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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	**BNR INFRASTRUCTURE PROJECTS PVT. LTD., CHENNAI**
PROJECT	**PROPOSED CONSTRUCTION OF RETAIL BUILDINGS IN BLOCK-01 (GROUND FLOOR) & BLOCK-02 (G+03 FLOORS) AT PLOT NO: A, B, C, D, E, F & G PER TSLR 11553 Sq.mt., COMPRISED IN (i) NEW T.S. No: 33/14 & T.S.NO: 33/15, (ii) T.S.NO: 33/16, T.S.NO: 33/17, T.S. No: 33/18 MEASURING 15,478 Sq. ft. & AS PER TSLR 1438 Sq.mt., T.S. No.: 33/19, TSLR 1478 Sq.mt., & T.S.NO: 33/20, SITUATED AT WARD NO: C, BLOCK NO: 35 of MADHAVARAM VILLAGE, MADHAVARAM TALUK, PREVIOUSLY AMBATTUR TALUK, THIRUVALLUR DISTRICT**
TITLE	**GEOTECHNICAL INVESTIGATION REPORT**

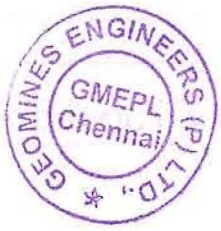
		For Geo Mines Engineers Pvt Ltd	
		Director	
0	09-05-2023	GMEPL/BNR INFRASTRUCTURE PROJECTS PVT. LTD/053/ 2023-24	
REV.	**DATE**	**REPORT NUMBER**	**PREP. BY**

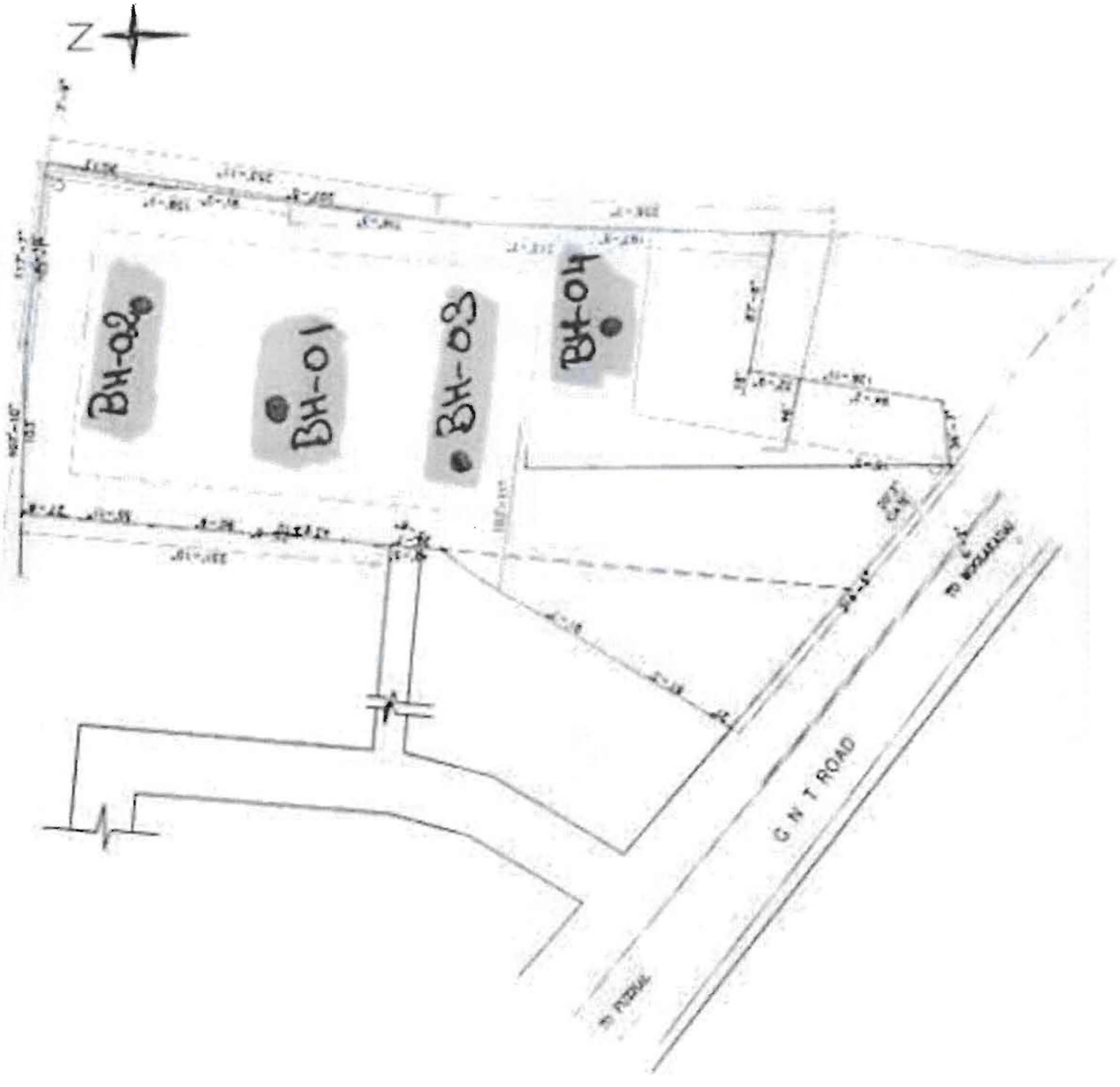
DISCLAIMER

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.



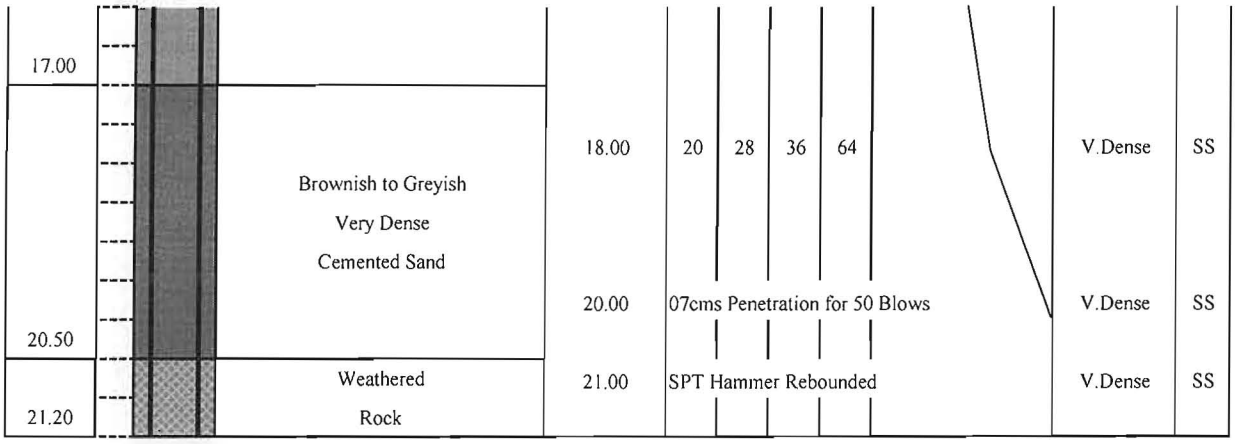

N
BH-02
BH-01
BH-03
BH-04
G N T ROAD

Project : Proposed Construction of Retail Buildings in Block-01 (Ground Floor) & Block-02 (G+03 Floor) at Plot No: A, B, C, D, E, F & G, per TSLR 11553 Sq.mts., Comprised in (i) New T.S.No: 33/14 & T.S.No: 33/15, (ii) T.S.No: 33/16, T.S.No: 33/17, T.S.No: 33/18 measuring 15,478 Square Feet and as per TSLR 1438 Sq.mts., T.S.No: 33/19 , TSLR 1478 Sq.mts., & T.S.No: 33/20, situated at Ward No: C, Block No: 35 of Madhavaram Village, MadhavaramTaluk, Previously AmbatturTaluk, Thiruvallur District

Location: BH-01

Started On : 05/04/2023; Ended On : 06/04/2023 G.W.T: 1.50m 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	Graphical Representation 0 1 2 3 4 5 6 7 8 9	Relative Density/Consistency	Type of Sample
			Filled Up Soil							-	DS
1.00											
G.W.T	▼		Brownish Medium Dense Silty Fine Sand	1.50	7	8	8	16		M.Dense	SS
2.00											
			Greyish Medium Dense Silty Clayey Fine Sand	3.00	9	12	14	26		M.Dense	SS
3.50											
			Greyish Dense Silty Clayey Fine Sand	4.50	10	14	17	31		Dense	SS
5.00											
			Greyish Medium Dense Silty Clayey Fine Sand	6.00	6	7	9	16		M.Dense	SS
6.50											
			Greyish Loose Silty Clayey Fine Sand	7.50	5	6	7	13		Loose	SS
8.00											
				9.00	7	7	10	17		M.Dense	SS
				10.00	8	10	12	22		M.Dense	SS
			Greyish Medium Dense Silty Clayey Fine Sand								
				12.00	8	12	17	29		M.Dense	SS
13.00											
				14.00	12	19	25	44		Dense	SS
			Greyish to Greenish Dense Cemented Sand								
				16.00	16	21	28	49		Dense	SS



Bore Hole Terminated at a depth of 21.20m below the existing ground level

Fig. 2.1 Soil Profile at BH-01 Location

Project : Proposed Construction of Retail Buildings in Block-01 (Ground Floor) & Block-02 (G+03 Floor) at Plot No: A, B, C, D, E, F & G, per TSLR 11553 Sq.mts., Comprised in (i) New T.S.No: 33/14 & T.S.No: 33/15, (ii) T.S.No: 33/16, T.S.No: 33/17, T.S.No: 33/18 measuring 15,478 Square Feet and as per TSLR 1438 Sq.mts., T.S.No: 33/19 , TSLR 1478 Sq.mts., & T.S.No: 33/20, situated at Ward No: C, Block No: 35 of Madhavaram Village, MadhavaramTaluk, Previously AmbatturTaluk, Thiruvallur District

Location: BH-02

Started On : 06/04/2023; Ended On : 07/04/2023 G.W.T: 1.50m 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	Graphical Representation of ## 1 2 3 4 5 6 7 8 9 0	Relative Density/Consistency	Type of Sample
1.00			Filled Up Soil							-	DS
G.W.T 2.00	▼		Brownish Medium Dense Silty Fine Sand	1.50	5	7	9	16		M.Dense	SS
5.00			Greyish Loose Silty Clayey Fine Sand	3.00	5	5	6	11		Loose	SS
				4.50	4	5	8	13		Loose	SS
7.00			Greyish Medium Dense Silty Clayey Fine Sand	6.00	7	8	9	17		M.Dense	SS
8.50			Greyish Loose Silty Clayey Fine Sand	7.50	5	7	8	15		Loose	SS
13.00			Greyish Medium Dense Silty Clayey Fine Sand	9.00	8	10	11	21		M.Dense	SS
				10 00	8	8	10	18		M.Dense	SS
				12.00	10	12	14	26		M.Dense	SS
15.00			Greyish to Greenish Dense Cemented Sand	14.00	16	19	22	41		Dense	SS
19.50			Brownish to Greyish Very Dense Cemented Sand	16.00	18	23	31	54		V.Dense	SS
				18.00	10cms Penetration for 50 Blows					V.Dense	SS
20.20			Weathered Rock	20.00	SPT Hammer Rebounded					V.Dense	SS

Bore Hole Terminated at a depth of 20.20m below the existing ground level

Fig. 2.2 Soil Profile at BH-02 Location

Project : Proposed Construction of Retail Buildings in Block-01 (Ground Floor) & Block-02 (G+03 Floor) at Plot No: A, B, C, D, E, F & G, per TSLR 11553 Sq.mts., Comprised in (i) New T.S.No: 33/14 & T.S.No: 33/15, (ii) T.S.No: 33/16, T.S.No: 33/17, T.S.No: 33/18 measuring 15,478 Square Feet and as per TSLR 1438 Sq.mts., T.S.No: 33/19 , TSLR 1478 Sq.mts., & T.S.No: 33/20, situated at Ward No: C, Block No: 35 of Madhavaram Village, MadhavaramTaluk, Previously AmbatturTaluk, Thiruvallur District

Location: BH-03

Started On : 08/04/2023; Ended On : 09/04/2023 G.W.T: 1.50m below existing ground level

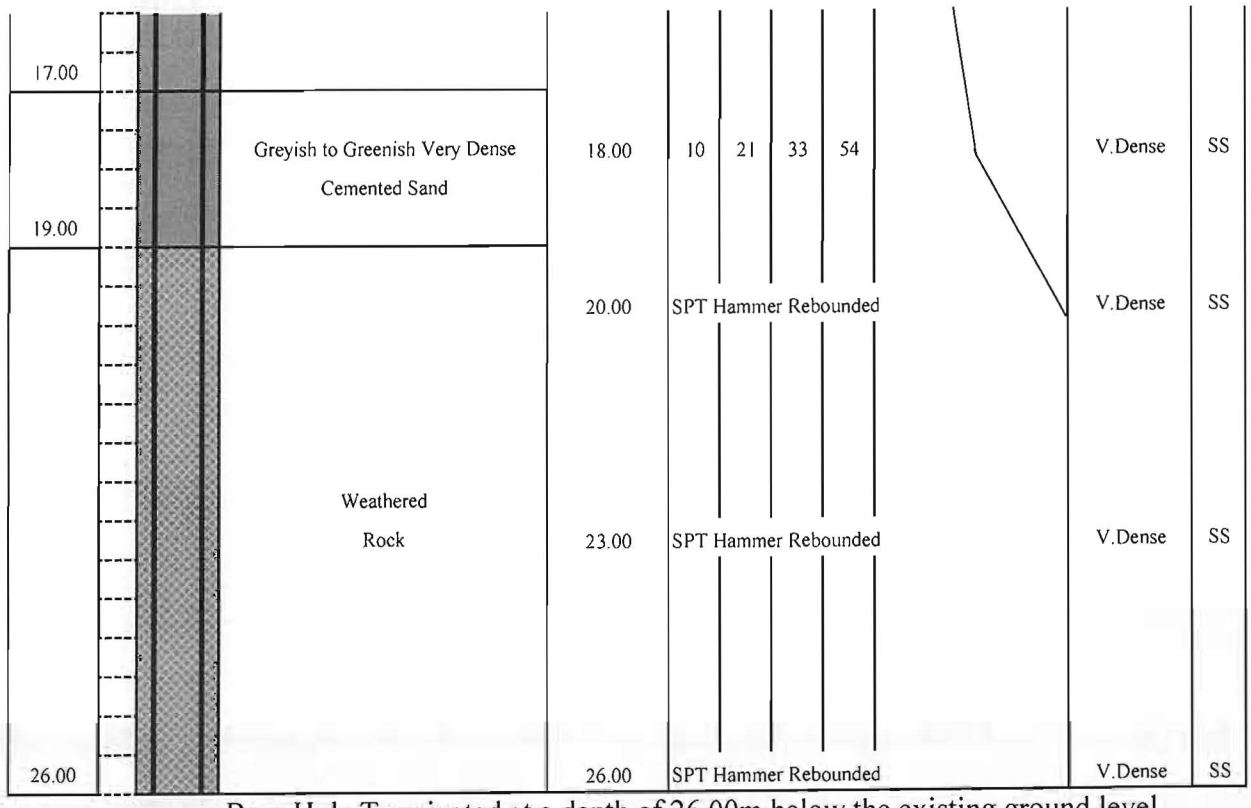
R.L of Layer (m)	G.W.T. (m)	Soil Profile	Engineering Description of Soil	SPT - Details: Depth of SPT below E.G.L (m)	0-15 cm	15-30 cm	30-45 cm	N-Value	Graphical Representation of N-Value (0 10 20 30 40 50 60 70 80 90)	Relative Density/Consistency	Type of Sample
			Filled Up Soil							-	DS
1.50	↓			1.50	5	6	6	12		Stiff	SS
2.00			Brownish Stiff Silty Sandy Clay								
			Greyish Medium Dense Silty Fine Sand	3.00	13	13	15	28		M.Dense	SS
4.00											
				4.50	4	4	6	10		Loose	SS
				6.00	5	7	7	14		Loose	SS
			Greyish Loose Silty Clayey Fine Sand	7.50	5	6	6	12		Loose	SS
				9.00	5	6	5	11		Loose	SS
10.00				10.00	7	10	10	20		M.Dense	SS
			Greyish Medium Dense Silty Clayey Fine Sand	12.00	7	11	12	23		M.Dense	SS
13.00											
			Greenish to Greyish Dense Cemented Sand	14.00	14	19	23	42		Dense	SS
15.00											
				16.00	18	24	28	52		V.Dense	SS

Project : Proposed Construction of Retail Buildings in Block-01 (Ground Floor) & Block-02 (G+03 Floor) at Plot No: A, B, C, D, E, F & G, per TSLR 11553 Sq.mts., Comprised in (i) New T.S.No: 33/14 & T.S.No: 33/15, (ii) T.S.No: 33/16, T.S.No: 33/17, T.S.No: 33/18 measuring 15,478 Square Feet and as per TSLR 1438 Sq.mts., T.S.No: 33/19 , TSLR 1478 Sq.mts., & T.S.No: 33/20, situated at Ward No: C, Block No: 35 of Madhavaram Village, MadhavaramTaluk, Previously AmbatturTaluk, Thiruvallur District

Location: BH-04

Started On : /04/2023; Ended On : /04/2023 G.W.T: 1.50m 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	hical Representation o (0 1 2 3 4 5 6 7 8 9 0)	Relative Density/Consistency	Type of Sample
			Filled Up Soil							-	DS
1.50	↓			1.50	6	7	9	16		M.Dense	SS
			Greyish Medium Dense								
2.50			Silty Clayey Fine Sand								
				3.00	5	7	7	14		Loose	SS
			Greyish	4.50	4	5	6	11		Loose	SS
			Loose								
			Silty Clayey Fine Sand	6.00	6	6	7	13		Loose	SS
7.00											
			Greyish	7.50	6	7	9	16		M.Dense	SS
			Medium Dense								
8.50			Silty Clayey Fine Sand								
			Greyish Loose	9.00	6	6	6	12		Loose	SS
9.50			Silty Clayey Fine Sand								
				10.00	5	10	13	23		M.Dense	SS
			Greyish								
			Medium Dense								
			Silty Clayey Fine Sand	12.00	4	7	11	18		M.Dense	SS
13.00											
				14.00	5	15	20	35		Dense	SS
			Greyish to Greenish Dense								
			Cemented Sand								
				16.00	8	18	23	41		Dense	SS



Bore Hole Terminated at a depth of 26.00m below the existing ground level

Fig. 2.4 Soil Profile at BH-04 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	Filled Up Soil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.00 to 2.00	16	SS	Silty Fine Sand	-	1.59	-	-	-	-	-	M.Dense	0	0	0	79	21	0	SM
2.00 to 3.50	26	SS	Silty Clayey Fine Sand	-	1.68	-	-	-	-	-	M.Dense	0	0	0	73	11	16	SM
3.50 to 5.00	31	SS	Silty Clayey Fine Sand	-	1.74	-	-	-	-	-	Dense	0	0	0	81	9	10	SM
5.00 to 6.50	16	SS	Silty Clayey Fine Sand	-	1.61	-	-	-	-	-	M.Dense	0	0	0	77	12	11	SM
6.50 to 8.00	13	SS	Silty Clayey Fine Sand	-	1.51	-	-	-	-	-	Loose	0	0	0	70	14	16	SM
8.00 to 13.00	22	SS	Silty Clayey Fine Sand	-	1.64	-	-	-	-	-	M.Dense	0	0	0	78	9	13	SM
13.00 to 17.00	46	SS	Cemented Sand	-	1.85	-	-	-	-	-	Dense	0	23	19	31	12	15	SM
17.00 to 20.50	82	SS	Cemented Sand	-	1.99	-	-	-	-	-	V.Dense	0	29	23	21	11	16	SM
20.50 to 21.20	>100	SS	Weathered Rock	-	2.03	-	-	-	-	-	V.Dense	39	31	22	6	2	0	SDR

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 2.00	16	SS	Silty Fine Sand	-	1.58	-	-	-	-	-	M.Dense	0	0	7	74	19	0	SM
2.00 to 5.00	12	SS	Silty Clayey Fine Sand	-	1.48	-	-	-	-	-	Loose	0	0	0	73	14	13	SM
5.00 to 7.00	17	SS	Silty Clayey Fine Sand	-	1.59	-	-	-	-	-	M.Dense	0	0	0	78	9	13	SM
7.00 to 8.50	15	SS	Silty Clayey Fine Sand	-	1.50	-	-	-	-	-	Loose	0	0	0	78	12	10	SM
8.50 to 13.00	21	SS	Silty Clayey Fine Sand	-	1.61	-	-	-	-	-	M.Dense	0	0	0	81	8	11	SM
13.00 to 15.00	41	SS	Cemented Sand	-	1.88	-	-	-	-	-	Dense	0	24	26	19	14	17	SM
15.00 to 19.50	77	SS	Cemented Sand	-	1.94	-	-	-	-	-	V.Dense	0	28	23	21	13	15	SM
19.50 to 20.20	>100	SS	Weathered Rock	-	2.04	-	-	-	-	-	V.Dense	38	17	21	16	8	0	SDR

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 1.50	-	DS	Filled Up Soil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.50 to 2.00	12	SS	Silty Sandy Clay	29	1.66	47	26	21	0.86	9	Stiff	0	0	0	16	9	75	CI
2.00 to 4.00	28	SS	Silty Fine Sand	-	1.71	-	-	-	-	-	M.Dense	0	0	0	78	22	0	SM
4.00 to 10.00	11	SS	Silty Clayey Fine Sand	-	1.53	-	-	-	-	-	Loose	0	0	0	61	15	24	SM
10.00 to 13.00	21	SS	Silty Clayey Fine Sand	-	1.67	-	-	-	-	-	M.Dense	0	0	0	70	14	16	SM
13.00 to 15.00	42	SS	Cemented Sand	-	1.93	-	-	-	-	-	Dense	0	27	16	21	14	22	SM
15.00 to 22.00	71	SS	Cemented Sand	-	1.93	-	-	-	-	-	V.Dense	0	25	19	25	20	11	SM
22.00 to 23.00	>100	SS	Weathered Rock	-	2.03	-	-	-	-	-	V.Dense	33	17	25	21	4	0	SDR
23.00 to 26.00	>100	SS	Hard Rock	-	2.13	-	-	-	-	-	V.Dense	-	-	-	-	-	-	-

Table 2.4: Laboratory Test Result on the Soil Sample Collected from BH-04

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 1.50	-	DS	Filled Up Soil	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1.50 to 2.50	16	SS	Silty Clayey Fine Sand	-	1.58	-	-	-	-	-	M.Dense	0	0	0	78	11	11	SM
2.50 to 7.00	12	SS	Silty Clayey Fine Sand	-	1.48	-	-	-	-	-	Loose	0	0	0	71	13	16	SM
7.00 to 8.50	16	SS	Silty Clayey Fine Sand	-	1.59	-	-	-	-	-	M.Dense	0	0	0	77	13	10	SM
8.50 to 9.50	12	SS	Silty Clayey Fine Sand	-	1.47	-	-	-	-	-	Loose	0	0	0	69	14	17	SM
9.50 to 13.00	20	SS	Silty Clayey Fine Sand	-	1.63	-	-	-	-	-	M.Dense	0	0	0	74	12	14	SM
13.00 to 17.00	38	SS	Cemented Sand	-	1.83	-	-	-	-	-	Dense	0	28	14	27	13	18	SM
17.00 to 19.00	54	SS	Cemented Sand	-	1.90	-	-	-	-	-	V.Dense	0	31	17	22	15	15	SM
19.00 to 26.00	>100	SS	Weathered Rock	-	2.09	-	-	-	-	-	V.Dense	42	20	20	13	5	0	SDR

Table 2.5: Chemical Analysis Results conducted on Water Samples collected from BH-01 to BH-04

Location	Depth of Sample below E.G.L. (m)	pH	Chlorides (ppm)	Sulphates (ppm)
BH-01	3.00	6.79	244.91	121.17
BH-02	3.00	6.77	252.98	129.83
BH-03	3.00	6.79	240.03	120.84
BH-04	3.00	6.78	250.86	126.19

CHAPTER-3

SUB-SURFACE STRATIFICATION

3.0 Preamble

The sub surface stratification at boreholes 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	Filled Up Soil
Colour	-
Thickness of Layer	1.00m

* **Layer-2 (from 1.00m to 2.00m depth)**

Type of Strata	Silty Fine Sand
Colour	Brownish
Thickness of Layer	1.00m
SPT of the layer	16
Relative Density	Medium Dense
Angle of Shearing Resistance, ϕ	31.80^0

* **Layer-3 (from 2.00m to 3.50m depth)**

Type of Strata	Silty Clayey Fine Sand
Colour	Greyish
Thickness of Layer	1.50m
SPT of the layer	26
Relative Density	Medium Dense
Angle of Shearing Resistance, ϕ	34.80^0

* **Layer-4 (from 3.50m to 5.00m depth)**

Type of Strata	Silty Clayey Fine Sand
Colour	Greyish
Thickness of Layer	1.50m
SPT of the layer	31

Relative Density	Dense
Angle of Shearing Resistance, ϕ	36.275^0
* **Layer-5 (from 5.00m to 6.50m depth)**	
Type of Strata	Silty Clayey Fine Sand
Colour	Greyish
Thickness of Layer	1.50m
SPT of the layer	16
Relative Density	Medium Dense
Angle of Shearing Resistance, ϕ	31.80^0
* **Layer-6 (from 6.50m to 8.00m depth)**	
Type of Strata	Silty Clayey Fine Sand
Colour	Greyish
Thickness of Layer	1.50m
SPT of the layer	13
Relative Density	Loose
Angle of Shearing Resistance, ϕ	30.90^0
* **Layer-7 (from 8.00m to 13.00m depth)**	
Type of Strata	Silty Clayey Fine Sand
Colour	Greyish
Thickness of Layer	5.00m
SPT of the layer	22
Relative Density	Medium Dense
Angle of Shearing Resistance, ϕ	33.60^0
* **Layer-8 (from 13.00m to 17.00m depth)**	
Type of Strata	Cemented Sand
Colour	Greyish to Greenish
Thickness of Layer	4.00m
SPT of the layer	46
Relative Density	Dense
Angle of Shearing Resistance, ϕ	40.10^0
* **Layer-9 (from 17.00m to 20.50m depth)**	
Type of Strata	Cemented Sand
Colour	Brownish to Greyish
Thickness of Layer	3.50m
SPT of the layer	82
Relative Density	Very Dense
Angle of Shearing Resistance, ϕ	42.50^0
* **Layer-10 (from 20.50m to 21.20m depth)**	
Type of Strata	Weathered Rock
Colour	-
Thickness of Layer	0.70m
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 1.50m below the existing ground level during the first week of April 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 2.00m depth)**

Type of Strata	Silty Fine Sand
Colour	Brownish
Thickness of Layer	1.00m
SPT of the layer	16
Relative Density	Medium Dense
Angle of Shearing Resistance, ϕ	31.80^0

* **Layer-3 (from 2.00m to 5.00m depth)**

Type of Strata	Silty Clayey Fine Sand
Colour	Greyish
Thickness of Layer	3.00m
SPT of the layer	12
Relative Density	Loose
Angle of Shearing Resistance, ϕ	30.60^0

* **Layer-4 (from 5.00m to 7.00m depth)**

Type of Strata	Silty Clayey Fine Sand
Colour	Greyish
Thickness of Layer	2.00m
SPT of the layer	17
Relative Density	Medium Dense
Angle of Shearing Resistance, ϕ	32.10^0

* **Layer-5 (from 7.00m to 8.50m depth)**

Type of Strata	Silty Clayey Fine Sand
Colour	Greyish
Thickness of Layer	1.50m
SPT of the layer	15
Relative Density	Loose
Angle of Shearing Resistance, ϕ	31.50^0

* **Layer-6 (from 8.50m to 13.00m depth)**

Type of Strata	Silty Clayey Fine Sand
Colour	Greyish
Thickness of Layer	4.50m
SPT of the layer	21
Relative Density	Medium Dense
Angle of Shearing Resistance, ϕ	33.30^0

* **Layer-7 (from 13.00m to 15.00m depth)**

Type of Strata	Cemented Sand
Colour	Greyish to Greenish
Thickness of Layer	2.00m
SPT of the layer	41
Relative Density	Dense
Angle of Shearing Resistance, ϕ	38.975^0

* **Layer-8 (from 15.00m to 19.50m depth)**

Type of Strata	Cemented Sand

Colour	Brownish to Greyish
Thickness of Layer	4.50m
SPT of the layer	77
Relative Density	Very Dense
Angle of Shearing Resistance, ϕ	42.50^0

* **Layer-9 (from 19.50m to 20.20m depth)**

Type of Strata	Weathered Rock
Colour	-
Thickness of Layer	0.70m
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 1.50m below the existing ground level during the first week of April 2023.

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 1.50m depth)**

Type of Strata	Filled Up Soil
Colour	-
Thickness of Layer	1.50m

* **Layer-2 (from 1.50m to 2.00m depth)**

Type of Strata	Silty Sandy Clay
Colour	Brownish
Thickness of Layer	0.50m
SPT of the layer	12
Consistency	Stiff
Un-drained Cohesion, Cu	80.00kPa

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

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

* **Layer-4 (from 4.00m to 10.00m depth)**

Type of Strata	Silty Clayey Fine Sand
Colour	Greyish
Thickness of Layer	6.00m
SPT of the layer	11
Relative Density	Loose
Angle of Shearing Resistance, ϕ	30.30^0

* **Layer-5 (from 10.00m to 13.00m depth)**

Type of Strata	Silty Clayey Fine Sand
Colour	Greyish
Thickness of Layer	3.00m
SPT of the layer	21

* **Layer-3 (from 2.50m to 7.00m depth)**	
Type of Strata	Silty Clayey Fine Sand
Colour	Greyish
Thickness of Layer	4.50m
SPT of the layer	12
Relative Density	Loose
Angle of Shearing Resistance, ϕ	30.60^0
* **Layer-4 (from 7.00m to 8.50m depth)**	
Type of Strata	Silty Clayey Fine Sand
Colour	Greyish
Thickness of Layer	1.50m
SPT of the layer	16
Relative Density	Medium Dense
Angle of Shearing Resistance, ϕ	31.80^0
* **Layer-5 (from 8.50m to 9.50m depth)**	
Type of Strata	Silty Clayey Fine Sand
Colour	Greyish
Thickness of Layer	1.00m
SPT of the layer	12
Relative Density	Loose
Angle of Shearing Resistance, ϕ	30.60^0
* **Layer-6 (from 9.50m to 13.00m depth)**	
Type of Strata	Silty Clayey Fine Sand
Colour	Greyish
Thickness of Layer	3.50m
SPT of the layer	20
Relative Density	Medium Dense
Angle of Shearing Resistance, ϕ	33.00^0
* **Layer-7 (from 13.00m to 17.00m depth)**	
Type of Strata	Cemented Sand
Colour	Greyish to Greenish
Thickness of Layer	4.00m
SPT of the layer	38
Relative Density	Dense
Angle of Shearing Resistance, ϕ	38.20^0
* **Layer-8 (from 17.00m to 19.00m depth)**	
Type of Strata	Cemented Sand
Colour	Greyish to Greenish
Thickness of Layer	2.00m
SPT of the layer	54
Relative Density	Very Dense
Angle of Shearing Resistance, ϕ	41.60^0
* **Layer-9 (from 19.00m to 26.00m depth)**	
Type of Strata	Weathered Rock
Colour	-
Thickness of Layer	7.00m
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 1.50m below the existing ground level during the third week of April 2023.

volumetric change phenomenon during variations in seasonal moisture content variations do not impact on the structural system of foundation.

Care shall also be taken in regulating the safe bearing capacity of open foundation system so that the dispersed open foundation stresses on the underlying relatively weak soil layer encountered at 4.00m depths from present existing ground level (SPT @ 4.50m is 10, Ref. BH-03) are within their safe bearing capacity limits.

Further, the refusal soil strata (SPT>60) encountered at a maximum depth of 22.00m from existing ground level (Ref. BH-03) can also 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 (Ref. Critical BH-03)

Considering the uniformity in sub-soil stratifications at shallow depths, shear strength characteristics, medium plasticity characteristics of fine-grained soil strata encountered at shallow depths and presence of underlying relatively weak soil layer at 4.00m depths from existing ground level (Ref. BH-03), open foundation system of ***Isolated Column Footing*** *type located at a design depth of 2.00m below present existing ground level 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	**2.30**	**0.30**	**2.00**	**14**	**42**

The computations for above are annexed to this report.

Notes

Safe Bearing Capacity of open foundation system is restricted considering the presence of underlying relatively weak soil layer encountered at 4.00m depths

CHAPTER-5

CONCLUSIONS & RECOMMENDATIONS

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

Open Foundation System

2. Safe bearing capacity of open foundation system is computed considering any rise in the ground water table up to or above the level of footing.
3. In no case, the least depth of foundation system can be less than 2.00m below present existing ground level located over 0.30m thick well compacted CNS Soil layer.
4. 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.
5. 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 10, Ref. BH-03) i.e. 2.00m distant apart from the bottom level of footing.
6. **Excavated 1.00m/1.50m thick filled up soil (Ref. BH-01 to BH-04) and medium plastic fine-grained soil (Ref. BH-03) encountered at shallow depths shall be in no case used for back filling purposes.**
7. **No structural units can be in direct contact of medium plastic fine-grained soil strata encountered at shallow depths. A 0.30m thick CNS soil layer is recommended to be sand-witched in between.**

Other Recommendations

8. Suitable provisions to contain the lateral collapse of soil from the walls of excavated open foundation pits are recommended.
9. It is recommended to connect the grade beams so that the entire structure can act as a single unit against any differential settlements in between the individual footings.

IMPORTANT RECOMMENDATIONS

10. 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

11. Suitable pile load tests (as per I.S: 2911, part-IV) shall be performed to confirm the presented **theoretical** safe load carrying capacities and arrive at the **design/allowable** load carrying capacity of piles under considerations.
12. Pile cap can be located over 0.30m thick well compacted existing ground to be replaced with well compacted CNS soil surface.
13. Piles shall be installed using DMC (direct mud circulation) technique only.
14. Piles shall be grouped according to the column design load requirements.
15. Safe load carrying capacities of piles shall be limited to their structural capacities.

General

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

DESIGN OF OPEN FOUNDATION SYSTEM (Ref. BH-03)

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
Total Depth of Excavations below Natural Ground Level (m) :	2.30	m
Recommended Thickness of Back-Fill (m):	0.30	m
Effective Depth of Foundation below natural ground level (D_f):	2.00	m
Design Width of Foundation (B):	1.00	m
Thickness of Foundation (T) :	0.20	m

I.2 Soil Data :

Type of Bearing Strata :	Silty Sandy Clay	
Design SPT-value of the Bearing Strata :	12	
(considered based upon the density of the strata)		
Type of Shear Failure:	General	
Undrained Cohesion, Cu:	80.00	kPa

1.3 Design Parameters:

Bulk Density of Soil above the foundation detph (γ_{bulk})	17.00	kN/m^3
Effective Overburden pressure at foundation level (q)	14.00	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 :

$D_c = 1.00$

$D_q = N/A$

DESIGN OF PILE FOUNDATION (BH-03)

Refer, IS:2911(Part I/Sec 2)-1979, Reaffirmed 1997

1.0 Type of Installation of Pile — **Bored Cast in Situ**

1.1 Geometrical Data

Assumed Diameter of pile(D):	**500.0**	mm
Assumed R.L of E.G.L:	0.000	m
Length of pile below E.G.L.(l) :	**22.000**	m
R.L. of Bot. of Pile	-22.00	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 Sandy Clay	
Average SPT of the strata,N:	12	
Bulk Density of the strata,γ:	17	kN/m^3
Undrained Shear Strength,C_u:	80.00	kPa
R.L of top of Strata:	-1.50	m
R.L of bottom of Strata:	-2.00	m
Average Thickness of Strata,I_c:	0.50	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}:	3.50	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	1.75	kN/m^2
Adhesion,α:	0.40	
Skin Resistance of the pile,q_s:	25.13	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:	28	
Bulk Density of the strata,γ:	18	kN/m^3
Angle of Shearing Resistance,ϕ:	35.4	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}:	3.50	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	19.50	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	11.50	kN/m^2
Coeff. Of Earth Pressure, k:	1.50	
Skin Resistance of the pile,q_s:	38.51	kN

(q_s:σ*k*tanϕ*pi()*d*Ic)

1.2.1.3 **Layer-IV**

Type of Strata:	Silty Clayey Fine Sand	
Average SPT of the strata,N:	11	
Bulk Density of the strata,γ:	15	kN/m^3
Angle of Shearing Resistance,ϕ:	30.3	Deg.
R.L of top of Strata:	-4.00	m
R.L of bottom of Strata:	-10.00	m
Average Thickness of Strata,I_c:	6.00	m
Effective overburden pressure over the top of strata,σ_{top}:	19.50	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	49.50	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	34.50	kN/m^2
Coeff. Of Earth Pressure, k:	1.00	
Skin Resistance of the pile,q_s:	190.01	kN

(q_s:σ*k*tanϕ*pi()*d*Ic)

1.2.1.4 **Layer-V**

Type of Strata:	Silty Clayey Fine Sand	
Average SPT of the strata,N:	21	
Bulk Density of the strata,γ:	17	kN/m^3
Angle of Shearing Resistance,ϕ:	33.3	Deg.
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}:	49.50	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	70.50	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	60.00	kN/m^2
Coeff. Of Earth Pressure, k:	1.50	
Skin Resistance of the pile,q_s:	278.59	kN

(q_s:σ*k*tanϕ*pi()*d*Ic)

1.2.1.5 **Layer-V1**

Type of Strata:	Cemented Sand	
Average SPT of the strata,N:	42	
Bulk Density of the strata,γ:	19	kN/m^3
Angle of Shearing Resistance,ϕ:	39.2	Deg.
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}:	70.50	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	88.50	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	79.50	kN/m^2
Coeff. Of Earth Pressure, k:	2.00	
Skin Resistance of the pile,q_s:	407.39	kN

(q_s:σ*k*tanϕ*pi()*d*Ic)

1.2.1.6 Layer-VII

Type of Strata:	Cemented 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:	-15.00	m
R.L of bottom of Strata:	-22.00	m
Average Thickness of Strata,I_c:	7.00	m
Effective overburden pressure over the top of strata,σ_{top}:	88.50	kN/m^2
Effective overburden pressure over the bottom of strata,σ_{bottom}:	158.50	kN/m^2
Effective overburden pressure at the middle of the strata,σ_{middle}:	123.50	kN/m^2
Coeff. Of Earth Pressure, k:	2.50	
Skin Resistance of the pile,q_s:	3110.84	kN
(q_s:σ*k*tanϕ*pi()*d*Ic)		
Ultimate Skin Resistance,q_s:	**4050.47**	**kN**

1.2.2 Computation of End Bearing Resistance:

Ultimate End Bearing Resistance (Qp) Neglected for Friction Pile

1.3.0	**Ultimate Load Carrying Capacity ($Qu=Qs+Q_p$)**	**4050.5**	**kN**
	Safe Load Carrying Capacity (Qsafe =Qu/2.5)	**1620.2**	**kN**
	However, limit Q_{safe} to the structural capacity of pile:	**1400.0**	**kN**



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