer**

1 When required by the particular contract documentation, facilities to the designated standard shall be provided for the use of the Engineer, as described in Section 1.

END OF PART