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NAME OF PROJECT

PROPOSED CONSTRUCTION OF RESIDENTIAL BUILDING (TWO BASEMENT + GROUND + 22 UPPER FLOORS) AT ARUMBAKKAM, CHENNAI

CLIENT

RDX ARCHITECTS,
#2,4TH STREET, KAMARAJ NAGAR,
SATHYA GARDEN, SALIGRAMAM,
CHENNAI – 600 093

TITLE

GEOTECHNICAL INVESTIGATION REPORT

REPORT NO.: GT- 2057

DATE	REVISON	DESCRIPTION		AUTHORISED SIGNATORY
03/03/2020	FIRST SUBMISSION	SUBMISSION OF GEOTECHNICAL REPORT	SIGN	
			DATE	03/03/2020
			DESIGNATION	MANAGING DIRECTOR
			NAME	DR. C.V.PRASAD

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CHAPTER-1

INTRODUCTION

1.0 Project Information Matrix

Nature of project : Residential Building (2 Basement + G +22 Floors)

Project Client : **RDX Architects**

Project Owner : **TAMILNADU HOUSING BOARD**

Project Location : Arumbakkam, Chennai

Job Code : GT-2057

1.1 Scope Of Work

1.1.1 Field Work

- Conducting five soil investigation bore holes of 150 mm diameter up to a maximum depth of 30m depth.
- Conducting Standard Penetration Test (SPT) within the borehole at every 1.0m depth interval up to 10.0m and thereafter at every 1.5m up to the borehole termination depth
- Collection of soil samples and undisturbed samples from the clayey strata with SPT-value greater than 2 to less than 15 if met within the investigation depth
- Collection of water samples if groundwater table met within the investigation depth

1.1.2 Laboratory Work

- Natural Moisture Content
- Atterberg limits
- Grain Size Analysis
- Chemical Analysis test on soil and water samples to give pH, Chlorides and Sulphates

1.2 Structure of the Report

- Contents
- Introduction
- Investigation Methodology & Test Results
- Sub-Surface Stratification
- Foundation System
- Recommendation
- Annexure

CHAPTER-2

INVESTIGATION METHODOLOGY & TEST RESULTS

2.0 Preamble:

Five soil investigation boreholes were put as per the planning of the engineer in-charge and these locations are shown in Fig.2.0.The equipment used and the methodology adopted to carry out the fieldwork is described below.

2.1 Methodology of Field Work:

2.1.1 Equipment Used and Method of Drilling:

All the boreholes were sunk by conventional rotary drilling rigs. For borehole Methodology followed for boring conformed to IS: 1892 -2000. Boring was progressed by the cutting action of rotating bit with water circulation and stabilizing the side of the boreholes by using casing pipes/bentonite slurry up to required depth to prevent collapse of sidewall. Boring was continued by normal boring process using MS soil cutter in soil. However Tungsten Carbide (TC) bit drilling was resorted to drill in highly weathered rock stratum where the normal boring process became slow. Diamond Core (DC) bit drilling was adopted in moderately weathered rock formations where penetration using TC bit was became slow.

2.1.2 Standard Penetration Tests:

This is a field test to determine "Penetration Resistance of Stratum at the Test Depth". This has been conducted in the boreholes generally up to refusal depth using procedures described in IS: 2131- 2002. In this test, split spoon sampler (50.8 mm OD and 35 mm ID) has replaced driving bit. Sampler is then driven by dropping 63.5 kg hammer on top of driving collar with free fall of 75 cm. The length of sampler is 60 cm.

The tests were conducted at the depth intervals indicated in Chapter-1 (Sec.1.1.1).

2.1.3 Collection of Soil Samples:

2.1.3.1 Disturbed Samples:

The SPT-samples collected were used as disturbed soil samples. These samples were used for visual and physical identification and for conducting laboratory classification tests as per I.S.1498-1970.

2.1.4 Collection of Ground Water Samples:

One representative water sample from each borehole was collected after 24 hours of completing the borehole if water table met within the investigated depth.

Note on Groundwater Table Record:

- Groundwater table observation in geotechnical report is predominantly to arrive at foundation design criteria and shall not be construed as design guidelines for the design of dewatering systems
- The groundwater level indicated in the bore logs is specific to the duration of investigation and intensity of the monsoon rains during the time of investigation. Hence, the level shall be taken as guidelines only to plan the investigation for the dewatering system

- No foundation excavation or basement excavations if anticipated within the groundwater table zone shall be carried out without implementing groundwater lowering schemes

2.2 Laboratory testing:

2.2.1 On Coarse Grained Soil

On the representative samples, sieve analysis tests were conducted to arrive at grain size distribution. These tests were conducted as per I.S.2720 (part 4)-1985 and the results are presented in Tables-2.1 to 2.5. The graphical representation of grainsize distribution curve for the representative samples in each bore is presented in Fig. 2.7 to 2.11.

2.2.2 On Fine Grained Soil

On the SPT sample index property tests were conducted to estimate consistency. These test results are presented in Tables-2.1 to 2.5. The graphical representation of hydrometer analyses curve for the representative samples in each bore is presented in Fig. 2.12 to 2.21.

2.2.3 Chemical Analysis Tests

On representative soil and water samples chemical analysis tests were conducted to estimate pH, Chloride and Sulphates and these results are presented in Table - 2.6.

2.3 Summary:

The locations of the field investigation boreholes are shown in site plan given in Fig.2.0. The average sub soil profiles encountered at each location along with their classification and engineering properties are presented in Figs.2.1 to 2.5. Further, the cross sectional variation of the sub surface profile through different bore holes in different directions are presented in Fig.2.7.



FIGURE 2.1 SITE PLAN CONSISTING OF FIELD INVESTIGATION BOREHOLE LOCATIONS

SITE INVESTIGATION RECORD

GEOMARINE — THE ART OF ENGINEERING

BORE HOLE No.	BH-01		
PAGE No.	1		
DIA OF BORE HOLE	150mm ✓	NX	
BORE START DATE	21/01/2020		
BORE END DATE	23/01/2020		
TOTAL DRILL DAYS	3		

PROJECT NAME	PROPOSED CONSTRUCTION OF RESIDENTIAL BUILDING						
LOCATION	Arumbakkam, Chennai	MACHINE No.	-	CHAINAGE (m)	-		
STRUCTURE	2 Basement + G + 22 Floors	DRILLING METHOD	Rotary	CO-ORDINATES	N	-	
JOB CODE	GT-2057	FLUSHING MEDIUM	Bentonite		E	-	

Depth below E.G.L. (m)	Drilling progress per metre: Date	Time: Hr.	Time: Min.	Type of Drill Bit (SC / TCB / DB)	Core Details: Total Core Recovery %	Core Details: R.Q.D %	SPT Details: Blows/cm. 0-15	15-30	30-45	SPT 'N' Value	Sample Details: Depth	No.	Type	RL (m)	Legend	No	Depth	Geotechnical Description
1	21/01/2020	16	59															
2		To																
3		17	48															
4	22/01/2020	11	09															
5		To																
6		11	50													L1	6.0	Filled up Materials consisting of old building debris, Brick pats & soil mixture
7	23/01/2020	14	30	SC	-	-	9	20	23	43	7.00	1	SS	-7.0				Brownish yellow,Moist,Poorly Graded,Fine to Medium Grains, Dense to Very Dense,Silty SAND (SM) With Clay Binder at times
8		To					18	28	34	62	7.45 ↓ 8.00	2	SS	-8.0		L2	8.5	
9		15	05								8.45 ↓							Borehole at this location is terminated at 8.0m due to uncontrollable water loss
10																		

CS - Core Sample	DS - Disturbed Sample	LOGGED	Muralikrishnan K.	PROJECT SITE DETAILS	REMARKS
SS - Split Spoon Sample	SC - Soil Cutter	DATE	23/01/2020	E.G.L WRT ROAD LEVEL(m) 0.00	Water table could not be established due to uncontrollable water loss
UDS- Undisturbed Sample	TCB - Tungsten Carbide Bit	CHECKED	Anitha Kondusamy	WATER TABLE (m) -	
WS - Wash Sample	DB - Diamond Bit	DATE	29/01/2020	CASING DEPTH (m) 0.0	

Borehole terminated at 8 m depth below E.G.L

FIG.2.1 Sub Soil Profile at BH-01 Location

SITE INVESTIGATION RECORD

GEOMARINE

BORE HOLE No.	BH-02		
SHEET	1	OF	3
DIA OF BORE HOLE	150mm	✓	
	NX		
BORE START DATE	10/01/2020		
BORE END DATE	20/01/2020		
TOTAL DRILL DAYS	5		

PROJECT NAME	PROPOSED CONSTRUCTION OF RESIDENTIAL BUILDING						
LOCATION	Arumbakkam, Chennai	MACHINE No.	-	CHAINAGE (m)	-	CO-ORDINATES	N -
STRUCTURE	2 Basement + G + 22 Floors	DRILLING METHOD	Rotary				E -
JOB CODE	GT-2057	FLUSHING MEDIUM	Bentonite				

Depth below E.G.L. (m)	Drilling progress per metre: Date	Time: Hr.	Time: Min.	Type of Drill Bit (SC / TCB / DB)	Core Details: Total Core Recovery %	Core Details: R.Q.D %	SPT Details: Blows/cm. 0-15	SPT Details: Blows/cm. 15-30	SPT Details: Blows/cm. 30-45	SPT 'N' Value	Sample Details: Depth	Sample Details: No.	Sample Details: Type	Sample Details: RL (m)	Layer Data: Legend	Layer Data: No	Layer Data: Depth	Layer Data: Geotechnical Description
1	10/01/2020	-	-	SC	-	-	3	5	8	13	1.00 / 1.45	1	SS	-1.0				
2		-	-	SC	-	-	4	3	3	6	2.00 / 2.45	2	SS	-2.0				
3		-	-	SC	-	-	-	-	-	-	3.00	-	-	-3.0				Filled up Materials consisting of old building debris, Brick pats & soil mixture
4		-	-	SC	-	-	9	8	9	17	4.00 / 4.45	3	SS	-4.0				
5		-	-	SC	-	-	8	11	13	24	5.00 / 5.45	4	SS	-5.0		L1	5.8	
6	11/01/2020	09	31	SC	-	-	3	7	16	23	6.00 / 6.45	5	SS	-6.0				Brownish Grey,Moist,Poorly Graded, Fine to Medium Grains,Medium Dense, **Clayey Silty SAND (SC)**
7		To 09	33	SC	-	-	25	24	22	46	7.00 / 7.45	6	SS	-7.0		L2	7.0	
8		09	58	SC	-	-	15	24	29	53	8.00 / 8.45	7	SS	-8.0				Greyish Brown,Grey,Moist,Poorly Graded, Fine to Medium Grains,Dense to Very Dense,**SAND - Silty SAND (SP/SP-SM) to Silty SAND (SM)**
9		To 10	00	SC	-	-	20	14	19	33	9.00 / 9.45	8	SS	-9.0				
10		10	20	SC	-	-	7	5	5	10	10.00 / 10.45	9	SS	-10.0		L3	10.0	
		To 10	22															Grey,Moist,Stiff,**Silty CLAY (CI)** Lean Clay of Meidum Plasticity
		10	41															
		To 10	43															
		11	06															
		To 11	08															

CS - Core Sample	DS - Disturbed Sample	LOGGED	Loganathan K.	PROJECT SITE DETAILS	REMARKS
SS - Split Spoon Sample	SC - Soil Cutter	DATE	11/01/2020	E.G.L WRT ROAD LEVEL(m) 0.00	Water table could not be established due to uncontrollable water loss
UDS- Undisturbed Sample	TCB - Tungsten Carbide Bit	CHECKED	Anitha Kondusamy	WATER TABLE (m) -	
WS - Wash Sample	DB - Diamond Bit	DATE	29/01/2020	CASING DEPTH (m) 0.00	

SITE INVESTIGATION RECORD

GEOMARINE

BORE HOLE No.	BH-02		
SHEET	2	OF	3
DIA OF BORE HOLE	150mm ✓		
	NX		

PROJECT NAME	PROPOSED CONSTRUCTION OF RESIDENTIAL BUILDING					BORE START DATE	10/01/2020
LOCATION	Arumbakkam, Chennai	MACHINE No.	-	CHAINAGE (m)	-	BORE END DATE	20/01/2020
STRUCTURE	2 Basement + G + 22 Floors	DRILLING METHOD	Rotary	CO-ORDINATES	N -	TOTAL DRILL DAYS	5
JOB CODE	GT-2057	FLUSHING MEDIUM	Bentonite		E -		

Depth below E.G.L. (m)	Drilling progress per metre: Date	Time: Hr.	Time: Min.	Type of Drill Bit (SC / TCB / DB)	Core Details: Total Core Recovery %	Core Details: R.Q.D %	SPT Details: Blows/cm. 0-15	Blows/cm. 15-30	Blows/cm. 30-45	SPT 'N' Value	Sample Details: Depth	No.	Type	RL (m)	Layer Data: Legend	No	Depth	Geotechnical Description
11	11/01/2020	11	36 To 11 39	SC	-	-	1	2	3	5	11.50 to 11.95	10	SS	-11.5		L4	11.5	Grey,Moist,Stiff,**Silty CLAY (CI)** Lean Clay of Meidum Plasticity
12		12	17 To 12 19	SC	-	-	7	10	17	27	13.00 to 13.45	11	SS	-13.0		L5	13.0	Grey,Moist,Poorly Graded,Fine to Medium Grans,Loose,**Clayey Silty SAND (SC)**
13		13	45 To 13 47	SC	-	-												
14							13	20	26	46	14.50 to 14.95	12	SS	-14.5				
15		14	30 To 14 32	SC	-	-												Grey,Moist,Poorly Graded,Fine to Medium Grains,Medium Dense to Dense,**Clayey Silty SAND (SC) to Silty SAND (SM)**
16							15	17	30	47	16.00 to 16.45	13	SS	-16.0				
17		16	02 To 16 04	SC	-	-										L6	17.5	
18	12/01/2020			SC	-	-	15	36	37	73	17.50 to 17.95	14	SS	-17.5				Grey,Moist,Poorly Graded,Fine to Medium Grains,Very Dense,**Silty SAND (SM)**
19																L7	19.0	
20							13	31	37	68	19.00 to 19.45	15	SS	-19.0				Brownish Grey,Moist,Hard,**Compacted CLAY (CH)** Clays of High Plasticity

CS - Core Sample	DS - Disturbed Sample	LOGGED	Loganathan K.	PROJECT SITE DETAILS	REMARKS
SS - Split Spoon Sample	SC - Soil Cutter	DATE	12/01/2020	E.G.L WRT ROAD LEVEL(m) 0.00	Water table could not be established due to uncontrollable water loss
UDS- Undisturbed Sample	TCB - Tungsten Carbide Bit	CHECKED	Anitha Kondusamy	WATER TABLE (m) -	
WS - Wash Sample	DB - Diamond Bit	DATE	29/01/2020	CASING DEPTH (m) 0.00	

SITE INVESTIGATION RECORD

GEOMARINE

BORE HOLE No.	BH-02		
SHEET	3	OF	3
DIA OF BORE HOLE	150mm	✓	
	NX		
BORE START DATE	10/01/2020		
BORE END DATE	20/01/2020		
TOTAL DRILL DAYS	5		

PROJECT NAME	PROPOSED CONSTRUCTION OF RESIDENTIAL BUILDING						
LOCATION	Arumbakkam, Chennai	MACHINE No.	-	CHAINAGE (m)	-		
STRUCTURE	2 Basement + G + 22 Floors	DRILLING METHOD	Rotary	CO-ORDINATES	N	-	
JOB CODE	GT-2057	FLUSHING MEDIUM	Bentonite		E	-	

Depth below E.G.L. (m)	Drilling progress per metre: Date	Time: Hr.	Time: Min.	Type of Drill Bit (SC / TCB / DB)	Core Details: Total Core Recovery %	Core Details: R.Q.D %	SPT Details: Blows/cm. 0-15	15-30	30-45	SPT 'N' Value	Sample Details: Depth	No.	Type	RL (m)	Layer Data: Legend	No	Depth	Geotechnical Description
21	12/01/2020	Total Drilling Time 10 Mins		SC	-	-	15	23	34	57	21.00 / 21.45	17	SS	-21.0				Brownish Grey,Moist,Hard,**Compacted CLAY (CH)** Clays of High Plasticity
22		Total Drilling Time 6Mins		SC	-	-												
23	13/01/2020						33	15Cm Penet for 60Blows		>100	23.00 / 23.30	18	SS	-23.0		L8	23.0	
24		Total Drilling Time 3Mins		SC	-	-												Brownish Grey,Moist,Poorly Graded, Fine Grains,Very Dense,**Clayey Silty SAND (SC)**
25							23	57	11Cm Penet for 52Blows	>100	25.00 / 25.41	19	SS	-25.0		L9	25.0	
26	20/01/2020	14 To 15	55 05	SC	-	-												Brownish Green,Moist,Hard, **Compacted CLAY (CI to CL)** Clays of Medium to Low Plasticity
27							40	40	8Cm Penet for 45Blows	>100	27.00 / 27.38	20	SS	-27.0		L10	27.5	
28																		**Borehole at this location is terminated at 27.0m due to uncontrollable water loss**
29																		
30																		

CS - Core Sample	DS - Disturbed Sample	LOGGED	Loganathan K.	PROJECT SITE DETAILS	REMARKS
SS - Split Spoon Sample	SC - Soil Cutter	DATE	20/01/2020	E.G.L WRT ROAD LEVEL(m) 0.00	Water table could not be established due to uncontrollable water loss
UDS- Undisturbed Sample	TCB - Tungsten Carbide Bit	CHECKED	Anitha Kondusamy	WATER TABLE (m) -	
WS - Wash Sample	DB - Diamond Bit	DATE	29/01/2020	CASING DEPTH (m) 0.00	

Borehole terminated at 27 m depth below E.G.L

FIG.2.2 Sub Soil Profile at BH-02 Location

SITE INVESTIGATION RECORD

GEOMARINE

BORE HOLE No.	BH-03		
SHEET	1	OF	3
DIA OF BORE HOLE	150mm	✓	
	NX	✓	
BORE START DATE	22/01/2020		
BORE END DATE	28/01/2020		
TOTAL DRILL DAYS	6		

PROJECT NAME	PROPOSED CONSTRUCTION OF RESIDENTIAL BUILDING					
LOCATION	Arumbakkam, Chennai	MACHINE No.	-	CHAINAGE (m)	-	
STRUCTURE	2 Basement + G + 22 Floors	DRILLING METHOD	Rotary	CO-ORDINATES	N -	
JOB CODE	GT-2057	FLUSHING MEDIUM	Bentonite		E -	

Depth below E.G.L. (m)	Drilling progress per metre: Date	Time: Hr.	Time: Min.	Type of Drill Bit (SC / TCB / DB)	Core Details: Total Core Recovery %	Core Details: R.Q.D %	SPT Details: Blows/cm. 0-15	15-30	30-45	SPT 'N' Value	Sample Details: Depth	No.	Type	RL (m)	Layer Data: Legend	No	Depth	Geotechnical Description
1	22/01/2020	10	45	SC	-	-										L1	2.5	Filled up Materials consisting of old building debris, Brick pats & soil mixture
		To																
2		11	15															
3		12	15				2	5	2	7	3.00	1	SS	-5.5				
		To		SC	-	-					3.45							
		12	27															Black,Moist,Medium Stiff,**Silty CLAY (CH)** Clays of High Plasticity
4		14	07				3	3	4	7	4.00	2	SS	-6.5				
		To		SC	-	-					4.45							
		14	30															
5		14	57				5	12	14	26	5.00	3	SS	-7.5		L2	5.2	
		To		SC	-	-					5.45							
		15	00															
6		15	19				5	6	8	14	6.00	4	SS	-8.5				
		To		SC	-	-					6.45							Brownish Grey,Moist,Poorly Graded, Fine to Medium Grains,Medium Dense to Dense, **Clayey Silty SAND (SC)**
7		15	21				5	4	6	10	7.00	5	SS	-9.5				
		15	42								7.45							
		To		SC	-	-												
8		15	47				7	12	8	20	8.00	-	*SS	-10.5		L3	8.0	
		16	14								8.45							
		To		SC	-	-												
9		16	16				12	15	19	34	9.00	6	SS	-11.5				Grey,Moist,Poorly Graded,Fine to Medium Grains,Medium Dense to Dense,**Silty SAND (SM)**
	23/01/2020	10	45								9.45							
		To		SC	-	-												
10		10	47				13	15	15	30	10.00	7	SS	-12.5				
											10.45							

CS - Core Sample	DS - Disturbed Sample	LOGGED	Muralikrishnan K.	PROJECT SITE DETAILS		REMARKS	
SS - Split Spoon Sample	SC - Soil Cutter	DATE	23/01/2020	E.G.L WRT ROAD LEVEL(m)	-2.50		
UDS- Undisturbed Sample	TCB - Tungsten Carbide Bit	CHECKED	Anitha Kondusamy	WATER TABLE (m)	4.50		
WS - Wash Sample	DB - Diamond Bit	DATE	29/01/2020	CASING DEPTH (m)	0.00		

SITE INVESTIGATION RECORD

GEOMARINE

BORE HOLE No.	BH-03		
SHEET	2	OF	3
DIA OF BORE HOLE	150mm	✓	
	NX		

PROJECT NAME	PROPOSED CONSTRUCTION OF RESIDENTIAL BUILDING					BORE START DATE	22/01/2020
LOCATION	Arumbakkam, Chennai	MACHINE No.	-	CHAINAGE (m)	-	BORE END DATE	28/01/2020
STRUCTURE	2 Basement + G + 22 Floors	DRILLING METHOD	Rotary	CO-ORDINATES	N -	TOTAL DRILL DAYS	6
JOB CODE	GT-2057	FLUSHING MEDIUM	Bentonite		E -		

Depth below E.G.L. (m)	Drilling progress per metre: Date	Time: Hr.	Time: Min.	Type of Drill Bit (SC / TCB / DB)	Core Details: Total Core Recovery %	Core Details: R.Q.D %	SPT Details: Blows/cm. 0-15	15-30	30-45	SPT 'N' Value	Sample Details: Depth	No.	Type	RL (m)	Layer Data: Legend	No	Depth	Geotechnical Description
11	23/01/2020	11	40	SC	-	-												
		To																
		11	50				11	14	19	33	11.50 / 11.95	8	SS	-14.0				
12		12	16	SC	-	-												Grey,Moist,Poorly Graded,Fine to Medium Grains,Medium Dense to Dense,**Silty SAND (SM) to Clayey Silty SAND (SC)**
		To																
		12	20				15	17	17	34	13.00 / 13.45	9	SS	-15.5				
13		10	16	SC	-	-												
		To																
		10	31				33	57	10Cm Penet for 50Blows	>100	14.50 / 14.90	10	SS	-17.0		L4	14.5	
14																		
15	24/01/2020	Total Drilling Time 42 Mins		SC	-	-												
		16	05				15	20	29	49	16.00 / 16.45	11	SS	-18.5				
16		To																
		16	54	SC	-	-												Greyish Brown,Moist,Hard,**Compacted CLAY (CH)** Clays of High Plasticity
17							14	44	46	90	17.50 / 17.95	12	SS	-20.0				
18		11	05															
	25/01/2020	To		SC	-	-												
		11	28				37	55	10Cm Penet for 51Blows	>100	19.00 / 19.40	13	SS	-21.5		L5	19.0	
19																		Greyish Brown,Moist,PoorlyG raded, Fine to Medium Grains,Very Dense, **Silty SAND (SM)**
20																		

CS - Core Sample	DS - Disturbed Sample	LOGGED	Muralikrishnan K.	PROJECT SITE DETAILS		REMARKS	
SS - Split Spoon Sample	SC - Soil Cutter	DATE	25/01/2020	E.G.L WRT ROAD LEVEL(m)	-2.50		
UDS- Undisturbed Sample	TCB - Tungsten Carbide Bit	CHECKED	Anitha Kondusamy	WATER TABLE (m)	4.50		
WS - Wash Sample	DB - Diamond Bit	DATE	29/01/2020	CASING DEPTH (m)	0.00		

GEOMARINE

SITE INVESTIGATION RECORD

BORE HOLE No.	BH-03		
SHEET	3	OF	3
DIA OF BORE HOLE	150mm ✓		
	NX ✓		

PROJECT NAME	PROPOSED CONSTRUCTION OF RESIDENTIAL BUILDING					BORE START DATE	22/01/2020
LOCATION	Arumbakkam, Chennai	MACHINE No.	-	CHAINAGE (m)	-	BORE END DATE	28/01/2020
STRUCTURE	2 Basement + G + 22 Floors	DRILLING METHOD	Rotary	CO-ORDINATES	N -	TOTAL DRILL DAYS	6
JOB CODE	GT-2057	FLUSHING MEDIUM	Bentonite		E -		

Depth below E.G.L. (m)	Drilling progress per metre: Date	Time: Hr.	Time: Min.	Type of Drill Bit (SC / TCB / DB)	Core Details: Total Core Recovery %	Core Details: R.Q.D %	SPT Details: Blows/cm. 0-15	SPT Details: Blows/cm. 15-30	SPT Details: Blows/cm. 30-45	SPT 'N' Value	Sample Details: Depth	Sample Details: No.	Sample Details: Type	Sample Details: RL (m)	Layer Data: Legend	Layer Data: No	Layer Data: Depth	Geotechnical Description
21	25/01/2020	12	30	SC	-	-												
		To																
		12	50				21	35	12Cm Penet for 55Blows	>100	21.00 / 21.42	14	SS	-23.5		L6	21.0	Greyish Brown,Moist,PoorlyG raded, Fine to Medium Grains,Very Dense, **Silty SAND (SM)**
22		Total Drilling Time 90 Mins		SC	-	-												
23							23	40	10Cm Penet for 60Blows	>100	23.00 / 23.40	15	SS	-25.5				Brownish Grey,Moist,Hard,**Compacted CLAY (CH)** Clays of High Plasticity
24		09	55	SC	-	-												
		To																
		10	30															
25							9Cm Penet for 55Blows			>100	25.00 / 25.09	16	SS	-27.5		L7	25.0	
																L8	26.0	Brownish Grey,Moist,Poorly Graded, Fine to Medium Grains,Very Dense, **Silty SAND (SM)**
26	27/01/2020	11	18	SC	-	-												
		To																
		12	40															
27							3Cm Penet for 55Blows			>100	27.00 / 27.03	-	*SS	-29.5				
		14	45															
		To		DB	0	0												
		15	40															
28							SPT Hammer Rebound			>100	28.00	-	*SS	-30.5				Grey,Fine Grains,Argilaceous,Fissile, Hard, **SHALE (Gondwana Formation)**
		15	25															
		To		DB	0	0												
		16	35															
29							SPT Hammer Rebound			>100	29.00	-	*SS	-31.5				
	28/01/2020	10	20															
		To		TCB	30	0												
		12	10				-	-	-	-	30.00	17	CS	-32.5		L9	30.0	
30																		

CS - Core Sample	DS - Disturbed Sample	LOGGED	Muralikrishnan K.	PROJECT SITE DETAILS	REMARKS
SS - Split Spoon Sample	SC - Soil Cutter	DATE	28/01/2020	E.G.L WRT ROAD LEVEL(m) -2.50	
UDS- Undisturbed Sample	TCB - Tungsten Carbide Bit	CHECKED	Anitha Kondusamy	WATER TABLE (m) 4.50	
WS - Wash Sample	DB - Diamond Bit	DATE	29/01/2020	CASING DEPTH (m) 0.00	

Borehole terminated at 30 m depth below E.G.L

FIG.2.3 Sub Soil Profile at BH-03 Location

SITE INVESTIGATION RECORD

GEOMARINE

BORE HOLE No.	BH-04		
SHEET	1	OF	3
DIA OF BORE HOLE	150mm ✓		
	NX ✓		

PROJECT NAME	PROPOSED CONSTRUCTION OF RESIDENTIAL BUILDING					BORE START DATE	28/01/2020
LOCATION	Arumbakkam, Chennai	MACHINE No.	-	CHAINAGE (m)	-	BORE END DATE	31/01/2020
STRUCTURE	2 Basement + G + 22 Floors	DRILLING METHOD	Rotary	CO-ORDINATES	N -	TOTAL DRILL DAYS	4
JOB CODE	GT-2057	FLUSHING MEDIUM	Bentonite		E -		

Depth below E.G.L. (m)	Drilling progress per metre: Date	Time: Hr.	Time: Min.	Type of Drill Bit (SC / TCB / DB)	Core Details: Total Core Recovery %	Core Details: R.Q.D %	SPT Details: Blows/cm. 0-15	Blows/cm. 15-30	Blows/cm. 30-45	SPT 'N' Value	Sample Details: Depth	No.	Type	RL (m)	Layer Data: Legend	No	Depth	Geotechnical Description
1	28/01/2020	16	04	SC	-	-	-	-	-	-	1.00	-	-	-3.5				
		To 16	15															
		16	24	SC	-	-												
2		To 16	33				-	-	-	-	2.00	-	-	-4.5				Filled up Materials consisting of old building debris, Brick pats & soil mixture
		16	40	SC	-	-												
3		To 16	58				17	18	20	38	3.00	1	SS	-5.5				
		10	15								3.45							
		To 10	25	SC	-	-										L1	4.0	
4		10	56				5	7	8	15	4.00	2	SS	-6.5				
		To 11	00	SC	-	-					4.45							Grey,Moist,Stiff to Very Stiff,**Silty CLAY (CH to CL)** Clays of High to Low Plasticity
5		11	27				6	8	10	18	5.00	3	SS	-7.5				
		To 11	30	SC	-	-					5.45					L2	5.5	
6		11	52				8	11	11	22	6.00	4	SS	-8.5				
	29/01/2020	To 11	55	SC	-	-					6.45							
7		12	24				6	10	8	18	7.00	5	SS	-9.5				Grey,Moist,Poorly Graded,Fine to Medium Grains,Medium Dense, **Silty SAND (SM) to Clayey Silty SAND (SC)**
		To 12	27	SC	-	-					7.45							
8		12	46				3	6	9	15	8.00	6	SS	-10.5				
		To 12	48	SC	-	-					8.45					L3	9.0	
9		13	49				10	14	17	31	9.00	7	SS	-11.5				
		To 14	00	SC	-	-					9.45							Grey,Moist,Poorly Graded,Fine to Medium Grains,Dense,**Clayey Silty SAND (SC)**
10							12	21	25	46	10.00	8	SS	-12.5				
											10.45							

CS - Core Sample	DS - Disturbed Sample	LOGGED	Murali Krishnan K	PROJECT SITE DETAILS		REMARKS	
SS - Split Spoon Sample	SC - Soil Cutter	DATE	29/01/2020	E.G.L WRT ROAD LEVEL(m)	-2.50		
UDS- Undisturbed Sample	TCB - Tungsten Carbide Bit	CHECKED	Anitha Kondusamy	WATER TABLE (m)	4.50		
WS - Wash Sample	DB - Diamond Bit	DATE	06/02/2020	CASING DEPTH (m)	0.00		

SITE INVESTIGATION RECORD

GEOMARINE

BORE HOLE No.	BH-04		
SHEET	2	OF	3
DIA OF BORE HOLE	150mm ✓		
	NX ✓		

PROJECT NAME	PROPOSED CONSTRUCTION OF RESIDENTIAL BUILDING					BORE START DATE	28/01/2020
LOCATION	Arumbakkam, Chennai	MACHINE No.	-	CHAINAGE (m)	-	BORE END DATE	31/01/2020
STRUCTURE	2 Basement + G + 22 Floors	DRILLING METHOD	Rotary	CO-ORDINATES	N -	TOTAL DRILL DAYS	4
JOB CODE	GT-2057	FLUSHING MEDIUM	Bentonite		E -		

Depth below E.G.L. (m)	Drilling progress per metre: Date	Time: Hr.	Time: Min.	Type of Drill Bit (SC / TCB / DB)	Core Details: Total Core Recovery %	Core Details: R.Q.D %	SPT Details: Blows/cm. 0-15	15-30	30-45	SPT 'N' Value	Sample Details: Depth	No.	Type	RL (m)	Layer Data: Legend	No	Depth	Geotechnical Description
11	29/01/2020	14	18	SC	-	-	19	24	25	49	11.50	9	SS	-14.0				Grey,Moist,Poorly Graded,Fine to Medium Grains,Dense,**Clayey Silty SAND (SC) to Silty SAND (SM)**
		To									11.95							
12		16	25															
		15	10	SC	-	-												
		To																
13		15	30				34	40	12Cm Penet for 55Blows	>100	13.00	10	SS	-15.5		L4	13.0	
											13.42							
		16	25	SC	-	-												
14		To																
		16	40															
							45	10Cm Penet for 50Blows		>100	14.50	11	SS	-17.0				Grey,Moist,Poorly Graded,Fine to Medium Grains,Very Dense,**Silty SAND (SM)**
15		10	19								14.75							
		To		SC	-	-												
		11	55															
16	30/01/2020						11	20	24	44	16.00	12	SS	-18.5		L5	16.0	
		Total Drilling Time 57Mints									16.45							
				SC	-	-												
17							12	21	25	46	17.50	13	SS	-20.0				
											17.95							
18		Total Drilling Time 43Mints																Brownish Grey,Moist,Hard,**Compacted CLAY (CH to CI)** Clays of High to Medium Plasticity
				SC	-	-												
							21	28	39	67	19.00	14	SS	-21.5				
19											19.45							
20																		

CS - Core Sample	DS - Disturbed Sample	LOGGED	Murali Krishnan K	PROJECT SITE DETAILS	REMARKS
SS - Split Spoon Sample	SC - Soil Cutter	DATE	30/01/2020	E.G.L WRT ROAD LEVEL(m) -2.50	
UDS- Undisturbed Sample	TCB - Tungsten Carbide Bit	CHECKED	Anitha Kondusamy	WATER TABLE (m) 4.50	
WS - Wash Sample	DB - Diamond Bit	DATE	06/02/2020	CASING DEPTH (m) 0.00	

SITE INVESTIGATION RECORD

GEOMARINE — SOIL & ROCK ENGINEERING

BORE HOLE No.	BH-04						
SHEET	3	OF	3				
DIA OF BORE HOLE	150mm ✓	NX ✓					
PROJECT NAME	PROPOSED CONSTRUCTION OF RESIDENTIAL BUILDING						
LOCATION	Arumbakkam, Chennai	MACHINE No.	-	CHAINAGE (m)	-	BORE START DATE	28/01/2020
STRUCTURE	2 Basement + G + 22 Floors	DRILLING METHOD	Rotary	CO-ORDINATES	N -	BORE END DATE	31/01/2020
JOB CODE	GT-2057	FLUSHING MEDIUM	Bentonite		E -	TOTAL DRILL DAYS	4

Depth below E.G.L. (m)	Drilling progress per metre: Date	Time: Hr.	Time: Min.	Type of Drill Bit (SC / TCB / DB)	Core Details: Total Core Recovery %	Core Details: R.Q.D %	SPT Details: Blows/cm. 0-15	15-30	30-45	SPT 'N' Value	Sample Details: Depth	No.	Type	RL (m)	Layer Data: Legend	No	Depth	Geotechnical Description
21	30/01/2020	15	14	SC	-	-	25	25	30	55	21.00	15	SS	-23.5				Brownish Grey,Moist,Hard,**Compacted CLAY (CH to CI)** Clays of High to Medium Plasticity
		To									21.45							
		15	35															
22		15	55	SC	-	-												
		To																
		16	18															
23							45	8Cm Penet for 55Blows		>100	23.00	16	SS	-25.5		L6	23.0	
											23.23							
		16	40															Grey,Moist,Poorly Graded,Fine to Medium Grains,Very Dense,**Silty SAND (SM)**
24		To		SC	-	-												
		17	10															
25							25	8Cm Penet for 48Blows		>100	25.00	17	SS	-27.5		L7	25.0	
											25.23							
		10	46															
26		To		SC	-	-												
		11	22															
27							25	40	SPT Hammer Rebounded	>100	27.00	18	SS	-29.5				Grey,Moist,Poorly Graded,Fine to Medium Grains,Very Dense,**Clayey Silty SAND (SC)**
											27.30							
28	31/01/2020	11	55															
		To		SC	-	-												
		12	30															
29								5Cm Penet for 55Blows		>100	29.00	19	SS	-31.5		L8	29.0	
											29.05							
		12	46															Grey,Greyish Green,Fine Grains, Argilaceous,Fissile, Hard, **SHALE** (Gondwana Formation)
		To		TC	35	0												
		14	15															
30							-	-	-	-	30.00	20	CS	-32.5		L9	30.0	

CS - Core Sample	DS - Disturbed Sample	LOGGED	Murali Krishnan K	PROJECT SITE DETAILS		REMARKS
SS - Split Spoon Sample	SC - Soil Cutter	DATE	31/01/2020	E.G.L WRT ROAD LEVEL(m)	-2.50	*(F) - Sample Failed
UDS- Undisturbed Sample	TCB - Tungsten Carbide Bit	CHECKED	Anitha Kondusamy	WATER TABLE (m)	4.50	
WS - Wash Sample	DB - Diamond Bit	DATE	06/02/2020	CASING DEPTH (m)	0.00	

Borehole terminated at 30 m depth below E.G.L

FIG.2.4 Sub Soil Profile at BH-04 Location

SITE INVESTIGATION RECORD

GEOMARINE

BORE HOLE No.	BH-05		
SHEET	1	OF	3
DIA OF BORE HOLE	150mm ✓		
	NX ✓		

PROJECT NAME	PROPOSED CONSTRUCTION OF RESIDENTIAL BUILDING					BORE START DATE	03/02/2020
LOCATION	Arumbakkam, Chennai	MACHINE No.	-	CHAINAGE (m)	-		
STRUCTURE	2 Basement + G + 22 Floors	DRILLING METHOD	Rotary	CO-ORDINATES	N -	BORE END DATE	06/02/2020
JOB CODE	GT-2057	FLUSHING MEDIUM	Bentonite		E -	TOTAL DRILL DAYS	4

Depth below E.G.L. (m)	Drilling progress per metre: Date	Time: Hr.	Time: Min.	Type of Drill Bit (SC / TCB / DB)	Core Details: Total Core Recovery %	Core Details: R.Q.D %	SPT Details: Blows/cm. 0-15	Blows/cm. 15-30	Blows/cm. 30-45	SPT 'N' Value	Sample Details: Depth	No.	Type	RL (m)	Layer Data: Legend	No	Depth	Geotechnical Description
1	03/02/2020	12	40	SC	-	-												
		To																Filled up Materials consisting of old building debris, Brick pats & soil mixture
		12	57															
2		13	50	SC	-	-												
		To																
		13	58															
3		15	57	SC	-	-	7	10	11	21	3.00 / 3.45	1	SS	-5.5		L1	3.0	
		To																
		16	10															
4		16	35	SC	-	-	4	8	9	17	4.00 / 4.45	2	SS	-6.5				Brown,Grey,Moist,Poorly Graded,Fine to Medium Grains, Medium Dense,**Silty SAND (SM)**
		To																
		16	38															
5		16	55	SC	-	-	4	7	8	15	5.00 / 5.45	3	SS	-7.5		L2	5.3	
		To																
		16	58															
6		17	10	SC	-	-	3	5	4	9	6.00 / 6.45	4	SS	-8.5				Grey,Moist,Poorly Graded,Fine to Medium Grains,Fine to Medium Grains, Loose,**Silty SAND (SM) With Lenses of Clay**
		To																
		17	13															
7		10	05	SC	-	-	5	8	9	17	7.00 / 7.45	5	SS	-9.5		L3	7.0	
		To																
		10	10															
8	04/02/2020	10	25	SC	-	-	4	9	9	18	8.00 / 8.45	6	SS	-10.5				Grey,Moist,Poorly Graded,Fine to Medium Grains,Fine to Medium Grains,Medium Dense,**Silty SAND (SM) to Clayey Silty SAND (SC)**
		To																
		10	33															
9		11	02	SC	-	-	6	11	11	22	9.00 / 9.45	7	SS	-11.5				
		To																
		11	06															
10							7	15	18	33	10.00 / 10.45	8	SS	-12.5				

CS - Core Sample	DS - Disturbed Sample	LOGGED	Muralikrishnan K.	PROJECT SITE DETAILS		REMARKS
SS - Split Spoon Sample	SC - Soil Cutter	DATE	04/02/2020	GROUND LEVEL (m)	-2.50	
UDS- Undisturbed Sample	TCB - Tungsten Carbide Bit	CHECKED	Anitha Kondusamy	WATER TABLE (m)	3.60	
WS - Wash Sample	DB - Diamond Bit	DATE	11/02/2020	CASING DEPTH (m)	0.00	

SITE INVESTIGATION RECORD

GEOMARINE

BORE HOLE No.	BH-05		
SHEET	2	OF	3
DIA OF BORE HOLE	150mm ✓		
	NX ✓		
BORE START DATE	03/02/2020		
BORE END DATE	06/02/2020		
TOTAL DRILL DAYS	4		

PROJECT NAME	PROPOSED CONSTRUCTION OF RESIDENTIAL BUILDING						
LOCATION	Arumbakkam, Chennai	MACHINE No.	-	CHAINAGE (m)	-	CO-ORDINATES	N -
STRUCTURE	2 Basement + G + 22 Floors	DRILLING METHOD	Rotary				E -
JOB CODE	GT-2057	FLUSHING MEDIUM	Bentonite				

Depth below E.G.L. (m)	Drilling progress per metre: Date	Time: Hr.	Time: Min.	Type of Drill Bit (SC / TCB / DB)	Core Details: Total Core Recovery %	Core Details: R.Q.D %	SPT Details: Blows/cm. 0-15	15-30	30-45	SPT 'N' Value	Sample Details: Depth	No.	Type	RL (m)	Layer Data: Legend	No	Depth	Geotechnical Description
11	04/02/2020	11	32	SC	-	-												
		To																
		11	37				8	15	15	30	11.50	9	SS	-14.0				
12		12	08	SC	-	-					11.95							Grey,Moist,Poorly Graded,Fine to Medium Grains,Fine to Medium Grains,Medium Dense,**Silty SAND (SM) to Clayey Silty SAND (SC)**
		To																
		12	14				7	12	13	25	13.00	10	SS	-15.5				
13		13	48								13.45							
		To		SC	-	-												
14		14	05				14	23	25	48	14.50	11	SS	-17.0		L4	14.5	
											14.95							
15		14	22															
		To		SC	-	-												
		14	49				14	21	27	48	16.00	12	SS	-18.5				
16											16.45							
		15	09															Greenish Grey to Brown,Moist,Hard, **Compacted CLAY (CH)** Clay of High Plasticity
		To		SC	-	-												
17		15	44															
							16	41	46	87	17.50	13	SS	-20.0				
18		Total Drilling Time 38mins									17.95							
				SC	-	-												
	05/02/2020						15	31	36	67	19.00	14	SS	-21.5		L5	19.0	
19											19.45							
																L6	20.0	Brown,Moist,Poorly Graded,Fine to Medium Grains,Very Dense,**Clayey Silty SAND (SC)**
20																		

CS - Core Sample	DS - Disturbed Sample	LOGGED	Muralikrishnan K.	PROJECT SITE DETAILS	REMARKS
SS - Split Spoon Sample	SC - Soil Cutter	DATE	05/02/2020	GROUND LEVEL (m) -2.50	
UDS- Undisturbed Sample	TCB - Tungsten Carbide Bit	CHECKED	Anitha Kondusamy	WATER TABLE (m) 3.60	
WS - Wash Sample	DB - Diamond Bit	DATE	11/02/2020	CASING DEPTH (m) 0.00	

SITE INVESTIGATION RECORD

GEOMARINE

BORE HOLE No.	BH-05						
SHEET	3	OF	3				
PROJECT NAME	PROPOSED CONSTRUCTION OF RESIDENTIAL BUILDING			DIA OF BORE HOLE	150mm ✓		
					NX ✓		
LOCATION	Arumbakkam, Chennai	MACHINE No.	-	CHAINAGE (m)	-	BORE START DATE	03/02/2020
STRUCTURE	2 Basement + G + 22 Floors	DRILLING METHOD	Rotary	CO-ORDINATES	N -	BORE END DATE	06/02/2020
JOB CODE	GT-2057	FLUSHING MEDIUM	Bentonite		E -	TOTAL DRILL DAYS	4

Depth below E.G.L. (m)	Drilling progress per metre: Date	Drilling progress per metre: Time Hr.	Drilling progress per metre: Time Min.	Type of Drill Bit (SC / TCB / DB)	Core Details: Total Core Recovery %	Core Details: R.Q.D %	SPT Details: Blows/cm. 0-15	SPT Details: Blows/cm. 15-30	SPT Details: Blows/cm. 30-45	SPT 'N' Value	Sample Details: Depth	Sample Details: No.	Sample Details: Type	Sample Details: RL (m)	Layer Data: Legend	Layer Data: No	Layer Data: Depth	Geotechnical Description
21	05/02/2020	Total Drilling Time 82mins		SC	-	-	20	33	11Cm Penet for 55Blows	>100	21.00 / 21.41	15	SS	-23.5				
22		14	52	SC	-	-												
		To																
23		15	28				21	35	8Cm Penet for 45Blows	>100	23.00 / 23.38	16	SS	-25.5				Greyish Brown,Moist,Hard,**Compacted CLAY (CI to CH)** Clay of Medium to High Plasticity
24		15	50	SC	-	-												
		To																
25		16	27				23	7Cm Penet for 55Blows		>100	25.00 / 25.22	-	*SS	-27.5		L7	25.6	
26		Total Drilling Time 59mins		TCB	0	0												
27	06/02/2020						8Cm Penet for 55Blows			>100	27.00 / 27.08	17	SS	-29.5				
28		11	04	TCB	0	0												Grey,Greenish Grey,Fissile, **SHALE**
		To																
29		11	56				SPT Hammer Rebound			>100	29.00	-	*CS	-31.5				
		Total Drilling Time 59mins		TCB	-	-												
30							-	-	-	-	30.00	-	*CS	-32.5		L8	30.0	

CS - Core Sample	DS - Disturbed Sample	LOGGED	Muralikrishnan K.	PROJECT SITE DETAILS		REMARKS	
SS - Split Spoon Sample	SC - Soil Cutter	DATE	06/02/2020	GROUND LEVEL (m)	-2.50	*(F) - Sample Failed	
UDS- Undisturbed Sample	TCB - Tungsten Carbide Bit	CHECKED	Anitha Kondusamy	WATER TABLE (m)	3.60		
WS - Wash Sample	DB - Diamond Bit	DATE	11/02/2020	CASING DEPTH (m)	0.00		

Borehole terminated at 30 m depth below E.G.L

FIG.2.5 Sub Soil Profile at BH-05 Location

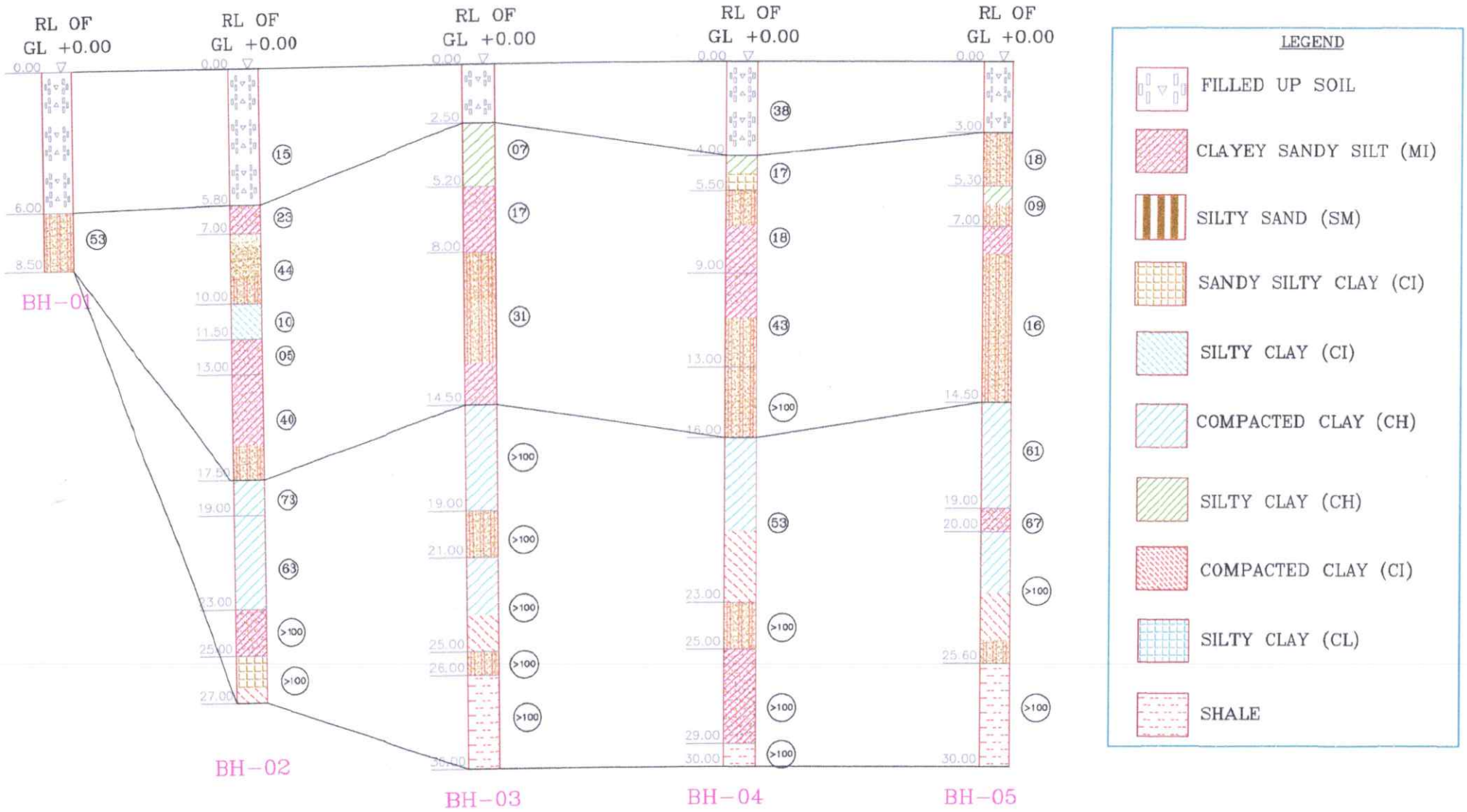


FIG.No.2.6 CROSS SECTIONAL VARIATION OF SUB SOIL PROFILE

THROUGH BH-01 TO 05

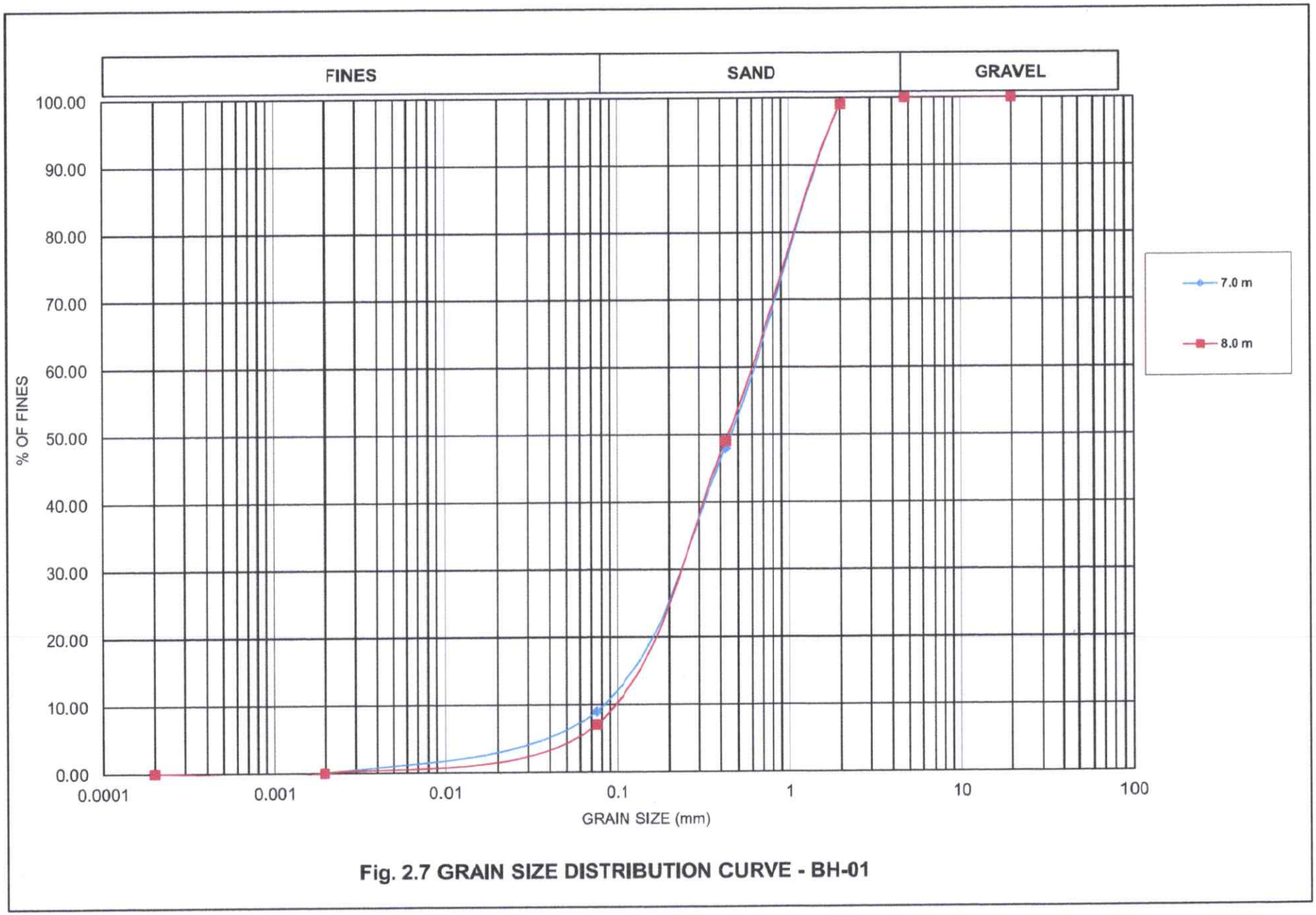


Fig. 2.7 GRAIN SIZE DISTRIBUTION CURVE - BH-01

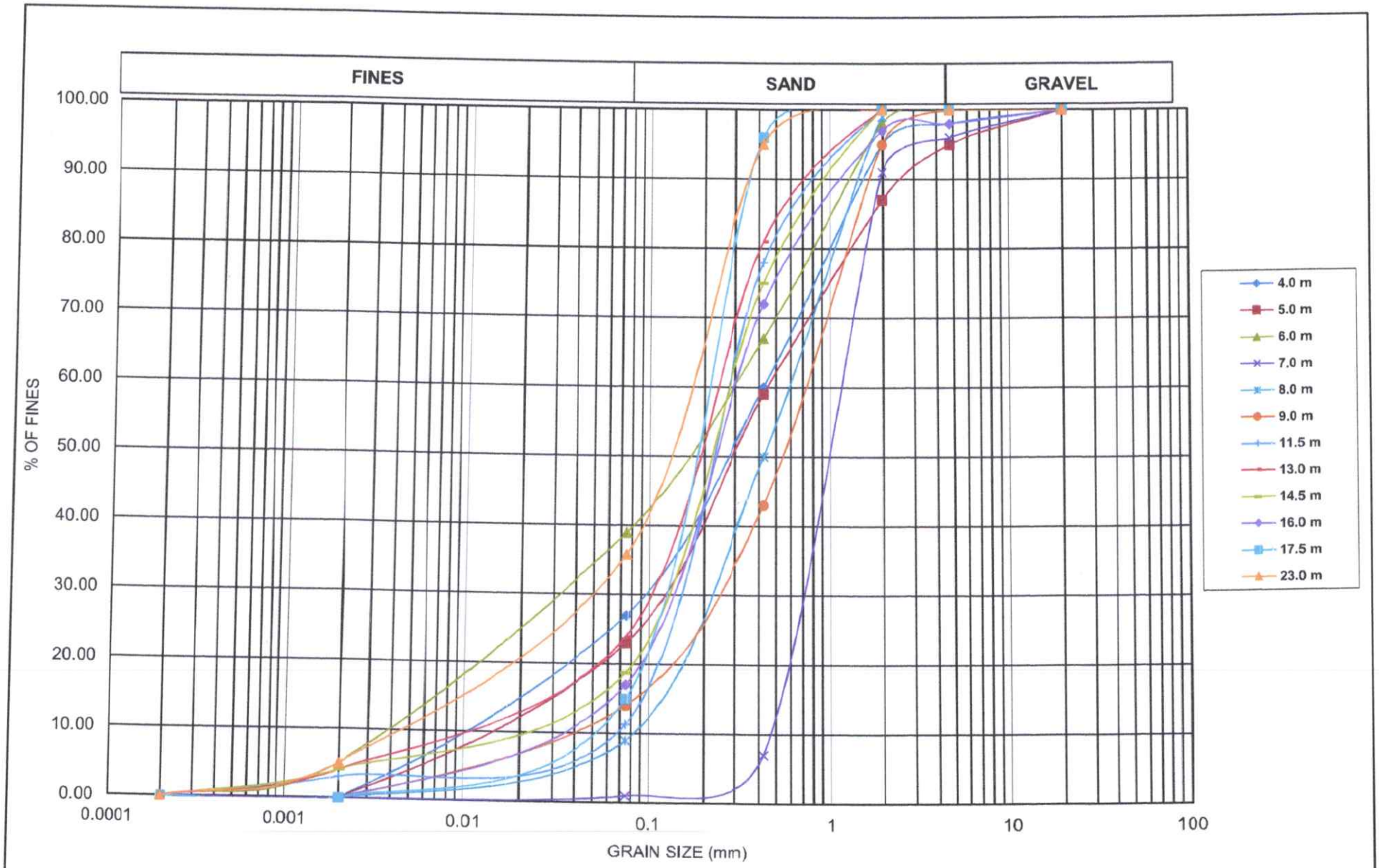


Fig. 2.8 GRAIN SIZE DISTRIBUTION CURVE - BH-02

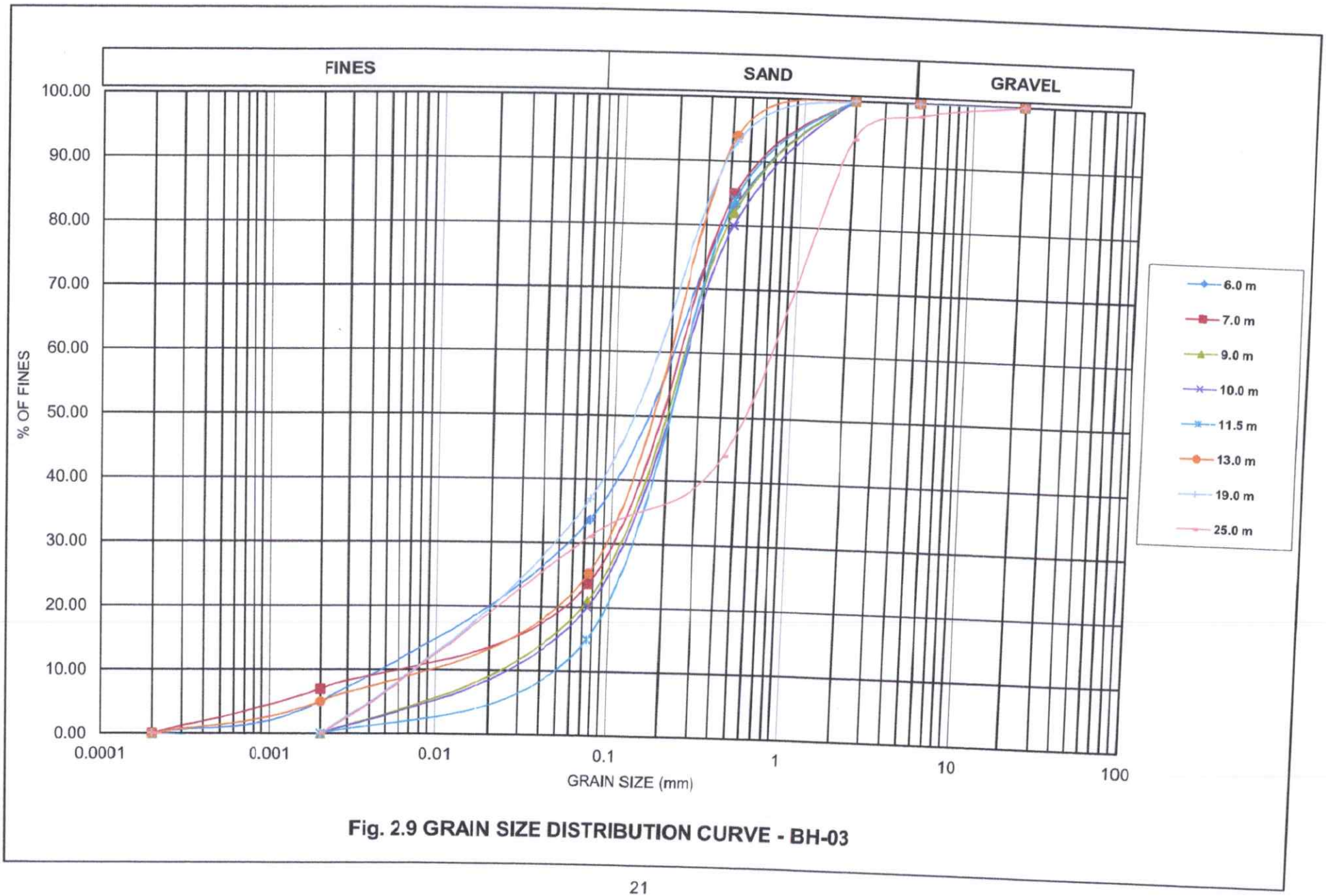


Fig. 2.9 GRAIN SIZE DISTRIBUTION CURVE - BH-03

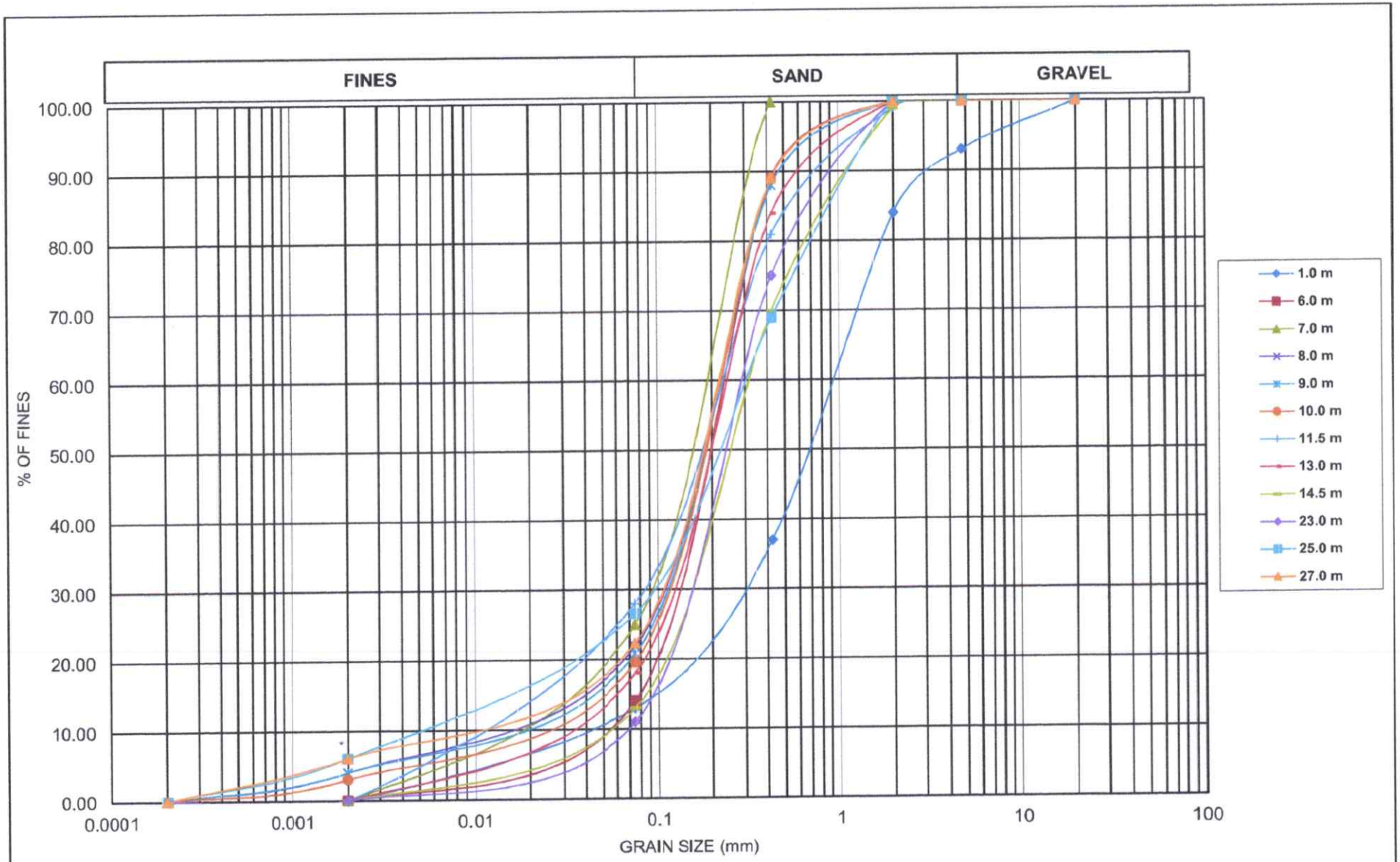


Fig. 2.10 GRAIN SIZE DISTRIBUTION CURVE - BH-04

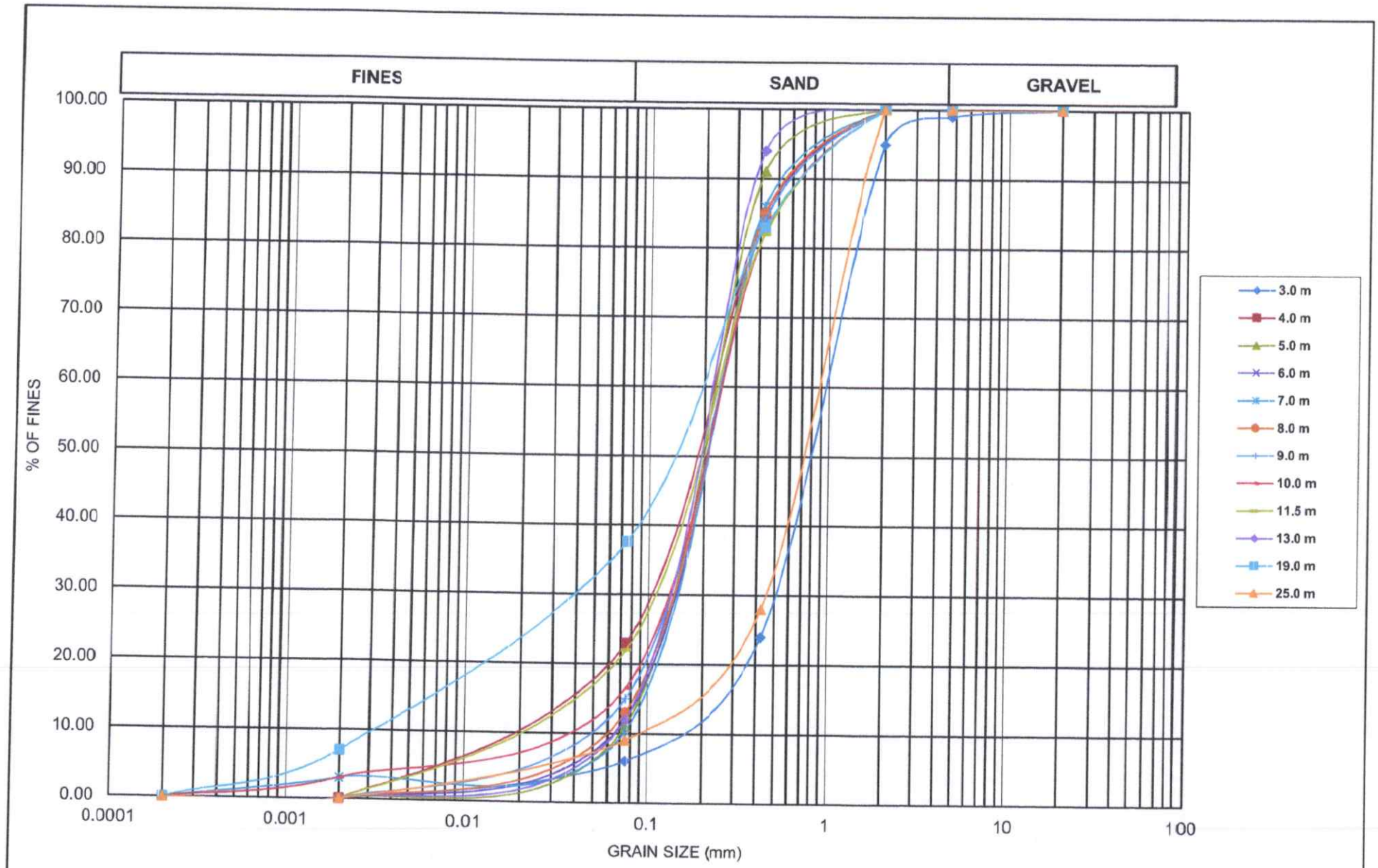


Fig. 2.11 GRAIN SIZE DISTRIBUTION CURVE - BH-05

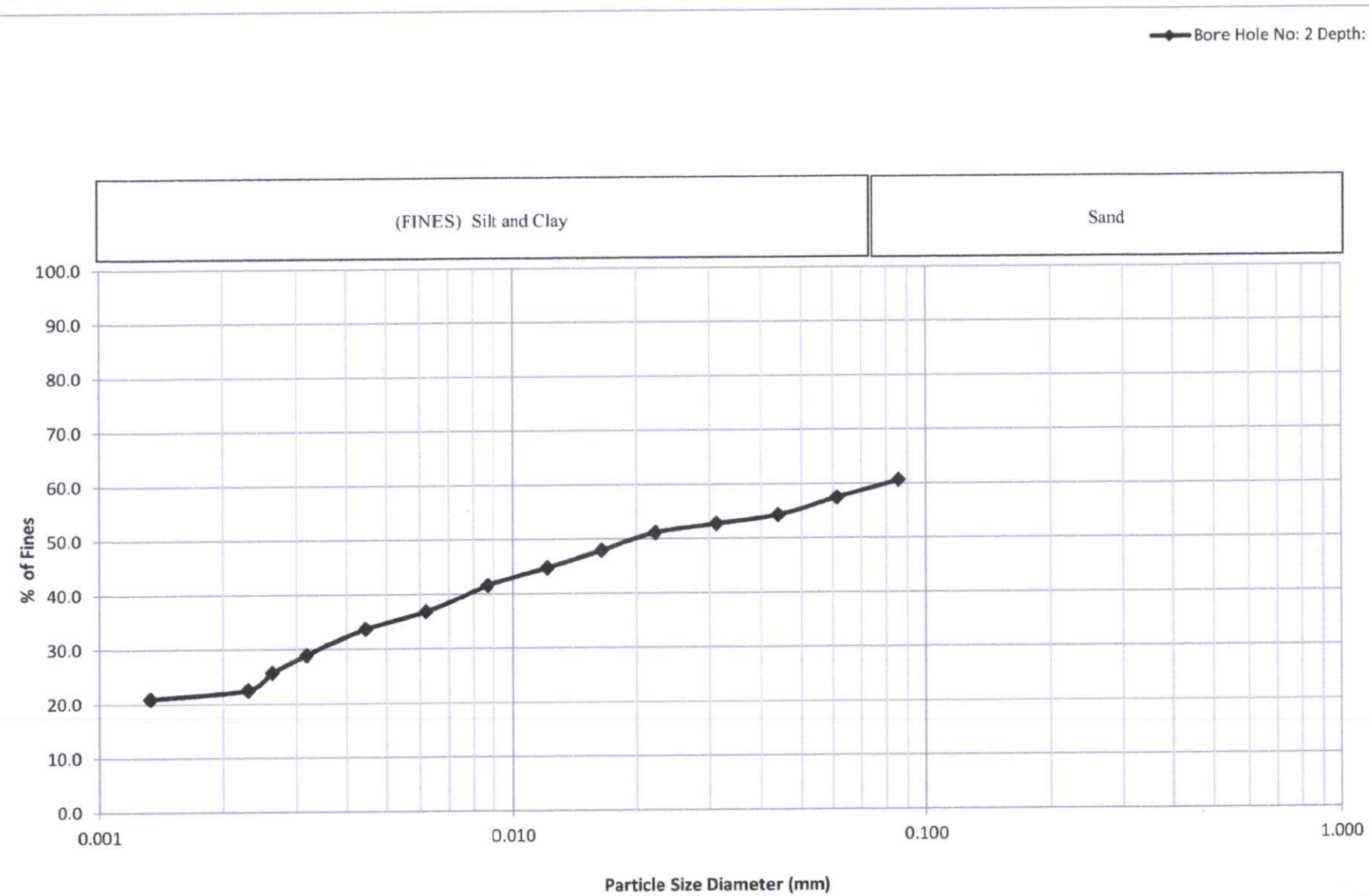


Fig 2.12 Hydrometer Analysis Master Curve

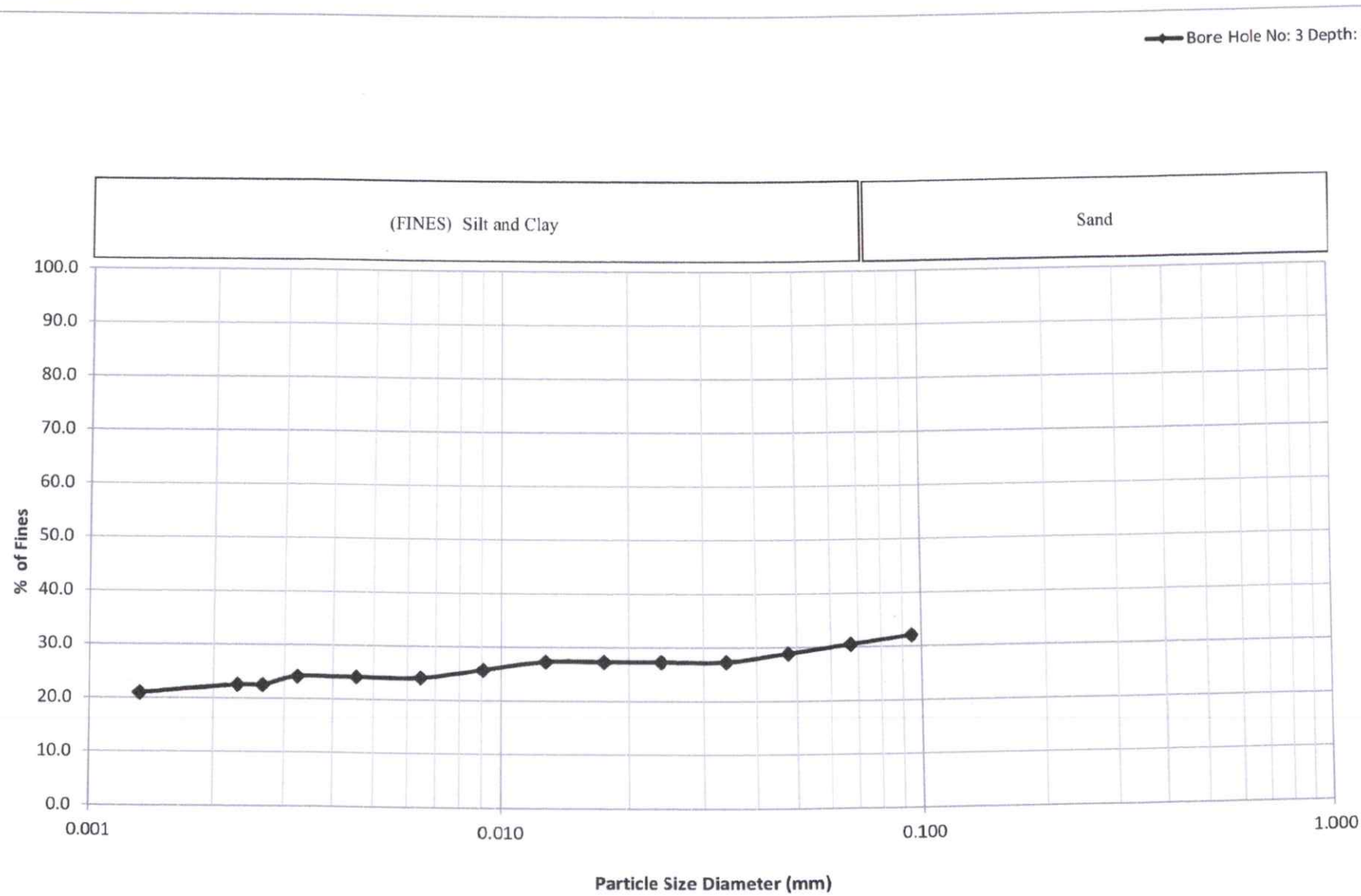


Fig 2.14 Hydrometer Analysis Master Curve

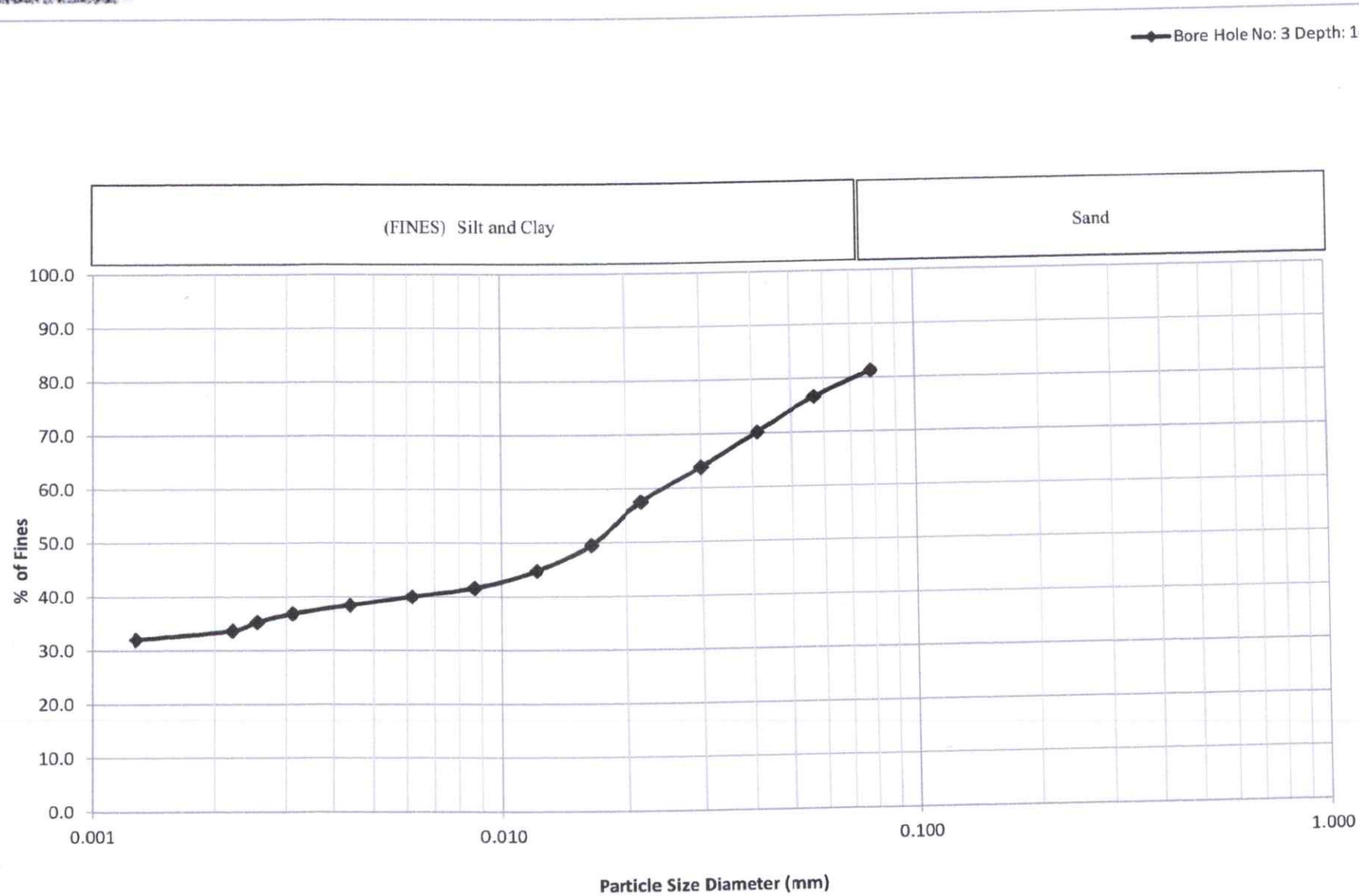


Fig 2.15 Hydrometer Analysis Master Curve

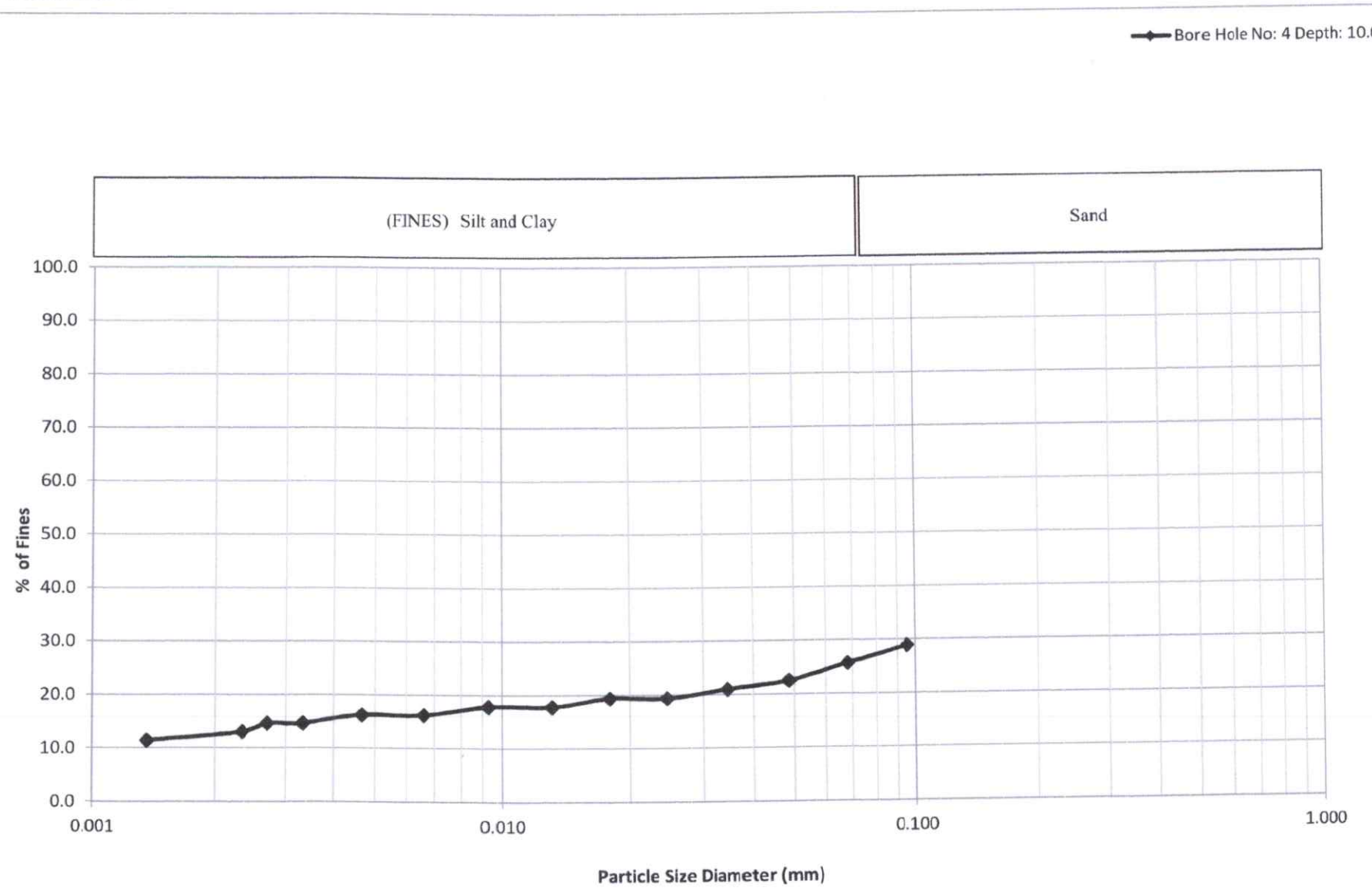


Fig 2.16 Hydrometer Analysis Master Curve

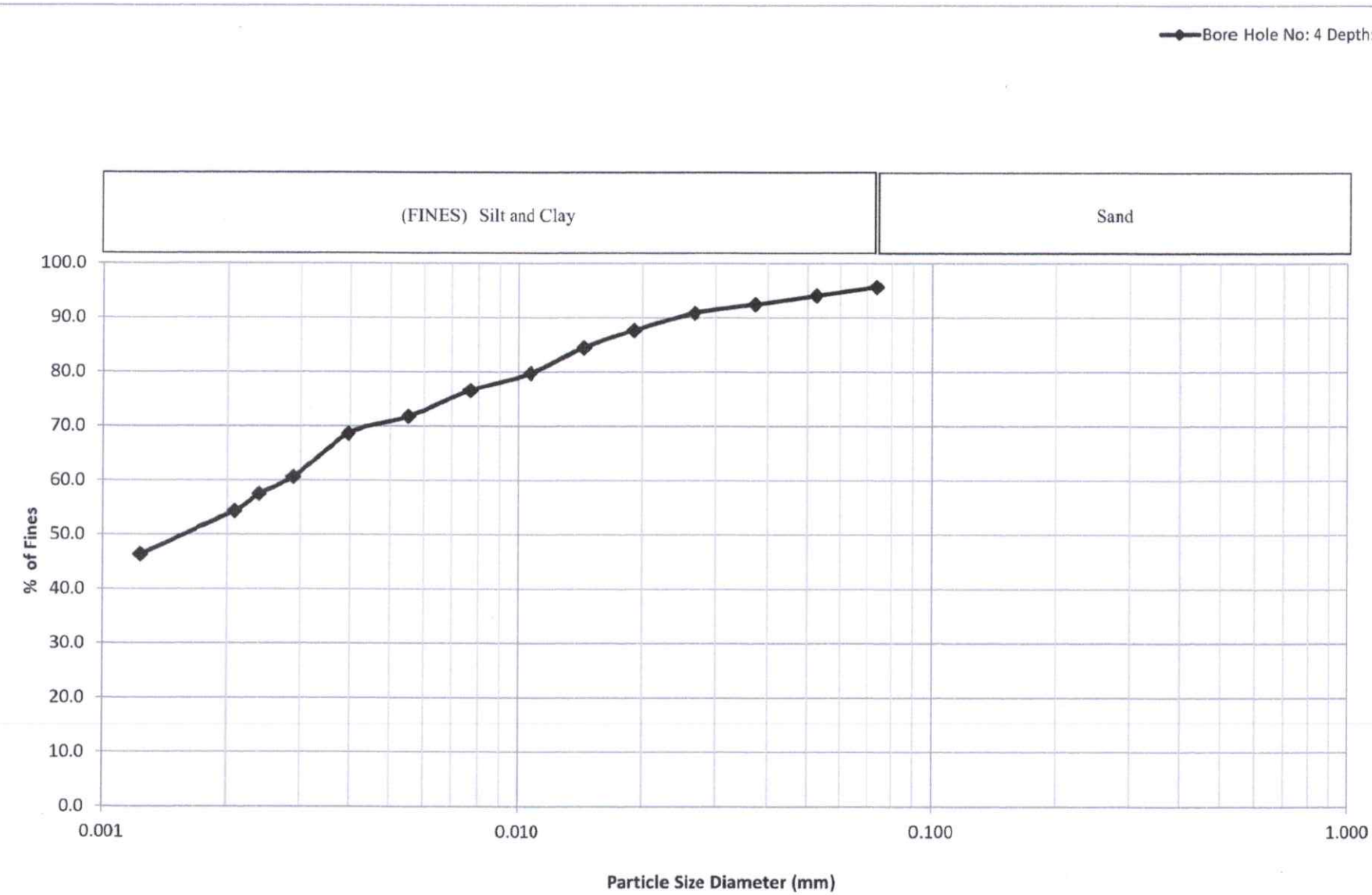


Fig 2.17 Hydrometer Analysis Master Curve

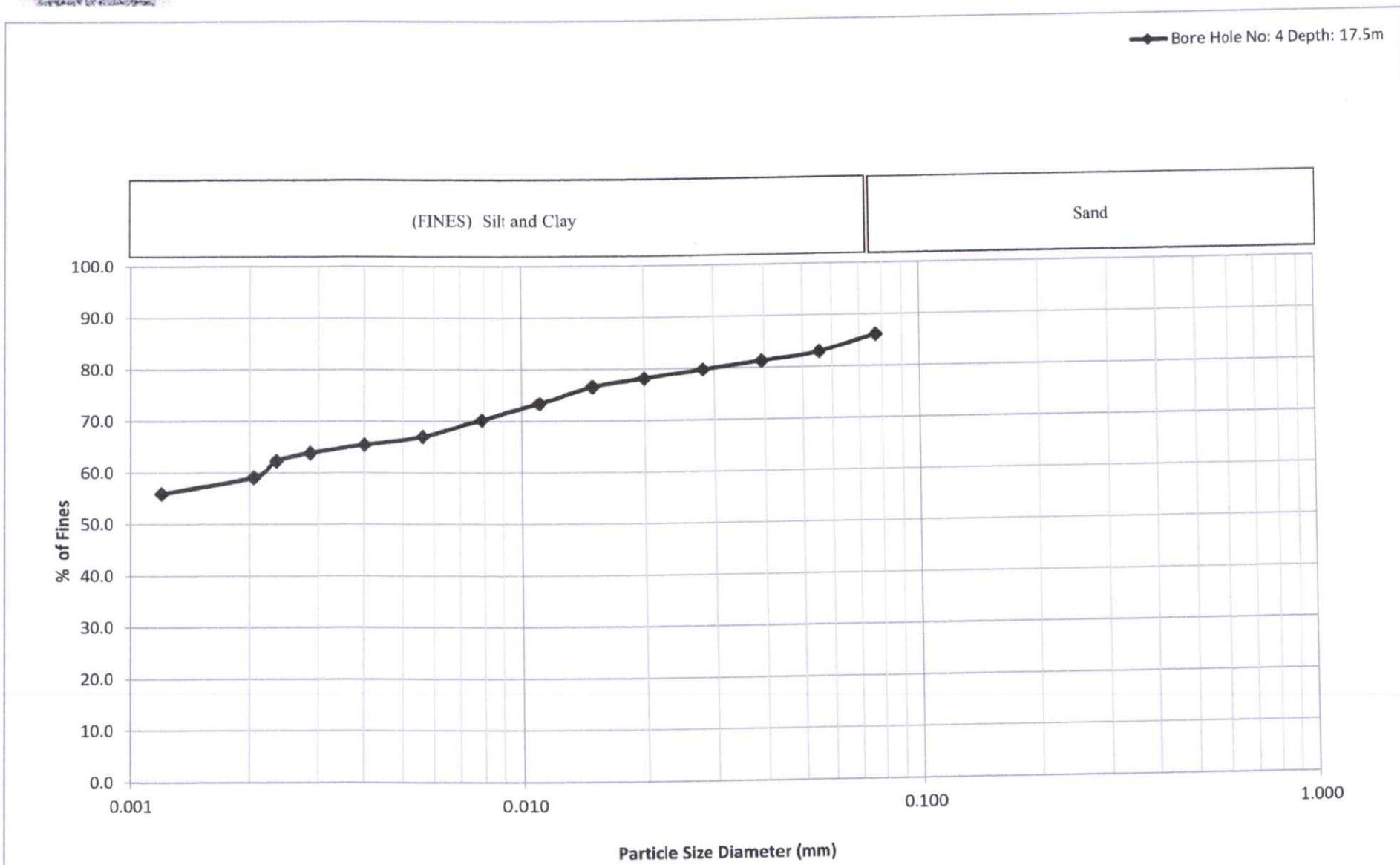


Fig 2.18 Hydrometer Analysis Master Curve

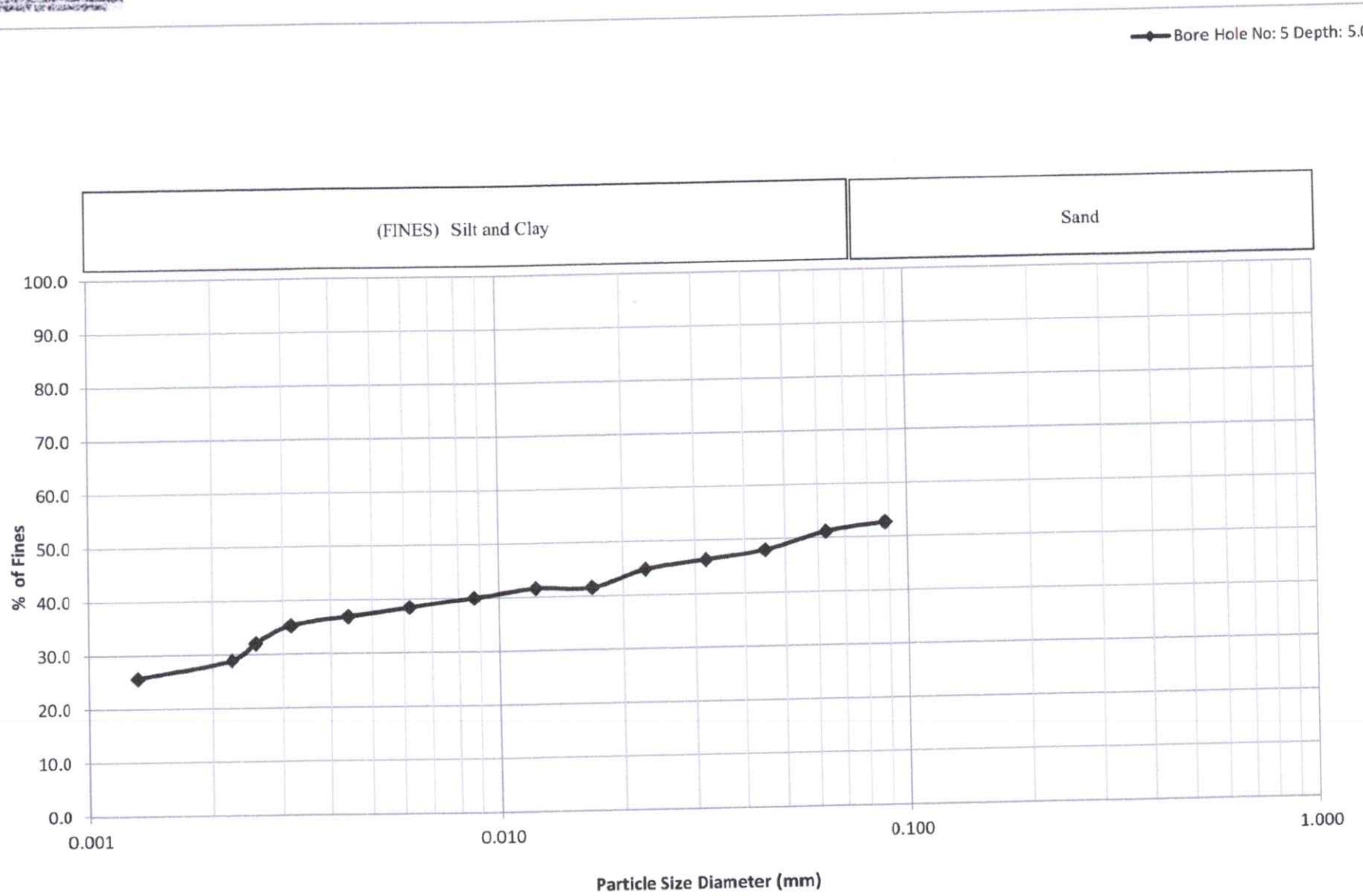


Fig 2.19 Hydrometer Analysis Master Curve

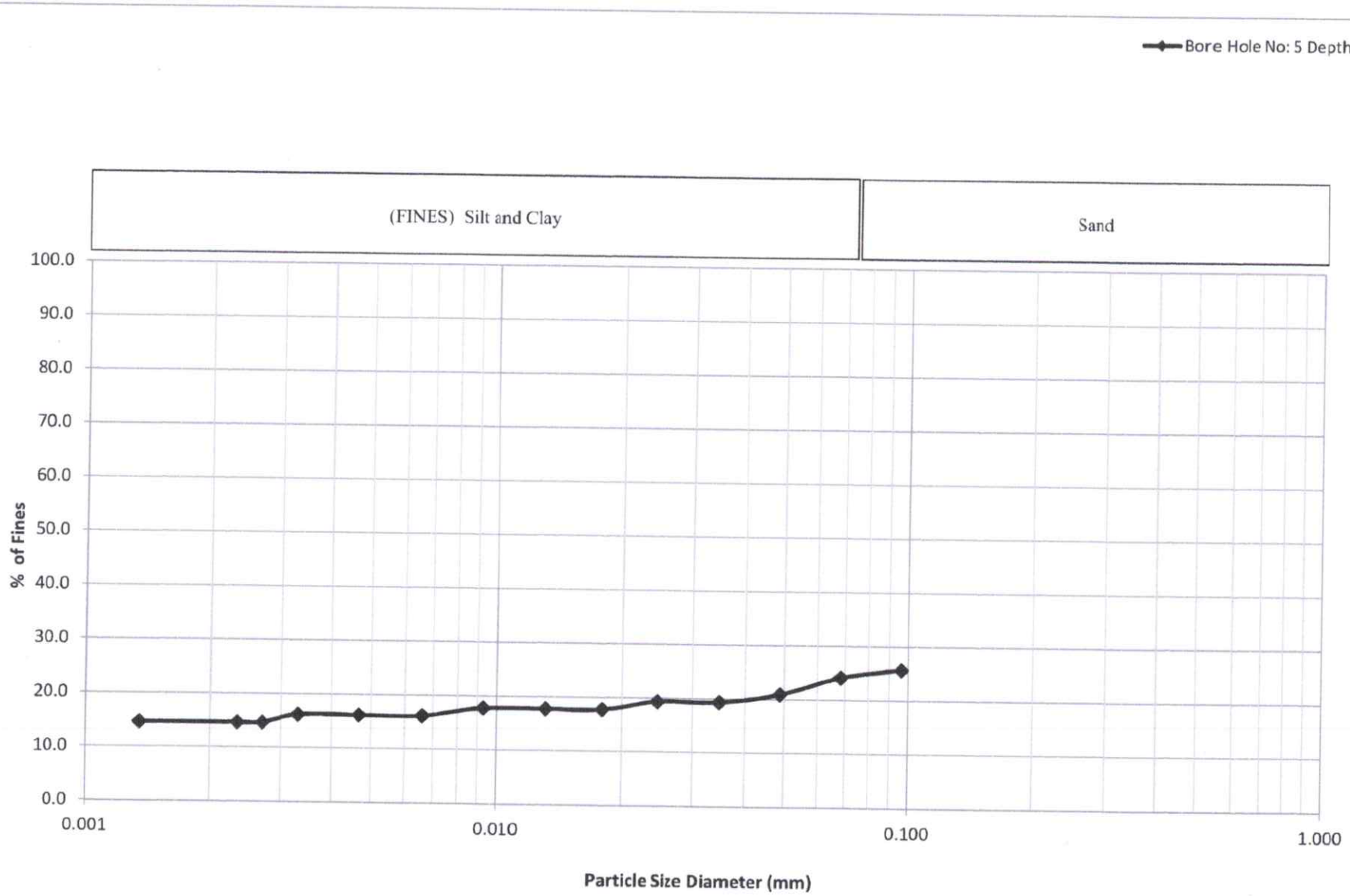


Fig 2.20 Hydrometer Analysis Master Curve

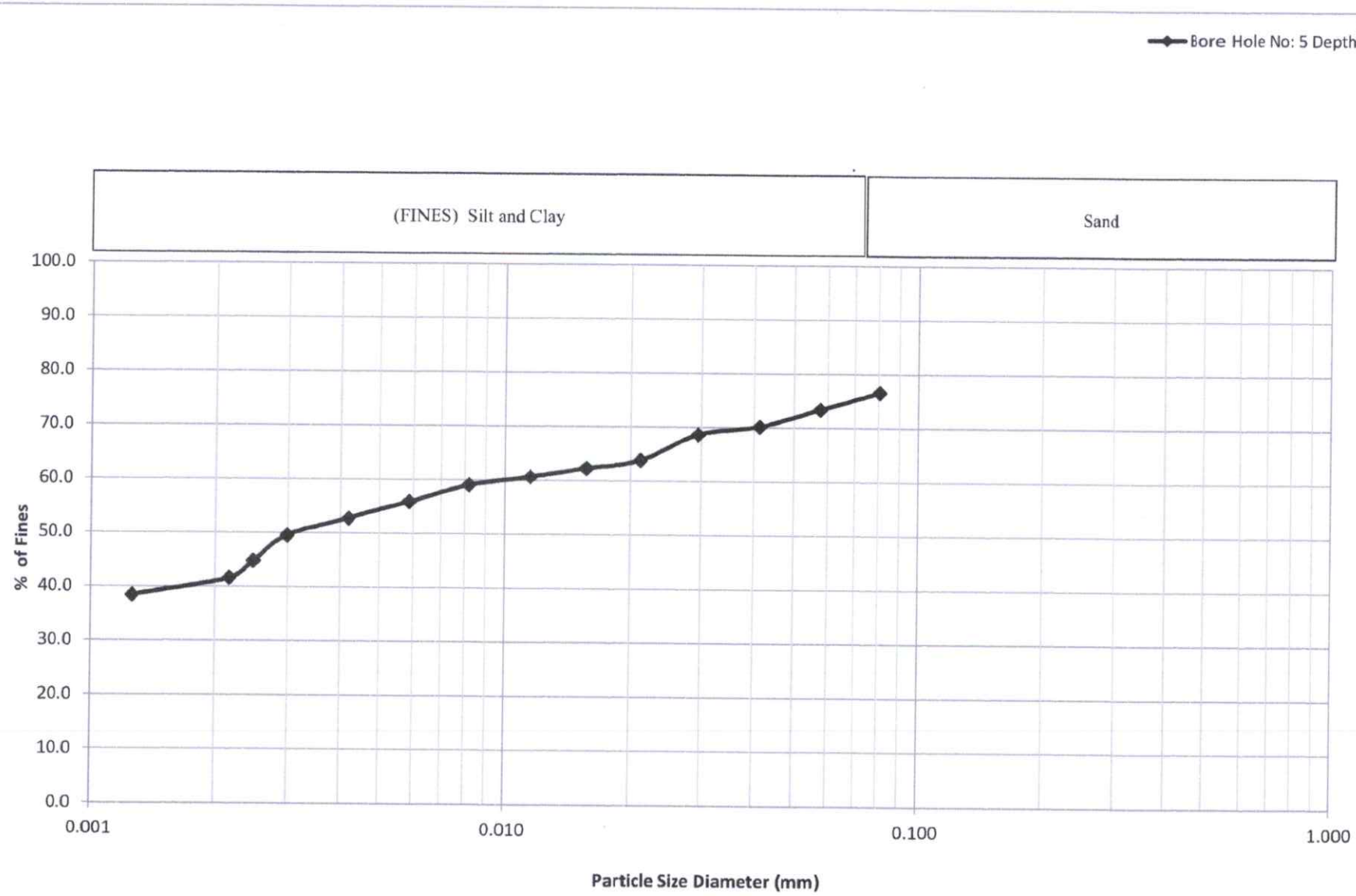


Fig 2.21 Hydrometer Analysis Master Curve

Table-2.1 Laboratory Classification of Soil Samples from BH-01

Depth of Sample below E.G.L. (m)	SPT-Value	Type of Sample	Sub Soil Classification																									
			Fine Grained (FG)										Coarse Grained (CG)													IS-Notation	
			N.M.C(%)	L.L (%)	P.L (%)	I_P	Ic	Shrinkage (cm^3)	D.F.S (%)	Consistancy	Position With Respect to A-Aline	IS:Notation	Gravel (%)	Coarse (%)	Medium (%)	Fine (%)	Silt (%)	Clay (%)	D_{10} (mm)	D_{30}(mm)	D_{60} (mm)	$C_U=D_{60}/D_{10}$	$C_c=D_{30}^2/(D_{10}xD_{60})$	Relative Density	Gravel	Sand
7.0	43	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	1	51	39	9	0	-	-	-	-	-	Dense	<50%	SP-SM
8.0	62	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	1	50	42	7	0	-	-	-	-	-	V.Dense	<50%	SP-SM

FG = Fine Grained PL = Plastic Limit FS = Differential Free Swell Index NMC= Nature Moisture Content Ic = (LL-NMC)/Ip LL = Liquid Limit

CG = Coarse Grained Ip = Plasticity Index C_U = Uniformity Coefficient C_C = Coefficient of Curvature SL = Shrinkage Limit

Table-2.2 Laboratory Classification of Soil Samples from BH-02

Depth of Sample below E.G.L. (m)	SPT-Value	Type of Sample	Sub Soil Classification																												
			Fine Grained (FG)										Coarse Grained (CG)														IS-Notation				
			N.M.C(%)	L.L (%)	P.L (%)	I_p	I_c	Shrinkage (cm^3)	D.F.S (%)	Consistancy	Position With Respect to A-Aline	IS:Notation	Gravel (%)	Coarse (%)	Medium (%)	Fine (%)	Silt (%)	Clay (%)	D_{10} (mm)	D_{30}(mm)	D_{60} (mm)	$C_U=D_{60}/D_{10}$	$C_c=D_{30}^2/(D_{10}xD_{60})$	Relative Density	Gravel	Sand
1.0	13	SS	Filling Soil (Mixture of clayey sand and brick pats)																												
2.0	6	SS																													
3.0	-	DS																													
4.0	17	SS											2	3	35	33	27	0	-	-	-	-	-	M.Dense	<50%	SM					
5.0	24	SS											5	8	28	36	23	0	-	-	-	-	-	M.Dense	<50%	SM					
6.0	23	SS	17	29	21	8	1.51	18	22	CG>50%	Above	-	0	2	31	25	37	5	-	-	-	-	-	M.Dense	<50%	SC					
7.0	46	SS	-	-	-	-	-	-	-	CG>50%	-	-	4	5	84	6	1	0	-	-	-	-	-	Dense	<50%	SP					
8.0	53	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	1	49	41	9	0	-	-	-	-	-	V.Dense	<50%	SP-SM					
9.0	33	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	5	52	29	14	0	-	-	-	-	-	Dense	<50%	SM					
10.0	10	SS	31	47	27	20	0.80	14	56	Stiff	Above	CI	-	-	-	-	78	22	-	-	-	-	-	FG>50%	FG>50%	FG>50%					
11.5	5	SS	22	26	20	5	0.67	19	39	CG>50%	Above	-	0	0	22	64	11	3	-	-	-	-	-	Loose	<50%	SC					
13.0	27	SS	14	27	20	8	1.76	20	20	CG>50%	Above	-	0	0	19	54	23	4	-	-	-	-	-	M.Dense	<50%	SC					
14.5	46	SS	13	29	19	10	1.54	18	44	CG>50%	Above	-	0	0	25	53	18	4	-	-	-	-	-	Dense	<50%	SC					
16.0	47	SS	-	-	-	-	-	-	-	CG>50%	-	-	2	1	25	55	17	0	-	-	-	-	-	Dense	<50%	SM					
17.5	73	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	0	4	81	15	0	-	-	-	-	-	V.Dense	<50%	SM					
19.0	68	SS	33	94	40	54	1.13	9	110	Hard	Above	CH	-	-	-	-	46	54	-	-	-	-	-	FG>50%	FG>50%	FG>50%					
21.0	57	SS	31	99	38	61	1.13	8	92	Hard	Above	CH	-	-	-	-	40	60	-	-	-	-	-	FG>50%	FG>50%	FG>50%					
23.0	>100	SS	19	27	21	7	1.21	19	50	CG>50%	Above	-	0	0	5	56	34	5	-	-	-	-	-	V.Dense	<50%	SC					
25.0	>100	SS	20	30	21	9	1.13	18	50	Hard	Above	CL	0	1	14	20	55	10	-	-	-	-	-	FG>50%	FG>50%	FG>50%					
27.0	>100	SS	14	42	18	24	1.20	15	43	Hard	Above	CI	0	0	4	30	54	12	-	-	-	-	-	FG>50%	FG>50%	FG>50%					

FG = Fine Grained PL = Plastic Limit FS = Differential Free Swell Index NMC= Nature Moisture Content Ic = (LL-NMC)/Ip LL = Liquid Limit

CG = Coarse Grained Ip = Plasticity Index C_U = Uniformity Coefficient C_C = Coefficient of Curvature SL = Shrinkage Limit

Table-2.3 Laboratory Classification of Soil Samples from BH-03

Depth of Sample below E.G.L. (m)	SPT-Value	Type of Sample	Sub Soil Classification																							
			Fine Grained (FG)										Coarse Grained (CG)												IS-Notation	
			N.M.C(%)	L.L (%)	P.L (%)	I_P	Ic	Shrinkage (cm^3)	D.F.S (%)	Consistancy	Position With Respect to A-Aline	IS:Notation	Gravel (%)	Coarse (%)	Medium (%)	Fine (%)	Silt (%)	Clay (%)	D_{10} (mm)	D_{30}(mm)	D_{60} (mm)	$C_U=D_{60}/D_{10}$	$C_c=D_{30}^2/(D_{10}xD_{60})$	Relative Density	Gravel	Sand
4.0	7	SS	43	71	30	40	0.69	10	43	M.Stiff	Above	CH	-	-	-	-	60	40	-	-	-	-	-	FG>50%	FG>50%	FG>50%
6.0	14	SS	16	26	13	13	0.77	18	11	CG>50%	Above	-	0	0	17	46	32	5	-	-	-	-	-	M.Dense	<50%	SC
7.0	10	SS	15	27	13	14	0.86	18	30	CG>50%	Above	-	0	0	15	56	22	7	-	-	-	-	-	Loose	<50%	SC
8.0	20	SS	Sample Failed																							
9.0	34	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	0	18	61	21	0	-	-	-	-	-	Dense	<50%	SM
10.0	30	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	0	20	60	20	0	-	-	-	-	-	M.Dense	<50%	SM
11.5	33	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	0	16	69	15	0	-	-	-	-	-	Dense	<50%	SM
13.0	34	SS	18	32	19	13	1.06	18	30	CG>50%	Above	-	0	0	6	65	24	5	-	-	-	-	-	Dense	<50%	SC
14.5	>100	SS	24	56	29	27	1.17	11	31	Hard	Above	CH	-	-	-	-	66	34	-	-	-	-	-	FG>50%	FG>50%	FG>50%
16.0	49	SS	33	101	40	62	1.12	7	53	Hard	Above	CH	-	-	-	-	40	60	-	-	-	-	-	FG>50%	FG>50%	FG>50%
17.5	90	SS	25	63	30	33	1.15	11	54	Hard	Above	CH	0	0	0	15	50	35	-	-	-	-	-	FG>50%	FG>50%	FG>50%
19.0	>100	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	0	7	56	37	0	-	-	-	-	-	V.Dense	<50%	SM
21.0	>100	SS	21	72	27	45	1.14	10	67	Hard	Above	CH	-	-	-	-	68	32	-	-	-	-	-	FG>50%	FG>50%	FG>50%
23.0	>100	SS	14	46	20	26	1.22	13	19	Hard	Above	CI	0	0	0	28	55	17	-	-	-	-	-	FG>50%	FG>50%	FG>50%
25.0	>100	SS	-	-	-	-	-	-	-	CG>50%	-	-	2	4	50	13	31	0	-	-	-	-	-	V.Dense	<50%	SM

FG = Fine Grained PL = Plastic Limit FS = Differential Free Swell Index NMC= Nature Moisture Content Ic = (LL-NMC)/Ip LL = Liquid Limit

CG = Coarse Grained Ip = Plasticity Index C_U = Uniformity Coefficient C_C = Coefficient of Curvature SL = Shrinkage Limit

Table-2.4 Laboratory Classification of Soil Samples from BH-04

Depth of Sample below E.G.L. (m)	SPT-Value	Type of Sample	Sub Soil Classification																									
			Fine Grained (FG)										Coarse Grained (CG)													IS-Notation	
			N.M.C(%)	L.L (%)	P.L (%)	I_p	Ic	Shrinkage (cm^3)	D.F.S (%)	Consistancy	Position With Respect to A-Aline	IS:Notation	Gravel (%)	Coarse (%)	Medium (%)	Fine (%)	Silt (%)	Clay (%)	D_{10} (mm)	D_{30}(mm)	D_{60} (mm)	$C_U=D_{60}/D_{10}$	$C_c=D_{30}^2/(D_{10}xD_{60})$	Relative Density	Gravel	Sand
3.0	38	SS	-	-	-	-	-	-	-	-	-	-	7	9	47	24	13	0	-	-	-	-	-	Dense	<50%	SM
4.0	15	SS	31	57	24	32	0.81	13	15	Stiff	Above	CH	-	-	-	-	65	35	-	-	-	-	-	FG>50%	FG>50%	FG>50%
5.0	18	SS	15	30	15	15	1.02	16	20	V.Stiff	Above	CL	-	-	-	-	85	15	-	-	-	-	-	FG>50%	FG>50%	FG>50%
6.0	22	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	0	11	75	14	0	-	-	-	-	-	M.Dense	<50%	SM
7.0	18	SS	Plastic Clay No LL/PL carried out						25	CG>50%	Above	-	0	0	0	75	25	0	-	-	-	-	-	M.Dense	<50%	SC
8.0	15	SS	15	25	13	12	0.79	19	4	CG>50%	Above	-	0	0	12	63	21	4	-	-	-	-	-	M.Dense	<50%	SC
9.0	31	SS	15	27	16	11	1.05	18	-5	CG>50%	Above	-	0	0	12	64	20	4	-	-	-	-	-	Dense	<50%	SC
10.0	46	SS	14	27	15	12	1.06	18	-5	CG>50%	Above	-	0	0	11	67	19	3	-	-	-	-	-	Dense	<50%	SC
11.5	49	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	1	18	53	28	0	-	-	-	-	-	Dense	<50%	SM
13.0	>100	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	0	16	66	18	0	-	-	-	-	-	V.Dense	<50%	SM
14.5	>100	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	1	29	57	13	0	-	-	-	-	-	V.Dense	<50%	SM
16.0	44	SS	31	92	38	54	1.13	9	64	Hard	Above	CH	-	-	-	-	46	54	-	-	-	-	-	FG>50%	FG>50%	FG>50%
17.5	46	SS	27	98	35	63	1.12	8	108	Hard	Above	CH	-	-	-	-	41	59	-	-	-	-	-	FG>50%	FG>50%	FG>50%
21.0	55	SS	18	37	19	18	1.05	13	55	Hard	Above	CI	0	0	0	41	40	19	-	-	-	-	-	FG>50%	FG>50%	FG>50%
23.0	>100	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	0	25	64	11	0	-	-	-	-	-	V.Dense	<50%	SP-SM
25.0	>100	SS	15	34	15	19	1.02	18	9	CG>50%	Above	-	0	0	31	38	25	6	-	-	-	-	-	V.Dense	<50%	SC
27.0	>100	SS	14	33	16	16	1.13	18	30	CG>50%	Above	-	0	0	11	62	21	6	-	-	-	-	-	V.Dense	<50%	SC
29.0	>100	SS	25	46	26	20	1.06	14	-13	Hard	Above	CI	-	-	-	-	80	20	-	-	-	-	-	FG>50%	FG>50%	FG>50%

FG = Fine Grained PI = Plastic Limit FS = Differential Free Swell Index NMC= Nature Moisture Content Ic = (LL-NMC)/Ip LL = Liquid Limit

CG = Coarse Grained Ip = Plasticity Index C_U = Uniformity Coefficient C_C = Coefficient of Curvature SL = Shrinkage Limit

Table-2.5 Laboratory Classification of Soil Samples from BH-05

Depth of Sample below E.G.L. (m)	SPT-Value	Type of Sample	Sub Soil Classification																								
			Fine Grained (FG)										Coarse Grained (CG)												IS-Notation		
			N.M.C(%)	L.L (%)	P.L (%)	I_p	Ic	Shrinkage (cm^3)	D.F.S (%)	Consistancy	Position With Respect to A-Aline	IS:Notation	Gravel (%)	Coarse (%)	Medium (%)	Fine (%)	Silt (%)	Clay (%)	D_{10} (mm)	D_{30}(mm)	D_{60} (mm)	$C_U=D_{60}/D_{10}$	$C_c=D_{30}^2/(D_{10}xD_{60})$	Relative Density	Gravel	Sand
3.0	21	SS	-	-	-	-	-	-	-	CG>50%	-	-	1	4	71	18	6	0	-	-	-	-	-	M.Dense	<50%	SP-SM
4.0	17	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	0	15	62	23	0	-	-	-	-	-	M.Dense	<50%	SM
5.0A	15	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	0	9	80	11	0	-	-	-	-	-	M.Dense	<50%	SP-SM
5.0B			28	56	25	31	0.90	12	13	Stiff	Above	CH	-	-	-	-	71	29	-	-	-	-	-	FG>50%	FG>50%	FG>50%
6.0	9	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	0	16	72	12	0	-	-	-	-	-	Loose	<50%	SP-SM
7.0	17	SS	11	23	12	11	1.09	18	10	CG>50%	Above	-	0	0	14	73	10	3	-	-	-	-	-	M.Dense	<50%	SC
8.0	18	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	0	15	72	13	0	-	-	-	-	-	M.Dense	<50%	SM
9.0	22	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	0	16	69	15	0	-	-	-	-	-	M.Dense	<50%	SM
10.0	33	SS	12	25	13	12	1.08	18	11	CG>50%	Above	-	0	0	18	63	16	3	-	-	-	-	-	Dense	<50%	SC
11.5	30	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	0	18	60	22	0	-	-	-	-	-	M.Dense	<50%	SM
13.0	25	SS	-	-	-	-	-	-	-	CG>50%	-	-	0	0	6	82	12	0	-	-	-	-	-	M.Dense	<50%	SP-SM
14.5	48	SS	32	89	37	53	1.10	10	75	Hard	Above	CH	-	-	-	-	52	48	-	-	-	-	-	FG>50%	FG>50%	FG>50%
16.0	48	SS	32	85	36	49	1.08	10	78	Hard	Above	CH	-	-	-	-	55	45	-	-	-	-	-	FG>50%	FG>50%	FG>50%
17.5	87	SS	33	83	37	46	1.08	12	69	Hard	Above	CH	-	-	-	-	58	42	-	-	-	-	-	FG>50%	FG>50%	FG>50%
19.0	67	SS	16	36	19	17	1.16	16	78	CG>50%	Above	-	0	0	17	41	35	7	-	-	-	-	-	V.Dense	<50%	SC
21.0	>100	SS	28	62	31	31	1.10	11	58	Hard	Above	CH	-	-	-	-	65	35	-	-	-	-	-	FG>50%	FG>50%	FG>50%
23.0	>100	SS	16	36	17	19	1.06	15	0	Hard	Above	Cl	-	-	-	-	74	26	-	-	-	-	-	FG>50%	FG>50%	FG>50%
25.0	>100	WS	-	-	-	-	-	-	-	CG>50%	-	-	0	0	72	19	9	0	-	-	-	-	-	V.Dense	<50%	SP-SM
27.0	>100	SS	23	45	26	19	1.17	14	15	Hard	Above	Cl	-	-	-	-	72	28	-	-	-	-	-	FG>50%	FG>50%	FG>50%

FG = Fine Grained; PL = Plastic Limit; FS = Differential Free Swell Index; NMC= Nature Moisture Content; Ic = (LL-NMC)/Ip; LL = Liquid Limit

CG = Coarse Grained; Ip = Plasticity Index; C_U = Uniformity Coefficient; C_c = Coefficient of Curvature; SL = Shrinkage Limit

GEOLOGY & SUB-SURFACE STRATIFICATION

3.0 Preamble:

Geotechnical investigation carried out at a specific site provides location specific sub surface characteristics based on which the design of sub structures/foundations is generally carried out. However, the macro-level understanding of the sub surface is also needed for a comprehensive understanding of the sub structure/foundation response to naturally super imposed loads like earthquake forces etc., The macro level understanding of the sub surface is better provided through the knowledge of the Geology of the region. Since, it is beyond the scope of the present study to carry out geological investigation to establish the geology of the study region; published data are presented below along with the sub surface stratification observed through the direct borehole investigation carried out at the specified locations.

3.1 Geology of Study Area (based on the published data)

Geologically, the present site is located close vicinity to coastal region with sub surface consisting of sedimentary deposits. The top sedimentary deposit is under laid by upper gondwana shale formation, particularly lower stage of Sriperumpudur formation. The formation mechanism of the sediments is chiefly due to transportation of surface water deposition.

Though the gondwana shale formation is not encountered within the investigation depth, however the geological characteristics observed in the direct borehole investigation confirms that the present site does not depict any surprising geological features that are different from that of the region.

3.2 DESIGN SUB SOIL PROFILE: (WRT Foundation Engineering Application)

The sub soil characteristics obtained at the test location are further processed to arrive at the design soil parameters required for the design of sub structure using the following shear strength correlations with respect to the Standard Penetration Test Values of different layers.

- For Coarse Grained Material, Ref. IS: 6403 to estimate Angle of Shearing Resistance (Reproduced and shown in Fig.A1)
- For Fine Grained Material, Ref. Terzaghi & Peck, 1948, to estimate Unconfined Compressive Strength (Reproduced and shown in Fig.A2)

Based on the above, the average design soil characteristics are given below:

REFERENCE BORE HOLE-BH:					1	Ref R.L. of G.L. (m):			0.00		
Layer No.	Layer Thk. (m)			Type of Strata	Colour	Ave. Design SPT	Relative Density	Consistency	(ϑ) kN/m³	Shear Parameters	
	Top. R.L.	Bot. R.L.	Thickness							(Cu) kPa	(I) Deg.
1	0.00	6.00	6.00	Filled up Soil	-	-	-	-	-	-	-
2	6.00	8.50	2.50	Silty Sand	Brownish Yellow	53	Very Dense	-	20.5	-	41.45

REFERENCE BORE HOLE-BH:					2	Ref R.L. of G.L. (m):			0.00		
Layer No.	Layer Thk. (m)			Type of Strata	Colour	Ave. Design SPT	Relative Density	Consistency	(ϑ) kN/m³	Shear Parameters	
	Top. R.L.	Bot. R.L.	Thickness							(C_{ui}) kPa	(I) Deg.
1	0.00	5.80	5.80	Filled up Soil	-	-	-	-	-	-	-
2	5.80	7.00	1.20	Clayey Silty Sand	Brownish Grey	23	Medium Dense	-	18.5	-	33.9
3	7.00	10.00	3.00	Silty Sand	Brownish Grey	44	Dense	-	20	-	39.65
4	10.00	11.50	1.50	Silty Clay	Grey	10	-	Stiff	17.5	67	-
5	11.50	13.00	1.50	Clayey Silty Sand	Grey	5	Loose	-	14	-	20.37
6	13.00	17.50	4.50	Clayey Silty Sand	Grey	40	Dense	-	20	-	38.75
7	17.50	19.00	1.50	Silty Sand	Grey	73	Very Dense	-	21	-	42.5
8	19.00	23.00	4.00	Compacted Clay	Brownish Grey	63	Very Dense	-	21	-	42.5
9	23.00	25.00	2.00	Clayey Silty Sand	Brownish Grey	>100	Very Dense	-	21	-	42.5
10	25.00	27.50	2.50	Compacted Clay	Brownish Green	>100	Very Dense	-	21	-	42.5

REFERENCE BORE HOLE-BH:					3	Ref R.L. of G.L. (m):			0.00		
Layer No.	Layer Thk. (m)			Type of Strata	Colour	Ave. Design SPT	Relative Density	Consistency	(ϑ) kN/m³	Shear Parameters	
	Top. R.L.	Bot. R.L.	Thickness							(Cu) kPa	(I) Deg.
1	0.00	2.50	2.50	Filled up Soil	-	-	-	-	-	-	-
2	2.50	5.20	2.70	Silty Clay	Black	7	-	Medium Stiff	16	47	-
3	5.20	8.00	2.80	Clayey Silty Sand	Brownish Grey	17	Medium Dense	-	18	-	32.1
4	8.00	14.50	6.50	Silty Sand	Grey	30	Medium Dense	-	19	-	36
5	14.50	19.00	4.50	Compacted Clay	Greyish Brown	80	Very Dense	-	21	-	42.5
6	19.00	21.00	2.00	Silty Sand	Greyish Brown	>100	Very Dense	-	21	-	42.5
7	21.00	25.00	4.00	Compacted Clay	Brownish Grey	>100	Very Dense	-	21	-	42.5
8	25.00	26.00	1.00	Silty Sand	Brownish Grey	>100	Very Dense	-	21	-	42.5
9	26.00	31.50	5.50	Shale	Grey	>100	Very Dense	-	22	400	-
10	31.50	32.50	1.00	Completely Weathered Rock	Grey	CRR 30% RQD 0%					

REFERENCE BORE HOLE-BH:					4	Ref R.L. of G.L. (m):			0.00		
Layer No.	Layer Thk. (m)			Type of Strata	Colour	Ave. Design SPT	Relative Density	Consistency	(ϑ) kN/m³	Shear Parameters	
	Top. R.L.	Bot. R.L.	Thickness							(Cu) kPa	(I) Deg.
1	0.00	4.00	4.00	Filled up Soil	-	-	-	-	-	-	-
2	4.00	5.50	1.50	Silty Clay	Grey	17	-	Very Stiff	20	113	-
3	5.50	9.00	3.50	Silty Sand	Grey	18	Medium Dense	-	18	-	32.4
4	9.00	13.00	4.00	Clayey Silty Sand	Grey	42	Dense	-	20	-	39.2
5	13.00	16.00	3.00	Silty Sand	Grey	>100	Very Dense	-	21	-	42.5
6	16.00	23.00	7.00	Compacted Clay	Brownish Grey	54	Very Dense	-	20.5	-	41.6
7	23.00	25.00	2.00	Silty Sand	Grey	>100	Very Dense	-	21	-	42.5
8	25.00	29.00	4.00	Clayey Silty Sand	Grey	>100	Very Dense	-	21	-	42.5
9	29.00	30.00	1.00	Shale	Grey	CRR 30% RQD 0%					

REFERENCE BORE HOLE-BH:					5	Ref R.L. of G.L. (m):			0.00		
Layer No.	Layer Thk. (m)			Type of Strata	Colour	Ave. Design SPT	Relative Density	Consistency	(γ) kN/m^3	Shear Parameters	
	Top. R.L.	Bot. R.L.	Thickness							(C_u) kPa	(I) Deg.
1	0.00	3.00	3.00	Filled up Soil	-	-	-	-	-	-	-
2	3.00	5.30	2.30	Silty Sand	Brown	18	Medium Dense	-	18	-	32.4
3	5.30	7.00	1.70	Silty Sand	Grey	9	Loose	-	14.5	-	29.8
4	7.00	14.50	7.50	Silty Sand	Grey	26	Medium Dense	-	19	-	34.8
5	14.50	19.00	4.50	Compacted Clay	Greenish Grey	61	Very Dense	-	21	-	42.5
6	19.00	25.60	6.60	Compacted Clay	Greyish Brown	>100	Very Dense	-	21	-	42.5
7	25.60	30.00	4.40	Shale	Grey	>100	Very Dense	-	22	400	-

CHAPTER-4

FOUNDATION SYSTEM

4.0 Preamble:

In the design of foundation system, the stress-strain compatibility of the super structure, sub structure and the bearing strata should be satisfied both individually and as a combined system. In view of this, the following data are needed for the design of foundation system, defined in terms of the type of sub structure and the bearing strata characteristics.

- The super structure characteristics along with the loading pattern on the sub structure
- The sub soil characteristics that define the required substructure configuration for a safe transfer of super-structural loads to the bearing strata

Considering the above aspects of the foundation design, the suitable type of foundation system is presented below.

4.1 Proposed Structures

An understanding of the proposed construction and the order of loads on the foundations is needed for choosing the appropriate foundation system. In the present case, the proposed structure is configured with two basement floors and twenty two upper floors, and is meant for residential purpose. For this kind of structure, the column loads could vary between 6500 kN to 7500 kN.

The above mentioned loads have no bearing on the design of either sub or super structures and are mentioned just to provide an insight to choose an appropriate foundation system with respect to subsoil conditions.

4.2 Foundation System

The depth of two basement floor is informed to be about 7.0m with respect to the adjacent road level.

Hence, for the kind of proposed structure and the sub soil conditions, it is not possible to adopt any kind of open foundation system from both shear and settlement considerations. Hence, it is advisable to adopt deep pile foundation system.

The piles can be installed by drilling with direct mud circulation technique **(Bored Cast Insitu Piles)** and the recommended safe load carrying capacity of bored cast insitu piles in compression, tension and lateral for different diameters is worked out as per IS 2911-Part-I-Section-2 and are presented in Table 4.1.

Typical computations are presented in Annexure

TABLE:- 4.1 RECOMMENDED SAFE LOAD CARRYING CAPACITIES OF BORED CAST-IN SITU PILES								
Sl.No	Reference Bore hole No.	Length of Pile below Adjacent Road Level	Assumed Length of Cut-Off Below E.G.L	Length of Pile below Cut-off	Dia.of Pile in (mm)	SAFE LOAD CARRYING CAPACITY (kN)		
						Vertical Load Carrying Capacity	Pull Out Capacity	Lateral Load Carrying Capacity
1	BH-03	28.0	7.5	20.50	600	1800	900	60
2					650	2000	1000	70
3					750	2300	1200	90
4					800	2600	1300	95
5					900	3000	1500	120
6					1000	3500	1700	140

CHAPTER-5

RECOMMENDATIONS

5.1 Recommendation for Deep pile foundation system

- For the kind of proposed structure and sub soil condition deep pile foundation is the suitable foundation to adopt. In the present case, **Bored Cast in situ piles** are recommended as the suitable foundation system.
- The allowable safe load carrying capacities of different diameters of piles as given in Table-4.1.can be adopted as provisional design loads, as the load carrying capacity of piles not only depends upon the sub soil properties, but also depends on the care and experience of installation of piles.
- The theoretical load carrying estimates of piles shall be confirmed by conducting pile loads tests as per the guide lines laid down in IS: 2911-Part-IV.
- The boring shall be carried out using direct mud circulation prepared out of sodium bentonite.
- After reaching the borehole termination depth, the borehole shall be cleaned using mud circulation for a minimum period of 30min or till the return mud is relatively clear of soil particles.
- After ensuring the borehole is clean, the tremie pipe shall be lowered and concreting can be done.

5.2 Construction method statement of pile foundation:

- The mud used shall be made out of sodium bentonite with minimum free swell index of more than 300% and liquid limit more than 100%. The silt content in bentonite shall not be more than 5%.
- The mud should be prepared using sodium bentonite with a density of 1.10 to 1.15 g/cc.

5.3 General Recommendation

- Since, chlorides and sulphates are well within the permissible limits, no special steel or cement is required for the construction.

AUTHORISED SIGNATORY

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GEO MARINE CONSULTANTS PRIVATE LIMITED

ESTIMATION OF SAFE LOAD CARRYING CAPACITY OF BORED CAST-INSITU PILES

Type of Pile	Bored	Diameter of Pile			Length of Pile below G.L. (m)	-28	As Per IS:2911-(P-I,S-2)-2010		
Reference Bore Hole	BH-03		600	mm	Surcharge Pressure	0	kPa		

Layer No.	Layer Thk. (m) Top. R.L.	Bot. R.L.	Thickness	Type of Strata	Ave. SPT	(γ) kN/m³ of Layer	(γ) kN/m³ Ave. upto Layer	Shear Parameters (C_u) kPa	Shear Parameters (ϕ) Deg.	Effective Overburden Pressure (kPa) At top of Layer	At Bot. of Layer	At Mid. of Layer	Adhesion Factor (α)	Earth Pressure Coefficient (k)	Skin Friction (Q_f) kN		
1	0.0	-7.5	7.5	Cut-Off Level													
2	-7.5	-10.5	3.0	Sand	17	18.0	18.0	-	32.1	0.0	24.0	12.0	-	1.1	qf	2	47.1
3	-10.5	-17.0	6.5	Sand	31	19.5	18.8	-	36.3	24.0	85.8	54.9	-	1.3	qf	3	650.3
4	-17.0	-21.5	4.5	Clay	60	22.0	20.8	400	-	85.8	139.8	112.8	0.3	-	qf	4	882.2
5	-21.5	-23.5	2.0	Sand	60	20.5	21.3	-	42.5	139.8	160.8	150.3	-	1.5	qf	5	779.4
6	-23.5	-28.0	4.5	Clay	60	22.0	21.3	400	-	160.8	214.8	187.8	0.3	-	qf	6	882.2

Summation of Positive Skin Resitance (kN) Q_f= 3241.05

Summation of Negative Skin Resistance (kN) -Qf= 0.00

Computation of End Bearing Resistance

		SPT	ϕ	C_u	N_q	N_c			
Bearing Stratum	Shale	100	-	600	-	9	Eff.Ht.of Overburden	9	m
							Effective Overburden Pressure	101.25	kN/m²

End Bearing Resistance (kN) Q_p= 1526.81

Ultimate Load Carrying Capacity (Q_{ult})	$Q_u=Q_f-Q_f+Q_p$ (kN)	4767.86
Safe Load Carrying Capacity (Q_{safe})	$Q_u/2.5$ (kN)	1907.15
Allowable Safe Load Carrying Capacity	$Q_{A\text{-}safe}$ (kN)	1907.15
Allowable Safe Pull out Capacity	$Q_{A\text{-}pull}$: Qf/3 (kN)	1080.35

Skin Resistance in Clay Layer is $\pi*d*T_i*C_u*\alpha$

Skin Resistance in Sand Layer is $\pi*d*T_i*q_i*K*\tan(\phi)$

End Bearing Resistance in Clay Layer is $\pi*d^2/4*C_u*N_c$

End Bearing Resistance in Sand Layer is $\pi*d^2/4*Q*N_q$

Where

Cu=Undrained Shear Strength of Clay

K=Coef. Earth Pressure at Rest

d=Dia. Of Pile

ϕ=Angle of Shearing Resistance

q_i=Effecitve Overburden Pressure at middle of Layer

α=Adhession Factor

N_c=Bearing Capacity Factor = 9

N_q=Bearing Capacity Factor, Ref. Fig.1 of IS: Code Referred above

T_i=Thickness of Layer

Q (i.e) Effecitve Overburden Pressure at pile tip=Effective height of overburden X (γ-10)

LATERAL LOAD CARRYING CAPACITY OF BORED CAST- SITU PILES

Reference Bore Hole : BH-03

1 Geometrical Data

Type of Pile Head Considered	Fixed	
Diameter of Pile (d) :	0.60	m
Free standing Length of Pile (e) :	0	m
Length of Pile below Adjacent Road Level (Le) :	28.0	m
Cut-Off Level From E.G.L :	7.5	
Length of Pile below Cut-Off Level (Le) :	20.5	m
Grade of Concrete (M) :	25	MN/m^2
Young's Modulus of Concrete (E) :	25000000	kN/m^2
Momemnt of Inertia (I) :	0.006362	m^4

2 Determination of Depth of Fixity

Type of Soil Strata :	Sand	
Ground Water Condition :	Submerged	
Design SPT "N" Value :	14	
T=(EI/nh)1/5		
(n can be read as h in the above and below equation in case of Sand)		
nh= :	1976	kN/m^3
In Case of Sand :	-	kN/m^4
T= :	2.41	m
L1/T :	0.00	
Lf/T :	2.20	
Depth of Fixity below Cut off (z_f) :	5.29	m

3 Determincation of Lateral Load and Moment Carrying Capacity for 0.005 m Lateral Deflection:

Allowable Lateral Deflection (Y) :	0.005	m
Lateral Load Carrying Capacity (H)= Y*12EI/(e+zf)^3 :	64.41	kN
Recommended Design Lateral Load carrying Capacity :	**64**	**kN**
Fixed End Moment,M_F=H(e+z_f)/2	170	
Reduction Factor (L_1/T) :	0.83	m
Actual Moment (Fixed End Moment/Reduction Factor),M_F	**141**	kN-m

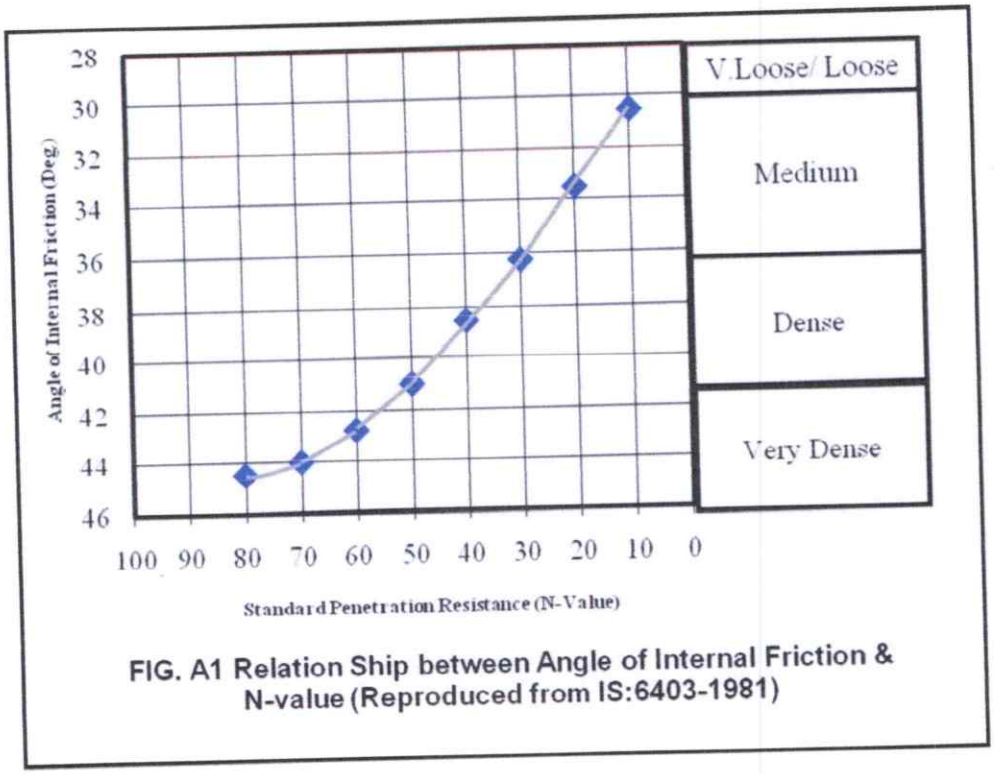


FIG. A1 Relation Ship between Angle of Internal Friction & N-value (Reproduced from IS:6403-1981)

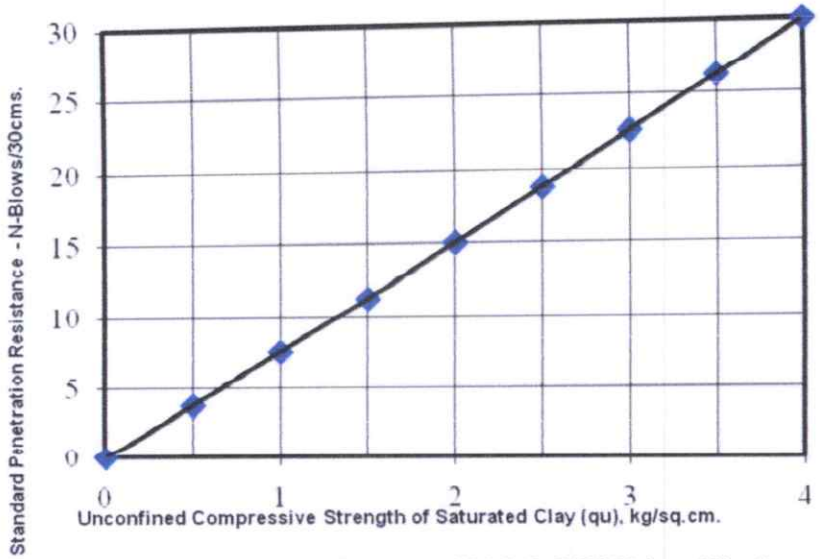


FIG. A2 : Relationship between UCC & SPT-Value (N) of Saturated Clay (AfterTerzhagi & Peck, 1948)

for BH-1 Co-ordinates: N 13.077317, E 80.205147

GEOMARINE
THE SPIRIT OF ENGINEERING

SITE INVESTIGATION RECORD

BORE HOLE No.: BH-01
PAGE No.: 01
DIA OF BORE HOLE: 150mm ✓ / 100mm
BORE START DATE: 21-01-2020
BORE END DATE: 23-01-2020
TOTAL DRILLING DAYS: 3

PROJECT NAME: TNHB - Arumbakkam, Chennai
LOCATION: Arumbakkam
MACHINE No.: H-DYSLUM
CHAINAGE (m):
STRUCTURE:
DRILLING METHOD: Rotary
JOB CODE:
FLUSHING MEDIUM: Bentonite
CO-ORDINATES: N 13.077317 / E 80.205147

Depth below E.G.L. (m)	Drilling progress per metre: Date	Time: Hr.	Time: Min	Type of Drill Bit (SC / TCB / DB)	Core Details: Total Core Recovery %	Core Details: R.Q.D %	SPT Details: Blows/cm. 0-15	SPT Details: Blows/cm. 15-30	SPT Details: Blows/cm. 30-45	SPT 'N' Value	Sample Details: Depth	Sample Details: No.	Sample Details: Type	Layer Data: Depth (m)	Layer Data: Geotechnical Description
0	21-01-2020	16	59												Filled up Building Materials, Concrete, DMTop to 1.0 mts
1		17	15								1				
		17	35												
		17	48								1.50m				
2											2				
				TC											
3											3				
		11	09												
		11	45	DB							4.0	D	(SS) Nil Sample		Filled up Rubble Building Stones
4							10 cm Gain Rbw. SPT Hammer								
		11	28												
		11	50												
5											5				
		11	57	DB											
		12	55												
											5.5m				
6											6.0				
		10	45	SC											
	22/01/20	10	58												
7							9	20	23	43	7.0	(1)	SS		YELLOWISH, BROWN, CEMENTED SILTY SAND FINE TO MEDIUM & SO N. DENSE
		14	50												
	23/01/20	15	05	SC											
8							18	28	34	62	8.0	(2)	SS		
							Water loss. 8.5m								
9							This bore hole for Geotechnical Soil Investigation could not be continued due to water loss starting from depth of 1.50 m below gl to 8m deeper depth, BH Terminated. The borehole at 8.0 mts								
0															

CS - Core Sample	DS - Disturbed Sample	SUPERVISOR NAME	
SS - Split Spoon Sample	SC - Soil Cutter	SIGNATURE	
UDS-Undisturbed Sample	TCB - Tungsten Carbide Bit	DATE	
WS - Wash Sample	DB - Diamond Bit	CLIENT IN-CHARGE	

PROJECT SITE DETAILS	
GROUND LEVEL (m)	
WATER TABLE (m)	—
CASING DEPTH (m)	

Remarks: water loss due to Building materials Not properly Maintaining of drilling. Encountered Sandstone at Ground Level Limit filled up Rubble Stones water loss 1.50 mts.

GEOMARINE
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SITE INVESTIGATION RECORD

BORE HOLE No.	02
PAGE No.	01
DIA OF BORE HOLE	150mm ✓ / 100mm
BORE START DATE	10/01/2020
BORE END DATE	20/01/2020
TOTAL DRILLING DAYS	5

PROJECT NAME	TNHB - Arumbakkam - Chennai				
LOCATION		MACHINE No.		CHAINAGE (m)	
STRUCTURE	2B+G+25	DRILLING METHOD	Rotary	CO-ORDINATES	N
JOB CODE		FLUSHING MEDIUM	Bentonite		E

Depth below E.G.L (m)	Drilling progress per metre: Date	Time: Hr.	Time: Min	Type of Drill Bit (SC / TCB / DB)	Core Details: Total Core Recovery %	Core Details: R.Q.D%	SPT Details: Blows/cm. 0-15	SPT Details: Blows/cm. 15-30	SPT Details: Blows/cm. 30-45	SPT 'N' Value	Sample Details: Depth	Sample Details: No.	Sample Details: Type	Layer Data: Depth (m)	Layer Data: Geotechnical Description
1	10-01-2020			Soil Cutter			3	5	8	13	1.00	01	DS		Filled up Soil / Building materials & clayey Soil
2							4	3	3	6	2.00	2	SS		
3											3.00	3	DS		
4							9	8	9	17	4.00	4	SS		
5							8	11	13	24	5.00	5	SS		
		9	31											5.50	
		9	33												Brownish Grey M. Dense fine Sand with clay packets
6							3	7	16	23	6.00	6	SS		
		9	58												
7	11-01-2020	10	00				25	24	22	46	7.00	7	DS		Greyish Brown Dense M. coarse to fine Sand
		10	20												
		10	22												— Do —
8							15	24	29	53	8.00	8	SS		
		10	41												
		10	63												
9							20	14	19	33	9.00	9	SS		Brownish Dense fine to M. coarse Sand
		11	06												
		11	08												
10							7	5	5	10	10.00	10	SS		Blackish Grey stiff silty Clay with Sand packets

CS - Core Sample	DS - Disturbed Sample	SUPERVISOR NAME	Mr. Loganathan	PROJECT SITE DETAILS	
SS - Split Spoon Sample	SC - Soil Cutter	SIGNATURE	Mr.	GROUND LEVEL (m)	
UDS-Undisturbed Sample	TCB - Tungsten Carbide Bit	DATE	11/01/2020	WATER TABLE (m)	—
WS - Wash Sample	DB - Diamond Bit	CLIENT IN-CHARGE		CASING DEPTH (m)	

GEOMARINE
THE SPIRIT OF ENGINEERING

SITE INVESTIGATION RECORD

BORE HOLE No.	02.
PAGE No.	02
DIA OF BORE HOLE	150mm: 5 / 100mm:
BORE START DATE	10/01/2020
BORE END DATE	20/01/2020
TOTAL DRILLING DAYS	5

PROJECT NAME	TNHB - Arumbakkam - Chennai				
LOCATION		MACHINE No.		CHAINAGE (m)	
STRUCTURE		DRILLING METHOD	Rotary	CO-ORDINATES	N
JOB CODE		FLUSHING MEDIUM	Bentonite		E

Depth below E.G.L. (m)	Drilling progress per metre: Date	Time: Hr.	Time: Min	Type of Drill Bit (SC / TCB / DB)	Core Details: Total Core Recovery %	Core Details: R.Q.D %	SPT Details: Blows/cm. 0-15	SPT Details: Blows/cm. 15-30	SPT Details: Blows/cm. 30-45	SPT 'N' Value	Sample Details: Depth	Sample Details: No.	Sample Details: Type	Layer Data: Depth (m)	Layer Data: Geotechnical Description
1	11-01-2020	11	36	SC			1	2	3	5	11.50	11	SS		Greyish loose clayey Sand
		11	39												
2															
		12	17												
3		12	19	SC			7	10	17	27	13.00	12	SS		Greyish M. Dense Cemented Sand
4		1	45												
		1	47												
5				SC			13	20	26	46	14.50	13	SS		Greyish Dense cemented Sand
		2	30												
Water loss.		2	32												
6				SC			15	17	30	47	16.00	14	SS		Greenish Grey Dense Cemented Sand.
		4	02												
7		4	04	SC			15	36	37	73	17.50	15	SS		Greyish very Dense Silty fine Sand (Sandy Silt)
8															
	12-01-2020														
9				SC			13	31	37	68	19.00	16	SS		Brownish Grey very Hard Compacted Clay
0															

				PROJECT SITE DETAILS	
CS - Core Sample	DS - Disturbed Sample	SUPERVISOR NAME	Logeshwaran K	GROUND LEVEL (m)	
SS - Split Spoon Sample	SC - Soil Cutter	SIGNATURE		WATER TABLE (m)	
UDS-Undisturbed Sample	TCB - Tungsten Carbide Bit	DATE		CASING DEPTH (m)	
WS - Wash Sample	DB - Diamond Bit	CLIENT IN-CHARGE			

GEOMARINE
THE SPIRIT OF ENGINEERING

SITE INVESTIGATION RECORD

BORE HOLE No.	BH-02		
PAGE No.	03		
DIA OF BORE HOLE	150mm	4	
	100mm		
BORE START DATE	10/01/2020		
BORE END DATE	20/01/2020		
TOTAL DRILLING DAYS	5		

PROJECT NAME	TNHB - Arumbakkam				
LOCATION	Arumbakkam	MACHINE No.	YUWHD	CHAINAGE (m)	
STRUCTURE	TNHB COMMERCIAL	DRILLING METHOD	Rotary	CO-ORDINATES	N
JOB CODE		FLUSHING MEDIUM	Bentonite		E

Depth below E.G.L. (m)	Drilling progress per metre: Date	Time: Hr.	Time: Min	Type of Drill Bit (SC/TCB/DB)	Core Details: Total Core Recovery %	Core Details: R.Q.D %	SPT Details: Blows/cm. 0-15	SPT Details: Blows/cm. 15-30	SPT Details: Blows/cm. 30-45	SPT 'N' Value	Sample Details: Depth	Sample Details: No.	Sample Details: Type	Layer Data: Depth (m)	Geotechnical Description
0	17/01	4	35												
		4	38												
	20/01	3	30	SC			15	23	34	57	2.00	17	SS		Greyish Brown V. Hard Compacted clay
1		3	40												
		0	06												
2	17/01														Greyish Brown very Dense SILTY fine sand
				SC			33	150mm/66 blows Hammer Refusal N>100			23.00	18	SS		
3	20/01														
4		0	8												
								115mm 50 blows							— Do —
5				SC			23	57		N>100	25.00	19	SS		
		14	55												
		15	05												
6	20/01/2020														
				SC			40 for 8cm → 100 45 blows SPT Refusal Met Penetration				27.20		SS		Hard, Brownish Greenish, Colour Hard compacted clay (SHALE YOUNGER STAGE)
7															
8															
9															
0															

This bore hole for investigation has been terminated at the depth of 27 mts due to water loss continuously occurring

CS - Core Sample	DS - Disturbed Sample	SUPERVISOR NAME	MURALI KRISHNAN.K	PROJECT SITE DETAILS	
SS - Split Spoon Sample	SC - Soil Cutter	SIGNATURE	K. Murali	GROUND LEVEL (m)	
UDS-Undisturbed Sample	TCB - Tungsten Carbide Bit	DATE	20.01.2020	WATER TABLE (m)	
WS - Wash Sample	DB - Diamond Bit	CLIENT IN-CHARGE		CASING DEPTH (m)	

GEOMARINE
THE SPIRIT OF ENGINEERING

SITE INVESTIGATION RECORD

BORE HOLE No. BH-03
PAGE No. 01

PROJECT NAME: TNHB - Arumbakkam, Chennai
DIA OF BORE HOLE: 150mm ✓ / 100mm
LOCATION: Arumbakkam | MACHINE No. | CHAINAGE (m) | BORE START DATE: 22-01-2020
STRUCTURE | DRILLING METHOD: Rotary | CO-ORDINATES N | BORE END DATE: 28-01-2020
JOB CODE | FLUSHING MEDIUM: Bentonite | E | TOTAL DRILLING DAYS: 6

Depth below E.G.L. (m)	Drilling progress per metre: Date	Time: Hr.	Time: Min	Type of Drill Bit (SC / TCB / DB)	Core Details: Total Core Recovery %	Core Details: R.Q.D %	SPT Details: Blows/cm. 0-15	15-30	30-45	SPT 'N' Value	Sample Details: Depth	No.	Type	Layer Data: Depth (m)	Geotechnical Description
0		10	45	SC											Filled up Rubbles. Concrete Material (0m Depth to 2.50mtrs)
3	22/01/2020	11	15				2	5	2	7	3.00	1	SS		Blackish Loose, Sandy clay
4		12	15 to 12		—		3	3	4	7	4.0	2	SS		Blackish M. stiff clay
		12	27								5.0	3	SS		Blackish to Grayish Color
5		14	07 to 14		—		5	12	14	26	Layer change		4/c		M Stiff clay to M. Dense
		14	30										4/c		(5.30m) Silty fine Sand.
		14	57												
6		15	00				5	6	8	14	6.0	4	SS		BLACKISH GREY COLOUR M. DENSE, FINE TO MEDIUM GRAINS SILTY SAND
		15	19 to	SC											
7		15	21				5	4	6	10	7.0	5	SS		LOOSE, COMPACTED CLAYEY SILTY SAND. (FINE TO MEDIUM GRAINS)
		15	42												
8		15	47	SC			7	12	8	20	8	6	SS		SPT SAMPLE SLIPPED IN BORE HOLE.
		16	14				(SAMPLE SLIPPED IN BORE HOLE)						WS		
		16	16	SC											
9	23/01/2020	10	45				12	15	19	34	9	7	(SS)		GREENISH COLOURS MEDIUM TO FINE SILTY SAND
		10	45 to 47	SC											
0							13	15	15	30	10	8	(SS)		GREENISH, M. DENSE, TO DENSE CEMENTED SAND FINE TO MEDIUM GRAINS

M. Venugopal Site

CS - Core Sample	DS - Disturbed Sample	SUPERVISOR NAME	MURALI KRISHNAN. R	PROJECT SITE DETAILS	
SS - Split Spoon Sample	SC - Soil Cutter	SIGNATURE	R. Murali	GROUND LEVEL (m)	
UDS-Undisturbed Sample	TCB - Tungsten Carbide Bit	DATE	22/01/2020	WATER TABLE (m)	4.5
WS - Wash Sample	DB - Diamond Bit	CLIENT IN-CHARGE		CASING DEPTH (m)	

GEOMARINE
THE SPIRIT OF ENGINEERING

SITE INVESTIGATION RECORD

BORE HOLE No.	BH-03		
PAGE No.	02		
DIA OF BORE HOLE	150mm ✓	100mm	
BORE START DATE	22-01-2020		
BORE END DATE	28-01-2020		
TOTAL DRILLING DAYS	6		

PROJECT NAME	TNHB – Arumbakkam						
LOCATION	ARUMBAKKAM	MACHINE No.	HD-2	CHAINAGE (m)		N	
STRUCTURE		DRILLING METHOD	Rotary	CO-ORDINATES		E	
JOB CODE		FLUSHING MEDIUM	Bentonite				

Depth below E.G.L (m)	Drilling progress per metre: Date	Time: Hr.	Time: Min	Type of Drill Bit (SC / TCB / DB)	Core Details: Total Core Recovery %	Core Details: R.Q.D %	SPT Details: Blows/cm. 0-15	SPT Details: Blows/cm. 15-30	SPT Details: Blows/cm. 30-45	SPT 'N' Value	Sample Details: Depth	Sample Details: No.	Sample Details: Type	Layer Data: Depth (m)	Geotechnical Description
1	23-01-2020	11	40	SC											DENSE, GREENISH GREY, SILTY SAND (COMPACTED) FINE TO MEDIUM GRAINS
		11	50				11	14	19	33	11.50	9	SS		
2				SC											
		12	16												
3		12	20				15	17	17	34	13.0	10	SS		DENSE, GREENISH & GREY (N. FINE GRAINS OF SILTY SOILS) & SILTY SAND
		10	30	SC											
4		10	35												LAYER CHANGES L/C
							33	57	10cm	100/7	14.5	11	SS		HARD, GREENISH & BROWN COMPACTED CLAY. (SHALE) HARD CLAY
5		14	40						SOBS						
		14	47	SC			SPT Hammer Released.								
	24/01/2020	14	55												
		14	30												
6							15	20	29	49	16.0	12	SS		HARD, GREENISH BROWN (COMPACTED CLAY SHALE) HARD SHALE.
				SC											
7		16	05												
		16	54												HARD LAYER CHANGE BROWN, GRENISH COLOUR COMPACTED HARD CLAY (SHALE) WITH VERY FINE SILTY SAND)
							14	44	46	9.0	17.5	13	SS		
8		11	05	SC											
		to													
9	25/01/2020	11	28												
							37	55	10cm	51/7.5cm	19.0	14	SS	19.0	HARD & V. DENSE. COMPACTED CLAY (SHALE) LOOK LIKE VERY VERY. FINE SILTY SAND
		12	30				SPT Hammer Released								
0		12	50	SC											

4c

CS - Core Sample	DS - Disturbed Sample	SUPERVISOR NAME	MURALIKRISHNAN K	PROJECT SITE DETAILS	
SS - Split Spoon Sample	SC - Soil Cutter	SIGNATURE	K. Muralikrishnan	GROUND LEVEL (m)	
UDS-Undisturbed Sample	TCB - Tungsten Carbide Bit	DATE	25/01/2020	WATER TABLE (m)	4.5
WS - Wash Sample	DB - Diamond Bit	CLIENT IN-CHARGE		CASING DEPTH (m)	

GEOMARINE
THE SPIRIT OF ENGINEERING

SITE INVESTIGATION RECORD

BORE HOLE No.	BH-02.		
PAGE No.	03		
DIA OF BORE HOLE	150mm ✓	100mm	
BORE START DATE	22-01-2020		
BORE END DATE	28-01-2020		
TOTAL DRILLING DAYS	6		

PROJECT NAME	TNHB - Arumbakkam.						
LOCATION	ARUMBAKKAM	MACHINE No.	HD-2	CHAINAGE (m)			
STRUCTURE		DRILLING METHOD	Rotary	CO-ORDINATES	N		
JOB CODE		FLUSHING MEDIUM	Bentonite		E		

Depth below E.G.L (m)	Drilling progress per metre: Date	Time: Hr.	Time: Min.	Type of Drill Bit (SC / TCB / DB)	Core Details: Total Core Recovery %	Core Details: R.Q.D %	SPT Details: Blows/cm. 0-15	SPT Details: Blows/cm. 15-30	SPT Details: Blows/cm. 30-45	SPT 'N' Value	Sample Details: Depth	Sample Details: No.	Sample Details: Type	Layer Data: Depth (m)	Geotechnical Description
1	25/01/2020			SC			21	35	19cm 55 Blows		21.0	15	(SS)		HARD, BROWNISH GREEN COMPACTED SILTY CLAY
2		Total Drilling Time Hammer Reversed		1-1/2 HR			SPT Hammer Reversed								
3		09	55	SC			23	40	10cm 55 Blows		27.0	16	(SS)		HARD, GREYISH GREEN COMPACTED SILTY CLAY
4		to 10	30				SPT Hammer Reversed								L/C
5	27/01/2020	11	18	SC			9cm 55 Blows			>100	25.0	17	(SS)		V. DENSE, BROWNISH & GREY, COARSE SAND.
6		to 12	40				No penetration SPT Hammer Reversed				L/C				MEDIUM TO COARSER GRAINS L/C 26m
7		14	45	SC			3cm 55 Blows SPT Hammer Reversed, No penetration			>100	27.0	18	(SS) WS NIL		V. HARD, SHALE, DARK GREY, (COMPACTED SILTY CLAY ROCK) SPT SAMPLE SLIPPED (WS) only
8		15	40	DB	0%	0%	SPT Hammer Rod No penetration				28	19	NS CS		- do -
9		15	25												
		to 16	35		0%	0%	SPT Hammer Reversed				29	20	(SS) WS CS		V. HARD, SHALE ROCK Dark Greyish.
10	28/01/2020	10	20	DB											
		to 12	10	TC	30%	0%	—	—	—	—	30	21	SS CS		V. HARD, SILTY COMPACTED CLAY/ SHALE ROCK, GREY, SEDIMENTARY ROCK ORIGIN

CS - Core Sample	DS - Disturbed Sample	SUPERVISOR NAME	MURALI KRISHNAN-E	PROJECT SITE DETAILS	
SS - Split Spoon Sample	SC - Soil Cutter	SIGNATURE	R. Muralikrishnan	GROUND LEVEL (m)	
UDS-Undisturbed Sample	TCB - Tungsten Carbide Bit	DATE	28/01/2020	WATER TABLE (m)	4.5
WS - Wash Sample	DB - Diamond Bit	CLIENT IN-CHARGE		CASING DEPTH (m)	

GEOMARINE
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SITE INVESTIGATION RECORD

BORE HOLE No. 04.
PAGE No. 01
DIA OF BORE HOLE 150mm / 100mm
BORE START DATE 28-01-2020
BORE END DATE 31-01-2020
TOTAL DRILLING DAYS 4

PROJECT NAME: TNHB - ARUMBAKKAM,
LOCATION: ARUMBAKKAM | MACHINE No.: HD-2 | CHAINAGE (m):
STRUCTURE: | DRILLING METHOD: Rotary | CO-ORDINATES: N, E
JOB CODE: | FLUSHING MEDIUM: Bentonite

Depth below E.G.L. (m)	Drilling progress per metre: Date	Time: Hr.	Time: Min	Type of Drill Bit (SC / TCB / DB)	Core Details: Total Core Recovery %	Core Details: R.Q.D %	SPT Details: Blows/cm. 0-15	Blows/cm. 15-30	Blows/cm. 30-45	SPT 'N' Value	Sample Details: Depth	No.	Type	Layer Data: Depth (m)	Geotechnical Description
0	28-01-2020	15	04	SC											Filled up Soil
1		16	15				Filled up Concreted & Rubbles.				1.0	-	NIL		Building Demolished Stones Concreted & Rubbles Material 0.0m top to below 2mts
		16	24	SC											
2		16	33				Concreted & Filled up Rubbles				2.0	-	NIL		2.50 MTS 4G
		16	40	SC											GREYISH YELLOW,
3		16	58				17	18	20	38	3.0	1	(SS)		DENSE, SILTY SAND MEDIUM TO COARSE GRAINS & GRAVELS WITH
		10	15	SC											
4		10	25				5	7	8	15	4.0	2	(SS)		FILLED UP SOILS COVERED
		10	56	SC											STIFF, SILTY CLAY, DARK
5	29-01-2020	11	00				6	8	10	18	5.0	3	SS		BLACK COLOURS, WET.
		11	27												STIFF, SILTY CLAYEY DARK
		11	30	SC										5.5	BLACK COLORS. SILTY SANDY CLAY LAYER CHATTRES
6		11	52				8	11	11	22	6.0	4	SS		M. DENSE TO DENSE SILTY SAND
		11	55	SC											
7		12	24				6	10	8	18	7.0	5	SS		M. DENSE, SILTY SAND
		12	27	SC											
8							3	6	9	15	8.0	6	SS		M. DENSE, GREENISH GREY CLAYEY SILTY SAND FINE TO MEDIUM GRAINS
		12	46	SC											
9		12	48				10	14	17	31	9.0	7	SS		DENSE, GREYISH GREEN CLAYEY SILTY SAND
		13	49	SC											
10		14	00				12	21	25	46	10.0	8	SS		DENSE, GREYISH GREEN, CLAYEY SILTY SAND

				PROJECT SITE DETAILS	
CS - Core Sample	DS - Disturbed Sample	SUPERVISOR NAME	MURALI KRISHNAN.C	GROUND LEVEL (m)	
SS - Split Spoon Sample	SC - Soil Cutter	SIGNATURE	K. Muralikrishnan	WATER TABLE (m)	4.0
UDS-Undisturbed Sample	TCB - Tungsten Carbide Bit	DATE	29/01/2020	CASING DEPTH (m)	
WS - Wash Sample	DB - Diamond Bit	CLIENT IN-CHARGE			

GEOMARINE
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SITE INVESTIGATION RECORD

BORE HOLE No.	04
PAGE No.	02
DIA OF BORE HOLE	150mm ✓ / 100mm
BORE START DATE	28-01-2020
BORE END DATE	31-01-2020
TOTAL DRILLING DAYS	4

PROJECT NAME	TNHB - ARUMBAKKAM				
LOCATION	ARUMBAKKAM	MACHINE No.	HD-2	CHAINAGE (m)	
STRUCTURE		DRILLING METHOD	Rotary	CO-ORDINATES	N
JOB CODE		FLUSHING MEDIUM	Bentonite		E

Depth below E.G.L (m)	Drilling progress per metre: Date	Time: Hr.	Time: Min	Type of Drill Bit (SC / TCB / DB)	Core Details: Total Core Recovery %	Core Details: R.Q.D %	SPT Details: Blows/cm. 0-15	SPT Details: Blows/cm. 15-30	SPT Details: Blows/cm. 30-45	SPT 'N' Value	Sample Details: Depth	Sample Details: No.	Sample Details: Type	Layer Data: Depth (m)	Geotechnical Description
1	29-01-2020	14	18												
		16	25	SC											
2		15	10				19	24	25	49	11.50	S1	SS		DARK DENSE, GREENISH COLOUR GREY, SILTY VERY FINE GRAINS SAND
		15	30	SC											
3							34	40	12cm→10 / 55		13.0	S2	SS		DENSE, DARK GREENISH GREY SILTY VERY FINE TO MEDIUM SAND
									SPT Hammered						
4		16	25	SC											
		16	40												
5		10	19				45	10cm / 50/8		71/10	14.50	S3	SS		DENSE, DARK GREEN & GREY SILTY SAND FINE TO MEDIUM COARSE GRAINS
		to		SC					SPT Hammered						
		10	55								4c 15.5		4c	15.5	
6		12	12				11	20	24	44	16.0	S4	SS		V.HARD, GREY BROWNISH RED COMPACTED SILTY CLAY (SHALE)
		to													
		12	50	SC											
7		13	05												
		to													
		13	24												
		13	50		13.50		12	21	25	46	17.5	S5	SS		V.HARD, GREY, BROWNISH RED, COMPACTED SILTY CLAY (SHALE)
8		13	29		to										
		14	18		14.38										
		to													
		14	55	SC	4.38										
		to			to										
9		15	14		14.53		21	28	39	67	19.0	S6	SS		V.HARD & V.DENSE, DARK BROWNISH GREY WITH SILTY CLAYEY SAND. (CEMENTED SAND)
		to		SC											
		15	35												
0															

4c

CS - Core Sample	DS - Disturbed Sample	SUPERVISOR NAME	MURALI KRISHNAN K	PROJECT SITE DETAILS	
SS - Split Spoon Sample	SC - Soil Cutter	SIGNATURE	K. Murali	GROUND LEVEL (m)	
UDS-Undisturbed Sample	TCB - Tungsten Carbide Bit	DATE	30-01-2020	WATER TABLE (m)	4.5m
WS - Wash Sample	DB - Diamond Bit	CLIENT IN-CHARGE		CASING DEPTH (m)	

GEOMARINE
THE SPIRIT OF ENGINEERING

SITE INVESTIGATION RECORD

BORE HOLE No.
PAGE No. 03

PROJECT NAME: TNHB- ARUMBAKKAM

DIA OF BORE HOLE: 150mm ✓ / 100mm

LOCATION: ARUMBAKKAM | MACHINE No.: HD-2 | CHAINAGE (m) | BORE START DATE: 28-01-2020

STRUCTURE | DRILLING METHOD: Rotary | CO-ORDINATES N | BORE END DATE: 31-01-2020

JOB CODE | FLUSHING MEDIUM: Bentonite | CO-ORDINATES E | TOTAL DRILLING DAYS: 4

Depth below E.G.L (m)	Drilling progress per metre: Date	Time: Hr.	Time: Min	Type of Drill Bit (DC / TCB / DB)	Core Details: Total Core Recovery %	Core Details: R.Q.D %	SPT Details: Blows/cm. 0-15	Blows/cm. 15-30	Blows/cm. 30-45	SPT 'N' Value	Sample Details: Depth	No.	Type	Layer Data: Depth (m)	Geotechnical Description
1	30-01-2020	15	55	SC			25	25	30	55	210	15	SS		HARD & VERY DENSE COMPACTED CLAYEY SILTY SAND BROWNISH YELLOW, (CEMENTED SAND)
2		to 16	10	SC											
3		16	40				45	8cm / 50Blw		100	230	16	SS		V. DENSE, HA SILTY SAND (CEMENTED SAND) Very fine to Medium grains.
							SPT Hammer Rejected								
4		to 17	10	SC											
5							25	8cm / 48Blw		100	250	17	SS		V. DENSE, GREYISH GREEN CEMENTED SILTY SAND VERY FINE TO MEDIUM GRAINS SOILS.
		10	46				SPT Hammer Rejected No Penetration								
6	31-01-2020	to 11	92												
7				SC							27	18	SS		V. DENSE, GREYISH GREEN COLOURS. SILTY SAND VERY FINE TO MEDIUM GRAINS SOILS.
		11	55												
8		to 12	30	SC											
							SPT No penetration								
9		12	46	TC	3%	0%	5cm / 5Blw			100	29	19	SS	4.5	L/change V. HARD, GREYISH GREEN SHALE ROCK COMPACTED SILTY CLAY.
		to 14	15				SPT Hammer Rejected				↓				
0											30	20	CS		HARD SHALE ROCK

				PROJECT SITE DETAILS	
CS - Core Sample	DS - Disturbed Sample	SUPERVISOR NAME	MURALI KRISHNA K.	GROUND LEVEL (m)	
SS - Split Spoon Sample	SC - Soil Cutter	SIGNATURE	K. Murali	WATER TABLE (m)	4.5
UDS-Undisturbed Sample	TCB - Tungsten Carbide Bit	DATE	31/01/2020	CASING DEPTH (m)	
WS - Wash Sample	DB - Diamond Bit	CLIENT IN-CHARGE			

GEOMARINE
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SITE INVESTIGATION RECORD

BORE HOLE No. BH-5.
PAGE No. 01

PROJECT NAME: TNHB- ARUMBAKKAM
DIA OF BORE HOLE: 150mm ✓ / 100mm

LOCATION: Arumbakkam Buildg | MACHINE No.: H-D-2 | CHAINAGE (m):
STRUCTURE: 24 Floors | DRILLING METHOD: Rotary | CO-ORDINATES: N
JOB CODE: | FLUSHING MEDIUM: Bentonite | E

BORE START DATE: 03-02-2020
BORE END DATE: 06/02/2020
TOTAL DRILLING DAYS: 4

Depth below E.G.L. (m)	Drilling progress per metre: Date	Time: Hr.	Time: Min	Type of Drill Bit (SC / TCB / DB)	Core Details: Total Core Recovery %	Core Details: R.Q.D %	SPT Details: Blows/cm. 0-15	SPT Details: Blows/cm. 15-30	SPT Details: Blows/cm. 30-45	SPT 'N' Value	Sample Details: Depth (M)	Sample Details: No.	Sample Details: Type	Layer Data: Depth (m)	Geotechnical Description
1	03-02-2020	12	40												Filled upsoil at
		to		SC			—	—	—	—	-1	—	—		00m depth. to 2.35m
2		12	57												above a depth
		13	50				—	—	—	—	-2	—	—		— NO SPT Sample —
		13	58												Building Material Concrete
3							7	10	11	21	-3.0	1	SS		M·DENSE, COARSE
		15	57	SC											SILTY SAND, MEDIUM TO COARSE
		16	10					Water table below 3.5m							YELLOWISH BROWN COLOURED,
4							4	8	9	17	-4.0	2	SS		M·DENSE,
		16	35												SILTY SAND
		16	38	SC											BLACKISH GREY MEDIUM GRAINED
5							4	7	8	15	-5.0	3	SS		LAYER CHANGES WITH CLAY
		16	55								UC			5.15m	NODULES — 5.15m — LCS
		16	58	SC											CLAYEY SILTY SAND
6		17	10				3	5	4	9	-6.0	4	SS		
		17	13	SC											DO
7							5	8	9	17	-7.0	5	SS		LOOSE TO MEDIUM
		10	05												DENSE, SILTY SAND
		10	10	SC											BLACKISH GREY.
8							4	9	9	18	-8.0	6	SS		M·DENSE, SILTY SAND
		10	29												BLACKISH GREY,
		10	33												FINE TO MEDIUM GRAINED
9				SC			6	11	11	22	-9.0	7	SS		
		11	02												M·DENSE SILTY SAND.
		11	06												BLACKISH GREY
10	04-02-2020						7	15	18	33	-10.0	8	SS		FINE TO MEDIUM GRAINS
				SC											DENSE, SILTY SAND.

CS - Core Sample	DS - Disturbed Sample	SUPERVISOR NAME	MURALI KRISHNAN K	PROJECT SITE DETAILS	
SS - Split Spoon Sample	SC - Soil Cutter	SIGNATURE	K. Murali	GROUND LEVEL (m)	
UDS-Undisturbed Sample	TCB - Tungsten Carbide Bit	DATE	04/02/2020	WATER TABLE (m)	3.6om
WS - Wash Sample	DB - Diamond Bit	CLIENT IN-CHARGE		CASING DEPTH (m)	

GEOMARINE
THE SPIRIT OF ENGINEERING

SITE INVESTIGATION RECORD

BORE HOLE No. BH-5.
PAGE No. 2
DIA OF BORE HOLE 150mm ✓ / 100mm
BORE START DATE 03-02-2020
BORE END DATE 06/02-2020
TOTAL DRILLING DAYS 4

PROJECT NAME: TNHB- ARUMBAKKAM.
LOCATION: Arumbakkam Bus
MACHINE No.: H.D-2
CHAINAGE (m):
STRUCTURE:
DRILLING METHOD: Rotary
CO-ORDINATES: N, E
JOB CODE:
FLUSHING MEDIUM: Bentonite

Depth below E.G.L. (m)	Drilling progress per metre: Date	Time: Hr.	Time: Min	Type of Drill Bit (SC / TCB / DB)	Core Details: Total Core Recovery %	Core Details: R.Q.D %	SPT Details: Blows/cm. 0-15	15-30	30-45	SPT 'N' Value	Sample Details: Depth	No.	Type	Layer Data: Depth (m)	Geotechnical Description
0	04/02/2020	11. 32													
1		11	37	SC			8	15	15	30	11.50	9	SS		DENSE, SILTY SAND, GREYISH GREEN, V. FINE. MEDIUM GRAINS
2		12	08 to 12	14 SC											
3							7	12	13	25	12.0	10	SS		DENSE, SILTY SAND GREENISH GREY, V-FINE TO MEDIUM. GRAINS SOILS.
4		13	48 to 14	05 SC											
5							14	28	25	48	14.50	11	SS		HARD, SILTY CLAY, (SHALE) (COMPACTED HARD CLAY)
6		14	22 to 14	49 SC											
7		15	09 to 15	44 SC			14	21	27	48	16	12	SS		V. HARD, SILTY CLAY (SHALE) REDISH GREY, GREEN BROWN
8		16	10												
		16	00 to 16	25 SC			16	41	46	87	17.50	13	SS		V. HARD, CLAY SHALE. REDISH BROWN, GREY SHALE
							Water Level below 18.m								
9	05/02/2020	11	05 to 11	28			9cm								
							15	31	36	67	19.0	14	SS		HARD TO V. DENSE. COMPACTED HARD CLAY TO SILTY MEDIUM GRAINS SAND SOILS
							SPT Anvil Rebd								
		11	56 to 12.	30											LAYER CHANGES (19.20 Mts)

CS - Core Sample	DS - Disturbed Sample	SUPERVISOR NAME	MURALI KRISHNAN K.	PROJECT SITE DETAILS	
SS - Split Spoon Sample	SC - Soil Cutter	SIGNATURE	K. Murali Krishnan	GROUND LEVEL (m)	
UDS-Undisturbed Sample	TCB - Tungsten Carbide Bit	DATE	05/02/2020	WATER TABLE (m)	3.60
WS - Wash Sample	DB - Diamond Bit	CLIENT IN-CHARGE		CASING DEPTH (m)	

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BORE HOLE No.	BH-5
PAGE No.	03
DIA OF BORE HOLE	150mm ✓ / 100mm
BORE START DATE	03/02/2020
BORE END DATE	06/02/2020
TOTAL DRILLING DAYS	4

PROJECT NAME	TNHB – Arumbakkam.						
LOCATION	ARUMBAKKAM – Bus Stop	MACHINE No.	HD-2	CHAINAGE (m)			
STRUCTURE		DRILLING METHOD	Rotary	CO-ORDINATES	N		
JOB CODE		FLUSHING MEDIUM	Bentonite		E		

Depth below E.G.L. (m)	Drilling progress per metre: Date	Time: Hr.	Time: Min	Type of Drill Bit (SC / TCB / DB)	Core Details: Total Core Recovery %	Core Details: R.Q.D %	SPT Details: Blows/cm. 0-15	SPT Details: Blows/cm. 15-30	SPT Details: Blows/cm. 30-45	SPT 'N' Value	Sample Details: Depth	Sample Details: No.	Sample Details: Type	Layer Data: Depth (m)	Geotechnical Description
0	05/02/2020	12	47												
		13	15												
		14	05												
1		14	25				20	33	11cm / 55blw	7/100	21.0	15	SS		V. HARD SILTY CLAY (or) HARD CLAY, (SHALE)
		14	50												
		to													
2		15	28	SC											
3							21	35	8cm / 45blw	7/100	23.0	16	SS		CLAYEY SILTY SAND
		15	50				SPT Hammer Lost								23.40 mts LC
4		16	07												SILTY SAND
				SC											VERY FINE SAND
															BROWNISH GREY
5							23	7cm		7/100	24.80 m	LC			V. DENSE
		16	54					05 blw			25	17	SS / WS		SILTY SAND
		17	30					(SS)							SPT SAMPLE SLIPPED IN THE BORE HOLE
6											26.50	Hard Strata		2.6m	Hard Strata Starting at the 26.50 mts depth
		10	12											LC	
		to		TC	0%	0%									
		10	35												
7							8cm				27	18	SS		V. Hard. SHALE
		11	04				55 blws								COMPACTED HARD CLAY
		to					Wash boring & SPT Hammer lost								[SHALE Rock pieces]
8		11	56												GREY & BLUISH GREY
		12			0%	0%									weathered,
															COMPLETELY TO
		12	16												HIGHLY WEATHERED
9		to									29.0	19	SS		(COMPACTED CLAY) SHALE
	06/02/2020	12	48				SPT Hammer Recovered			7/100					Rock
		14	08												
		to													
10		14	35								30.0	20	SS		— DO —

CS - Core Sample	DS - Disturbed Sample	SUPERVISOR NAME	MURALI KRISHNAN. K	PROJECT SITE DETAILS	
SS - Split Spoon Sample	SC - Soil Cutter	SIGNATURE	K. Murali Krishnan	GROUND LEVEL (m)	
UDS-Undisturbed Sample	TCB - Tungsten Carbide Bit	DATE	06/02/2020	WATER TABLE (m)	3.60
WS - Wash Sample	DB - Diamond Bit	CLIENT IN-CHARGE		CASING DEPTH (m)	

THE LANDLENS SUITE

Eight ways to know a piece of land before you pay for it.

This report covers one part of the picture. These cover the rest, drawn from the same government records, for any property in Tamil Nadu.

LandLens One
Ask anything about a property and get an answer grounded in live government records, with the sources shown.
/landlens/one

Verify My Land
Every record check run on one property and returned as a single report.
/landlens/verify-my-land

Legal Opinion
An advocate's written opinion on the title, built on the records we pull for it.
/landlens

One Map
Every layer on one map: the parcel, its boundary, zoning, water bodies and what sits around it.
/landlens/one/map

PriceMap
What land actually changed hands for around this plot, taken from the registered deeds.
/landlens/pricemap

Build Scope
What you are allowed to build here: floor space, height, coverage and setbacks.
/landlens/build-scope

Property Tracker
Watch a property and hear about it when something new is registered against it.
/landlens/property-tracker

Deal Room
Run the transaction in one place: documents, stamping, signatures and the parties.
/landlens/deal-room

FREE TOOLS · NO ACCOUNT NEEDED

Twenty-four checks you can run yourself, at no cost.

Records and verification

The registers themselves, read for you.

- Encumbrance Certificate
- Patta and Chitta
- Field Measurement Sketch
- EC Analyzer
- Bank charge check
- Court case search
- Seller background check
- Approval check by survey

Value and duty

What it is worth and what it costs to register.

- Guideline value by street
- Guideline value by survey
- Stamp duty and registration fees
- Capital gains
- Floor space index
- Area unit converter

Zoning and land use

What the plan says can happen on this land.

- Land use zone finder
- CMDA land use check
- Coastal regulation zone
- Master plan check
- Water bodies finder
- Airport height clearance

Registers and directories

Who holds it, and which office keeps the record.

- Find your registering office
- Temple property check
- Waqf property check
- RERA register

Every free tool
/tools

Services we run for you
/services

The LandLens suite
/landlens/one

Verified RealEstate™

Every claim in this document traces back to a government record.

- Legal opinions, due diligence and title verification
- Building plan, layout and sub-division approvals
- Completion and occupancy certificates, regularisation
- Escrow, negotiation and NRI property management
- Land survey, soil testing, architecture and construction

Verified RealEstate
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Prepared from the registers named on the page each finding sits on. Where a register could not be read, this document says so in its place rather than leaving the gap to be read as a clean result.