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CLIENT	**M/s. RAMANIYAM REALTORS LLP, CHENNAI**
PROJECT	**PROPOSED CONSTRUCTION OF STILT+05 FLOORS (HEIGHT-18.30M) RESIDENTIAL BUILDING WITH 20 DWELLING UNITS AVAILING PREMIUM FSI AT PLOT NO: 224 & 225, 42nd STREET, 8thSECTOR, K.K. NAGAR, CHENNAI-600078, COMPRISED IN OLD S.NO: 261/1 PART, T.S.NO: 42 & 43, BLOCK NO: 48 OF VIRUGAMBAKKAM VILLAGE, WITH IN THE LIMITS OF GREATER CHENNAI CORPORATION, ZONE: X, DIVISION NO: 137**
TITLE	**GEOTECHNICAL INVESTIGATION REPORT**

		Dr. R. Venkata Krishnaiah M.E., Ph.D., Geotechnical Expert Regd. No. GTE/19/07/032 No. 7/4, Munavar Avenue, 4th Street, Pallavaram, Chennai -43	
		For Geo Mines Engineers Pvt Ltd	
		Director	GEO MINES ENGINEERS (P) LTD. GMEPL Chennai
0	20-06-2023	GMEPL/M/s. RAMANIYAM REALTORS LLP/147/2023-24	
REV.	**DATE**	**REPORT NUMBER**	**PREP. BY**

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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

M/s. Ramaniyam Realtors LLP, Chennai proposed to construct a **Residential Building (Stilt+05) at Plot No: 224 & 225, 8th Sector, 42nd Street, K.K. Nagar, Chennai.**

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 24.00m 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)

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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 is 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 have been 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 boreholes 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.

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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 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 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:

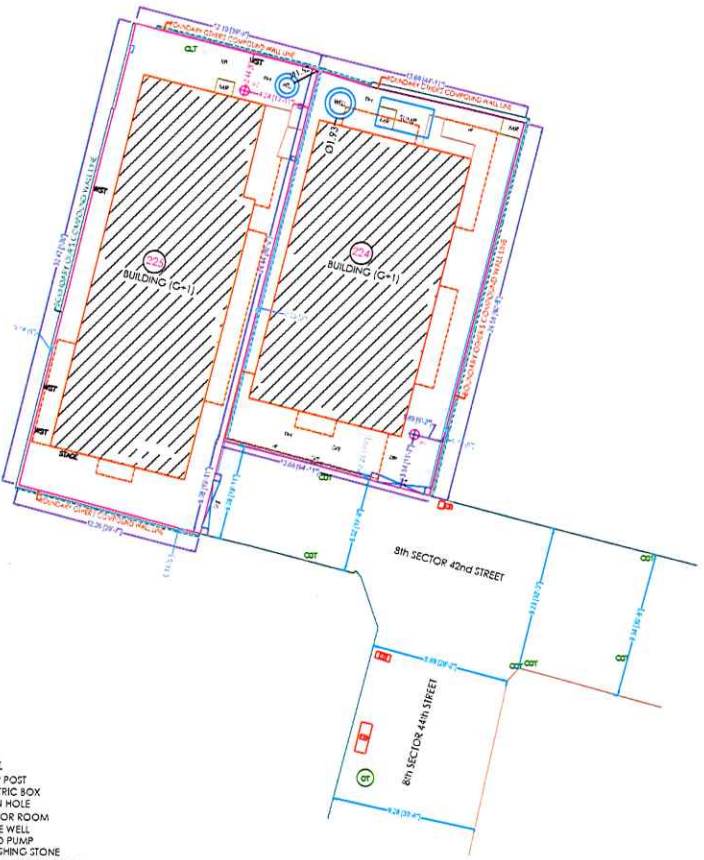
On representative water samples, chemical analysis tests were conducted to estimate pH, Chlorides and Sulphates. These results are presented in Table-2.3.

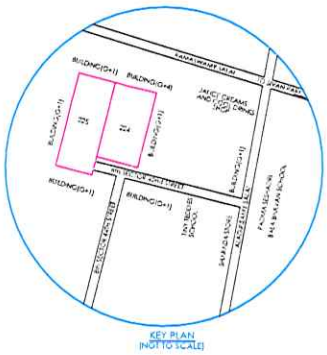
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LEGEND:
LP-LAMP POST
EB-ELECTRIC BOX
MH-MAN HOLE
MR-MOTOR ROOM
BW-BORE WELL
HP-HAND PUMP
WST-WASHING STONE
RWH-RAIN WATER HARVESTING
LT-LEMON TREE
OT-OTHER TREE

SPOT LEVEL -

AREA STATEMENT:

PLOT SURVEYED AREA (224) = 3598 SQ.FT. (OR) 1.499 GROUNDS.
PLOT SURVEYED AREA (225) = 3960 SQ.FT. (OR) 1.65 GROUNDS.
(INCLUDING OUR'S COMPOUND WALL AREA ONLY)

TOTAL SURVEYED AREA (224 & 225) = 7558 SQ.FT. (OR) 3.149 GROUNDS.

NOTE:
ALL DIMENSIONS ARE IN METRES, FEET & INCHES.

SURVEYED BY:

abide landmark
SURVEYORS
#11 (Old No:6A), Govindasamy street,
Kattabomman Block,
Jafferkhanpet, Chennai-600 083.
Mobile:9840166595
E-mail: abidelandmark@gmail.com

CLIENT

SITE
NEW No.224 & 225, OLD No.1 & 3, 8th SECTOR 42nd STREET,
K.K NAGAR, CHENNAI-600083.

	NAME	DATE
SURVEYED	K.K.K	01.12.2022
DRAWN	K.K.K	02.12.2022
CHECKED		
APPROVED		

TITLE
PLAN SHOWING THE DETAILED BOUNDARY MAP WITH EXISTING FEATURES AND LEVELS.

SCALE 1:150
SHEET A2
CODE ALS
DRAWING No: KN/149/2022
REV. R0

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Project : Proposed Construction of Residential Building (Stilt+05) at Plot No: 224 & 225, 8th Sector, 42nd Street, K.K. Nagar, Chennai

Location: BH-01

Started On : 14/06/2023; Ended On : 15/06/2023 G.W.T: 1.50m below existing ground level

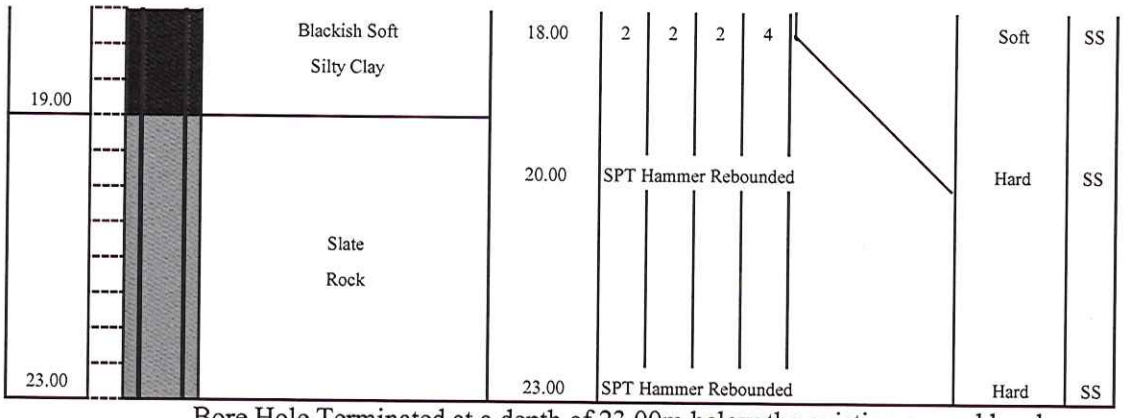
R.L of Layer (m)	G.W.T. (m)	Soil Profile	Engineering Description of Soil	Depth of SPT below E.G.L (m)	SPT - Details 0-15 cm	15-30 cm	30-45 cm	N-Value	Graphical Representation 0 1 2 3 4 5 6 7 8 9	Relative Density/Consistency	Type of Sample
G.W.T	↓			1.50	4	6	8	14		Stiff	SS
			Brownish Stiff Silty Clay	3.00	2	4	7	11		Stiff	SS
5.00				4.50	5	5	8	13		Stiff	SS
			Blackish Stiff Silty Clay	6.00	3	4	6	10		Stiff	SS
7.00											
			Blackish Medium Stiff Silty Clay	7.50	2	3	3	6		M.Stiff	SS
8.50											
			Brownish Medium Dense Silty Clayey Fine Sand	9.00	5	7	9	16		M.Dense	SS
				10.00	6	11	13	24		M.Dense	SS
11.00											
			Blackish Stiff Silty Clay	12.00	3	5	7	12		Stiff	SS
13.00											
			Blackish Medium Stiff Silty Clay	14.00	2	4	4	8		M.Stiff	SS
				16.00	2	2	3	5		M.Stiff	SS
17.00											

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

Fig. 2.1 Soil Profile at BH-01 Location

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Project : Proposed Construction of Residential Building (Stilt+05) at Plot No: 224 & 225, 8th Sector, 42nd Street, K.K. Nagar, Chennai

Location: BH-02

Started On : 15/06/2023; Ended On : 16/06/2023 G.W.T: 1.50m below existing ground level

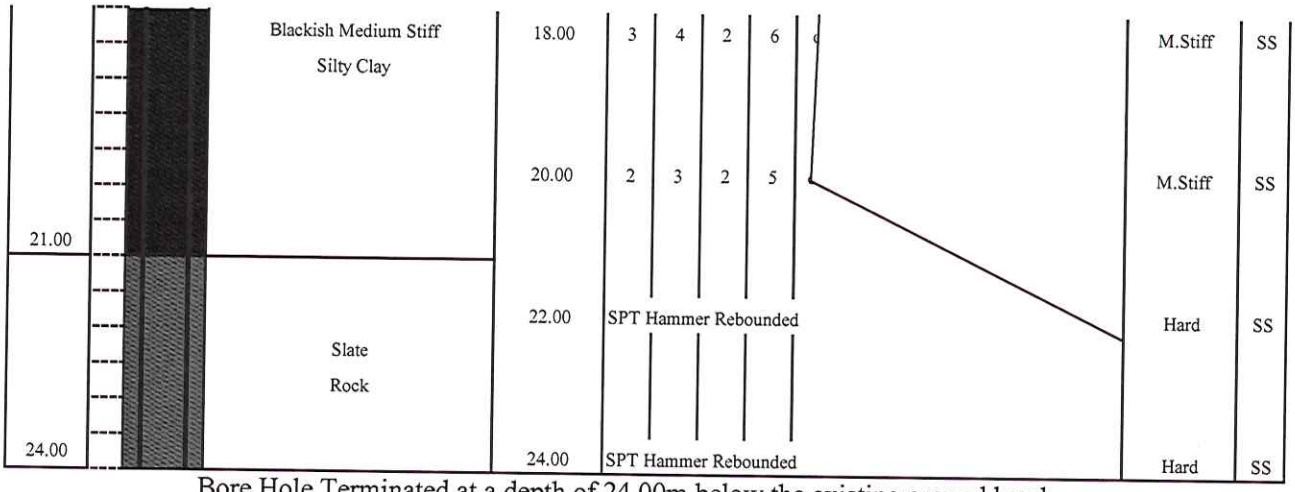
R.L of Layer (m)	G.W.T. (m)	Soil Profile	Engineering Description of Soil	Depth of SPT below E.G.L (m)	SPT - Details 0-15 cm	15-30 cm	30-45 cm	N-Value	Graphical Representation of SPT (0 10 20 30 40 50 60 70 80 90)	Relative Density/Consistency	Type of Sample
G.W.T				1.50	5	6	6	12		Stiff	SS
			Brownish Stiff Silty Clay	3.00	4	6	9	15		Stiff	SS
				4.50	3	4	5	9		Stiff	SS
5.00											
			Blackish Medium Stiff Silty Clay	6.00	3	3	4	7		M.Stiff	SS
6.50											
			Blackish Stiff Silty Clay	7.50	6	5	6	11		Stiff	SS
8.00											
				9.00	5	7	12	19		M.Dense	SS
				10.00	7	9	14	23		M.Dense	SS
			Brownish Medium Dense Silty Fine Sand	12.00	6	7	11	18		M.Dense	SS
13.00											
			Blackish Stiff Silty Clay	14.00	4	6	7	13		Stiff	SS
15.00											
				16.00	2	4	3	7		M.Stiff	SS

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Bore Hole Terminated at a depth of 24.00m below the existing ground level

Fig. 2.2 Soil Profile at BH-02 Location

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Table 2.1: Laboratory Test Result on the Soil Sample Collected from BH-01

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 5.00	12	SS	Silty Clay	32	1.7	55	27	28	0.82	12	Stiff	0	0	0	0	20	80	CH
5.00 to 7.00	10	SS	Silty Clay	35	1.7	56	29	27	0.78	-	Stiff	0	0	0	0	19	81	CH
7.00 to 8.50	6	SS	Silty Clay	39	1.5	63	21	42	0.57	-	M.Stiff	0	0	0	0	17	83	CH
8.50 to 11.00	20	SS	Silty Clayey Fine Sand	-	1.6	-	-	-	-	-	Mdense	0	0	0	69	14	17	SM
11.00 to 13.00	12	SS	Silty Clay	31	1.7	54	27	27	0.85	-	Stiff	0	0	0	0	21	79	CH
13.00 to 17.00	6	SS	Silty Clay	41	1.5	66	21	45	0.56	-	M.Stiff	0	0	0	0	16	84	CH
17.00 to 19.00	4	SS	Silty Clay	47	1.4	68	17	51	0.41	-	Soft	0	0	0	0	14	86	CH
19.00 to 23.00	>100	SS	Slate Rock	16	2.0	34	28	6	3.00	-	Hard	0	0	0	0	28	72	CL

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Table 2.2: Laboratory Test Result on the Soil Sample Collected from BH-02

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 5.00	12	SS	Silty Clay	33	1.7	56	28	28	0.82	13	Stiff	0	0	0	0	21	79	CH
5.00 to 6.50	7	SS	Silty Clay	39	1.6	60	26	34	0.62	-	M.Stiff	0	0	0	0	18	82	CH
6.50 to 8.00	11	SS	Silty Clay	34	1.7	56	29	27	0.81	-	Stiff	0	0	0	0	20	80	CH
8.00 to 13.00	20	SS	Silty Fine Sand	-	1.6	-	-	-	-	-	Mdense	0	0	0	77	23	0	SM
13.00 to 15.00	13	SS	Silty Clay	29	1.7	52	27	25	0.92	-	Stiff	0	0	0	0	22	78	CH
15.00 to 21.00	6	SS	Silty Clay	41	1.5	61	22	39	0.51	-	M.Stiff	0	0	0	0	16	84	CH
21.00 to 24.00	>100	SS	Slate Rock	16	2.0	35	28	7	2.71	-	Hard	0	0	0	0	28	72	CL

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

Location	Depth of Sample below E.G.L. (m)	pH	Chlorides (ppm)	Sulphates (ppm)
BH-01	3.00	6.79	300.18	133.85
BH-02	3.00	6.77	310.38	136.18

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CHAPTER-3

SUB-SURFACE STRATIFICATION

3.0 Preamble

The sub surface stratification at boreholes 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 5.00m depth)**

Type of Strata	Silty Clay
Colour	Brownish
Thickness of Layer	5.00m
SPT of the layer	12
Consistency	Stiff
Un-drained Cohesion, Cu	80.00kPa

* **Layer-2 (from 5.00m to 7.00m depth)**

Type of Strata	Silty Clay
Colour	Blackish
Thickness of Layer	2.00m
SPT of the layer	10
Consistency	Stiff
Un-drained Cohesion, Cu	66.66kPa

* **Layer-3 (from 7.00m to 8.50m depth)**

Type of Strata	Silty Clay
Colour	Blackish
Thickness of Layer	1.50m
SPT of the layer	06
Consistency	Medium Stiff
Un-drained Cohesion, Cu	40.00kPa

* **Layer-4 (from 8.50m to 11.00m depth)**

Type of Strata	Silty Clayey Fine Sand

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Colour	Brownish
Thickness of Layer	2.50m
SPT of the layer	20
Relative Density	Medium Dense
Angle of Shearing Resistance, ϕ	33.00^0

* **Layer-5 (from 11.00m to 13.00m depth)**

Type of Strata	Silty Clay
Colour	Blackish
Thickness of Layer	2.00m
SPT of the layer	12
Consistency	Stiff
Un-drained Cohesion, Cu	80.00kPa

* **Layer-6 (from 13.00m to 17.00m depth)**

Type of Strata	Silty Clay
Colour	Blackish
Thickness of Layer	4.00m
SPT of the layer	06
Consistency	Medium Stiff
Un-drained Cohesion, Cu	40.00kPa

* **Layer-7 (from 17.00m to 19.00m depth)**

Type of Strata	Silty Clay
Colour	Blackish
Thickness of Layer	2.00m
SPT of the layer	04
Consistency	Soft
Un-drained Cohesion, Cu	26.66kPa

* **Layer-8 (from 19.00m to 23.00m depth)**

Type of Strata	Slate Rock
Colour	-
Thickness of Layer	4.00m
SPT of the layer	>100
Consistency	Hard
Un-drained Cohesion, Cu	666.66kPa

Ground Water

Ground water table was encountered at a depth of 1.50m below the existing ground level during the third week of June 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 5.00m depth)**

Type of Strata	Silty Clay
Colour	Brownish
Thickness of Layer	5.00m
SPT of the layer	12
Consistency	Stiff
Un-drained Cohesion, Cu	80.00kPa

* **Layer-2 (from 5.00m to 6.50m depth)**

Type of Strata	Silty Clay

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Colour	Blackish
Thickness of Layer	1.50m
SPT of the layer	07
Consistency	Medium Stiff
Un-drained Cohesion, Cu	46.66kPa

* **Layer-3 (from 6.50m to 8.00m depth)**

Type of Strata	Silty Clay
Colour	Blackish
Thickness of Layer	1.50m
SPT of the layer	11
Consistency	Stiff
Un-drained Cohesion, Cu	73.33kPa

* **Layer-4 (from 8.00m to 13.00m depth)**

Type of Strata	Silty Fine Sand
Colour	Brownish
Thickness of Layer	5.00m
SPT of the layer	20
Relative Density	Medium Dense
Angle of Shearing Resistance, ϕ	33.00^0

* **Layer-5 (from 13.00m to 15.00m depth)**

Type of Strata	Silty Clay
Colour	Blackish
Thickness of Layer	2.00m
SPT of the layer	13
Consistency	Stiff
Un-drained Cohesion, Cu	86.66kPa

* **Layer-6 (from 15.00m to 21.00m depth)**

Type of Strata	Silty Clay
Colour	Blackish
Thickness of Layer	6.00m
SPT of the layer	06
Consistency	Medium Stiff
Un-drained Cohesion, Cu	40.00kPa

* **Layer-7 (from 21.00m to 24.00m depth)**

Type of Strata	Slate Rock
Colour	-
Thickness of Layer	3.00m
SPT of the layer	>100
Consistency	Hard
Un-drained Cohesion, Cu	666.66kPa

Ground Water

Ground water table was encountered at a depth of 1.50m below the existing ground level during the third week of June 2023.

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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 varying shear strength characteristics, BH-02 being relatively weak from deformation considerations and shall be considered as design borehole to determine the bearing strata and its safe bearing capacity.

Considering BH-02 as design borehole, it can further be envisaged that the highly plastic fine-grained soil strata encountered at shallow depths will hold good to act as bearing strata from shear strength characteristics and deformation considerations for nominal column loads.

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

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Care shall also be taken in regulating the safe bearing capacity of open foundation system so that the dispersed open foundation stresses on the underlying relatively weak soil layer encountered at 4.50m depths from present existing ground level (SPT @ 4.50m is 09, Ref. BH-02) are within their safe bearing capacity limits

However, the compacted clay soil strata encountered below 21.00m depths from present existing ground level can also be considered as good end bearing strata for proposed impending loads from structure.

Considering the above, suitable foundation systems are presented below.

4.2 Foundation System

4.2.1 Open Foundation System – Strip Raft

Considering the uniformity in sub-soil stratifications at shallow depths, shear strength, presence of underlying relatively weak soil layer at 4.50m depths from existing ground level, medium plastic characteristics 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 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)	Recommended Thickness of CNS Back-Fill at Site (m)	Depth of **Strip Raft** below Present Existing Ground Level (m)	Safe Bearing Capacity (MT/m^2)	Elastic Settlements (mm)
Strip Raft	**2.30**	**0.30**	**2.00**	**11**	**55**

The computations for above are annexed to this report.

Notes

Safe Bearing Capacity of open foundation system is restricted considering the presence of underlying relatively weak soil layer encountered at 4.50m depths from existing ground level i.e. 2.50m distant apart from the bottom level of strip raft.

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4.2.2 Deep Foundation System-22.00m long Bored Cast-in-Situ Friction cum End Bearing Piles

In case the foundation stresses are more than the safe bearing capacity of open foundation system as presented in Clause 4.2.1 as presented above, deep foundation system consisting of 22.00m long bored cast-in-situ Friction cum End Bearing 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 22.00m long bored cast-in-situ Friction cum End Bearing 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	22.00	450	70	55
2			500	80	61
3			550	90	67
4			600	100	74

The computations of safe load carrying capacity for 450mm diameter and 22.00m long bored cast-in-situ Friction cum End Bearing Pile are annexed to this report.

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CHAPTER-5

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.
4. Safe Bearing Capacity of open foundation system is restricted considering the presence of underlying relatively weak soil strata encountered at 4.50m depths below existing ground level (SPT @ 4.50m is 09, Ref. BH-01) i.e. 2.50m distant apart from the bottom level of strip raft.

Open Foundation Depths

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

Usage of Excavated Earth

8. **Excavated highly plastic fine-grained soil encountered at shallow depths shall be in no case used for back filling purposes.**
9. **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

10. 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

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any underground plumbing line leakages which may lead to softening of highly plastic fine-grained soil recommended as bearing strata.

DEEP FOUNDATION SYSTEM

11. Suitable pile load tests (as per I.S: 2911, part-IV) shall be performed to confirm the presented **theoretical** safe load carrying capacities and arrive at the **design/allowable** load carrying capacity of piles under considerations. (**Mandatory**).
12. Care shall be taken so that the end bearing soil strata are none other than recommended **"Slate Rock" Soil** strata.
13. Pile cap can be located over 0.30m thick well compacted ground replaced CNS (Cohesive Non-Swelling) soil surface.
14. Piles shall be grouped according to the column design load requirements.
15. Safe load carrying capacities of piles shall be limited to their structural capacities.

General

16. **CNS can be well graded coarse-grained soil like quarry dust or clean river sand or sand: gravels mix (1:2) or fly-ash.**
17. 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 foundation construction purposes.

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DESIGN OF OPEN FOUNDATION SYSTEM (Ref. 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
Total Depth of Excavations below Existing Ground Level (m) :	2.30	m
Recommended Thickness of CNS back-fill:	0.30	m
Effective Depth of Footing below existing ground level (D_f):	2.00	m
Design Width of Foundation (B):	1.00	m
Thickness of Foundation (T) :	0.20	m

1.2 Soil Data :

Type of Bearing Strata :	Silty Clay	
Design SPT-value of the Bearing Strata :	12	
(considered based upon the density of the strata)		
Type of Shear Failure:	General	
Undrained Cohesion, Cu:	80.00	kPa

1.3 Design Parameters:

Bulk Density of Soil above the foundation detph (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:

$N_c = 5.14$

$N_q = N/A$

$N_\gamma = N/A$

Shape Factors:

$S_c = 1.30$

$S_q = N/A$

$S_\gamma = N/A$

Depth Factors :

$D_c = 1.00$

$D_q = N/A$

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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 = 534.56 kPa

1.5 Safe Bearing Capacity (Qsafe) :

Factor of Safety (F.S.) : 2.50

Qsafe : 213.82 kPa

Recommended Safe Bearing Capacity: 110.00 kPa

Restricted considering the presence of underlying relatively weak soil layer encountered at 4.50m depths from existing ground level i.e. 2.50m distant apart from the bottom level of strip footing.

1.6 Settlements

Since, the bearing strata are stiff fine-grained type, the settlements under the allowable safe bearing pressure 110kPa will be of immediate elastic nature. The elastic settlements corresponding to a safe bearing pressure of 110kPa and average SPT of 12 considering extent of pressure bulb below bottom level of footing are computed to be in the order of 55mm which is within the permissible limits of 70mm for strip footings as per I.S:1904.

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DESIGN OF PILE FOUNDATION (Ref. 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):	**450.0**	mm
Assumed R.L of E.G.L:	0.000	m
Length of pile below E.G.L.(l) :	**22.000**	m
R.L. of Bot. of Pile	-22.00	m

1.2 Design of Pile for Vertical Compression

1.2.1 Computation of Skin Resistance:

1.2.1.1

Layer-I

Type of Strata:	Silty Clay	
Average SPT of the strata,N:	12	
Bulk Density of the strata,γ:	17	kN/m^3
Undrained Shear Strength,C_u:	80.00	kPa
R.L of top of Strata:	0.00	m
R.L of bottom of Strata:	-5.00	m
Average Thickness of Strata,I_c:	5.00	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}:	35.00	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	17.50	kN/m^2
Adhesion,α:	0.40	
Skin Resistance of the pile,q_s:	226.19	kN

(q_s:α*Cu*pi()*d*Ic)

1.2.1.2

Layer-II

Type of Strata:	Silty Clay	
Average SPT of the strata,N:	7	
Bulk Density of the strata,γ:	16	kN/m^3
Undrained Shear Strength,C_u:	46.6667	kPa
R.L of top of Strata:	-5.00	m
R.L of bottom of Strata:	-6.50	m
Average Thickness of Strata,I_c:	1.50	m
Effective overburden pressure over the top of strata,σ_{top}:	35.00	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	44.00	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	39.50	kN/m^2
Adhesion,α:	0.60	
Skin Resistance of the pile,q_s:	59.38	kN

(q_s:α*Cu*pi()*d*Ic)

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1.2.1.3 **Layer-III**

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:	73.3333	kPa
R.L of top of Strata:	-6.50	m
R.L of bottom of Strata:	-8.00	m
Average Thickness of Strata,I_c:	1.50	m
Effective overburden pressure over the top of strata,σ_{top}:	44.00	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	54.50	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	49.25	kN/m^2
Adhesion,α:	0.40	
Skin Resistance of the pile,q_s:	62.20	kN

(q_s:α*Cu*pi()*d*Ic)

1.2.1.4 **Layer-IV**

Type of Strata:	Silty Fine Sand	
Average SPT of the strata,N:	20	
Bulk Density of the strata,γ:	16	kN/m^3
Angle of Shearing Resistance,ϕ:	33	Deg.
R.L of top of Strata:	-8.00	m
R.L of bottom of Strata:	-13.00	m
Average Thickness of Strata,I_c:	5.00	m
Effective overburden pressure over the top of strata,σ_{top}:	54.50	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	84.50	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	69.50	kN/m^2
Coeff. Of Earth Pressure, k:	1.50	
Skin Resistance of the pile,q_s:	478.55	kN

(q_s:σ*k*tanϕ*pi()*d*Ic)

1.2.1.5 **Layer-V**

Type of Strata:	Silty Clay	
Average SPT of the strata,N:	13	
Bulk Density of the strata,γ:	17	kN/m^3
Undrained Shear Strength,C_u:	86.6667	kPa
R.L of top of Strata:	-13.00	m
R.L of bottom of Strata:	-15.00	m
Average Thickness of Strata,I_c:	2.00	m
Effective overburden pressure over the top of strata,σ_{top}:	84.50	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	98.50	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	91.50	kN/m^2
Adhesion,α:	0.40	
Skin Resistance of the pile,q_s:	98.02	kN

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(q_s:α*Cu*pi()*d*Ic)

1.2.1.6 **Layer-VI**

Type of Strata:	Silty Clay	
Average SPT of the strata,N:	6	
Bulk Density of the strata,γ:	15	kN/m^3
Undrained Shear Strength,C_u:	40	kPa
R.L of top of Strata:	-15.00	m
R.L of bottom of Strata:	-21.00	m
Average Thickness of Strata,I_c:	6.00	m
Effective overburden pressure over the top of strata,σ_{top}:	98.50	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	128.50	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	113.50	kN/m^2
Adhesion,α:	0.70	
Skin Resistance of the pile,q_s:	237.50	kN

(q_s:α*Cu*pi()*d*Ic)

1.2.1.7 **Layer-VII**

Type of Strata:	Slate Rock	
Average SPT of the strata,N:	60	
Bulk Density of the strata,γ:	20	kN/m^3
Undrained Shear Strength,C_u:	400	kPa
R.L of top of Strata:	-21.00	m
R.L of bottom of Strata:	-22.00	m
Average Thickness of Strata,I_c:	1.00	m
Effective overburden pressure over the top of strata,σ_{top}:	128.50	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	138.50	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	133.50	kN/m^2
Adhesion,α:	0.40	
Skin Resistance of the pile,q_s:	226.19	kN

(q_s:α*Cu*pi()*d*Ic)

Ultimate Skin Resistance,q_s: 1388.04 kN

1.2.2 Computation of End Bearing Resistance:

Type of Bearing Strata	Slate Rock	
Cross-Sectional Area of pile,Ap:	0.159	m^2
R.L of bottom of pile:	-22.00	
Minimum SPT-value of the Bearing Strata	60	
Undrained Cohesion, Cu=(q_u/2):	400.00	kPa
Bearing Capacity Factor(Nc)	9.00	
Ultimate End Bearing Resistance (Qp)	**572.6**	**kN**

(Qp=Ap*Cu*Nc)

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	Ultimate Load Carrying Capacity ($Qu=Qs+Q_p$)	**1960.6**	**kN**
1.3.0	**Safe Load Carrying Capacity ($Qsafe=Qu/2.50$)**	**784.2**	**kN**
	However, limit Q_{safe} to the structural capacity of pile:	**700.0**	**kN**

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