

GEOTECHNICAL INVESTIGATION REPORT
for Indian Bank Velachery Branch Building at Velachery Main Road,
Velachery, Chennai

EXECUTIVE SUMMARY

Indian Bank, Corporate office, Chennai are associated in construction of Indian Bank Velachery Branch Building at No:32/B, Velachery Main Road, Velachery, Chennai.

The site for the proposed Indian Bank Velachery Branch Building is situated at No:32/B on the eastern side of Velachery Main Road, Velachery, Chennai. The site is irregular in shape and measures approximately 400m². The site is bounded by compound wall on all the sides and is fairly level. There is double storeyed building existing with in the site. Vegetation in the form of trees were grown within the site.

The proposed structure is a Indian Bank Velachery Branch Building comprising of an 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 two borehole down to 15m depth or refusal strata where $N > 100$, whichever is met early and further drilling in refusal strata by 3m.

The soil strata consists of filled up soil upto 0.5m depth (only at the location of borehole 1) followed by virgin soil. The virgin soil comprises of silt and sand with gravels with varying proportions. The refusal strata in the form of Weathered rock was encountered between 2.5 and 4m depth and continued till termination depth. The soil strata is in a medium dense to dense state with observed N-values varying at 3 & 83 from existing ground level to a depth of 2.5-4m depth and increase to >100 at 2.5-4m depth.

Ground water table was encountered between 4m and 4.8m depth in the boreholes during the period of field investigations.

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In view of the observed subsoil strata conditions the proposed structure can be supported on Isolated/Strip or Raft foundation at a depth of 2.5m from the existing ground level. An allowable bearing pressure of 30t/m^2 (3.0kg/cm^2) can be adopted for the design of foundation.

The excavated soil can be used for backfilling purposes. However, the excavated filled up strata cannot be used for backfilling purposes.

After the excavation, the foundation trenches should be flooded for 24 hours and then the top slush should be removed and the surface compacted properly before laying foundation. As a precautionary measure, brick-bats/gravels/coarse aggregates (20mm down) should be spread on the flooded surface and then the compaction should be done. The foundations can be subsequently be built over this prepared surface.

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

**REPORT ON GEOTECHNICAL INVESTIGATION FOR
INDIAN BANK VELACHERY BRANCH BUILDING ATVELACHERY MAIN ROAD,
VELACHERY, CHENNAI**

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 Indian Bank Velachery Branch Building.

1.1.2 Indian Bank, Corporate office, Chennai are associated in construction of Indian Bank Velachery Branch Building at No:32/B, Velachery Main Road, Velachery, Chennai.

1.2 Authority

1.2.1 A comprehensive soil investigation programme has been conducted as per the authorisation by Indian Bank, Corporate office, Chennai vide our oral Work Order No. CO:EST:PBR:ST:2019-20 dated 12.11.2019.

2.0 PROJECT DETAILS

2.1 Site Location

2.1.1 The site for the proposed Indian Bank Velachery Branch Building is situated at No:32/B on the eastern side of Velachery Main Road, Velachery, Chennai. 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 irregular in shape and measures approximately 400m². The site is bounded by compound wall on all the sides and is fairly level. There is double storeyed building existing with in the site. Vegetation in the form of trees were grown within the site.

2.2.2 The colour of the exposed soil surface is Brown.

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2.3 The Structure

2.3.1 As per the client's information, the proposed project is a Indian Bank Velachery Branch Building comprising of an open stilt floor at ground level and five upper floors.

2.4 Seismic Zone

2.4.1 Site for the proposed project is situated in Velachery, Chennai which falls under Seismic Zone III as per IS 1893 (Part 1) - 2002.

2.5 Geographical Information

2.5.1 The proposed site lies in:

- a) Latitude : 12°58'
- b) Longitude : 80°13'

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.

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4.0 SCOPE OF INVESTIGATIONS

4.1 Scope of investigations as given in the work order:

- a) Sinking 2 borehole down to 15m depth or refusal strata (where N value is >100) whichever is met earlier and further drilling in refusal strata by 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 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 third week of November 2019.

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 mechanically operated rotary core drill method using calyx as per IS 1892 - 1979.

5.2.2 The boreholes were terminated after drilling by a minimum of 3 m in refusal/rock strata.

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The refusal strata encountered is in the form of weathered rock strata. The N value in this strata is >100. 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	9	4.8
2	5.5	4.0

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 was encountered between 4m and 4.8m depth in the boreholes during the period of field investigations.

6.0 LABORATORY INVESTIGATIONS

6.1 The disturbed soil samples and rock core 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 The rock samples were subjected to various tests to determine the following properties
- a) Compressive strength
 - b) Water absorption
- 6.4 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) Direct share test
 - f) Specific Gravity
 - g) Free Swell Index tests.
- 6.5 In order to determine the above properties listed in 6.3, the following tests were conducted.
- a) Point load test and unconfirmed compressive strength of rock to determine the compressive strength of rock
 - b) Water absorption on rock samples.

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 & 2 give the details of borehole no.1 & 2 respectively.
- 7.1.2 The soil profile tables indicate the following:

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- 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
- g) Compressive strength of rock derived from point load index and Unconfined compressive strength
- h) Water absorption of rock samples

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
- b) Stratum II : Grey silty sand with gravels
- c) Stratum III : Brown/Brownish yellow clayey silty sand with gravels
- d) Stratum IV : Refusal Strata - Weathered Rock

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 (m) : from - to			
	Stratum I	Stratum II	Stratum III	Stratum IV
1	0.0 - 0.5	0.5 - 2.4	2.4 - 4	4 - 9
2	-	-	0.0 - 2.5	2.5 - 5.5

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 : Grey silty sand with gravels

BH NO.	Gravel %	Sand %	Silt %	Clay %
1	10	79	11	0

This stratum was not encountered in borehole no 2.

b) Stratum III : Brown/Brownish yellow clayey silty sand with gravels

BH NO.	Gravel %	Sand %	Silt %	Clay %
1	2	56	24	18
2	2	55	24	19

7.3.3 The above results indicate that :

- a) Stratum II consists of about 11% of silt, 79% of sand and 10% of gravels.
- b) Stratum III consists of about 18 - 19% of clay, 24% of silt, 55 - 56% of sand and 2% of gravels.

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

7.4.1 The In-situ bulk density of the sub soil stratum is 1.85g/cm³, water content is 11.62% and In-situ dry density of the sub soil stratum is 1.66g/cm³.

BH No	Depth (m)	Water Content (%)	In-situ Bulk Density (g/cm ³)	Dry Density (g/cm ³)
2	2	11.62	1.85	1.66

7.5 Atterberg Limits:

7.5.1 The Atterberg Limits in Stratum II (Grey silty sand with gravels) indicate that the stratum is non plastic in nature which are given in tables.

7.5.2 The Atterberg Limits in Stratum III (Brown/Brownish yellow clayey silty sand with

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gravels) are given below:

BH No	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
1	22	14	8
2	24	15	9

7.6 Standard Penetration Tests

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

7.7 Shear Test Results

7.7.1 The cohesion obtained from consolidated drained triaxial compression test at 2m depth at the location of borehole no 2 is 0.15kg/cm² and the angle of shearing resistance ϕ of the soil is 25°.

7.7.2 The cohesion obtained from consolidated drained triaxial compression test at 4m depth at location of borehole no 1 on naturally powdered remoulded weathered rock samples are negligible and the angle of shearing resistance ϕ is 38°.

7.8 Specific Gravity

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

BH NO	Specific Gravity at Depth (m)	
	1.5	3.0
1	2.65	2.64
2	2.63	-

7.9 Free Swell Index

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

BH NO	Free Swell Index (%) at Depth (m)	
	1.5	3.0
1	3.2	13.5
2	15.8	-

7.9.2 The above results indicate that the top soil is low swelling nature. Hence, the excavated soil can be used for backfilling purposes. However, the excavated filled up strata cannot be used for backfilling purposes.

7.10 Water Absorption

7.10.1 The water absorption of rock samples varies between 0.05% to 0.10%. The water absorption of rock samples at specific depths are given in tables.

7.11 Compressive Strength of rock

7.11.1 The compressive strength of rock samples derived from point load index and uniaxial compressive strength of rock varies between 456kg/cm² to 1133kg/cm². The point load index an unconfined compressive strength of rock samples at specific depths are given in tables.

7.12 Compiled Soil Profile

7.12.1 An overview of the results and their analysis has been presented in the form of 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.

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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 Indian Bank Velachery Branch Building comprising of an open stilt floor at ground level and five upper floors.

8.2.3 As seen from the investigations the soil is in a medium dense to dense state.

8.2.4 For the above conditions, Isolated/Strip or Raft foundations can be adopted for the proposed projects.

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 (Indian Bank Velachery Branch Building comprising of an open stilt floor at ground level and five upper floors).

8.3.2 In view of the above factors, foundations of the proposed structure can be made to rest at

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a depth of 2.5m from the existing ground level. The soil available at the founding level will be Brown/Brownish yellow clayey silty sand with gravels or weathered rock.

8.4 Allowable Bearing Pressure

8.4.1 An allowable settlement of 40mm has been considered to evaluate the allowable bearing pressure for Isolated/Strip/Raft 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 2.5m depth is 30t/m².

9.0 RECOMMENDATIONS

9.1 The recommendations for the proposed structure (Indian Bank Velachery Branch Building comprising of an open stilt floor at ground level and five upper floors) are given below:

- a) Type of Foundations : Isolated/Strip or Raft
- b) Depth of foundations : 2.5m from the existing ground level
- c) Allowable bearing pressure : 30t/m²
- d) Settlement considered for calculations: 40mm.

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

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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 can be used for backfilling purposes. However, the excavated filled up strata cannot be used for backfilling purposes.
- 10.3 After the excavation, the foundation trenches should be flooded for 24 hours and then the top slush should be removed and the surface compacted properly before laying foundation. As a precautionary measure, brick-bats/gravels/coarse aggregates (20mm down) should be spread on the flooded surface and then the compaction should be done. The foundations can be subsequently be built over this prepared surface.
- 10.4 Stiff Tie-beams connecting the columns in both directions may be provided which will render additional rigidity to the structure.

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.

Dr N SANTOSH RAO

For NAGADI CONSULTANTS PVT. LTD.

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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

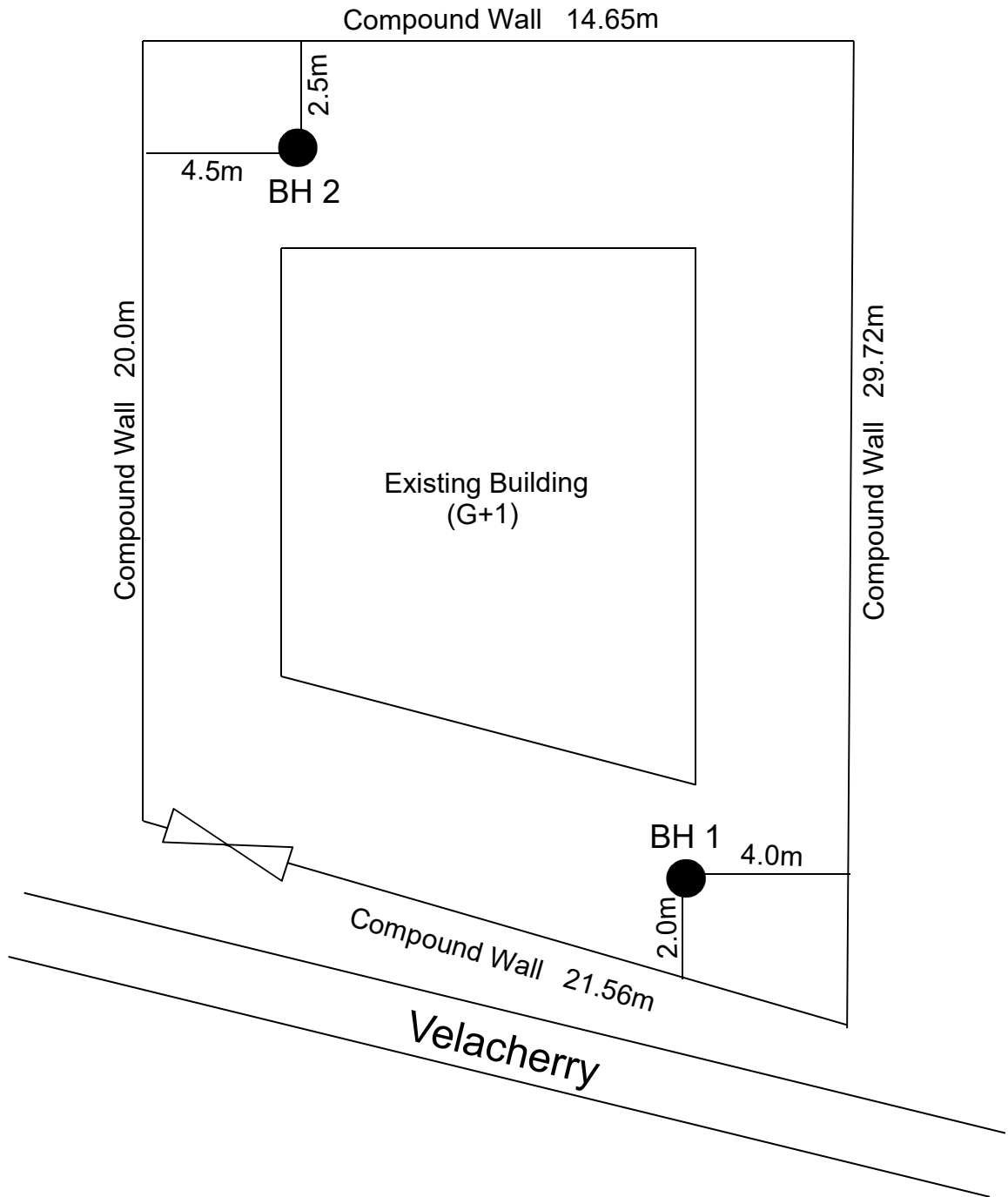
1. IS : 2720 - 1983 (Part 1) : Methods of test for soils: Preparation of dry soil samples for various tests (Second revision)
2. IS : 2720 - 1980 (Part 2) : Method of test for soils: Determination of water content (Second revision) Amendment 1
3. IS : 2720 - 1980 (Part 3/Sec 1) : Method of test for soils : 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.

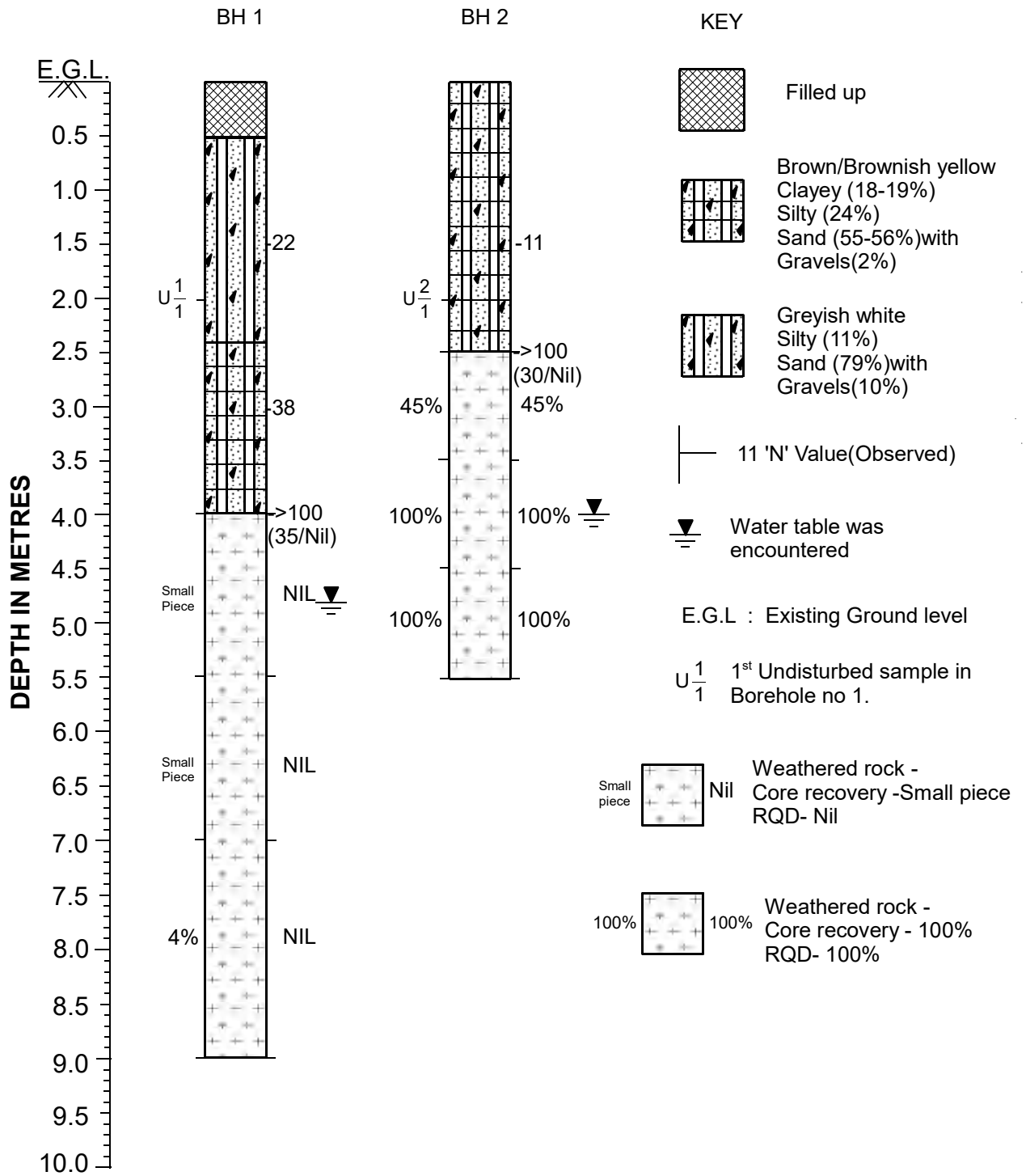
SOIL PROFILE		Project: Indian Bank Velachery Branch Building at No:32/B, Velachery Main Road, Velachery, Chennai.												
		B.H. Location:		Water Table: 4.8m		Term. Depth : 9.0m			B.H. No. : 1					
N - Value#	Depth (m)	Soil Description	Grain Size Analysis				Atterberg Limits		In-situ properties		Triaxial Test			
			Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Liquid (%)	Plastic (%)	Density* (g/cm ³)	Water Cont (%)	Type	c (kg/cm ²)	φ (°)	
	0.0	Ground level												
		Filled up strata												
	0.5	Change of strata												
22	1.5	Grey silty sand with gravels	10	79	11	0	-	NP						
	2.0	Grey silty sand with gravels										Tube	damaged	
	2.4	Change of strata												
38	3.0	Brownish yellow clayey silty sand with gravels	2	56	24	18	22	14						
	4.0	Change of strata												
>100 (35/Nil)		Brownish grey Weathered rock										D	-	38
	5.5	Brownish grey Weathered rock (Core recovery - small piece RQD - Nil)												
	7.0	Brownish grey Weathered rock (Core recovery - small piece RQD - Nil)												
	9.0	Brownish grey Weathered rock (Core recovery - 4% RQD - Nil)												
		*-Natural Bulk Density # -N Values (Observed)												

SOIL PROFILE		Project: Indian Bank Velachery Branch Building at No:32/B, Velachery Main Road, Velachery, Chennai.											
		B.H. Location:		Water Table: 4.0m		Term. Depth : 5.5m			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/cm ³)	Water Cont (%)	Type	c (kg/cm ²)	φ (°)
11	0.0	Ground level											
	1.5	Brown clayey silty sand with gravels	2	55	24	19	24	15					
>100 (30/Nil)	2.0	Brown clayey silty sand with gravels							1.85	11.62	CD	0.15	25
	2.5	Change of strata											
		Brownish grey Weathered rock											
	3.5	Brownish grey Weathered rock (Core recovery - 45% RQD - 45%)											
	4.5	Brownish grey Weathered rock (Core recovery - 100% RQD - 100%)											
	5.5	Brownish grey Weathered rock (Core recovery - 100% RQD - 100%)											
		*-Natural Bulk Density # -N Values (Observed)											



LOCATION PLAN (NOT TO SCALE)

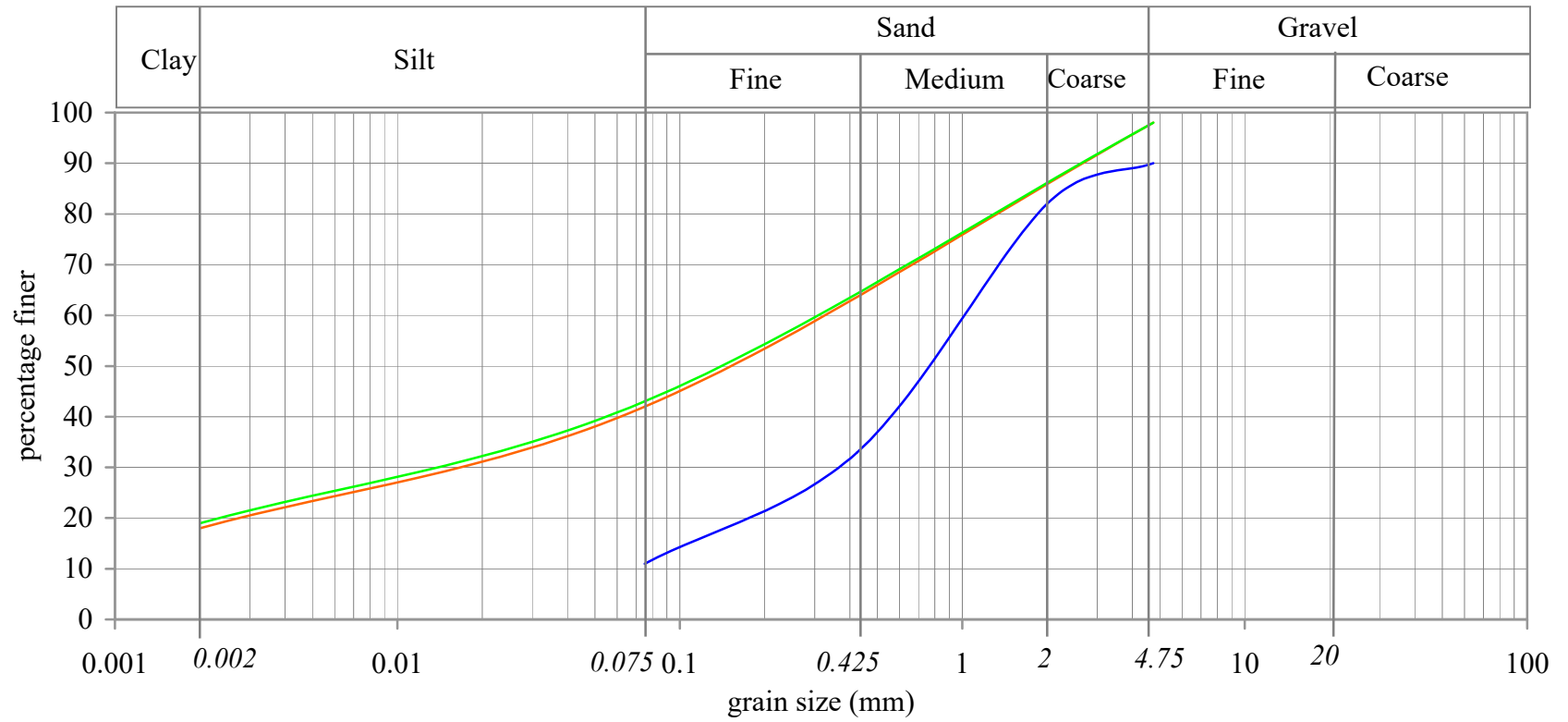
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COMPILED SOIL PROFILE

**PROJECT : INDIAN BANK VELACHERY BRANCH BUILDING AT
VELACHERY MAIN ROAD, VELACHERY, CHENNAI**

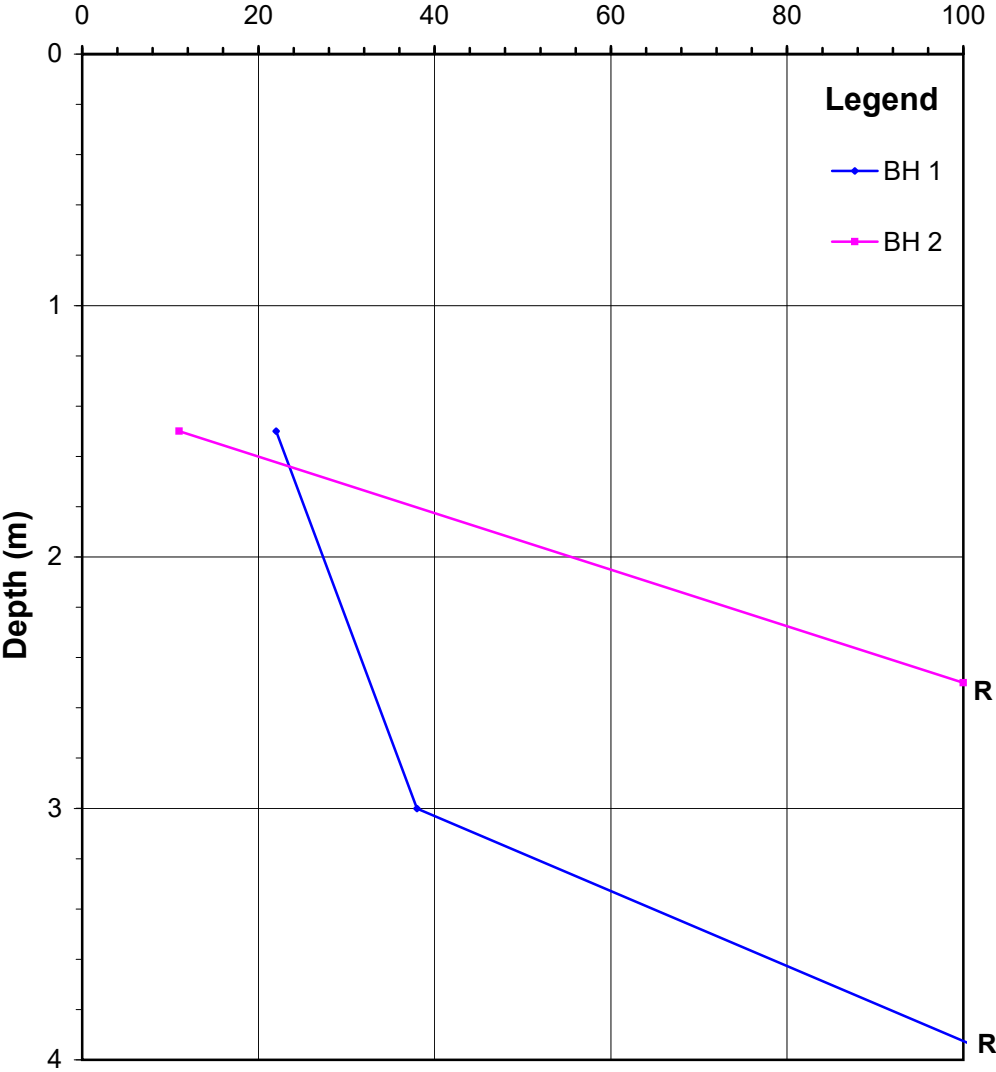
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Line Style	Bore hole	Depth (m)	Description	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	d ₆₀	d ₁₀	U
	1	1.5	Silty sand with gravels	10	79	11	0	1.000	-	-
	1	3.0	Clayey silty sand with gravels	2	56	24	18	0.330	-	-
	2	1.5	Clayey silty sand with gravels	2	55	24	19	0.300	-	-
									-	-
									-	-
									-	-
									-	-
									-	-

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SPT Values (Observed)



SPT Values (Observed) Vs Depth Curves