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CONSULTANTS	**GEO MINES ENGINEERS PVT. LTD.** **GEOTECHNICAL ENGINEERING DIVISION,** **NO: 96, 3RD FLOOR, VELLALAR STREET,** **MOGAPPAIR WEST, CHENNAI-37** **Ph. No. 98413 16631, 9840157478** **Hello: 9840496660** **Email : geomines@gmail.com, gmepl77@gmail.com** **Website: www.geominesengineers.com**
CLIENT	**Mr. R. MURALI, CHENNAI**
PROJECT	**PROPOSED CONSTRUCTION OF RESIDENTIAL BUILDING (G+04) AT SURVEY NO: 26/1 PART & 26/2 PART, (AS PER DOCUMENT) S.NO: 26/1B1, 26/1B2 & 26/2B (AS PER PATTA) KOLAPAKKAM MAIN ROAD, CHENNAI-600122**
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 PVT. LTD. GMEPL Chennai

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Dr. R. Venkat... Regd. No. ... 4th Street, ...

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Dr. R. Venkata Krishnaiah M.E., PhD.,
Geotechnical Expert,
Regd. No. GTE/19/07/032
No. 7/4, Munavar Avenue,
4th Street, Pallavaram, Chennai -43

CHAPTER-1

INTRODUCTION

1.0 Preamble

Mr. R. Murali proposed to construct a **Residential Building (G+04) at Survey No: 26/1 Part & 26/2 Part, (As per Document) & S.No: 26/1B1, 26/1B2 & 26/2B (As per Patta), Kolapakkam Main Road, Chennai – 600122.**

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 Three Standard Soil investigation bore holes of 150mm diameter up to a depth of 20.00m 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)

Dr. R. Venkata Krishnaiah M.E., Ph.D.
Geotech. Eng. Consultant,
Regd. No. GTE/2007/032
No. 7/4, Munuswamy Street,
4th Street, Pallavaram, Chennai-43

CHAPTER-2

INVESTIGATION METHODOLOGY & TEST RESULTS

2.0 Field Testing:

2.1 Preamble:

Three 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.

Dr. R. Venkat... Geotech...
Regd. No. G... 332
No. 7/4, Mun... Avenue,
4th Street, Pallavaram, Chennai-43

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 locations are shown in Figs.2.1 to 2.2.

2.6 Laboratory Testing:

2.6.1 Coarse Grained Samples:

2.6.1.1 Grain size Analysis Tests:

On the coarse grained samples, grain size distribution tests were conducted as per I.S.2720 (Part 4)-1985, to know the gradation characteristics and to classify them. These results are presented in Tables 2.1 to 2.3.

2.6.2 Fine Grained Samples:

2.6.2.1 Index Property – Free Swell Tests:

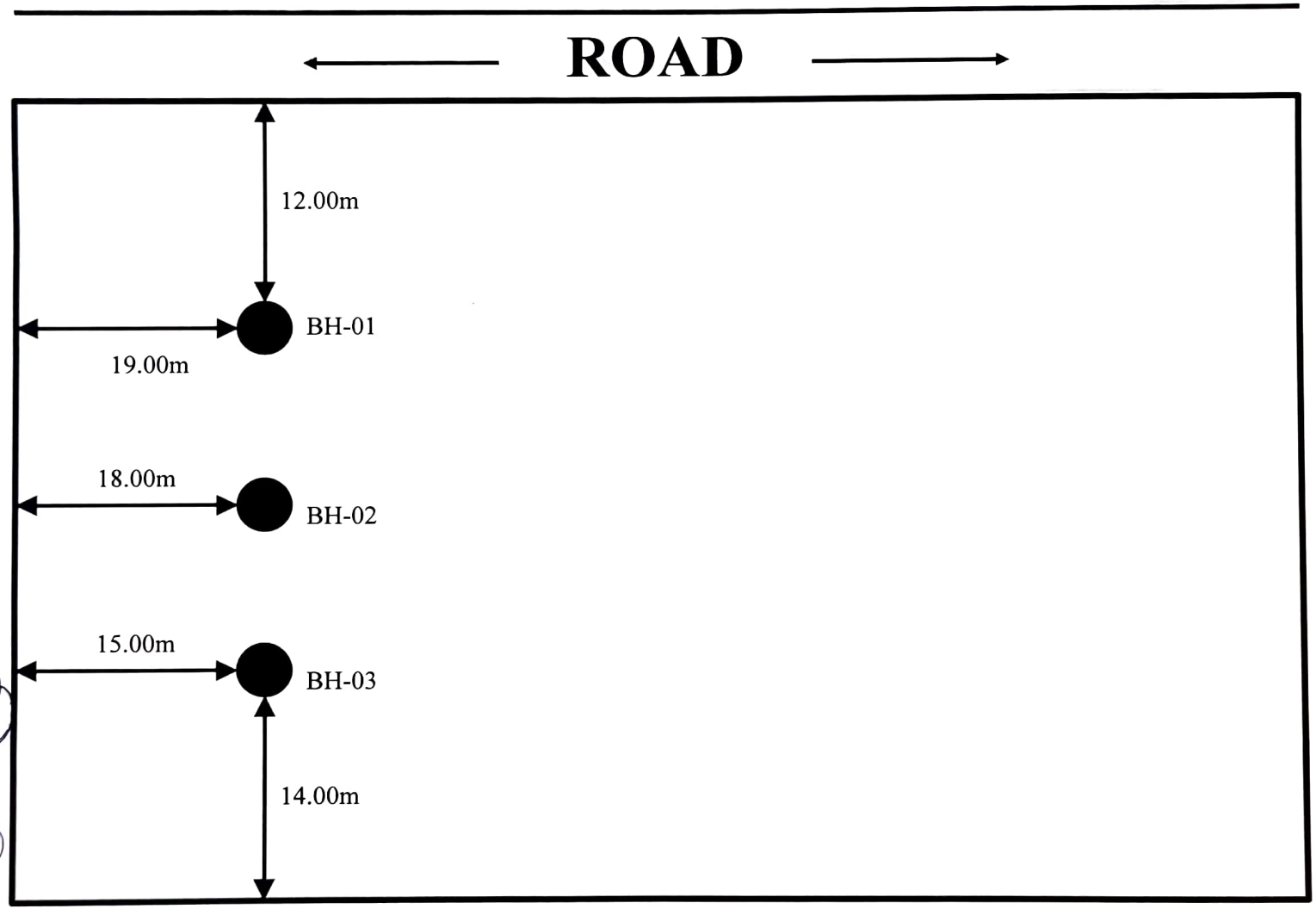
Atterberg Limits were carried out on fine grained soil samples to evaluate the limits of different consistency states. Generally Liquid limits, Plastic limits and Shrinkage Limits tests were conducted as per I.S.2720 (Part-5)-1985 and I.S.2720 (Part 6)-1972. On such type of soil strata encountered at the investigation locations, such tests were conducted and the test results are presented in Tables 2.1 to 2.3.

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-2.4.

Dr. R. Venkata Krishnaiah M.E., Ph.D.,
Geotechnical Expert
Regd. No. GTE/[illegible]/032
No. 7/4, Munavar Avenue,
4th Street, Pallavaram, Chennai -43



Dr. R. Venkatesh
Geotechnical Engineer
Regd. No. GTE/0077/32
No. 7/2, Muneswar Avenue,
4th Street, Pallavaram, Chennai-43

Project : Proposed Construction of Residential Building (G+04) at Survey No: 26/1 Part & 26/2 Part, (As per Document) & S.No: 26/1B1, 26/1B2 & 26/2B (As per Patta), Kolapakkam Main Road, Chennai – 600122.

Location: BH-01

Started On : 25/07/2017; Ended On : 25/07/2017 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	Graphical Representation of SPT (0 10 20 30 40 50 60 70 80 90)	Relative Density/Consistency	Type of Sample
G.W.T	↓		Brownish Loose Silty Fine Sand	1.50	10	7	4	11		Loose	SS
				3.00	4	9	5	14		Loose	SS
4.00											
			Blackish Medium Stiff Silty Clay	4.50	2	2	4	6		M.Stiff	SS
				6.00	1	3	5	8		M.Stiff	SS
7.00											
			Blackish Very Soft Silty Clay	7.50	2	1	1	2		V.Soft	SS
				9.00	0	1	1	2		V.Soft	SS
10.00											
			Blackish Medium Stiff Silty Clay	10.50	2	3	3	6		M.Stiff	SS
				12.00	1	1	4	5		M.Stiff	SS
13.00											
			Blackish Soft Silty Clay	14.00	1	2	2	4		Soft	SS
15.00											
			Blackish Dense Cemented Sand	16.00	4	9	22	31		Dense	SS
17.00											
			Blackish Very Dense Cemented Sand	18.00	39	8cms Penetration for 50 Blows				V.Dense	SS
18.20											

Bore Hole Terminated at a depth of 18.20m below the existing ground level

Fig. 2.1 Soil Profile at BH-01 Location

Dr. R. Venkata Krishnaiah M.E., Ph.D.,
Geotechnical Engineer
Regd. No. GTE/ [illegible]
No. 7/4, Munaval Avenue,
4th Street, Pallavaram, Chennai-43

Project : Proposed Construction of Residential Building (G+04) at Survey No: 26/1 Part & 26/2 Part, (As per Document) & S.No: 26/1B1, 26/1B2 & 26/2B (As per Patta), Kolapakkam Main Road, Chennai – 600122.

Location: BH-02

Started On : 26/07/2017; Ended On : 26/07/2017 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	Graphical Representation of SPT (0 10 20 30 40 50 60 70 80 90)	Relative Density/Consistency	Type of Sample
	G.W.T		Brownish Medium Dense Silty Fine Sand	1.50	7	11	13	24		M.Dense	SS
				3.00	5	8	11	19		M.Dense	SS
4.00											
			Blackish Medium Stiff Silty Clay	4.50	2	3	3	6		M.Stiff	SS
				6.00	5	3	4	7		M.Stiff	SS
6.50											
			Brownish Loose Silty Fine to Medium Coarse Sand	7.50	2	4	5	9		Loose	SS
8.00											
			Brownish Medium Dense Silty Fine to Medium Coarse Sand	9.00	13	7	11	18		M.Dense	SS
9.50											
			Brownish Dense Silty Fine to Medium Coarse Sand	10.50	10	17	19	36		Dense	SS
10.70											

Bore Hole Terminated at a depth of 10.70m below the existing ground level

Fig. 2.2 Soil Profile at BH-02 Location

Dr. R. Venkata [illegible]
Geotech[illegible]
Regd. No. G[illegible]
No. 7/4, Munaval[illegible],
4th Street, Pallavaram, Chennai-43

Project : Proposed Construction of Residential Building (G+04) at Survey No: 26/1 Part & 26/2 Part. (As per Document) & S.No: 26/1B1, 26/1B2 & 26/2B (As per Patta), Kolapakkam Main Road, Chennai – 600122.

Location: BH-03

Started On : 27/07/2017; Ended On : 28/07/2017 G.W.T: 1.75m 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 SPT (### 10 20 30 40 50 60 70 80 90)	Relative Density/Consistency	Type of Sample
G.W.T 2.50			Brownish Medium Dense Silty Fine Sand	1.50	4	7	9	16		M.Dense	SS
				3.00	3	5	2	7		M.Stiff	SS
5.50			Blackish Medium Stiff Silty Clay	4.50	2	3	3	6		M.Stiff	SS
7.00			Blackish Soft Silty Clay	6.00	1	1	3	4		Soft	SS
8.50			Blackish Medium Stiff Silty Clay	7.50	2	3	2	5		M.Stiff	SS
10.00			Brownish' Loose Silty Fine Sand	9.00	3	4	3	7		Loose	SS
11.50			Brownish' Medium Dense Silty Fine Sand	10.50	4	14	15	29		M.Dense	SS
				12.00	8	14	19	33		Dense	SS
15.00			Brownish Dense Silty Fine Sand	14.00	11	14	18	32		Dense	SS
17.00			Blackish Medium Stiff Silty Clay	16.00	2	3	5	8		M.Stiff	SS
				18.00	19	27	31	58		V.Dense	SS
20.00			Weathered Rock	20.00	07cms Penetration for 50 Blows					V.Dense	SS

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

Fig. 2.3 Soil Profile at BH-03 Location

Dr. R. Venkat... Geotech...
Regd. No. ...
No. 7/4, Mun... Avenue,
4th Street, Pallavaram, Chennai -...

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 4.00	12	SS	Silty Fine Sand	-	1.5	-	-	-	-	-	Loose	0	0	0	77	23	0	SM
4.00 to 7.00	7	SS	Silty Clay	29	1.6	82	16	66	0.8	-	M.Stiff	0	0	0	0	16	84	CH
7.00 to 10.00	2	SS	Silty Clay	68	1.2	96	15	81	0.3	-	V.Soft	0	0	0	0	12	88	CH
10.00 to 13.00	5	SS	Silty Clay	44	1.5	88	21	67	0.7	-	M.Stiff	0	0	0	0	15	85	CH
13.00 to 15.00	4	SS	Silty Clay	47	1.4	80	18	62	0.5	-	Soft	0	0	0	0	13	87	CH
15.00 to 17.00	31	SS	Cemented Sand	-	1.9	-	-	-	-	-	Dense	0	0	21	58	11	10	SM
17.00 to 18.20	>100	SS	Cemented Sand	-	2.0	-	-	-	-	-	V.Dense	0	24	13	41	8	14	SM

Dr. R. Venkata Krishnaiah
Geotech Engineer
Regd. No. GTE-0007-032
No. 7/4, Munuswamy Avenue,
4th Street, Pallavaram, Chennai-43

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 4.00	21	SS	Silty Fine Sand	-	1.7	-	-	-	-	-	M.Dense	0	0	0	81	19	0	SM
4.00 to 6.50	6	SS	Silty Clay	36	1.5	82	16	66	0.7	-	M.Stiff	0	0	0	0	16	84	CH
6.50 to 8.00	9	SS	Silty Fine to Medium Coarse Sand	-	1.5	-	-	-	-	-	Loose	0	0	11	66	23	0	SM
8.00 to 9.50	18	SS	Silty Fine to Medium Coarse Sand	-	1.6	-	-	-	-	-	M.Dense	0	0	31	47	22	0	SM
9.50 to 10.70	36	SS	Silty Fine to Medium Coarse Sand	-	1.9	-	-	-	-	-	Dense	0	19	21	47	13	0	SM

Dr. R. Venkata Krishnaiah
Geotechnical Engineer
Regd. No. GTE/A/0732
No. 7/4, Munuswamy Avenue,
4th Street, Pallavaram, Chennai-43

Table 2.3: Laboratory Test Result on the Soil Sample Collected from BH-03

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 2.50	16	SS	Silty Fine Sand	-	1.6	-	-	-	-	-	M.Dense	0	0	0	83	17	0	SM
2.50 to 5.50	6	SS	Silty Clay	36	1.5	85	16	69	0.7	-	M.Stiff	0	0	0	0	11	89	CH
5.50 to 7.00	4	SS	Silty Clay	59	1.4	97	22	75	0.5	-	Soft	0	0	0	0	14	86	CH
7.00 to 8.50	5	SS	Silty Clay	46	1.5	85	21	64	0.6	-	M.Stiff	0	0	0	0	13	87	CH
8.50 to 10.00	7	SS	Silty Fine Sand	-	1.5	-	-	-	-	-	Loose	0	0	0	69	31	0	SM
10.00 to 11.50	29	SS	Silty Fine Sand	-	1.8	-	-	-	-	-	M.Dense	0	0	0	81	19	0	SM
11.50 to 15.00	32	SS	Silty Fine Sand	-	1.9	-	-	-	-	-	Dense	0	0	0	85	15	0	SM
15.00 to 17.00	8	SS	Silty Clay	33	1.6	88	21	67	0.8	-	M.Stiff	0	0	0	0	14	86	CH
17.00 to 20.00	>100	SS	Weathered Rock	-	2.0	-	-	-	-	-	V.Dense	33	26	14	16	11	0	SDR

Dr. R. Venkata Krishnaiah M.E., Ph.D.
Geotech Engineer
Regd. No. GTE-167/032
No. 774, Munavar Avenue,
4th Street, Pallavaram, Chennai-43

Table 2.4: Chemical Analysis Results conducted on Water Samples collected from BH-01 to BH-03

Location	Depth of Sample below E.G.L. (m)	pH	Chlorides (ppm)	Sulphates (ppm)
BH-01	3.00	7.76	313.05	352.18
BH-02	3.00	7.76	321.47	361.65
BH-03	3.00	7.76	318.51	358.32

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

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 4.00m depth)**

Type of Strata	Silty Fine Sand
Colour	Brownish
Thickness of Layer	4.00m
SPT of the layer	12
Relative Density	Loose
Angle of Shearing Resistance, ϕ	30.60^0

* **Layer-2 (from 4.00m to 7.00m 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	46.67kPa

* **Layer-3 (from 7.00m to 10.00m depth)**

Type of Strata	Silty Clay
Colour	Blackish
Thickness of Layer	3.00m
SPT of the layer	02
Consistency	Very Soft
Un-drained Cohesion, Cu	13.33kPa

Dr. R. Venkata Krishnaiah
Geotechnical Expert
Regd. No. GTE/9907/032
No. 7/4, Munavar Avenue,
4th Street, Pallavaram, Chennai-43

* **Layer-4 (from 10.00m to 13.00m depth)**

Type of Strata	Silty Clay
Colour	Blackish
Thickness of Layer	3.00m
SPT of the layer	05
Consistency	Medium Stiff
Un-drained Cohesion, Cu	33.33kPa

* **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	04
Consistency	Soft
Un-drained Cohesion, Cu	26.67kPa

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

Type of Strata	Cemented Sand
Colour	Blackish
Thickness of Layer	2.00m
SPT of the layer	31
Relative Density	Dense
Angle of Shearing Resistance, ϕ	31.265^0

* **Layer-7 (from 17.00m to 18.00m depth)**

Type of Strata	Cemented Sand
Colour	Blackish
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 2.00m below the existing ground level during the last week of July 2017.

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 4.00m depth)**

Type of Strata	Silty Fine Sand
Colour	Brownish
Thickness of Layer	4.00m
SPT of the layer	21
Relative Density	Medium Dense
Angle of Shearing Resistance, ϕ	33.33^0

* **Layer-2 (from 4.00m to 6.50m depth)**

Type of Strata	Silty Clay
Colour	Blackish
Thickness of Layer	2.50m
SPT of the layer	06
Consistency	Medium Stiff
Un-drained Cohesion, Cu	40.00kPa

Dr. R. Venka... M.E., Ph.D.,
Geotech...
Regd. No. GT...
No. 7/4, Munavar Avenue,
4th Street, Pallavaram, Chennai -43

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

Type of Strata	Silty Fine to Medium Coarse Sand
Colour	Brownish
Thickness of Layer	1.50m
SPT of the layer	09
Relative Density	Loose
Angle of Shearing Resistance, ϕ	29.80^0

* **Layer-4 (from 8.00m to 9.50m depth)**

Type of Strata	Silty Fine to Medium Coarse Sand
Colour	Brownish
Thickness of Layer	1.50m
SPT of the layer	18
Relative Density	Medium Dense
Angle of Shearing Resistance, ϕ	32.40^0

* **Layer-5 (from 9.50m to 10.50m depth)**

Type of Strata	Silty Fine to Medium Coarse Sand
Colour	Brownish
Thickness of Layer	1.00m
SPT of the layer	36
Relative Density	Dense
Angle of Shearing Resistance, ϕ	37.65^0

Ground Water

Ground water table was encountered at a depth of 2.00m below the existing ground level during the last week of July 2017.

3.1.3 Soil Profile at BH-03 Location
(At BH-03 Location, as presented in Site plan)

* **Layer-1 (from E.G.L to 2.50m depth)**

Type of Strata	Silty Fine Sand
Colour	Brownish
Thickness of Layer	2.50m
SPT of the layer	16
Relative Density	Medium Dense
Angle of Shearing Resistance, ϕ	31.80^0

* **Layer-2 (from 2.50m to 5.50m 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

* **Layer-3 (from 5.50m to 7.00m depth)**

Type of Strata	Silty Clay
Colour	Blackish
Thickness of Layer	1.50m

Dr. R. Venkata
Rego. No.
No. 7/4, Mu
4th Street, Pallava

SPT of the layer	04
Consistency	Soft
Un-drained Cohesion, Cu	26.67kPa

* **Layer-4 (from 7.00m to 8.50m depth)**

Type of Strata	Silty Clay
Colour	Blackish
Thickness of Layer	1.50m
SPT of the layer	05
Consistency	Medium Stiff
Un-drained Cohesion, Cu	33.33kPa

* **Layer-5 (from 8.50m to 10.00m depth)**

Type of Strata	Silty Fine Sand
Colour	Brownish
Thickness of Layer	1.50m
SPT of the layer	07
Relative Density	Loose
Angle of Shearing Resistance, ϕ	29.40^0

* **Layer-6 (from 10.00m to 11.50m depth)**

Type of Strata	Silty Fine Sand
Colour	Brownish
Thickness of Layer	1.50m
SPT of the layer	29
Relative Density	Medium Dense
Angle of Shearing Resistance, ϕ	35.70^0

* **Layer-7 (from 11.50m to 15.00m depth)**

Type of Strata	Silty Fine Sand
Colour	Brownish
Thickness of Layer	3.50m
SPT of the layer	32
Relative Density	Dense
Angle of Shearing Resistance, ϕ	36.55^0

* **Layer-8 (from 15.00m to 17.00m 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-9 (from 17.00m to 20.00m depth)**

Type of Strata	Weathered Rock
Colour	-
Thickness of Layer	3.00m
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 1.75m below the existing ground level during the last week of July 2017.

Dr. R. Venkata Krishnaiah M.E., Ph.D.,
Geotechnical Engineer
Regd. No. GTE/S/C7/032
No. 7/4, Munavar Avenue,
4th Street, Pallavaram, Chennai -43

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 weak from both shear strength characteristics and deformation considerations and hence cannot be considered as bearing strata for proposed impending loads from structure.

However, the sub-soil strata encountered uniformly below 17.00m depths from existing ground level are good to be considered as end bearing strata for proposed impending loads from structure.

Considering the above, suitable foundation system is presented below.

4.2 Foundation System

4.2.1 Deep Foundation System-19.00m long Bored Cast-in-Situ Friction cum End Bearing Piles

Considering the weak shear strength characteristics of sub-soil strata encountered at shallow depths, deep foundation system consisting of 19.00m long bored cast-in-situ Friction cum End Bearing Piles can be adopted.

Piles shall be drilled through DMC (direct mud circulation) technique.

For four different diameters, the safe load carrying capacities of 19.00m long bored cast-in-situ Friction cum End Bearing Piles are computed and presented below which can be adopted for foundation design purposes.

Dr. R. Venkatesh
Regd. No. GTE
No. 7/4, Muniyan Avenue,
4th Street, Pallavaram, Chennai-43

S. No	Type of Installation of Pile	Length of Pile below Existing Ground Level (m)	Diameter of Pile (mm)	Safe Load Carrying Capacity (t)	Safe Pull Out Capacity (t)
1	Bored Cast-in-Situ	19.00	450	60	29
2			500	70	32
3			550	80	35
4			600	90	38

The computations of safe load carrying capacity for 450mm diameter and 19.00m long bored cast-in-situ Friction cum End Bearing pile are annexed to this 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

CHAPTER-5

CONCLUSIONS & RECOMMENDATIONS

1. Deep foundation system presented in Clause 4.2.1, Chapter-IV can be adopted for foundation design purposes.
2. Suitable pile load tests (as per I.S: 2911, part-IV) shall be performed to confirm the presented safe load carrying capacities **(provisional)**.
3. Pile cap can be located over 0.30m thick well compacted ground replaced CNS (Cohesive Non-Swelling) soil surface.
4. **CNS can be non-plastic clean river sand or quarry dust or fly-ash or sand-gravels mix.**
5. Piles shall be grouped according to the column design load requirements.
6. Safe load carrying capacities of piles shall be limited to their structural capacities.
7. Care shall be taken so that the ultimate end bearing strata are none other than "Cemented Sand" or "Weathered Rock" type only.

General

8. As the chlorides and sulphates present in water samples are within the permissible limits, no special steel or cement is recommended to be used for foundation construction purposes. **However, it is recommended to test the water samples at deeper levels from a dug-well or an open well to establish the parameters as per the requirements of the proposed structure.**

For Geo Mines Engineers Pvt. Ltd.

Director

Dr. R. Venkata Krishnaiah
Geotech
Regd. No. GTE
No. 7/4, Munavar Avenue,
4th Street, Pallavaram, Chennai-43

DESIGN OF PILE FOUNDATION (Ref.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):	**450.0**	mm
Assumed R.L of E.G.L:	0.000	m
Length of pile below E.G.L.(l) :	**19.000**	m
R.L. of Bot. of Pile	-19.00	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 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:	0.00	m
R.L of bottom of Strata:	-4.00	m
Average Thickness of Strata,l_c:	4.00	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}:	20.00	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	10.00	kN/m^2
Coeff. Of Earth Pressure, k:	1.00	
Skin Resistance of the pile,q_s:	33.44	kN

(q_s:σ*k*tanϕ*pi()*d*lc)

1.2.1.2 **Layer-II**

Type of Strata:	Silty Clay	
Average SPT of the strata,N:	7	
Bulk Density of the strata,γ:	16	kN/m^3
Undrained Cohesion, Cu:	46.6667	kPa
R.L of top of Strata:	-4.00	m
R.L of bottom of Strata:	-7.00	m
Average Thickness of Strata,l_c:	3.00	m
Effective overburden pressure over the top of strata,σ_{top}:	20.00	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	38.00	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	29.00	kN/m^2
Adhesion Factor, α:	0.60	
Skin Resistance of the pile,q_s:	118.75	kN

(q_s:α*Cu*pi()*d*lc)

Dr. R. Venkata [illegible]
Geotech [illegible]
Regd. No. GTE[illegible]/07/032
No. 7/4, Munavar Avenue,
4th Street, Pallavaram, Chennai -43

1.2.1.3

Layer-III

Type of Strata:	Silty Clay	
Average SPT of the strata,N:	2	
Bulk Density of the strata,γ:	12	kN/m^3
Undrained Cohesion, Cu:	13.3333	kPa
R.L of top of Strata:	-7.00	m
R.L of bottom of Strata:	-10.00	m
Average Thickness of Strata,I_c:	3.00	m
Effective overburden pressure over the top of strata,σ_{top}:	38.00	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	44.00	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	41.00	kN/m^2
Adhesion Factor, α:	1.00	
Negative Skin Resistance of the pile,q_s:	**-56.55**	**kN**

(q_s:α*Cu*pi()*d*Ic)

1.2.1.4

Layer-IV

Type of Strata:	Silty Clay	
Average SPT of the strata,N:	5	
Bulk Density of the strata,γ:	15	kN/m^3
Undrained Cohesion, Cu:	33.3333	kPa
R.L of top of Strata:	-10.00	m
R.L of bottom of Strata:	-13.00	m
Average Thickness of Strata,I_c:	3.00	m
Effective overburden pressure over the top of strata,σ_{top}:	44.00	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	59.00	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	51.50	kN/m^2
Adhesion Factor, α:	0.70	
Skin Resistance of the pile,q_s:	98.96	kN

(q_s:α*Cu*pi()*d*Ic)

1.2.1.5

Layer-V

Type of Strata:	Silty Clay	
Average SPT of the strata,N:	4	
Bulk Density of the strata,γ:	14	kN/m^3
Undrained Cohesion, Cu:	26.6667	kPa
R.L of top of Strata:	-13.00	m
R.L of bottom of Strata:	-15.00	m
Average Thickness of Strata,I_c:	2.00	m
Effective overburden pressure over the top of strata,σ_{top}:	59.00	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	67.00	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	63.00	kN/m^2
Adhesion Factor, α:	1.00	
Negative Skin Resistance of the pile,q_s:	**-75.40**	**kN**

(q_s:α*Cu*pi()*d*Ic)

Dr. R. Venkata [illegible]
Geotech [illegible]
Regd. No. G[illegible]
No. 7/4, Muna[illegible] Avenue,
4th Street, Pallavaram, Chennai-43

1.2.1.6 **Layer-VI**

Type of Strata:	Cemented Sand	
Average SPT of the strata,N:	31	
Bulk Density of the strata,γ:	19	kN/m^3
Angle of Shearing Resistance,ϕ:	36.275	Deg.
R.L of top of Strata:	-15.00	m
R.L of bottom of Strata:	-17.00	m
Average Thickness of Strata,I_c:	2.00	m
Effective overburden pressure over the top of strata,σ_{top}:	67.00	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	85.00	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	76.00	kN/m^2
Coeff. Of Earth Pressure, k:	2.00	
Skin Resistance of the pile,q_s:	315.41	kN
(q_s:σ*k*tanϕ*pi()*d*Ic)		

1.2.1.7 **Layer-VII**

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:	-17.00	m
R.L of bottom of Strata:	-18.00	m
Average Thickness of Strata,I_c:	1.00	m
Effective overburden pressure over the top of strata,σ_{top}:	85.00	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	95.00	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	90.00	kN/m^2
Coeff. Of Earth Pressure, k:	2.50	
Skin Resistance of the pile,q_s:	291.47	kN
(q_s:σ*k*tanϕ*pi()*d*Ic)		

Ultimate Skin Resistance,q_s: 726.09 kN

1.2.2 Computation of End Bearing Resistance:

Type of Bearing Strata	Weathered Rock	
Cross-Sectional Area of pile,Ap:	0.159	m^2
R.L of bottom of pile:	-19.00	
Minimum SPT-value of the Bearing Strata	60	
Angle of Shear Resistance, ϕ:	42.50	Deg.
Effective Overburden Pressure, q:	27.00	kPa
Bearing Capacity Factor(Nq)	220.00	
Ultimate End Bearing Resistance (Qp)	**944.7**	**kN**
(Qp=Ap*q*Nq)		

1.3.0 **Ultimate Load Carrying Capacity (Qu=Qs+Q_p) 1670.8 kN**
Safe Load Carrying Capacity (Qsafe =Qu/2.50) 668.3 kN
However, limit Q_{safe} to the structural capacity of pile: 600.0 kN

Dr. R. Venkata Krishnaiah M.E., Ph.D.,
Geotechnical Expert
Regd. No. GTE/R/07/032
No. 7/4, Munavar Avenue,
4th Street, Pallavaram, Chennai -43



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hello@verified.realestate
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