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CLIENT	MEGH PROMOTERS PRIVATE LTD., CHENNAI
PROJECT	PROPOSED CONSTRUCTION OF RESIDENTIAL BUILDING (G+05) AT S.NO:109/1A1 & 109/6, ANNAMALAI AVENUE, NOLAMBUR, CHENNAI- 600 095.
TITLE	GEOTECHNICAL INVESTIGATION REPORT

Dr. ASHOK KUMAR NAGINDAS PATEL M.Tech (Soil Engg)
CMDA RGTE No. GTE/19/04/025

For Geo Mines Engineers Pvt. Ltd

Director

GEOMINES ENGINEERS (P) LTD. GMEPL Chennai

REV.	DATE	REPORT NUMBER	PREP. BY
0	02-08-2022	GMEPL/MEGH PROMOTERS PRIVATE LTD/231/2021-22	

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.

GEO MINES ENGINEERS (P) LTD. GMEPL Chennai

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CHAPTER-1

INTRODUCTION

1.0 Preamble

MEGH Promoters Private Ltd., Chennai proposed to construct a **Residential Building (G+05) at S.No: 109/1A1 & 109/6, Annamalai Avenue, Nolambur, Chennai-600095.** For the purpose of designing the foundations, the responsibility of carrying out suitable soil investigations was entrusted to **M/s. Geo Mines ENGINEERS, 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 depth of 30.00m 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 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 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 sample was 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 test results are presented in Table-2.3.

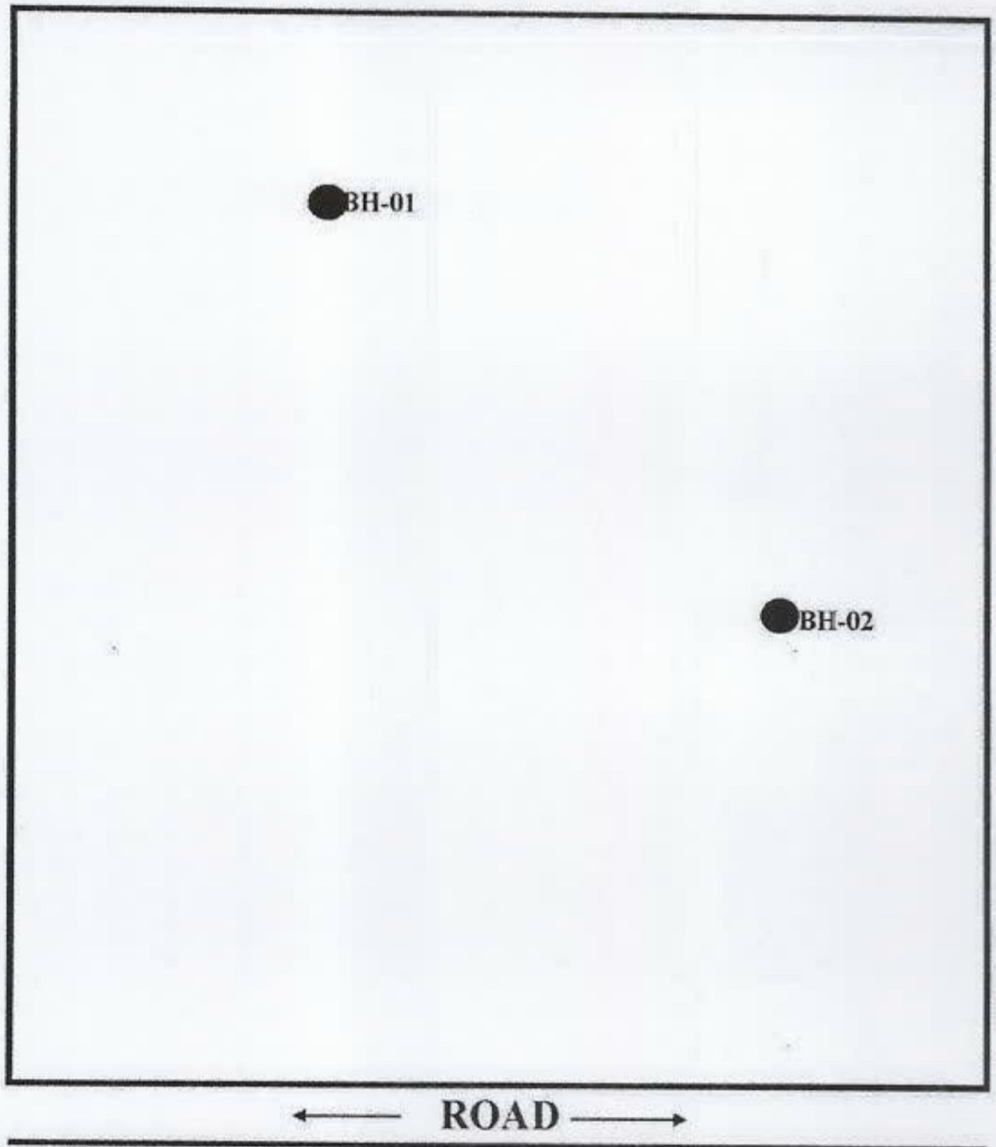


Fig. 2.0: Site Plan Representing the locations of Field Investigation Points

Project : Proposed Construction of Residential Building (G+05) at S.No: 109/1A1 & 109/6, Annamalai Avenue, Nolambur, Chennai-600095.

Location: BH-01

Started On : 30/07/2022; Ended On : 31/07/2022 G.W.T: 3.00m 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 ## 1 2 3 4 5 6 7 8 9	Relative Density/Consistency	Type of Sample
			Brownish Medium Stiff Silty Clay	1.50	3	4	4	8	o	M.Stiff	SS
2.00											
G.W.T				3.00	8	10	11	21		M.Dense	SS
			Brownish Medium Dense Silty Fine Sand	4.50	10	10	12	22		M.Dense	SS
				6.00	8	10	12	22		M.Dense	SS
				7.50	10	10	15	25		M.Dense	SS
8.00											
				9.00	4	5	5	10	o	Stiff	SS
			Greyish Stiff Silty Clay	10.00	5	5	6	11	o	Stiff	SS
11.00											
			Blackish Medium Stiff Silty Clay	12.00	2	3	5	8	o	M.Stiff	SS
13.00											
			Blackish Stiff Silty Clay	14.00	2	3	6	9	o	Stiff	SS
15.00											
			Blackish Soft Silty Clay	16.00	1	1	3	4	o	Soft	SS
17.00											
			Blackish Medium Stiff Silty Clay	18.00	2	3	3	6	o	M.Stiff	SS
20.00				20.00	2	3	3	6	o	M.Stiff	SS

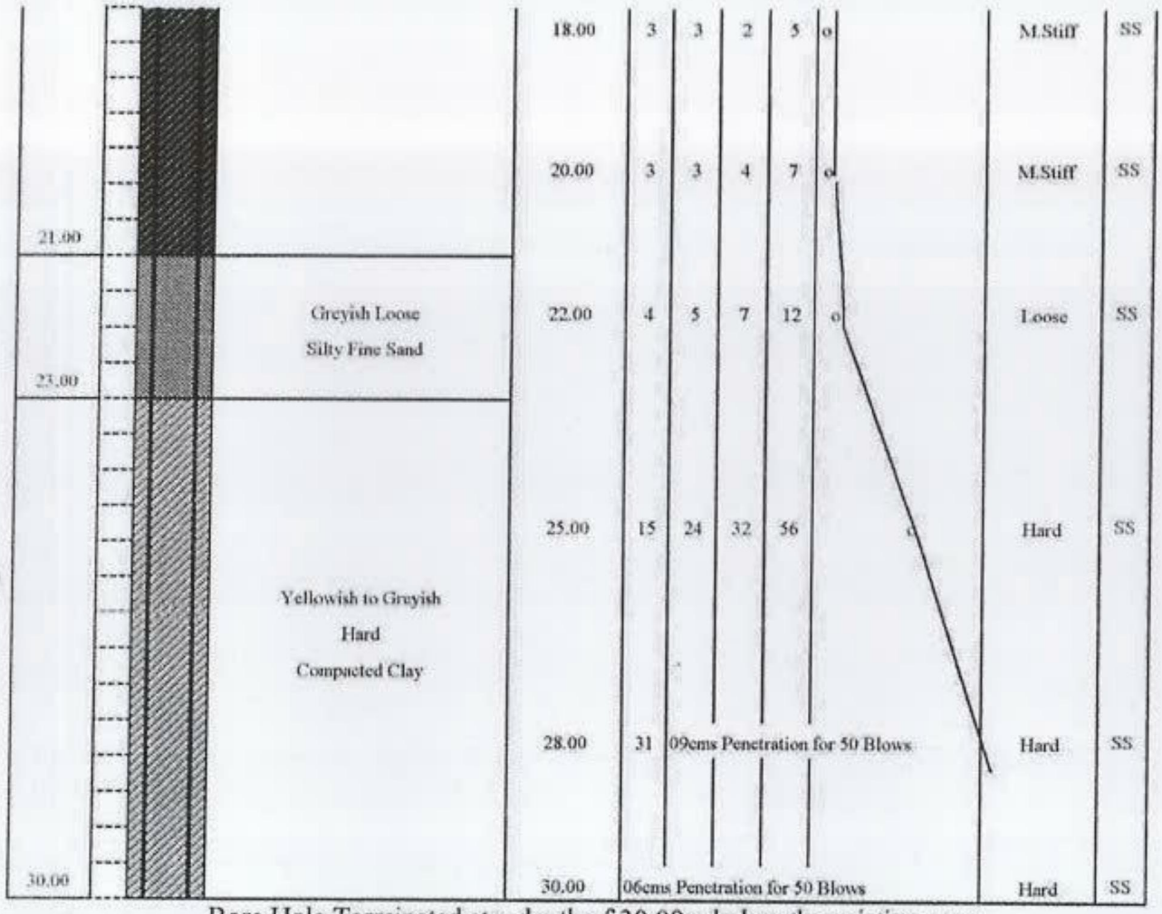
Bore Hole Terminated at a depth of 20.00m below the existing groun

Project : Proposed Construction of Residential Building (G+05) at S.No: 109/1A1 & 109/6, Annamalai Avenue, Nolambur, Chennai-600095.

Location: BH-02

Started On : 31/07/2022; Ended On : 01/08/2022 G.W.T: 3.00m 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 N-Value (0 1 2 3 4 5 6 7 8 9)	Relative Density/Consistency	Type of Sample
			Brownish Stiff Silty Clay	1.50	4	5	5	10	o	Stiff	SS
2.00											
G.W.T			Brownish Medium Dense Silty Fine Sand	3.00	8	10	11	21		M.Dense	SS
				4.50	7	8	11	19		M.Dense	SS
5.00											
			Blackish Medium Stiff Silty Clay	6.00	2	2	4	6	o	M.Stiff	SS
				7.50	2	4	4	8	o	M.Stiff	SS
8.00											
			Blackish Stiff Silty Clay	9.00	4	4	5	9	o	Stiff	SS
				10.00	3	4	5	9	o	Stiff	SS
11.00											
				12.00	2	2	3	5	o	M.Stiff	SS
				14.00	2	3	4	7	o	M.Stiff	SS
			Blackish Medium Stiff Silty Clay	16.00	3	3	3	6	o	M.Stiff	SS



Bore Hole Terminated at a depth of 30.00m below the existing grou

Fig. 2.2 Soil Profile at BH-02 Location

Table 2.1: Laboratory Test Results on the Soil Samples 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 2.00	8	SS	Silty Clay	39	1.6	66	26	40	0.68	33	M.Stiff	0	0	0	0	18	82	CH
2.00 to 8.00	22	SS	Silty Fine Sand	-	1.7	-	-	-	-	-	M.Dense	0	0	0	79	21	0	SM
8.00 to 11.00	10	SS	Silty Clay	31	1.7	57	27	30	0.87	-	Stiff	0	0	0	0	23	77	CH
11.00 to 13.00	8	SS	Silty Clay	41	1.6	69	26	43	0.65	-	M.Stiff	0	0	0	0	18	82	CH
13.00 to 15.00	9	SS	Silty Clay	39	1.7	65	31	34	0.76	-	Stiff	0	0	0	0	20	80	CH
15.00 to 17.00	4	SS	Silty Clay	55	1.4	73	21	52	0.35	-	Soft	0	0	0	0	15	85	CH
17.00 to 20.00	6	SS	Silty Clay	43	1.5	68	25	43	0.58	-	M.Stiff	0	0	0	0	19	81	CH

Table 2.2: Laboratory Test Results on the Soil Samples 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	IL	FS		Gravel (%)	Coarse (%)	Medium (%)	Fine (%)	Silt (%)	Clay (%)	
0.00 to 2.00	10	SS	Silty Clay	34	1.7	64	29	35	0.86	50	Stiff	0	0	0	0	21	79	CH
2.00 to 5.00	20	SS	Silty Fine Sand	-	1.6	-	-	-	-	-	M.Dense	0	0	0	80	20	0	SM
5.00 to 8.00	7	SS	Silty Clay	40	1.6	67	26	41	0.66	-	M.Stiff	0	0	0	0	18	82	CH
8.00 to 11.00	9	SS	Silty Clay	37	1.7	66	29	37	0.78	-	Stiff	0	0	0	0	20	80	CH
11.00 to 21.00	6	SS	Silty Clay	43	1.5	69	23	46	0.57	-	M.Stiff	0	0	0	0	16	84	CH
21.00 to 23.00	12	SS	Silty Fine Sand	-	1.5	-	-	-	-	-	Loose	0	0	0	78	22	0	SM
23.00 to 30.00	78	SS	Compacted Clay	16	2.0	43	31	12	2.25	-	Hard	0	0	0	0	25	75	CI

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	6.96	322.95	363.31
BH-02	3.00	7.00	319.41	359.33

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 2.00m depth)**

Type of Strata	Silty Clay
Colour	Brownish
Thickness of Layer	2.00m
SPT of the layer	08
Consistency	Medium Stiff
Un-drained Cohesion, Cu	53.33kPa

* **Layer-2 (from 2.00m to 8.00m depth)**

Type of Strata	Silty Fine Sand
Colour	Brownish
Thickness of Layer	6.00m
SPT of the layer	22
Relative Density	Medium Dense
Angle of Shearing Resistance, ϕ	33.60^0

* **Layer-3 (from 8.00m to 11.00m depth)**

Type of Strata	Silty Clay
Colour	Greyish
Thickness of Layer	3.00m
SPT of the layer	10
Consistency	Stiff
Un-drained Cohesion, Cu	66.66kPa

* **Layer-4 (from 11.00m to 13.00m depth)**

Type of Strata	Silty Clay
Colour	Blackish
Thickness of Layer	2.00m
SPT of the layer	08
Consistency	Medium Stiff
Un-drained Cohesion, Cu	53.33kPa

* **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	09
Consistency	Stiff
Un-drained Cohesion, Cu	60.00kPa

* **Layer-6 (from 15.00m to 17.00m 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-7 (from 17.00m to 20.00m depth)**

Type of Strata	Silty Clay
Colour	Blackish
Thickness of Layer	3.00m
SPT of the layer	06
Consistency	Medium Stiff
Un-drained Cohesion, Cu	40.00kPa

Ground Water

Ground water table was encountered at a depth of 3.00m below the existing ground level during the last week of July 2022.

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 2.00m depth)**

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

* **Layer-2 (from 2.00m to 5.00m depth)**

Type of Strata	Silty Fine Sand
Colour	Brownish
Thickness of Layer	3.00m
SPT of the layer	20
Relative Density	Medium Dense
Angle of Shearing Resistance, ϕ	33.00^0

* **Layer-3 (from 5.00m to 8.00m depth)**	
Type of Strata	Silty Clay
Colour	Blackish
Thickness of Layer	3.00m
SPT of the layer	07
Consistency	Medium Stiff
Un-drained Cohesion, Cu	46.66kPa
* **Layer-4 (from 8.00m to 11.00m depth)**	
Type of Strata	Silty Clay
Colour	Blackish
Thickness of Layer	3.00m
SPT of the layer	09
Consistency	Stiff
Un-drained Cohesion, Cu	60.00kPa
* **Layer-5 (from 11.00m to 21.00m depth)**	
Type of Strata	Silty Clay
Colour	Blackish
Thickness of Layer	10.00m
SPT of the layer	06
Consistency	Medium Stiff
Un-drained Cohesion, Cu	40.00kPa
* **Layer-6 (from 21.00m to 23.00m depth)**	
Type of Strata	Silty Fine Sand
Colour	Greyish
Thickness of Layer	2.00m
SPT of the layer	12
Relative Density	Loose
Angle of Shearing Resistance, ϕ	30.60^0
* **Layer-7 (from 23.00m to 30.00m depth)**	
Type of Strata	Compacted Clay
Colour	Yellowish to Greyish
Thickness of Layer	7.00m
SPT of the layer	78
Consistency	Hard
Un-drained Cohesion, Cu	520.00kPa

Ground Water

Ground water table was encountered at a depth of 3.00m below the existing ground level during the last week of July 2022.

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 i.e. below 2.00m thick highly plastic fine-grained soil strata are coarse-grained type which are good from both shear strength characteristics and deformation considerations to act as bearing strata for proposed impending loads form structure.

If coarse-grained soil strata encountered below 2.00m depths from present existing ground level are considered as bearing strata, the safe bearing capacity of open foundation system will be a function of least dimension of footing and effective surcharge over the bearing strata.

Care shall also be taken so that the dispersed foundation stresses on the underlying relatively weak soil strata encountered at 5.00m depths below existing ground level (SPT @ 6.00m is 06, Ref. BH-02) are within its safe bearing capacity limits.

Further, the sub-soil strata encountered up to the depth of investigations can also offer a good frictional resistance against a suitable 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 (BH-02)

Considering the shear strength characteristics of coarse-grained soil strata encountered at shallow depths i.e. below 2.00m depths from present existing ground level and presence of underlying relatively weak soil layer encountered at 5.00m depths below existing ground level, open foundation system of ***Strip Raft type with Restricted Least Dimension Parameter*** *located at a design depth of 2.50m below present existing ground level 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	Depth of Strip Raft below Existing Ground Level (m)	Observed Thickness of Fill (m)	Depth of Strip Raft below Natural Ground Level (m)	Type of Bearing Strata	Safe Bearing Capacity (MT/m^2)	Elastic Settlements <50mm (mm)
Strip Raft	2.50	0.00	2.50	Silty Fine Sand	15	30

The computations for above are annexed to this report.

Notes

Safe Bearing Capacity presented above is restricted considering the presence of underlying relatively weak soil layer encountered at 5.00m depths form existing ground level i.e. 2.50m distant apart from the bottom level of strip raft.

4.2.2 Deep Foundation System-26.00m Long Bored Cast-in-Situ Friction Piles

In case, the safe bearing capacity of open foundation system presented above in Clause 4.2.1 is lower than the foundation stresses, deep foundation system consisting of 26.00m 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 26.00m 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	Type 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	Fixed Head Pile	26.00	500	70	70
2				550	75	75
3				600	80	80
4				650	85	85

The computations of safe load carrying capacity for 500mm diameter and 26.00m long bored cast-in-situ Friction Pile are annexed to this report.

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. Care shall be taken so that the ultimate bearing strata are none other than recommended "Silty Fine Sand" type. The same shall be checked and verified by our Geotechnical Engineer during open foundation excavations. (IMPORTANT).
4. Safe Bearing Capacity of open foundation is restricted considering the presence of underlying relatively weak soil layer encountered at a depth of 5.00m below existing ground level i.e. 2.50m distant apart from the bottom level of strip raft.
5. Excavated coarse-grained soil strata encountered below 2.00m thick highly plastic fine-grained soil strata can only be used for back-filling purposes. 2.00m thick highly plastic fine-grained soil strata encountered at shallow depths shall be in no case used for back-filling purposes.
6. Care shall be taken so that the ultimate bearing strata are none other than Medium Dense Silty Fine Sand type only. (Note)
7. No structural units or members can be in direct contact of highly plastic fine-grained soil strata encountered up to 2.00m depths from present existing ground level. A 0.30m thick well compacted Cohesive Non-Swelling (CNS) soil cushion is recommended to be sand-witched in between.

Open Foundation Depths & Foundations Restrictions (if any)

8. Depth of open excavations below present existing ground level shall be 2.50m.

9. For the recommended safe bearing capacity of 15MT/sq.m., the least dimension of foundation shall be in no case more than 2.50m.

Other Recommendations

10. It is recommended to connect the grade beams so that the structure can act as a single unit against any differential settlements in between the individual footings.
11. Special provisions to contain any lateral collapse of soil from the walls excavated foundation pits are required up to the recommended depths of open foundation system.
12. In case, ground water table is encountered within the recommended depths of foundation system, the same shall be bailed out continuously to keep the sub-grade well consolidated.

Deep Foundation System

13. Suitable pile load tests (as per I.S: 2911, part-IV) shall be performed to confirm the presented safe load carrying capacities **(Mandatory)**.
14. Pile cap can be located over 0.30m thick well compacted existing ground to be replaced with CNS (Cohesive Non-Swelling) soil surface.
15. Piles shall be grouped according to the column design load requirements.
16. Safe load carrying capacities of piles shall be limited to their structural capacities.

General

17. **CNS can be well graded coarse-grained soil like quarry dust or clean river sand or sand: gravels mix (1:2) or fly-ash.**
18. 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.

For Geo Mines Engineers Pvt. Ltd

Director

Dr. ASHOK KUMAR NAGINDAS PATEL M.Tech. (Soil Engg.)
CMDA RGTE No. GTE/19/04/025

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
Depth of Foundation below existing ground level (D_f):	2.50	m
Observed Thickness of fill at site:	0.00	m
Effective Depth of Foundation below natural ground level (D_f):	2.50	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 Fine Sand	
Design SPT-value of the Bearing Strata :	21	
(considered based upon the density of the strata)		
Type of Shear Failure:	General	
Angle of Shearing Resistance - Limited to a Maximum of:	33.30	Deg.

1.3 Design Parameters:

Bulk Density of Soil above the foundation depth (γ_{bulk})	16.00	kN/m^3
Effective Overburden pressure at foundation level (q)	15.00	kPa
Water Table Correction Factor (w')	0.50	

Bearing Capacity Factors:

N_c = N/A

N_q = 28.23

N_γ = 39.32

Shape Factors:

S_c = N/A

S_q = 1.66

S_γ = 0.60

Depth Factors :

D_c = N/A

D_q = 1.00

$D_\gamma = 1.00$

Inclination Factor:

$I_c = N/A$

$I_q = 1.00$

$I_\gamma = 1.00$

1.4 Ultimate Bearing Capacity (Qu) :

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

$Q_u =$ 796.06 kPa

1.5 Safe Bearing Capacity (Qsafe) :

Factor of Safety (F.S.) :	2.50
Qsafe :	318.42 kPa
Recommended Safe Bearing Capacity:	150.00 kPa

Safe bearing capacity presented above is restricted considering the presence of underlying relaltively weak soil layer encountered at 5.00m depths below existing ground level i.e. 2.50m distant apart from the bottom level of strip raft .

1.6 Settlements

Since, the bearing strata are coarse-grained type, the settlements under the allowable safe bearing pressure 150kPa will be of immediate elastic nature. The elastic settlements corresponding to a safe bearing pressure of 150kPa and average SPT of 21 considering extent of pressure bulb below bottom level of footing are computed to be in the order of 30mm which is within the permissible limits of 70mm for Strip Raft as per I.S:1904.

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):	**500.0**	mm
Assumed R.L of E.G.L:	0.000	m
Length of pile below E.G.L.(l) :	**26.000**	m
R.L. of Bot. of Pile	-26.00	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:	10	
Bulk Density of the strata,γ:	17	kN/m^3
Undrained Cohesion, Cu:	66.67	kPa
R.L of top of Strata:	0.00	m
R.L of bottom of Strata:	-2.00	m
Average Thickness of Strata,I_c:	2.00	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}:	14.00	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	7.00	kN/m^2
Adhesion Factor, α:	0.40	
Skin Resistance of the pile,q_s:	83.78	kN

(q_s:α*Cu*pi()*d*Ic)

1.2.1.2 **Layer-II**

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:	-2.00	m
R.L of bottom of Strata:	-5.00	m
Average Thickness of Strata,I_c:	3.00	m
Effective overburden pressure over the top of strata,σ_{top}:	14.00	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	32.00	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	23.00	kN/m^2
Coeff. Of Earth Pressure, k:	1.50	
Skin Resistance of the pile,q_s:	105.58	kN

(q_s:σ*k*tanϕ*pi()*d*Ic)

1.2.1.3 **Layer-III**

Type of Strata:	Silty Clay
Average SPT of the strata,N:	7

Bulk Density of the strata,γ:	16	kN/m^3
Undrained Cohesion, Cu:	46.67	kPa
R.L of top of Strata:	-5.00	m
R.L of bottom of Strata:	-8.00	m
Average Thickness of Strata,l_c:	3.00	m
Effective overburden pressure over the top of strata,σ_{top}:	32.00	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	50.00	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	41.00	kN/m^2
Adhesion Factor, α:	0.60	
Skin Resistance of the pile,q_s:	131.95	kN

(q_s:α*Cu*pi()*d*lc)

1.2.1.4 **Layer-IV**

Type of Strata:	Silty Clay	
Average SPT of the strata,N:	9	
Bulk Density of the strata,γ:	17	kN/m^3
Undrained Cohesion, Cu:	60.00	kPa
R.L of top of Strata:	-8.00	m
R.L of bottom of Strata:	-11.00	m
Average Thickness of Strata,l_c:	3.00	m
Effective overburden pressure over the top of strata,σ_{top}:	50.00	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	71.00	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	60.50	kN/m^2
Adhesion Factor, α:	0.40	
Skin Resistance of the pile,q_s:	113.10	kN

(q_s:α*Cu*pi()*d*lc)

1.2.1.5 **Layer-V**

Type of Strata:	Silty Clay	
Average SPT of the strata,N:	6	
Bulk Density of the strata,γ:	15	kN/m^3
Undrained Cohesion, Cu:	40.00	kPa
R.L of top of Strata:	-11.00	m
R.L of bottom of Strata:	-21.00	m
Average Thickness of Strata,l_c:	10.00	m
Effective overburden pressure over the top of strata,σ_{top}:	71.00	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	121.00	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	96.00	kN/m^2
Adhesion Factor, α:	0.70	
Skin Resistance of the pile,q_s:	439.82	kN

(q_s:α*Cu*pi()*d*lc)

1.2.1.6 **Layer-VI**

Type of Strata:	Silty Fine Sand
Average SPT of the strata,N:	12

Bulk Density of the strata,γ:	15	kN/m^3
Angle of Shearing Resistance,ϕ:	30.6	Deg.
R.L of top of Strata:	-21.00	m
R.L of bottom of Strata:	-23.00	m
Average Thickness of Strata,l_c:	2.00	m
Effective overburden pressure over the top of strata,σ_{top}:	121.00	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	131.00	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	126.00	kN/m^2
Coeff. Of Earth Pressure, k:	1.00	
Skin Resistance of the pile,q_s:	234.10	kN
(q_s:σ*k*tanϕ*pi()*d*lc)		

1.2.1.7 **Layer-VII**

Type of Strata:	Compacted Clay	
Average SPT of the strata,N:	60	
Bulk Density of the strata,γ:	20	kN/m^3
Undrained Cohesion, Cu:	400.00	kPa
R.L of top of Strata:	-23.00	m
R.L of bottom of Strata:	-26.00	m
Average Thickness of Strata,l_c:	3.00	m
Effective overburden pressure over the top of strata,σ_{top}:	131.00	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	161.00	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	146.00	kN/m^2
Adhesion Factor, α:	0.40	
Skin Resistance of the pile,q_s:	753.98	kN
(q_s:α*Cu*pi()*d*lc)		

Ultimate Skin Resistance,q_s: 1862.30 kN

1.2.2 Computation of End Bearing Resistance:

Ultimate End Bearing Resistance (Qp) Neglected for Fricit

1.3.0 Ultimate Load Carrying Capacity (Qu=Qp+Qs	**1862.3**	**kN**
Safe Load Carrying Capacity (Qsafe =Qu/2.5)	**744.9**	**kN**
However, limit Q_{safe} to the structural capacity of pile:	**700.0**	**kN**



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