13. All survey, grid levels shall be done by Total Station and contour plan shall be prepared on computer through digitization process and the soft copy shall be provided for the same immediately.

14 On completion of all fieldwork, collection of pertinent field data and preparation of drawings the agency shall submit a formal draft report containing all the information/field observations and drawings, in triplicate for review of Supervising Agency. Thereafter the agency shall visit to Supervising Agency's office for detail discussions on Supervising Agency's comments if any. After discussion with the Supervising Agency, the agency shall incorporate the agreed modifications in the draft report at their own cost and submit six copies of the detailed final report (plastic coated with spiral binding) and 6 sets of drawings (the drawings shall bear the logo of HSCC and the format of the same can be obtained from HSCC) along with a set of reproducible drawings and related CD. The agency shall also submit along with report a copy of field book in original or an authenticated copy of the same duly certified by Engineer.

15 Description and photos of general surrounding and plot and of the team while carrying out the work awarded.

16 Plot has to be cleared of all vegetation including shrubs, bushes, etc. whatsoever before start of the work and all removed vegetation to be thrown as per HSCC directives.

17 The any above is not relevant or not covered in the report to be specifically listed out in draft report and obtain the above from HSCC/Client. Otherwise agency has to provide the same without an extra cost or paid accordingly.

18 Payment shall be made for actual survey area but not to exceed the quantity in the tender document.

B. GEOTECHNICAL INVESTIGATION AND REPORT SUBMISSION

1.01 Detailed Geo-technical Investigation is to be carried out of the area of plot and submission of a detailed Geo-technical report which shall be the basis for the design and detailing of foundations for buildings and structures.

1.02 Item wise list of investigations to be conducted along with approximate estimated quantities are given at Schedule of Quantities against which the agency shall quote the rates in figures as well as in words. However, payment shall be made as per quantities actually executed.

1.03 The work shall include mobilisation of all necessary equipments, providing necessary engineering supervision and technical personnel, skilled and unskilled labour etc. as required to carry out the entire field as well as laboratory investigation, analysis and interpretation of data collected and preparation of a Geo-technical report.

1.04 The Agency shall make their own arrangements for locating the coordinates and positions of bore holes, trial pits, dynamic cone penetration tests and other field tests as per the drawings/sketches supplied to him and for determining the reduced levels (R.L's) at these locations with respect to the single bench mark indicated by the Engineer. Two established reference lines will be indicated to him.

1.05 All the field and laboratory data shall be recorded in the proforma recommended in Indian Standards codes. The Agency shall submit to the HSCC one copy of field borelogs and all the field records (countersigned by the Engineer) soon after the completion of each borehole/test**.**

1.06 The Agency shall interact with HSCC and get acquainted with the broad guidelines about the different types of structures envisaged and in assessing the load intensities on the foundations for the various structures of the project in order to enable him to make specific recommendations for the depth, founding stratum, type of foundation and the allowable bearing pressure.

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/m2 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 SO3 and SO4), 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 25^0 C and chemical contents such as Carbonates, Sulphates (both SO_3 and SO_4), 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 envelops 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.