TECHNICAL SPECIFICATION
FOR
GEOTECHNICAL INVESTIGATION

1.0 INTRODUCTION

RABINDRA BHARATI UNIVERCITY , AT B.T ROAD intends to construct a Hostel Complex at 24 Ganpati Sur Sarani (South Sinthi Road) , Kolkata-700050. The project will cater for the hostel requirements of RBU by constructing two Tower blocks. The Tower Blocks will be of 6 and 8 storey. The buildings will normally be of R.C. framed concrete structures.

Geo-technical investigation will be required to carry out the foundations and other design properly.

The Scope of Work under the soil investigation tender package and technical specification has been delineated in various sections following this item. The layout of test locations and the site plan is shown in the enclosed Drawing for understanding the Scope of services.

2.0 SCOPE

This specification covers complete soil exploration work including carrying out field tests and laboratory tests to evaluate soil parameters and preparation of detailed report including the recommendation regarding the following main items

- The type of foundation system to be used.
- The depth of foundation
- Bearing capacity at the foundation strata with the permissible settlement.
- Pile capacity in case the report recommends piles for Tower Blocks
- Suitability of the excavated earth in back filling
- Quantitative assessment of chlorides and sulphate contents in the ground water and earth. Recommendations on the use of water for concreting and drinking purposes.
- Modulus of sub-grade reaction for the design of raft foundations.
- Other soil parameters required for design of sub-structure including retaining walls, reinforced earth walls.
- Requirements for stabilisation of earth slopes in open excavations.

2.0 SCOPE (contd.)

- Electrical resistivity of soil
- Level of ground water table and its' expected seasonal variation.
- Recommendation for the composition of sub-grade for the internal road design
- Precaution to be taken for excavation
- Dewatering method to be adopted for excavation related to foundation work.

3.0 **GENERAL**

The contractor shall perform all work under the purview of this specification along with all incidental and related work including setting out, slogging, approach to test locations, contractor's office, stores and protection of adjacent buildings, structures of services / facilities. No separate payments shall be made on such accounts. The tenderer should therefore take into account all such relevant items while quoting his unit rates against the schedule of items.

3.01 **Work to be provided by the Contractor**

The work to be provided by the contractor, unless specified otherwise shall include but not limited to the following :

a) Furnish necessary plant and equipment, tools and tackles, instruments, necessary power, fuel, water, labour, supervisions by qualified and experienced engineers and supervisors specialised in the type of investigation, transport of materials, men and equipment etc., services, full insurance and all other incidental items as may be necessary for entire and successful completion of the work as per tender terms, drawings, specifications and instruction of the owner/engineer.

b) Locate in the field and in layout drawing all boreholes and other field investigation items.

c) Furnish progressively and periodically field bore logs, investigation observations, test results with relevant data and features in triplicate.

d) Prepare and submit draft (in duplicate) and final (after incorporating comments, if any) sub soil investigation report as per specification, schedule of items and instructions of the owner/his engineer.

3.02 **Work to be provided by others**

No work under this specification will be provided by any agency other than the contractor unless specifically mentioned elsewhere in the contract.

3.03 **Location and Levels**

Location of all boreholes and field test points and levels of the existing ground at such locations shall be established by the contractor at his own cost from two reference grids and one bench mark given by the owner/his engineer and these shall be subsequently plotted in the layout plan, bore logs and other relevant field test data sheets/tables to be incorporated in the report by the contractor.

Making bench mark pillar(s) and reference line pillars (whatever are required for the work) and maintaining them upto the completion of the work shall be the responsibility of the contractor at no extra cost to the owner.

3.04 **Codes and Standards**

The work shall be carried out as per IS Codes to be used for the soil investigation work and preparation of report. In all cases latest revision along with amendments, if any, shall be referred to :

IS : 1490 - Classification and identification of soils for General Engineering purposes.

IS : 1888 - Method of load tests on soils

IS : 1892 - Subsurface investigation for foundation

IS : 1904 - Structural safety of buildings : shallow foundations

IS : 2131 - Method for standard penetration test for soils

IS : 2132 - Code of Practice for thin walled tube sampling of soils

IS : 2720 - Methods of tests for soils

IS : 2809 - Glossary of terms and symbols relating to Soil Engineering.

IS : 3025 - Methods of sampling and testing for water used in industry

IS : 3043 - Code of Practice for earthing

IS : 4078 - Indexing and storage of drill cores

IS : 4434 - Code of Practice for in situ vane shear test for soils

3.04 Codes and Standards (contd.)

IS : 4453	-	Code of Practice for exploration by pits, trenches, drifts and shafts
IS : 4464	-	Presentation of drilling information and core description in foundation investigation.
IS : 4968 (Part-II)	-	Dynamic Cone Penetration Test.
IS : 4968 (Part-III)	-	Static Cone Penetration Test.
IS : 5249	-	Method of test for determination of dynamic properties of soil.
IS : 5313	-	Guide for core drilling observations
IS : 5529 (Part-I)	-	In situ permeability tests - tests in over-burden
IS : 5529 (Part-II)	-	In situ permeability tests - tests in bed rock
IS : 6403	-	Determination of allowable bearing pressure on shallow foundations.
IS : 6926	-	Diamond core drilling for site investigation for river valley projects.
IS : 6935	-	Method of determination of water level in boreholes
IS : 7746	-	In situ shear test on rock
IS : 8009 (Part-I)	-	Calculation of settlement of foundations - shallow foundations subjected to symmetrical static vertical loads
(Part-II)		deep foundations subjected to symmetrical static vertical loading.
IS : 8763	-	Guide for undisturbed sampling of sands
IS : 8764	-	Method for determination of point load strength index of rocks
IS : 9143	-	Method for the determination of unconfined compressive strength of rock materials
IS : 9179	-	Method of preparation of rock specimen for laboratory testing
IS : 9214	-	Method of determination of modulus of subgrade reaction (k-value) of soils in field.
IS : 9221	-	Method for determination of modulus of elasticity and poison's ratio of rock materials in uniaxial compression.

3.04 Codes and Standards (contd.)

IS : 9259	-	Liquid limit apparatus for soils
IS : 9640	-	Specification for split spoon sampler
IS : 10108	-	Sampling of soils by thin wall samples with stationary piston
IS : 10589	-	Equipment for subsurface sounding of soils
IS : 10837	-	Specification of molds for determination of relative density and its accessories.
IS : 11229	-	Specification for shear box testing of soils
IS : 11315 (Part-II)	-	Description of discontinuities in rock mass - core recovery and rock quality.

4.0 SOIL EXPLORATION

4.01 Test Boring

Test Boring through different layers of soil shall be carried out by the contractor at the locations marked in the enclosed Drawing and/or at such other locations as directed by the Engineer in a manner described below.

Various methods of boring as described in IS:1892 may be adopted. The tenderer shall furnish in his tender the complete details of the equipment and the method he proposes to follow. Minimum diameter of boring shall be 150 mm.

During the boring operations if rock strata is not encountered. The boring shall be continued upto 35 m depth for five bore holes upto 30m depth for the remaining boreholes unless stated otherwise by the Engineer. If the present formation level is above the natural ground with filled-up soil, the depth of boring mentioned above shall exclude such filled-up soil.

The contractor shall describe in detail the equipment and method of boring he proposes to use. In the absence of dry boring equipment, wash boring at the discretion of the Engineer may be allowed, but the particular way of cleaning the casing by washing has to be approved by the Engineer. However, if the engineer, at any time, feels that the washing process is disturbing the samples to be taken, he may stop the work and the contractor shall have no claim whatsoever on this score. If the contractor can, however, improve the method to the satisfaction of the Engineer, he may be allowed to resume the wash boring work.

4.01 Test Boring (contd.)

When boring cannot be advanced due to presence of hard material, it should be checked whether there is continuous strata of hard material below before resorting to drilling methods. If only a local boulder is present it should be chopped using suitable chopping bits and the debris removed and normal boring continued.

Ground water level for each hole shall be checked during boring operation and shall be recorded in bore log. Sub-soil water samples shall also be collected from each borehole and recorded. All the boreholes shall be backfilled by the contractor using sand fill as and when directed by the Engineer.

4.02 **Stabilisation of Boreholes**

Boreholes shall be stabilised, whenever required, against caving of the sides of the drill hole and heaving of the bottom of the hole, especially in cases where the hole is carried below the ground water level, by use of drive pipe or casing or by means of drilling fluids (water or mixtures of water and colloidal, gel forming thixotropic clays such as bentonite), grouting (in rock) or other suitable methods.

4.03 **Sampling**

Bored spoil shall be collected continuously during boring to note any change of strata. Samples of undisturbed soil shall be obtained preferably at every 1.5 m where a change in strata is indicated by the slurry flowing out. In no case shall the depth between successive sampling be more than 3.0m and a sample shall be obtained on the average for every 2.0m depth of boring, since it is intended to ascertain the characteristics of the soil at various depths. If, however, there is fair uniformity in the characteristics of the soil for certain depths the engineer may limit the number of samples stipulated above.

4.04 **Tube Sampling**

For obtaining undisturbed samples in its simplest from, an open drive thin wall tube sampler shall be attached to a rod and shall be lowered to the bottom after completely cleaning the borehole bottom by washing. The samplers to be used should have area ratio less than 13 percent and preferably less than 10 percent. The head should have check valve and ports to permit easy escape of drilling fluid or air from the sample tube as the sample enters it.

Sampling will be accomplished by jacking or driving the tube depending on the type of soil to be sampled. Upon completion of the sampling operation the sampler shall be withdrawn from the borehole and the sample of soil carefully taken out. Approximately one inch length of soil is to be removed from each end for identification. If there is any surface water on the sample, this shall be wiped off with soaking paper, all sludge of cuttings from advancement of borehole removed and the sample immediately packed in an airtight, close fitting container marked with

4.04 Tube Sampling (contd.)

respective test bore numbers, elevation at which the sample was taken and other relevant information as per IS:1892. The size of soil test samples shall preferably be 65 mm dia x 200 mm high, but not less than 50 mm dia. x 150 mm high.

Representative / disturbed samples shall also be taken in different strata for visual classification, water content, grain size analysis, atterberg limits, determination of specific gravity and compaction tests.

4.05 **Record of Boring**

Detailed chronological record of drilling and sampling operations shall be maintained in the field log and should be submitted to the owner after completion of boring work at site. The final log showing pertinent subsurface information and results of field and laboratory testing should be submitted with the soil report.

The field log should contain at least the following information :

a) Reference information like project number, title and location, exploration number and location by coordinates, inclination of the boring and if inclined the bearing or azimuth of the dip of the hole, reference level and datum.

b) Personnel information – name of drilling contractor, driller and inspecting engineer.

c) Equipment data – manufacturer's name and model designation.

d) Sampling and coring information :

   i) General : Sample type and number, sampler dimension, depth at start and completion of sampling, length of sample, recovery ratio and complete visual description of each sample in "as retrieved" state.

   ii) Drive samplers : weight and height of drop of hammer and number of blows for each 150 mm penetration.

   iii) Push samplers : hydraulic pressure and rate of penetration.

e) Description of material penetration but not sampled.

f) Casing information - size, depth at which required, length and depth of bottom of casing weight and height of drop of and number of blows for each 300 mm of penetration for driven casing, and average rotational speed and downward pressure on casing and average rate of penetration for drilled casing.

4.05 Record of Boring (contd.)

g) Seepage pressure test information-depth and duration of test.

h) Ground water information - depth to water surface recorded daily and continued till water level has stabilised.

i) Artesian pressure information - depth at which encountered, measured head and lime at which each measurement is made.

j) Elevation of top and bottom of hole and top of rock.

k) Date and time of all operations and delays with reasons.

l) Miscellaneous information to aid interpretation of subsurface conditions.

m) Additional pertinent information.

The final log shall be a condensation of the field log refined on the basis of field and laboratory tests. The final log should present a clear, concise and accurate picture of subsurface conditions to be utilised by the engineer.

5.00 PENETRATION TESTS

Penetration tests using various types of equipment as specified shall be conducted to measure the resistance of soil to penetration.

5.01 Standard Penetration Test

Standard Penetration Test (SPT) shall be carried out in accordance with IS:2131 at every change in strata or at 1.5m intervals or as directed by the engineer. The contractor shall record the number of blows for each 150 mm penetration of the standard split spoon sampler over a depth of 450 mm. The number of blows for the first 150mm of penetration shall not be considered in evaluating the penetration resistance. Hammer used for driving the sampler rod shall be 65 kg and drops of 750 mm shall be maintained. Records of the test including depth at which driving is initiated and the number of blows for each 150 mm penetration shall be shown in the field log, the final log shall indicate the actual SPT value (sum of number of blows for last 300 mm of penetration) at appropriate depths.

5.02 **Static Cone Penetration Test**

The test shall be carried out at locations as shown on the drawing and / or at such other locations as directed by the Engineer. A steel cone with an apex angle of 60° and overall base diameter of 35.7 mm giving a cross-sectional area of 10 Sq.cm. shall be pushed through soil strata through a distance in accordance with the design of the equipment and cone resistance is noted. Thereafter the cone and the friction jacket with 36 mm OD are pushed together for a distance depending upon the design of the cone and the friction jacket assembly and combined values of cone and friction resistance noted. The procedure shall be repeated upto the desired depth. Rate of penetration shall be 1 cm/sec. Unless otherwise instructed by the Engineer. The test shall be carried out upto a depth of 35 m.

The driving mechanism shall have a capacity of not less than 10 tone for the mechanically operated equipment. If approved by the Engineer, manually operated equipment may be used for shallow depths (Not greater than 10m) in case of soft clay layer.

The contractor shall get the dial and pressure gauges calibrated by an approved testing laboratory before commencing the actual test and produce the test certificates to the Engineer.

The test shall be carried out in accordance with IS:4968 (Part-III), latest edition. Cone resistance and frictional resistance shall be separately provided in the report together with a borehole log.

6.00 **GROUND WATER INVESTIGATION**

Ground water investigation shall comprise determination of groundwater levels and pressures and permeability of subsurface materials. The effect of tidal variations (if applicable for the site) on ground water level shall also be observed by noting the water level in boreholes during high and low tide periods.

6.01 **Ground water level observation**

The contractor shall make necessary arrangements to prepare the boreholes for ground water observation. Completed boreholes should be capped and a G.I.pipe inserted in order to preserve them for future ground water observation. These observations will be taken by the contractor during the period of investigation work

7.00 **FIELD TESTS**

In situ tests shall be performed as desired by the engineer to measure properties of soil during the field investigation work.

7.01 **Plate Load Tests on Soils**

The plate load tests on soil shall be carried out in the trial pits specified in enclosed Drawing and / or at such other locations as directed by the Engineer. This test is to be carried out at 1.2m below the natural ground level as indicated in the above drawing as directed by the Engineer. The plate sizes to be used shall depend on the nature of the soil, a 45 cm square plate will be used in clayey soil and in sandy soils, three plates of size varying between 30 cm to 75 cm will be used. The test shall be carried out in a manner as to give dependable assessment of bearing capacities of the soils at particular level. The results of the test shall also be used for arriving at the modulus of subgrade reaction and deformation modulus of soil.

The tenderer shall furnish in his tender the complete details of the equipment and method he proposes to follow.

The excavation and side protection during the test and back-filling after the test shall be carried out by the contractor. If ground water table is at a depth higher than the specified test depth, the ground water table shall be lowered and maintained at the test depth for the entire duration of the test. The cost of dewatering shall be borne by the contractor.

The contractor will submit, for approval of the Engineer, a detailed arrangement drawing for the tests and satisfy the Engineer about its adequacy in respect of strength and safety and of its being capable of giving accurate data. However, the contractor shall have to modify the arrangement at his own cost if it is ultimately found to be deficient.

The contractor must get the dial and pressure gauges calibrated by an approved testing laboratory before commencing the direct load tests at the site and produce the certificates of the tests to the Engineer. There shall be adequate number of standby gauges available at the site for quick replacement of faulty gauges. The contractor shall bring not less than two dial gauges and one pressure gauge as standby.

In no case settlement observations by means of level and staff shall be accepted.

The tests shall be carried out as described in IS:1888 unless otherwise specifically directed. The application of load may be by gravity or by reaction as detailed out in the above standard.

The test plate shall be pre-loaded with a load of 700 Kg./Sq.m. retained for a reasonable period and then replaced to take out all slacks of the arrangement. All settlement observations shall start thereafter. Unless the ultimate bearing capacity

7.01 Plate Load Tests on Soils (contd.)

can be calculated from the available soil data, the contractor shall assess ultimate bearing capacity of the soil under test. Increments of the load shall be of about one fifth of the ultimate bearing capacity. The increments shall continue to an extent that allows locating the 'Yield Value of the Soil' as defined in IS : 1888 or upto practicable limit of testing.

While releasing the loads, the rebounds are to be observed in a similar manner as the settlement observations.

The observations shall be recorded directly in log books, proforma of which has to be approved by the Engineer, who shall also be present to check the data. The Engineer shall be notified well in advance of the detailed programme of the test and shall also be informed prior to start of releasing the load so that the total settlement can be checked by him. In addition to carrying out plate load tests, undisturbed / disturbed soil samples shall also be collected at regular intervals during excavation.

The payment shall be lumpsum for each test and shall include all costs inclusive of earthwork in excavation upto 1.20m depth below natural ground level, shoring for side protection, if necessary, and back filling after the test. For the depths over 1.20m extra payments shall be made only for earthwork and shoring, if any. If water table is required to be lowered during the test, necessary diesel operated pumping arrangement will have to be provided by the contractor himself. All expenses in this connection shall be included in his quoted rates.

7.02 **Test for Measurement of Soil Resistivity**

For designing the earthing system for the project it is necessary to find out the electric resistivity of the soil at some representative locations of the project site.

Soil resistivity is determined in Ohmmeter by using "WENNER's FOUR ELECTRODE METHOD". The principle of the above method is generally as under :

Four electrodes are driven into the earth along a straight line at equal intervals of 'S'. This distance 'S' can be varied and different readings taken for electrode spacing S = 5, 10, 15, 20 metres etc. to detect the vertical variations of resistivity at a certain location. A current I is passed through the two outer electrodes and the earth. The voltage difference, V, between the two inner electrodes is measured. The current I flowing into the earth produces an electric field proportional to its density and to the resistivity of the soil. The voltage V measured between the inner electrodes is, therefore, proportional to this field. Consequently, the resistivity will be proportional to the ratio of voltage to current.

If the depth of burial of electrodes in the ground is negligible compared to the spacing between the electrodes, then the soil resistivity.

7.02 Test for Measurement of Soil Resistivity (contd.)

= 2 x 3.14 x S.V / I

Where, Resistivity of soil in Ohm-meter

S = Spacing between electrodes in metre

V = Voltage difference between two inner electrodes in volts.

I = Current flowing through two outer electrodes in amp.

Earth testers normally used for the above purpose comprise the current source and meters in a single instrument and directly read the resistance. Such an instrument is known as four terminal meggar. Using such meggar for measurement, above formula becomes

= 2 x 3.14 x S.R.

where R is meggar reading in Ohms.

Depths of burial of electrodes shall not be more than 1/20 or the spacing between the electrodes.

Correction of the test results should be done, if necessary, using the method outlined in IS : 3043.

The location and number of the test points are shown in the plant layout. The number shall be increased if the test results obtained in different locations show a significant difference.

8.00 FIELD DETERMINATION OF CALIFORNIA BEARING RATIO

The test shall be carried out at locations as shown on the drawing or at locations as directed by the engineer. The test shall be carried out at a depth of 500mm or at appropriate depth as per the instruction of the Engineer-in-charge below the finished ground level.

The Contractor shall submit, for approval of the Engineer complete detail of the equipment and the method he proposes to use. However, the contractor shall have to modify the arrangement at his own cost if it is ultimately found to be deficient.

The surface area to be tested shall be exposed, cleaned of all loose and dried material, levelled and then soaked till saturation with a surcharge weight of 15 kg. After soaking is complete, the test surface shall be drained of all free water and allowed to stand for at least 15 minutes before starting further operations.

The test shall be carried out strictly in accordance with the provisions as laid down in IS : 2720 (Part XXXI) latest edition. Surcharge weights of 15 kg. including that of the annular weight of 5 kg. shall be applied before applicatiion of load on the penetration piston. Load shall be applied on the penetration piston such that the penetration is approximately 1.25 mm/min. The load readings shall be recorded at penetrations of 0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 4.0, 5.0, 7.5, 10.0 and 12.5 mm. The maximum load and penetration shall be recorded if its occurs for a penetration of less than 12.5mm.

8.01 FIELD DETERMINATION OF CALIFORNIA BEARING RATIO (contd.)

After completion of the test, a sample of soil shall be taken from the point of penetration for moisture content determination. In place density shall also be determined. From the plot of load penetration curve, after necessary correction, the bearing ratios shall be calculated for penetrations of 2.5mm and 5mm. If the bearing ratio at 2.5mm penetration is greater than that at 5mm penetration the former shall be taken as the bearing ratio. If bearing ratio at 2.5 mm penetration is less than that at 5mm penetration, the test shall be repeated and if the ratio at 5 mm penetration is consistently greater than that at 2.5mm penetration, the ratio at 5mm penetration shall be taken.

9.0 LABORATORY TESTS ON SOIL SAMPLES

The contractor shall carry out the tests as listed out in the Schedule of Items, and/or as decided by the Engineer, in laboratory. He shall furnish the name(s) of laboratories where he proposes to have the tests carried out and have them approved by the Engineer.

The owner shall have the right of access to contractor's laboratory and / or any other laboratory where tests have been arranged to be carried out during the progress of this investigation.

Adequate volume of test samples of soil shall have to be collected from site and stored, labelled and transported carefully to the approved laboratory for carrying out the tests. The method and procedure of testing to be followed shall be as per the relevant Indian Standard Codes of Practice. The results of the tests shall be submitted to the Engineer in sixtruplicate duly signed by the laboratory-in-charge.

10.0 REPORT ON SUB-SOIL INVESTIGATION

10.01 General

a) On completion of all the field and laboratory work, the contractor 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 borelogs, subsoil sections, field test results, laboratory observations and test results both in tabular as well as graphical form, practical and theoretical considerations for the

10.01 General (contd.)

interpretation of test results, the supporting calculation for the conclusions drawn etc. Initially, the contractor shall submit two (2) copies of the report in draft form for the owner's review.

b) The contractor's qualified geotechnical engineer shall visit the owner's corporate office for a detailed discussion on the owner's comments on his draft report. During the discussions, it shall be decided as to the modifications that need to be done in the draft report. Thereafter the contractor shall incorporate in his report the agreed modifications and after getting the amended draft report approved, five (5) copies of the detailed final report shall be submitted alongwith one set of reproducibles of the graphs, tables, etc.

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

10.02 **Data to be Furnished**

The report shall include the enlisted items but not be limited to them.

a) Purpose and scope of investigation

b) Authorisation enabling the contractor to carry out the work at the site.

c) Project description including proposed facilities and construction materials required for the works.

d) Description of the site which shall include

i) Location of the site and existing facilities

ii) Topography of the site

iii) Drainage Characteristics

e) A plot plan showing the locations and reduced levels of all field tests e.g., boreholes, static cone penetration tests, plate load tests etc., properly drawn to scale and dimensioned with reference to the established grid lines.

f) A true cross section of all individual bore holes 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.

10.02 Data to be Furnished (contd.)

g) A set of longitudinal and transverse profiles connecting various boreholes shall be presented in order to give a clear picture of the site, how soil/rock strata is varying vertically and horizontally.

h) Geological Information

i) Regional geology - geologic province, topographic position of site, processes of formation of subsurface materials at site.

ii) Description of overburden and bear rock at the site (if applicable for the site)

iii) Comments on texture and structure of rock, joints, bedding planes, fissures, weathering condition etc. (if applicable for the site.)

iv) Effect of geologic features on design.

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

j) Bore hole and trial pit logs on standard proforma showing the depths, extent of various soil strata etc.

k) Plot of SPT (N) value (both uncorrected and corrected) with depth.

l) Procedure of investigations employees - field tests and laboratory investigation.

m) Results of all laboratory test summarised (i) for each sample as well as (ii) for each layer along with all the relevant charts, tables, graphs, figures, supporting calculations, conclusions.

n) For all triaxial 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 along with relevant calculations.

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

e vs log p
e vs p and
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 conditions (e.p) of the soil shall be marked on the curves.

10.02 Data to be Furnished (contd.)

p) 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.

q) From the pressure meter test results the value of cohesion, angle of internal friction, pressure meter modulus, shear modulus and coefficient of subgrade reaction shall be furnished along with sample calculation. Calculation for allowable bearing pressures and corresponding total settlements, for shallow foundations mentioned below the capacity calculation of piles in various modes shall also be included.

10.03 **Recommendations**

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

a) Type of foundations to be adopted for various structures, duly considering the sub soil characteristics, water table, total settlements permissible for structures and equipment. Minimum depth and width of foundation shall also be recommended. The provision in relevant Indian Standard Codes indicated in Clause 3.04.00 shall be considered.

b) For shallow foundations, the following shall be indicated with comprehensive supporting calculations :

i) Net safe allowable bearing pressure for isolated square and continuous strip footings of different sizes at different founding depths below ground level considering both shear failure and settlement criteria, giving reasons for type of shear failure adopted in the calculation.

ii) Net safe allowable bearing pressure for mat foundations at different founding depths below ground level considering both shear failure and settlement criteria.

iii) Rate and magnitude of settlement expected of the structure.

iv) Modulus of subgrade reaction, modulus of elasticity, deformation modulus from plate load test results alongwith time-settlement and load-settlement curves for the various footing sizes at different founding levels indicated above. The recommended values shall includes the effect of size, shape and depth of foundation.

10.03.00 Recommendations (contd.)

c) If piling is envisaged, the following shall be indicated with comprehensive supporting calculations.

i) Type of pile and reasons for recommending the same considering soil characteristics.

ii) Suitable founding strata for pile.

iii) Estimated length and diameter of pile for various values of pile capacities. End bearing and frictional resistance shall be indicated separately. Group action shall be considered as applicable.

iv) Magnitude of negative skin friction, if any, to be considered in pile design.

d) Recommendations on foundations for special structures like tanks, transformers, sub-station structures etc.

e) Recommendations regarding bases of roads and pavements.

10.04 **Additional Recommendations**

a) Cone resistance, frictional resistance, total resistance, relation between cone resistance and SPT (N) value and settlement analysis for different footing sizes based on CPT/SPT.

b) Electricity resistivity of sub-soil based on electrical resistivity tests including electrode spacing vs cumulative resistivity curve.

c) Coefficient of earth pressure at rest and stress strain modulus of soil.

d) Recommendations regarding earth pressure as a function of depth below grade as applied to side walls of underground structures. Values of co-efficient of permeability shall be included in the report

e) Recommendations regarding method and slope of deep excavations.

f) Recommendations regarding stability of slopes, during excavations, etc.

g) If expansive soil is met with recommendation on removal or retainment of the same under the structures / roads etc. shall be given, in the latter case detailed specification of any special treatment required including specification for materials to be used, construction method, equipment to be deployed etc. shall be furnished.

10.04 Additional Recommendations (contd.)

h) Susceptibility of sub soil strata to liquefaction in the event of earthquake and recommendation on remedial measures, if necessary.

i) Information of special significance like dewatering schemes etc. which may have a bearing on design and construction.

j) Aggressiveness of percolating water through sub-soil / rock fissures to reinforced concrete foundation / sub-structures and also recommended protective measures, if required.

k) Recommendation for the type of cement to be used and any treatment to the underground concrete structures based on the chemical composition of soil and sub-soil water.

l) Recommendations on suitability of the overburden soil as material of construction of earthen embankments and in back filling or excavated pits / trenches.

m) Recommendations for additional investigation beyond the scope of the present work if the contractor considers it necessary.

n) Drawings :

i) General plan showing location of site, and Aerial geology.

ii) Plan showing existing features, proposed facilities, contours and locations of boring and other investigations.

iii) Geologic sections and soil profiles.

o) Appendices :

i) Logs of subsurface explorations

ii) Field test results

iii) Laboratory test results.

11.00.00 **TIME SCHEDULE**

The time schedule for the total Geotechnical Investigation work shall be furnished by the tenderer. It is expected that the total job shall be completed within the following time schedule :

(a) Preliminary Report within - 6 weeks

(b) Final Report within - 2 weeks

PROPOSED HOSTEL COMPLEX FOR RBU, KOLKATA

SCHEDULE OF ITEMS FOR GEOTECHNICAL INVESTIGATION

1. The Tenderer's quoted rate for the complete items shall include all costs towards power, fuels, tools and plants, tackle, equipment, materials, transport of materials, labour, supervision, layout, setting out the locations for field tests, all taxes, levies, contingencies, overheads, profits and all incidental items not specifically mentioned but reasonably implied and necessary according to the Contract.

2. Quantities mentioned in the Schedule of Items depend upon the type of soil actually met with during execution and may therefore vary to any extent. The quantities are indicated merely for the purpose of quoting rates. Payments shall be based on actual work done both in the total value of the works executed under this contract, including extra items, if any, remain within $\pm$ 20% (Twenty percent) of the tendered value of the works. The Contractor, in his own interest, should get an indication of the probable extent of work to be executed under any particular item in this schedule before undertaking any preliminary work.

GEOTECHNICAL BOQ FOR HOSTEL COMPLEX - RBU

ITEM NO.	DESCRIPTION	APPROX. QTY.	UNIT	RATE IN RUPEES	TOTAL AMOUNT IN RUPEEES
1.00	Mobilisation of boring plant, oher in -situ test equipment etc. and personal at site and demoliation on completion and removal from site:				
	a) Mobilisation		L.S		
	b) Demobilisation		L.S		
2.00	Making test bores on soil including taking out undisturbed and disturbed soild samples, maintaining necessary driving records of Standard Penetration tests at various depths in soil only and furnishing the necessary report and data in the bore log in sixtuplicate to the Engineer.				
	a) Upto 35 m depth from natural ground level.	5	Each		
	b) Upto 30 m depth from natural ground level.	4	Each		
3.00	Digging drial pits, taking undisturbed/disturbed soil samples, and carrying out plate load tests as per specification at depth of 1.5m below natural ground level including backfilling after tests using:				
	a) 45 cm x 45 cm plates	2	Each		
4.00	Carrying out in situ tests for measurement of soil reislivity it various location as per specification, drawing and instructions of the engineer.	7	Each		

GEOTECHNICAL BOQ FOR HOSTEL COMPLEX - RBU

ITEM NO.	DESCRIPTION	APPROX. QTY.	UNIT	RATE	TOTAL AMOUNT
5.00	Soil sample tests in approved laboratory				
	a) Natural Moisture content	45	Each		
	b) Particle size analysis				
	i) Sieve	45	Each		
	ii) Mechanical analysis (Hydrometer)	45	Each		
	c) Index Properties (liquid and plastic limits, shrinkage and plasticity index)	45	Each		
	d) Bulk and dry density	45	Each		
	e) Unconfined compression test	35	Each		
	f) Shear test by Triaxial compression	35	Each		
	g) Direct Shear test	35	Each		
	h) Consolidation test (Oedometer)	35	Each		
	i) Specific Gravity of soil	35			
	j) Chemical analysis for:				
	i) Soil	10	Each		
	ii) Sub-soil water	10	Each		
	iii) P.H. value of subsoil water	10	Each		

GEOTECHNICAL BOQ FOR HOSTEL COMPLEX - RBU

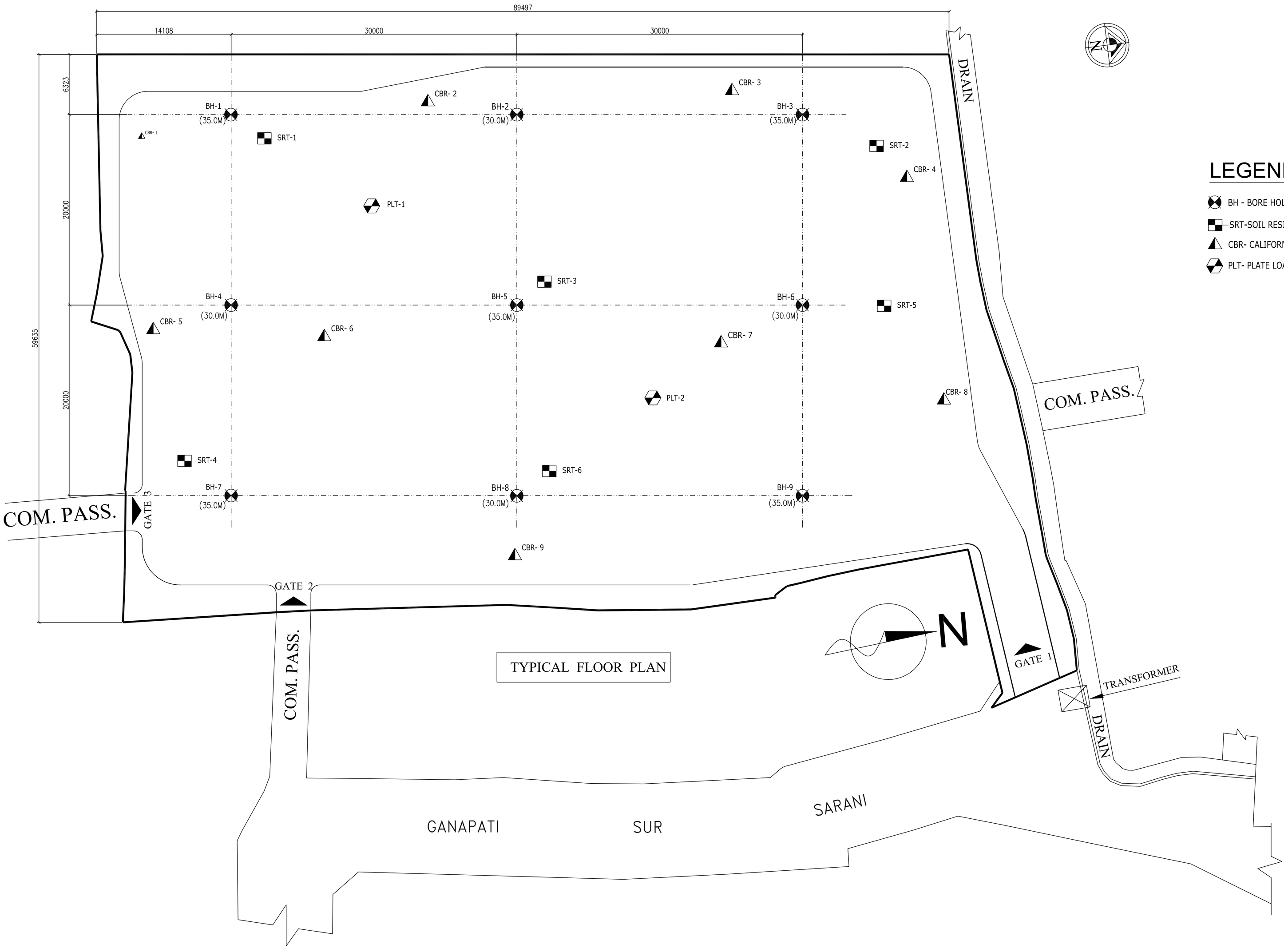
ITEM NO.	DESCRIPTION	APPROX. QTY.	UNIT	RATE	TOTAL AMOUNT
	k) Determination of water content-dry density relationship using light compaction-standard proctor density test.	10	Each		
6.00	Preparaion and submisson of soil report (preliminary & final) including recommendeion as per specification and instruction of the engineer		L.S		

TOTAL Rs.

TOTAL RUPEES……) ONLY

Time required to complete the Contract from the date of Letter of Intent…….Weeks

Date…….. Signature of the Tender…….



LEGEND :

- BH - BORE HOLES----------9 NOS
- SRT-SOIL RESISTIVITY TEST----------6 NOS
- CBR- CALIFORNIA BEARING RATIO TEST-----9 NOS
- PLT- PLATE LOAD TEST----------2 NOS

LAYOUT OF BORE HOLES & TEST LOCATIONS

SCALE 1:200

SIGN. OF ARCHITECT

SIGN. OF OWNER

CONSULTANT

MOYTEC

10 B, JATIN DAS ROAD, KOLKATA 700029

HOSTEL BLDG.S (16.65 M. & 21.00 M.) FOR RABINDRA BHARATI UNIVERSITY AT PRE. NO. 24 GANAPATI SUR SARANI (SOUTH SINTHI RPOAD, KOLKATA 700050 (WARD NO. 02, BOROUGH I)

GEO-TECHNICAL INVESTIGATION

BORE HOLES & TEST LOCATIONS

SCALE	1:200	DELT. BY	MP	DRG. NO. RBU-HOS-GEO-01
DATE	07.11.16	CHKD. BY	DCP	

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