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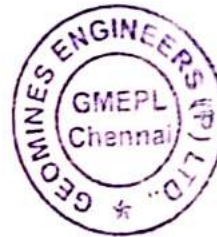


DISCLAIMER

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.



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CHAPTER-1

INTRODUCTION

1.0 Preamble

Yes Gee Constructions, Chennai proposed to construct a **Residential Building (Stilt+03)** at Door No: 15/8, 17(5/9), Mandapam Road 4th Street, Comprised in T.S.No: 55/76 & 55/97, Block No: 03 of Kilpauk Village, Egmore Taluk, Zone-8, Division-101, Greater Chennai Corporation.

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 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 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 results are presented in Table-2.3.

Project : Proposed Construction of Residential Building (Stilt+03) at Door No: 15/8, 17(5/9), Mandapam Road 4th Street, Comprised in T.S.No: 55/76 & 55/97, Block No: 03 of Kilpauk Village, Egmore Taluk, Zone-8, Division-101, Greater Chennai Corporation

Location: BH-01

Started On : 08/06/2023; Ended On : 08/06/2023 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				SPT - Graphical Representation										Relative Density/Consistency	Type of Sample																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
				Depth of SPT below E.G.L (m)	0-15 cm	15-30 cm	30-45 cm	N-Value																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							

Bore Hole Terminated at a depth of 10.20m below the existing ground level

Fig. 2.1 Soil Profile at BH-01 Location

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Location: BH-02

Started On : 10/09/2023; Ended On : 10/09/2023 G.W.T: 1.00m below existing ground level

R.L of Layer (m)	G.W.T. (m)	Soil Profile	Engineering Description of Soil	SPT - Details			Semi-logarithmic Representation of SPT Data										Relative Density/Consistency	Type of Sample							
				Depth of SPT below E.G.L (m)	0-15 cm	15-30 cm	30-45 cm	N-Value																	
G.W.T	↓		Brownish Medium Dense Silty Clayey Fine Sand	1.50	8	9	11	20											M Dense	SS					
4.00				3.00	8	9	12	21											M Dense	SS					
8.00			Yellowish Medium Dense Silty Fine Sand	4.50	9	9	12	21											M Dense	SS					
				6.00	13	13	14	27											M Dense	SS					
				7.50	7	7	17	24											M Dense	SS					
10.00			Yellowish Dense Silty Fine Sand	9.00	12	13	19	32											Dense	SS					
				10.00	15	16	19	35											Dense	SS					

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

Fig. 2.2 Soil Profile at BH-02 Location

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

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_p	FS		Gravel (%)	Coarse (%)	Medium (%)	Fine (%)	Silt (%)	Clay (%)	
0.00 to 2.00	6	SS	Silty Sandy Clay	36	1.5	58	23	35	0.63	9	M.Stiff	0	0	0	7	9	84	CH
2.00 to 4.00	11	SS	Silty Fine Sand	-	1.5	-	-	-	-	-	Loose	0	0	0	73	27	0	SM
4.00 to 5.50	24	SS	Silty Fine Sand	-	1.7	-	-	-	-	-	M.Dense	0	0	0	81	19	0	SM
5.50 to 7.00	13	SS	Silty Fine Sand	-	1.5	-	-	-	-	-	Loose	0	0	0	78	22	0	SM
7.00 to 9.50	19	SS	Silty Fine Sand	-	1.6	-	-	-	-	-	M.Dense	0	0	0	80	20	0	SM
9.50 to 10.20	36	SS	Silty Fine Sand	-	1.9	-	-	-	-	-	Dense	0	0	6	73	21	0	SM

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

Depth of Sample below F.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 4.00	20	SS	Silty Clayey Fine Sand	-	1.6	-	-	-	-	-	M.Dense	0	0	0	67	13	20	SM
4.00 to 8.00	24	SS	Silty Fine Sand	-	1.7	-	-	-	-	-	M.Dense	0	0	0	78	22	0	SM
8.00 to 10.00	32	SS	Silty Fine Sand	-	1.9	-	-	-	-	-	Dense	0	0	0	81	19	0	SM

Table 2.3: Chemical Analysis Results conducted on Water Samples collected from BH-01 and BH-02				
Location	Depth of Sample below E.G.L. (m)	pH	Chlorides (ppm)	Sulphates (ppm)
BH-01	3.00	6.78	300.18	145.83
BH-02	3.00	6.79	291.91	142.95

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-03 Location

(At BH-03 Location, as presented in Site plan)

- * **Layer-1 (from 0.00m to 2.00m depth)**

Type of Strata	Silty Sandy Clay
Colour	Brownish
Thickness of Layer	2.00m
SPT of the layer	06
Consistency	Medium Stiff
Un-drained Cohesion, Cu	40.00kPa
- * **Layer-2 (from 2.00m to 4.00m depth)**

Type of Strata	Silty Fine Sand
Colour	Brownish
Thickness of Layer	2.00m
SPT of the layer	11
Relative Density	Loose
Angle of Shearing Resistance, ϕ	30.30°
- * **Layer-3 (from 4.00m to 5.50m depth)**

Type of Strata	Silty Fine Sand
Colour	Yellowish
Thickness of Layer	1.50m
SPT of the layer	24
Relative Density	Medium Dense
Angle of Shearing Resistance, ϕ	34.20°

* **Layer-4 (from 5.50m to 7.00m depth)**

Type of Strata	Silty Fine Sand
Colour	Yellowish
Thickness of Layer	1.50m
SPT of the layer	13
Relative Density	Loose
Angle of Shearing Resistance, ϕ	30.90°

* **Layer-5 (from 7.00m to 9.50m depth)**

Type of Strata	Silty Fine Sand
Colour	Yellowish
Thickness of Layer	2.50m
SPT of the layer	19
Relative Density	Medium Dense
Angle of Shearing Resistance, ϕ	32.70°

* **Layer-6 (from 9.50m to 10.20m depth)**

Type of Strata	Silty Fine Sand
Colour	Yellowish
Thickness of Layer	0.70m
SPT of the layer	36
Relative Density	Dense
Angle of Shearing Resistance, ϕ	37.65°

Ground Water

Ground water table was encountered at a depth of 2.00m below the existing ground level during the second week of June 2023.

3.1.2 Soil Profile at BH-04 Location

(At BH-04 Location, as presented in Site plan)

* **Layer-1 (from 0.00m to 4.00m depth)**

Type of Strata	Silty Clayey Fine Sand
Colour	Brownish
Thickness of Layer	4.00m
SPT of the layer	20
Relative Density	Medium Dense
Angle of Shearing Resistance, ϕ	33.00°

* **Layer-2 (from 4.00m to 8.00m depth)**

Type of Strata	Silty Fine Sand
Colour	Yellowish
Thickness of Layer	4.00m
SPT of the layer	24
Relative Density	Medium Dense
Angle of Shearing Resistance, ϕ	34.20°

* **Layer-3 (from 8.00m to 10.00m depth)**

Type of Strata	Silty Fine Sand
Colour	Yellowish
Thickness of Layer	2.00m
SPT of the layer	32
Relative Density	Dense
Angle of Shearing Resistance, ϕ	36.55°

Ground Water

Ground water table was encountered at a depth of 1.00m below the existing ground level during the second week of September 2023.

CHAPTER-4

FOUNDATION SYSTEM

4.0 Preamble

The foundation system design is an interface between super structure and the sub soil bearing strata characteristics. A sound foundation system should be safe against bearing strata shear response under the super structure load intensity. Similarly, the stability of the foundation system is governed by the bearing strata deformation response under the super structure load intensity. In addition, as a combined system of super structure and foundation, the overall stability is also governed by the super structure arrangement. Considering the above aspects of foundation design, the suitable type of foundation system with respect to the sub soil conditions encountered at the borehole locations is presented in the subsequent sections.

4.1 Bearing Strata Characteristics

From field investigations, it can be observed that the sub-soil strata encountered at shallow depths are uniformly stratified from type but possess varying shear strength characteristics, BH-01 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-01 as design borehole, it can further be envisaged that the coarse-grained soil strata encountered below 2.00m thick highly plastic fine-grained soil strata will hold good to act as bearing strata from shear strength characteristics and deformation considerations for presumptive column loads in the range of 600kN to 700kN respectively.

If coarse-grained soil strata encountered uniformly 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 foundation and effective overburden pressure over the bearing strata.

Considering the above, suitable foundation system is 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 below 2.00m depths from present existing ground level, open foundation system of **Isolated Column Footing** type located at a design depth of 2.50m below present existing ground level (EGL) 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 <u>Isolated Column Footing</u> below Present Existing Ground Level (m)	Type of Bearing Strata	Safe Bearing Capacity (MT/m ²)	Elastic Settlements (mm)
<u>Isolated Column Footing</u>	2.50	0.00	2.50	Silty Fine Sand	12	48

The computations for above are annexed to this report.

CHAPTER 5

CONCLUSIONS & RECOMMENDATIONS

1. Open Foundation system presented in Clause 4.2.1. Chapter-IV can be adopted for foundation design purposes.
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. **In no case, the least depth of foundation system can be less than 2.50m below present existing ground level.**
4. Care shall be taken so that the ultimate bearing strata are none other than coarse-grained "Silty Fine Sand" type.
5. **Excavated highly plastic fine-grained soil strata encountered up to 2.00m depths from present existing ground level shall be in no case used for back filling purposes.**
6. **No structural units can be in direct contact of highly plastic fine-grained soil strata encountered at shallow depths. A 0.30m thick CNS soil layer is recommended to be sand-witched in between.**
7. **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.**
8. Special provisions to contain any lateral collapse of soil from the walls excavated foundation pits are required.
9. In case, the 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.
10. CNS can be non-plastic coarse-grained soil material like fly-ash, sand-gravels mix or quarry dust, etc.

11. 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

h. a. a.

DESIGN OF OPEN FOUNDATION SYSTEM (Ref.BH-01)

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
Depth of Foundation below existing ground level (D_f):	2.50 m
Anticipated Depth of Soil Liquefaction:	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 :	11
(considered based upon the density of the strata)	
Type of Shear Failure:	General
Angle of Shearing Resistance - Limited to a Maximum of:	30.30 Deg.

1.3 Design Parameters:

Bulk Density of Soil above the foundation depth (γ_{bulk})	15.00 kN/m ³
Effective Overburden pressure at foundation level (q)	12.50 kPa
Water Table Correction Factor (w')	0.50

Bearing Capacity Factors:

$$N_c = N/A$$

$$N_q = 19.29$$

$$N_\gamma = 23.94$$

Shape Factors:

$$S_c = N/A$$

$$S_q = 1.58$$

$$S_\gamma = 0.60$$

Depth Factors :

$$D_c = N/A$$

$$D_q = 1.00$$

$$D_r = 1.00$$

Inclination Factor:

$$I_c = N/A$$

$$I_q = 1.00$$

$$I_\gamma = 1.00$$

1.4 Ultimate Bearing Capacity (Q_u) :

$$Q_u = C_u * N_c * S_c * D_c * I_c + q * (N_q - 1) * S_q * D_q * I_q + 0.5 * B * \gamma * N_\gamma * S_\gamma * D_\gamma * I_\gamma * w'$$

$$Q_u = 435.97 \text{ kPa}$$

1.5 Safe Bearing Capacity (Q_{safe}) :

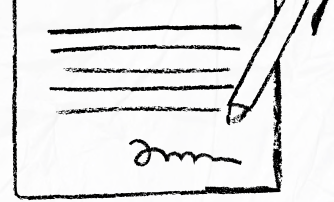
$$\text{Factor of Safety (F.S.) : } 2.50$$

$$Q_{safe} : 174.39 \text{ kPa}$$

$$\text{Recommended Safe Bearing Capacity: } 120.00 \text{ kPa}$$

1.6 Settlements

Since, the bearing strata are coarse-grained type, the settlements under the allowable safe bearing pressure 120kPa will be of immediate elastic nature. The elastic settlements corresponding to a safe bearing pressure of 120kPa and average SPT of 11 considering extent of pressure bulb below bottom level of footing are computed to be in the order of 48mm which is within the permissible limits of 50mm for Isolated Column Footings as per I.S:1904.



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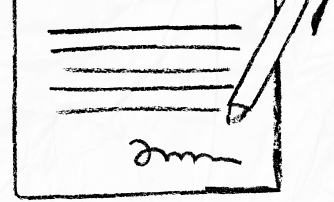
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We're honored to be part of your
real estate journey

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