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GEOTECHNICAL Solutions^{A1}

RESIDENTIAL PROJECT 'COROMANDEL ENCLAVE'
TS NO:398/1, SRINIVASA NAGAR, UPPILIPALAYAM, COIMBATORE

TRISHUL CONCRETE PRODUCTS LIMITED
COROMANDEL TOWERS
NO:93 SANTHOME HIGH ROAD, KARPAGAM AVENUE
R.A. PURAM, CHENNAI - 600 028

1Z/TICL/UPILI/G-962

29 JUNE 2012

44/17 'BHASKARA'
19 USHA STREET
DR. SEETHAPATHY NAGAR
VELACHERY, CHENNAI 600 042

EXECUTIVE SUMMARY

Project	:	**Residential Project 'COROMANDEL ENCLAVE' No:398/1, Srinivasa Nagar, Uppilipalayam, Coimbatore.**
Project Reference	:	**TICL/UPILI/G-962**
Owner	:	Trishul Concrete Products Limited, Coromandel Towers, No:93, Santhome High Road, Karpagam Avenue, R.A. Puram, Chennai 600 028.
Architects:	:	M/s. Nataraj & Venkat, Chennai
Type of Structure	:	Residential buildings with stilt Floor + 4 upper floors
Scope	:	Geotechnical Investigation for the area of construction
Tests Conducted	:	Four exploratory borehole up to varying depth , conducting standard penetration tests, collecting soil samples, laboratory classifications tests, rock drilling etc.
FINDINGS		
Soil at shallow depth	:	Reddish brown sandy clay (dry at surface) followed by clayey sand
Weak stratum	:	None
Hard stratum & type	:	Weathered quartzite from 2.4m to 3.40m depth from GL
Ground water table	:	Boreholes recorded water at 1.10m to 1.40m and the ground water table is expected at about 1.70m below GL. Ground water table is expected at ground level during rains and such condition is considered in the foundation design.

RECOMMENDATIONS			
Type of foundation	:	Shallow footings	Individual footings*
Depth of foundation	:	1.80m below GL^	2.00m to 3.00mbelow GL*
Type of soil at FL	:	Dense clayey sand	weathered rock (quartzite)
Size of foundation	:	1.5m to 4.5m	1.5m to 4.50m
Capacity	:	Net allowable pressure = 35 t/m^2	Net allowable pressure = 55 t/m^2
Expected settlement	:	<25mm total settlement and 0.0020L differential settlement^^	<10mm total settlement
Comments	:		

^ The depth is w.r.t. the present ground level that is roughly 0.30m below the road level. The RL of foundation is +7.20m. The site reference datum is 10.00RL at the temporary bench mark located in the North East corner of the land.

The ground water table shall be established by digging few trial pits below the final excavation level. The ground water table shall be lowered well below the foundation excavation level before commencing the foundation excavation. Dewatering shall be carried out through small excavations made outside the building footprint area exclusively for the purpose. Dewatering from foundation excavation shall not be allowed.

The sandy silty clay excavated from the site may be avoided in the backfilling of foundation excavations. Even though the sandy clay is not expansive type, compaction of such cohesive soil may prove to be very difficult.

*If the proposed construction is having a basement, the column footings supported on weathered rock available at varying elevations of +6.80m and +5.80m RL can be used. The recommended net safe bearing capacity of such column footings is 55.0 t/m^2. The depth of foundation with respect to the existing ground level is 2.20m to 3.20m.

For Geotechnical Solutions

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29 June 2012

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REPORT ON SOIL INVESTIGATION FOR
RESIDENTIAL PROJECT 'COROMANDEL ENCLAVE'
UPPILIPALAYAM, COIMBATORE

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Report on Soil Investigation for RESIDENTIAL PROJECT 'COROMANDEL ENCLAVE' UPPILIPALAYAM, COIMBATORE

1 INTRODUCTION

1.1 **M/s. Trishul Concrete Products Limited**, Chennai, is developing a residential apartment project in their land at TS No: 398/1, Srinivasa Nagar, Upilipalayam, Coimbatore. The site is almost a rectangular plot having an area of approximately 10000 sq metre. The front 10m wide stretch is left as open space reserve and the constructions will be taken up in the rest of the area. The proposed construction will have stilt floor and four upper floors.

M/s Nataraj and Venkat, Chennai, are the architects for this project.

1.2 The average load intensity at the foundation level of this Stilt + 4 residential construction may be about 7.0 t/m^2. Light to moderate column loads are expected.

1.3 The top soil is reddish brown clayey sand / sandy clay expected to be followed by weathered rock at shallow depth. A detailed sub-soil exploration was proposed in this site for establishing the soil profile and then to decide the type and the depth of best suitable foundation for the proposed constructions. **M/s. Geotechnical Solutions[A1]**, Chennai, conducted this soil investigation during 19-21 June 2012 according to the instructions from the project owners. Four exploratory boreholes sufficiently penetrated into weathered rock were made for this purpose.

1.4 The report describes the procedure of investigation adopted and then presents the complete investigation data. The data obtained from the investigation are reviewed and analysed to recommend the shear strength and compressibility parameters as described in Section 3.0. The bearing capacity of shallow foundation is estimated in section 4.0, while the conclusions are drawn in section 5.0.

1.5 The sub-soil profiles and the shear strength profiles revealed from these four boreholes are somewhat uniform. Even though the stratification is somewhat similar, the thickness and elevation of different soil layers and weathered rock varied marginally between the borehole locations.

1.6 The top sandy clay layer is of medium plasticity classified as SC-CI. The soil has insignificant swelling characteristics. The proposed stilt + 4 residential apartment building can be supported by column footings placed at 1.80m to 2.00m below present GL. Buildings with one basement can also be supported on column footings placed at relatively deeper levels and supported on weathered rock.

2 INVESTIGATION PROGRAMME, PROCEDURE AND DATA

2.1 *Investigation Programme*

2.1.1 The investigation programme comprised sinking four exploratory boreholes at the locations shown in the key plan provided in **Figure 1** of this report. The boreholes were advanced up to varying depths between 2.80m to 4.70m below respective ground levels. Very dense residual sand layers are occurring from shallow depths. The boreholes have penetrated 1.50m to 2.5m into weathered rock stratum with SPT rebound.

2.1.2 Field-tests in the boreholes included Standard Penetration Tests, Disturbed sampling, Identification of different soil layers, Ground water table observation, drilling through weathered fractured rock and weathered jointed rock, complete logging of the boreholes, etc.

2.1.3 Laboratory investigation mainly consisted of classification tests like determination of limit values for samples from clay and sandy clay and grain size distribution analysis for sand samples. Natural moisture contents of different soil layers were determined from the disturbed soil samples collected using the SPT sampler. These samples were preserved in two polythene bags so as to minimise the loss of moisture during transit to the laboratory. Laboratory shear strength test was conducted on-the undisturbed sample. The top clay samples were subjected to swelling index tests.

2.2 *Investigation Procedure*

2.2.1 Exploratory boreholes were advanced from the existing ground level using rotary drilling technique supplemented by bentonite mud circulation. The mud circulation was employed through the drill rods and letting it out through the side jets provided in the cutting tool thus preventing any disturbance at the borehole bottom. It is important to note that the mud jet is not used to cut the soils as in the case of wash boring technique. Mud circulation was used to stabilise the sides and the bottom of the boreholes, and then to bring the soil cuts to the surface. Use of drilling mud will also help in preventing the disturbance to the soil at the borehole bottom during drilling operations. Rotary drilling procedure with mud circulation is found most suitable for making exploratory boreholes.[1] Diameter of the borehole is about 150 mm. Borehole was always kept full with the drilling mud so that a positive head is maintained in the borehole thus preventing any disturbance to the soil within the test zone.

2.2.2 Standard Penetration Tests were conducted at regular depth intervals in the boreholes and N values were recorded. These tests were carried out using winch and cathead device for which the expected energy level is roughly 65 to 70%. The N value resulting from this procedure may be considered equivalent to N_{70}. The samples collected through the SPT sampler were packed in two layers of polythene bags to retain the natural moisture content. These samples were subjected to natural moisture content determination on the next day.

2.2.3 Different soil layers collected from different levels were identified and classified. Boreholes were terminated at varying depths of 2.80m to 4.70m after drilling 1.50m to 2.50m into highly weathered rock identified weathered quartzite. Drilling through this layer required relatively large effort.

2.2.4 The top clay layers were subjected to differential free swell index tests on air dried samples. The Atterberg's limit values were determined directly on the natural soil adding necessary amount of distilled water to the soil specimens. Grain size analyses on sandy samples were

[1] D.J. Douglas, "Standard Penetration Tests", Proceedings, In-situ Testing for Geotechnical Investigations, Sydney 1983, A.A. Balkema

conducted on oven dried samples since accurate dry weights of test specimen is necessary in this case.

2.2.5 All the field and laboratory tests were conducted according to the procedures stipulated in relevant IS Codes[2].

2.3 *Investigation Data*

2.3.1 All the field test results obtained from the exploratory boreholes are recorded in the bore logs illustrated in **Annexure 1** to **4**. Field N values at different depths and the depths from which the samples were collected are recorded in the bore logs. The depths and thickness of different soil layers are also presented in these logs. Laboratory test results are summarised in **Table 1** of this report.

The grain size distribution curves are presented in **Annexure G-1** & **G-2.** The photograph of rock core samples is presented in **Plate 1** of this report.

3 REVIEW OF FIELD AND LABORATORY TEST RESULTS

3.1 *Site Topography and Soil Profile*

3.1.1 The ground level at the borehole locations varied between 8.67m and 9.04m RL with respect to the site TBM 10.0mm located in the North East corner. The road top level is about 9.20m RL. The site is only 200mm to 500mm below the road top level and roughly 500mm to 800mm thick filling is required for site grading.

3.1.2 The soil stratification and its variations across the construction area as identified from these boreholes are presented in **Figures P-1** and **P-2**. Sub-soil profile between BH/1 and BH/4 is presented in Figure P-1 and the profile between BH/2 and BH/3 is presented in Figure P-2. The depth of weathered rock is relatively shallow in the location of BH/2 (South West corner) and at 4.50m depth in the North side. The thickness of top sandy cay is 1.50m in most of the area. BH/2 recorded only 0.60m thick sandy clay. Dense clayey sand with SPT N 38 to 50 is present between sandy clay and weathered disintegrated rock.

3.1.3 The top reddish brown sandy clay is of medium plasticity. The liquid limit is 44% to 47% and the plasticity index PI is 22.5% to 24%. The differential free swell index values are in the range of 20% to 50%. The soil is classified as SC-CI and further identified as low swelling type comparing the plasticity index, percentage of fines and the differential free swell index.

3.1.4 The clayey sand and dirty sand layers found below the clay layer have varying percentage of fines smaller than 75 microns. It varied from 12% to 29%. These layers also recorded low plasticity. The percentage of gravel size particles varied from 7% to 27%. The grain size distribution curves presented stepped gradation suggesting that these clay layers are residual type deposits.

3.1.5 The wash samples collected during drilling through weathered rock mostly consists of quartzite pieces of gravel size. The particles are angular making it evident that the wash material is from fracturing of the weathered rock. The quartzite is partially laterised and possesses reddish shade. The photographs of weathered rock core samples derived from rock drilling using diamond drilling are presented in Plate 1.

[2] Compendium of Indian Standards on Soil Engineering SP 36 (Part 1 and Part 2)

3.2 ***Groundwater Table***

3.2.1 The site has no open well. The boreholes recorded water at 1.10m to 1.40m below respective ground level. Local sources suggested that the present ground water table is below 8.0m. The water level at shallow depths stabilised in the boreholes may be due to perched water table in the site.

3.2.2 Local sources suggested that the ground water table during the rains is very shallow and the water table is very deep during dry season. Since ground water table will affect the foundation, very shallow ground water table condition expected during rains is considered while estimating the bearing capacities.

3.3 ***Shear Strength of Different Soil Layers***

3.3.1 Standard Penetration Test blow counts N is measured at different levels in the borehole. Mainly these N values are used to assess the shear strength of different soil layers.

3.3.2 *Clay Layers:* The classification of N values in moderate to high plasticity sedimentary clay deposits developed by Terzaghi[3] is used for estimating the unconfined compression strength and undrained shear strength of medium stiff clay and sandy clay layers. The undrained shear strength in terms of t/m^2 is slightly larger than half the SPT N.

3.3.3 *Sand Layers*: The sand layers found here are residual type. Conventional method of estimating the angle of shearing resistance ϕ corresponding to the relative density and the grain size distribution usually adopted for sedimentary deposits is adopted here also. However, the presence of plastic fines will significantly reduce the friction angle, while the cohesion may not be present when fully saturated. The classification used for sedimentary deposits as suggested by Peck and suitably modified by the proposal by R.K. Hough to account for the influence of grain size distribution[4] is used here to estimate the angle of friction of these sand layers. The N values are corrected for overburden and ground water table as usual before arriving at the angle of friction.

3.3.4 *Weathered rock layers*: Cole & Stroud extended the classification by Terzaghi to low plasticity deposits formed by weathering and decomposition of rock and can be effectively used to estimate the shear strength of weathered rock and soft rock. The weathered rock formation found below the dense sand recorded SPT rebound. The parent rock being quartzite that has relatively high shear strength, the shear strength of this weathered layer is estimated assuming SPT N as more than 300.

3.3.5 **Shear strength of different soil layers** at different levels in this borehole are derived from the above correlations and presented in **Appendix A.**

3.4 ***Compressibility of Different Soil Layers***

3.4.1 The top sandy silty clay up to about 1.50m is stiff and has medium plasticity. This sandy clay is not of high swelling type. However, the clayey sand fou8nd below this depth recorded much better shear strength and hence shallow foundations placed over this layer at about 1.80m to 2.0m below present ground level are suitable for supporting the proposed constructions. The soil layers below this depth have very high shear strength and low compressibility. The overall thickness of overburden soil layers below the possible founding level is very small and will not result any significant settlement. Hence detailed estimation of compressibility parameters is

[3] K. Terzaghi & R.B. Peck, 'Soil Mechanics in Engineering Practice' Table 45.2 Art 45.
[4] T.William Lambe & R.V.Whitman, 'Soil Mechanics SI Version', Figure 11.14 & Table 11.3, pp. 148-149

not made here. The overall settlement of column footings for which the net safe bearing capacity is estimated considering the shear strength of dense sand immediately below the founding level will be very small as the shear strength is rapidly improving towards depth.

4 BEARING CAPACITY OF SOIL AND FOUNDATION

4.1 The proposed constructions are residential apartment buildings with the ground floor designed as a stilt floor and four upper floors. The average load intensity at the foundation level is not expected to be more than 7.5 t/m². Light to moderate column loads are only expected. Suitability of column footings for supporting the proposed construction is reviewed.

4.2 ***Shallow Foundation – Column Footings***

4.2.1 The expected column loads are light to moderate. The dense clayey sand layers found below 1.50m have good angle of friction and can offer good safe bearing capacity. Since the depth of embedment is critical for offering good safe bearing capacity for footings over sandy soil, the minimum depth of embedment is taken as 1.80m. The angel of friction for clayey sand immediately below the founding level is 36° and it rapidly increases to 45° where weathered fractured / disintegrated rock is present.

4.2.2 Since the safe bearing capacity of column footings over dense sand can be large, the size of footings required for supporting the proposed G+4 structure may be 1.50m to 3.00m. Hence, the net safe bearing capacity of 1.50m to 3.5m square footings is estimated as illustrated in **Appendix B-1**. Similar estimations for rectangular footings are presented in **Appendix B-2**. The ground water table is assumed at the present ground level to consider the worst condition. The estimated net safe bearing capacity is in the range of 38.5 t/m² to 45.5 t/m². The net SBC for shallow footings is uniformly selected as 35 t/m².

4.2.3 Weathered rock is present from varying depths of +6.80m RL to +5.80m RL. Footings supported on this weathered rock can offer net safe bearing capacity more than 55 t/m². Column footings placed over weathered rock at varying depths of 6.80m to 5.80m RL (2.20m to 3.20m below GL) can be adopted if the proposed construction is having basement. The recommended net SBC in such case is 55.0 t/m².

4.3 IS 1904-1986 recommends that the total settlement of shallow footings supporting an RCC framed structure may be limited to 50 to 60mm depending on the type of soil. Here the founding soil is dense sand and weathered rock that would produce immediate settlement. Hence a lower limit of 45mm is appropriate here for deciding the allowable bearing pressure. The soil layers below the founding level are very dense and the total settlements are expected to be well within the permissible limits. Detailed settlement estimations are not hence made here. The net safe bearing capacities from shear criterion are taken as the allowable bearing pressures limiting the total settlement to less than 45mm.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Residential apartment buildings with stilt floor and four upper floors are planned in the proposed residential project 'COROMANDEL ENCLAVE' at TS No: 398/1 Srinivasa Nagar, Upplipalayam, Coimbatore. The total area of the project land is approximately 10000 sq metres. The average load intensity at the founding level of this five level residential building is expected to be 7.0 t/m² to 7.5 t/m². Light to moderate column loads are expected.

5.2 The site is roughly 0.500m below the road top level. The stilt floor is expected to be roughly 500mm above the road top level.

5.3 Detailed sub-soil exploration using four exploratory boreholes is conducted in the site for studying the sub-soil conditions and then for deciding suitable foundation system for the proposed construction. These boreholes recorded more or less similar stratification, but with minor variations in the thickness of different soil layers and in the elevation of weathered rock. The top soil is sandy silty clay of medium plasticity that is classified as SC-CI with low swelling potential. Thickness of this layer is about 1.50m. The clayey sand layers those followed the top sandy clay are of residual type having high relative density. These sand layers are derived from complete weathering of laterised quartzite. Highly weathered and jointed quartzite is found below the dense sand layers. Elevation of weathered jointed rock varied between 7.00m RL and 5.80m RL. The present ground level is at +8.80m RL with respect to the site reference and the road top level is +9.20m RL.

5.4 The subsoil stratification and its variations across the construction area, shear strength and compressibility parameters of different soil layers, etc. are established from the field and laboratory tests.

5.5 The site has no open well. The boreholes recorded water at very shallow depth. The ground water table is expected to be very shallow during rains and such conditions are used in the estimation of foundation capacities. Water table may go down to deep levels during dry season.

5.6 ***Shallow Foundation –Column Footings***

5.6.1 The minimum depth of foundation is recommended as 1.80mm below present average ground level taken as 8.80m where dense dirty / clayey sand with gravel is present. The estimated net safe bearing capacities varied between 38.5 t/m² and 45.5 t/m² and the design net safe bearing capacity of shallow individual footings is recommended as 35.0 t/m². The soil layers immediately below the founding level are very dense rapidly followed by weathered quartzite. Hence the total settlement of shallow footings with such limited net safe bearing capacity will be much smaller than the allowable limits. The allowable bearing pressure is thus taken as same as the net SBC.

5.6.2 Shallow individual footings placed over weathered rock will have much better net safe bearing capacity. The recommended net SBC of footings resting over weathered quartzite available at varying elevations of 6.80m and 5.80m RL is 55.0 t/m².

5.7 ***Foundation Recommendations***

5.7.1 The proposed construction is a residential apartment building with stilt floor and four upper floors. The expected average load intensity at the foundation level is about 7.5 t/m². The foundation recommendations are as follows.

Type of foundation	- Individual column footings
Recommended depth of foundation	- 1.80m below GL*
Type of soil at founding depth	- Dense clayey sand with gravel
Recommended Net SBC	- 35 t/m²
Expected settlement	- <25mm

* The depth is w.r.t. the present ground level that is roughly 0.30m below the road level. The RL of foundation is +7.20m. The site reference datum is 10.00RL at the temporary bench mark located in the North East corner of the land.

5.7.2 The ground water table shall be established by digging few trial pits below the final excavation level. The ground water table shall be lowered well below the foundation excavation level

before commencing the foundation excavation. Dewatering shall be carried out through small excavations made outside the building footprint area exclusively for the purpose. Dewatering from foundation excavation shall not be allowed.

5.7.3 The sandy silty clay excavated from the site may be avoided in the backfilling of foundation excavations. Even though the sandy clay is not expansive type, compaction of such cohesive soil may prove to be very difficult.

5.7.4 If the proposed construction is having a basement, the column footings supported on weathered rock available at varying elevations of +6.80m and +5.80m RL can be used. The recommended net safe bearing capacity of such column footings is 55.0 t/m². The depth of foundation with respect to the existing ground level is 2.20m to 3.20m.

For **Geotechnical Solutions**

29 June 2012

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APPENDIX A

SHEAR STRENGTH PARAMETERS FOR DIFFERENT LAYERS
RESIDENTIAL PROJECT 'COROMANDEL ENCLAVE'
SRINIVASA NAGAR UPPILIPALAYAM, COIMBATORE

Ground water table = 1.10m to 1.50m (June 2012)

Borehole BH/1 (GL = 9.04m RL)

Depth Below GL	Soil	N	Design N	Shear Strength c_u or ϕ
0.00m to 0.60m	Dark reddish brown sandy silty clay (dry)			
0.60m to 1.40m	Reddish brown sandy silty clay	21	15	c_u = 7.5 t/m²
1.40m to 2.20m	Reddish brown clayey silty fine to coarse sand with gravel and stones	44	>45	ϕ = 36°
2.20m to 2.60m	Brownish dirty fine to coarse sand with gravel	>100	>75	ϕ = 45
2.60m to 4.70m	Brownish and light grey weathered and laterised quartzite		>300	c_u = 180 t/m²

Borehole BH/2 (GL = 8.67m RL)

Depth Below GL	Soil	N	Design N	Shear Strength c_u or ϕ
0.00m to 0.60m	Dark reddish brown sandy clay/ clayey sand (dry)			
0.60m to 1.40m	Reddish brown clayey fine to coarse sand with gravel and stones	47	>45	ϕ = 36°
1.40m to 1.80m	Dark brown clayey fine to coarse sand with gravel	>100	>75	ϕ = 45°
1.80m to 2.80m	Light yellowish weathered and laterised quartzite		>300	c_u = 180 t/m²

Borehole BH/3 (GL = 8.74m RL)

Depth Below GL	Soil	N	Design N	Shear Strength c_u or ϕ
0.00m to 1.40m	Dark reddish brown sandy silty clay (dry in the surface)	37	15	c_u = 7.5 t/m²
1.40m to 2.20m	Dark reddish brown clayey fine to coarse sand with gravel &weathered stones	53	>45	ϕ = 36°
2.20m to 3.00m	Brownish dirty fine to coarse sand with weathered stones	>100	>75	ϕ = 45°
3.00m to 4.00m	Brownish and grey highly weathered and laterised quartzite		>300	c_u = 180 t/m²

Borehole BH/4 (GL = 8.92m RL)

Depth Below GL	Soil	N	Design N	Shear Strength c_u or ϕ
0.00m to 1.40m	Dark reddish brown sandy silty clay (dry at the surface)	38	15	c_u = 7.5 t/m²
1.40m to 2.40m	Reddish brown dirty fine to coarse sand with gravel	38,>100	>45	ϕ = 36°
2.40m to 3.20m	Brownish & grey highly weathered fractured rock	>1100 to RB	>75	ϕ = 45°
3.20m to 4.20m	Brownish and grey weathered and laterised quartzite		>300	c_u = 180 t/m²

BEARING CAPACITY — SQUARE FOOTINGS AT 1.80M BELOW GL (+7.20M RI

Project:	Residential Project 'COROMANDEL ENCLAVE', Upplipalayam, Coimbatore
Structure	Stilt + 4, RCC Frame

Ultimate Bearing Capacity = $cN_cs_cd_ci_cg_c + 1/2B\gamma N_\gamma s_\gamma d_\gamma i_\gamma g_\gamma + \gamma D(N_q-1)s_qd_qi_qg_q$

Bearing Capacity Estimation using IS Code 6403 -1981

Soil Data			
Reference Bore Hole	**BH/1 to BH/4**		
Type of Soil	Clayey fine to coarse sand with gravel		
Corrected SPT N	50		*Failure Case*
Cohesion c	0.0	t/m²	*Local Shear failure when angle of friction is 28deg or less*
Bulk density above FL	1.80	gm/cc	*Angle of frcition is adjusted to 0.67 tan(phi)*
Bulk density below FL	1.90	gm/cc	*General shear failure when angle of friction is 36deg or more*
Ground water table	0.00	m	*Angle of frcition is equal to original value*
			Intermediate case when 28deg < PHI <36deg
Factor of safety	3.00		*Angle of frcition is interpolated*

ESTIMATION 1

Depth of Foundation	**1.80 m**	Angle of Friction ϕ	36.0 deg
Shape of Footing	**Square**	Failure Case	General
Width of Foundation	**1.50 m**	Design Angle of Friction	36.0 deg.

	N_i	s_i	d_i	i_i	N	Ultimate
N_c	50.63	1.30	1.40	1.00	92.2	0.0
N_q	37.79	1.20	1.24	1.00	54.5	88.4
N_r	56.36	0.60	1.24	1.00	41.8	28.2

Total Ultimate Bearing capacity 116.6 t/m²

Net Safe Bearing Capacity 38.5 t/m²

ESTIMATION 2

Depth of Foundation	**1.80 m**	Angle of Friction ϕ	36.0 deg
Shape of Footing	**Square**	Failure Case	General
Width of Foundation	**2.50 m**	Design Angle of Friction	36.0 deg

	N_i	s_i	d_i	i_i	N	Ultimate
N_c	50.63	1.30	1.28	1.00	84.4	0.0
N_q	37.79	1.20	1.14	1.00	50.4	81.6
N_r	56.36	0.60	1.14	1.00	38.6	43.4

Total Ultimate Bearing capacity 125.0 t/m²

Net Safe Bearing Capacity 41.5 t/m²

ESTIMATION 3

Depth of Foundation	**1.80 m**	Angle of Friction ϕ	36.0 deg
Shape of Footing	**Square**	Failure Case	General
Width of Foundation	**3.50 m**	Design Angle of Friction	36.0 deg

	N_i	s_i	d_i	i_i	N	Ultimate
N_c	50.63	1.30	1.20	1.00	79.1	0.0
N_q	37.79	1.20	1.10	1.00	48.6	78.7
N_r	56.36	0.60	1.10	1.00	37.2	58.6

Total Ultimate Bearing capacity 137.4 t/m²

Net Safe Bearing Capacity 45.5 t/m²

Note: If loading is eccentric, total load shall be estimated for corrected area = L' x B' where L'=L-2e_i and B'= B-2e_b

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Velachery, Chennai 600 042

BEARING CAPACITY **RECTANGULAR FOOTINGS AT 1.80M BELOW GL (+7**

Project:	**Residential Project 'COROMANDEL ENCLAVE', Upplipalayam, Coimbatore**		
Structure	**Stilt + 4, RCC Frame**		

Ultimate Bearing Capacity $= cN_c s_c d_c i_c g_c + 1/2 B \gamma N_\gamma s_\gamma d_\gamma i_\gamma g_\gamma + \gamma D(N_q - 1) s_q d_q i_q g_q$

Soil Data		**Bearing Capacity Estimation using**	**IS Code 6403 -1981**
Reference Bore Hole	**BH/1 to BH/4**		
Type of Soil	Clayey fine to coarse sand with gravel		
Corrected SPT N	50	*Failure Case*	
Cohesion c	0.0 t/m²	*Local Shear failure when angle of friction is 28deg or less*	
Bulk density above FL	1.80 gm/cc	*Angle of frcition is adjusted to 0.67 tan(phi)*	
Bulk density below FL	1.90 gm/cc	*General shear failure when angle of friction is 36deg or more*	
Ground water table	0.00 m	*Angle of frcition is equal to original value*	
		Intermediate case when 28deg < PHI <36deg	
Factor of safety	3.00	*Angle of frcition is interpolated*	

ESTIMATION 1

Depth of Foundation	**1.80 m**	Angle of Friction ϕ			36.0 deg				
Shape of Footing	**Rectangle**	Failure Case			General				
Width of Foundation	**1.50 m**	Design Angle of Friction			36.0 deg.				
Length of Foundation m	**3.00 m**		N_i	s_i	d_i	i_i		N	Ultimate
		N_c	50.63	1.15	1.40	1.00		81.5	0.0
		N_q	37.79	1.10	1.24	1.00		50.0	81.0
		N_r	56.36	0.80	1.24	1.00		55.7	37.6
		Total Ultimate Bearing capacity						118.6	t/m²
		Net Safe Bearing Capacity						**39.5**	**t/m²**

ESTIMATION 2

Depth of Foundation	**1.80 m**	Angle of Friction ϕ			36.0 deg				
Shape of Footing	**Rectangle**	Failure Case			General				
Width of Foundation	**2.00 m**	Design Angle of Friction			36.0 deg				
Length of Foundation m	**3.50 m**		N_i	s_i	d_i	i_i		N	Ultimate
		N_c	50.63	1.17	1.35	1.00		80.3	0.0
		N_q	37.79	1.11	1.18	1.00		48.2	78.1
		N_r	56.36	0.77	1.18	1.00		51.2	46.0
		Total Ultimate Bearing capacity						124.2	t/m²
		Net Safe Bearing Capacity						**41.0**	**t/m²**

ESTIMATION 3

Depth of Foundation	**1.80 m**	Angle of Friction ϕ			36.0 deg				
Shape of Footing	**Rectangle**	Failure Case			General				
Width of Foundation	**2.00 m**	Design Angle of Friction			36.0 deg				
Length of Foundation m	**4.00 m**		N_i	s_i	d_i	i_i		N	Ultimate
		N_c	50.63	1.15	1.35	1.00		78.8	0.0
		N_q	37.79	1.10	1.18	1.00		47.6	77.1
		N_r	56.36	0.80	1.18	1.00		53.1	47.7
		Total Ultimate Bearing capacity						124.9	t/m²
		Net Safe Bearing Capacity						**41.5**	**t/m²**

Note: If loading is eccentric, total load shall be estimated for corrected area = L' x B' where L'=L-2e_l and B'= B-2e_b

Geotechnical Solutions
44/17 "BHASKARA", 44 Usha Street, Dr. Seethapathy Nagar
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FIGURE 1
LOCATION OF BORE HOLES

SOIL INVESTIGATION FOR
THE PROPOSED RESIDENTIAL PROJECT ' COROMANDEL ENCLAVE'
SRINIVASA NAGAR, UPPILIPALAYAM, COIMBATORE

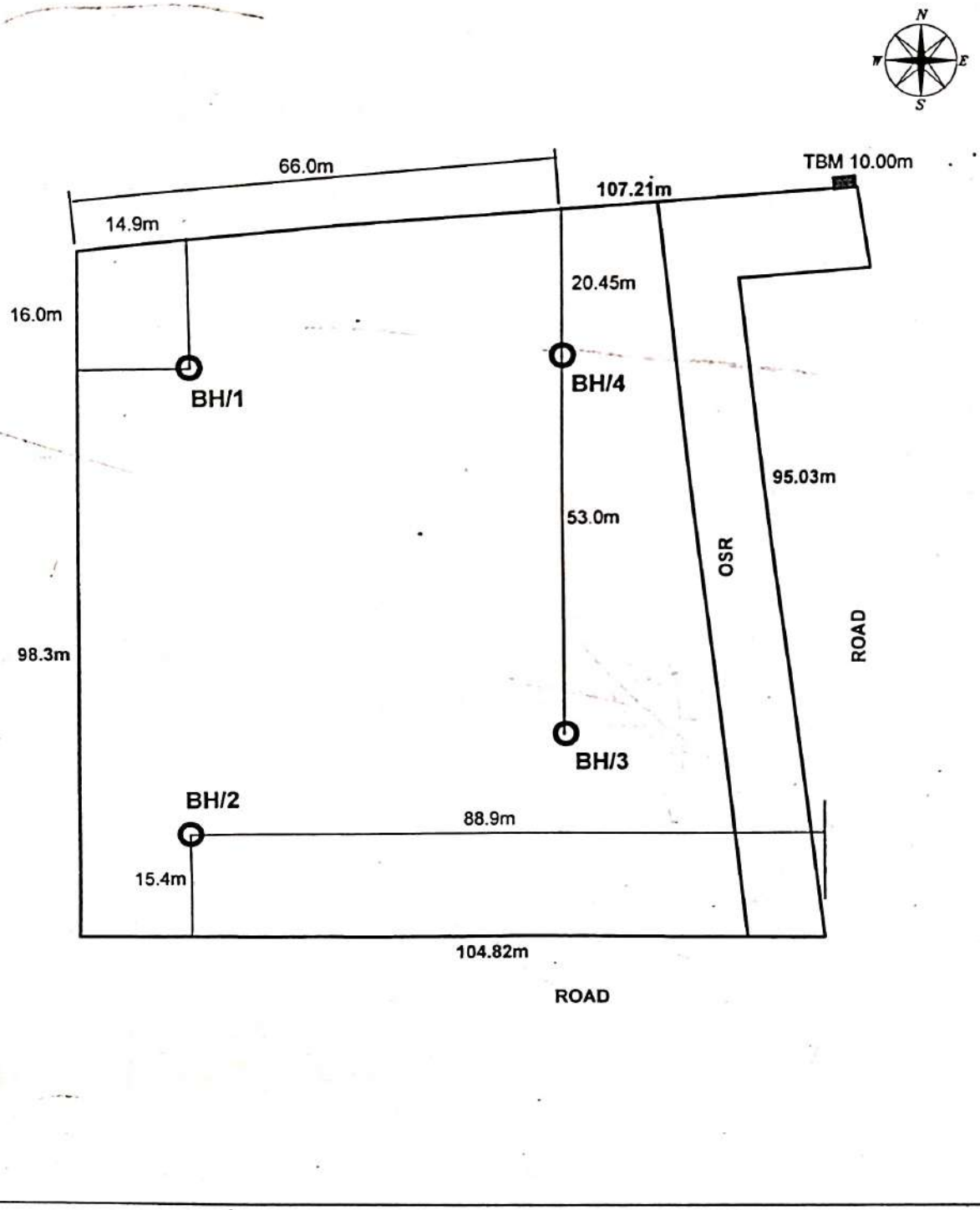
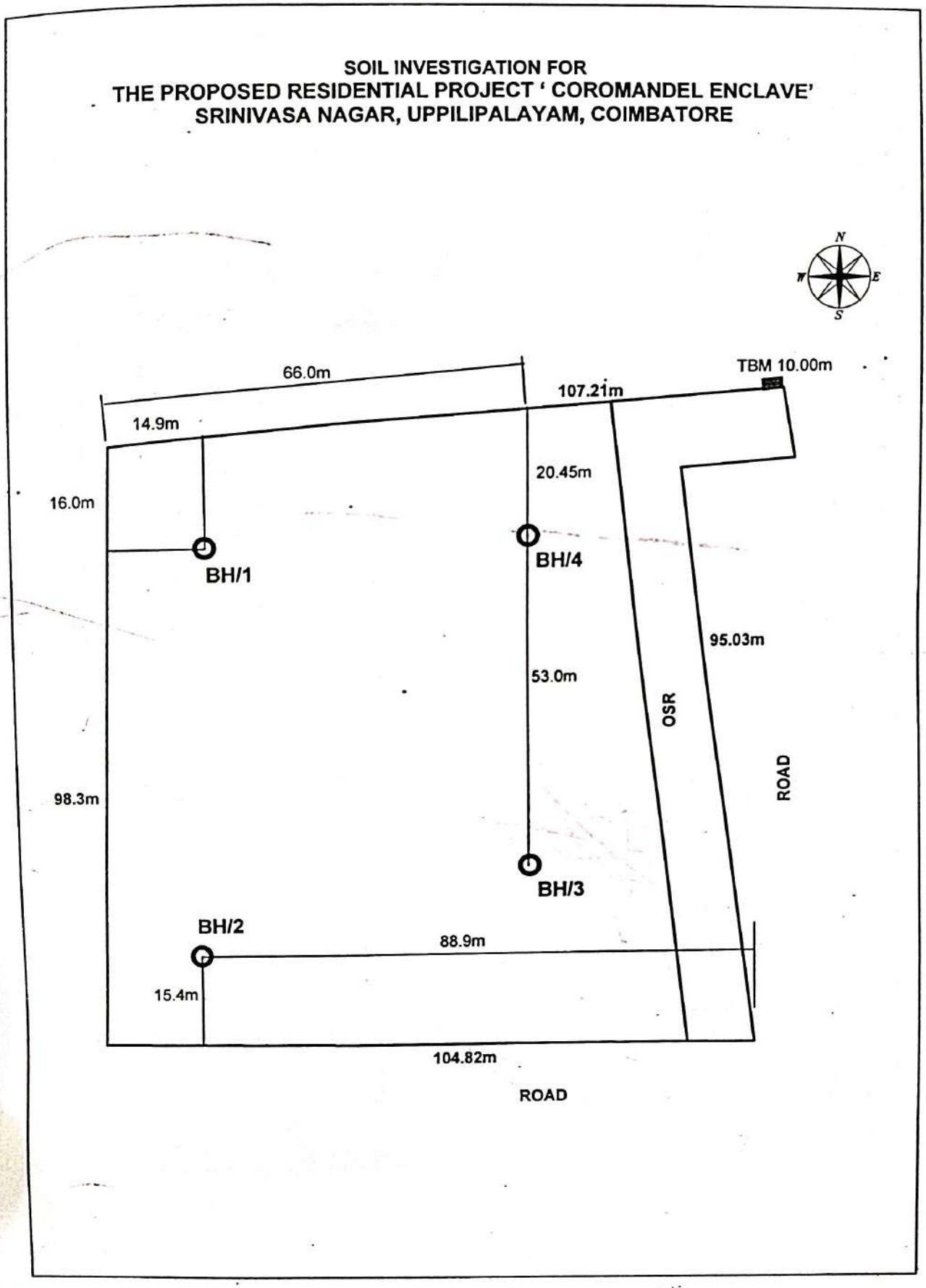
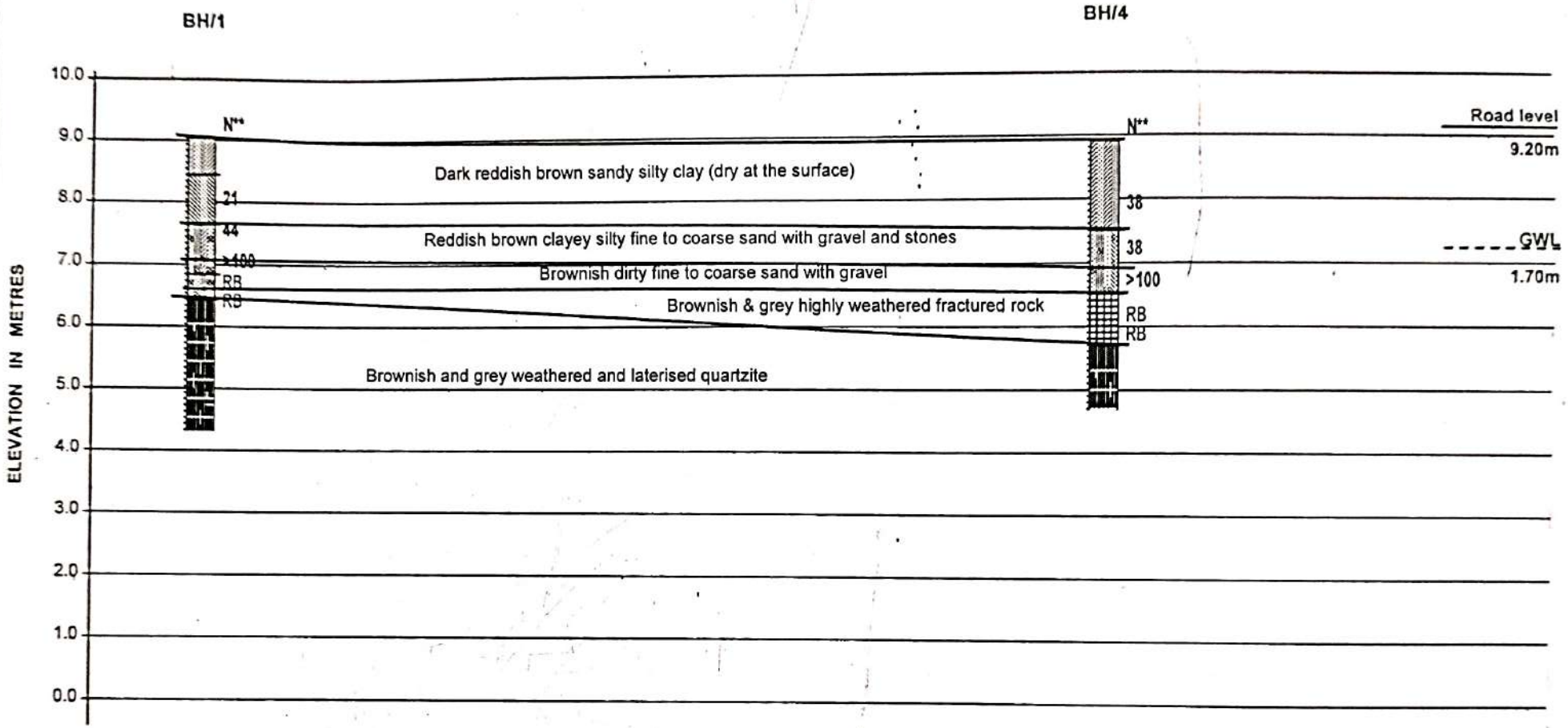


FIGURE 1
LOCATION OF BORE HOLES

SOIL INVESTIGATION FOR
THE PROPOSED RESIDENTIAL PROJECT ' COROMANDEL ENCLAVE'
SRINIVASA NAGAR, UPPILIPALAYAM, COIMBATORE

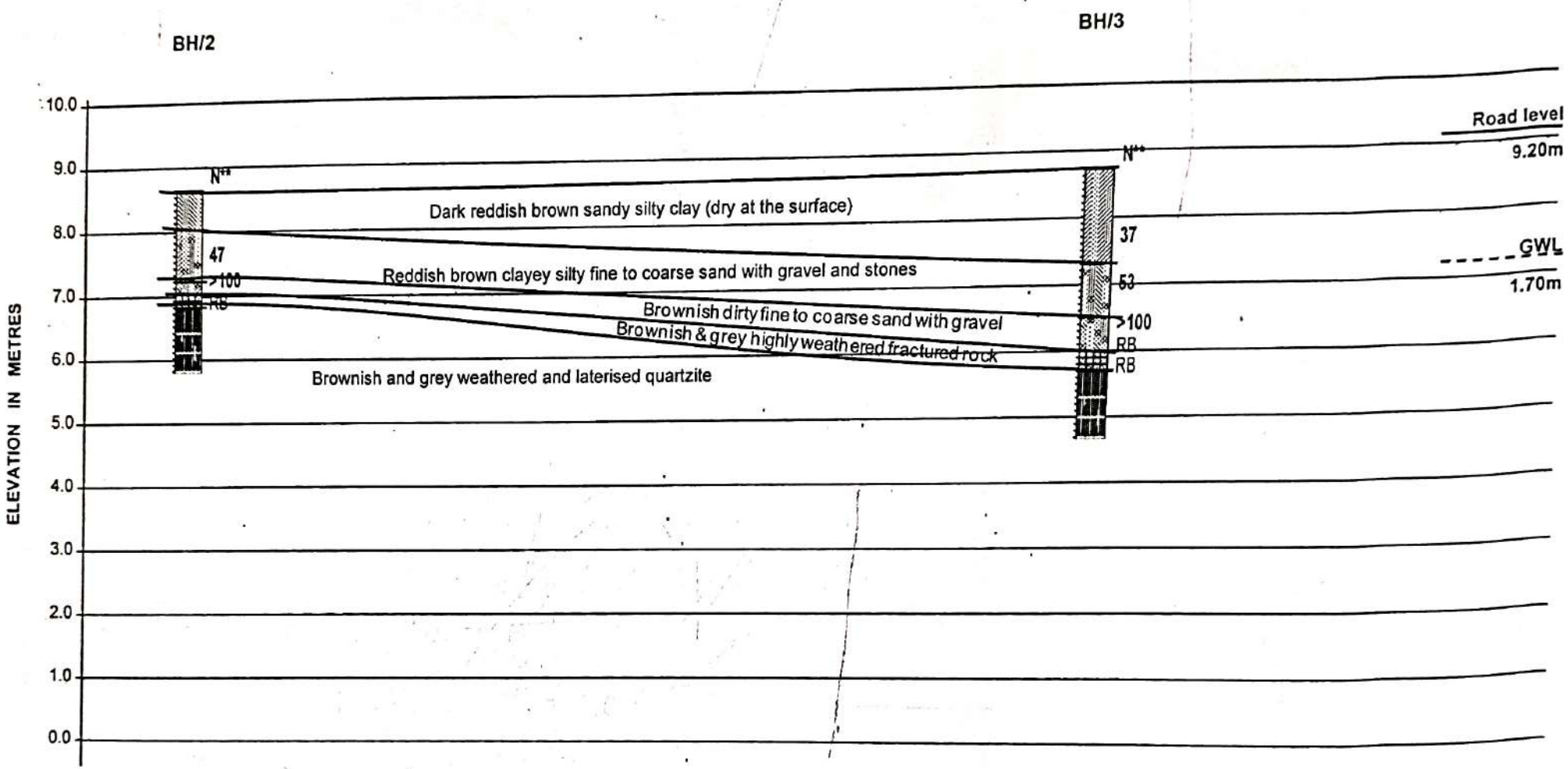




Ground elevation is with respect to site TBM 10.00m at the North East corner of the project land.
Ground water table from observation in the boreholes

FIGURE P-1

SUB-SOIL PROFILE BH/1 – BH/4
RESIDENTIAL PROJECT, COROMANDEL ENCLAVE, UPPLIPALAYAM, COIMBATORE

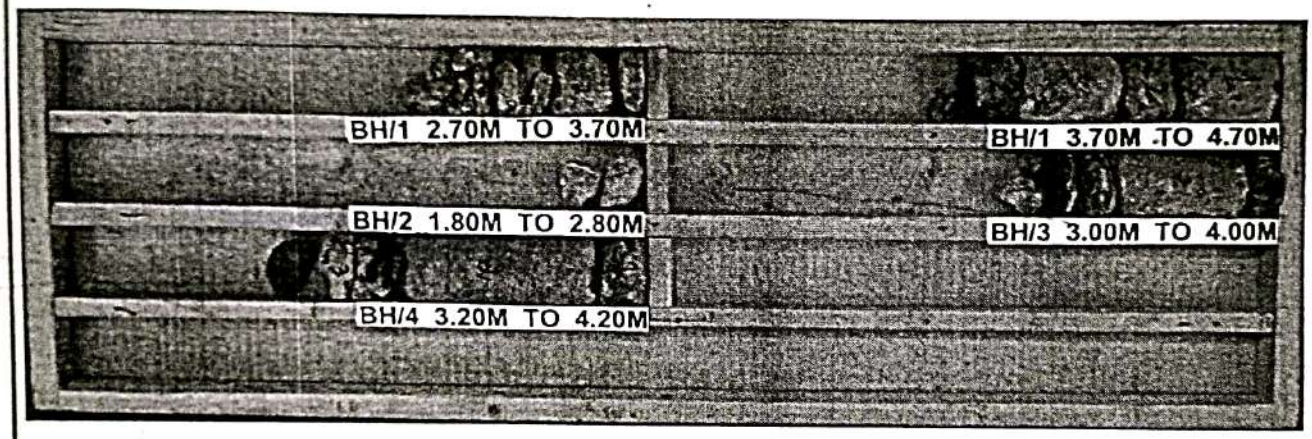


Ground elevation is with respect to site TBM 10.00m at the North East corner of the project land.
Ground water table from observation in the boreholes

FIGURE P-2

SUB-SOIL PROFILE BH/2 – BH/3
RESIDENTIAL PROJECT, COROMANDEL ENCLAVE, UPPLIPALAYAM, COIMBATORE

ROCK CORE SAMPLES FROM BH/1 TO BH/4
RESIDENTIAL PROJECT 'COROMANDEL ENCLAVE'
UPPILIPALAYAM, COIMBATORE



GEOTECHNICAL SOLUTIONS[A1]

SUMMARY OF LABORATORY TEST RESULTS

Project: **Residential Project, 'COROMANDEL ENCLAVE', Srinivasa Nagar, Uppilipalayam, Coimbatore**
Borehole Nos: **BH/1 to BH/4**
Type of Boring and dia of bore hole: 150mm diameter rotary boring with mud circulation

Ground Water Table: Not up to 4.50m

TABLE 1
SHEET 1 OF 2

Sample Depth m	Sample Type	Visual Identification of Soil	SPT "N"	Classification	Natural Moisture content %	Liquid Limit %	Plastic Limit %	Plasticity Index %	Liquidity Index	Free Swell Index %	Specific Gravity	Gravel %	Coarse Sand %	Medium Sand %	Fine Sand %	Silt %	Clay %
Depth (1)	Type (2)	Description (3)	(4)	CLASS (5)	NMC (6)	LL (7)	PL (8)	PI (9)	LI (10)	FSI (11)	SG (12)	G (13)	CS (14)	MS (15)	FS (16)	Silt (17)	Clay (18)
		BORE HOLE BH/1															
GL-0.50	DS	Dark reddish brown sandy silty clay (dry)			6.7												
0.75	SPT	Reddish brown sandy silty clay	21	SC-CI	18.8	47.0	LSL-12.14%						1.3	13.2	19.2	66.3	
1.50	SPT	Reddish brown clayey silty fine to coarse sand with gravel and stones	44	SCG-SW	11.3							27.2	19.0	17.0	15.7	21.1	
2.25	SPT	Brownish dirty fine to coarse sand with gravel and stones	>100		22.4												
2.70-3.70		Brownish and light grey weathered and laterised quartzite															
3.70-4.70		Brownish and light grey weathered and laterised quartzite															
		BORE HOLE BH/2															
GL-0.50	DS	Dark reddish brown sandy clay/ clayey sand (dry)			6.7												
0.75	SPT	Reddish brown clayey fine to coarse sand with gravel and stones	47	SCG-SW	11.4							16.9	28.2	15.2	10.5	29.2	
1.50	SPT	Dark brown clayey fine to coarse sand with gravel	>100		11.1												
1.80-2.80		Light yellowish weathered and laterised quartzite															

TABLE 1

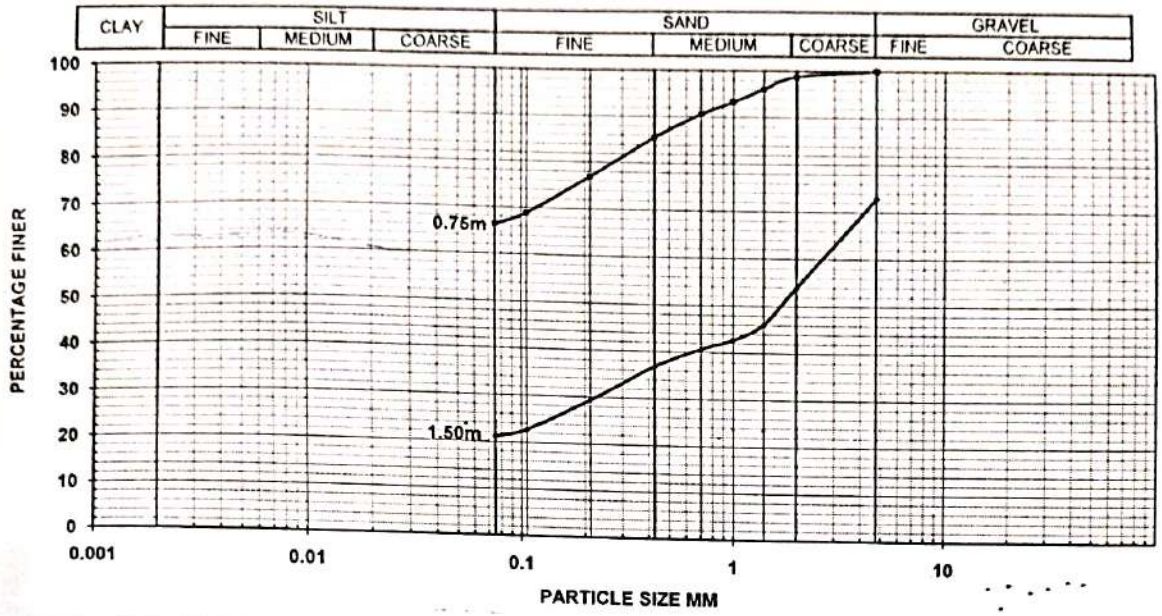
Project: **Residential Project, 'COROMANDEL ENCLAVE', Srinivasa Nagar, Uppilipalayam, Coimbatore**

Depth (1)	Type (2)	Description (3)	"N" (4)	CLASS (5)	NMC (6)	LL (7)	PL (8)	PI (9)	LI (10)	FSI (11)	SG (12)	G (13)	CS (14)	MS (15)	FS (16)	Silt (17)	Clay (18)
		BORE HOLE BH/3															
GL-0.50	DS	Dark reddish brown sandy silty clay (dry)			10.1												
0.75	SPT	Dark reddish brown sandy silty clay	37	SC-CI	17.2	46.7	23.1	23.6	<0.00	20.0							
1.50	SPT	Dark reddish brown clayey fine to coarse sand with gravel &weathered sto	54	SCG-SW	19.3							16.9	17.8	24.4	18.3	22.6	
2.25	SPT	Brownish dirty fine to coarse sand with weathered stones	>100	SW	19.3							9.8	32.4	29.4	16.6	11.8	
3.00-4.00		Brownish and grey highly weathered and laterised quartzite															
		BORE HOLE BH/4															
GL-0.50	DS	Dark reddish brown sandy silty clay (dry)			6.4												
0.75	SPT	Dark reddish brown sandy silty clay	38	SC-CI	16.5	44.1	21.6	22.5	<0.00	50.0							
1.50	SPT	Reddish brown dirty fine to coarse sand with gravel	38	SCG	17.0							11.3	13.5	29.6	26.7	18.9	
2.25	SPT	Reddish brown dirty fine to coarse sand with gravel	>100	SC-SP	19.0							6.8	19.6	28.0	27.0	18.6	
3.20-4.20		Brownish and grey weathered and laterised quartzite															

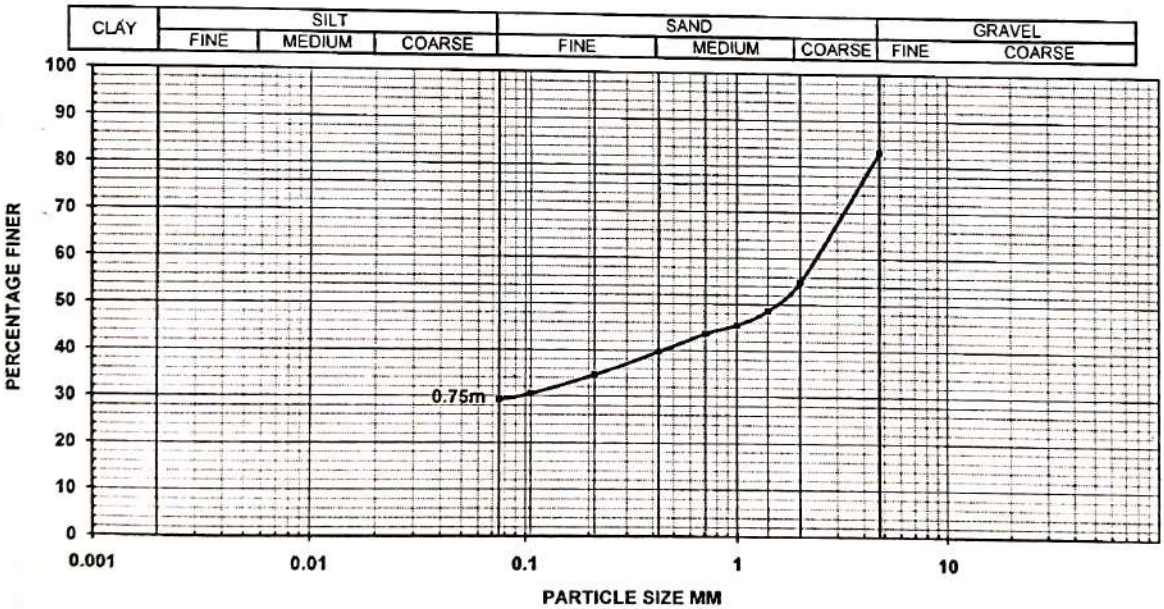
ANNEXURE G-1

GRAIN SIZE DISTRIBUTION CURVES

PROJECT: Residential Project, 'COROMANDEL ENCLAVE', Srinivasa Nagar, Uppilipalayam, Coimbatore



BH NO	DEPTH	PERCENTAGE FINER							Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Classification	D50 mm	cu (sand)	cc (sand)
	M	80mm	20mm	4.75m	2.0m	425m	75m	2m	A	B	C	E	D	E	F	G	H	I
BH/1	0.75m		100.0	100.0	98.7	85.5	66.3			1.3	13.2	19.2	66.3		SC		4.123	0.769
BH/1	1.50m		100.0	72.8	53.8	36.8	21.1		27.2	19.0	17.0	15.7	21.1		SCG-SW	1.681	12.946	2.853

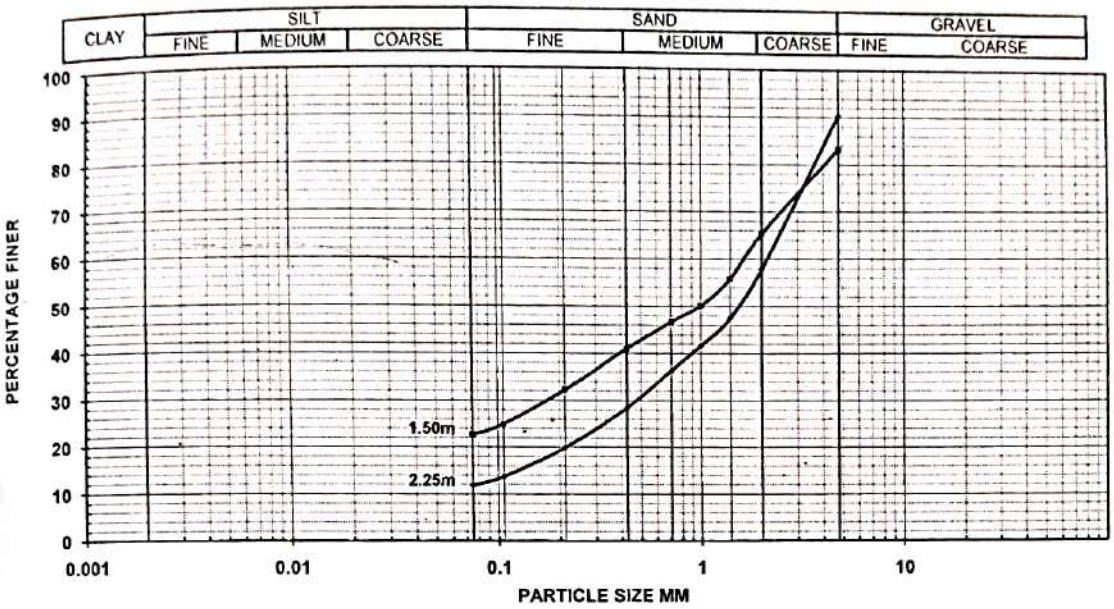


BH NO	DEPTH	PERCENTAGE FINER							Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Classification	D50 mm	cu (sand)	cc (sand)
	M	80mm	20mm	4.75m	2.0m	425m	75m	2m	A	B	C	E	D	E	F	G	H	I
BH/2	0.75m		100.0	83.1	54.9	39.7	29.2		16.9	28.2	15.2	10.5	29.2		SCG-SW	1.516	10.350	3.282

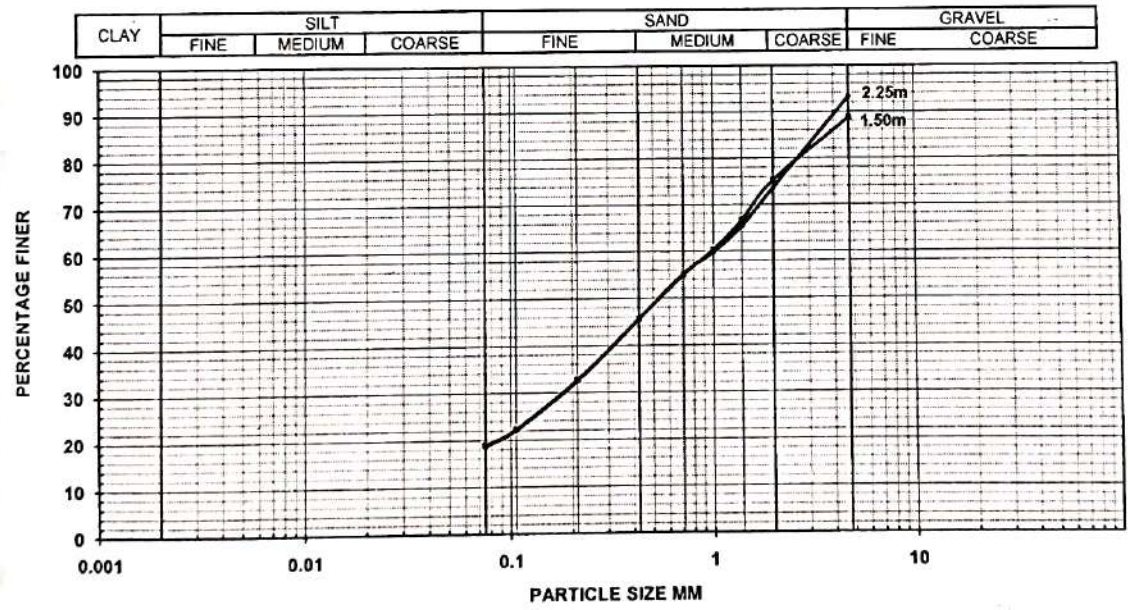
ANNEXURE G-2

GRAIN SIZE DISTRIBUTION CURVES

PROJECT: Residential Project, 'COROMANDEL ENCLAVE', Srinivasa Nagar, Uppilipalayam, Coimbatore



BH NO	DEPTH	PERCENTAGE FINER							Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Classification	D50 mm	cu (sand)	cc (sand)
	M	80mm	20mm	4.75m	2.0m	425m	75m	2m	A	B	C	E	D	E	F	G	H	I
BH/3	1.50m		100.0	83.1	65.3	40.9	22.6		16.9	17.8	24.4	18.3	22.6		SCG-SW	0.990	12.355	1.106
BH/3	2.25m		100.0	90.2	57.8	28.4	11.8		9.8	32.4	29.4	16.6	11.8		SW	1.527	10.248	1.242



BH NO	DEPTH	PERCENTAGE FINER							Fine Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Classification	D50 mm	cu (sand)	cc (sand)
	M	80mm	20mm	4.75m	2.0m	425µ	75µ	2µ	A	B	C	E	D	E	F	G	H	I
BH/4	1.50m		100.0	88.7	75.2	45.6	18.9		11.3	13.5	29.6	26.7	18.9		SCG-SP	0.540	10.003	0.664
BH/4	2.25m		100.0	93.2	73.6	45.6	18.6		6.8	19.6	28.0	27.0	18.6		SC-SP	0.536	10.630	0.620

FIELD BORE LOG

ANNEXURE 1

GEOTECHNICAL Solutions[A1]

PROJECT NO:	TICL/UPILI/G-962
BORE HOLE NO:	BH/1

Project : Residential Project, 'COROMANDEL ENCLAVE'
Site : Srinivasa Nagar, Uppilipalayam, Coimbatore
Co-ordinates : As shown in Figure 1
Diameter and type of boring : 150mm Rotary boring with drilling mud circulation

Date of start : 19-Jun-2012
Date of finish : 19-Jun-2012
GWL from GL : 1.40m
Ground level RL : 9.04m

Depth from GL(m)	Soil Profile	Field Description	Depth of samples collected UDS	Depth of samples collected DS	SPT / VST Test depth m	SPT blow counts 15	30	45	60	N**	RD / Consistency
0.6		Dark reddish brown sandy silty clay (dry)		0.50							Dry
1.0		Reddish brown sandy silty clay		0.75	0.75	10	10	11	12	21	Stiff
1.4		Reddish brown clayey silty fine to coarse sand with gravel and stones		1.50	1.50	12	19	25	30	44	Dense
2.0				2.25	2.25	50/10cm				>100	
2.2		Brownish dirty fine to coarse sand with gravel			2.50	Rebound				RB	Very dense
2.6			2.50-2.70		2.70	Rebound				RB	
3.0		Brownish and light grey weathered and laterised quartzite	2.70-3.70		Diamond core drilling NX size, recovery 13%, RQD nil						Moderately strong
4.0			3.70-4.70		Diamond core drilling NX size, recovery 21%, RQD nil						
5.0											
6.0											
7.0											
8.0											
9.0											
10.0											
11.0											
12.0											
13.0											
14.0											
15.0											
16.0											
17.0											
18.0											
19.0											
20.0		TC core drilling from 2.50m to 2.70m DC core drilling from 2.70m to 4.70m									

Borehole terminated at 4.70m

**Note: SPT Conducted using winch cat-head device, N values reported are close to N_{70}

FIELD BORE LOG

ANNEXURE 2

GEOTECHNICAL Solutions[A1]

PROJECT NO:	TICL/UPILI/G-962
BORE HOLE NO:	BH/2

Project Residential Project, 'COROMANDEL ENCLAVE'
Site Srinivasa Nagar, Uppilipalayam, Coimbatore
Co-ordinates : As shown in Figure 1
Diameter and type of boring : 150mm Rotary boring with drilling mud circulation

Date of start : 20-Jun-2012
Date of finish : 20-Jun-2012
GWL from GL : 1.10m
Ground level RL : 8.67m

Depth from GL(m)	Soil Profile	Field Description	Depth of samples collected UDS	Depth of samples collected DS	SPT / VST Test depth m	SPT blow counts 15	30	45	60	N**	RD / Consistency
0.6		Dark reddish brown sandy clay/ clayey sand (dry)		0.50							Dry
1.0		Reddish brown clayey fine to coarse sand with gravel and stones		0.75	0.75	10	26	21		47	Dense
1.4				1.50	1.50	50/10cm				>100	Very dense
1.8		Dark brown clayey fine to coarse sand with gravel	1.60-1.80		1.80	Rebound				RB	
2.0		Light yellowish weathered and laterised quartzite	1.80-2.80		Diamond core drilling NX size, recovery 5%, RQD nil						Moderately strong
3.0											
4.0											
5.0											
6.0											
7.0											
8.0											
9.0											
10.0											
11.0											
12.0											
13.0											
14.0											
15.0											
16.0											
17.0											
18.0											
19.0											
20.0		TC core drilling from 1.60m to 1.80m DC core drilling from 1.80m to 2.80m									

Borehole terminated at 2.80m

**Note: SPT Conducted using winch cat-head device, N values reported are close to N_{70}

FIELD BORE LOG

ANNEXURE 3

GEOTECHNICAL Solutions[A1]

PROJECT NO:	TICL/UPILI/G-962
BORE HOLE NO:	BH/3

Project : Residential Project, 'COROMANDEL ENCLAVE'
Site : Srinivasa Nagar, Uppilipalayam, Coimbatore
Co-ordinates : As shown in Figure 1
Diameter and type of boring : 150mm Rotary boring with drilling mud circulation

Date of start : 20-Jun-2012
Date of finish : 20-Jun-2012
GWL from GL : 1.30m
Ground level RL : 8.74m

Depth from GL(m)	Soil Profile	Field Description	Depth of samples collected		SPT / VST						RD / Consistency
			UDS	DS	Test depth m	SPT blow counts 15	30	45	60	N**	
1.0		Dark reddish brown sandy silty clay (dry in the surface)		0.50							Dry
1.4				0.75	0.75	11	19	18	20	37	Stiff
2.0		Dark reddish brown clayey fine to coarse sand with gravel &weathered stones		1.50	1.50	13	22	31		53	Dense
2.2				2.25	2.25	50/14cm				>100	
3.0		Brownish dirty fine to coarse sand with weathered stones	2.80-3.00		2.80	Rebound				RB	Very dense
					3.00	Rebound				RB	
4.0		Brownish and grey highly weathered and laterised quartzite	3.00-4.00		Diamond core drilling NX size, recovery 16%, RQD 10%						Moderately strong
5.0											
6.0											
7.0											
8.0											
9.0											
10.0											
11.0											
12.0											
13.0											
14.0											
15.0											
16.0											
17.0											
18.0											
19.0											
20.0		TC core drilling from 2.80m to 3.00m DC core drilling from 3.00m to 4.00m									

Borehole terminated at 4.00m

**Note: SPT Conducted using winch cat-head device, N values reported are close to N_{70}

FIELD BORE LOG

ANNEXURE 4

GEOTECHNICAL Solutions[A1]

PROJECT NO:	TICL/UPILI/G-962
BORE HOLE NO:	BH/4

Project : Residential Project, 'COROMANDEL ENCLAVE'
Site : Srinivasa Nagar, Uppilipalayam, Coimbatore
Co-ordinates : As shown in Figure 1
Diameter and type of boring : 150mm Rotary boring with drilling mud circulation

Date of start : 21-Jun-2012
Date of finish : 21-Jun-2012
GWL from GL : 1.50m
Ground level RL : 8.92m

Depth from GL(m)	Soil Profile	Field Description	Depth of samples collected		SPT / VST						RD / Consistency
			UDS	DS	Test depth m	SPT blow counts 15	30	45	60	N**	
1.0		Dark reddish brown sandy silty clay (dry at the surface)		0.50							Dry
1.4				0.75	0.75	18	18	20	19	38	Stiff
2.0		Reddish brown dirty fine to coarse sand with gravel		1.50	1.50	13	18	20	22	38	Dense
2.4				2.25	2.25	35	50/10cm			>100	
3.0		Brownish & grey highly weathered fractured rock			2.90	Rebound				RB	Weak
3.2			2.90-3.20		3.20	Rebound				RB	
4.0		Brownish and grey weathered and laterised quartzite	3.20-4.20		Diamond core drilling NX size, recovery 23%, RQD 14%						Moderately strong
5.0											
6.0											
7.0											
8.0											
9.0											
10.0											
11.0											
12.0											
13.0											
14.0											
15.0											
16.0											
17.0											
18.0											
19.0											
20.0		TC core drilling from 2.90m to 3.20m DC core drilling from 3.0m to 4.20m									

Borehole terminated at 4.20m

**Note: SPT Conducted using winch cat-head device, N values reported are close to N_{70}



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