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CLIENT	**GATALA DEVELOPERS & PROPERTIES PVT. LTD.**
PROJECT	**PROPOSED CONSTRUCTION OF RESIDENTIAL APARTMENT (STILT+05) AT PLOT NO: 5, OLD D.NOS. 46 & 46/1 & NEW D.NOS: 89 & 89/1, BAZULLAH ROAD, T. NAGAR, CHENNAI-600017. LAND COMPRISED IN T.S. NO: 7991/11, OLD T.S. NO: 4698 PART, BLOCK NO: 106 OF T. NAGAR VILLAGE, GUINDY TALUK, CHENNAI DISTRICT**
TITLE	**GEOTECHNICAL INVESTIGATION REPORT**

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Director

GEOMINES ENGINEERS (P) LTD. GMEPL Chennai

REV.	DATE	REPORT NUMBER	PREP. BY
0	30-12-2023	GMEPL/GATALA DEVELOPERS & PROPERTIES PVT. LTD /447/2023-24	

DISCLAIMER

We've been asked to look into the ground and identify and quantify everything that mother nature has put thereand predict how those materials will react to construction and long-term performance of a facility - and we may fall short of this lofty goal.

We have made reasonable and prudent conclusions but a cloud of uncertainty inherently looms over the project as per the pre and post facilities laid and their elemental behaviour on the mother soil.

Also, the variable nature of soil strata and it's varying characteristics may make the recommended foundation system disqualify and hence it's recommended that special care shall be taken by the owner during and after the construction is complete and during the run period of the building.

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CHAPTER-1

INTRODUCTION

1.0 Preamble

Gatala Developers & Properties Pvt. Ltd., Chennai proposed to construct a **Residential Apartment (Stilt+05) at Plot No: 05, Old Door No's: 46 & 46/1 & New Door No's: 89 & 89/1, Bazullah Road, T.Nagar, Chennai-600017. Land Comprised in T.S. No: 7991/11, Old T.S. No: 4698 Part, Block No: 106 of T. Nagar Village, Guindy Taluk, Chennai District.**

For the purpose of designing the foundations, the responsibility of carrying out suitable soil investigations was entrusted to **M/s. Geo Mines ENGINEERS Pvt. Ltd., Chennai.**

This report contains the field and laboratory test results along with Design computations and recommendations for suitable foundation systems.

1.1 Scope of Work

- Sinking Two Standard Soil investigation bore holes of 150mm diameter up to a depth of 23.00m below existing ground level as directed by the engineer-in-charge.
- Conducting Standard Penetration Test (SPT) at regular depth intervals.
- Collection of Split Spoon Samples or Disturbed Soil Samples
- Collection of water samples from each bore hole.
- Conducting relevant laboratory test results.

1.2 Structure of the Report

- Contents
- Introduction
- Investigation Methodology & Test Results
- Figures & Tables
- Sub-Surface Stratification
- Foundation Systems
- Recommendations
- Annexure (Design Computations)

CHAPTER-2

INVESTIGATION METHODOLOGY & TEST RESULTS

2.0 Field Testing:

2.1 Preamble:

Two standard soil investigation boreholes were put. The equipment used and the methodology adopted to carry out the fieldwork is described below.

2.2 Equipment Used and Method of Drilling:

2.2.1 Equipment Used

The equipment used for performing the drilling operations was a Calyx Rotary Drill Rig with direct mud circulation technique. The drill mud used was made out of Sodium Bentonite.

2.2.2 Methodology of drilling

In the soil strata, the drilling operations were carried out using special drill bits and cutters coupled with direct mud circulation.

2.3 In-Situ Strength Tests:

2.3.1 Standard Penetration Test:

Standard penetration tests were conducted at the borehole locations, in accordance with IS: 2131. The tests were conducted at every change of strata up to the depth of termination of the borehole as directed by the engineer-in-charge.

2.4. Collection of Samples:

2.4.1 Disturbed Soil Samples

The SPT-samples collected were used as disturbed soil samples. These samples were used for visual and physical identification and for conducting laboratory classification tests as per I.S.1498-1970.

2.4.2 Ground Water

For conducting suitable chemical tests, the ground water samples were collected from the respective boreholes.

2.5 Summary of Field Work

The locations of the boreholes are shown in site plan given in Fig. 2.0. The soil profiles obtained at each location is shown in Figs. 2.1 & 2.2.

2.6 Laboratory Testing:

2.6.1 Coarse Grained Samples:

2.6.1.1 Grain size Analysis Tests:

On the coarse-grained soil samples, grain size distribution tests were conducted as per I.S.2720 (Part 4)-1985, to know the gradation characteristics and to classify them. These results are presented in Tables 2.1 & 2.2.

2.6.2 Fine Grained Samples:

2.6.2.1 Index Property – Free Swell Tests:

Atterberg Limits were carried out on fine grained soil samples to evaluate the limits of different consistency states. Generally Liquid limits, Plastic limits and Shrinkage Limits tests were conducted as per I.S.2720 (Part-5)-1985 and I.S.2720 (Part 6)-1972. On such type of soil strata encountered at the investigation locations, such tests were conducted and the test results are presented in Tables 2.1 & 2.2.

2.6.3 Chemical Analysis Tests:

2.6.3.1 Water Samples:

On representative water samples, chemical analysis tests were conducted to estimate pH, Chlorides and Sulphates. These results are presented in Table-2.3.

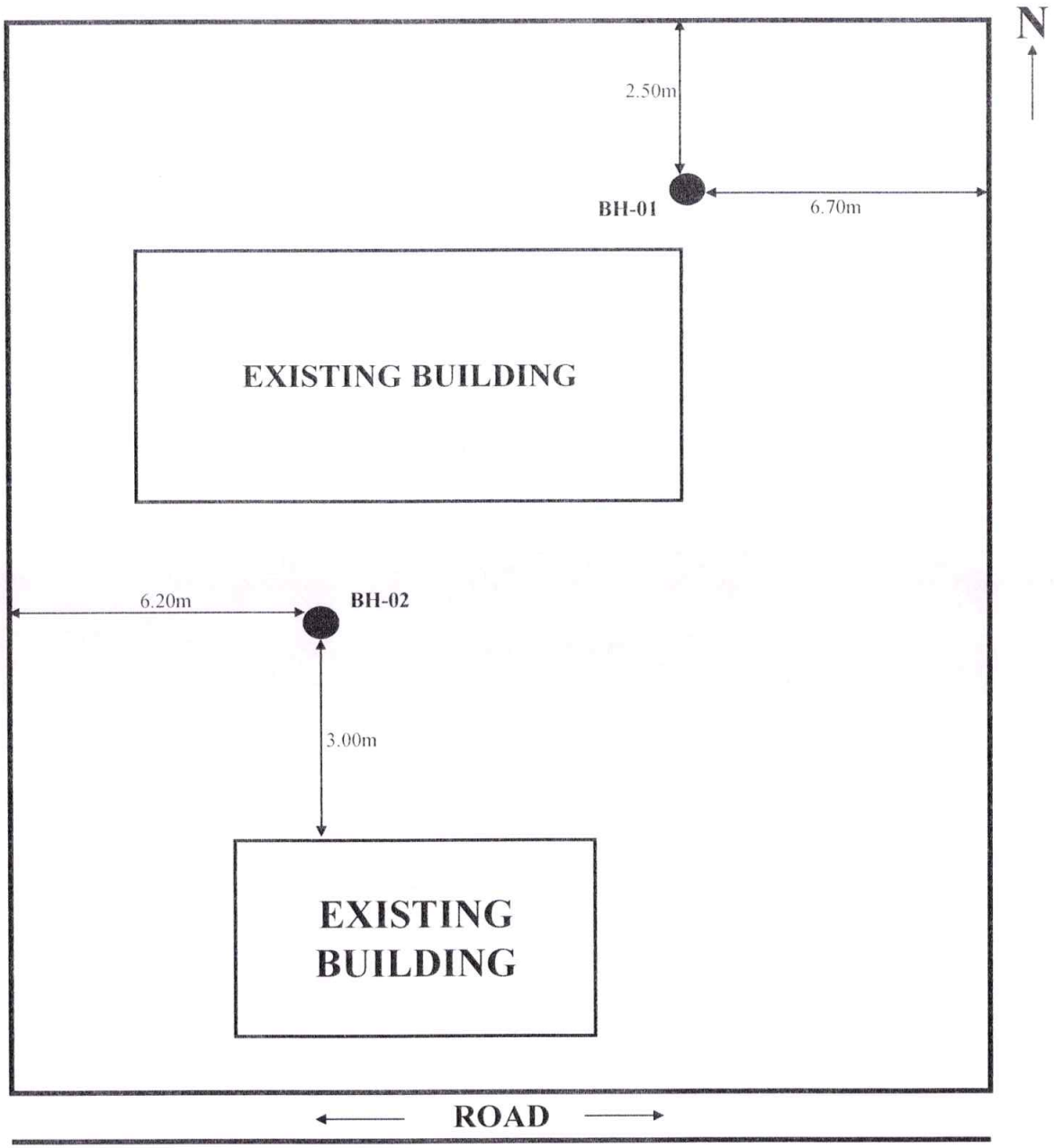


Fig. 2.0: Site Plan Representing the locations of Field Investigation Points

Project : Proposed Construction of Residential Apartment (Stilt+05) at Plot No: 5, Old Door Nos: 46 & 46/1 & New Door Nos: 89 & 89/1, Bazullah Road, T.Nagar, Chennai-600017. Land Comprised in T.S. No: 7991/11, Old T.S. No: 4698 Part, Block No: 106 of T. Nagar Village, Guindy Taluk, Chennai District.

Location: BH-01

Started On : 23/12/2023; Ended On : 24/12/2023 G.W.T: 1.40m below existing ground level

R.L of Layer (m)	G.W.T. (m)	Soil Profile	Engineering Description of Soil	SPT - Details: Depth of SPT below E.G.L (m)	0-15 cm	15-30 cm	30-45 cm	N-Value	Graphical Representation ## 1 2 3 4 5 6 7 8 9	Relative Density/Consistency	Type of Sample
0.40			Filled Up Soil							-	DS
G.W.T	▼			1.50	3	5	6	11		Stiff	SS
			Brownish Stiff Silty Clay	2.25	5	5	8	13		Stiff	SS
3.00				3.00	8	5	10	15		Loose	SS
			Brownish Loose Silty Fine Sand	4.50	4	7	7	14		Loose	SS
5.00											
				6.00	12	10	13	23		M Dense	SS
				7.50	7	10	12	22		M Dense	SS
			Brownish Medium Dense Silty Clayey Fine Sand	9.00	7	9	10	19		M Dense	SS
				10.00	9	12	13	25		M Dense	SS
11.50											
				12.00	29	24	29	53		V Dense	SS
			Greyish to Greenish Very Dense Cemented Sand	14.00	26	28	31	59		V Dense	SS
15.00											
			Yellowish to Greyish Hard Compacted Clay mixed with gravels	16.00	17	19	25	44		Hard	SS
16.50											
			Greyish Very Dense Cemented Sand	18.00	24	29	37	66		V Dense	SS
19.50											
			Yellowish Hard Compacted Clay	20.00	05cms Penetration for 50 Blows					Hard	SS
20.20											

Bore Hole Terminated at a depth of 20.20m below the existing ground level

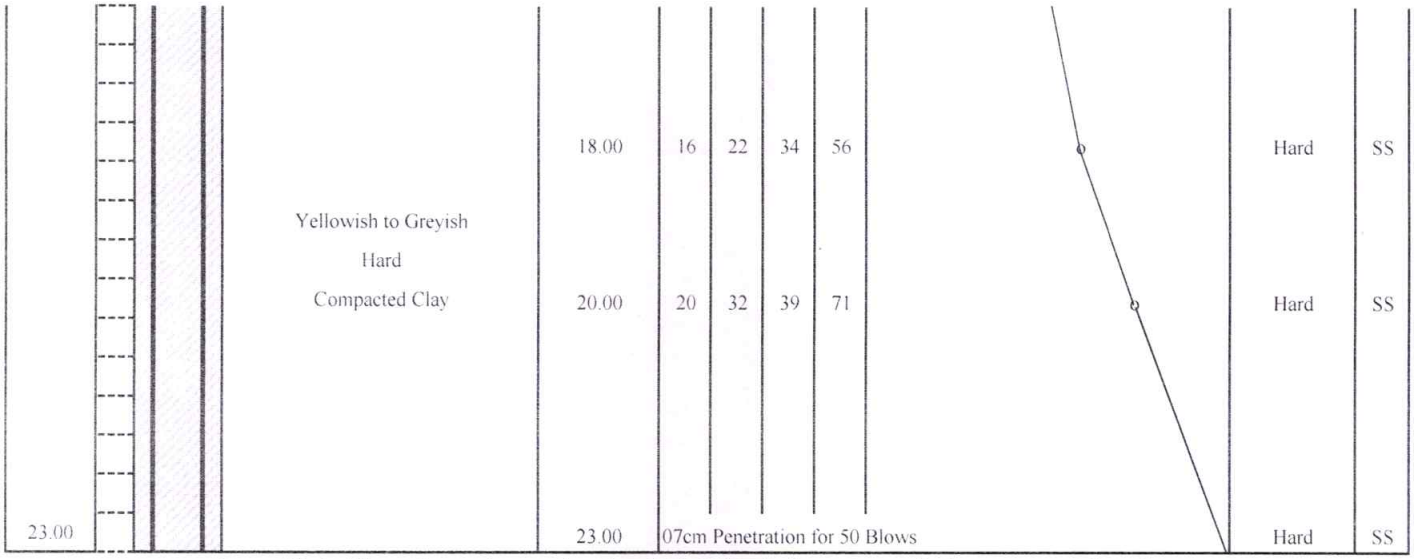
Fig. 2.1 Soil Profile at BH-01 Location

Project : Proposed Construction of Residential Apartment (Stilt+05) at Plot No: 5, Old Door Nos: 46 & 46/1 & New Door Nos: 89 & 89/1, Bazullah Road, T.Nagar, Chennai-600017. Land Comprised in T.S. No: 7991/11, Old T.S. No: 4698 Part, Block No: 106 of T. Nagar Village, Guindy Taluk, Chennai District.

Location: BH-02

Started On : 24/12/2023; Ended On : 25/12/2023 G.W.T: 1.30m below existing ground level

R.L of Layer (m)	G.W.T. (m)	Soil Profile	Engineering Description of Soil	SPT - Details: Depth of SPT below E.G.L (m)	0-15 cm	15-30 cm	30-45 cm	N-Value	Graphical Representation of SPT (0 10 20 30 40 50 60 70 80 90)	Relative Density/Consistency	Type of Sample
0.40			Filled Up Soil							-	DS
G.W.T			Brownish Stiff Silty Clay	1.50	5	5	6	11		Stiff	SS
2.50				2.25	4	6	6	12		Stiff	SS
3.40			Brownish Loose Silty Fine Sand	3.00	6	7	7	14		Loose	SS
7.00			Brownish Medium Dense Silty Fine Sand	4.50	5	8	8	16		M.Dense	SS
				6.00	6	9	14	23		M.Dense	SS
8.50			Brownish Medium Dense Silty Clayey Fine Sand	7.50	7	8	8	16		M.Dense	SS
11.50			Greyish to Greenish Medium Dense Silty Clayey Fine Sand	9.00	8	10	11	21		M.Dense	SS
				10.00	11	12	12	24		M.Dense	SS
14.00			Greyish to Greenish Dense Cemented Sand	12.00	16	20	22	42		Dense	SS
15.50			Reddish Very Dense Silty Sandy Gravels	14.00	29	09cm Penetration for 50 Blows				V.Dense	SS
				16.00	19	23	25	48		Hard	SS



Bore Hole Terminated at a depth of 23.00m below the existing ground level

Fig. 2.2 Soil Profile at BH-02 Location

Table 2.1: Laboratory Test Results on the Soil Samples Collected from BH-01 Investigation Location

Depth of Sample below E.G.L. (m)	SPT of Sample	Type of Sample	Engineering Description of Soil	NMC(%)	Natural Density (g/cc)	Clay					Relative Density/ Consistency	Sieve Analysis						IS-Classification
						LL (%)	PL (%)	PI	I_c	FS		Gravel (%)	Coarse (%)	Medium (%)	Fine (%)	Silt (%)	Clay (%)	
0.00 to 0.40	-	DS	Filled Up Soil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.40 to 3.00	12	SS	Silty Clay	31	1.63	53	27	26	0.85	8	Stiff	0	0	0	0	19	81	CH
3.00 to 5.00	14	SS	Silty Fine Sand	-	1.51	-	-	-	-	-	Loose	0	0	0	78	22	0	SM
5.00 to 11.50	22	SS	Silty Clayey Fine Sand	-	1.66	-	-	-	-	-	M.Dense	0	0	0	79	9	12	SM
11.50 to 15.00	56	SS	Cemented Sand	-	1.93	-	-	-	-	-	V.Dense	0	21	19	38	11	11	SM
15.00 to 16.50	44	SS	Compacted Clay mixed with gravels	18	1.89	39	28	11	1.91	-	Hard	17	0	0	0	18	65	CI-GP
16.50 to 19.50	66	SS	Cemented Sand	-	1.97	-	-	-	-	-	V.Dense	0	20	23	31	13	13	SM
19.50 to 20.20	>100	SS	Compacted Clay	13	2.00	32	24	8	2.38	-	Hard	0	0	0	0	27	73	CL

Table 2.2: Laboratory Test Results on the Soil Samples Collected from BH-02 Investigation Location

Depth of Sample below E.G.L. (m)	SPT of Sample	Type of Sample	Engineering Description of Soil	NMC(%)	Natural Density (g/cc)	Clay					Relative Density/ Consistency	Sieve Analysis						IS-Classification
						LL (%)	PL (%)	PI	I_c	FS		Gravel (%)	Coarse (%)	Medium (%)	Fine (%)	Silt (%)	Clay (%)	
0.00 to 0.40	-	DS	Filled Up Soil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.40 to 2.50	11	SS	Silty Clay	33	1.7	54	26	28	0.75	11	Stiff	0	0	0	0	18	82	CH
2.50 to 3.40	14	SS	Silty Fine Sand	-	1.5	-	-	-	-	-	Loose	0	0	0	77	23	0	SM
3.40 to 7.00	19	SS	Silty Fine Sand	-	1.6	-	-	-	-	-	M.Dense	0	0	0	78	22	0	SM
7.00 to 8.50	16	SS	Silty Clayey Fine Sand	-	1.6	-	-	-	-	-	M.Dense	0	0	0	70	13	17	SM
8.50 to 11.50	22	SS	Silty Clayey Fine Sand	-	1.7	-	-	-	-	-	M.Dense	0	0	0	78	10	12	SM
11.50 to 14.00	42	SS	Cemented Sand	-	1.9	-	-	-	-	-	Dense	0	18	18	37	12	15	SM
14.00 to 15.50	>100	SS	Silty Sandy Gravels	-	2.0	-	-	-	-	-	V.Dense	54	8	12	14	12	0	GP
15.50 to 23.00	58	SS	Compacted Clay	16	2.0	35	28	7	2.71	-	Hard	0	0	0	0	26	74	CL

Table 2.3: Chemical Analysis Results conducted on Water Samples collected from BH-01 & BH-02 Investigation Locations

Location	Depth of Sample below E.G.L. (m)	pH	Chlorides (ppm)	Sulphates (ppm)
BH-01	3.00	6.78	240.38	133.27
BH-02	3.00	6.77	244.82	139.04

CHAPTER-3

SUB-SURFACE STRATIFICATION

3.0 Preamble

The sub surface stratification at borehole locations, with respect to foundation/geotechnical engineering application are derived based on the visual identification, laboratory classification tests and field in-situ strength tests. Further, the strength parameters are estimated based on the in-situ strength test results as per the following correlation.

* **For Coarse Grained Samples, Ref. Fig.1, IS: 6403 to estimate Angle of Shearing Resistance.**
* **For Fine Grained Samples, Ref. Terzaghi & Peck, 1948, to estimate Unconfined Compressive Strength.**

3.1 Sub Surface Stratification:

3.1.1 Soil Profile at BH-01 Location

(At BH-01 Location, as presented in Site plan)

* **Layer-1 (from E.G.L to 0.40m depth)**

Type of Strata	Filled Up Soil
Colour	-
Thickness of Layer	0.40m

* **Layer-2 (from 0.40m to 3.00m depth)**

Type of Strata	Silty Clay
Colour	Brownish
Thickness of Layer	2.60m
SPT of the layer	12
Consistency	Stiff
Un-drained Cohesion, Cu	80.00kPa

* **Layer-3 (from 3.00m to 5.00m depth)**

Type of Strata	Silty Fine Sand
Colour	Brownish
Thickness of Layer	2.00m
SPT of the layer	14
Relative Density	Loose
Angle of Shearing Resistance, ϕ	31.20^0

* **Layer-4 (from 5.00m to 11.50m depth)**

Type of Strata	Silty Clayey Fine Sand
Colour	Brownish
Thickness of Layer	6.50m
SPT of the layer	22

Relative Density	Medium Dense
Angle of Shearing Resistance, ϕ	33.30^0

* **Layer-5 (from 11.50m to 15.00m depth)**

Type of Strata	Cemented Sand
Colour	Greyish to Greenish
Thickness of Layer	3.50m
SPT of the layer	56
Relative Density	Very Dense
Angle of Shearing Resistance, ϕ	41.90^0

* **Layer-6 (from 15.00m to 16.50m depth)**

Type of Strata	Compacted Clay mixed with gravels
Colour	Yellowish to Greyish
Thickness of Layer	1.50m
SPT of the layer	44
Consistency	Hard
Un-drained Cohesion, Cu	293.33kPa

* **Layer-7 (from 16.50m to 19.50m depth)**

Type of Strata	Cemented Sand
Colour	Greyish
Thickness of Layer	3.00m
SPT of the layer	66
Relative Density	Very Dense
Angle of Shearing Resistance, ϕ	42.50^0

* **Layer-8 (from 19.50m to 20.20m depth)**

Type of Strata	Compacted Clay
Colour	Yellowish
Thickness of Layer	0.70m
SPT of the layer	>100
Consistency	Hard
Un-drained Cohesion, Cu	666.66kPa

Ground Water

Ground water table was encountered at a depth of 1.40m below the existing ground level during the last week of December 2023.

3.1.2 Soil Profile at BH-02 Location

(At BH-02 Location, as presented in Site plan)

* **Layer-1 (from E.G.L to 0.40m depth)**

Type of Strata	Filled Up Soil
Colour	-
Thickness of Layer	0.40m

* **Layer-2 (from 0.40m to 2.50m depth)**

Type of Strata	Silty Clay
Colour	Brownish
Thickness of Layer	2.10m
SPT of the layer	11
Consistency	Stiff
Un-drained Cohesion, Cu	73.33kPa

* **Layer-3 (from 2.50m to 3.40m depth)**

Type of Strata	Silty Fine Sand
Colour	Brownish
Thickness of Layer	0.90m
SPT of the layer	14
Relative Density	Loose
Angle of Shearing Resistance, ϕ	31.20^0

* **Layer-4 (from 3.40m to 7.00m depth)**

Type of Strata	Silty Fine Sand
Colour	Brownish
Thickness of Layer	3.60m
SPT of the layer	19
Relative Density	Medium Dense
Angle of Shearing Resistance, ϕ	32.70^0

* **Layer-5 (from 7.00m to 8.50m depth)**

Type of Strata	Silty Clayey Fine Sand
Colour	Brownish
Thickness of Layer	1.50m
SPT of the layer	16
Relative Density	Medium Dense
Angle of Shearing Resistance, ϕ	31.80^0

* **Layer-6 (from 8.50m to 11.50m depth)**

Type of Strata	Silty Clayey Fine Sand
Colour	Greyish to Greenish
Thickness of Layer	3.00m
SPT of the layer	22
Relative Density	Medium Dense
Angle of Shearing Resistance, ϕ	33.60^0

* **Layer-7 (from 11.50m to 14.00m depth)**

Type of Strata	Cemented Sand
Colour	Greyish to Greenish
Thickness of Layer	2.50m
SPT of the layer	42
Relative Density	Dense
Angle of Shearing Resistance, ϕ	39.20^0

* **Layer-8 (from 14.00m to 15.50m depth)**

Type of Strata	Silty Sandy Gravels
Colour	Reddish
Thickness of Layer	1.50m
SPT of the layer	>100
Relative Density	Very Dense
Angle of Shearing Resistance, ϕ	42.50^0

* **Layer-9 (from 15.50m to 23.00m depth)**

Type of Strata	Compacted Clay
Colour	Yellowish to Greyish
Thickness of Layer	7.50m
SPT of the layer	58
Consistency	Hard
Un-drained Cohesion, Cu	386.66kPa

Ground Water

Ground water table was encountered at a depth of 1.30m below the existing ground level during the last week of December 2023.

CHAPTER-4

FOUNDATION SYSTEM

4.0 Preamble

The foundation system design is an interface between super structure and the sub soil bearing strata characteristics. A sound foundation system should be safe against bearing strata shear response under the super structure load intensity. Similarly, the stability of the foundation system is governed by the bearing strata deformation response under the super structure load intensity. In addition, as a combined system of super structure and foundation, the overall stability is also governed by the super structure arrangement.

Considering the above aspects of foundation design, the suitable type of foundation system with respect to the sub soil conditions encountered at the borehole locations is presented in the subsequent sections.

4.1 Bearing Strata Characteristics

From field investigations, it can be observed that the sub-soil strata encountered at shallow depths are uniformly stratified from type but possess non-uniform shear strength characteristics, BH-02 being relatively weak from deformation considerations than that of BH-01 investigation location and hence shall be considered as design borehole to determine the bearing strata and its safe bearing capacity.

Considering BH-02 as design borehole, it can be envisaged that the highly plastic fine-grained soil strata encountered at shallow depths can be considered as bearing strata for **presumed** column loads in the range of 500kN to 600kN respectively.

If fine-grained soil strata encountered at shallow depths are considered as bearing strata, the safe bearing capacity of open foundation system will be a function of un-drained cohesive strength of the bearing strata.

Care shall be taken in locating the foundation system on such type of highly plastic fine-grained soil strata so that ordinate pressures resulting from its volumetric change phenomenon during variations in seasonal moisture content variations do not impact on the structural system of foundation.

Also, the refusal strata encountered up to the depth of investigations can also offer a good frictional resistance against a suitably designed structural member or element if being cast or driven in such soils.

Considering the above, suitable foundation systems are presented below.

4.2 Foundation System

4.2.1 Open Foundation System (Ref. Critical Borehole BH-02)

*Considering the shear strength characteristics and highly plasticity nature of fine-grained soil strata encountered at shallow depths, open foundation system of **Strip Raft** type located at a design depth of 2.00m below present existing ground level (EGL) over 0.30m thick well compacted CNS (cohesive non-swelling) soil can be adopted.*

The safe bearing capacity of such type of open foundation system is presented below which can be adopted for foundation design purposes.

Type of Open Foundation System	Total Depth of Excavations below existing ground level (m)	Backfill with well compacted CNS (m)	Depth of **Strip Raft** below Present Existing Ground Level (m)	Bearing Strata	Safe Bearing Capacity (MT/m^2)	Elastic Settlements (mm)
Strip Raft	**2.20**	**0.30**	**1.90**	**Silty Clay**	**12**	**48**

The computations for above are annexed to this report.

4.2.2 Deep Foundation System-20.00m Long Bored Cast-in-Situ Friction Piles (Ref. BH-02)

In case, the safe bearing capacity of open foundation system as presented in Clause 4.2.1 is lower than the impending proposed foundation stresses, deep foundation system consisting of 20.00m long bored cast-in-situ Friction Piles can also be adopted.

Piles shall be drilled through DMC (direct mud circulation) technique.

For four different diameters, the safe load carrying capacities of 20.00m long bored cast-in-situ Friction Piles are computed and presented below which can be adopted for foundation design purposes.

S. No	Type of Installation of Pile	Length of Pile below Existing Ground Level (m)	Diameter of Pile (mm)	Safe Load Carrying Capacity (MT)	Safe Pull Out Capacity (MT)
1	Bored Cast-in-Situ	20.00	500	100	110
2			550	110	110
3			600	120	120
4			650	130	130

The computations of safe load carrying capacity for 500mm diameter and 20.00m long bored cast-in-situ Friction pile are annexed to this report.

CHAPTER5

CONCLUSIONS & RECOMMENDATIONS

1. Foundation systems presented in Clause 4.2.1 & 4.2.2, Chapter-IV can be adopted for foundation design purposes.

Open Foundation System

2. Safe bearing capacity of open foundation system is computed considering any rise in the ground water table up to or above the level of strip raft.
3. In case, ground water table is encountered within recommended depth of foundation system, provision shall be made to continuously bail the water out of the foundation pits to keep the surfaces of pit consolidated dry.

Open Foundation Depths

4. Depth of open excavations below present existing ground level shall be 2.30m.
5. Recommended Thickness of CNS Back-Fill @ Site is 0.30m.
6. Depth of Strip Raft below existing ground level will be 2.00m below existing ground level.

Usage of Excavated Earth

7. **Excavated 0.40m thick filled up soil and highly plastic fine-grained soil encountered at shallow depths shall be in no case used for back filling purposes.**
8. **No structural units can be in direct contact of highly plastic fine-grained soil strata encountered at shallow depths. A 0.30m thick well compacted CNS is recommended to be sand-witched in between.**

IMPORTANT RECOMMENDATIONS

9. Open foundation system presented above will be conducive only if proper drainage arrangements are made to channel the run-off into the drains and hence containing any water seepage into the ground. Also, there shall not be any underground plumbing line leakages which may lead to softening of highly plastic fine-grained soil recommended as bearing strata.

Deep Foundation System

10. Suitable pile load tests (as per I.S: 2911, part-IV) shall be performed to confirm the presented **theoretical** safe load carrying capacities and shall be used as **allowable** load capacities on the pile under considerations. **(Note)**.
11. Pile cap can be located over 0.30m thick well compacted existing ground to be replaced soil surface. Ground replacement can be carried out with CNS (cohesive non-swelling) soil.
12. Piles shall be installed using DMC (direct mud circulation) technique only.
13. Piles shall be grouped according to the column design load requirements.
14. Allowable load carrying capacities of piles shall be limited to their structural capacities.

General

15. **CNS can be well graded and non-plastic earth like quarry dust or clean river sand or sand: gravels mix (1:2) or fly-ash that shall be well compacted at site to achieve more than 95% of laboratory maximum dry density at optimum moisture content.**
16. As the chlorides and sulphates present in the collected water samples are within the permissible limits, no special steel or cement is recommended to be used for **open** foundation (if) construction purposes. **However, it is recommended to extract the water samples at different intervals up to higher depths from an open-well/dug-well and tested for the chemical parameters as per the required usage/s and also to decide upon the construction material to be used for deep foundation purposes.**

For Geo Mines Engineers Pvt. Ltd.

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DESIGN OF OPEN FOUNDATION SYSTEM (BH-02)

1 COMPUTATION OF BEARING CAPACITY AS PER IS:6403

1.1 Geometrical Data :

Type of Foundation System:	Strip Raft	
R.L of the top of Borehole (m):	0.00	m
Depth of Open Foundation Excavations below existing ground level (D_f):	2.30	m
Recommended Thickness of CNS Back-fill:	0.30	m
Effective Depth of Foundation below existing ground level (D_f):	2.00	m
Design Width of Foundation (B):	1.00	m
Thickness of Foundation (T) :	0.25	m

1.2 Soil Data :

Type of Bearing Strata :	Silty Clay	
Design SPT-value of the Bearing Strata :	11	
(considered based upon the density of the strata)		
Type of Shear Failure:	General	
Un-drained Cohesiive Strngth, Cu:	73.33	kPa

1.3 Design Parameters:

Bulk Density of Soil above the foundation depth (γ_{bulk})	17.00	kN/m^3
Effective Overburden pressure at foundation level (q)	14.00	kPa
Water Table Correction Factor (w')	0.50	

Bearing Capacity Factors:

N_c = 5.14

N_q = N/A

N_γ = N/A

Shape Factors:

S_c = 1.30

S_q = N/A

S_γ = N/A

Depth Factors :

D_c = 1.00

D_q = N/A

D_γ = N/A

Inclination Factor:

I_c = 1.00

I_q = N/A

I_γ = N/A

1.4 Ultimate Bearing Capacity (Qu) :

$Qu = Cu*Nc*Sc*D_C*I_C+q*(Nq-1)*Sq*Dq*Iq + 0.5*B*\gamma*N\gamma*S\gamma*D\gamma*Ig*w'$

Q_u = 490.01 kPa

1.5 Safe Bearing Capacity (Qsafe) :

Factor of Safety (F.S.) :	2.50
Qsafe :	196.01 kPa
Recommended Safe Bearing Capacity:	120.00 kPa

1.6 Settlements

Since, the bearing strata are stiff fine-grained type, the settlements under the allowable safe bearing pressure 120kPa will be of immediate elastic nature. The elastic settlements corresponding to a safe bearing pressure of 120kPa and average SPT of 11 considering extent of pressure bulb below bottom level of footing are computed to be in the order of 48mm which is within the permissible limits of 70mm for strip raft as per I.S:1904.

DESIGN OF PILE FOUNDATION (BH-02)

Refer, IS:2911(Part I/Sec 2)-1979, Reaffirmed 1997

1.0 Type of Installation of Pile — **Bored Cast in Situ**

1.1 Geometrical Data

Assumed Diameter of pile(D):	**500.0**	mm
Assumed R.L of E.G.L:	0.000	m
Length of pile below E.G.L.(l) :	**20.000**	m
R.L. of Bot. of Pile	-20.00	m

1.2 Design of Pile for Vertical Compression

1.2.1 Computation of Skin Resistance:

1.2.1.1 **Layer-II**

Type of Strata:	Silty Clay	
Average SPT of the strata,N:	11	
Bulk Density of the strata,γ:	17	kN/m^3
Undrained Shear Strength,C_u:	73.33	kPa
R.L of top of Strata:	-0.40	m
R.L of bottom of Strata:	-2.50	m
Average Thickness of Strata,I_c:	2.10	m
Effective overburden pressure over the top of strata,σ_{top}:	0.00	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	14.70	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	7.35	kN/m^2
Adhesion,α:	0.40	
Skin Resistance of the pile,q_s:	96.76	kN
(q_s:α*Cu*pi()*d*Ic)		

1.2.1.2 **Layer-III**

Type of Strata:	Silty Fine Sand	
Average SPT of the strata,N:	14	
Bulk Density of the strata,γ:	15	kN/m^3
Angle of Shearing Resistance,ϕ:	31.2	Deg.
R.L of top of Strata:	-2.50	m
R.L of bottom of Strata:	-3.40	m
Average Thickness of Strata,I_c:	0.90	m
Effective overburden pressure over the top of strata,σ_{top}:	14.70	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	19.20	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	16.95	kN/m^2
Coeff. Of Earth Pressure, k:	1.00	
Skin Resistance of the pile,q_s:	14.51	kN
(q_s:σ*k*tanϕ*pi()*d*Ic)		

1.2.1.3 **Layer-IV**

Type of Strata:	Silty Fine Sand	
Average SPT of the strata,N:	19	
Bulk Density of the strata,γ:	16	kN/m^3
Angle of Shearing Resistance,ϕ:	32.7	Deg.
R.L of top of Strata:	-3.40	m
R.L of bottom of Strata:	-7.00	m
Average Thickness of Strata,I_c:	3.60	m
Effective overburden pressure over the top of strata,σ_{top}:	19.20	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	40.80	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	30.00	kN/m^2
Coeff. Of Earth Pressure, k:	1.50	
Skin Resistance of the pile,q_s:	163.37	kN

(q_s:σ*k*tanϕ*pi()*d*Ic)

1.2.1.4

Layer-V

Type of Strata:	Silty Clayey Fine Sand	
Average SPT of the strata,N:	16	
Bulk Density of the strata,γ:	16	kN/m^3
Angle of Shearing Resistance,ϕ:	31.8	Deg.
R.L of top of Strata:	-7.00	m
R.L of bottom of Strata:	-8.50	m
Average Thickness of Strata,I_c:	1.50	m
Effective overburden pressure over the top of strata,σ_{top}:	40.80	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	49.80	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	45.30	kN/m^2
Coeff. Of Earth Pressure, k:	1.50	
Skin Resistance of the pile,q_s:	99.27	kN

(q_s:σ*k*tanϕ*pi()*d*Ic)

1.2.1.5

Layer-VI

Type of Strata:	Silty Clayey Fine Sand	
Average SPT of the strata,N:	22	
Bulk Density of the strata,γ:	17	kN/m^3
Angle of Shearing Resistance,ϕ:	33.6	Deg.
R.L of top of Strata:	-8.50	m
R.L of bottom of Strata:	-11.50	m
Average Thickness of Strata,I_c:	3.00	m
Effective overburden pressure over the top of strata,σ_{top}:	49.80	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	70.80	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	60.30	kN/m^2
Coeff. Of Earth Pressure, k:	1.50	
Skin Resistance of the pile,q_s:	283.19	kN

(q_s:σ*k*tanϕ*pi()*d*Ic)

1.2.1.6

Layer-VII

Type of Strata:	Cemented Sand	
Average SPT of the strata,N:	42	
Bulk Density of the strata,γ:	19	kN/m^3
Angle of Shearing Resistance,ϕ:	39.2	Deg.
R.L of top of Strata:	-11.50	m
R.L of bottom of Strata:	-14.00	m
Average Thickness of Strata,I_c:	2.50	m
Effective overburden pressure over the top of strata,σ_{top}:	70.80	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	93.30	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	82.05	kN/m^2
Coeff. Of Earth Pressure, k:	2.00	
Skin Resistance of the pile,q_s:	525.58	kN
(q_s:σ*k*tanϕ*pi()*d*Ic)		

1.2.1.7

Layer-VIII

Type of Strata:	Silty Sandy Gravels	
Average SPT of the strata,N:	60	
Bulk Density of the strata,γ:	20	kN/m^3
Angle of Shearing Resistance,ϕ:	42.5	Deg.
R.L of top of Strata:	-14.00	m
R.L of bottom of Strata:	-15.50	m
Average Thickness of Strata,I_c:	1.50	m
Effective overburden pressure over the top of strata,σ_{top}:	93.30	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	108.30	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	100.80	kN/m^2
Coeff. Of Earth Pressure, k:	2.50	
Skin Resistance of the pile,q_s:	544.08	kN
(q_s:σ*k*tanϕ*pi()*d*Ic)		

1.2.1.8

Layer-XI

Type of Strata:	Compacted Clay	
Average SPT of the strata,N:	58	
Bulk Density of the strata,γ:	20	kN/m^3
Undrained Shear Strength,C_u:	386.67	kPa
R.L of top of Strata:	-15.50	m
R.L of bottom of Strata:	-20.00	m
Average Thickness of Strata,I_c:	4.50	m
Effective overburden pressure over the top of strata,σ_{top}:	108.30	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	153.30	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	130.80	kN/m^2
Adhesion,α:	0.40	
Skin Resistance of the pile,q_s:	1093.27	kN
(q_s:α*Cu*pi()*d*Ic)		

Ultimate Skin Resistance,q_s: 2820.03 kN

1.2.2 Computation of End Bearing Resistance:

Ultimate End Bearing Resistance (Qp) Neglected for Fricitor

1.3.0	**Ultimate Load Carrying Capacity ($Qu=Qs+Q_p$)**	**2820.0**	**kN**
	Safe Load Carrying Capacity (Qsafe =Qu/2.5)	**1128.0**	**kN**
	However, limit Q_{safe} to the structural capacity of pile:	**1000.0**	**kN**



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