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GEOTECHNICAL REPORT FOR

COMMERCIAL BUILDING AT PLOT NO.4363, OLD DOOR NO.23, NEW DOOR NO.9, X-BLOCK, 5TH STREET, ANNA NAGAR, CHENNAI - 600 040.

Client :

Mr. Kumar Mehra and Others.,
Chennai.

Architect :

Consultant :

Structural Consultant :

Job No. G(C)9616B Date : 29.11.2021

NAGADI CONSULTANTS PRIVATE LIMITED

Branch :

Chennai

Project :

COMMERCIAL BUILDING AT PLOT NO.4363, OLD DOOR NO.23, NEW DOOR NO.9, X-BLOCK, 5TH STREET, ANNA NAGAR, CHENNAI - 600 040.

CONTENTS

		Page No.
	Executive Summary	1 and 2
1.	Introduction	3
2.	Project Details	
	The Site	3 and 4
	Structure	4
	Seismic Zone	4
	Geographical Information	4
3.	Object of Investigation	4 and 5
4.	Scope of Investigation	5
5.	Field Investigations	5 and 6
6.	Laboratory Investigations	6 and 7
7.	Results of Investigations & Analysis	7 to 10
8.	Design Criteria - A Discussion	10 to 12
9.	Recommendations	12
10.	Construction Advisory	13
11.	References	13
12.	Limitations	14
	List of IS Codes	Tables & Figures

GEOTECHNICAL INVESTIGATION REPORT

for Commercial Building at Plot No.4363, Old Door No.23, New Door No.9, X-Block, 5th Street, Anna Nagar, Chennai - 600 040

EXECUTIVE SUMMARY

Mr. Kumar Mehra and Others are proposing to construct a commercial building at Plot No.4363, Old Door No.23, New Door No.9, X-Block, 5th Street, Anna Nagar, Chennai - 600 040.

The site for the proposed project is situated at Plot No.4363, New Door No.9 on the northern side of road at 5th Street, X-Block, 5th Street, Anna Nagar, Chennai - 600 040. The site is rectangular in shape and measures approximately 23.17 x 13.71m. The site is bounded by compound wall on all the sides and it is fairly level. Vegetation in the form of coconut trees were grown within the site. There is a single storeyed building existing with in the site which will be demolished before the construction of new building. There is a well of 1.2m diameter in the north eastern side of the site and water table was observed at 0.3m from the existing ground level.

The proposed structure is a commercial building comprising of stilt floor and four upper floors.

Geotechnical investigations have been undertaken at the site as per the scope of investigations, stipulated by the client, which consisted of two boreholes down to 8m depth.

The soil strata consists of filled up soil upto 0.8m to 0.9m depth followed by virgin soil. The virgin soil comprises of sand, silt and clay with varying proportions. The soil strata is in a stiff/medium dense state with observed N-values varying at 10 & 17 from existing ground level to the investigated depth of 8m.

Ground water table had been encountered at 1.6m depth in both the boreholes during the period of field investigations.

In view of the observed subsoil strata conditions the proposed structure can be supported on Isolated/strip footings at a depth of 1.75m from the existing ground level. An allowable bearing pressure of $12t/m^2$ ($1.2kg/cm^2$) can be adopted for the design of foundation.

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

After excavation for foundation, spread brick bats and compact the bottom of the pit. This compaction would not only compact the possible pockets of filled up/loose soil but also provide a hard/uniform base to lay the foundation.

Stiff tie beams connecting the columns in both directions may be provided which will render additional rigidity to the structure.

There is a well located in the site. In case, the well is not utilised, it can be closed by back filling with sand-gravel mix. The back filling should be done in layers and well compacted. Incase, the well is to be utilised, the sides should be properly lined. Also the distance of the nearest footing to the well should not be less than 1 to 1.5 times the width of the foundation.

REPORT ON GEOTECHNICAL INVESTIGATION FOR COMMERCIAL BUILDING AT PLOT NO.4363, OLD DOOR NO.23, NEW DOOR NO.9, X-BLOCK, 5TH STREET, ANNA NAGAR, CHENNAI - 600 040

1.0 INTRODUCTION

1.1 Overview

1.1.1 The geotechnical investigation has been done to ascertain the soil properties and to aid the design of viable foundations for the proposed commercial building.

1.1.2 Mr. Kumar Mehra and Others are proposing to construct a commercial building at Plot No.4363, Old Door No.23, New Door No.9, X-Block, 5th Street, Anna Nagar, Chennai - 600 040.

1.2 Authority

1.2.1 A comprehensive soil investigation programme has been conducted as per the oral authorisation by Mr. Kumar Mehra and Others., vide our oral Work Order No. NCC/OWO/KMAO/014D/C/2021.

2.0 PROJECT DETAILS

2.1 Site Location

2.1.1 The site for the proposed project is situated at Plot No.4363, New Door No.9 on the northern side of road at X-Block, 5th Street, Anna Nagar, Chennai - 600 040. The key map showing the location of the site is given in fig 1.

2.2 Site Layout and Topography

2.2.1 The site is rectangular in shape and measures approximately 23.17 x 13.71m. The site is bounded by compound wall on all the sides and it is fairly level. Vegetation in the form of coconut trees were grown within the site. There is a single storeyed building existing with in the site which will be demolished before the construction of new

building. There is a well of 1.2m diameter in the north eastern side of the site and water table was observed at 0.3m from the existing ground level.

2.2.2 The colour of the exposed soil surface is Brown.

2.3 The Structure

2.3.1 As per the client's information, the proposed structure is a commercial building comprising of stilt floor and four upper floors.

2.4 Seismic Zone

2.4.1 Site for the proposed project is situated in Anna Nagar, Chennai which falls under Seismic Zone III as per IS 1893 (Part 1) - 2016.

2.5 Geographical Information

2.5.1 The proposed site lies in:

a) Latitude : 13°05'

b) Longitude : 80°12'

3.0 OBJECT OF INVESTIGATIONS

3.1 For designing the foundation system of the proposed structures, 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 sub soil profile indicating thickness 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 The object of conducting field and laboratory investigations and analysis is to get data for the parameters mentioned in 3.2 and providing the recommendations.

4.0 SCOPE OF INVESTIGATIONS

4.1 Scope of investigations as given in the work order:

a) Sinking 2 boreholes down to 8m depth or refusal strata (where N value is >50) whichever is met earlier, as required by the client.

b) Conducting standard penetration tests at 1.5m intervals.

c) Recovering undisturbed soil samples from various levels of the sub soil 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 Weather Conditions

Weather was clear during field investigations which was carried out on the last week of November 2021. However, there were rains before the field investigations.

5.1.2 Locations of Tests

The location of the boreholes were shown at site by the client. A Schematic site plan showing the location of the test points marked by the client is given in fig 1.

5.2 Boreholes

5.2.1 The boreholes were progressed by shell and auger method as per IS 1892 - 1979.

5.2.2 The borehole was terminated at 8m from the existing ground level. The termination depth of boreholes and depth of water table encountered in the boreholes during the period of field investigations are given in the following table.

Borehole No	Termination depth from Existing G L (m)	Depth of water table from Existing G L (m)
1	8	1.6
2	8	1.6

5.2.3 Standard penetration tests were conducted at 1.5m intervals. Disturbed soil samples recovered from split spoon samples were packed in polythene bags, labelled and retained for identification purposes.

5.2.4 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 50 mm and its length was 45 cm. The ends of sample tubes were sealed by wax to prevent loss/ ingress of moisture and labelled.

5.3 Ground water table

5.3.1 Ground water table had been encountered at 1.6m depth in both the boreholes during the period of field investigations.

6.0 LABORATORY INVESTIGATIONS

6.1 The undisturbed and disturbed soil samples brought to the laboratory were used for the tests, as appropriate.

6.2 The soil samples 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

6.3 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 compression tests

f) Specific Gravity

g) Free Swell Index tests

7.0 RESULTS OF INVESTIGATION 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 boreholes have been presented in the form of tables. Table No 1 and 2 give the details of borehole no 1 and 2 respectively.

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 sub soil

d) Atterberg limits

e) In-situ bulk density and Water content

f) Triaxial compression 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 strata.

a) Stratum I : Filled up strata

b) Stratum II : Brown/brownish grey sandy silty sand

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

BH NO.	depth in m : from - to	
	Stratum I	Stratum II
1	0.0 - 0.9	0.9 - 8
2	0.0 - 0.8	0.8 - 8

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, as fig 3 and in tables below them.

7.3.2 The variations in the grain size distribution - strata wise across the boreholes are as follows:

a) Stratum II : Brown/brownish grey sandy silty sand

BH NO.	Gravel %	Sand %	Silt %	Clay %
1	0	24 - 30	31 - 35	36 - 40
2	0	24 - 31	33 - 34	36 - 43

7.3.3 The above results indicate that :

a) Stratum - II consists of about 24 -31% of sand, 31 - 35% of silt and 36 - 43% of clay.

7.4 In-situ Bulk Density, Water Content and Dry density

7.4.1 The In-situ bulk density of the sub soil stratum varies between 1.78 to 1.81g/cm^3, water content varies between 13.10 to 14.10% and In-situ dry density of the sub soil stratum varies between 1.56 to 1.61g/cm^3.

BH No	Depth (m)	Water Content (%)	In-situ Bulk Density (g/cm^3)	Dry Density (g/cm^3)
1	2	13.60	1.80	1.58
	4	13.10	1.82	1.61
2	1.5	14.10	1.78	1.56
	2.5	13.60	1.81	1.59

7.5 Atterberg Limits:

7.5.1 The Atterberg Limits in Stratum II (Brown/brownish grey sandy silty sand) are given below:

BH No	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
1	13.60	1.80	1.58
2	13.10	1.82	1.61

7.6 Standard Penetration Tests

7.6.1 Standard Penetration Test values (N-values observed) are presented in the soil profile table no 1 and 2. The curve showing the relation between the N value and depth is given in fig 4. The N values indicate the soil to be in a stiff state.

7.7 Shear Test Results

7.7.1 The cohesion obtained from consolidated drained triaxial shear test on the samples varies between negligible to 0.26 and 0.28kg/cm^2 and the angle of shearing resistance ϕ of the soil varies between 15° & 17°.

7.8 Specific Gravity

7.8.1 The specific gravity of the soil particles is given below:

BH NO	Specific Gravity at Depth (m)			
	1	1.5	2	3
1	-	2.61	-	2.65
2	2.59	-	2.67	2.64

7.9 Free Swell Index

7.9.1 The free swell index of the soil particles is given below:

BH NO	Free Swell Index (%) at Depth (m)			
	1	1.5	2	3
1	-	36.10	-	38.60
2	38.10	-	35.90	36.66

7.9.2 The above results indicate that the top soil is medium swelling nature. Hence, the excavated soil cannot be used for backfilling purposes.

7.10 Compiled Soil Profile

7.10.1 An overview of the results and their analysis has been presented in the form of compiled soil profile in fig 2.

8.0 DESIGN CRITERIA - A DISCUSSION

8.1 Primary 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 these are given in paras 8.2 to 8.4.

8.2 Type of Foundations

8.2.1 The type of foundation depends on the following:

a) Sub soil conditions

b) Type of structure

c) Configuration at loading points

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

8.2.2 As per the client's information, the proposed structure is a commercial building comprising of stilt floor and four upper floors.

8.2.3 As seen from the investigations the soil is in a stiff state.

8.2.4 For the above conditions, Isolated/strip foundations can be adopted for the proposed structure.

8.3 Depth of Foundation

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

a) There should be sufficient thickness of soil above the footings/foundations so that they are neither exposed or undermined by natural/manmade forces in the future.

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 (commercial building comprising of stilt floor and four upper floors).

8.3.2 In view of the above factors, foundations of the proposed structure can be made to rest at a depth of 1.75m below the existing ground level. The soil available at the founding level will be Brown sandy silty clay.

8.4 Allowable Bearing Pressure

8.4.1 An allowable settlement of 50mm has been considered to evaluate the allowable bearing pressure for Isolated / strip foundations.

8.4.2 Allowable bearing pressure has been evaluated by:

a) Shear failure criteria taking the average soil data

b) Settlement criteria taking SPT values (N-values)

c) Settlement criteria based on deformation modulus

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

8.4.4 The allowable bearing pressure at 1.75m depth is 12t/m².

9.0 RECOMMENDATIONS

9.1 The recommendations for the proposed structure (commercial building comprising of stilt floor and four upper floors) are given below:

a) Type of Foundations : Isolated / strip

b) Depth of foundations : 1.75m below the existing ground level

c) Allowable bearing pressure : 12t/m²

d) Settlement considered for calculations: 50mm.

9.2 Note

9.2.1 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.

10.0 CONSTRUCTION ADVISORY

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

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

10.3 After excavation for foundation, spread brick bats and compact the bottom of the pit. This compaction would not only compact the possible pockets of filled up/loose soil but also provide a hard/uniform base to lay the foundation.

10.4 Stiff tie beams connecting the columns in both directions may be provided which will render additional rigidity to the structure.

10.5 There is a well located in the site. In case, the well is not utilised, it can be closed by back filling with sand-gravel mix. The back filling should be done in layers and well compacted. Incase, the well is to be utilised, the sides should be properly lined. Also the distance of the nearest footing to the well should not be less than 1 to 1.5 times the width of the foundation.

11.0 REFERENCES

11.1 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 A.

12.0 LIMITATIONS

12.1 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 sub-soil 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.

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for **Dr.N.SANTOSH RAO**
For NAGADI CONSULTANTS PVT. LTD.

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)

TABLES



SOIL PROFILE

Project:Proposed Commercial bldg at Plot No.4363, Old Door No.23, New Door No.9, X-Block, 5th St, Anna Ngr, Ch-600 040.

B.H. Location:

Water Table: 1.6m | Term. Depth : 8.0m | B.H. No. : 1

N - Value#	Depth (m)	Soil Description	Grain Size Analysis				Atterberg Limits		In-situ properties		Triaxial Test		
			Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Liquid (%)	Plastic (%)	Density* (g/cm^3)	Water Cont (%)	Type	c (kg/cm^2)	ϕ (°)
	0.0	Ground level											
	0.50	Filled up (silty sand with brickbats 0.0m to 0.90m)											
11	1.50	Brown sandy silty clay	0	27	31	42	43	22					
	2.0	Brown sandy silty clay							1.80	13.60	CD	0.27	17
12	3.0	Brown sandy silty clay	0	24	34	42	45	23					
	4.0	Brown sandy silty clay							1.82	13.10	CD	0.28	15
	4.40	Change of colour											
15	4.50	Brownish grey sandy silty clay	0	30	34	36	40	18					
15	6.0	Brownish grey sandy silty clay											
16	7.50	Brownish grey sandy silty clay	0	25	35	40	44	20					
	8.0	Brownish grey sandy silty clay											

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

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Job No. G(C)9616B

Sheet No. : 1

SOIL PROFILE

Project:Proposed Commercial bldg at Plot No.4363, Old Door No.23, New Door No.9, X-Block, 5th St, Anna Ngr, Ch-600 040.

B.H. Location: | Water Table: 1.6m | Term. Depth : 8.0m | B.H. No. : 2

N - Value#	Depth (m)	Soil Description	Grain Size Analysis				Atterberg Limits		In-situ properties		Triaxial Test		
			Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Liquid (%)	Plastic (%)	Density* (g/cm³)	Water Cont (%)	Type	c (kg/cm²)	ϕ (°)
	0.0	Ground level											
	0.50	Filled up (silty sand with brickbats 0.0m to 0.80m)											
10	1.0	Brown sandy silty clay	0	24	33	43	46	22					
	1.50	Brown sandy silty clay							1.78	14.10	CD	0.26	16
12	2.0	Brown sandy silty clay											
	2.50	Brown sandy silty clay	0	26	34	40	42	20	1.81	13.60	CD	0.28	17
15	3.0	Brown sandy silty clay											
	4.30	Change of colour											
12	4.50	Brownish grey sandy silty clay	0	28	33	39	40	19					
14	6.0	Brownish grey sandy silty clay											
17	7.50	Brownish grey sandy silty clay	0	31	33	36	39	18					
	8.0	Brownish grey sandy silty clay											

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

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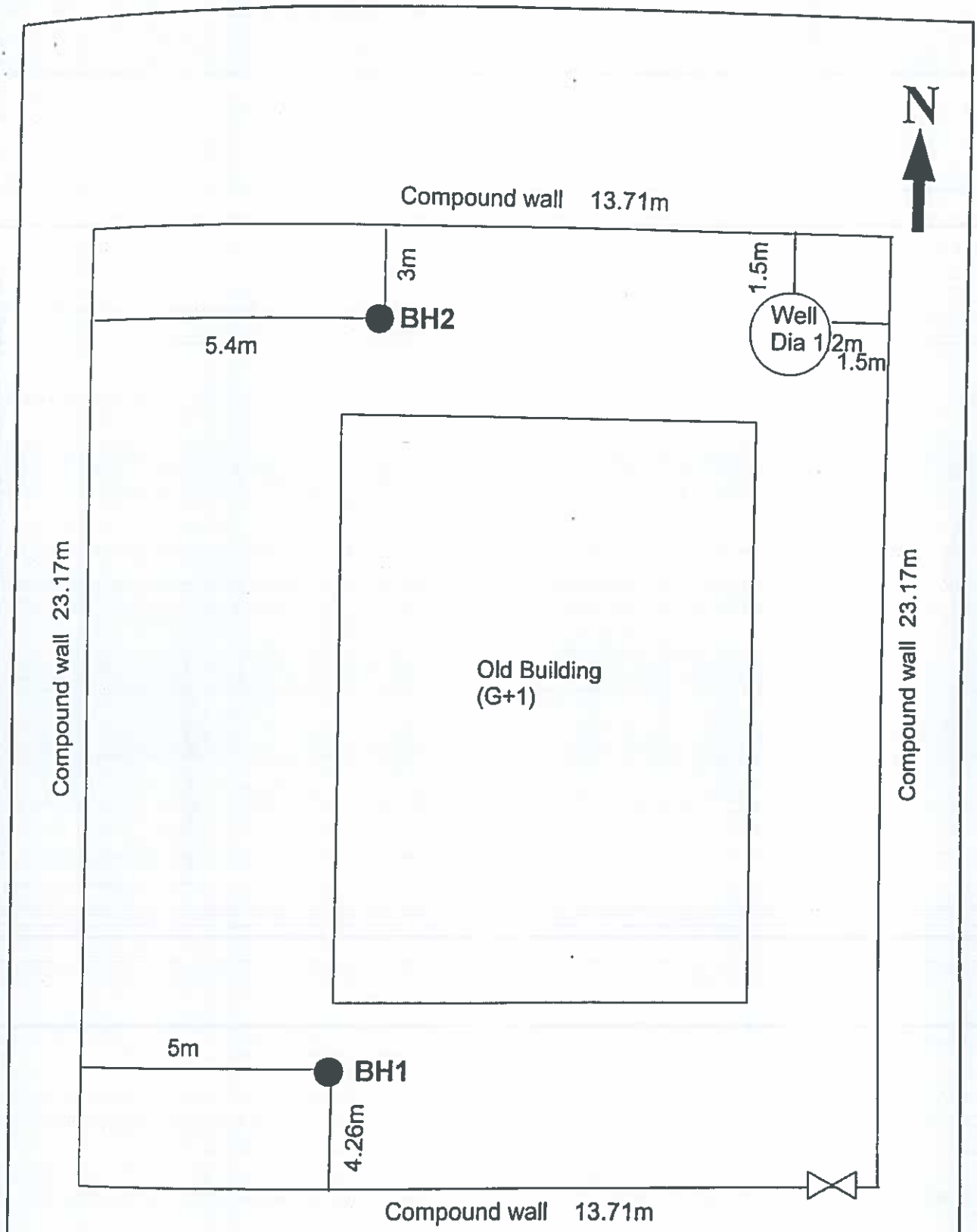
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FIGURES

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LOCATION PLAN (NOT TO SCALE)

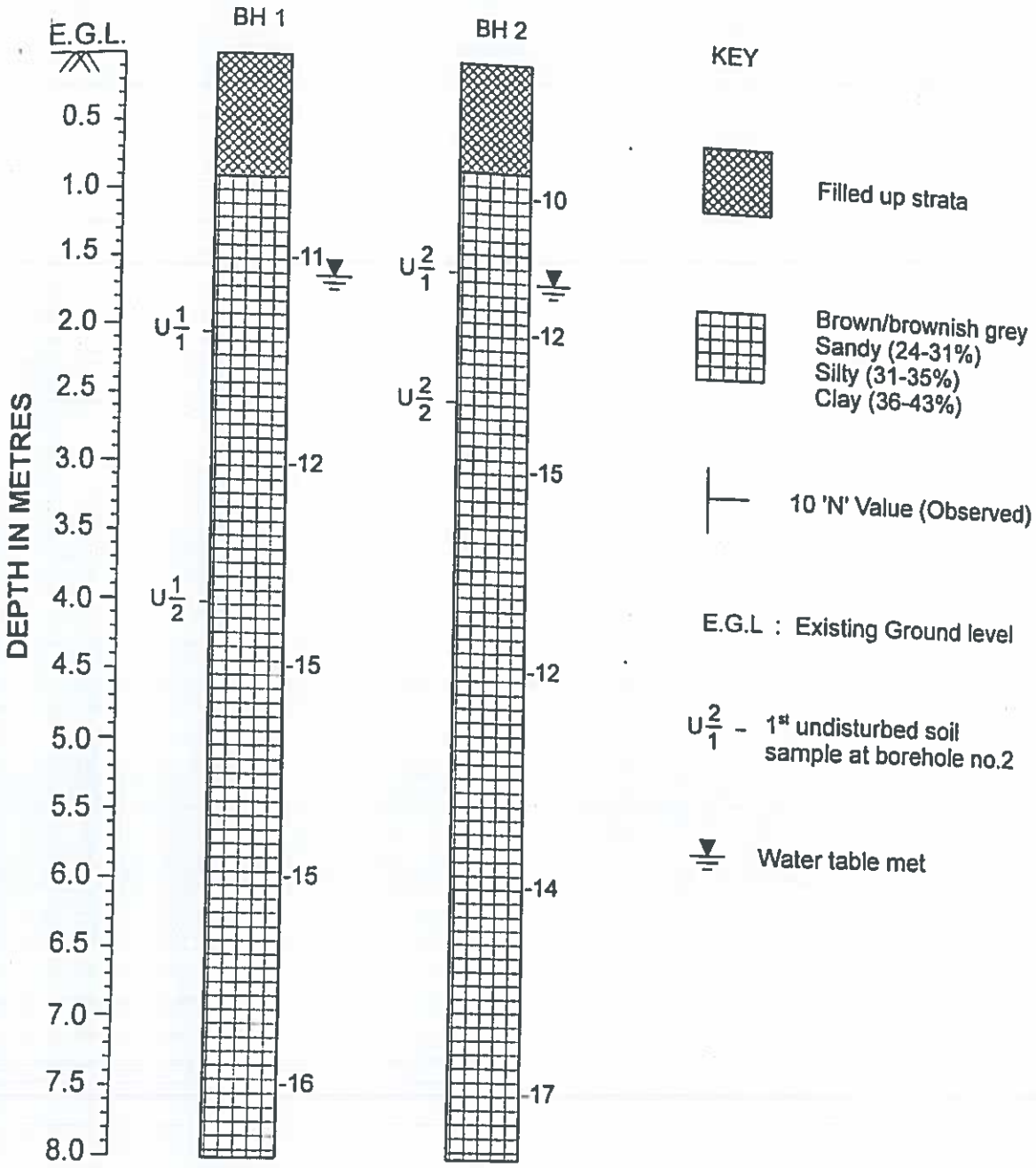
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COMPILED SOIL PROFILE

PROJECT : COMMERCIAL BUILDING AT PLOT NO.4363, OLD DOOR NO.23, NEW DOOR NO.9, X-BLOCK, 5TH STREET, ANNA NAGAR, CHENNAI - 600 040

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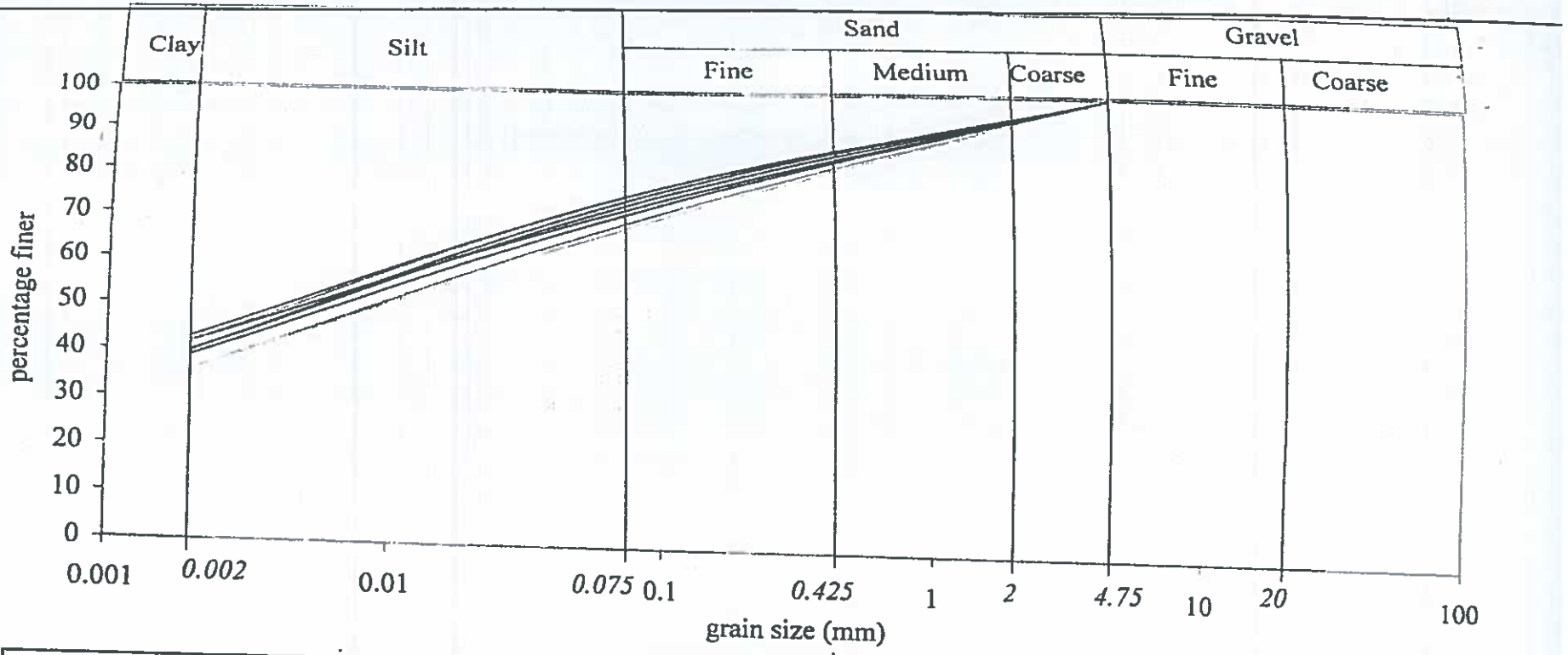
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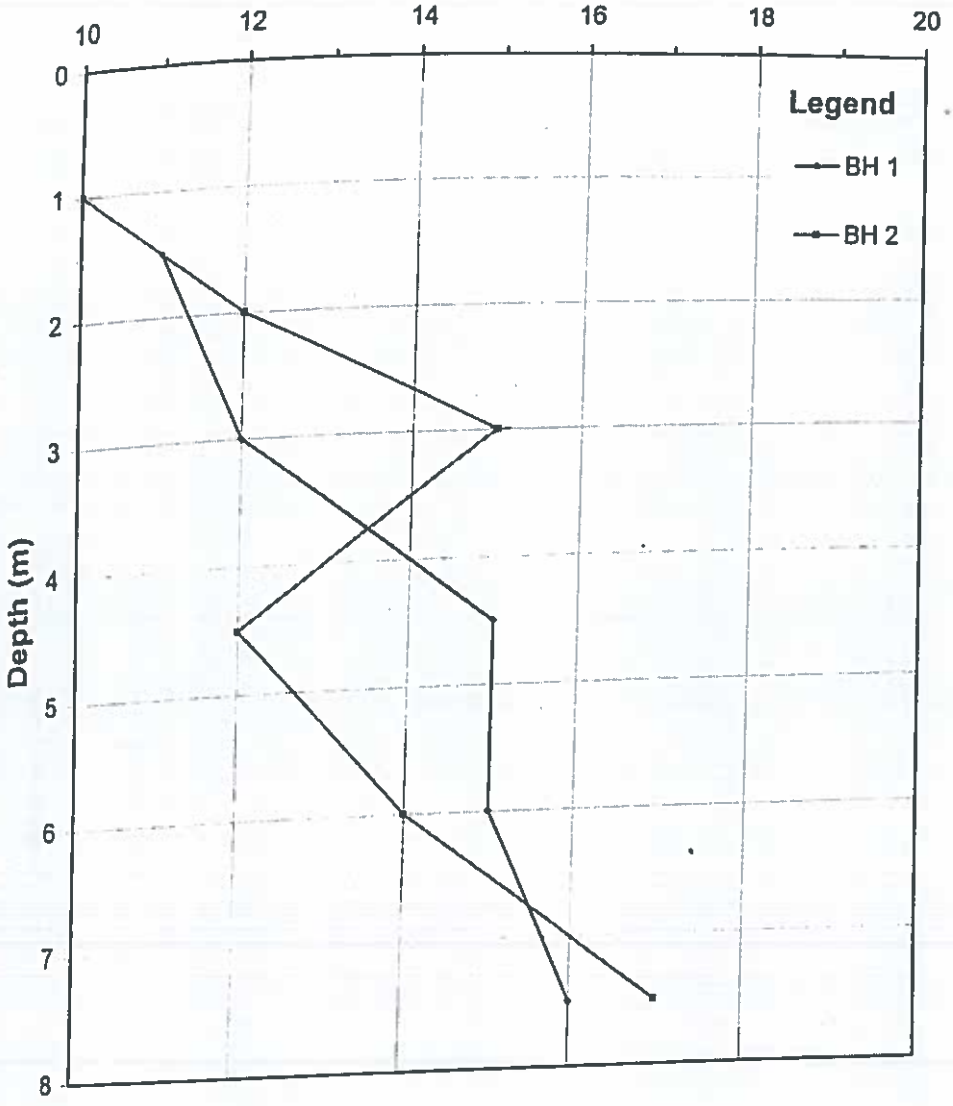
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Sheet No. : 3



Line Style	Bore hole	Depth (m)	Description	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	d_{60}	d_{10}	U
	1	1.5	Sandy silty clay	0	27	31	42	0.050	-	-
	1	3.0	Sandy silty clay	0	24	34	42	0.020	-	-
	1	4.5	Sandy silty clay	0	30	34	36	0.025	-	-
	1	7.5	Sandy silty clay	0	25	35	40	0.050	-	-
	2	1.0	Sandy silty clay	0	24	33	43	0.020	-	-
	2	2.5	Sandy silty clay	0	26	34	40	0.050	-	-
	2	4.5	Sandy silty clay	0	28	33	39	0.150	-	-
	2	7.5	Sandy silty clay	0	31	33	36	0.155	-	-

SPT Values (Observed)



SPT Values (Observed) Vs Depth Curves

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Job No. G(C)9616B

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