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CONSULTANTS	**GEO MINES ENGINEERS PVT. LTD.** GEOTECHNICAL ENGINEERING DIVISION, #96, 3rd FLOOR, VELLALAR STREET, MOGAPPAIR WEST, CHENNAI-600037 Ph. No. 98413 16631, 9840157478 Email: geomines@gmail.com, gmepl77@gmail.com Website: www.geominesengineers.com
CLIENT	RAMAKRISHNAN & 2 OTHERS, CHENNAI
PROJECT	PROPOSED CONSTRUCTION OF RESIDENTIAL BUILDING (STILT+05) AT 2nd NORTON STREET, MANDAVELIPAKKAM, RAJA ANNAMALAIPURAM, CHENNAI-600028
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

REV.	DATE	REPORT NUMBER	PREP. BY
0	06-11-2023	GMEPL/RAMAKRISHNAN & 2 OTHERS/391/2023-24	

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

Ramakrishnan & 2 others, Chennai proposed to construct a **Residential Building (Stilt+05) at 2nd Norton Street, Mandavelipakkam, Raja Annamalaipuram, Chennai-600028.** For the purpose of designing the foundations, the responsibility of carrying out suitable soil investigation 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 10.00m 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 borehole are shown in site plan given in Fig. 2.0. The soil profiles obtained at each location are shown in Fig. 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 Tables-2.3.

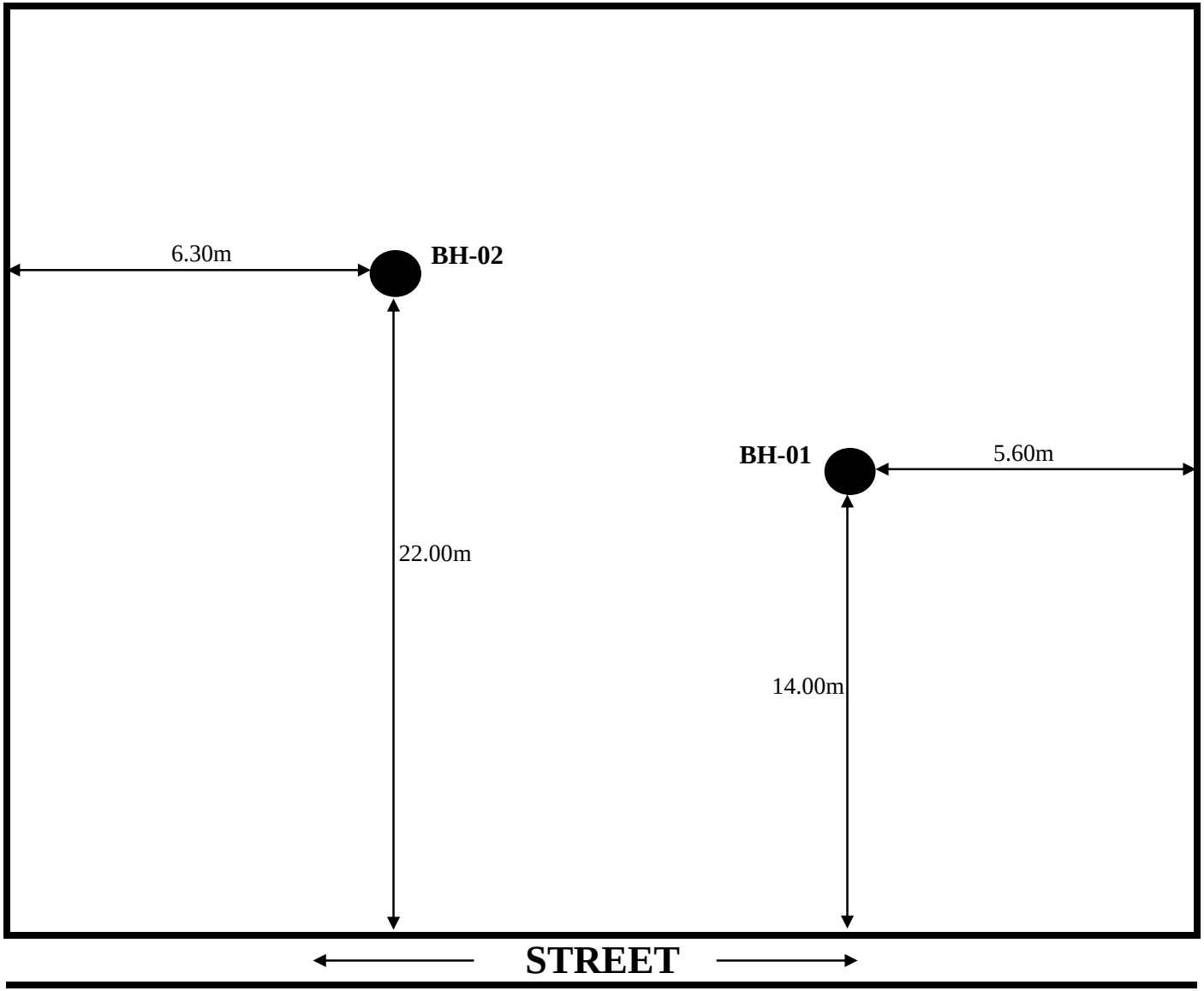


Fig. 2.0: Site Plan Representing the locations of Field Investigation Points

Project : Proposed Construction of Residential Building (Stilt+05) at 2nd Norton Street, Mandavelipakkam, Raja Annamalaipuram, Chennai-600028.

Location: BH-01

Started On : 31/10/2023 Ended On : 31/10/2023 G.W.T: 2.00m 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	ical Representation o (0 1 2 3 4 5 6 7 8 9)	Relative Density/Consistency	Type of Sample
0.50			Filled Up Soil							-	DS
			Brownish Stiff Silty Clay	1.50	3	5	8	13		Stiff	SS
2.00	▼										
			Brownish Dense Silty Fine to Medium Coarse Sand	3.00	13	20	26	46		Dense	SS
4.00											
			Brownish Medium Dense Silty Fine to Medium Coarse Sand	4.50	7	15	14	29		M.Dense	SS
6.00				6.00	43	10cms Penetration for 50 Blows				V.Dense	SS
			Brownish Very Dense Silty Fine Sand	7.50	10cms Penetration for 50 Blows					V.Dense	SS
				9.00	12cms Penetration for 50 Blows					V.Dense	SS
10.00				10.00	11cms Penetration for 50 Blows					V.Dense	SS

Bore Hole Terminated at a depth of 10.00m below the existing ground level

Fig. 2.1 Soil Profile at BH-01 Location

Project : Proposed Construction of Residential Building (Stilt+05) at 2nd Norton Street, Mandavelipakkam, Raja Annamalaipuram, Chennai-600028.

Location: BH-02

Started On : 01/11/2023 Ended On : 01/11/2023 G.W.T: 2.00m 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	ical Representation c 0 1 2 3 4 5 6 7 8 9	Relative Density/Consistency	Type of Sample
			Filled Up							-	DS
1.00			Soil								
			Brownish	1.50	4	9	13	22		V.Stiff	SS
G.W.T	↓		Very Stiff								
2.50			Silty Clay								
			Brownish	3.00	14	17	22	39		Dense	SS
			Dense								
4.00			Silty Fine to Medium Coarse Sand								
			Brownish	4.50	3	13	15	28		M.Dense	SS
			Medium Dense								
			Silty Fine to Medium								
6.00			Coarse Sand	6.00	12cms Penetration for 50 Blows					V.Dense	SS
				7.50	17	35	40	75		V.Dense	SS
			Brownish Very Dense								
			Silty Fine Sand								
				9.00	SPT Hammer Rebounded					V.Dense	SS
10.00				10.00	32	13cms Penetration for 50 Blows				V.Dense	SS

Bore Hole Terminated at a depth of 10.20m 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 0.50	-	DS	Filled Up Soil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
0.50 to 2.00	13	SS	Silty Clay	32	1.7	54	28	26	0.85	13	Stiff	0	0	0	0	19	81	CH
2.00 to 4.00	46	SS	Silty Fine to Medium Coarse Sand	-	1.9	-	-	-	-	-	Dense	0	18	23	43	16	0	SM
4.00 to 6.00	29	SS	Silty Fine to Medium Coarse Sand	-	1.8	-	-	-	-	-	M.Dense	0	9	24	47	20	0	SM
6.00 to 10.00	>100	SS	Silty Fine Sand	-	2.0	-	-	-	-	-	V.Dense	0	0	0	83	17	0	SM

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 1.00	-	DS	Filled Up Soil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.00 to 2.50	22	SS	Silty Clay	27	1.9	46	31	15	1.27	11	V.Stiff	0	0	0	0	21	79	CI
2.50 to 4.00	39	SS	Silty Fine to Medium Coarse Sand	-	1.9	-	-	-	-	-	Dense	0	18	21	46	15	0	SM
4.00 to 6.00	28	SS	Silty Fine to Medium Coarse Sand	-	1.8	-	-	-	-	-	M.Dense	0	14	18	51	17	0	SM
6.00 to 10.00	91	SS	Silty Fine Sand	-	2.0	-	-	-	-	-	V.Dense	0	0	0	82	18	0	SM

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	6.88	333.07	140.12
BH-02	3.00	6.90	330.12	133.99

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 0.50m depth)**

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

* **Layer-2 (from 0.50m to 2.00m depth)**

Type of Strata	Silty Clay
Colour	Brownish
Thickness of Layer	1.50m
SPT of the layer	13
Consistency	Stiff
Un-drained Cohesion, Cu	86.66kPa

* **Layer-3 (from 2.00m to 4.00m depth)**

Type of Strata	Silty Fine to Medium Coarse Sand
Colour	Brownish
Thickness of Layer	2.00m
SPT of the layer	46
Relative Density	Dense
Angle of Shearing Resistance, ϕ	40.10^0

* **Layer-4 (from 4.00m to 6.00m depth)**

Type of Strata	Silty Fine to Medium Coarse Sand
Colour	Brownish

Thickness of Layer	2.00m
SPT of the layer	29
Relative Density	Medium Dense
Angle of Shearing Resistance, ϕ	35.70^0

* **Layer-5 (from 6.00m to 10.00m depth)**

Type of Strata	Silty Fine Sand
Colour	Brownish
Thickness of Layer	4.00m
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 2.00m below the existing ground level during the last week of October 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 1.00m depth)**

Type of Strata	Filled Up Soil
Colour	-
Thickness of Layer	1.00m

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

Type of Strata	Silty Clay
Colour	Brownish
Thickness of Layer	1.50m
SPT of the layer	22
Consistency	Very Stiff
Un-drained Cohesion, Cu	146.66kPa

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

Type of Strata	Silty Fine to Medium Coarse Sand
Colour	Brownish
Thickness of Layer	1.50m
SPT of the layer	39
Relative Density	Dense
Angle of Shearing Resistance, ϕ	38.475^0

* **Layer-4 (from 4.00m to 6.00m depth)**

Type of Strata	Silty Fine to Medium Coarse Sand
Colour	Brownish
Thickness of Layer	2.00m
SPT of the layer	28
Relative Density	Medium Dense
Angle of Shearing Resistance, ϕ	35.40^0

* **Layer-5 (from 6.00m to 10.00m depth)**

Type of Strata	Silty Fine Sand
Colour	Brownish
Thickness of Layer	4.00m
SPT of the layer	91

Relative Density	Very Dense
Angle of Shearing Resistance, ϕ	42.50^0

Ground Water

Ground water table was encountered at a depth of 2.00m below the existing ground level during the first week of November 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 i.e. below 2.50m thick highly or medium plastic fine-grained soil strata are coarse-grained type and 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 2.50m 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 4.00m depths below existing ground level (SPT @ 4.50m is 28, Ref. BH-02) are within its safe bearing capacity limits.

Also, the sub-soil 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 (BH-01)

Considering the shear strength characteristics of coarse-grained soil strata encountered at shallow depths and presence of underlying relatively weak soil strata encountered at 4.00m below existing ground level, open foundation system of ***Isolated Column Footing*** *located at a design depth of 2.50m below present existing ground level can be adopted.*

The safe bearing capacity of open foundation system located at least recommended depth of 2.50m below E.G.L is computed and presented below which can be adopted for foundation design purposes.

Type of Open Foundation System	Total Depth of Excavations below Present Existing Ground Level (m)	Observed Maximum Thickness of Fill at Site (m)	Effective Depth of **Isolated Column Footing** below Existing Ground Level (m)	Type of Bearing Strata	Safe Bearing Capacity (MT/m^2)	Elastic Settlements (mm)
Isolated Column Footing	**2.50**	**1.00**	**1.50**	**Silty Sand**	**22**	**25**

The computations for above are annexed to this report.

Notes

Safe Bearing Capacity of open foundation system is restricted considering the impact of dispersed overlapping allowable stresses on underlying relatively weak soil strata encountered at 4.00m depths from existing ground level i.e. 1.50m distant apart from the bottom level of footing.

4.2.2 Deep Foundation System-9.00m 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 impending foundation stresses, deep foundation system consisting of 9.00m 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 9.00m 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 Head Group	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	9.00	400	30	30
2				450	34	34
3				500	38	38
4				550	41	41

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.

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 footing.
3. Care shall be taken so that the ultimate bearing strata are none other than recommended **"Silty Sand"** type. The same shall be confirmed by our Geo-Technical Engineer during open foundation excavations are under progress.
4. Safe Bearing Capacity of open foundation system is restricted considering the presence of underlying relatively weak soil strata encountered at 4.00m depths below existing ground level (SPT @ 4.50m is 28, Ref. BH-01) i.e. 1.50m distant apart from the bottom level of footing.
5. Excavated coarse-grained soil encountered below 1.00m thick filled up soil strata and 1.50m thick medium or highly plastic fine-grained soil strata can only be used for back-filling purposes.

Open Foundation Depths & Foundations Restrictions (if any)

6. Depth of open excavations below present existing ground level shall be 2.50m.
7. Observed Thickness of filled up soil @ Site is 1.00m. (Ref. BH-02)
8. Depth of Isolated Column Footing below natural ground level will be 1.50m.

Other Recommendations

9. 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.
10. **No structural units or members can be in direct contact of medium or highly plastic fine-grained soil strata. A 0.30m thick well compacted non-plastic soil shall be sand-witched in between to contain any volume change impact on the structural elements.**

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 **theoretical** safe load carrying capacities and shall be used as **allowable/design** load capacities on the pile under considerations. **(Note).**
14. 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.
15. Piles shall be installed using DMC (direct mud circulation) technique only.
16. Piles shall be grouped according to the column design load requirements.
17. Safe load carrying capacities of piles shall be limited to their structural capacities.

General

18. CNS can be non-plastic soil material like clean river sand or sand-gravels mix or M-Sand, etc. that shall be well compacted to achieve more than 95% of laboratory proctor density parameters.
19. As the chlorides and sulphates present in the water samples are, within the permissible limits, no special steel or cement is required to be used for **open** foundation construction purposes. **However, it is recommended to sample the water samples at different intervals from an open well or borewell and test for the desired parameters as per the required usages and also to understand that the water can be used for deep foundation construction purposes.**

For Geo Mines Engineers Pvt Ltd

Director

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

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 Column Footing	
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:	1.00	m
Effective Depth of Foundation below natural ground level (D_f):	1.50	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 : (considered based upon the density of the strata)	39	
Type of Shear Failure:	General	
Angle of Shearing Resistance - Limited to a Maximum of:	38.48	Deg.

1.3 Design Parameters:

Bulk Density of Soil above the foundation depth (γ_{bulk})	18.00	kN/m^3
Effective Overburden pressure at foundation level (q)	12.00	kPa
Water Table Correction Factor (w')	0.50	

Bearing Capacity Factors:

N_c = N/A
N_q = 54.78
N_γ = 90.69

Shape Factors:

S_c = N/A
S_q = 1.79
S_γ = 0.60

Depth Factors :

D_c = N/A
D_q = 1.00

D_γ = 1.00

Inclination Factor:

I_c = N/A

I_q = 1.00

I_γ = 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*γ*Nγ*Sγ*Dγ*Ig*w'

Q_u = 1424.54 kPa

1.5 Safe Bearing Capacity (Qsafe) :

Factor of Safety (F.S.) : 2.50

Qsafe : 569.82 kPa

Recommended Safe Bearing Capacity: 220.00 kPa

Restricted considering the presence of underlying relatively weak soil layer encountered at 4.00m depths from existing ground level i.e. 1.50m distant apart from the bottom level of footing.

1.6 Settlements

Since, the bearing strata are coarse-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 39 considering extent of pressure bulb below bottom level of footing are computed to be in the order of 25mm which is within the permissible limits of 50mm for isolated column footing as per I.S:1904.

DESIGN OF PILE FOUNDATION (BH-01)

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-II**

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:	86.67	kPa
R.L of top of Strata:	-0.50	m
R.L of bottom of Strata:	-2.00	m
Average Thickness of Strata,I_c:	1.50	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}:	10.50	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	5.25	kN/m^2
Adhesion,α:	0.40	
Skin Resistance of the pile,q_s:	65.35	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:	46	
Bulk Density of the strata,γ:	19	kN/m^3
Angle of Shearing Resistance,ϕ:	40.1	Deg.
R.L of top of Strata:	-2.00	m
R.L of bottom of Strata:	-4.00	m
Average Thickness of Strata,I_c:	2.00	m
Effective overburden pressure over the top of strata,σ_{top}:	10.50	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	28.50	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	19.50	kN/m^2
Coeff. Of Earth Pressure, k:	2.00	
Skin Resistance of the pile,q_s:	82.54	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:	29	
Bulk Density of the strata,γ:	18	kN/m^3
Angle of Shearing Resistance,ϕ:	35.7	Deg.
R.L of top of Strata:	-4.00	m
R.L of bottom of Strata:	-6.00	m
Average Thickness of Strata,I_c:	2.00	m
Effective overburden pressure over the top of strata,σ_{top}:	28.50	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	44.50	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	36.50	kN/m^2
Coeff. Of Earth Pressure, k:	1.50	
Skin Resistance of the pile,q_s:	98.88	kN
(q_s:σ*k*tanϕ*pi()*d*Ic)		

1.2.1.4 Layer-V

Type of Strata:	Silty Fine Sand	
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:	-6.00	m
R.L of bottom of Strata:	-9.00	m
Average Thickness of Strata,I_c:	3.00	m
Effective overburden pressure over the top of strata,σ_{top}:	44.50	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	74.50	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	59.50	kN/m^2
Coeff. Of Earth Pressure, k:	2.50	
Skin Resistance of the pile,q_s:	513.85	kN
(q_s:σ*k*tanϕ*pi()*d*Ic)		
Ultimate Skin Resistance,q_s:	**760.62**	**kN**

1.2.2 Computation of End Bearing Resistance:

Ultimate End Bearing Resistance (Qp) Neglected for Friciton l

Ultimate Load Carrying Capacity (Qu=Qs+Q_p)	**760.6**	**kN**
Safe Load Carrying Capacity (Qsafe =Qu/2.5)	**304.2**	**kN**
However, limit Q_{safe} to the structural capacity of pile:	**300.0**	**kN**

1.3.0

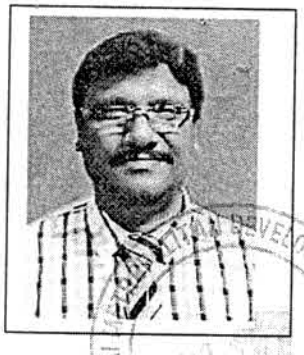
CHENNAI METROPOLITAN DEVELOPMENT AUTHORITY
'ThalamuthuNatarajan Building', No.1, Gandhi Irwin Road,
Egmore, Chennai-600 008.

PROFESSIONAL REGISTRATION CERTIFICATE

This is to certify that the **Thiru R.VENKATA KRISHNAIAH** has enrolled as **Registered Geo-Technical Engineer (RGTE)** with Chennai Metropolitan Development Authority (CMDA) who has the qualification of **M.E.,(Civil) - Geo Technical Engg.** and experience in the relevant field for **10 years**.

He has been given the Registration No.**GTE/19/07/032** on **05.07.2019.** He shall be required to comply with the duties and responsibilities prescribed by the Government of Tamil Nadu in Part-V, "Registration of Professionals", Tamil Nadu Combined Development and Building Rules, 2019 approved vide G.O.(Ms) No.18 MAWS (MA1) Dept. dated 04.02.2019.

This Registration is valid upto **04.07.2024**.



05/07/2019

(R.SHIVAKUMAR)

ASSISTANT PLANNER
CHENNAI METROPOLITAN DEVELOPMENT AUTHORITY
CHENNAI-600 008

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



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3/350/2 Mettukuppam,
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hello@verified.realestate
+91 9996 12 9996
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