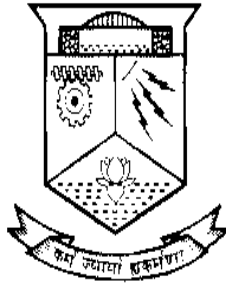


GEOTECHNICAL INVESTIGATION REPORT

**FOR THE CONSTRUCTION OF
TWO NON-TECHNICAL BUILDINGS
AT
LIFE SCIENCE PARK, THONNAKKAL THIRUVANANTHAPURAM**

**FOR
M/s. HITES, HLL Lifecare Ltd, Thiruvananthapuram 695012**



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17 OCTOBER 2017

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Figure - 1 Site Plan – Location of Boreholes

Table 1: Details of rock strata, core recovery & RQD

Table 2: Laboratory test results on rock samples

Table 3: Load carrying capacity of piles (IS:2911)

Table 4: Lateral load carrying capacity of piles (as per IS:2911)

Table 5: Uplift carrying capacity of piles ((IS:2911)

Annexure - I Borehole log sheets

1. INTRODUCTION

This geotechnical investigation was conducted for the proposed two non-technical buildings (Three storey Biotech Lab building and two storey office building) at Life Science Park, Thonnakkal, Thiruvananthapuram. The objective is to study the subsoil characteristics below the proposed locations of the construction, to enable the design of the most appropriate and economical foundations.

2. SCOPE OF WORK

- (a) Drilling boreholes up to the depth required or refusal whichever is earlier.
- (b) Conducting Standard Penetration Tests in the boreholes as per IS Code of Practice.
- (c) Drilling into the underlying rock, coring, logging, sampling and testing wherever necessary.
- (d) Recording of water table level in the boreholes after completion of boring.
- (e) Conducting all the necessary laboratory tests on the samples collected.
- (f) Preparation of report summarizing the details of soil classification, analysis of test data, type & depth of foundation to be adopted.

3. FIELD WORK

3.1 BORING

The borehole points taken are marked in the Site Plan, Fig 1, attached. The field work was done on September & October 2017. The boreholes of 100mm were drilled using machine augering method (Calyx type), as per I.S. Specifications. All the borehole details are given in log sheets in Annexure- I.

3.2. STANDARD PENETRATION TEST

These tests were conducted at approximately 1.5m depth intervals and wherever there was a change in stratification. The tests were performed by driving into the soil (boreholes cleaned of any loose material) standard split spoon sampler with the help of a standard hammer with a free fall of 75cm on a driving head as specified in IS:2131-1981. The number of blows needed to penetrate the first, second and third stages (each of 15cm

depth) of the sampler length were noted. The SPT values ('N'-value) are given in the borehole log data sheets.

3.3 BORING INTO THE ROCK

Boring into the rock was carried out using diamond bits of NX size (54.7mm) and the details are given in the borehole log sheets and Table 1.

3.4 RECORDING OF WATER TABLE

Water table was generally recorded as per standard practice, 24 hours after the completion of the boreholes. The investigation was done in September & October 2017. The water table level was observed up to the depth bored and is given in the borehole log sheets in Annexure I.

4. LABORTORY TESTS

A preliminary visual examination of the soil samples was made before the laboratory tests. The tests done on soil samples are Grain size analysis, Moisture content etc. The test results of the soil samples are reported in the corresponding borehole log sheets. The rock cores obtained are tested in the laboratory and the results are shown in Table 2.

5.0 LOCATION OF BOREHOLES

The location of all boreholes is given in the Site Plan (Fig. 1).

6. DISCUSSION OF BOREHOLES

The field log sheets of the all boreholes are attached. All depths mentioned are with reference to the ground level as on the date of investigation. A brief description of each borehole is given in Annexure I attached. The sub soil profile details of all six boreholes are given in Fig. 2.

Borehole: BH-01 (Three storey biotech lab building)

The soil near the existing ground level is dark brown gravelly sand with silt & some clay, up to 2.2m. Below this, brownish red & light grey laterite (grain size: silty sand with gravel & clay) was obtained up to 3.70m. Below this, brownish red & light grey laterite (grain size: silty sand) was obtained up to 5.0m. Below this, brownish red & light grey laterite (grain size: silty sand with clay) was obtained up to 6.30m. Below this, light brown & light grey silty sand was obtained up to 8.0m. Below this, brownish red & light grey laterite (grain size: gravelly sand with silt & clay) was obtained up to 9.50m. Below this, light brownish yellow silty sand was obtained up to 13.50m. Below this, brown silty sand was obtained up to 15.50m. Below this, brown & light grey silty sand was obtained up to 17.50m. Below this, brown & light grey silty fine & medium sand was obtained up to 19.0m. Below this, brown weathered rock material (silty sand) was obtained up to 20.50m. Below this, dark greenish grey weathered rock material (silty sand) was obtained and in this layer 'refusal' was encountered at 21.51m. Hence for the further boring drill bits were used.

The brown soft rock with poor core recovery & RQD value was obtained up to 26.54m. Below this, light brownish grey jointed medium hard rock with core recovery & some RQD values was obtained up to 29.73m. The boring was stopped at this depth.

Borehole: BH-02 (Three storey biotech lab building)

The soil near the existing ground level is brownish red laterite (grain size: sandy gravel with silt & clay) was obtained up to 2.50m. Below this, reddish brown & grey laterite (grain size: silty clay with sand) was obtained up to 4.0m. Below this, reddish brown & grey laterite (grain size: gravelly sand with silt & clay) was obtained up to 5.40m. Below this, brownish red & grey laterite (grain size: clayey silt with sand) was obtained up to 7.50m. Below this, yellow silty sand was obtained up to 9.50m. Below this, brown silty sand was obtained up to 12.0m. Below this, brown silty fine & medium sand was obtained up to 14m. Below this, grey weathered rock material (silty sand) was obtained up to 15.50m. Below this, greenish grey weathered rock material (silty sand) was obtained and in this layer 'refusal' was encountered at 16.56m. Hence for the further boring drill bits were used.

The dark brownish grey soft rock was obtained up to 19.37m. Below this, light greyish brown or yellowish brown soft rock was obtained up to 31.75m. Below this, light brownish grey medium hard rock was obtained up to 32.09m. Below this, brown highly

jointed hard rock with core recovery & poor RQD values was obtained up to 32.9m. The boring was stopped at this depth.

Borehole: BH-03 (Three storey biotech lab building)

The soil near the existing ground level is reddish brown laterite (grain size: silty sand) was obtained up to 2.50m. Below this, light grey & brown laterite (grain size: silty clay with fine sand) was obtained up to 4.0m. Below this, grey & some brown silty clay with fine sand was obtained up to 5.50m. Below this, brownish red & light grey laterite (grain size: silty sand with some clay) was obtained up to 8.0m. Below this, dark reddish brown & white laterite (grain size: silty sand with some clay) was obtained up to 10m. Below this, brownish red silty sand was obtained up to 12.5m. Below this, brown silty sand was obtained up to 14m. Below this, reddish brown silty sand was obtained up to 16m. Below this, grey weathered rock material (silty sand) was obtained up to 17.50m. Below this, brown weathered rock material (silty medium sand) was obtained and in this layer 'refusal' was encountered at 18.66m. Hence for the further boring drill bits were used.

The brown & grey soft rock was obtained up to 26.2m. Below this, grey jointed medium hard rock was obtained up to 26.94m. Below this, light greyish brown jointed hard rock was obtained up to 28.81m. The boring was stopped at this depth.

Borehole: BH-04 (Three storey biotech lab building)

The soil near the existing ground level is brown laterite (grain size: silty sand) was obtained up to 2.50m. Below this, brownish red laterite (grain size: silty sand) was obtained up to 4.0m. Below this, light reddish brown laterite (grain size: silty sand) was obtained up to 6.0m. Below this, reddish brown laterite (grain size: silty sand) was obtained up to 8.0m. Below this, brown laterite (grain size: silty medium sand) was obtained up to 10.0m. Below this, light yellowish grey silty medium sand was obtained up to 12.0m. Below this, yellowish brown silty medium sand was obtained and in this layer 'refusal' was encountered at 12.99m. Hence for the further boring drill bits were used.

The brown or light brown or light yellowish brown soft rock was obtained up to 24.34m. Below this, light brownish yellow & grey soft rock was obtained up to 29.06m. The boring was stopped at this depth.

Borehole: BH-05 (two storey office building)

The soil near the existing ground level is brown & light grey laterite (grain size: silty sand with clay) was obtained up to 2.0m. Below this, reddish pink laterite (grain size: silty clay) was obtained up to 3.5m. Below this, light reddish pink laterite (grain size: silty sand with clay) was obtained up to 5.50m. Below this, brown silty sand was obtained up to 7.50m. Below this, red & light grey laterite (grain size: silty sand with two cobbles) was obtained up to 9.50m. Below this, dark brown laterite (grain size: sandy gravel with silt & clay) was obtained up to 11.5m. Below this, light pinkish brown silty fine & medium sand was obtained up to 13m. Below this, brown & light grey laterite (grain size: silty sand) was obtained up to 14.5m. Below this, grey silty sand with some clay was obtained up to 18m. Below this, white weathered rock material (silty sand) was obtained up to 20m. Below this, light grey weathered rock material (silty sand) was obtained and in this layer 'refusal' was encountered at 24.34m. Hence for the further boring drill bits were used.

The grey soft rock was obtained up to 33.92m. Below this, yellowish brown & light grey soft rock was obtained up to 35.59m. The boring was stopped at this depth.

Borehole: BH-06 (two storey office building)

The soil near the existing ground level is reddish brown & light grey laterite (grain size: gravelly sand with silt & clay) was obtained up to 2.50m. Below this, white & light grey silty medium sand was obtained up to 4.0m. Below this, light brownish pink silty fine & medium sand with clay was obtained up to 5.50m. Below this, light brownish yellow silty fine & medium sand with clay was obtained up to 7.50m. Below this, light brown silty sand was obtained up to 12.0m. Below this, dark brown & dark grey silty sand with clay was obtained up to 13.5m. Below this, light reddish brown silty sand was obtained up to 15m. Below this, light brown & light grey silty fine sand was obtained and in this layer 'refusal' was encountered at 15.62m. Hence for the further boring drill bits were used.

The light grey or grey or brown soft rock was obtained up to 35.2m. Below this, grey highly jointed hard rock was obtained up to 37.1m. The boring was stopped at this depth.

The Table 1 shows the details of rock coring and Table 2 gives the details of the rock core tested.

7. DESIGN CONSIDERATIONS AND RECOMMENDATIONS

The site investigation was carried out at the six locations of the proposed two non-technical buildings (Three storey Biotech lab building and two storey office building) at Life Science Park, Thonnakkal, Thiruvananthapuram. The locations of boreholes are shown in Fig. 1. The existing ground level (October 2017) of the proposed building area is almost level and is obtained after removing the soil cover over a height of about 5.0m to 8.0m.

7.1 Three Storey building

The column loads are not assessed by the structural designers so far, but it is assumed that the maximum column loads will be in the order of 175t (this has to be confirmed by structural designers).

The sub soil profile details are given in Fig. 2 & Annexure I. From the soil profile, it can be seen that the soil at shallow depths have some low SPT 'N' values and then increases with depth. Therefore two types of foundations are recommended and suitable choice can be made based on economical point of view.

The first alternative is spread foundation and the second alternative is deep foundation (piles) (at BH-01 to BH-04 locations) are recommended and the details are given below:

Spread foundation

For the proposed three storey building, it is recommended to adopt spread footing or combined footing, over the dense silty sand stratum at 1.5m, from the existing ground level. The allowable bearing pressure for this depth for a 1.5m to 3.0m wide footing can be taken as 20t/m^2 , for design. The individual footing may be provided for the outer columns and combined footing each for the two columns near the corridor. One part of this building is three storied and other part is three storied and therefore footing shall be kept away from the cutting.

Pile foundations

If the column loads are higher, this alternative may be economically viable. The soft/weathered rock and hard rock strata occur at different levels at different borehole points (refer Fig .2).

Two options for piles are:-

- (i) Piles on soft/weathered (weak) rock and**
- (ii) Piles on hard rock.**

It is recommended that either option (i) or option (ii) should be adopted for the entire structure. That is: all the piles should be anchored either in the soft rock stratum or in the hard rock stratum.

As the core recovery in the soft rock stratum is very poor and the soft rock stratum is easily penetrable, pile resting on medium hard rock is recommended. Also, the higher carrying capacity of piles can be achieved on hard rock. Therefore alternative (ii) is preferred for adoption. It is recommended to install pile on medium hard at depths of 27.0m in BH-01 & BH-02 and 25.0m in BH-03 & BH-04, from the existing ground level.

It is recommended that rotary drilling method (to ensure the recommended depth of piles) using with or without DMC method may be adopted to install the piles. This will have only very negligible impact (noise/vibration) in the environment. The recommended depth shall be ensured and hence required machinery shall be used.

The carrying capacity of piles is calculated on the basis of IS: 2911-2010 (Code of Practice for Design and Construction of pile foundation), as the rock core obtained has poor RQD values. The bored and cast-in-situ piles (installed by rotary boring method) should be socketed into the medium hard rock stratum as given below, to develop necessary lateral and uplift capacities.

Borehole No	Pile depth from existing ground level, m	Safe vertical load, t					Safe lateral load, t				
		Pile diameter, m					Pile diameter, m				
		0.60	0.70	0.80	0.90	1.00	0.60	0.70	0.80	0.90	1.00
BH-01	27.0	75	120	165	210	275	9.1	12.7	17.1	22.1	27.9
BH-02	27.0	75	120	165	210	275	9.1	12.7	17.1	22.1	27.9
BH-03	25.0	75	120	165	210	275	9.1	12.7	17.1	22.1	27.9
BH-04	25.0	75	120	165	210	275	9.1	12.7	17.1	22.1	27.9

Borehole No	Pile depth from existing ground level, m	Safe lateral load, t				
		Pile diameter, m				
		0.60	0.70	0.80	0.90	1.00
BH-01	27.0	23.5	32.0	41.8	52.9	65.3
BH-02	27.0	32.0	43.6	56.9	72.0	88.9
BH-03	25.0	22.7	30.8	40.3	51.0	62.9
BH-04	25.0	27.8	37.8	49.4	62.5	77.1

All calculations details are given in **Table 3, Table 4** and **Table 5**. All the salient provisions & specifications of IS: 2911-2010 (Code of Practice for Design and Construction of pile foundation) and IS: 14593-1998 (Design & construction of bored cast-in-situ piles founded on rocks-Guidelines) shall be closely adhered to. The allowable pile capacities realized in the field recommended in the Table above should be ensured by conducting full scale initial pile load tests (as mandated in the IS code: 2911-2010-part IV) **before adopting them for design.**

Group of piles (at least, two) is generally preferable to a single pile for any column. Structural capacity of the pile shall be adequate.

Density of bentonite during the pile construction shall be as per IS code of practice.

If the pile tip is terminated before the recommended depths, pile capacities will be much lower.

7.2 Two Storey Office building

The column loads are not assessed by the structural designers so far, but it is assumed that the maximum column loads will be in the order of 70t (this has to be confirmed by structural designers).

The sub soil profile details are given in Fig. 2 & Annexure I. From the soil profile, it can be seen that the soil at shallow depths have some SPT 'N' values and then increases with depth.

Spread foundation: For the proposed two storey building, it is recommended to adopt spread footing or combined footing, over the dense silty sand stratum at 1.5m, from the existing ground level. The allowable bearing pressure for this depth for a 1.5m to 2.50m wide footing can be taken as 20t/m^2 , for design.

General Notes:

- (1). The various SPT N-values & soil properties are given in Annexure I.
- (2). The recommendations given above are based on the soil data as revealed in the boreholes actually taken at the borehole points. Any variation at other points should be closely monitored during execution and modification in design should be made if necessary.

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Countersigned