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GEOTECHNICAL REPORT FOR

RESIDENTIAL BUILDING AT PAMMAL, CHENNAI - 600 075

Client :

M/s. DAC Developers Private Limited.,
Chennai

Architect :

Consultant :

Structural Consultant :

Job No. : G(C)9762 Date : 05.12.2022

NAGADI CONSULTANTS PRIVATE LIMITED

Branch :

Chennai

Project :

RESIDENTIAL BUILDING AT PAMMAL,
CHENNAI - 600 075

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GEOTECHNICAL INVESTIGATION REPORT

for Residential Building at Pammal, Chennai

EXECUTIVE SUMMARY

M/s. DAC Developers Private Limited, Chennai are associated in the construction of a Residential Building at Pammal, Chennai - 600075.

The site for the proposed residential building is situated on the south eastern side of road in Pammal, Chennai - 600075. The site is irregular in shape and measures approximately 1.27acres in area. The site is open on all the sides and is undulating with a level difference of about 0.7m. Vegetation in the form of grass was observed within the site during the field investigations. A portion southern side of the site was waterlogged due to the rains prior to the field investigations.

The proposed residential building consists of a single basement, open stilt floor at ground level and five upper floors.

Geotechnical investigations have been undertaken at the site as per the scope of investigations, stipulated by the client, which consisted of total 4 boreholes down to refusal strata and drilling further in refusal strata by 3m only in 2boreholes.

The results of investigations have shown the presence of filled-up strata down to 1/1.2/1.3m depth below which virgin soil was encountered. The virgin soil encountered is Brown sandy silty clay/ clayey silty sand with gravel down to 5.4/5.5/5.9m depth below existing ground level at which refusal strata in the form of completely weathered rock strata (Charnockites based) was encountered and continued down to the termination depths of 8.5/9m depth below existing ground level.

The soil strata is in a medium stiff/loose to medium dense state down to the depths of refusal strata encountered at 5.4/5.5/5.9m depth below existing ground level.

Ground water table was encountered at 0.5m depth below existing ground level in the boreholes during the period of field investigations. This high water table might be due to the recent rains

that occurred prior to the field investigations and may go down in due course of time.

In view of the observed subsoil conditions, the proposed structure can be supported on *Raft Foundations laid at a minimum depth of 4m below the existing ground level (on account of provision of single basement)* with a *Net allowable bearing pressure of 16t/m^2 (1.6kg/cm^2).* Alternatively, *Bored Pile Foundations* can be adopted. The safe capacities of pile for various diameters are given below:

Diameter of Pile (mm)	*Depth of Pile Toe Below EGL (m)*	*Safe Pile Capacity (t)*	*Safe Uplift Capacity (t)*
450	8	85	20
500	8	100	25
600	8.5	150	40

Raft Foundations

The excavated soil cannot be used for backfilling purposes as the soil is medium swelling type. After carrying out the excavations for the foundations, the top slush should be removed and the surface compacted heavily. If any loose pockets are observed, the same shall be filled with brickbats/ gravel and compacted well. Foundations can subsequently be placed over such a prepared surface.

The raft foundation should be adequately stiffened with reinforcement both at top and bottom so that the anticipated seasonal deformations of the underlying soil can be satisfactorily sustained without distress.

Pile Foundations

The Bentonite being used for Piling should be as per IS 2911.

REPORT ON GEOTECHNICAL INVESTIGATION FOR RESIDENTIAL BUILDING AT PAMMAL, CHENNAI

1.0 INTRODUCTION

1.1 Overview

1.1.1 M/s. DAC Developers Private Limited, Chennai are associated in the construction of a Residential Building at Pammal, Chennai - 600075.

1.1.2 The geotechnical investigations have been carried to ascertain the soil conditions for the design of foundations of the proposed residential building.

1.2 Authority

A detailed geotechnical investigations programme has been conducted as per the authorisation by M/s. DAC Developers Private Limited., Chennai vide their confirmation mail dated 14.11.2022.

2.0 PROJECT DETAILS

2.1 Site Location

The site for the proposed residential building is situated on the south eastern side of road in Pammal, Chennai - 600075.

2.2 Site Layout and Topography

2.2.1 The site is irregular in shape and measures approximately 1.27acres in area. The site is open on all the sides and is undulating with a level difference of about 0.7m. Vegetation in the form of grass was observed within the site during the field investigations. A portion southern side of the site was waterlogged due to the rains prior to the field investigations.

2.2.2 The colour of the exposed soil surface is Brown.

2.3 The Structure

As per information provided by the client, the proposed residential building consists of a single basement, open stilt floor at ground level and five upper floors.

2.4 Seismic Zone

Site for the proposed residential building is situated in Pammal, Chennai which falls under Seismic Zone III as per IS 1893 (Part 1) - 2016.

2.5 Geographical Information

2.5.1 Site for the proposed residential building is located at:

a) Latitude : 12°97'

b) Longitude : 80°13'

3.0 OBJECT OF INVESTIGATIONS

3.1 For designing the foundation system of the proposed structure, the following data are required:

a) Type of foundation system.

b) Depth below the ground level at which the foundation system is to be laid.

c) Allowable bearing pressure on the foundations levels.

3.2 To determine above factors, the following information would be required:

a) The subsoil profile indicating thicknesses of the various soil strata, to a depth down to the influence zone below the foundations.

b) Engineering properties of the soil strata at various levels.

c) Physical characteristics of the soil strata.

d) Variation of the strength of the strata with depth.

3.3 For evaluating the above parameters, field investigations and laboratory investigations on the soil samples collected during the field investigations, have been carried out.

3.4 The results from these investigations have been analysed to provide the recommendations for the design of foundations.

4.0 SCOPE OF INVESTIGATIONS

4.1 Scope of investigations as given in the work order consisted of:

a) Conducting a total of 4 boreholes; 2 boreholes down to 8m depth or refusal strata (where N>50), whichever is met earlier and 2 boreholes down to refusal strata (where N>100) and further drilling in refusal strata by minimum 3m, as required by the client.

b) Conducting standard penetration tests at 1.5m intervals.

c) Recovering undisturbed soil samples from various levels of the subsoil strata.

d) Recording ground water table levels, if met with.

e) Conducting relevant laboratory tests on soil samples recovered.

f) Preparation and submission of a technical report containing the details of the tests carried out, their analysis and recommendations regarding the foundation system to be adopted. Two copies of the report are to be submitted.

5.0 FIELD INVESTIGATIONS

5.1 General Details

5.1.1 The locations of the boreholes were shown at site by the client's representative. A Schematic site plan showing the boreholes locations marked by the client is given in fig.1.

5.1.2 Weather was clear during the period of field investigations which were carried out in the third week of November 2022. There were rains just before the field investigations.

5.2 Boreholes

5.2.1 Two boreholes (BH1 and BH4) were progressed by shell and auger method. The other

two boreholes (BH2 and BH3) were progressed by mechanically operated rotary core drill method. The boreholes were terminated as per the stipulated scope of work.

5.2.2 The boreholes BH1 and BH4 were terminated at refusal strata where further augering and penetration were not possible and the observed N-value was >50.

5.2.3 The boreholes BH2 and BH3 were terminated after drilling a minimum of 3m in refusal/rock strata (where N-value >100). The drilling in refusal/rock strata was conducted using NX size core barrel fitted with diamond bits.

5.2.4 Refusal strata in the form of completely weathered rock (Charnockite Based) was encountered at 5.4/5.5/5.9m and continued down to the termination depth of 5.6/5.7/8.5/9m depth below existing ground level.

5.2.5 The depths at which ground water table was encountered in the boreholes during the period of field investigations, depths of refusal strata encountered and termination depths of the boreholes are given below.

BH. No.	Depth of Water Table Below EGL (m)	Depth of Refusal Strata Below EGL (m)	Termination Depth Below EGL (m)
1	0.5	5.4	5.6
2	0.5	5.9	9
3	0.5	5.5	8.5
4	0.5	5.5	5.7

5.2.6 Ground water table was encountered at about 0.5m depth below existing ground level in the boreholes during the period of field investigations. This high water table might be due to the recent rains prior to the field investigations and may go down in due course of time.

5.2.7 Standard Penetration Tests were conducted in soil strata at 1.5m depth intervals.

5.2.8 Disturbed soil samples recovered from split spoon samples were packed in polythene bags, labelled and retained for identification purposes.

5.2.9 Undisturbed soil samples were recovered by thin walled tubes conforming to IS 2132. These tubes had an area ratio of less than 10%. The diameter of soil samples were 50mm and length 45cm.

6.0 LABORATORY INVESTIGATIONS

6.1 The soil samples brought to the laboratory were subjected to various tests to determine the following properties

a) Type of soil and its gradation

b) Consistency limits

c) Natural density

d) Natural water content

e) Shear strength properties

f) Swell Pressure

g) Consolidation properties

6.2 In order to determine the above properties listed in 6.2, the following tests were conducted.

a) Sieve analysis on the coarse grained soil fraction

b) Hydrometer analysis on the fine grained soil fraction

c) Liquid and plastic limits

d) Natural Density and Water Content tests

e) Triaxial tests

f) Free Swell Index tests

g) Swell Pressure test

h) Consolidation test

7.0 RESULTS AND ANALYSIS

7.1 Presentation of Results

7.1.1 The results of borehole investigations and of the laboratory investigations conducted on the soil samples collected from the borehole have been presented in the form of soil profile table in Table No.1 to 4.

7.1.2 The soil profile tables indicate the following:

a) Standard Penetration Test Values (i.e. N- values observed) at various depths

b) Soil description identifying the type of soil

c) Grain size analysis indicating composition of subsoil

d) Consistency limits

e) In-situ bulk density and Water content

f) Triaxial test results

7.2 Analysis of Soil Profile

7.2.1 A perusal of the data presented in the soil profile tables indicate the presence of the following substrata.

a) Stratum - I : Filled-up (soil)

b) Stratum - II : Brown sandy silty clay

c) Stratum - III : Brown clayey silty sand with gravel

d) Stratum - IV : Refusal strata - Brown with white completely weathered rock (Charnockite Based)

7.2.2 The thicknesses in each borehole of each strata described in 7.2.1 are given in the table below:

BH No.	Depth (m) : from - to			
	Stratum - I	Stratum - II	Stratum - III	Stratum - IV
1	0.0 - 1	1 - 4.1	4.1 - 5.4	5.4 - 5.6
2	0.0 - 1	1 - 5.9	-	5.9 - 9
3	0.0 - 1.2	1.2 - 5.5	-	5.5 - 8.5
4	0.0 - 1.3	1.3 - 5.5	-	5.5 - 5.7

7.2.3 The above results show that :

a) Stratum - I consisting of Filled-up strata having soil has been encountered down to the depth of 1/1.2/1.3m depth below existing ground level.

b) Stratum - II consisting of Brown sandy silty clay having significant percentages of clay and varying percentages of silt and sand, has been encountered from 1/1.2/1.3m depth to 4.1/5.5/5.9m depth below existing ground level.

c) Stratum - III consisting of Brown clayey silty sand with gravel having significant percentages of sand and varying percentages of silt, clay and gravel has been encountered between the depths of 4.1 and 5.4m below existing ground level only at the location of BH1.

d) Stratum - IV consisting of Refusal strata - Brown with white completely weathered rock - Charnockites based was encountered beyond the depth of 5.4/5.5/5.9m below existing ground level down to the termination depth of 5.6/5.7/8.5/9m depth below existing ground level.

7.3 Soil Composition

7.3.1 The grain size distribution of the soil samples at various depths, as determined in the laboratory have been presented in the form of grain size analysis curves in fig.3a and 3b.

7.3.2 The variations in the grain size distribution of the soil in the two soil strata in the boreholes are as follows:

a) Stratum - II : Brown sandy silty clay

BH No.	Gravel (%)	Sand (%)	Silt (%)	Clay (%)
1	0	17 - 27	35 - 37	38 - 46
2	0	14 - 16	34 - 36	48 - 52
3	0	19 - 29	31 - 36	40 - 45
4	0	17 - 23	34 - 37	43 - 46

b) Stratum - III : Brown clayey silty sand with gravel

BH No.	Gravel (%)	Sand (%)	Silt (%)	Clay (%)
1	5	50	27	18

This stratum was encountered only at the location of borehole BH1.

7.3.3 The above results indicate that:

a) Stratum - II consists of about 14 - 29 % of sand, 31 - 37% of silt and 38 - 52% of clay.

b) Stratum - III consists of about 18 % of clay , 27% of silt and 50% of sand with 0-5% of gravel.

7.4 In-situ Density and Water Content

7.4.1 The in-situ bulk densities, water contents and dry densities obtained from undisturbed soil samples are tabulated below.

BH No.	Depth (m)	In-situ Bulk Density (g/cm^3)	Water Content (%)	Dry Density (g/cm^3)
1	2	1.81	18.2	1.53
	3.5	1.83	20.9	1.51
	5	1.91	13.8	1.68
2	2	1.84	23.9	1.49
	3.5	1.87	24.2	1.51

BH No.	Depth (m)	In-situ Bulk Density (g/cm^3)	Water Content (%)	Dry Density (g/cm^3)
	5	1.93	22.9	1.57
	2	1.79	19.6	1.50
3	3.5	1.84	21.5	1.51
	5	1.93	19.9	1.61
	2	1.82	19.9	1.52
4	3.5	1.86	22.7	1.52
	5	1.90	19.7	1.59

7.4.2 The dry densities indicate that the subsoil is in a medium stiff/loose to medium dense state down to the depths of refusal/rock strata encountered at about 5.5-6m depths below existing ground level.

7.5 Consistency Limits

7.5.1 The Consistency Limits of the soil in Stratum - II (Brown sandy silty clay) indicates that the liquid limit varies between 23% to 50%, plastic limit varies between 14% to 23% and plasticity index varies between 9% to 27%.

7.5.2 The Consistency Limits of the soil in Stratum - III (Brown clayey silty sand with gravel) indicate that the soil in this strata is non plastic in nature.

7.5.3 The Consistency Limits indicate that the soil in :

a) Stratum - II (Brown sandy silty clay) is high plastic in nature.

b) Stratum - III (Brown clayey silty sand with gravel) is low plastic in nature.

7.6 Standard Penetration Tests

7.6.1 Standard Penetration Test values (N-values observed) are presented in the soil profile table no.1 to 4.

7.6.2 Standard Penetration Test values (N-values observed) have also been presented in form

of plots of N-values vs depth in fig.4.

7.6.3 The N-values indicate that the subsoil is in a stiff/medium dense state with observed N-values varying between 6 and 18 till refusal/rock strata.

7.7 Triaxial Test Results

7.7.1 The cohesion 'c' obtained from consolidated drained triaxial test varies between negligible to 0.12kg/cm² and 0.33kg/cm² and the angle of shearing resistance 'ϕ' of the soil varies between 13° and 25°.

7.7.2 The major and minor stress at failure of sample during the test along with the cohesion and angle of internal friction obtained from the tests are tabulated below:

BH No.	Depth (m)	Stress (kg/cm²)		Stress (kg/cm²)		c (kg/cm²)	ϕ (°)
		Major (σ_{11})	Minor (σ_{31})	Major (σ_{12})	Minor (σ_{32})		
1	2	2.46	1	1.61	0.5	0.29	15
	3.5	2.44	1	1.62	0.5	0.31	14
	5	2.84	1	1.61	0.5	0.12	25
2	2	2.4	1	1.61	0.5	0.33	13
	3.5	2.48	1	1.66	0.5	0.33	14
	5	2.56	1	1.68	0.5	0.3	16
3	2	2.37	1	1.58	0.5	0.31	13
	3.5	2.44	1	1.62	0.5	0.31	14
	5	2.53	1	1.65	0.5	0.29	16
4	2	2.4	1	1.58	0.5	0.3	14
	3.5	2.51	1	1.66	0.5	0.31	15
	5	2.61	1	1.71	0.5	0.29	17

7.8 Free Swell Index

7.8.1 The free swell index of the soil samples collected at various depths are given below:

BH No.	Free Swell Index (%) at Depth (m)	
	1.5	3
1	42.2	49.6
2	54.8	53.2
3	48.6	45.9
4	49.2	48.1

7.8.2 The above results indicate that the subsoil strata is medium swelling in nature. Hence, the excavated soil cannot be used for backfilling purposes.

7.9 Swell Pressure

7.9.1 The results of swell pressure tests are given below:

BH No.	Depth (m)	Swell Pressure (kg/cm²)
1	3.5	0.09
2	5	0.06
3	5	0.07
4	5	0.07

7.10 Consolidation tests

7.10.1 The results of the consolidation tests are tabulated below.

BH No	Depth (m)	e_o	C_c	a_v (cm²/kg)	m_v (cm²/kg)
2	5	0.811	0.096	0.021	0.0115
3	5	0.809	0.094	0.020	0.0113
4	5	0.806	0.092	0.020	0.0111

7.10.2 Settlement calculations from the parameters derived from the tests are given in

Appendix A1.

7.11 Compiled Soil Profile

7.11.1 An overview of the results and their analysis has been presented in the form of a compiled soil (fig. 2).

7.11.2 The above figure shows the various strata encountered and their thicknesses in each of the boreholes and also gives the soil composition and the observed N-values at various depths along with the depth at which undisturbed soil samples were collected.

8.0 DESIGN CRITERIA

8.1 Design Parameters

8.1.1 The parameters required for the design of foundation system for the proposed structure are:

a) Type of foundation to be adopted

b) Depth at which the foundations have to be laid

c) Allowable bearing pressure on the soil at the foundation level

8.1.2 On the basis of the analysis of the results of investigations, the required design parameters have been arrived at and are given in the following sections.

8.2 Type of Foundations

8.2.1 The type of foundation depends on the following:

a) Subsoil conditions

b) Type of structure

c) Configuration at loading points

d) Loading intensity on each sub-structure/structural element.

8.2.2 As per information provided by the client, the proposed residential building consists of a single basement, open stilt floor at ground level and five upper floors.

8.2.3 The results of the investigations have shown that the subsoil is in a medium stiff/loose to medium dense state down to the depths of refusal/rock strata.

8.2.4 Ground water table has been encountered at a shallow depth of about 0.5m below the existing ground level during the period of investigations. While the ground water table may go down in the dry season, the basement floor slab of the proposed structure will necessarily have to be designed for the possible uplift pressures due to shallow ground water table level.

8.2.5 Giving due consideration to the soil conditions and the fact that the basement floor will have to be designed for uplift water pressure, *Raft Foundations* can be adopted for the proposed residential building. Alternatively *Bored Pile Foundations* can be adopted.

8.3 Raft Foundations

8.3.1 Depth of Foundations

8.3.1.1 The depth at which foundations should be laid will be governed by the following criteria.

a) Top filled up strata/loose soil, if any

b) There should be sufficient thickness of soil above the footing/foundations so that the bearing capacity of the soil can be fully mobilised.

c) Soil below the level of footings/foundations should have the requisite strength to support the anticipated bearing pressures on the foundations without allowing the settlement of footings/foundations to exceed the acceptable limits.

d) Requirements of the type of structure (residential building consists of a single basement, open stilt floor at ground level and five upper floors).

8.3.1.2 In view of the above factors, foundations of the proposed structure can be made to rest at a minimum depth of *4m below the existing ground level (on account of the provision*

of single basement). The soil available at the founding level will be Brown sandy silty clay.

8.3.2 Allowable Bearing Pressure

8.3.2.1 Allowable bearing pressure has been evaluated by:

a) Shear failure criteria based on the average soil data

b) Settlement criteria based on the SPT values (N-values)

c) Settlement criteria based on deformation modulus

8.3.2.2 An allowable settlement of 30mm has been considered to evaluate the allowable bearing pressure for Raft Foundations.

8.3.2.3 A water table correction factor of 0.5 has been considered.

8.3.2.4 On the basis of the above analysis, *net allowable bearing pressure of 16t/m² can be adopted.*

8.3.2.5 The calculations for the allowable bearing pressure have been provided in Appendix A of this report.

8.4 Bored Pile Foundations

8.4.1 Depth fo Pile

8.4.1.1 To ensure similarity of settlement of all the pile foundations for the proposed building, the pile foundations should be founded in the refusal/rock strata.

8.4.1.2 As the pile foundations will be founded in refusal/rock strata, to achieve economy as well as maximum efficacy, the pile foundations should preferably be loaded to the safe structural capacity.

8.4.1.3 To ensure the mobilization of the full safe structural capacity, the Bored Piles should be embedded or socketed in refusal/completely weathered rock strata to a minimum depth equivalent to four times the diameter of the pile.

8.4.1.4 Accordingly the depth of pile toe for various diameters of piles are given below:

Diameter of Pile (mm)	Depth of Pile Toe Below EGL (m)
450	8
500	8
600	8.5

8.4.2 Pile Capacity

8.4.2.1 The safe pile capacities of piles of different diameters are given below:

Diameter of Pile (mm)	*Depth of Pile Toe Below EGL (m)*	*Safe Pile Capacity (t)*	*Safe Uplift Capacity (t)*
450	8	85	20
500	8	100	25
600	8.5	150	40

8.4.3 Sample calculations for pile capacity are given in Appendix B of this report.

9.0 RECOMMENDATIONS

9.1 Type of Foundations

Raft Foundations OR Bored Pile Foundations

9.2 Raft Foundations

9.2.1 Depth of Foundations

Minimum of 4m below the existing ground level (on account of the provision of single basement)

9.2.2 Allowable Bearing Pressure

Net allowable bearing pressure of 16t/m² can be adopted for an allowable settlement of 30mm.

9.3 Bored Pile Foundations

Diameter of Pile (mm)	*Depth of Pile Toe Below EGL (m)*	*Safe Pile Capacity (t)*	*Safe Uplift Capacity (t)*
450	*8*	*85*	*20*
500	*8*	*100*	*25*
600	*8.5*	*150*	*40*

9.4 Notes

9.4.1 The recommendations given in this report have been arrived at on the basis of design parameters which have been judiciously adopted by giving due consideration to the results of field and laboratory investigations as well as NAGADI's experience of over four decades in working in various types of soil and rock conditions all over India.

9.4.2 The entire report should be studied before adopting the recommendations given in the report.

9.5 Construction Advisories

9.5.1 The soil of each strata has been described with name, colour etc. During excavation, any variations observed in the nature and condition of the soil from those given in this Report should be noted and appropriate action should be taken.

9.5.2 Raft Foundations

9.5.2.1 The excavated soil cannot be used for backfilling purposes as the soil is medium swelling type.

9.5.2.2 After carrying out the excavations for the foundations, the top slush should be removed and the surface compacted heavily. If any loose pockets are observed, the same shall be filled with brickbats/ gravel and compacted well. Foundations can subsequently be placed over such a prepared surface.

9.5.2.3 The raft foundation should be adequately stiffened with reinforcement both at top and bottom so that the anticipated seasonal deformations of the underlying soil can be satisfactorily sustained without distress.

9.5.3 Pile Foundations

The Bentonite being used for Piling should be as per IS 2911.

9.6 References

A list of IS codes referred for providing the recommendations and that which might be required to implement the same has been given in Appendix C.

10.0 LIMITATIONS

This Geotechnical investigation has been carried out at locations in the site chosen by the client as representing the entire site. The recommendations provided in this Report are hence valid only for those test locations. However, if there is any change in the subsoil conditions and properties at places between or beyond the chosen test locations, Nagadi may be contacted for further actions. Fresh investigations will have to be carried out at such locations.

Dr. N. Santosh Rao
Technical Director
For NAGADI CONSULTANTS PVT. LTD.

ANALYSIS FOR ALLOWABLE BEARING PRESSURE

Data

(i) Soil Properties :

c (kg/cm^2) = 0.30 $\phi = 14°$ γ (g/cm^3) = 1.79

(ii) Depth of Foundation, D (m) = 4 (Effective 3m)

(iii) Allowable Settlement, s (mm) = 30

Shear Failure Criterion (Ref. IS : 6403)

$N_c = 10.37$ $N_q = 3.58$ $N_\gamma = 2.28$ $R_w = 0.50$ $R_w' = 0.50$

$$q_s = \frac{1}{2.5}\left(c \cdot N_c + \gamma D \cdot N_q \cdot R_w + 0.5 \cdot \gamma \cdot B \cdot N_\gamma \cdot R'_w\right) - \gamma D.R_w$$

B (m)	≥6
q_s (t/m^2)	16.7

Settlement Criterion (Ref. IS : 8009) ***From N Values***

B (m)	≥10
N corrected	38
Settlement for 1kg/cm² (mm) as per IS 8009 (Part 1) Fig.9	8
Therefore the bearing pressure for 30mm settlement (kg/cm²)	3.75
Therefore the bearing pressure for 60mm settlement (t/m²)	37.5
ABP considering a water table correction of 0.5 (t/m²)	18.7

The lower of the above is to be adopted.

ADOPT	**B (m)**	**≥6**
	q (t/m^2)	**16**

Note : ***q_s and q_a are NET VALUES, Weight of backfill etc. need not be added to the loading except in case of filling above original G.L.***

SETTLEMENT CALCULATION BASED ON CONSOLIDATION TEST

Data

(i) Compression Index C_c = 0.096

(ii) Initial void ratio e_o = 0.811

The total settlement of the foundation due to underlying compressible stratum is given by:

$$S = \{C_c / (1 + e_o)\}\ H.\ \log_{10}\ \{(P_o + \Delta P)\ /P_o\ \}$$

Where:

S	=	Settlement
C_c	=	Compression index
H	=	Thickness of compressible strata
P_o	=	Original intensity of pressure acting at mid height of compressible stratum
ΔP	=	Increment in pressure due to the additional load imposed through Foundation
e_o	=	Original Void Ratio

Data

Depth of foundation	=	400cm
Dimension of footing (assumed)	=	600 x 600cm
Bulk density	=	1.90gm/cc
Compression index C_c	=	0.096
Initial void ratio e_o	=	0.811
Compressible strata (H)	=	150cms

P_o {Bulk density x (Depth of footing + Compressible Strata /2)}= 0.9025kg/cm²

ΔP = $\{(q_a\ (B \times L)\}/\{(B+Z)(L+Z)\}$

Where:

q_a	=	Allowable bearing pressure = 16t/m² = 1.6kg/cm²
B & L	=	Dimension of footing = 600 x 600cm
Z	=	depth below foundation level of mid height of compressible stratum = 75cm
ΔP	=	1.264kg/cm²

substituting the values in the above equation, we get

S = 3.02cm = 30mm

The calculated settlement for an allowable bearing pressure of 16t/m² is 30mm which is equal to 30mm.

CALCULATION FOR LOAD CARRYING CAPACITY OF PILE

Typical calculations for the pile capacity has been given hereunder for a pile of diameter 500mm. For piles of other diameters, a similar procedure has been used to arrive at the recommended pile capacities.

Safe Pile Capacity

As per IS 2911 (Part 1/sec 2):2010, the following calculation can be used for the pile capacity

$$Q_a = C_{u1}N_c.\pi B^2/4F_s + \alpha c_{u2}.\pi BL/F_s$$

Where,

Q_a = The allowable load on the pile in kN

C_{u1} = shear strength of rock below the base of the pile, in kN/m² = 800kN/m²

N_c = bearing capacity factor taken as 9;

F_s = factor of safety usually taken as 3;

α = 0.9 (recommended value);

c_{u2} = average shear strength of rock in the socketed length of pile, in kN/m² = 600kN/m²

B = minimum width of pile shaft (diameter in case of circular piles), in m = 0.5m

L = socket length of pile, in m = 4 times x 0.5 = 2m.

Substituting the values in the above equation we get,

Q_a = 47.12t + 56.54t

= 103.7t

Therefore, adopt *100t*

Safe Uplift Capacity

As per the above, the skin friction along the pile shaft is = 56.54t

Considering a Factor of Safety of 2, Safe Uplift Capacity = 56.54/2 = 28.3t.

Therefore, adopt *Safe Uplift Capacity = 25t*

LIST OF IS CODES

Field Investigation

1. IS : 1498 - 1970 : Classification and identification of soils for general engineering purposes (First Revision) (Amendment 2)
2. IS : 1892 - 1979 : Code of practice for sub surface investigations for foundations (First revision)
3. IS : 2131 - 1981 : Method of Standard Penetration Tests for soils (First revision)
4. IS : 2132 - 1986 : Code of practice for thin walled tube sampling of soils (Second revision)

Laboratory Tests

1. IS : 2720 - 1983 (Part 1) : Methods of test for soils: Preparation of dry soil samples for various tests (Second revision)
2. IS : 2720 - 1980 (Part 2) : Method of test for soils: Determination of water content (Second revision) Amendment 1
3. IS : 2720 - 1980 (Part 3/Sec 1) : Method of test for soils : Determination of Specific Gravity : Fine grained soils. (First revision)
4. IS : 2720 - 1980 (Part 3/Sec 2) : Method of test for soils : Determination of Specific Gravity : Fine, Medium & Coarse grained soils. (First revision).
5. IS : 2720 - 1985 (Part 4) : Method of test for soils : Grain size analysis (Second revision)
6. IS : 2720 - 1985 (Part 5) : Method of test for soils : Determination of liquid and plastic limit (Second revision)
7. IS : 2720 - 1977 (Part 40) : Methods of tests for soils: Determination of free swell index of soils.

Foundation Construction

1. IS : 1080 - 1986 : Code of practice for design and construction of shallow foundations on soils (other than raft, ring and shell) (Second revision)
2. IS : 1904 - 1986 : Code of practice for design and construction of foundation in soils: General requirements (Third revision)
3. IS 6403 - 1981 : Code of practice for determination of bearing capacity of shallow foundations : First revision (Amendment 1)
4. IS 8009 - 1976 (Part 1) : Code of practice for calculation of settlements of foundations : Shallow foundations subject to symmetrical static vertical loads (Amendment 2)
5. IS 2911 (Part I to IV) : Design and construction of Pile Foundations

TABLES



SOIL PROFILE

Project: Residential Building at Pammal, Chennai - 600075

B. H. Location: | Water Table: 0.5m | Term. Depth : 5.6m | B.H. No. : 1

N - Value#	Depth (m)	Soil Description	Grain Size Analysis				Atterberg		In-situ			Triaxial Test		
			Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Liquid (%)	Plastic (%)	Density* (g/cm³)	Water Cont (%)	Type	c (kg/cm²)	ϕ (°)
	0.0	Ground level											
	1.0	Filled up strata											
	1.5	Change of strata											
7	2.0	Brown sandy silty clay	0	27	35	38	43	19	1.81	18.2	CD	0.29	15
	3.0	Brown sandy silty clay											
7	3.5	Brown sandy silty clay	0	17	37	46	50	23	1.83	20.9	CD	0.31	14
	4.1	Change of strata											
	4.5	Brown clayey silty sand with gravel	5	50	27	18	23	14					
17	5.0	Brown clayey silty sand with gravel							1.91	13.8	CD	0.12	25
	5.4	Change of strata											
>50 (50/8cm)	5.6	Brown with white completely weathered rock (Charnockites Based) Termination Depth											

*-Natural Bulk Density # -N Values (Observed)

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SOIL PROFILE

Project: Residential Building at Pammal, Chennai - 600075

B. H. Location: | Water Table: 0.5m | Term. Depth : 9.0m | B.H. No. : 2

N - Value#	Depth (m)	Soil Description	Grain Size Analysis				Atterberg		In-situ		Triaxial Test		
			Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Liquid (%)	Plastic (%)	Density* (g/cm³)	Water Cont (%)	Type	c (kg/cm²)	ϕ (°)
	0.0	Ground level											
		Filled up strata											
	1.0	Change of strata											
7	1.5	Brown sandy silty clay	0	14	34	52	55	25					
	2.0	Brown sandy silty clay							1.84	23.9	CD	0.33	13
7	3.0	Brown sandy silty clay	0	15	34	51	55	25					
	3.5	Brown sandy silty clay							1.87	24.2	CD	0.33	14
15	4.5	Brown sandy silty clay	0	16	36	48	53	24					
	5.0	Brown sandy silty clay							1.93	22.9	CD	0.30	16
>50 (50/6cm)	5.9	Change of strata											
		Brown with white completely weathered rock (Charnockites Based)											
>50 (35/Nil)	7.5	Brown with white completely weathered rock (Charnockites Based)											
>50 (30/Nil)	9.0	Brown with white completely weathered rock (Charnockites Based)											
		*-Natural Bulk Density # -N Values (Observed)											

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SOIL PROFILE

Project: Residential Building at Pammal, Chennai - 600075

B. H. Location: | Water Table: 0.5m | Term. Depth : 8.5m | B.H. No. : 3

N - Value#	Depth (m)	Soil Description	Grain Size Analysis				Atterberg		In-situ		Triaxial Test		
			Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Liquid (%)	Plastic (%)	Density* (g/cm^3)	Water Cont (%)	Type	c (kg/cm^2)	ϕ (°)
	0.0	Ground level											
	1.2	Filled up strata											
	1.5	Change of strata											
6	2.0	Brown sandy silty clay	0	19	36	45	49	22	1.79	19.6	CD	0.31	13
10	3.0	Brown sandy silty clay	0	20	36	44	50	22					
	3.5	Brown sandy silty clay							1.84	21.5	CD	0.31	14
17	4.5	Brown sandy silty clay	0	29	31	40	44	20					
	5.0	Brown sandy silty clay							1.93	19.9	CD	0.29	16
>100 (50/5cm)	5.5	Change of strata											
		Brown with white completely weathered rock (Charnockites Based)											
>100 (35/Nil)	7.0	Brown with white completely weathered rock (Charnockites Based)											
>50 (35/Nil)	8.5	Brown with white completely weathered rock (Charnockites Based)											

*-Natural Bulk Density # -N Values (Observed)

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SOIL PROFILE

Project: Residential Building at Pammal, Chennai - 600075

B. H. Location: | Water Table: 0.5m | Term. Depth : 5.7m | B.H. No. : 4

N - Value#	Depth (m)	Soil Description	Grain Size Analysis				Atterberg		In-situ		Triaxial Test		
			Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Liquid (%)	Plastic (%)	Density* (g/cm³)	Water Cont (%)	Type	c (kg/cm²)	ϕ (°)
	0.0	Ground level											
		Filled up strata											
	1.3	Change of strata											
6	1.5	Brown sandy silty clay	0	20	35	45	49	22					
	2.0	Brown sandy silty clay							1.82	19.9	CD	0.30	14
8	3.0	Brown sandy silty clay	0	17	37	46	52	23					
	3.5	Brown sandy silty clay							1.86	22.7	CD	0.31	15
18	4.5	Brown sandy silty clay	0	23	34	43	47	21					
	5.0	Brown sandy silty clay							1.90	19.7	CD	0.29	17
>50 (5C/8cm)	5.5	Change of strata											
		Brown with white completely weathered rock (Charnockites Based)											
	5.7	Termination Depth											

*-Natural Bulk Density # -N Values (Observed)

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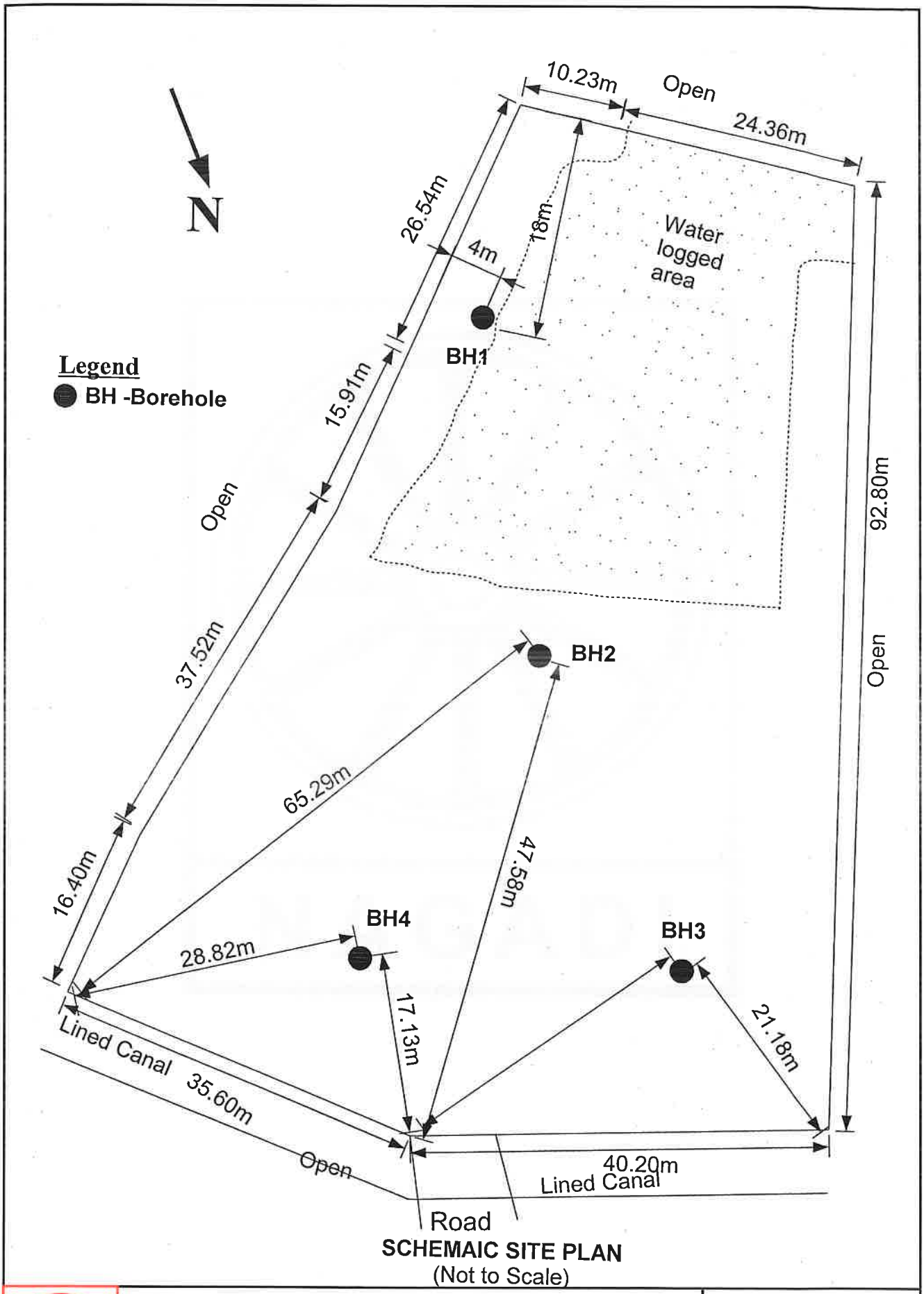
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FIGURES

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SCHEMAIC SITE PLAN
(Not to Scale)

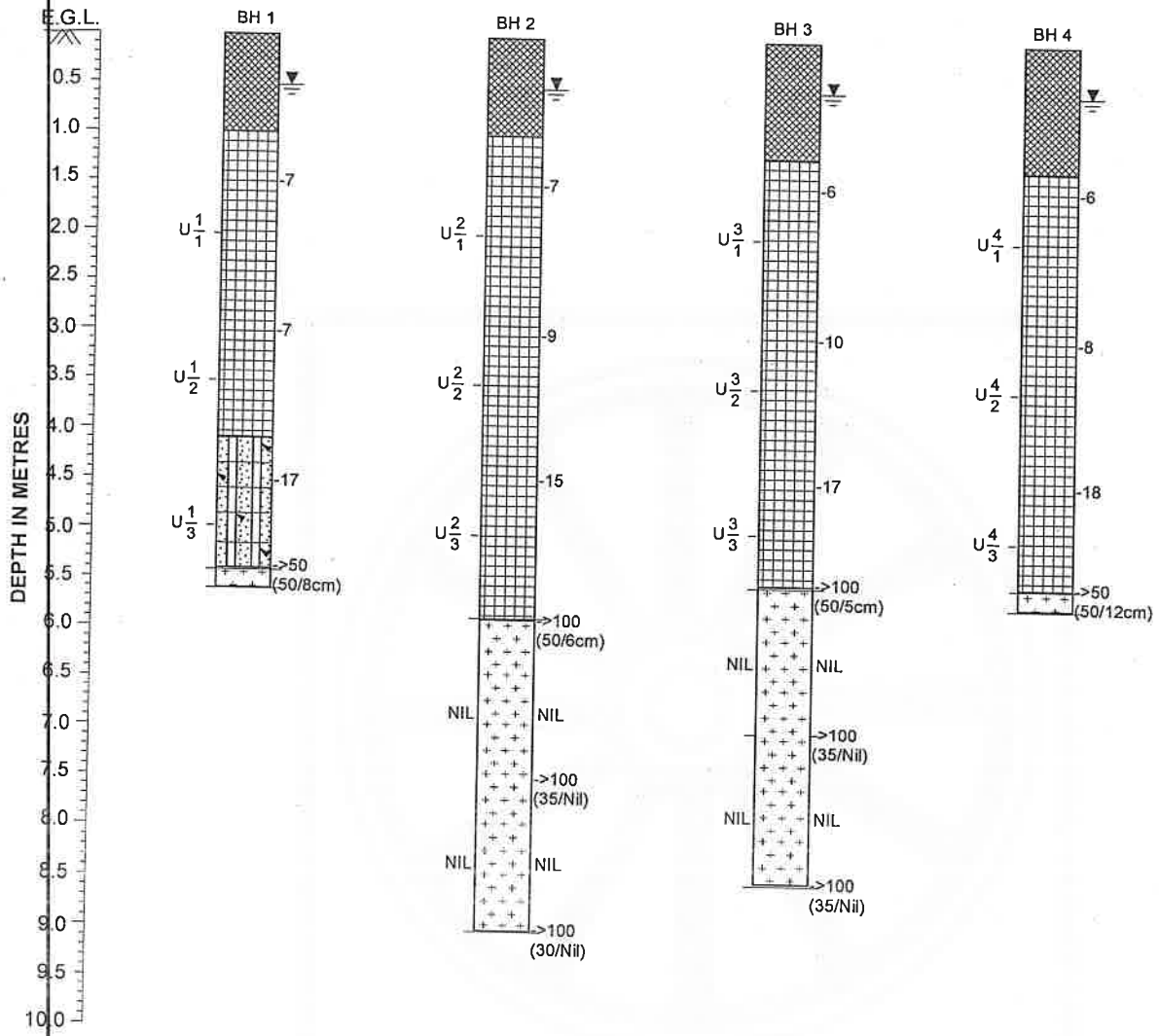
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LEGEND

Filled up strata

Brown
Sandy (14-29%)
Silty (31-37%)
Clay (38-52%)

Brown
Clayey (18%)
Silty (27%)
Sand (50%)
Gravel (5%)

Brown with white
Completely Weathered
rock -(Charnockites
based)

Nil Core recovery – Nil

Nil RQD- Nil

6 'N' Value (Observed)

E.G.L : Existing Ground level

$U\frac{2}{1}$ - 1st undisturbed soil sample at borehole no.2

Water table observed

COMPILED SOIL ROCK PROFILE

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Geotechnical Investigation for the Proposed Residential Building at Pammal, Chennai – 600075

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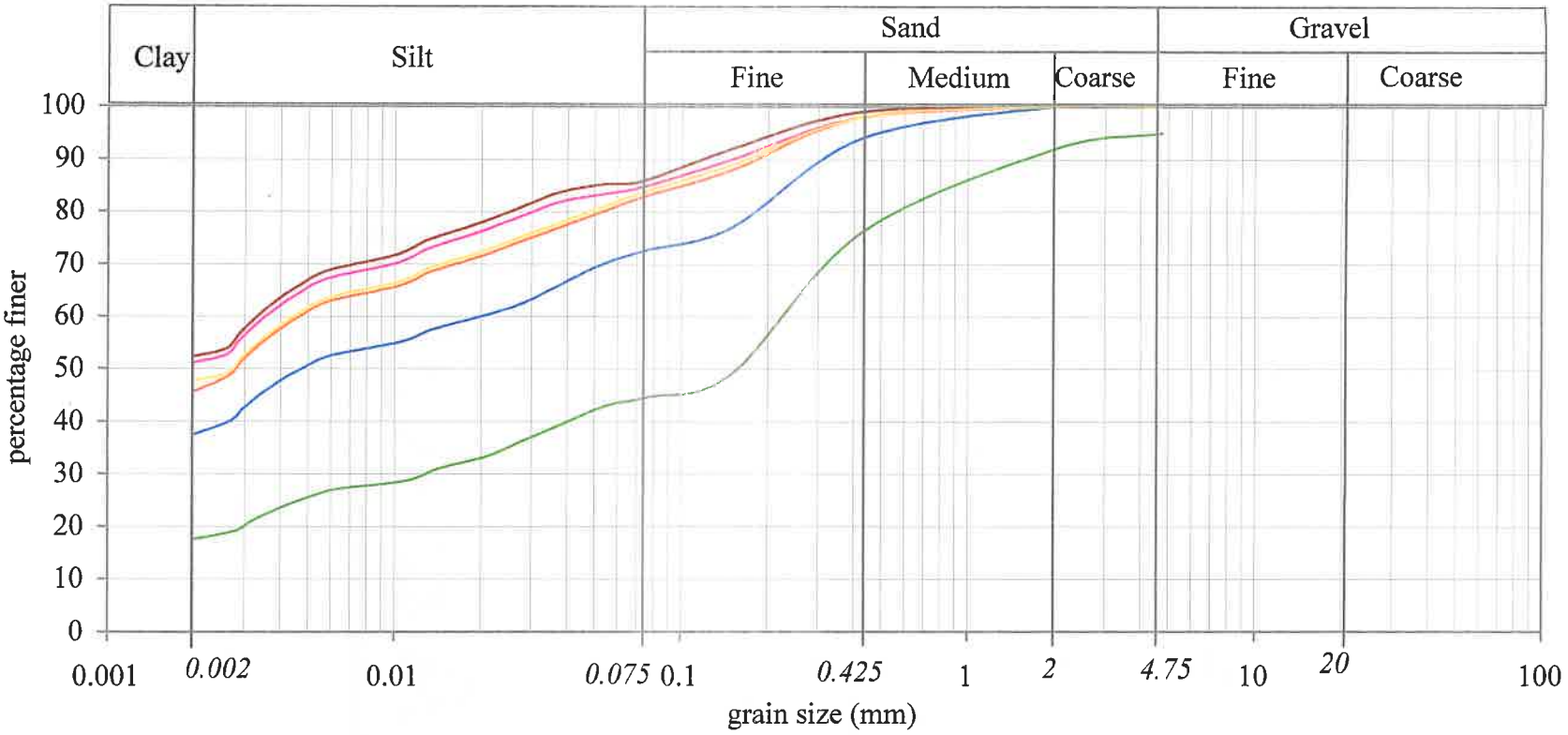
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Sheet No. : 3a



Line Style	Bore hole	Depth (m)	Description	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	d_{60}	d_{10}	U
	1	1.5	Sandy silty clay	0	27	35	38	0.020	-	
	1	3.0	Sandy silty clay	0	17	37	46	0.005	-	
	1	4.5	Clayey silty sand with gravel	5	50	27	18	0.005	-	
	2	1.5	Sandy silty clay	0	14	34	52	0.003	-	
	2	3.0	Sandy silty clay	0	15	34	51	0.004	-	
	2	4.5	Sandy silty clay	0	16	36	48	0.005	-	

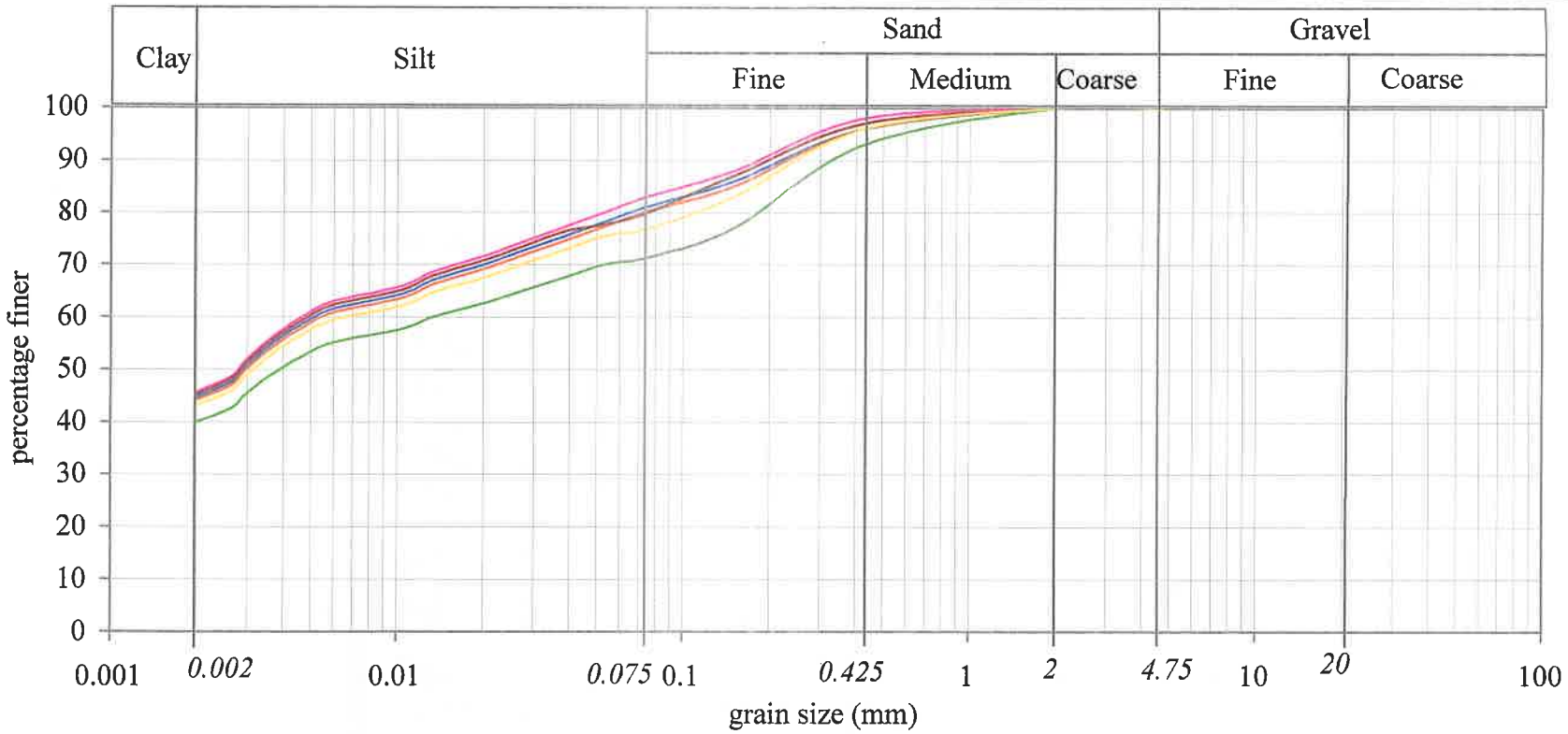
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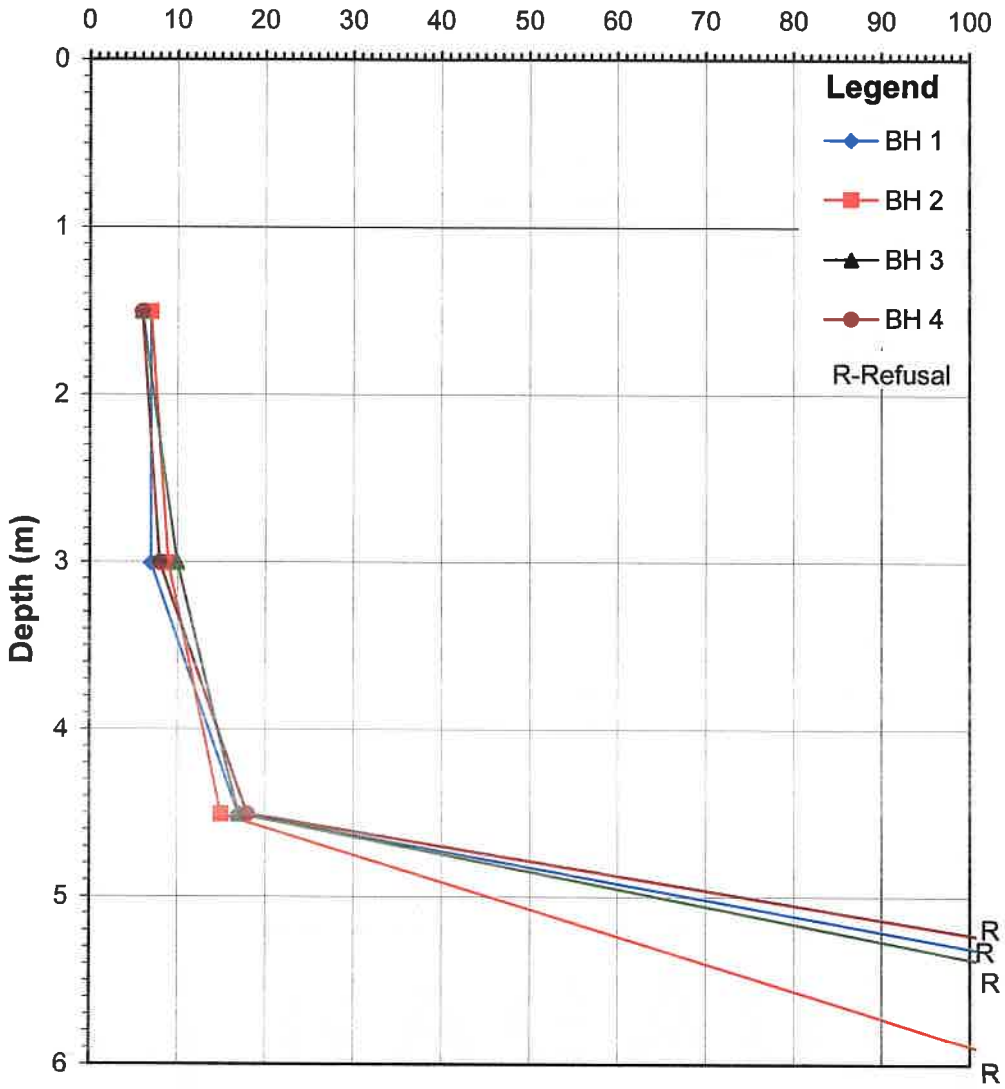
Job No. : G(C)9748

Sheet No. : 3b



Line Style	Bore hole	Depth (m)	Description	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	d_{60}	d_{10}	U
	3	1.5	Sandy silty clay	0	19	36	45	0.005	-	
	3	3.0	Sandy silty clay	0	20	36	44	0.005	-	
	3	4.5	Sandy silty clay	0	29	31	40	0.014	-	
	4	1.5	Sandy silty clay	0	20	35	45	0.005	-	
	4	3.0	Sandy silty clay	0	17	37	46	0.005	-	
	4	4.5	Sandy silty clay	0	23	34	43	0.006	-	

SPT Values (Observed)



SPT Values (Observed) Vs Depth Curves

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