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CLIENT	**MARUTHAM APARTMENT, CHENNAI**
PROJECT	**PROPOSED CONSTRUCTION OF RESIDENTIAL BUILDING (STILT+05) AT OLD S.NO: 267/1, AS PER PATTA NEW S.NO: 267/1B , MANIMANGALAM 'A' VILLAGE, KUNDRATHUR TALUK, KANCHIPURAM DISTRICT**
TITLE	**GEOTECHNICAL INVESTIGATION REPORT**

Dr. ASHOK KUMAR NAGINDAS PATEL M.Tech. (Soil Engg)
SCCP SCOPE No. CGLRGN_RGTE_2019/07/0068

For Geo Mines Engineers Pvt Ltd

Director

GEO MINES ENGINEERS GMEPL Chennai

REV.	DATE	REPORT NUMBER	PREP. BY
1	24-11-2022	GMEPL/MARUTHAM APARTMENT/204/2022-23	
0	20-07-2022	GMEPL/MARUTHAM APARTMENT/204/2022-23	

DISCLAIMER

We've been asked to look into the ground and identify and quantify everything that mother nature has put there and 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

Marutham Apartment, Chennai proposed to construct a **Residential Building (Stilt+05) at Old S.No: 267/1, As Per Patta New S.No: 267/1B , Manimangalam 'A' Village, Kundrathur Taluk, Kanchipuram 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 13.00m 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 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:

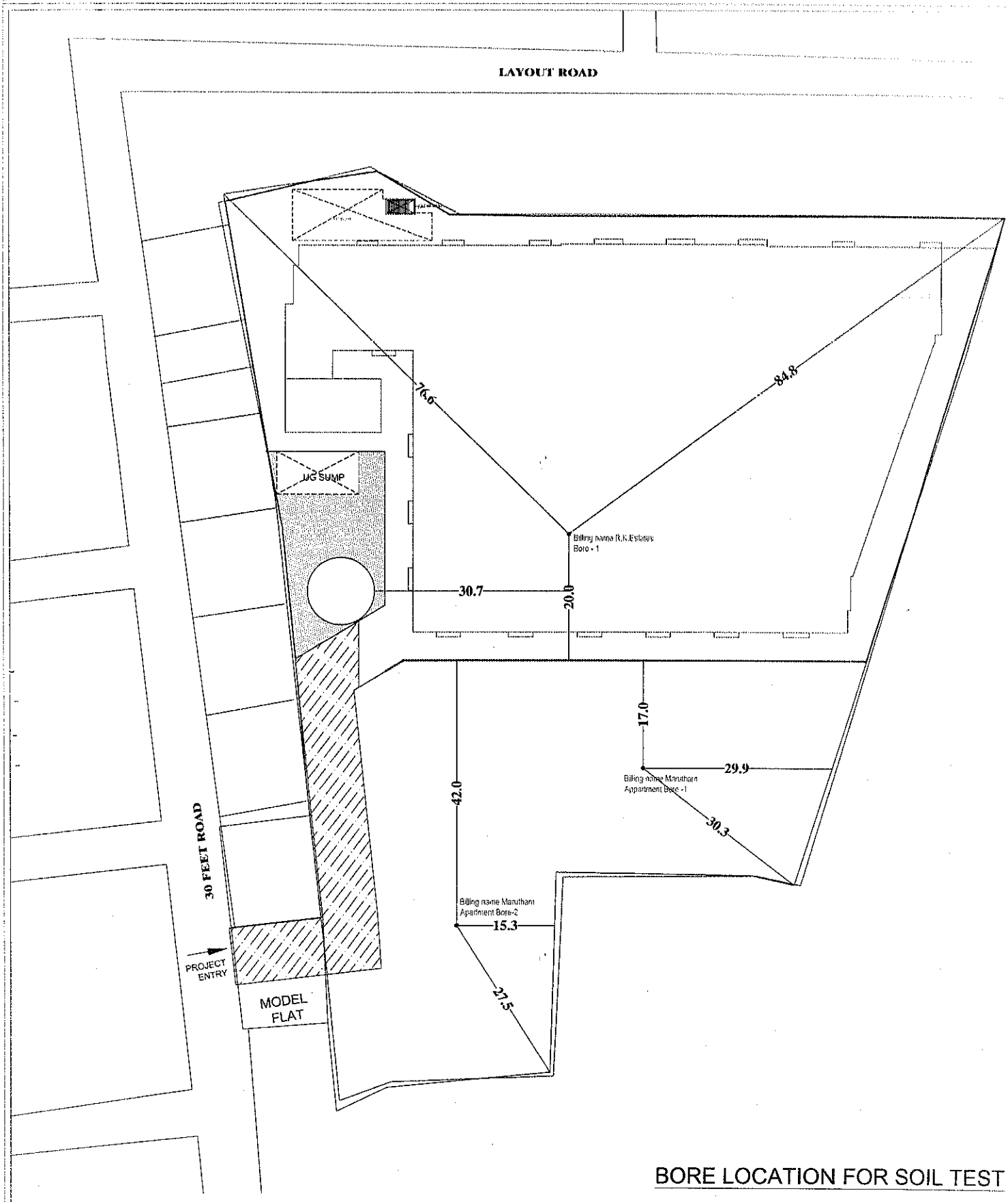
2.6.2.1 Index Property – Free Swell Tests:

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.



BORE LOCATION FOR SOIL TEST

MARUTHAM GROUP
... building values

ROYAL GARDENS

SITE CUM FIRST FLOOR PLAN

SCALE :-N.T.S

04-JULY-2022

N
W E
S

Project : Proposed Construction of Residential Building (Stilt+05) at Old S.No: 267/1, As Per Patta New S.No: 267/1B , Manimangalam 'A' Village, Kundrathur Taluk, Kanchipuram District.

Location: BH-01

Started On : 15/07/2022; Ended On : 16/07/2022 G.W.T: 0.50m 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	ical Representation (0 1 2 3 4 5 6 7 8 9)	Relative Density/Consistency	Type of Sample
G.W.T	↓		Brownish Soft							Soft	DS
1.00			Silty Clay								
			Brownish	1.50	4	5	7	12		Stiff	SS
			Stiff								
2.50			Silty Sandy Clay								
			Greyish	3.00	12	24	29	53		V.Dense	SS
			Very Dense								
4.00			Silty Clayey Fine to Medium Coarse Sand								
				4.50	SPT Hammer Rebounded					V.Dense	SS
				6.00	SPT Hammer Rebounded					V.Dense	SS
				7.00	SPT Hammer Rebounded					V.Dense	SS
			Weathered	8.00	SPT Hammer Rebounded					V.Dense	SS
			Rock	9.00	SPT Hammer Rebounded					V.Dense	SS
				10.00	SPT Hammer Rebounded					V.Dense	SS
				11.00	SPT Hammer Rebounded					V.Dense	SS
12.00				12.00	SPT Hammer Rebounded					V.Dense	SS
			Hard		Rock Core Recovery: 51cms					V.Dense	CS
13.00			Rock	13.00	SPT Hammer Rebounded					V.Dense	SS

Bore Hole Terminated at a depth of 13.00m below the existing ground level

Fig. 2.1 Soil Profile at BH-01 Location

Project : Proposed Construction of Residential Building (Stilt+05) at Old S.No: 267/1, As Per Patta New S.No: 267/1B , Manimangalam `A` Village, Kundrathur Taluk, Kanchipuram District.

Location: BH-02

Started On : 18/07/2022; Ended On : 19/07/2022 G.W.T: 0.50m 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
0.50	↓		Filled Up Soil							-	DS
1.00			Brownish Soft Silty Clay							Soft	DS
			Brownish to Greyish Very Stiff Silty Sandy Clay	1.50	5	6	10	16		V.Stiff	SS
				3.00	8	12	14	26		V.Stiff	SS
4.00											
			Weathered Rock	4.50	SPT Hammer Rebounded					V.Dense	SS
				6.00	SPT Hammer Rebounded					V.Dense	SS
				7.00	SPT Hammer Rebounded					V.Dense	SS
				8.00	SPT Hammer Rebounded					V.Dense	SS
9.00				9.00	SPT Hammer Rebounded					V.Dense	SS
			Soft Rock		Rock Core Recovery: 17cms					V.Dense	CS
				10.00	SPT Hammer Rebounded					V.Dense	SS
					Rock Core Recovery: 16cms					V.Dense	CS
11.00				11.00	SPT Hammer Rebounded					V.Dense	SS
			Hard Rock		Rock Core Recovery: 55cms					V.Dense	CS
12.00				12.00	SPT Hammer Rebounded					V.Dense	SS

Bore Hole Terminated at a depth of 12.00m below the existing ground level

Fig. 2.2 Soil Profile at BH-02 Location

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 1.00	-	DS	Silty Clay	54	1.4	66	21	45	0.27	44	Soft	0	0	0	0	15	85	CH
1.00 to 2.50	12	SS	Silty Sandy Clay	36	1.7	57	31	26	0.81	-	Stiff	0	0	0	13	9	78	CH
2.50 to 4.00	53	SS	Silty Clayey Fine to Medium Coarse Sand	-	1.9	-	-	-	-	-	Dense	0	21	15	39	11	14	SM
4.00 to 12.00	>100	SS	Weathered Rock	-	2.0	-	-	-	-	-	V.Dense	34	16	24	21	5	0	SDR
12.00 to 13.00	>100	SS	Hard Rock	-	2.0	-	-	-	-	-	V.Dense	100	0	0	0	0	0	HR

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 0.50	-	DS	Filled Up Soil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.50 to 1.00	-	DS	Silty Clay	55	1.3	69	23	46	0.30	38	Soft	0	0	0	0	16	84	CH
1.00 to 4.00	21	SS	Silty Sandy Clay	29	1.9	48	33	15	1.27	-	V.Stiff	0	0	0	14	11	75	CI
4.00 to 9.00	>100	SS	Weathered Rock	-	2.0	-	-	-	-	-	V.Dense	37	16	22	21	4	0	SDR
9.00 to 11.00	>100	SS	Soft Rock	-	2.0	-	-	-	-	-	V.Dense	100	0	0	0	0	0	SR
11.00 to 12.00	>100	SS	Hard Rock	-	2.0	-	-	-	-	-	V.Dense	100	0	0	0	0	0	HR

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	7.05	329.55	370.74
BH-02	3.00	7.07	320.06	360.06

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 1.00m depth)**

Type of Strata	Silty Clay
Colour	Brownish
Thickness of Layer	1.00m
SPT of the layer	-
Consistency	Soft
Un-drained Cohesion, Cu	-

* **Layer-2 (from 1.00m to 2.50m depth)**

Type of Strata	Silty Sandy Clay
Colour	Brownish
Thickness of Layer	1.50m
SPT of the layer	12
Consistency	Stiff
Un-drained Cohesion, Cu	80.00kPa

* **Layer-3 (from 2.50m to 4.00m depth)**

Type of Strata	Silty Clayey Fine to Medium Coarse Sand
Colour	Greyish
Thickness of Layer	1.50m
SPT of the layer	53
Relative Density	Very Dense
Angle of Shearing Resistance, ϕ	41.45^0

* **Layer-4 (from 4.00m to 12.00m depth)**

Type of Strata	Weathered Rock
Colour	-
Thickness of Layer	8.00m
SPT of the layer	>100
Relative Density	Very Dense
Angle of Shearing Resistance, ϕ	42.50^0

* **Layer-5 (from 12.00m to 13.00m depth)**

Type of Strata	Hard Rock
Colour	-
Thickness of Layer	1.00m
SPT of the layer	>100
Relative Density	Very Dense
Angle of Shearing Resistance, ϕ	42.50^0

Ground Water

Ground water table was encountered at a depth of 0.50m below the existing ground level during the third 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 0.50m depth)**

Type of Strata	Filled Up Soil
Colour	-
Thickness of Layer	0.50m

* **Layer-2 (from 0.50m to 1.00m depth)**

Type of Strata	Silty Clay
Colour	Brownish
Thickness of Layer	0.50m
SPT of the layer	-
Consistency	Soft
Un-drained Cohesion, Cu	-

* **Layer-3 (from 1.00m to 4.00m depth)**

Type of Strata	Silty Sandy Clay
Colour	Brownish to Greyish
Thickness of Layer	3.00m
SPT of the layer	21
Consistency	Very Stiff
Un-drained Cohesion, Cu	140.00kPa

* **Layer-4 (from 4.00m to 9.00m depth)**

Type of Strata	Weathered Rock
Colour	-
Thickness of Layer	5.00m
SPT of the layer	>100
Relative Density	Very Dense
Angle of Shearing Resistance, ϕ	42.50^0

* **Layer-5 (from 9.00m to 11.00m depth)**

Type of Strata	Soft Rock
Colour	-
Thickness of Layer	2.00m

SPT of the layer	>100
Relative Density	Very Dense
Angle of Shearing Resistance, ϕ	42.50^0

* **Layer-6 (from 11.00m to 12.00m depth)**

Type of Strata	Hard Rock
Colour	-
Thickness of Layer	1.00m
SPT of the layer	>100
Relative Density	Very Dense
Angle of Shearing Resistance, ϕ	42.50^0

Ground Water

Ground water table was encountered at a depth of 0.50m below the existing ground level during the fourth 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 are uniformly stratified from type but possess non-uniform shear strength characteristics, BH-02 being relatively weak from deformation considerations than that of other borehole 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 further envisaged that the medium 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 in the range of 600kN to 700kN 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 medium 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.

Further, the refusal strata encountered below a maximum depth of 4.00m below existing ground level can 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 (BH-02)

*Considering the shear strength characteristics and medium plasticity nature of fine-grained soil strata encountered at shallow depths, open foundation system of **Isolated Column Footing** type located at a design depth of 2.50m 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 **Isolated Column Footing** below existing ground level (m)	Safe Bearing Capacity (MT/m^2)	Elastic Settlements (mm)
Isolated Column Footing	**2.80**	**0.30**	**2.50**	**22**	**33**

The computations for above are annexed to this report.

4.2.2 Deep Foundation System-12.00m Long Bored Cast-in-Situ Friction cum End Bearing Piles

In case, the safe bearing capacity of open foundation system presented above in Clause 4.2.1 is less than the impending foundation stresses, deep foundation system consisting of 12.00m long bored cast-in-situ Friction cum End Bearing Piles can be adopted. Pile shall be drilled through DMC (direct mud circulation) technique.

For four different diameters, the safe load carrying capacities of 12.00m 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	12.00	400	95	58
2			450	105	65
3			500	115	73
4			550	125	81

The computations of safe load carrying capacity for 400mm diameter and 12.00m long bored cast-in-situ Friction cum End Bearing pile are annexed to this report.

4.2.3 Deep Foundation System-9.00m Long Bored Cast-in-Situ Friction cum end Bearing Piles

As an alternate to foundation system presented in Clause 4.2.2, deep foundation system consisting of 9.00m long bored cast-in-situ Friction cum End Bearing Piles can also be adopted.

For four different diameters, the safe load carrying capacities of 9.00m 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	9.00	400	75	38
2			450	85	43
3			500	95	48
4			550	105	52

The computations of safe load carrying capacity for 400mm diameter and 9.00m long bored cast-in-situ Friction cum End Bearing pile are annexed to this report.

CHAPTER-5

CONCLUSIONS & RECOMMENDATIONS

1. Foundation systems presented in Clause 4.2.1, 4.2.2 & 4.2.3, Chapter-IV can be adopted for foundation design purposes.

Open Foundation System

2. The safe bearing capacity of open foundation system is computed considering rise in the ground water table up to or above the level of footing.
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 2.80m.
5. Back-fill Thickness with well compacted CNS soil shall be 0.30m.
6. Depth of Isolated column Footing below present existing ground level will be 2.50m.

Usage of Excavated Earth

7. **Excavated 0.50m thick filled up soil and medium 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 medium plastic fine-grained soil strata encountered at shallow depths. A 0.30m thick well compacted and non-plastic 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 medium 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 safe load carrying capacities. (**Mandatory**)
11. Recommended length of pile shall be considered from its cut-off level.
12. Considering the unstable/non-self-supportive soil strata, pile liner is recommended to be provided up to the recommended length of piles.
13. **Pile cap can be located on 0.50m thick existing ground to be replaced surface. Ground replacement can be done with well compacted CNS (Cohesive Non-Swelling) Soil.**
14. CNS can be well graded, non-plastic soil material like quarry dust or clean river sand or sand-gravel mix.
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.
17. Care shall be taken so that the ultimate end bearing strata are none other than recommended **Soft/ Hard Rock** type. (Note)

General

18. As the chlorides and sulphates present in water samples are within the permissible limits and hence **no** chloride resistant steel or sulphate resistant 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)
DTCP RGTE No. CGLRGN RGTE 2011/0[illegible]

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:	Isolated Col. Footing	
R.L of the top of Borehole (m):	0.00	m
Total Depth of Excavations below Existing Ground Level (m) :	2.80	m
Recommended Thickness of CNS Back-Fill (m):	0.30	m
Effective Depth of Foundation below existing ground level (D_f):	2.50	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 Sandy Clay	
Design SPT-value of the Bearing Strata :	26	
(considered based upon the density of the strata)		
Type of Shear Failure:	General	
Undrained Cohesion, Cu:	173.33	kPa

1.3 Design Parameters:

Bulk Density of Soil above the foundation detph (γ_{bulk})	19.00	kN/m^3
Effective Overburden pressure at foundation level (q)	22.50	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:

$S_c = 1.00$

$S_q = N/A$

$S_\gamma = N/A$

Depth Factors :

$D_c = 1.00$

$D_q = N/A$

D_γ = N/A

Inclination Factor:

I_c = 1.00

I_q = N/A

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 = 890.93 kPa

1.5 Safe Bearing Capacity (Qsafe) :

Factor of Safety (F.S.) :	2.50
Qsafe :	356.37 kPa
Recommended Safe Bearing Capacity:	220.00 kPa

1.6 Settlements

Since, the bearing strata are very stiff fine-grained type, the settlements under the allowable safe bearing pressure 220kPa will be of immediate elastic nature. The elastic settlements corresponding to a safe bearing pressure of 220kPa and average SPT of 26 considering extent of pressure bulb below bottom level of footing are computed to be in the order of 33mm which is within the permissible limits of 50mm for isolated column footings 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):	**400.0**	mm
Assumed R.L of E.G.L:	0.000	m
Length of pile below E.G.L.(l) :	**12.000**	m
R.L. of Bot. of Pile	-12.00	m

1.2 Design of Pile for Vertical Compression

1.2.1 Computation of Skin Resistance:

1.2.1.1 **Layer-III**

Type of Strata:	Silty Sandy Clay	
Average SPT of the strata,N:	21	
Bulk Density of the strata,γ:	19	kN/m^3
Undrained Shear Strength,C_u:	140.00	kPa
R.L of top of Strata:	-1.00	m
R.L of bottom of Strata:	-4.00	m
Average Thickness of Strata,I_c:	3.00	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}:	27.00	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	13.50	kN/m^2
Adhesion,α:	0.40	
Skin Resistance of the pile,q_s:	211.12	kN

(q_s:α*Cu*pi()*d*Ic)

1.2.1.2 **Layer-IV**

Type of Strata:	Weathered Rock	
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:	-4.00	m
R.L of bottom of Strata:	-9.00	m
Average Thickness of Strata,I_c:	5.00	m
Effective overburden pressure over the top of strata,σ_{top}:	27.00	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	77.00	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	52.00	kN/m^2
Coeff. Of Earth Pressure, k:	2.50	
Skin Resistance of the pile,q_s:	748.47	kN

(q_s:σ*k*tanϕ*pi()*d*Ic)

1.2.1.3 **Layer-V**

Type of Strata:	Soft Rock
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:	-9.00	m
R.L of bottom of Strata:	-11.00	m
Average Thickness of Strata,l_c:	2.00	m
Effective overburden pressure over the top of strata,σ_{top}:	77.00	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	97.00	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	87.00	kN/m^2
Coeff. Of Earth Pressure, k:	2.50	
Skin Resistance of the pile,q_s:	500.90	kN
(q_s:σ*k*tanϕ*pi()*d*lc)		
Ultimate Skin Resistance,q_s:	**1460.49**	**kN**

1.2.2 Computation of End Bearing Resistance:

Type of Bearing Strata	Hard Rock	
Cross-Sectional Area of pile,Ap:	0.126	m^2
R.L of bottom of pile:	-12.00	
Minimum SPT-value of the Bearing Strata	60	
Angle of Shear Resistance, ϕ:	42.50	Deg.
Bearing Capacity Factor(Nq)	220.00	
Effective overburden pressure, q:	36.00	kPa
Ultimate End Bearing Resistance (Qp)	**995.3**	**kN**
(Qp=Ap*q*Nq)		

1.3.0	**Ultimate Load Carrying Capacity (Qu=Qp+Qs**	**2455.7**	**kN**
	Safe Load Carrying Capacity (Qsafe =Qu/2.5)	**982.3**	**kN**
	However, limit Q_{safe} to the structural capacity of pile:	**950.0**	**kN**

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):	**400.0**	mm
Assumed R.L of E.G.L:	0.000	m
Length of pile below E.G.L.(l) :	**9.000**	m
R.L. of Bot. of Pile	-9.00	m

1.2 Design of Pile for Vertical Compression

1.2.1 Computation of Skin Resistance:

1.2.1.1 **Layer-III**

Type of Strata:	Silty Sandy Clay	
Average SPT of the strata,N:	21	
Bulk Density of the strata,γ:	19	kN/m^3
Undrained Shear Strength,C_u:	140.00	kPa
R.L of top of Strata:	-1.00	m
R.L of bottom of Strata:	-4.00	m
Average Thickness of Strata,l_c:	3.00	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}:	27.00	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	13.50	kN/m^2
Adhesion,α:	0.40	
Skin Resistance of the pile,q_s:	211.12	kN

(q_s:α*Cu*pi()*d*Ic)

1.2.1.2 **Layer-IV**

Type of Strata:	Weathered Rock	
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:	-4.00	m
R.L of bottom of Strata:	-9.00	m
Average Thickness of Strata,l_c:	5.00	m
Effective overburden pressure over the top of strata,σ_{top}:	27.00	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	77.00	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	52.00	kN/m^2
Coeff. Of Earth Pressure, k:	2.50	
Skin Resistance of the pile,q_s:	748.47	kN

(q_s:σ*k*tanϕ*pi()*d*Ic)

Ultimate Skin Resistance,q_s: 959.59 kN

1.2.2 Computation of End Bearing Resistance:

Type of Bearing Strata	Weathered/ Soft Rock	
Cross-Sectional Area of pile,Ap:	0.126	m^2
R.L of bottom of pile:	-9.00	
Minimum SPT-value of the Bearing Strata	60	
Angle of Shear Resistance, ϕ:	42.50	Deg.
Bearing Capacity Factor(Nq)	220.00	
Effective overburden pressure, q:	36.00	kPa
Ultimate End Bearing Resistance (Qp)	**995.3**	**kN**
(Qp=Ap*q*Nq)		

1.3.0	**Ultimate Load Carrying Capacity (Qu=Qp+Qs**	**1954.8**	**kN**
	Safe Load Carrying Capacity (Qsafe =Qu/2.5)	**781.9**	**kN**
	However, limit Q_{safe} to the structural capacity of pile:	**750.0**	**kN**

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