

1.07 The Agency shall carry out all work meant within Para 1.01 of this specification even if not explicitly mentioned under the scope. All work shall be executed to the satisfaction of the Engineer.

1.08 FIELD INVESTIGATIONS - SOIL

1.08.1 BORING

a) Bore holes shall be taken at specified locations to obtain information about the subsoil profile, its nature and strength and to collect soil samples for strata identification and conducting laboratory tests. The sequence of boring shall be fixed with the approval of the Engineer and on ascertaining preliminary nature of subsoil profile, the Engineer shall reserve the right to increase or decrease the number of proposed Bore holes by any limit. However, as per Clause 1.02, payment shall be made as per actual quantities executed. The minimum diameter of the bore holes shall be 150 mm and boring shall be carried out in accordance with the provisions of IS: 1892.

b) All boreholes shall extend up to 15.0 to 30.0 Mtr. depths or depths shown on the construction drawings or as directed by the Engineer. The refusal criteria shall be strictly as per IS: 1892. When the boreholes are to be terminated in soil strata an additional Standard Penetration Test shall be carried out at the termination depth. No extra payment shall be made for carrying out Standard Penetration Tests. **The site data shall be made available to HSCC as and when each bore is completed either by fax/ courier/speed post/ hand delivery showing location of the borehole on the plan and the soil data along with visual description. The comments regarding the strata and the nature of variations shall also be included.**

c) On completion of the boreholes, the Agency shall backfill all the bore holes as directed by the Engineer. The boreholes shall not be back filled till verified by the Engineer. Arrangements shall be made by the agency to preserve the boreholes so that the depth can be verified.

1.08.2 **PLATE LOAD TEST**

Plate load test shall be conducted to determine the allowable bearing pressure. A pit of size 2.0m square shall be excavated up to a depth of 2.0m deep from virgin soil. The size of plate should be of 0.75mX0.75m. It should be made of mild steel and 25 mm thick. Load shall be applied on this plate by means of hydraulic jack. The reaction to the jack shall be provided by means of loaded platform (kentledge). A seating load of 7 kN/m<sup>2</sup> shall be first applied which shall be released after some time. The load shall then be applied in increments of 20% of the estimated safe load or one-tenth of the ultimate load. The settlement shall be recorded at 1, 2.25, 4, 6.25,9,16 and 25 minutes and thereafter at hourly intervals to nearest 0.02mm. The test shall be conducted until failure or at least until the settlement of about 25mm has occurred. The specifications for the equipment and accessories required for performing this test, test procedure, field observation and reporting of results shall conform to IS: 1888-1982

1.08.3 **SAMPLING**

1.08.3.1 General

All the accessories required for sampling and the method of sampling shall conform to IS: 2132. All the disturbed and undisturbed samples collected in the field shall be classified at the site as per IS: 1498.

1.08.3.2 Disturbed Sample

Disturbed soil samples shall be collected from bore holes at regular intervals. Jar samples weighing approximately 1 Kg. shall be collected in bore holes at 0.5 m below ground level and at every identifiable change of strata to supplement the boring records. Samples shall be immediately stored in air tight jars and shall fill the jar as far as possible.

Sufficient number of soil samples shall be collected. Disturbed soil samples shall be collected for field identification and conducting tests such as sieve analysis, index properties, specific gravity, chemical analysis,(chemical tests on undisturbed samples to be done so that representative chemical state of the total depth of the

soil is obtained) etc. Undisturbed samples shall be collected to estimate the physical strength and settlement properties of the soil.

1.08.3.3 Undisturbed Sample

In each borehole undisturbed sample shall be collected at every change of strata and depths of 1.0 m, 4.0 m, 7.0 m, 10.0 m, 13.0 m, 15.0 m and as directed by the Engineer. Undisturbed samples shall be of 100 mm dia and 450 mm length. Samples shall be collected in such a manner that the structure of the soils and its moisture content do not get altered.

The specifications for the accessories required for sampling and the sampling procedure shall conform to IS: 1892 and IS: 2132. Undisturbed sampling in sand shall be done using compressed air technique mentioned in IS: 8763.

1.08.3.4 One of the methods shall be adopted for determining the ground water table in bore holes as per IS: 6935 and as per the instructions of the Engineer.

1.08.3.5 a) Sub-soil water samples

Sub-soil water samples shall be collected for carrying out chemical analysis thereon. Representative samples of ground water shall be collected when it is first encountered in boreholes before the addition of water to aid boring or drilling.

b) Chemical analysis of water samples shall include determination of PH value; turbidity; sulphate; carbonate; nitrate and chloride contents; presence of organic matter and suspended

c) Standard Penetration Test

This test shall be conducted in all types of soil deposits met within a bore hole to find the variation in the soil stratification by co-relating with the number of blows required for unit penetration of a standard penetrometer. This test shall be conducted at 1.50 m interval and every change of strata and as per the direction of the Engineer. The depth interval between the top levels of standard penetration test and next undisturbed sampling shall not be less than 1.0 m.

d) Dynamic Cone Penetration Test

Dynamic cone penetration test shall be conducted to predict stratification, density, bearing capacity etc. of soils. The test shall be conducted by driving a standard

size cone attached to the bottom of a string of drill rods. The test shall be conducted up to the specified depth or refusal whichever is earlier. Refusal shall be considered when the blow count exceeds 150 for 300 mm penetration. The specifications for the equipment and accessories required for performing this test, test procedure, field observation and reporting of results shall conform to IS : 4968, Part - II.

1.08.4 Earth Resistivity of soil

Resistivity of soil /earth shall be measured at 2 locations as per instructions of the Engineer. Measurements shall be carried out as per IS-3043.

1.9 **LABORATORY TESTING**

1.9.1 Essential Requirements

a) Tests indicated in the schedule of items shall be performed on soil, water and rock samples as per relevant IS codes.

b) Laboratory tests shall be conducted using approved apparatus complying with the requirements of Indian Standards or other approved standards for this class of work. The tests shall be conducted at an approved laboratory.

1.9.2 Tests

Tests as indicated in this specification and as called for by the Engineer shall be conducted. These tests shall include but not be limited to the following: -

a) Tests on Disturbed and Undisturbed samples: -

- Visual and Engineering Classification
- Sieve analysis and Hydrometer analysis
- Liquid, Plastic and Shrinkage limits
- Specific Gravity
- Chemical Analysis
- Swell pressure and free swell index determination (applicable only for black cotton soil)
- Proctor Compaction Test

- b) Tests on undisturbed samples
  - Bulk density and moisture content
  - Relative density (for sand)
  - Unconfined compression test
  - Box shear test (in case of sand)
  - Tri-axial shear tests: (depending on the type of soil and field conditions on undisturbed or re-moulded samples).
- c) Unconsolidated undrained
- d) Consolidated undrained test with the measurement of Pore Water Pressure.
- e) Consolidated drained.
- f) Consolidation Test (In case of cohesive soil)

1.9.3

#### **Salient Test Requirement**

a) Chemical analysis of sub-soil shall include determination of pH value, carbonate, sulphate (both SO<sub>3</sub> and SO<sub>4</sub>), chloride and nitrate contents; organic matter; salinity and any other chemical harmful to the foundation material. The contents in soil shall be indicated as percentage (%).

b) Chemical analysis of sub-soil water sample include the determination of the properties such as colour, odour, turbidity, pH value and specific conductivity both at 25<sup>0</sup> C and chemical contents such as Carbonates, Sulphates (both SO<sub>3</sub> and SO<sub>4</sub>), Chlorides, Nitrates, Organic matter and any other chemical harmful to the foundation material. **The contents such as Sulphates, Saltpetre, etc. shall be indicated as ppm by weight.**

1.10

#### **REPORT**

1.10.1

#### **General**

a) On completion of all the field and laboratory work, the Agency shall submit a formal report containing Geological information of the region, procedure adopted for investigation, field observations, summarised test data, conclusion and recommendations. The report shall include detailed bore-logs, subsoil sections, field test results, laboratory observations and test results both in tabular as well as

graphical form, practical results both in tabular as well as graphical form, practical and theoretical considerations for the interpretation of test results, the supporting calculations for the conclusions drawn, etc. Initially the Agency shall submit three copies of the report in draft form for the Supervising Agency's review. The format of the cover page of the reports shall be got approved by the Engineer.

b) The Agency's qualified Geotechnical Engineer shall visit Supervising Agency's office for a detailed discussion on Supervising Agency's comments on his draft report. During the discussions, Supervising Agency shall decide as to the modifications that need to be done in the draft report. Thereafter the Agency shall incorporate in his report the agreed modifications and after getting the amended draft report approved, six copies of the detailed final report (in A4 size and spiral binding with plastic covers) shall be submitted along with one set of reproducible of the graphs, tables, etc.

c) The detailed final report based on field observation, in-situ and laboratory tests shall encompass theoretical as well as practical considerations for foundations for different types of structures envisaged in the area under investigation. The Agency shall acquaint himself about the type of structures, foundation loads and other information required from the Engineer.

#### 1.10.2 **Data to be furnished**

The report (in soft as well as hard copy) shall also include but not be limited to the following: -

a) A plot plan in A1/A0 sheet showing the locations and reduced levels of all field tests e.g. boreholes, trial pits, static cone penetration tests, dynamic cone penetration tests, plate load tests, etc., properly drawn to scale and dimensioned with reference to the established grid lines.

b) A true cross section of **all individual boreholes and trial pits** with reduced

levels and coordinates showing the classification and thickness of individual stratum, position of ground water table, various in-situ tests conducted and samples collected at different depths and the rock stratum, if met with.

c) A set of longitudinal and transverse soil profiles connecting various boreholes in order to give a clear picture of the variation of the subsoil strata as per IS: 6065. (each soil profile to be submitted in separate sheets).

d) Past observations and historical data, if available, for the area or for other areas with similar soil profile or with similar structures in the surrounding areas.

e) Plot of Standard Penetration Test (N values both uncorrected and corrected) with depth for identified areas.

f) Results of all laboratory tests summarised (i) for each sample and for each layer along with all the relevant charts, tables, graphs, figures, supporting calculations, conclusions and photographs of representative 'rock cores'.

g) For all tri-axial shear tests stress vs strain diagrams as well as Mohr's circle envelopes shall be furnished. If back pressure is applied for saturation, the magnitude of the same shall be indicated. The value of modulus of elasticity, E shall be furnished for all tests alongwith relevant calculations.

h) Soil resistivity Test results

i) For all consolidation tests, the following curves shall be furnished:-

e vs log p

or e vs p and as per applicability

Compression vs log t or

Compression vs square root of t (depending upon the shape of the plot for proper determination of co-efficient of consolidation).

The point showing the initial condition of the soil shall be marked on curves.

The procedure adopted for calculating the compression index from the field curve and settlement of soil strata shall be clearly specified. The time required for 50% and 90% primary consolidation along with secondary settlements, if significant, shall also be calculated.

### 1.10.3 **Recommendations**

Recommendations shall be given area wise duly considering the type of soil, structure and foundation in the area. The recommendations shall include but not be limited to the following:-

#### 1.10.3.1 **For shallow foundations**

The following shall be indicated with comprehensive supporting calculations.

- i. Net safe allowable bearing pressure for isolated footings and continuous strip footings of suitable sizes ( Varying from 1 to 4m ) at suitable foundation depth as per site condition below ground level considering both shear failure and settlement criteria, giving reasons for type of shear failure adopted in the calculations. Such Footings to be suggested for single storeyed buildings are proposed.
- ii. Net safe allowable bearing pressure for Raft Foundation at suitable foundation depth as per site condition below ground level considering both shear failure and settlement criteria, giving reasons for type of shear failure adopted in the calculations. Such Footings to be suggested for Raft Foundation giving data for modulus of Sub grade Reaction .
- iii. Rate and magnitude of settlement expected of the structure.

#### 1.10.3.2 **For Pile foundations**

If piling is required, the following shall be indicated with comprehensive supporting calculations:-

- a) Type of pile and reasons for recommending the same duly considering the soil characteristics.



- b) Suitable founding strata for the pile and the pile depth at respective locations.
- c) Estimated length of pile for 300 mm dia, 350 mm, 400 mm dia and 450 mm dia and any other diameter to be suggested by the investigating agencies.
- d) Type of pile- End bearing and/or Frictional resistance and whether bored cast-in-situ or Pre cast driven pile shall be indicated separately. The estimated pile capacity clearly identifying the end bearing and treated resistance capacities contributes in the total capacity.
- e) Magnitude of negative skin friction, if any, to be considered in pile design.

### **C. GROUND WATER / RAIN WATER HARVESTING**

The scope of work includes conducting Geo-physical and Geo-hydrological survey of the entire area and a study of the environmental conditions that may affect the fitness of the underground water source for domestic and non-domestic purpose. The total water requirement for the proposed site is approximately 2 lakh liters per day. The alternative sources of ground water i.e tube well and rain water-harvesting scheme be assessed scientifically. This also includes the assessment of the capacity and dependability of the different sources to meet water for project.

#### **The detailed scope of work will be as below:**

1. With the objective to meet total water requirement at least 4 points shall be subjected to vertical electrical sounding to ascertain suitability for locating tube wells with a depth range upto 150 meters or whatever suitable in and around project site. A/C or D/C (digital type) resistivity meter will be used for the study. The resistivity data so procured shall be analysed, computed and plotted on log-log graph paper with modules of 62.5 mm, smooth curves shall be drawn for each vertical electrical sounding. Geophysical interpretations of the curves drawn by computer and using auxiliary charts shall reveal the following information.
2. Full details of the existing underground sources of water, nature and extent aquifers, their depth and yield expected from tube well or open dug wells in entire campus.
3. Best point selection on the field for the tube well drilling. The same to be marked on overall plot plan with co-ordinate. The exact bench markings for individual wells suggested will be got done by your representative at site as directed by Engineer.
4. Apparent resistivity of existing sub-Geoelectrical layers and corresponding geology of the layer. Correlation of data with CGWB data.
5. Detailed design and specification for tube wells.
6. Recommended drilling depth and drilling techniques of each tube well.
7. Expected yield of tube well in (litre /hr) and rate of withdrawal.
8. Suggest number of tube wells required to meet total water requirement.
9. Recommended capacity (discharge, head) of submersible pump, pumping hrs for individual bore well, type of material and dia. of pipe for tube well.
10. Recommended spacing between the tube wells to avoid minimum interference.
11. Recommendations for functional utility of the bore wells/ dug wells.
12. Suggest method for improvement of bore well yield and quality of water.
13. Suggest scheme for piping network for interconnection of different tube wells.
14. Suggest rainwater harvesting scheme / ground water recharge method and maximum percolation rate through recharge pit.
15. Water quality Assessment

The quality of surface as well as Ground water is to be tested as per IS: 10500, (23 parameters) standards. The scope of water analysis is not limited to ascertaining potability or being semi-salty or salty. It should also include chemical and bacteriological tests. A range regarding percentage salt content shall be given which should be close to 90% of salt content once water is actually pumped out.

The study report shall also include the required Geo-electrical sections for the area, as well as samples of the curves used for matching.

16. Contents of the report.

A. The Geo-hydrological investigation report should have the following contents:

- a. Introduction
- b. Location of the Study Area
- c. Objectives of Ground Water studies
- d. Applied Methodologies
- e. Available basic Data
- f. Ground Water level
- g. Geology of the area
- h. Information and details of existing ground water sources.
- i. Delineation of potential ground water bearing zones
- j. Assessment of hydraulic parameters of aquifers
- k. Water producing capabilities of aquifers likely to be tapped for construction of tube wells/ Dug wells in liters/hour
- l. Correlation of the data obtained from site with data from CGWB etc.
- m. Number of tube wells/ dug wells to meet the water requirement of the project.
- n. Spacing between tube wells/ dug wells.
- o. Specification of tube wells/ dug wells and type of pump set, type of material and dia of pipe for tube well.
- p. Details of rain water harvesting scheme.
- q. Recommendations.