GEOTECHNICAL INVESTGATION FOR AREA DEVELOPMENT WORKS AT BOROSOLA BEEL AREA,GUWAHATI

GUWAHATI SMART CITY PROJECT

GEO-TECHNICAL INVESTIGATION REPORT

Prepared for :

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Submitted by :

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1. INTRODUCTION

1.1 General

ESS Foundations Pvt. Ltd. was assigned the task of geotechnical investigation works for **Area Development works at Borosola Beel-Guwahati** by **Tata Consulting Engineers Limited**. The objectives were to find out the sub-soil conditions as a pre-requisite for construction and to find out soil data for subsequent design of foundations at the site. The site is located middle of Guwahati citya aprox. 2 kms. Southwest of the Guwahati Railway Station by the Road. The site is shown in the map in this report. The soil investigation work was carried out during the month of **May - 2017** at the Proposed site at various locations. The work involved boring to appropriate depths, extracting soil samples for visual as well as laboratory investigations. Besides boring, Standard Penetration Tests at specified intervals were also performed as per relevant I.S. specifications, undisturbed as well as disturbed samples were collected from the bore-holes for classification of soil, shear strength tests and all other relevant tests were performed to determine the safe bearing capacity of the soil.

1.2 Objective :

The objective of the **report** is restricted to the collection of factual information during the investigation period and submission of laboratory tests results,so as to sequence,extent of **soil** stratification,bearing capacity of soil,to ascertain the design parameters for the foundations from the recommended safe bearing capacity of **foundation soil**.

1.3 SITE DESCRIPTION:

The site is located middle of the Guwahati citya aprox. 2 kms. Southwest of the Guwahati Railway Station by the Road. The co-ordinates (in Lat-Long.) of the site is 26°10'22.9"N 91°44'45.8"E.The area under investigation is a water body and uneven.

Fig: Google Image of Proposed Site

1.4 GEOLOGY :

Geologically, the entire Greater Guwahati Area lies on the pre-cambrian rocks foundation of the Meghalaya plateau akin to rocks basement of the Deccan peninsula. In the area there lie hither and thither the standing hills, hillocks of archean and precambrian rocks, plains of quaternary sediments of Pleistocene epoch to sediments of recent age. The archean rocks are represented here by gneisses, schists and granites. In Guwahati the standing hills and hillocks excluding the elongated ones, occur mostly as isolated inselbergs. The precambrian rocks act as the parent material for soil formation in Greater Guwahati. The pre-cambrian rocks show utcrops in different ocations of the inselbergs. In places the geology of the area is complex where the older gneisses, schist and granoliths are intruded by granites, pegmatites, feldspar and the uartzo feldspethic veins. Outcrops of granites and gneisses are best observed in the hills of Fatasil, Ambari, Dispur, Kacharibasti, Nabagraha Chunsali and Sarania areas. A belt of pink granite gneiss from Khargulli to Chunsali runs more or less parallel to the Brahmaputra river (Maswood, 1981). Grey porphyritic granite is present in the Udayachal hill, Sonaighuli hill, Kamakhya hill and the hills of Jalukbari area. Pink granite with limited outcrops occurs at the Kalapahar and Ganeshguri areas along a narrow belt running from Kahilipara to Odalbakara. The low-lying plain and valley areas over the pre-cambrian rocks basement are deposited by the eroded material coming down from the surrounding hills. These materials are termed as quaternary alluvial deposits ranging from Pleistocene epoch to recent age. Such deposits in the low lying and valley areas consist of angular fragments of rocks, gravels, pebbles, silt and clay.

1.5 SCENARIO OF SEISMIC HAZARD IN ASSAM

INTRODUCTION:

Geomorphologically, NE India is located in an earthquake prone zone (zone-V) of the Indian subcontinent. In this region earthquake comes with landsliding flood and along series of smaller magnitude earthquakes. Here earthquakes of upto MM intensity IX can be expected. According to a hazard map by the Global Seismic Hazard Assessment Programme, the state can expect to have a peak gravitational acceleration (PGA) of 0.24g to 0.48g. The region where the highest PGA can be expected is along the state's border with Meghalaya, the site of the Great Indian earthquake of 1897.The area falls in zone-v.

EARTHQUAKE HISTORY

Much of Assam lies in the Bramaputra River Valley, except for a few southern districts. The northern and eastern parts of this valley are bounded by the Himalayan Frontal Thrust (HFF). In the eastern parts along with the HFF, there is the arc of the Lohit and Naga thrusts. Among the large earthquakes, in this region were the events in 1897 and 1950. The 1897 earthquake is well known for the dramatic accounts of violent upthrow during the shock.

SIGNIFICANT EARTHQUAKES IN ASSAM

Both instrumented and non-instrumented events may be listed below. Reported magnitudes are listed for instrumented events while the maximum observed intensities are listed for non-instrumented shocks. Some of the latter might also have magnitudes assigned to them by various authors, in which case the reference is stated.

EARTHQUAKES DURING NON-INSTRUMENTAL PERIOD IN

ASSAM 1548, 1596,1601, 1642, 1663, 1696, 1756, 1772, 1838, & 1841.

EARTHQUAKE DURING INSTRUMENTAL PERIOD IN ASSAM 1869, 1897, 1923,1930,1943, 1947, 1950, 1985, 1984 &1988.

Reported magnitudes for instrumented events are given below

SI.NO	Date	Magnitude	Epicentre
1	**10 th January 1869**	7.5	9.4 Kms North of Kumbhir (Assam)
2	**12 June 1897**	8.7	14 Kms ESE of Sangsik (Meghalaya)
3	**9th september 1923**	7.1	South Meghalaya
4	**2nd July 1930**	7.1	3.9 kms NNW of Dabigiri (Meghalaya)
5	**21 st January 1941**	6.5	Near Tezpur,Assam
6	**23 rd October 1943**	7.2	13.6 kms E of Hojai (Assam)
7	**29th July 1947**	7.7	Arunachal Pradesh
8	**15th August 1950**	8.7	20.7 kms NW of Tajobam,Arunachal Pradesh
9	**21st March 1954**	7.7	Manipur Burma border
10	**1st July 1957**	7.0	Indo Burma border
11	**31st December 1984**	6.0	SSE of Silchar
12	**6th August 1988**	7.3	Indo Burma border

The 1897 earthquake is the 2nd largest earthquake in the recorded history.The earthquake originated on a south-southwest dipping fault,named the oldham fault,bounding the North-Western section of the Shillong Plateau.During the event,the total slip on this fault,amounted to 16 m. which is among the greatest for any known earthquake.The towns of Dhubri,Goalpara,Guwahati and kuch Bihar in Assam and West Bengal was heavily damaged.At Guwahati is located in an earthquake prone zone(zone v as per IS:1893-2002),the earth subsided along the Brahmaputra and several sand vents were formed.The Brahmaputra is also reported to have risen by several mtrs. and even reversed its flow during the shock. The earthquake 15th August 1950 was the 6th largest earthquake of the recorded history.

Though it hit in a mountainous region along India's international border with China, 1500 people were killed and the drainage of the region was greatly affected. The resultant floods were the cause of most of the fatalities aftermath of this earthquake. The initial shock was followed by thousands of aftershocks, some of which were big earthquakes enough to be reckoned. It had a magnitude of 8.7 and struck a relatively sparsely populated region along the Indo-China border. This earthquake is often referred to as the “Assam Earthqake of 1950”.It was also felt throughout Bangladesh, Bhutan and Myanmar. Damage occurred in the entire region as far as Kolkata. It was felt across a wide area of the subcontinent, over an area totalling 4.5 million square miles.

SITE PHOTOGRAPHS

SITE PHOTOGRAPHS

1.6 Test point Locations

As desired *Seven (07) nos.* of bore holes were carried out keeping in view of soil strata so as to ascertain the safe bearing capacity of soil at different depths.

Table: List of Field Test along with co-ordinates and RLs.

Test Point	Co-ordinates	RL of Test Points (m)	Termination Depth from GL (m)
BH-01	N = 2896014.000 E = 0374993.000	46.888 (Bed Level)	30.00
BH-02	N = 2895938.939 E = 0374931.709	49.256	25.00
BH-03	N = 2895873.818 E = 0374877.391	49.473	30.00
BH-04	N = 2895532.000 E = 0374679.000	49.237	30.00
BH-05	N = 2895414.000 E = 0374604.000	49.483	30.00
BH-06	N = 2895396.980 E = 0374625.000	43.945 (Bed Level)	30.00
BH-07	N = 2895073.000 E = 0374386.000	50.361	30.00
SCPT-01	N = 2896027.000 E = 0374978.000	49.868	15.00
SCPT-02	N = 2895871.940 E = 0374875.380	49.475	20.00
ERT-01	N = 2895872.280 E = 0374873.18	49.481	-
FIELD CBR-01	N = 2895541.180 E = 0374784.519	48.011	-
FIELD CBR-02	N = 2895153.590 E = 0374402.985	48.120	-
LAB CBR-01	N = 2895759.340 E = 0374816.408	47.967	-
LAB CBR-02	N = 2895273.140 E = 0374589.350	48.113	-

1.7 Planning And Soil Exploration :

On the basis of nature of work it was decided to carry out **soil** exploration in order to :

a) Obtain **soil** samples, both representative disturbed and undisturbed wherever necessary for classification and other laboratory tests for determining engineering properties of **soil** strata.

b) Obtain soundings of penetration resistance by standard Penetration test in the bore holes.

1.8 Design criteria For Footings :

i) Footing must be safe against **shear failure** of supporting **soil**.

ii) Footing must not settle more than **permissible limit of settlement.**

Net safe bearing capacity 'qns' is obtained by using the S.P.T value of **foundation** & the relevant shear parameters of **soil**. Factor of safety of 2.5 is applied on ultimate bearing capacity as recommended by B.I.S. Net loading intensity 'qns' is obtained by using physical characteristics of **foundation** & relevant compressibility characteristics of the underlying **soil**. The settlement so obtained shall be with in permissible limits as **per** BIS recommendations.

The computed values i.e. **'qns' as the allowable bearing capacity for designing foundations of structure** is adopted after settlement criteria is satisfied or within the permissible limit .

1.9 Sub soil water level

The sub soil water level is encountered at various bore holes as shown in Bore Hole logs.

2. DETAILS OF FIELD WORK

2.1 Boring operation & Sampling :

150 mm dia hole was advanced at the location Using shell and auger/Drilling method.

150 mm nominal dia flush steel casing was advanced with the boring and the full length of the bore hole was encased at each location.

2.2 Disturbed and Undisturbed Sample :

Disturbed and undisturbed **soil** samples were obtained depending upon the nature of **soil** from different depths in the bore hole. The undisturbed samples were collected in sampling tubes. The ends of the tubes are sealed with molten wax to prevent evaporation. These samples were subsequently tested in the laboratory so as to determine the various index and engineering properties of various sub **soil** strata met in the bore holes.

2.3 Standard Penetration Test

Standard Penetration test was performed in the boreholes. The standard split spoon sampler, attached to a string of drill rod was lowered to the bottom of the hole and allowed to rest under self weight. The drill rod was connected to driving assembly which consisted of a hoisting equipments, a drive weight (Hammer) of 65 Kg, and a guide to ensure a 75 cm free fall of hammer on an anvil. The number of hammer blows that were required to penetrate the sampler through three runs of 150 mm each were recorded. Initial driving of 150 mm was disregarded and the number of blows required to drive the sampler through the remaining 300 mm is called BLOW COUNT or PENETRATION NUMBER,N. At the end of the test, the sampler was withdrawn and the **soil** extracted for subsequent **testing** in the laboratory . If the penetration was less than 30 cm for 100 blows, it is considered as refusal and the actual penetration was recorded.

Correction of 'N' value :

In case of Sandy **soil** & Non plastic silts, the observed SPT values, designated as 'N', are to be corrected to account for the following two effects.

(i) Correct to account for the effect of overburden pressure.

N' = Cn x N

Cn' is overburden pressure correction and is calculated from the figure No. 1 given on page No. 8 in IS : 2131-1981.

(ii) Correction due to submergence Correction.

N" = 15 + (N'-15)/2 provided N' is >15 where 'N" is the final corrected value where ever both the overburden and submergence corrections are necessary the overburden correction is applied first correction of N values of Bore Hole.

3.0 LABORATORY TESTS :

3.1 Index Properties

All the relevant classification on the samples obtained from the bore holes were carried out in the laboratory. The index properties obtained from such classification tests at different depths in the bore holes are reported.

3.2 DISTURBED SOIL SAMPLES:

Disturbed **soil** sample collected in field have been tested in laboratory and preparation of sample for the under mentioned tests have been done in accordance with I.S.2720-(Part-I)-1983.

1. Sieve analysis test as **per** I.S. Specification No. 2720 --(Part-IV).

2. Atterburg limit test (L.L. & P.I.) as **per** I.S. Specification No. 2720 --(Part-II).

3. Natural moisture content as **per** I.S.Specification No.2720 – (Part-IV).

4. Particle size analysis test as **per** I.S.Specification No. 2720-(Part-VI).

5. Wet density test as **per** I.S.Specification No 2720- (Part-VI).

6. Dry density test as **per** I.S.Specification No. 2720- (Part-VI)

7. Specific Gravity test as **per** I.S.Specification No-2720-(Part-III)-Sec.2.

3.3 UNDISTURBED SOIL SAMPLES:

Undisturbed **Soil** samples have been prepared in accordance with I.S. Specification No. 2720- (Part-I)- 1983 and tested as follows:-

1. Sieve analysis test as **per** I.S. Specification No. 2720 --(Part-IV).

2. Atterburg limit test (L.L. & P.I.) as **per** I.S. Specification No. 2720 --(Part-II).

3. Natural moisture content as **per** I.S.Specification No.2720 – (Part-IV).

4. Particle size analysis test as **per** I.S.Specification No. 2720-(Part-VI).

5. Wet density test as **per** I.S.Specification No 2720- (Part-VI).

6. Dry density test as **per** I.S.Specification No. 2720- (Part-VI)

7. Specific Gravity test as **per** I.S.Specification No-2720-(Part-III)-Sec.2.

8. Triaxial compression test and determination of shear parameter

   (C & Ø as **per** I.S. XII) & I.S. 2720 – (part – XIII).

9. Consolidation test conducted as **per** I.S Specification No. 2720-(Part-XV).

Calculation of bearing capacity is governed generally by I.S. Specification No . 8009-)Part-I)- 1976, I.S.No.2720- (Part – II)- 1980, I.S. No 6403-1981, I.S. 1904-1978 and I.S. 1080-1985 and other relevant I.S. Codes as well as based on assessment and latest developments.

3.4 DELETERIOUS CHEMICALS:

The nature of strata was fairly identical through the site therefore representative **soil** sample from the site was prepared & tested for deleterious chemicals which may effective the concrete & reinforcement the results are given below :

CHEMICAL ANALYSIS OF SOIL:

SL.No.	Particulars	BH-01	BH-02	BH-03	BH-04	BH-05	BH-06	BH-07
1	pH	5.30	5.50	5.60	5.25	5.35	5.50	5.40
2	Total Sulphate (ppm)	192.18	189.66	190.52	188.65	195.88	186.25	193.66
3	Chloride (%)	0.0270	0.0265	0.0280	0.0269	0.0250	0.0260	0.0270

CHEMICAL ANALYSIS OF WATER:

SL.No.	Particulars	BH-01	BH-02	BH-03	BH-04	BH-05	BH-06	BH-07
1	pH	5.63	5.75	5.65	5.49	5.85	5.55	5.60
2	Total Sulphate (ppm)	24.00	23.50	24.85	25.63	24.55	25.87	24.79
3	Chloride (%)	0.0069	0.0065	0.0062	0.0071	0.0069	0.0068	0.0066

CHEMICAL ANALYSIS OF SOIL & WATER EXTRACT:

SL.No.	Particulars	BH-01	BH-02	BH-03	BH-04	BH-05	BH-06	BH-07
1	pH	6.07	6.11	5.96	6.22	6.10	6.12	6.09
2	Total Sulphate (ppm)	28.80	30.25	26.95	27.52	28.66	26.85	27.49
3	Chloride (%)	0.0078	0.0076	0.0074	0.0071	0.0068	0.0076	0.0079

Above results show that the strata is quite safe for concrete & reinforcement for the site.

Calculation for the corrected N value:(Reffer to BH-01)

The N values obtained from the field SPT has been corrected for the following effects

a) Correction for overburden pressure

N values recorded from the field data at different effective overburden pressures is corrected to a standard effective overburden pressure -

$N' = C_N \times N$

where N' = corrected value of observed N

C_N = correction factor for overburden pressure

= 0.77 log 20/p = 1.04

p = effective overburden pressure at depth in which

N value is estimated in kg/cm2

= 0.90

At depth 2.0 m , N value = 12 , for depth 900 cm

N' = 12 .

STANDARD PENETRATION TEST

The field S.P.T is corrected for both Over burden pressure and for dilatancy (As per IS:2131-1982)

Depth (m)	Bore Hole No.01		Bore Hole No.02		Bore Hole No.03	
	Observed N-value	Corrected N-value	Observed N-value	Corrected N-value	Observed N-value	Corrected N-value
9.0	12	12	-	-	-	-
10.5	22	18	-	-	-	-
12.0	28	21	-	-	-	-
13.5	32	22	-	-	28	20
15.0	37	24	-	-	35	23
16.5	14	12	35	22	39	24
18.0	27	19	41	24	49	28
19.5	34	21	47	26	53	29
21.0	40	23	53	28	57	29
22.5	45	24	58	29	61	30
24.0	53	27	65	31	64	31
25.5	56	27	-	-	67	31
27.0	60	28	-	-	71	32
28.5	65	29	-	-	73	32
30.0	73	31	-	-	69	30

STANDARD PENETRATION TEST

The field S.P.T is corrected for both Over burden pressure and for dilatancy (As per IS:2131-1982)

Depth (m)	Bore Hole No.04		Bore Hole No.05		Bore Hole No.06		Bore Hole No.07	
	Observed N-value	Corrected N-value	Observed N-value	Corrected N-value	Observed N-value	Corrected N-value	Observed N-value	Corrected N-value
15.0	36	23	20	16	-	-	-	-
18.0	40	24	35	22	-	-	-	-
21.0	51	27	41	23	41	23	43	24
24.0	56	28	54	27	51	26	53	27
27.0	57	27	59	28	63	29	57	27
30.0	67	29	72	31	69	30	65	29

PILE LOAD CAPACITY

The safe load carrying capacity of a bored cast in-situ concrete pile passing through clayey soil layer and resting on granular soil has been worked out by using the following formular as per IS: 2911 (Part I/Sec 2) - 2010

$$Q_s = ((Ap(0.5 D \gamma N_\gamma + P_D N_q) + \Sigma^n_{i=1} k P_{Di} \tan \delta A_{si} + \Sigma^n_{i=1} \alpha_i C_i A_{si}) / F) / 1000 \text{ t}$$

Where A_p = Cross sectional area of pile stem at toe level in cm^2

D = Stem diameter in cm

γ = Effective unit weight of soil at pile toe in kgf / cm^3

P_D = Effective overburden pressure at pile toe in kgf / cm^2

$N\gamma$ & N_q = Bearing capacity factors depending upon the angle of internal friction f at toe

α = Reduction factor

C' = Average cohesion of the soil along the pile stem in kgf / cm^2

A_s = Surface area of the stem in cm^2

F = Factor of safety

PILE LOAD CAPACITY CALCULATION

For Borehole No. 01

Length of pile = 2000 cm

D = 40 cm

Effective pile length for overburden pressure = 15 x 40 = 600 cm

γ = 0.001 kgf/cm^3

P_D = 0.60 kgf / cm^2

ϕ = 30 ^{o}

N_γ = 22.40

N_q = 22.0

Ap = (3.1415 / 4) x 40^2 = 1,256.64 cm^2

$\alpha_{i=1}$ = 0.5			
$C_{i=1}$ = 0.130 kgf / cm^2			
Pile shaft length	= 250	cm	**For layer i =1**
$A_{si=1}$ = 31,415.93 cm^2			
$\alpha_1 C_1 As_1$ = 2042.04 kgf / cm^2			
$\alpha_{i=2}$ = 0.5			
$C_{i=2}$ = 0.340 kgf / cm^2			
Pile shaft length	= 300	cm	**For layer i =2**
$A_{si=1}$ = 37,699.11 cm^2			
$\alpha_2 C_2 As_2$ = 6408.85 kgf / cm^2			
$\alpha_{i=3}$ = 0.5			
$C_{i=3}$ = 0.410 kgf / cm^2			
Pile shaft length	= 200	cm	**For layer i =3**
$A_{si=3}$ = 25,132.74 cm^2			
$\alpha_3 C_3 As_3$ = 5152.2 kgf / cm^2			
δ = 30 ^{o}			
K = 1.00			
n = 1		**Layer No.**	
tn = 400.00	cm	**layer thickness**	
D_i = 600.00	cm		
P_{Di} = 0.6000	kgf/cm^2		
A_{si} = 50,265.48	cm^2		
$KP_{Di} \tan\delta A_{si}$ = 17412.47			
δ = 30 ^{o}			
K = 1.00			
n = 2		**Layer No.**	
tn = 300.00	cm	**layer thickness**	
D_i = 600.00	cm		
P_{Di} = 0.6000	kgf/cm^2		
A_{si} = 28,274.33	cm^2		
$KP_{Di} \tan\delta A_{si}$ = 9794.52			

$\Sigma^n_{i=1} \alpha_i C_i A_{si}$ = 13603.10 kgf /cm^2

$\Sigma^n_{i=1} K P_{Di} \tan\delta A_{si}$ = 27206.99 kgf /cm^2

F = 2.5

Qs = ((1,256.64 x (0.5 x 40 x 0.001 x 22.40 + 0.6 x 22) + 27,206.99 + 13,603.10) / 2.5) / 1000

= 23.18 ton

LATERAL PILE LOAD CAPACITY

The lateral capacity of Pile can be determined as per IS 2911(Part 1/sec 2 -2010)

$Q = (12 \times E \times I \times Y)/(L + L_f)^3/(F.O.S=3)$

Where,

Q = Lateral load for the pile

E = Young's modulus of pile material in KN/mm^2

I = Moment of inertia of pile cross section in mm^4

Y = Pile (Fixed) head Deflection = 1.2 cm

L = Depth of fixity of Pile in cm

L_f = Pile length above Ground level in cm

Stifness factor for pile in clay, in m

$R = (EI/KB)^{1/4}$

$E = 5000 \times \sqrt{fck}$ = 29580.40 N/mm^2 f_{ck} = 35 N/mm^2

B = 0.40 m (Dia. Of pile)

k_1 = 5000 KN/m^3

$K = (k_1 \times 0.3)/(1.5 \times B)$ = 2500 KN/m^3

I = 0.001256 m^4

EI = 37.15 N/mm^2 = 37152.98 kN/m^2

R = 0.439 m

Dia. (cm)	I (cm^4)	k Kg/cm^2	L/D	L (cm)	$L+L_f$ (cm)	E (Ton/cm^2)	Y (cm)	Q (Ton)
40	125600.00	5.0	8.00	320	320	295.80	0.40	1.81
50	306640.63	5.0	8.00	400	400	295.80	0.50	2.83
60	635850.00	5.0	8.00	480	480	295.80	0.60	4.08
75	1552368.16	5.0	8.00	600	600	295.80	0.75	6.38
90	3218990.63	5.0	8.00	720	720	295.80	0.90	9.18

UPLIFT CAPACITY OF PILE(IS 2911(Part 1/sec 1 -2010)

Q_u = $W + Q_s$

where

Q_s,Frictional resistance of the pile along the length = $\Sigma^n_{i=1}\alpha_i c_i A_{si} + \Sigma^n_{i=1} K P_{Di} \tan\delta A_{si}$

W	=	weight of the pile			
unit weight of RCC	=	2500	kg/m^3		
W	=	6283.185	kg	Dia of Pile =	400 mm
Qs		40810.09		Length of pile =	20 m
F.O.S	=	3			
Q_u	=	47093.275	kg		
		47.093	ton		
$Q_{u(factored)}$	=	15.70	ton		

PILE LOAD CAPACITY TABLE

Table:2.0

Type of Pile	B.H No.	Length of Pile (m)	Diameter Of Pile (mm)	Pile Load Capacity (ton)		
				Axial	Lateral	Uplift
Bored Cast-in-situ R.C.C Concrete Pile	1	20.0	400	23.18	1.81	15.70
			500	35.98	2.83	22.09
			600	52.86	4.08	29.47
			750	87.26	6.37	42.39
			900	134.46	9.18	57.53
Bored Cast-in-situ R.C.C Concrete Pile	2	18.0	400	21.68	1.81	14.23
			500	33.55	2.83	19.74
			600	49.29	4.08	26.03
			750	81.57	6.37	36.92
			900	126.17	9.18	49.57
Bored Cast-in-situ R.C.C Concrete Pile	3	18.0	400	22.13	1.81	14.61
			500	35.20	2.83	21.11
			600	52.58	4.08	28.76
			750	88.13	6.37	42.38
			900	136.98	9.18	58.57
Bored Cast-in-situ R.C.C Concrete Pile	4	18.0	400	21.84	1.81	14.37
			500	33.76	2.83	19.91
			600	49.55	4.08	26.24
			750	81.89	6.37	37.18
			900	126.55	9.18	49.88
Bored Cast-in-situ R.C.C Concrete Pile	5	18.0	400	22.25	1.81	14.71
			500	34.27	2.83	20.34
			600	50.16	4.08	26.74
			750	82.65	6.37	37.82
			900	127.46	9.18	50.64
Bored Cast-in-situ R.C.C Concrete Pile	6	20.0	400	22.63	1.81	15.24
			500	33.93	2.83	20.38
			600	48.77	4.08	26.06
			750	79.08	6.37	35.58
			900	120.98	9.18	46.30
Bored Cast-in-situ R.C.C Concrete Pile	7	20.0	400	27.49	1.81	19.29
			500	40.00	2.83	25.44
			600	56.06	4.08	32.13
			750	88.19	6.37	43.17
			900	131.90	9.18	55.40

4.0 RECOMMENDATION:

I) For Heavily Loaded Structures:

From field and laboratory investigations,it is found that the soil is unsuitable for shalllow foundation heavily loaded structure, the following recommendations have been made for the purpose of design of foundation at the site.

For the safe design criteria of structure it, is recommended to addopt Cast-in-situ R.C.C pile as tabulated in Pile load capacity table 2.0.

However,the theoretical load carrying capacity of pile is to be verified by conducting load test on pile.

Note:

i) The recommended pile load capacity is considered as lower value as only single bore hole is sinked in the pile group location it may be possible of encounter of loose sand layer.So from the structural safety point of view it is recommended to adopt lower value of pile load capacity.

ii) Contractor shall establish the pile capacities at site by conducting initial pile load tests on tests piles before commencement of pilling works as per IS:2911 Part-IV.Routine pile load test shall be conducted on job piles as per IS:2911 Part-IV.

iii) The concrete shall have a minimum strength of 30 N/mm^2 at 28 days.Ordinary Portland cement/Portland slag cement/Portland Pozzolana cement may be used.The cement content for concrete shall not be less than 400 kg/m^3 with maximum water cement ratio 0.45.Reiforcement steel shall be high strength deformed bar of grade Fe 500 conforming to IS:1786.

iv) Pile shall be designed as per the actual pile head force.

II) Deep excavation:

In case of deep excavation,special measures like side protection supports and appropiate dewatering system i.e well point or deep well shall have to be resorted.It shall be contractor's responsibility to mobilize necessary equipments & men power to carryout deep excavation wherever required without any extra cost and time implication to the owner.

III) Road & Pavement :

For laying pavement,crust formation shall be prepared as per IRC-37-2012. The road and pavement shall be laid as per IRC-37-2012 specification considering a CBR value of 4.0 %.

IV) Minor/Lightly Loaded structures not sensitive to settlement:

A foundation pit of 2.5 m deep shall be made having size more than 250mm (all around) than the foundation dimensions. Base of the foundation pit shall be compacted to 85% of standard Proctor density as per IS:2720 Part-VIII before filling the pit with 300 mm thick sand gravel mix (1:1) laid in layers of maximum 150 mm thick and compacted to 85% of standard Proctor density. On this compacted fill, foundation for these structures may be placed at a depth of 750 mm from FGL for foundation width up to 1.0 m and for pressure not exceeding 3.0 t/m^2.Minimum width of foundation shall be 1.0 m.Backfilling after casting of foundation shall be done as per the compaction criteria.The bearing capacity will be confirmed by conducting plate load test.

V) Aggressiveness of soil and ground water to foundation concrete:

Chemical test on subsoil and ground water samples shows that sulphate and chloride contents are within permissible limit as per IS 456-2000.Hence no special measures for foundation concrete are not required. Ordinary Portland cement/Portland pozzolana cement /Portland slag cement may be used for all substructures concreting works. The minimum cover to reinforcement including links and ties shall be as per IS 456 (latest version).

V) Back Filling:

The soil available in this project area is suitable for back filling. The back filling in foundations may be done with excavated soil as per direction of Engineer-in-Charge .This shall be compacted in layers not exceeding 150 mm thickness to 95% Standard Proctor density as per IS 2720 part-VII.

VI) Reclamation for Low lying Area:

Excavate the slushy /marshy soil,decomposed organic matter mixed with brickbats,broken glass panes,broken earthen posts etc. removal stumps and other deleterious matter in the proposed area first then compact the virgin soil and filled the area with approved soil with γ =1.80 gm/cc in layers not more than 500 mm of each layer up to the finished ground level.After compacting the area the field density will be confirmed by suitable test method.

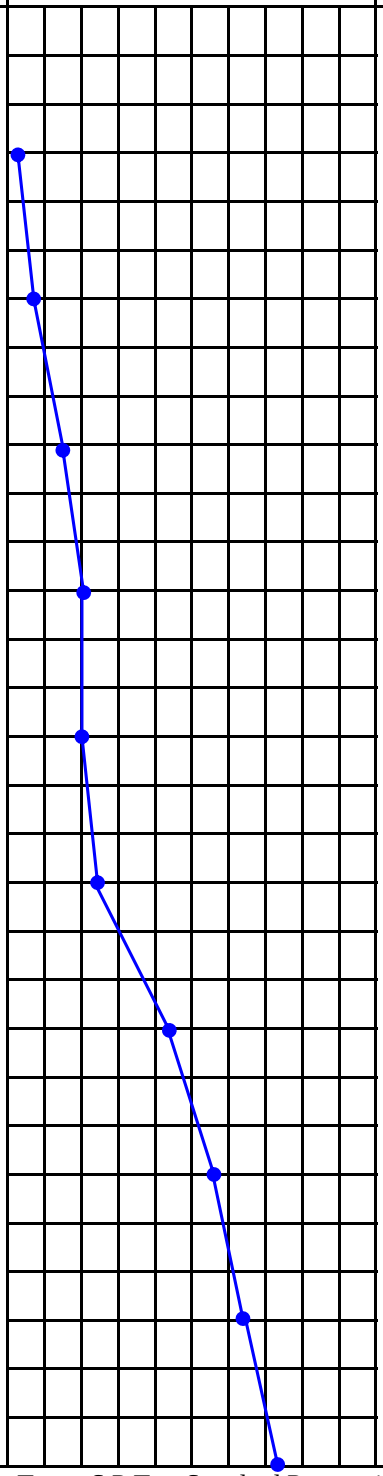
Proposed tests.

- Water Boreholes -
- Land Boreholes -
- Static Cone penetrat
- ERT - 2 Nos.

Type of Boring : Rotary Drilling N = 2896014.00 E = 0374993.00 Ground Elevation: RL- 46.888	BORE HOLE NO. 01 (Water Body)	Date Started : 12.05.2017 Date Completed : 13.05.2017

DESCRIPTION OF STRATA	DEPTH (m)	STRATA	SAMPLE COLLECTED D/S	SAMPLE COLLECTED U/S	GROUND WATER LEVEL	N - VALUE
	0.5					
	1.5		**1.5**			1
Deposited soil black in colour (CI)	2.5					
			3.0			3
	3.5			**V/S**		
Clay grey in colour(CI)	4.5		**4.5**			7
				V/S		
	5.5					
			6.0			10
	6.5			**6.5**		
	7.5		**7.5**			10
Clay brown in colour(CI)				**8.0**		
	8.5					
			9.0			12
	9.5					
Sand brown in colour(SM-SC)	10.5		**10.5**			22
	11.5					
			12.0			28
	12.5					
Sand grey in colour (SM-SC)	13.5		**13.5**			32
	14.5					
	15.0		**15.0**			37

1.50 m from static water surface to bed level



D/S = Disturbed Sample U/S = Undisturbed Sample V/S=Vane Shear Test S.P.T. = Standard Penetration Test

Type of Boring : Rotary Drilling **N = 2896014.00 E = 0374993.00** **Ground Elevation: RL- 46.888**	**BORE HOLE NO. 01 (Water Body)**	**Date Started : 12.05.2017** **Date Completed : 13.05.2017**

DESCRIPTION OF STRATA	DEPTH (m)	STRATA	SAMPLE COLLECTED D/S	SAMPLE COLLECTED U/S	GROUND WATER LEVEL	Depth - N-value curve (10, 20, 30, 40)	N - VALUE
Silty clay brown in colour (CI)	15.5						
	16.5		**16.5**				14
	17.5						
			18.0				27
	18.5						
	19.5		**19.5**				34
	20.5						
			21.0				40
	21.5						
Sand brown in colour (SW-SM)	22.5		**22.5**		**1.50 m from static water surface to bed level**		45
	23.5						
			24.0				53
	24.5						
	25.5		**25.5**				56
	26.5						
			27.0				60
	27.5						
	28.5		**28.5**				65
	29.5						
	30.0		**30.0**				73

D/S = Disturbed Sample U/S = Undisturbed Sample V/S=Vane Shear Test S.P.T. = Standard Penetration Test

Type of Boring : Rotary Drilling N = 2895938.939 E = 0374931.709 Ground Elevation: RL- 49.256	BORE HOLE NO. 02	Date Started : 14.05.2017 Date Completed : 15.05.2017

DESCRIPTION OF STRATA	DEPTH (m)	STRATA	SAMPLE COLLECTED D/S	SAMPLE COLLECTED U/S	GROUND WATER LEVEL	Depth - N-value curve (10 20 30 40)	N - VALUE
	0.5						
	1.5		1.5				2
Fillup soil brown in colour(CI)	2.5						
			3.0				3
	3.5			V/S			
Clay brown in colour(CI)	4.5		4.5				4
				V/S			
	5.5						
			6.0				5
	6.5			V/S	0.40 m Below		
Clay grey in colour(CI)	7.5		7.5				7
				8.0			
	8.5						
			9.0				9
	9.5			9.5			
	10.5		10.5				17
				11.0			
	11.5						
			12.0				19
Silty clay brown in colour (CI)	12.5						
				12.5			
	13.5		13.5				22
	14.5						
	15.0		15.0				28

D/S = Disturbed Sample U/S = Undisturbed Sample V/S=Vane Shear Test S.P.T. = Standard Penetration Test

Type of Boring : Rotary Drilling **N = 2895938.939 E = 0374931.709** **Ground Elevation: RL- 49.256**	**BORE HOLE NO. 02**	**Date Started : 14.05.2017** **Date Completed : 15.05.2017**

DESCRIPTION OF STRATA	DEPTH (m)	STRATA	SAMPLE COLLECTED D/S	SAMPLE COLLECTED U/S	GROUND WATER LEVEL	Depth - N-value curve (10, 20, 30, 40)	N - VALUE
	15.5						
	16.5		**16.5**				35
	17.5						
			18.0				41
	18.5						
Sand brown in colour (SM-SC)	19.5		**19.5**				47
	20.5						
			21.0				53
	21.5				**0.40 m Below**		
	22.5		**22.5**				58
	23.5						
			24.0				65
	24.5						
	25.0						

D/S = Disturbed Sample U/S = Undisturbed Sample V/S=Vane Shear Test S.P.T. = Standard Penetration Test

Type of Boring : Rotary Drilling N = 2895873.818 E = 0374877.391 Ground Elevation: RL- 49.473	BORE HOLE NO. 03	Date Started : 13.05.2017 Date Completed : 16.05.2017

DESCRIPTION OF STRATA	DEPTH (m)	STRATA	SAMPLE COLLECTED D/S	SAMPLE COLLECTED U/S	GROUND WATER LEVEL	Depth - N-value curve (10 20 30 40)	N - VALUE
	0.5						
	1.5		1.5				-
Fillup soil	2.5						
			3.0				1
	3.5			V/S			
	4.5		4.5				3
				V/S			
	5.5						
			6.0				5
	6.5			6.5	Below 0.55 m		
	7.5		7.5				7
				8.0			
	8.5						
			9.0				8
	9.5			9.5			
Clay grey in colour(CI)							
	10.5		10.5				10
				11.0			
	11.5						
			12.0				12
	12.5			12.5			
	13.5		13.5				21
Sand brown in colour (SM-SC)							
	14.5						
	15.0		15.0				28

D/S = Disturbed Sample U/S = Undisturbed Sample V/S=Vane Shear Test S.P.T. = Standard Penetration Test

Type of Boring : Rotary Drilling **N = 2895873.818 E = 0374877.391** **Ground Elevation: RL- 49.473**	**BORE HOLE NO. 03**	**Date Started : 13.05.2017** **Date Completed : 16.05.2017**

DESCRIPTION OF STRATA	DEPTH (m)	STRATA	SAMPLE COLLECTED D/S	SAMPLE COLLECTED U/S	GROUND WATER LEVEL	Depth - N-value curve (10 20 30 40)	N - VALUE
	15.5						
	16.5		**16.5**				35
Sand grey in colour (SM-SC)	17.5						
			18.0				39
	18.5						
	19.5		**19.5**				49
	20.5						
			21.0				53
	21.5				**Below 0.55 m**		
Sand brown in colour (SW-SM)	22.5		**22.5**				57
	23.5						
			24.0				61
	24.5						
	25.5		**25.5**				64
	26.5						
			27.0				67
	27.5						
	28.5		**28.5**				71
	29.5						
	30.0		**30.0**				73

D/S = Disturbed Sample U/S = Undisturbed Sample V/S=Vane Shear Test S.P.T. = Standard Penetration Test

Type of Boring : Rotary Drilling **N = 2895532.00 E = 0374679.00** **Ground Elevation: RL- 49.237**	**BORE HOLE NO. 04**	**Date Started : 05.05.2017** **Date Completed : 07.05.2017**

DESCRIPTION OF STRATA	DEPTH (m)	STRATA	SAMPLE COLLECTED D/S	SAMPLE COLLECTED U/S	GROUND WATER LEVEL	Depth - N-value curve (10 20 30 40)	N - VALUE
	0.5						
	1.5						
Fillup Soil	2.5						
			3.0				2
	3.5			**3.5**			
Clay black in colour(CI)	4.5						
				5.0			
	5.5						
			6.0				4
	6.5			**6.5**	**Below 0.60 m**		
	7.5		**D/S**				
Clay grey in colour(CI)				**8.0**			
	8.5						
			9.0				6
	9.5			**9.5**			
	10.5						
				11.0			
	11.5						
			12.0				
	12.5						27
Clay brown in colour (CI)	13.5		**D/S**				
	14.5						
	15.0		**15.0**				36

D/S = Disturbed Sample U/S = Undisturbed Sample V/S=Vane Shear Test S.P.T. = Standard Penetration Test

Type of Boring : Rotary Drilling N = 2895532.00 E = 0374679.00 Ground Elevation: RL- 49.237	BORE HOLE NO. 04	Date Started : 05.05.2017 Date Completed : 07.05.2017

DESCRIPTION OF STRATA	DEPTH (m)	STRATA	SAMPLE COLLECTED D/S	SAMPLE COLLECTED U/S	GROUND WATER LEVEL	Depth - N-value curve (10 20 30 40)	N - VALUE
	15.5						
	16.5		D/S				
	17.5						
			18.0				40
	18.5						
	19.5						
	20.5						
			21.0				51
	21.5						
Sand brown in colour (SM-SC)	22.5				Below 0.60 m		
	23.5						
			24.0				56
	24.5						
	25.5						
	26.5						
			27.0				57
	27.5						
	28.5						
	29.5						
	30.0		30.0				67

D/S = Disturbed Sample U/S = Undisturbed Sample V/S=Vane Shear Test S.P.T. = Standard Penetration Test

Type of Boring : Rotary Drilling N = 2895414.00 E = 0374604.00 Ground Elevation: RL- 49.483	BORE HOLE NO. 05	Date Started : 10.05.2017 Date Completed : 11.05.2017

DESCRIPTION OF STRATA	DEPTH (m)	STRATA	SAMPLE COLLECTED D/S	SAMPLE COLLECTED U/S	GROUND WATER LEVEL	Depth - N-value curve (10 20 30 40)	N - VALUE
Fillup Soil	0.5						
	1.5						
	2.5						
Clay black in colour(CI)	3.5		3.0	3.5			3
	4.5						
	5.5						
Clay grey in colour(CI)	6.5		6.0	6.5	Below 0.65 m		4
	7.5						
	8.5			8.0			
	9.5		9.0	9.5			6
	10.5						
	11.5			11.0			
	12.5		12.0				11
Clay brown in colour (CI)	13.5		D/S				
	14.5						
	15.0		15.0				20

D/S = Disturbed Sample U/S = Undisturbed Sample V/S=Vane Shear Test S.P.T. = Standard Penetration Test

Type of Boring : Drilling N = 2895414.00 E = 0374604.00 Ground Elevation: RL- 49.483	BORE HOLE NO. 05	Date Started : 10.05.2017 Date Completed : 11.05.2017

DESCRIPTION OF STRATA	DEPTH (m)	STRATA	SAMPLE COLLECTED D/S	SAMPLE COLLECTED U/S	GROUND WATER LEVEL	Depth - N-value curve (10 20 30 40)	N - VALUE
	15.5						
	16.5						
	17.5						
			18.0				35
	18.5						
	19.5		**D/S**				
	20.5						
			21.0				41
	21.5						
Sand brown in colour (SW-SM)	22.5				**Below 0.65 m**		
	23.5						
			24.0				54
	24.5						
			D/S				
	25.5						
	26.5						
			27.0				59
	27.5						
	28.5						
	29.5						
	30.0		**30.0**				72

D/S = Disturbed Sample U/S = Undisturbed Sample V/S=Vane Shear Test S.P.T. = Standard Penetration Test

Type of Boring : Rotary Drilling N = 2895396.980 E = 0374625.530 Ground Elevation: RL- 43.945	BORE HOLE NO. 06 (Water Body)	Date Started : 06.05.2017 Date Completed : 08.05.2017

DESCRIPTION OF STRATA	DEPTH (m)	STRATA	SAMPLE COLLECTED D/S	SAMPLE COLLECTED U/S	GROUND WATER LEVEL	Depth - N-value curve (10 20 30 40)	N - VALUE
Clay black in colour(CI)	0.5				3.40 m from static water surface to bed level		
	1.5						
	2.5						
			3.0				3
	3.5			3.5			
	4.5						
				5.0			
	5.5						
			6.0				4
	6.5			6.5			
	7.5		D/S				
Clay grey in colour(CI)				8.0			
	8.5						
			9.0				5
	9.5						
				9.5			
	10.5						
				11.0			
	11.5						
			12.0				16
	12.5						
	13.5						
Clay brown in colour (CI)							
	14.5						
	15.0		15.0				27

D/S = Disturbed Sample U/S = Undisturbed Sample V/S=Vane Shear Test S.P.T. = Standard Penetration Test

Type of Boring : Rotary Drilling N = 2895396.980 E = 0374625.530 Ground Elevation: RL- 43.945	BORE HOLE NO. 06 (Water Body)	Date Started : 06.05.2017 Date Completed : 08.05.2017

DESCRIPTION OF STRATA	DEPTH (m)	STRATA	SAMPLE COLLECTED D/S	SAMPLE COLLECTED U/S	GROUND WATER LEVEL	Depth - N-value curve (10, 20, 30, 40)	N - VALUE
Clay brown in colour (CI)	15.5				3.40 m from static water surface to bed level		
	16.5		D/S				
	17.5						
	18.0						36
	18.5						
	19.5						
	20.5						
	21.0						41
	21.5						
Sand brown in colour (SW-SM)	22.5						
	23.5						
	24.0						51
	24.5		D/S				
	25.5						
	26.5						
	27.0						63
	27.5						
	28.5						
	29.5						
	30.0		30.0				69

D/S = Disturbed Sample U/S = Undisturbed Sample V/S=Vane Shear Test S.P.T. = Standard Penetration Test

Type of Boring : Rotary Drilling **N = 2895073.00 E = 0374386.00** **Ground Elevation: RL- 50.361**	**BORE HOLE NO. 07**	**Date Started : 03.05.2017** **Date Completed : 05.05.2017**

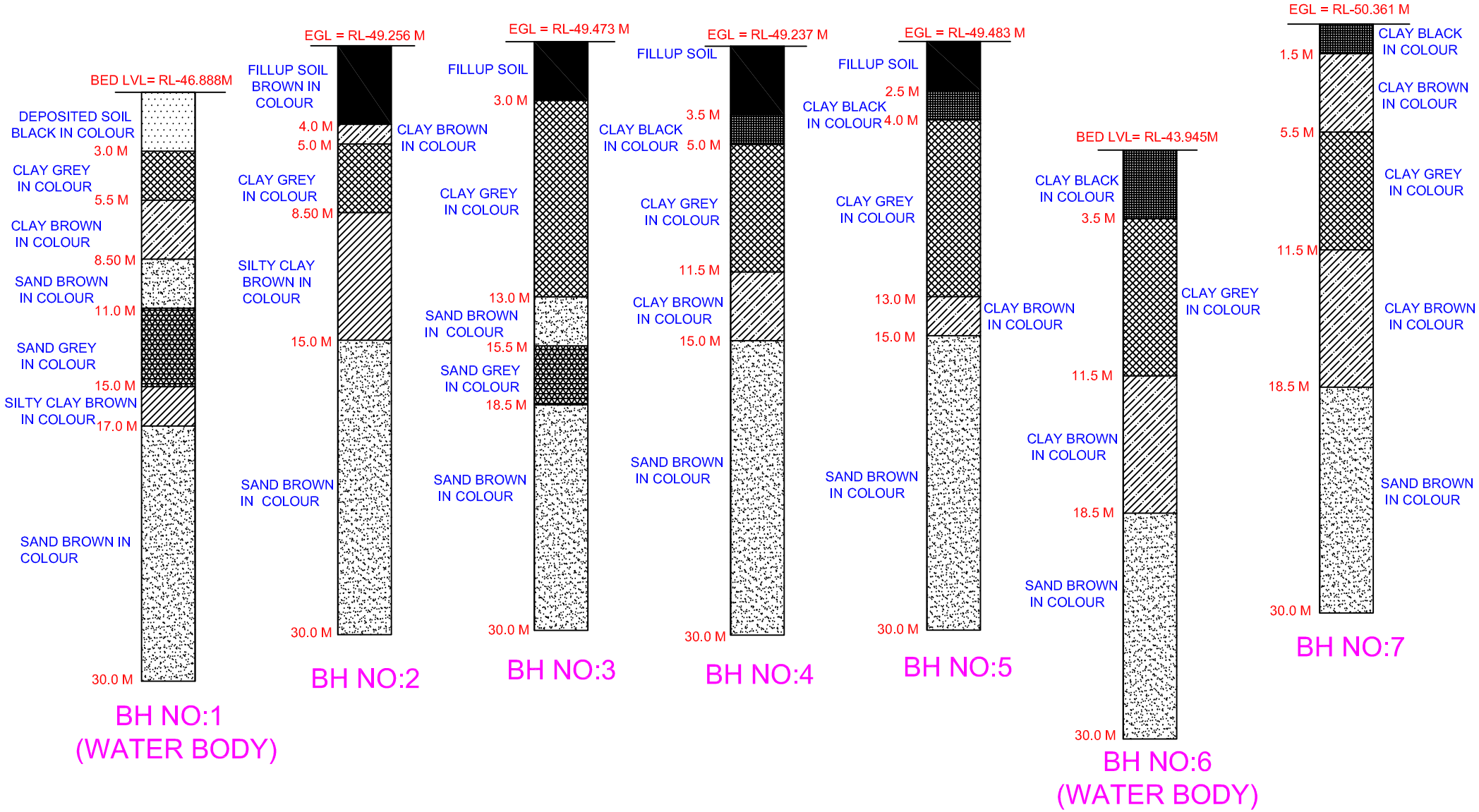
DESCRIPTION OF STRATA	DEPTH (m)	STRATA	SAMPLE COLLECTED D/S	SAMPLE COLLECTED U/S	GROUND WATER LEVEL	Depth - N-value curve (10 20 30 40)	N - VALUE
Clay black in colour(CI)	0.5						
	1.5		**D/S**				
				2.0			
	2.5						
			3.0				4
	3.5			**3.5**			
Clay brown in colour(CI)							
	4.5		**D/S**				
				5.0			
	5.5						
			6.0				6
	6.5			**6.5**	**Below 2.50 m**		
	7.5		**D/S**				
Clay grey in colour(CI)				**8.0**			
	8.5						
			9.0				8
	9.5						
				9.5			
	10.5						
	11.5						
			12.0				14
	12.5						
	13.5						
Clay brown in colour (CI)							
	14.5						
	15.0		**15.0**				25

D/S = Disturbed Sample U/S = Undisturbed Sample V/S=Vane Shear Test S.P.T. = Standard Penetration Test

Type of Boring : Rotary Drilling **N = 2895073.00 E = 0374386.00** **Ground Elevation: RL- 50.361**	**BORE HOLE NO. 07**	**Date Started : 03.05.2017** **Date Completed : 05.05.2017**

DESCRIPTION OF STRATA	DEPTH (m)	STRATA	SAMPLE COLLECTED D/S	SAMPLE COLLECTED U/S	GROUND WATER LEVEL	Depth - N-value curve (10 20 30 40)	N - VALUE
Clay brown in colour (CI)	15.5						
	16.5						
	17.5						
			18.0				38
	18.5						
	19.5						
	20.5						
			21.0				43
	21.5				**Below 2.50 m**		
Sand brown in colour (SW-SM)	22.5						
	23.5						
			24.0				53
	24.5						
			D/S				
	25.5						
	26.5						
			27.0				57
	27.5						
	28.5						
	29.5						
	30.0		**30.0**				65

D/S = Disturbed Sample U/S = Undisturbed Sample V/S=Vane Shear Test S.P.T. = Standard Penetration Test


BED LVL= RL-46.888M
DEPOSITED SOIL BLACK IN COLOUR
3.0 M
CLAY GREY IN COLOUR
5.5 M
CLAY BROWN IN COLOUR
8.50 M
SAND BROWN IN COLOUR
11.0 M
SAND GREY IN COLOUR
15.0 M
SILTY CLAY BROWN IN COLOUR
17.0 M
SAND BROWN IN COLOUR
30.0 M
BH NO:1
(WATER BODY)
EGL = RL-49.256 M
FILLUP SOIL BROWN IN COLOUR
4.0 M
5.0 M
CLAY BROWN IN COLOUR
CLAY GREY IN COLOUR
8.50 M
SILTY CLAY BROWN IN COLOUR
15.0 M
SAND BROWN IN COLOUR
30.0 M
BH NO:2
EGL = RL-49.473 M
FILLUP SOIL
3.0 M
CLAY GREY IN COLOUR
13.0 M
SAND BROWN IN COLOUR
15.5 M
SAND GREY IN COLOUR
18.5 M
SAND BROWN IN COLOUR
30.0 M
BH NO:3
EGL = RL-49.237 M
FILLUP SOIL
3.5 M
CLAY BLACK IN COLOUR
5.0 M
CLAY GREY IN COLOUR
11.5 M
CLAY BROWN IN COLOUR
15.0 M
SAND BROWN IN COLOUR
30.0 M
BH NO:4
EGL = RL-49.483 M
FILLUP SOIL
2.5 M
CLAY BLACK IN COLOUR
4.0 M
CLAY GREY IN COLOUR
13.0 M
CLAY BROWN IN COLOUR
15.0 M
SAND BROWN IN COLOUR
30.0 M
BH NO:5
BED LVL= RL-43.945M
CLAY BLACK IN COLOUR
3.5 M
CLAY GREY IN COLOUR
11.5 M
CLAY BROWN IN COLOUR
18.5 M
SAND BROWN IN COLOUR
30.0 M
BH NO:6
(WATER BODY)
EGL = RL-50.361 M
CLAY BLACK IN COLOUR
1.5 M
CLAY BROWN IN COLOUR
5.5 M
CLAY GREY IN COLOUR
11.5 M
CLAY BROWN IN COLOUR
18.5 M
SAND BROWN IN COLOUR
30.0 M
BH NO:7

PHYSICAL PROPERTIES

Bore Hole No.	Depth (m)	Type of Sample	Moisture Content (%)	Specific gravity	Bulk Density (gm/cc)	Dry Density (gm/cc)	Void Ratio
1	3.0	SPT	27.11	2.65	-	-	-
	4.5	SPT	29.63	2.65	-	-	-
	6.0	SPT	27.21	2.66	-	-	-
	6.5	UDS	26.38	2.66	1.92	1.52	0.75
	7.5	SPT	24.52	2.66	-	-	-
	8.0	UDS	26.36	2.65	1.94	1.54	0.73
	9.0	SPT	25.92	2.66	-	-	-
	10.5	SPT	23.65	2.65	-	-	-
	12.0	SPT	22.14	2.67	-	-	-
	13.5	SPT	23.58	2.66	-	-	-
	15.0	SPT	21.80	2.66	-	-	-
	16.5	SPT	21.54	2.66	-	-	-
	18.0	SPT	20.69	2.67	-	-	-
	19.5	SPT	20.74	2.66	-		-
	24.0	SPT	19.65	2.66	-	-	-
	27.0	SPT	23.87	2.67	-	-	-
	30.0	SPT	21.51	2.67	-	-	-

PHYSICAL PROPERTIES

Bore Hole No.	Depth (m)	Type of Sample	Moisture Content (%)	Specific gravity	Bulk Density (gm/cc)	Dry Density (gm/cc)	Void Ratio
2	3.0	SPT	31.89	2.65	-	-	-
	4.5	SPT	32.65	2.66	-	-	-
	6.0	SPT	32.04	2.66	-	-	-
	7.5	SPT	29.18	2.66	-	-	-
	8.0	UDS	27.85	2.65	1.91	1.49	0.77
	9.0	SPT	28.26	2.66	-	-	-
	9.5	UDS	27.44	2.66	1.92	1.51	0.77
	10.5	SPT	28.65	2.65	-	-	-
	11.0	UDS	27.19	2.65	1.95	1.53	0.73
	12.0	SPT	30.87	2.67	-	-	-
	12.5	UDS	29.23	2.66	1.94	1.50	0.77
	13.5	SPT	30.33	2.66	-	-	-
	15.0	SPT	25.62	2.66	-	-	-
	16.5	SPT	23.64	2.67	-	-	-
	18.0	SPT	22.52	2.67	-	-	-
	19.5	SPT	21.67	2.66	-		-
	24.0	SPT	20.59	2.66	-	-	-

PHYSICAL PROPERTIES

Bore Hole No.	Depth (m)	Type of Sample	Moisture Content (%)	Specific gravity	Bulk Density (gm/cc)	Dry Density (gm/cc)	Void Ratio
3	3.0	SPT	33.52	2.66	-	-	-
	4.5	SPT	31.25	2.65	-	-	-
	6.0	SPT	30.63	2.66	-	-	-
	6.5	UDS	31.41	2.64	1.89	1.44	0.84
	7.5	SPT	29.63	2.65	-	-	-
	8.0	UDS	28.65	2.66	1.90	1.48	0.80
	9.0	SPT	27.45	2.67	-	-	-
	9.5	UDS	29.31	2.66	1.92	1.48	0.79
	10.5	SPT	28.52	2.65	-	-	-
	11.0	UDS	29.22	2.65	1.94	1.50	0.77
	12.0	SPT	27.45	2.67	-	-	-
	12.5	UDS	28.13	2.67	1.94	1.51	0.76
	13.5	SPT	23.52	2.66	-	-	-
	15.0	SPT	22.47	2.67	-	-	-
	16.5	SPT	21.85	2.67	-	-	-
	18.0	SPT	20.42	2.67	-	-	-
	19.5	SPT	21.52	2.66	-		-
	24.0	SPT	20.63	2.66	-	-	-
	27.0	SPT	21.85	2.67	-	-	-
	30.0	SPT	20.93	2.67	-	-	-

PHYSICAL PROPERTIES

Bore Hole No.	Depth (m)	Type of Sample	Moisture Content (%)	Specific gravity	Bulk Density (gm/cc)	Dry Density (gm/cc)	Void Ratio
4	3.0	SPT	38.68	2.65	-	-	-
	3.5	UDS	31.22	2.65	1.88	1.43	0.85
	5.0	UDS	30.97	2.66	1.88	1.44	0.85
	6.0	SPT	30.68	2.65	-	-	-
	6.5	UDS	31.28	2.66	1.89	1.44	0.85
	7.5	DS	32.68	2.66	-	-	-
	8.0	UDS	28.50	2.65	1.89	1.47	0.80
	9.0	SPT	30.19	2.66	-	-	-
	9.5	UDS	26.19	2.67	1.91	1.51	0.76
	11.0	UDS	29.87	2.65	1.92	1.48	0.79
	12.0	SPT	30.45	2.67	-	-	-
	13.5	DS	29.68	2.66	-	-	-
	15.0	SPT	27.53	2.66	-	-	-
	16.5	DS	25.85	2.66	-	-	-
	18.0	SPT	24.14	2.67	-	-	-
	21.0	SPT	23.54	2.66	-		-
	24.0	SPT	21.21	2.65	-	-	-
	27.0	SPT	20.58	2.66	-	-	-
	30.0	SPT	21.85	2.66	-	-	-

PHYSICAL PROPERTIES

Bore Hole No.	Depth (m)	Type of Sample	Moisture Content (%)	Specific gravity	Bulk Density (gm/cc)	Dry Density (gm/cc)	Void Ratio
5	3.0	SPT	32.02	2.64	-	-	-
	3.5	UDS	30.74	2.65	1.88	1.44	0.84
	6.0	SPT	29.52	2.65	-	-	-
	6.5	UDS	27.77	2.65	1.89	1.48	0.79
	8.0	UDS	28.15	2.66	1.90	1.48	0.79
	9.0	SPT	30.35	2.66	-	-	-
	9.5	UDS	28.76	2.66	1.90	1.48	0.80
	11.0	UDS	26.03	2.65	1.90	1.51	0.76
	12.0	SPT	30.07	2.67	-	-	-
	13.5	DS	27.58	2.66	-	-	-
	15.0	SPT	20.32	2.65	-	-	-
	18.0	SPT	22.36	2.67	-	-	-
	19.5	DS	24.71	2.67	-	-	-
	21.0	SPT	22.85	2.67	-	-	-
	24.0	SPT	20.57	2.66	-	-	-
	25.0	DS	21.35	2.67	-	-	-
	27.0	SPT	20.85	2.67	-	-	-
	30.0	SPT	26.28	2.67	-	-	-

PHYSICAL PROPERTIES

Bore Hole No.	Depth (m)	Type of Sample	Moisture Content (%)	Specific gravity	Bulk Density (gm/cc)	Dry Density (gm/cc)	Void Ratio
6	3.0	SPT	35.63	2.66	-	-	-
	3.5	UDS	33.54	2.66	1.87	1.40	0.90
	5.0	UDS	34.02	2.66	1.88	1.40	0.90
	6.0	SPT	35.38	2.65	-	-	-
	6.5	UDS	33.73	2.65	1.88	1.41	0.89
	7.5	DS	30.51	2.66	-	-	-
	8.0	UDS	29.91	2.65	1.89	1.45	0.82
	9.0	SPT	30.44	2.65	-	-	-
	9.5	UDS	29.61	2.66	1.92	1.48	0.80
	11.0	UDS	30.22	2.66	1.94	1.49	0.79
	12.0	SPT	31.92	2.67	-	-	-
	15.0	SPT	26.35	2.66	-	-	-
	16.5	DS	25.41	2.67	-	-	-
	18.0	SPT	24.87	2.67	-	-	-
	21.0	SPT	25.32	2.66	-	-	-
	24.0	SPT	23.05	2.67	-	-	-
	25.0	DS	21.52	2.66	-	-	-
	27.0	SPT	22.39	2.66	-	-	-
	30.0	SPT	20.47	2.67	-	-	-

PHYSICAL PROPERTIES

Bore Hole No.	Depth (m)	Type of Sample	Moisture Content (%)	Specific gravity	Bulk Density (gm/cc)	Dry Density (gm/cc)	Void Ratio
7	1.5	DS	33.65	2.66	-	-	-
	2.0	UDS	32.14	2.66	1.86	1.41	0.89
	3.0	SPT	32.81	2.66	-	-	-
	3.5	UDS	31.58	2.66	1.87	1.42	0.87
	4.5	DS	28.69	2.66	-	-	-
	5.0	UDS	29.82	2.66	1.88	1.45	0.84
	6.0	SPT	32.56	2.65	-	-	-
	6.5	UDS	31.47	2.65	1.88	1.43	0.85
	7.5	DS	29.38	2.66	-	-	-
	8.0	UDS	29.55	2.65	1.91	1.47	0.80
	9.0	SPT	32.21	2.65	-	-	-
	9.5	UDS	30.58	2.66	1.93	1.48	0.80
	12.0	SPT	31.54	2.67	-	-	-
	15.0	SPT	25.63	2.66	-	-	-
	18.0	SPT	23.14	2.67	-	-	-
	21.0	SPT	22.58	2.66	-	-	-
	24.0	SPT	20.57	2.67	-	-	-
	25.0	DS	22.47	2.66	-	-	-
	27.0	SPT	20.69	2.66	-	-	-
	30.0	SPT	21.74	2.67	-	-	-

Particle Size Analysis

Bore Hole No.	Depth (m)	Clay (%)	Silt (%)	Fine Sand (%)	Medium Sand (%)	Coarse Sand (%)	Gravel (%)
1	3.0	71.00	17.00	12.00	-	-	-
	4.5	73.00	13.00	14.00	-	-	-
	6.0	75.00	12.00	13.00	-	-	-
	7.5	70.00	13.00	17.00	-	-	-
	9.0	6.00	8.00	86.00	-	-	-
	10.5	7.00	6.00	87.00	-	-	-
	12.0	7.00	10.00	83.00	-	-	-
	13.5	8.00	12.00	80.00	-	-	-
	15.0	5.00	5.00	90.00	-	-	-
	16.5	39.00	52.00	9.00	-	-	-
	18.0	6.00	8.00	86.00	-	-	-
	19.5	6.00	8.00	86.00	-	-	-
	21.0	5.00	6.00	89.00	-	-	-
	24.0	7.00	5.00	88.00	-	-	-
	27.0	6.00	7.00	87.00	-	-	-
	30.0	5.00	8.00	87.00	-	-	-

Particle Size Analysis

Bore Hole No.	Depth (m)	Clay (%)	Silt (%)	Fine Sand (%)	Medium Sand (%)	Coarse Sand (%)	Gravel (%)
2	3.0	73.00	15.00	12.00	-	-	-
	4.5	75.00	14.00	11.00	-	-	-
	6.0	73.00	15.00	12.00	-	-	-
	7.5	70.00	13.00	17.00	-	-	-
	9.0	73.00	14.00	13.00	-	-	-
	10.5	71.00	13.00	16.00	-	-	-
	12.0	72.00	15.00	13.00	-	-	-
	13.5	75.00	11.00	14.00	-	-	-
	15.0	71.00	13.00	16.00	-	-	-
	16.5	6.00	10.00	84.00	-	-	-
	18.0	5.00	6.00	89.00	-	-	-
	19.5	7.00	9.00	84.00	-	-	-
	21.0	6.00	8.00	86.00	-	-	-
	24.0	3.00	7.00	90.00	-	-	-

Particle Size Analysis

Bore Hole No.	Depth (m)	Clay (%)	Silt (%)	Fine Sand (%)	Medium Sand (%)	Coarse Sand (%)	Gravel (%)
3	3.0	76.00	12.00	12.00	-	-	-
	4.5	72.00	11.00	17.00	-	-	-
	6.0	74.00	10.00	16.00	-	-	-
	7.5	71.00	13.00	16.00	-	-	-
	9.0	73.00	12.00	15.00	-	-	-
	10.5	72.00	14.00	14.00	-	-	-
	12.0	71.00	12.00	17.00	-	-	-
	13.5	6.00	8.00	86.00	-	-	-
	15.0	8.00	6.00	86.00	-	-	-
	16.5	6.00	9.00	85.00	-	-	-
	18.0	5.00	7.00	88.00	-	-	-
	19.5	5.00	6.00	89.00	-	-	-
	21.0	4.00	5.00	91.00	-	-	-
	24.0	3.00	8.00	89.00	-	-	-
	27.0	4.00	6.00	90.00	-	-	-
	30.0	5.00	8.00	87.00	-	-	-

Particle Size Analysis

Bore Hole No.	Depth (m)	Clay (%)	Silt (%)	Fine Sand (%)	Medium Sand (%)	Coarse Sand (%)	Gravel (%)
4	3.0	75.00	16.00	9.00	-	-	-
	6.0	72.00	21.00	7.00	-	-	-
	7.5	74.00	19.00	7.00	-	-	-
	9.0	73.00	22.00	5.00	-	-	-
	12.0	71.00	25.00	4.00	-	-	-
	13.5	72.00	20.00	8.00	-	-	-
	15.0	75.00	17.00	8.00	-	-	-
	16.5	3.00	8.00	89.00	-	-	-
	18.0	7.00	7.00	86.00	-	-	-
	21.0	5.00	7.00	88.00	-	-	-
	24.0	4.00	4.00	92.00	-	-	-
	27.0	3.00	10.00	87.00	-	-	-
	30.0	1.00	6.00	93.00	-	-	-

Particle Size Analysis

Bore Hole No.	Depth (m)	Clay (%)	Silt (%)	Fine Sand (%)	Medium Sand (%)	Coarse Sand (%)	Gravel (%)
5	3.0	82.00	11.00	7.00	-	-	-
	6.0	79.00	17.00	4.00	-	-	-
	9.0	78.00	19.00	3.00	-	-	-
	12.0	80.00	12.00	8.00	-	-	-
	13.5	83.00	6.00	11.00	-	-	-
	15.0	76.00	21.00	3.00	-	-	-
	18.0	5.00	5.00	90.00	-	-	-
	19.5	6.00	5.00	89.00	-	-	-
	21.0	4.00	6.00	90.00	-	-	-
	24.0	5.00	4.00	91.00	-	-	-
	25.0	6.00	4.00	90.00	-	-	-
	27.0	4.00	5.00	91.00	-	-	-
	30.0	3.00	3.00	94.00	-	-	-

Particle Size Analysis

Bore Hole No.	Depth (m)	Clay (%)	Silt (%)	Fine Sand (%)	Medium Sand (%)	Coarse Sand (%)	Gravel (%)
6	3.0	73.00	18.00	9.00	-	-	-
	6.0	74.00	14.00	12.00	-	-	-
	7.5	75.00	13.00	12.00	-	-	-
	9.0	70.00	17.00	13.00	-	-	-
	12.0	76.00	14.00	10.00	-	-	-
	15.0	65.00	21.00	14.00	-	-	-
	16.5	72.00	17.00	11.00	-	-	-
	18.0	69.00	20.00	11.00	-	-	-
	21.0	17.00	11.00	72.00	-	-	-
	24.0	7.00	4.00	89.00	-	-	-
	25.0	3.00	6.00	91.00	-	-	-
	27.0	5.00	5.00	90.00	-	-	-
	30.0	5.00	6.00	89.00	-	-	-

Particle Size Analysis

Bore Hole No.	Depth (m)	Clay (%)	Silt (%)	Fine Sand (%)	Medium Sand (%)	Coarse Sand (%)	Gravel (%)
7	1.5	80.00	6.00	14.00	-	-	-
	3.0	79.00	12.00	9.00	-	-	-
	4.5	76.00	6.00	18.00	-	-	-
	6.0	72.00	16.00	12.00	-	-	-
	7.5	60.00	29.00	11.00	-	-	-
	9.0	65.00	22.00	13.00	-	-	-
	12.0	10.00	6.00	84.00	-	-	-
	15.0	10.00	4.00	86.00	-	-	-
	18.0	6.00	5.00	89.00	-	-	-
	21.0	8.00	6.00	86.00	-	-	-
	24.0	9.00	5.00	86.00	-	-	-
	25.0	6.00	5.00	89.00	-	-	-
	27.0	8.00	3.00	89.00	-	-	-
	30.0	7.00	3.00	90.00	-	-	-

ATTERBERG LIMITS

Bore Hole No.	Depth (m)	Liquid Limit	Plastic Limit	Plasticity Index
1	3.0	38.65	26.55	12.10
	4.5	37.52	27.45	10.07
	6.0	36.98	25.98	11.00
	7.5	38.54	26.35	12.19
2	4.5	37.54	25.47	12.07
	6.0	36.55	25.68	10.87
	7.5	38.45	26.35	12.10
3	3.0	37.45	25.87	11.58
	4.5	36.85	26.35	10.50
	6.0	37.45	27.05	10.40
	7.5	36.59	25.18	11.41
	9.0	37.80	26.11	11.69

ATTERBERG LIMITS

Bore Hole No.	Depth (m)	Liquid Limit	Plastic Limit	Plasticity Index
4	3.0	37.24	25.97	11.27
	6.0	36.04	24.21	11.83
	7.5	36.04	24.21	11.83
	9.0	37.82	26.71	11.11
	12.0	39.01	28.45	10.56
	13.5	37.52	25.63	11.89
5	3.0	38.55	25.94	12.61
	6.0	36.04	24.19	11.85
	9.0	37.82	25.04	12.78
	12.0	36.71	25.50	11.21
	13.5	35.85	24.88	10.97
6	3.0	38.55	25.94	12.61
	6.0	36.04	24.19	11.85
	7.5	37.41	26.32	11.09
	9.0	37.82	25.04	12.78
	12.0	37.41	25.50	11.91
	15.0	36.55	24.89	11.66
7	1.5	37.44	26.31	11.13
	3.0	36.43	25.94	10.49
	4.5	35.83	24.15	11.68
	6.0	36.04	24.12	11.92
	9.0	35.25	23.99	11.26
	12.0	37.06	25.18	11.88
	15.0	36.54	26.06	10.48

SHEAR TEST RESULTS

BoreHole No.	Depth (m)	Triaxial Test		Direct shear test	
		C (kg/cm^2)	ϕ^o	C (kg/cm^2)	ϕ^o
1	3.5 (UU)	0.12	-	-	-
	5.0 (UU)	0.13	-	-	-
	6.5 (UU)	0.33	04°	-	-
	8.0 (UU)	0.36	05°	-	-
	9.0	-	-	-	29°
	10.5	-	-	-	29°
	12.0	-	-	-	30°
	13.5	-	-	-	30°
	15.0	-	-	-	30°
	16.5	-	-	-	30°
	18.0	-	-	-	30°
	21.0	-	-	-	30°
	24.0	-	-	-	31°
	27.0	-	-	-	31°
	30.0	-	-	-	31°
2	3.5 (UU)	0.11	-	-	-
	5.0 (UU)	0.13	-	-	-
	6.5 (UU)	0.14	-	-	-
	8.0 (UU)	0.31	04°	-	-
	9.5 (UU)	0.34	05°	-	-
	11.0 (UU)	0.48	07°	-	-
	12.5 (UU)	0.52	07°	-	-
	16.5	-	-	-	30°
	18.0	-	-	-	30°
	19.5	-	-	-	30°
	21.0	-	-	-	30°
	24.0	-	-	-	30°
3	3.5 (UU)	0.11	-	-	-
	5.0 (UU)	0.13	-	-	-
	6.5 (UU)	0.29	07°	-	-
	8.0 (UU)	0.30	07°	-	-
	9.5 (UU)	0.31	06°	-	-
	11.0 (UU)	0.33	04°	-	-
	12.5 (UU)	0.36	05°	-	-
	13.5	-	-	-	29°
	16.5	-	-	-	30°
	19.5	-	-	-	30°
	22.5	-	-	-	30°
	27.0	-	-	-	31°
	30.0	-	-	-	31°

SHEAR TEST RESULTS

BoreHole No.	Depth (m)	Triaxial Test		Direct shear test	
		C (kg/cm^2)	ϕ^o	C (kg/cm^2)	ϕ^o
4	3.5 (UU)	0.21	03°	-	-
	5.0 (UU)	0.22	04°	-	-
	6.5 (UU)	0.24	04°	-	-
	8.0 (UU)	0.28	06°	-	-
	9.5 (UU)	0.30	05°	-	-
	11.0 (UU)	0.34	04°	-	-
	12.0 (UU)	0.46	06°	-	-
	13.5 (UU)	0.51	05°	-	-
	15.0 (UU)	0.55	05°	-	-
	16.5	-	-	-	30°
	18.0	-	-	-	30°
	21.0	-	-	-	30°
	24.0	-	-	-	31°
	27.0	-	-	-	31°
	30.0	-	-	-	31°
5	3.5 (UU)	0.23	04°	-	-
	6.5 (UU)	0.26	04°	-	-
	8.0 (UU)	0.29	06°	-	-
	9.5 (UU)	0.31	04°	-	-
	11.0 (UU)	0.33	05°	-	-
	12.0 (UU)	0.36	08°	-	-
	13.5 (UU)	0.42	07°	-	-
	15.0 (UU)	0.49	08°	-	-
	18.0	-	-	-	30°
	19.5	-	-	-	30°
	21.0	-	-	-	30°
	24.0	-	-	-	30°
	25.0	-	-	-	31°
	27.0	-	-	-	31°
	30.0	-	-	-	31°
6	3.5 (UU)	0.22	05°	-	-
	5.0 (UU)	0.23	03°	-	-
	6.5 (UU)	0.25	04°	-	-
	8.0 (UU)	0.27	07°	-	-
	9.5 (UU)	0.26	06°	-	-
	12.0 (UU)	0.39	04°	-	-
	15.0 (UU)	0.48	07°	-	-
	16.5 (UU)	0.53	05°	-	-
	21.0	-	-	-	30°
	24.0	-	-	-	30°
	25.0	-	-	-	30°
	27.0	-	-	-	31°
	30.0	-	-	-	31°

SHEAR TEST RESULTS

BoreHole No.	Depth (m)	Triaxial Test		Direct shear test	
		C (kg/cm^2)	ϕ^o	C (kg/cm^2)	ϕ^o
7	2.0 (UU)	0.24	04°	-	-
	3.5 (UU)	0.29	06°	-	-
	5.0 (UU)	0.31	05°	-	-
	6.5 (UU)	0.33	06°	-	-
	8.0 (UU)	0.37	03°	-	-
	9.5 (UU)	0.39	04°	-	-
	12 (UU)	0.48	05°	-	-
	15 (UU)	0.57	05°	-	-
	18 (UU)	0.61	04°	-	-
	21.0	-	-	-	30°
	24.0	-	-	-	30°
	25.0	-	-	-	30°
	27.0	-	-	-	31°
	30.0	-	-	-	31°

Swelling pressure :

Swelling Pressure is defined as the pressure required for preventing volume expansion in soil in contact with water.

Free swell :

Free swell S_f is defined as follows,

$S_f = (V_f - V_i) / V_i \times 100$

S_f = Free swell percent

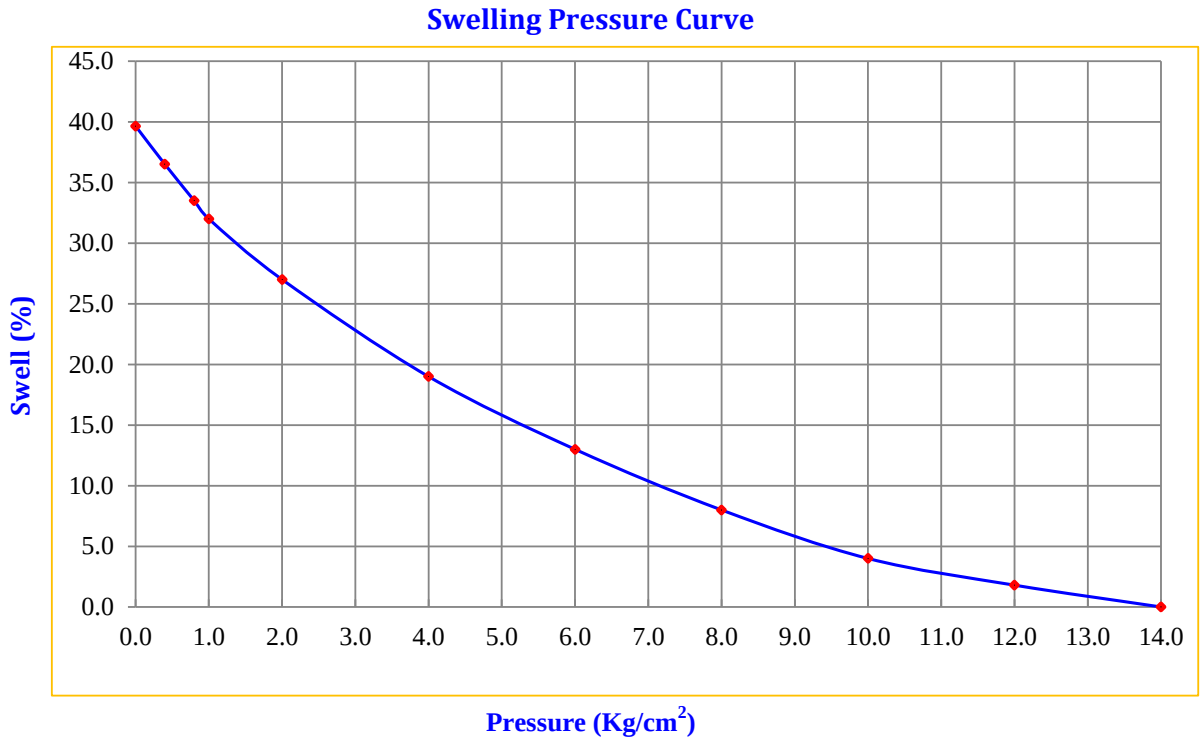
V_f = Final volume of poured soil

V_i = Initial dry volume of poured soil

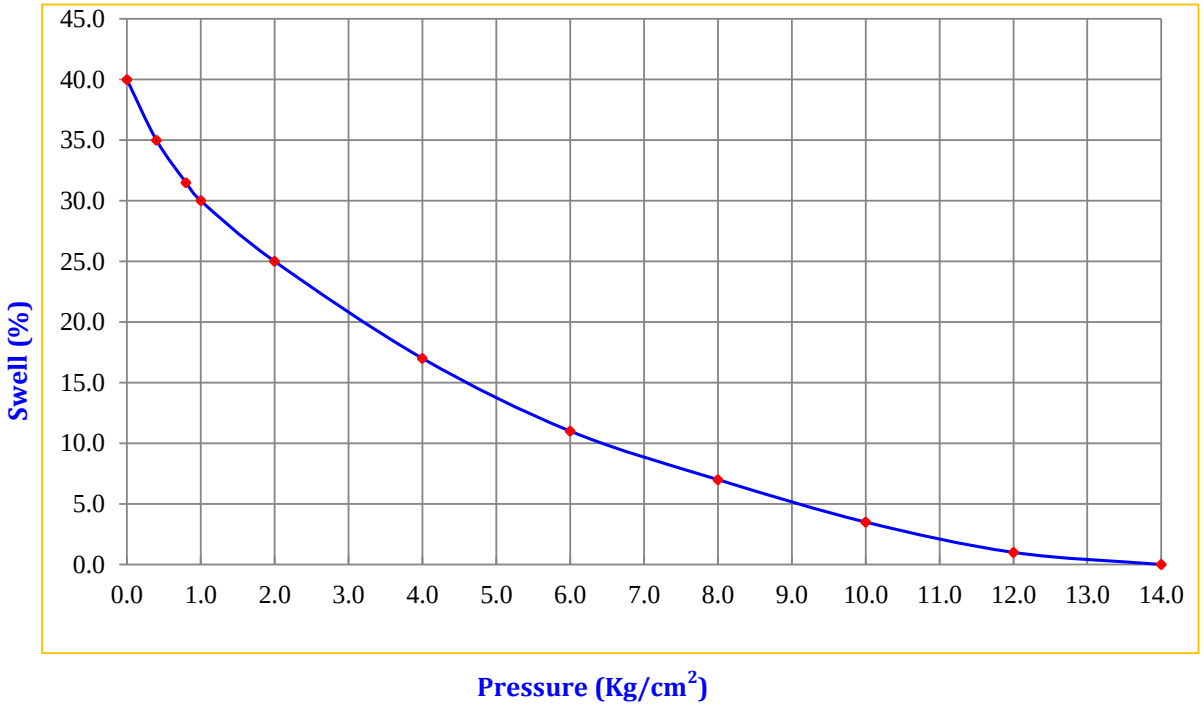
FREE SWELL OF SOIL

BORE HOLE NO	Depth (m)	Free swell (%)
1	3.0	28.65
	6.0	29.35
2	6.0	30.12
	9.0	31.54
3	3.0	28.65
	6.0	29.32
4	3.0	32.54
	6.0	31.04
5	6.0	31.55
	9.0	30.65
6	6.0	29.61
	9.0	28.54
7	6.0	31.25
	9.0	30.65

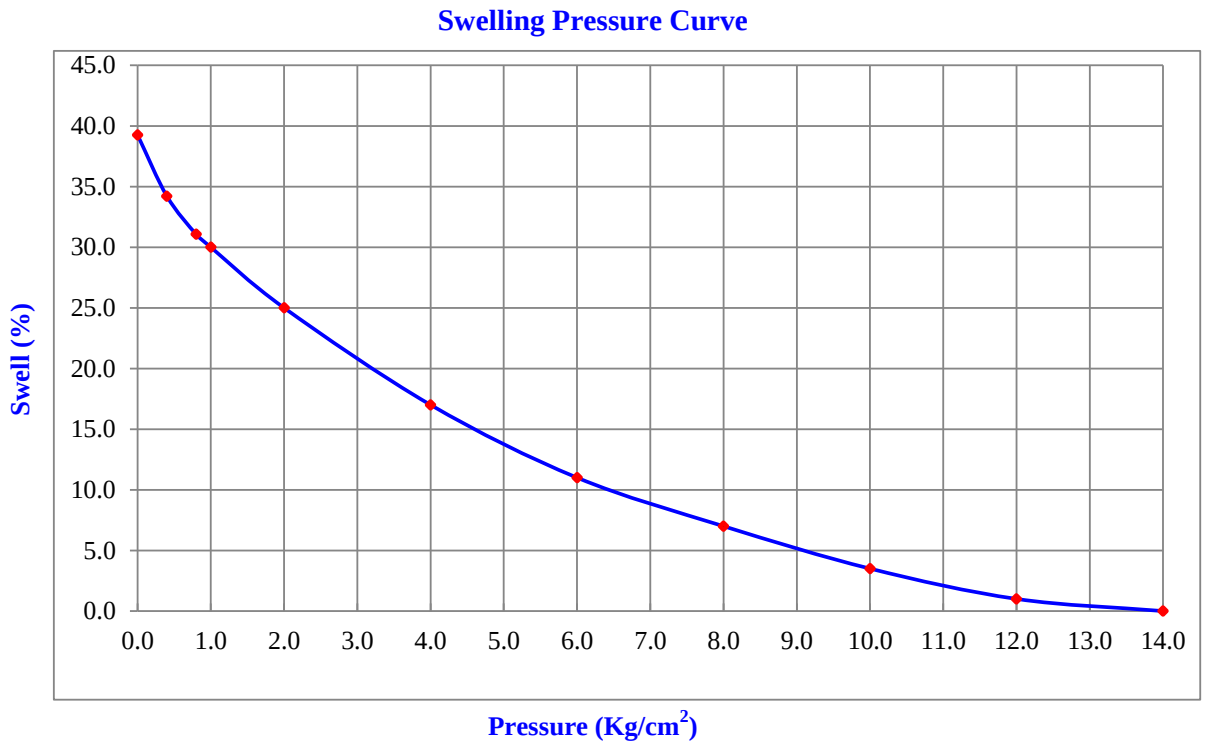
A) Sample No.01 (Bore Hole-1,Depth-6.0 m)



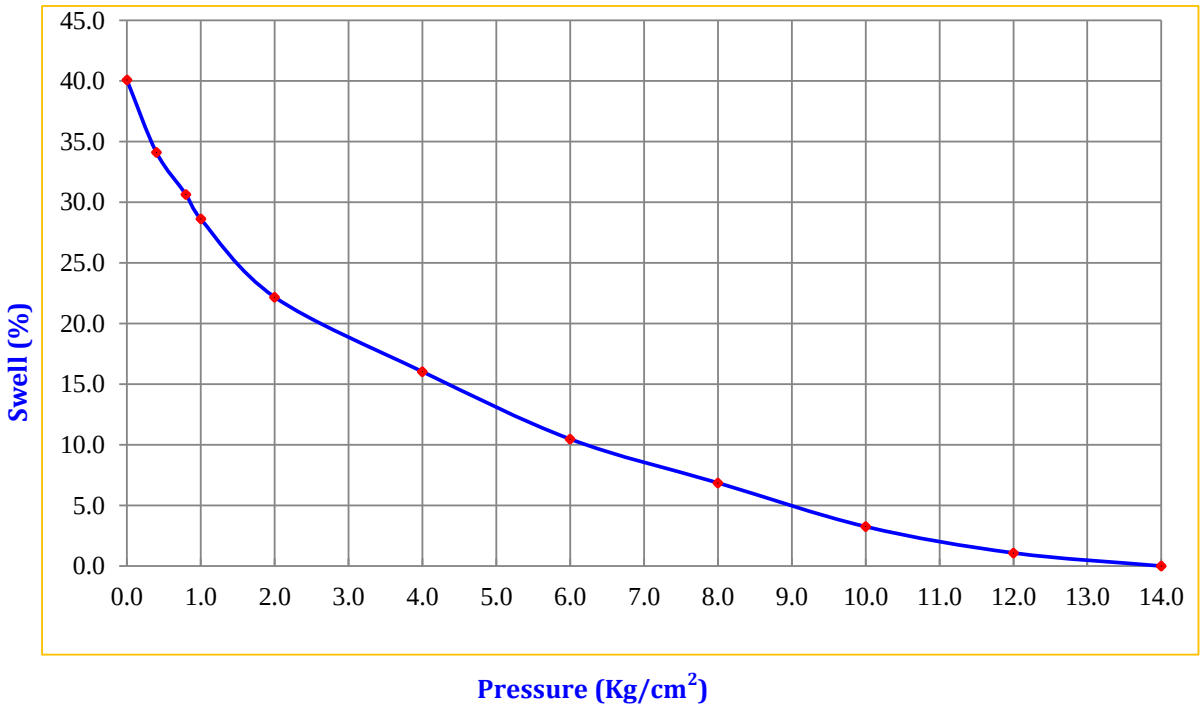
B) Sample No.02 (Bore Hole-02,Depth-6.0 m)



C) Sample No.03 (Bore Hole-3,Depth-6.0 m)

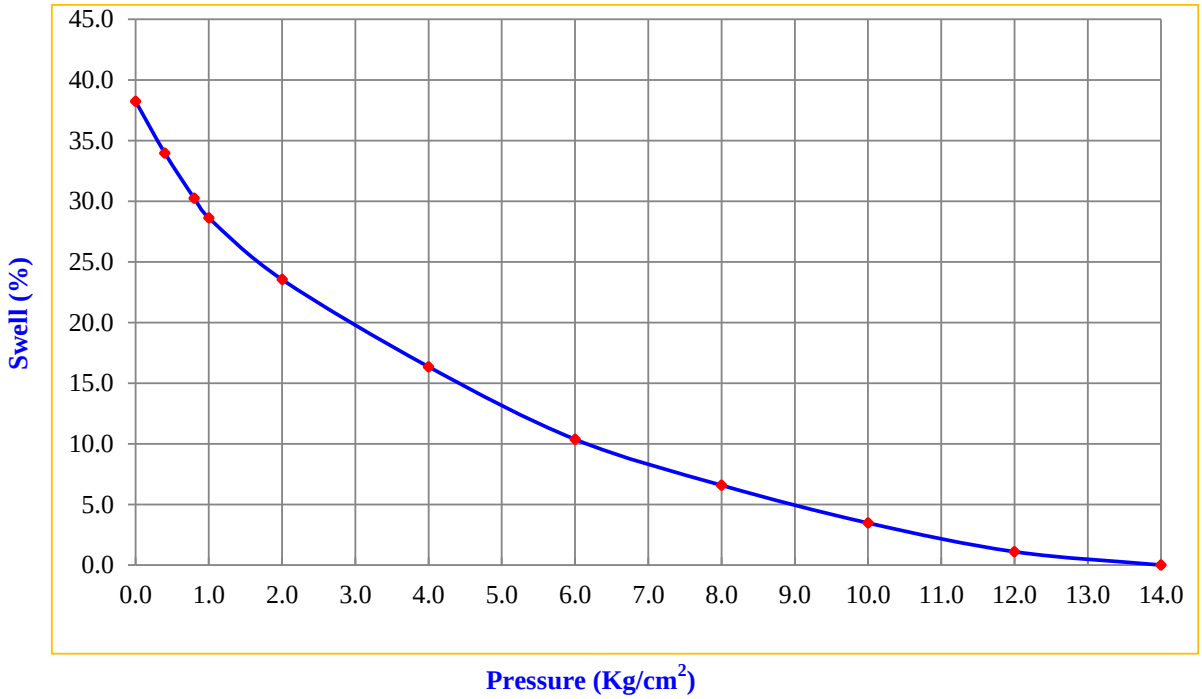


D) Sample No.04 (Bore Hole-04,Depth-6.0 m)

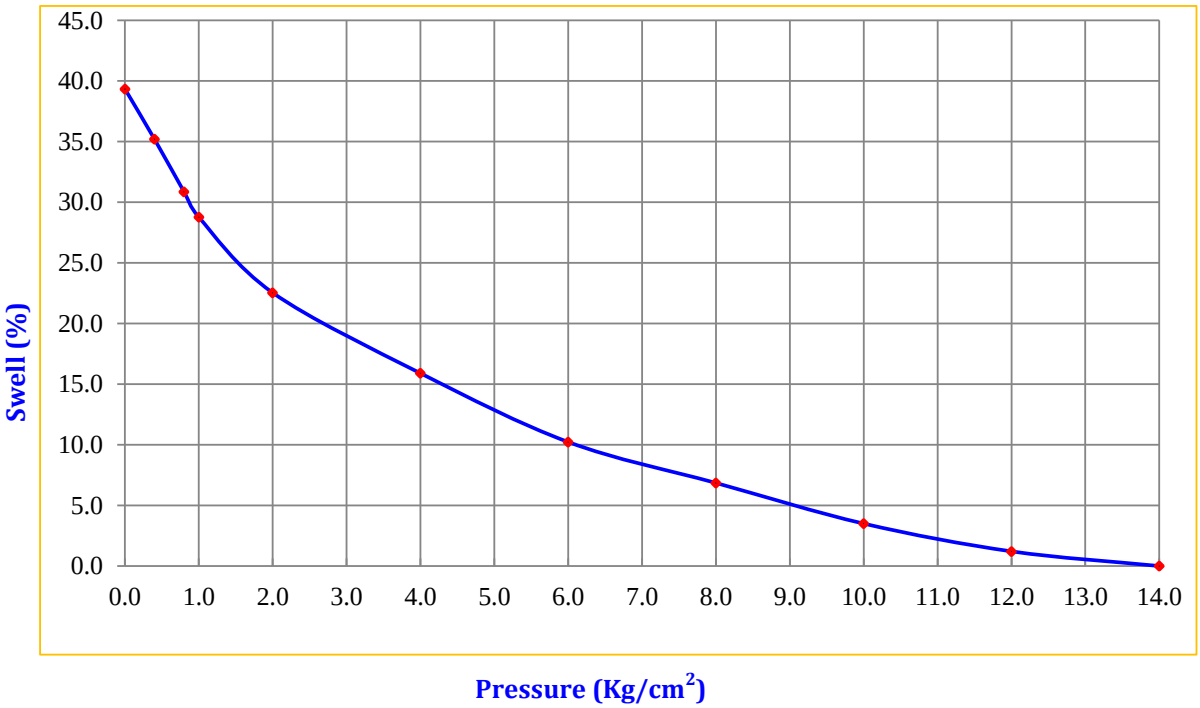


E) Sample No.05 (Bore Hole-05,Depth-6.0 m)

Swelling Pressure Curve

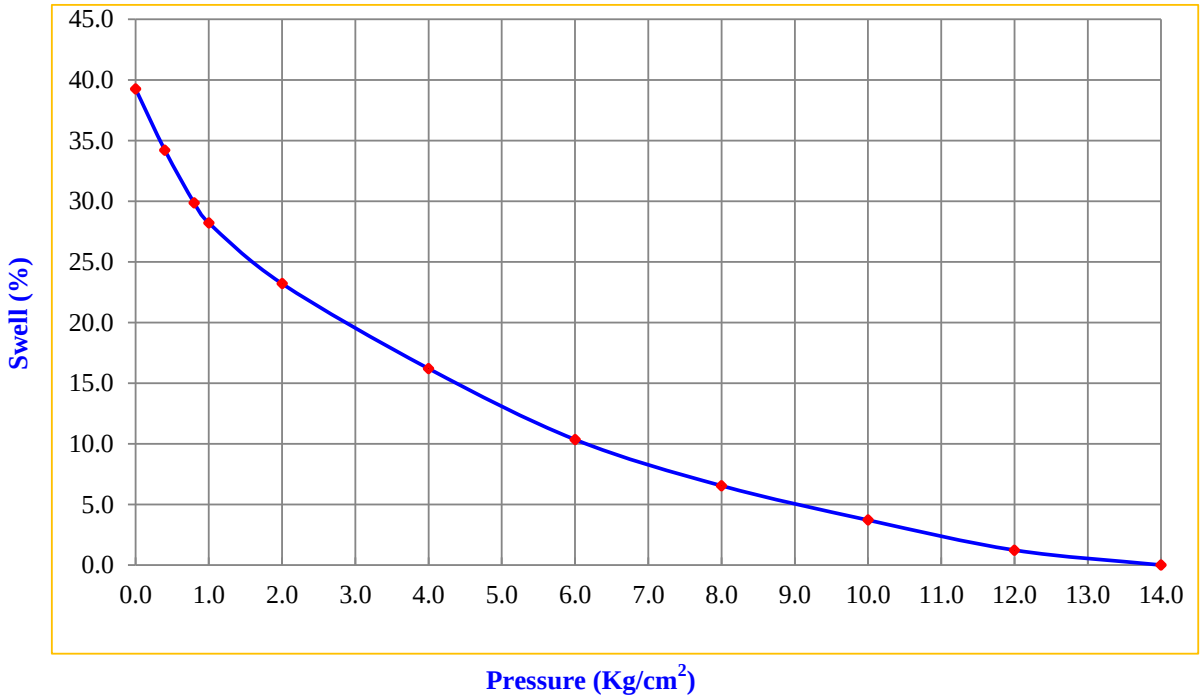


F) Sample No.06 (Bore Hole-06,Depth-6.0 m)



G) Sample No.07 (Bore Hole-07,Depth-6.0 m)

Swelling Pressure Curve

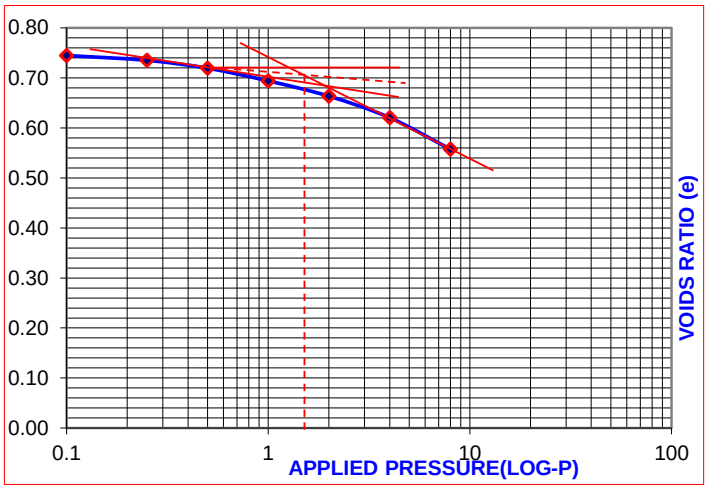


Consolidation Parameters

BH NO.	DEPTH (M)	Co-Efficient of consolidation C_V (cm^2/min)	Compression index C_C
1	6.0	0.074	0.209
1	8.0	0.048	0.233
2	8.0	0.064	0.235
2	9.5	0.072	0.241
3	6.5	0.047	0.232
3	9.5	0.064	0.224
4	3.5	0.071	0.249
4	5.0	0.048	0.234
5	3.5	0.065	0.229
5	6.5	0.072	0.232
6	3.5	0.048	0.243
6	5.0	0.065	0.237
7	3.5	0.071	0.255
7	5.0	0.048	0.232

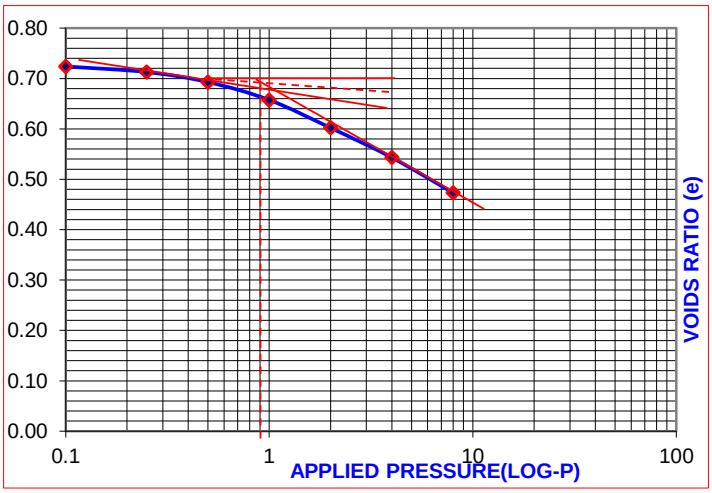
CONSOLIDATION PARAMETERS

Bore Hole No.	Depth (m)	Field void ratio e_o	Ht. of solid = $H/(1 + e_o)$ H = 2 cm	Applied force (kg/cm^2)	Settlement (cm)	Total Settlement (cm)	Ht. of Sample (cm)	Void ratio	Mv (cm^2/kg)
1	6.0	0.75	1.143	0.1	0.006	0.006	1.994	0.745	0.030
				0.25	0.011	0.017	1.983	0.735	0.037
				0.5	0.018	0.035	1.965	0.719	0.036
				1	0.029	0.064	1.936	0.694	0.030
				2	0.035	0.099	1.901	0.663	0.018
				4	0.049	0.148	1.852	0.621	0.013
				8	0.072	0.220	1.780	0.558	0.010
1	8.0	0.73	1.156	0.1	0.007	0.007	1.993	0.724	0.035
				0.2	0.013	0.020	1.980	0.713	0.065
				0.5	0.023	0.043	1.957	0.693	0.039
				1	0.041	0.084	1.916	0.657	0.042
				2	0.064	0.148	1.852	0.602	0.033
				4	0.068	0.216	1.784	0.543	0.018
				8	0.081	0.297	1.703	0.473	0.011
2	8.0	0.77	1.130	0.1	0.008	0.008	1.992	0.763	0.040
				0.2	0.014	0.022	1.978	0.751	0.070
				0.5	0.029	0.051	1.949	0.725	0.049
				1	0.043	0.094	1.906	0.687	0.044
				2	0.059	0.153	1.847	0.635	0.031
				4	0.071	0.224	1.776	0.572	0.019
				8	0.080	0.304	1.696	0.501	0.011



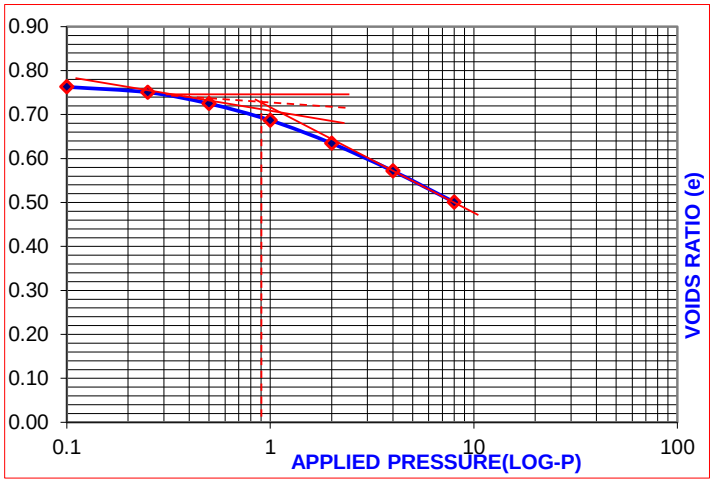
Pre consolidation pressure, $P_{c} =$ 1.6 kg/cm^2

B.H No.	1
Depth (m)	6.0



Pre consolidation pressure, $P_{c} =$ 0.90 kg/cm^2

B.H No.	1
Depth (m)	8.0

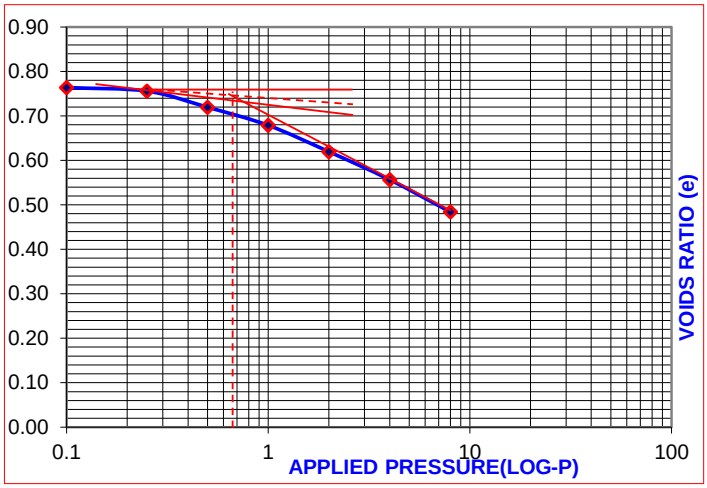


Pre consolidation pressure, $P_{c} =$ 0.90 kg/cm^2

B.H No.	2
Depth (m)	8.0

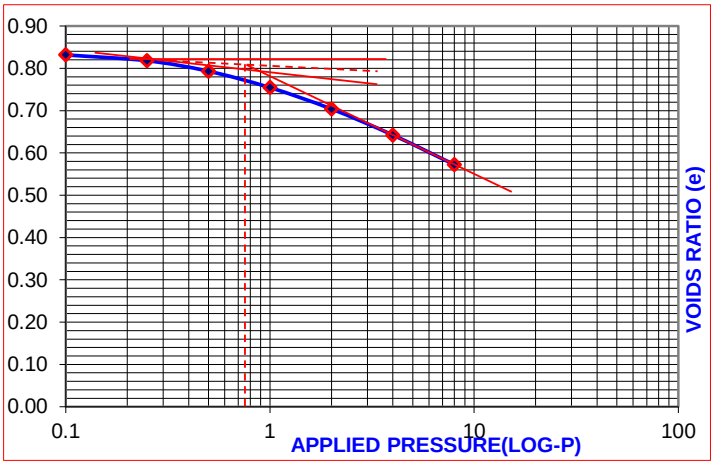
CONSOLIDATION PARAMETERS

Bore Hole No.	Depth (m)	Field void ratio e_o	Ht. of solid = $H/(1 + e_o)$ H = 2 cm	Applied force (kg/cm^2)	Settlement (cm)	Total Settlement (cm)	Ht. of Sample (cm)	Void ratio	Mv (cm^2/kg)
2	9.5	0.77	1.130	0.1	0.007	0.007	1.993	0.764	0.035
				0.25	0.014	0.016	1.984	0.756	0.030
				0.5	0.036	0.057	1.943	0.720	0.083
				1	0.046	0.103	1.897	0.679	0.047
				2	0.067	0.170	1.830	0.620	0.035
				4	0.071	0.241	1.759	0.557	0.019
				8	0.082	0.323	1.677	0.484	0.012
3	6.5	0.84	1.087	0.1	0.009	0.009	1.991	0.832	0.045
				0.2	0.015	0.024	1.976	0.818	0.075
				0.5	0.027	0.051	1.949	0.793	0.046
				1	0.042	0.093	1.907	0.754	0.043
				2	0.055	0.148	1.852	0.704	0.029
				4	0.067	0.215	1.785	0.642	0.018
				8	0.076	0.291	1.709	0.572	0.011
3	9.5	0.8	1.111	0.1	0.008	0.008	1.992	0.793	0.040
				0.2	0.013	0.021	1.979	0.781	0.065
				0.5	0.026	0.047	1.953	0.758	0.044
				1	0.044	0.091	1.909	0.718	0.045
				2	0.053	0.144	1.856	0.670	0.028
				4	0.068	0.212	1.788	0.609	0.018
				8	0.075	0.287	1.713	0.542	0.010



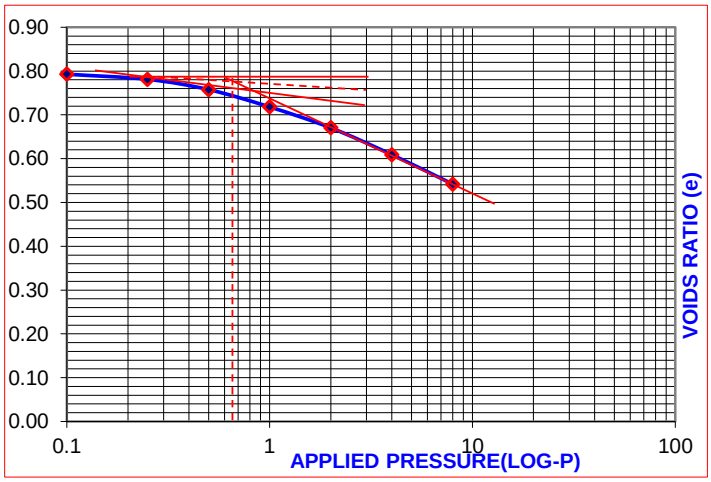
Pre consolidation pressure, $P_{c} =$ 0.66 kg/cm^2

B.H No.	2
Depth (m)	9.5



Pre consolidation pressure, $P_{c} =$ 0.74 kg/cm^2

B.H No.	3
Depth (m)	6.5

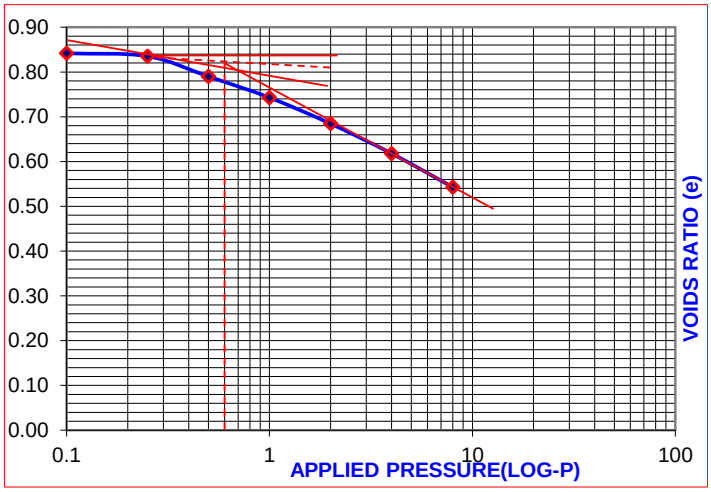


Pre consolidation pressure, $P_{c} =$ 0.65 kg/cm^2

B.H No.	3
Depth (m)	9.5

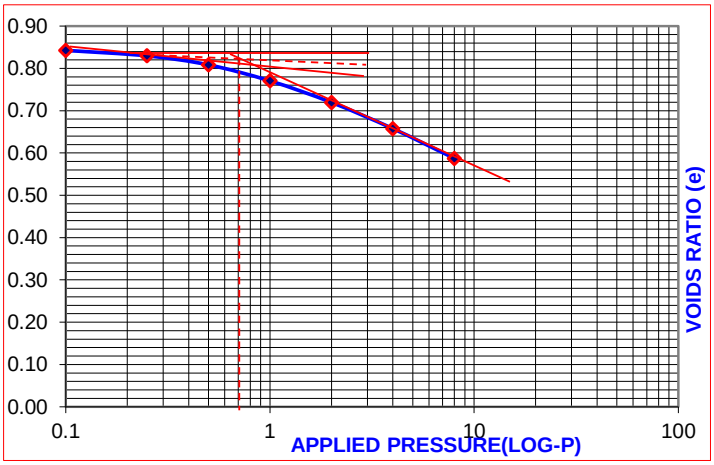
CONSOLIDATION PARAMETERS

Bore Hole No.	Depth (m)	Field void ratio e_o	Ht. of solid = $H/(1 + e_o)$ H = 2 cm	Applied force (kg/cm^2)	Settlement (cm)	Total Settlement (cm)	Ht. of Sample (cm)	Void ratio	Mv (cm^2/kg)
4	3.5	0.85	1.081	0.1	0.009	0.009	1.991	0.842	0.045
				0.25	0.017	0.016	1.984	0.835	0.023
				0.5	0.039	0.065	1.935	0.790	0.099
				1	0.051	0.116	1.884	0.743	0.053
				2	0.063	0.179	1.821	0.684	0.033
				4	0.072	0.251	1.749	0.618	0.020
				8	0.081	0.332	1.668	0.543	0.012
4	5.0	0.85	1.081	0.1	0.008	0.008	1.992	0.843	0.040
				0.2	0.014	0.022	1.978	0.830	0.070
				0.5	0.023	0.045	1.955	0.808	0.039
				1	0.041	0.086	1.914	0.770	0.042
				2	0.055	0.141	1.859	0.720	0.029
				4	0.067	0.208	1.792	0.658	0.018
				8	0.076	0.284	1.716	0.587	0.011
5	3.5	0.84	1.087	0.1	0.008	0.008	1.992	0.833	0.040
				0.2	0.013	0.021	1.979	0.821	0.065
				0.5	0.025	0.046	1.954	0.798	0.042
				1	0.039	0.085	1.915	0.762	0.040
				2	0.043	0.128	1.872	0.722	0.022
				4	0.065	0.193	1.807	0.662	0.017
				8	0.075	0.268	1.732	0.593	0.010



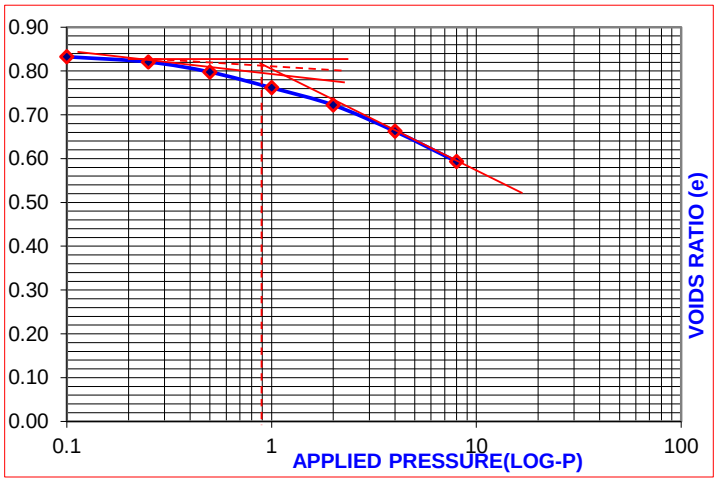
Pre consolidation pressure, $P_{c} =$ 0.60 kg/cm^2

B.H No.	4
Depth (m)	3.5



Pre consolidation pressure, $P_{c} =$ 0.70 kg/cm^2

B.H No.	4
Depth (m)	5.0

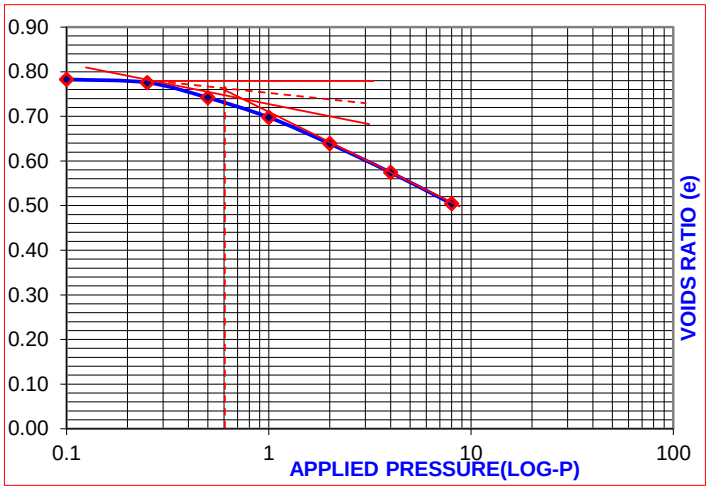


Pre consolidation pressure, $P_{c} =$ 0.89 kg/cm^2

B.H No.	5
Depth (m)	3.5

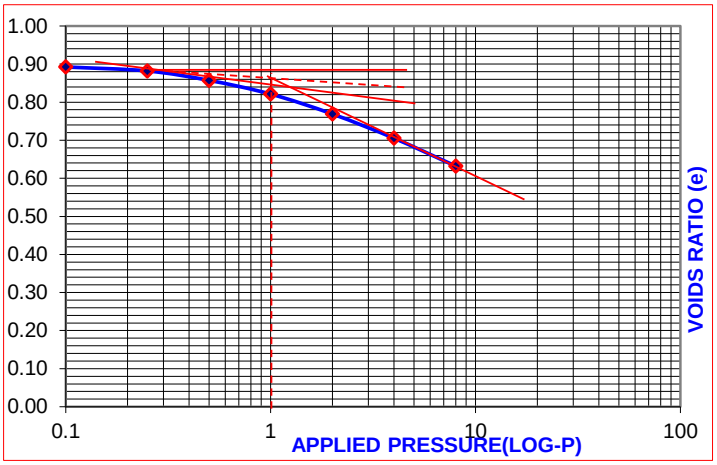
CONSOLIDATION PARAMETERS

Bore Hole No.	Depth (m)	Field void ratio e_o	Ht. of solid = $H/(1 + e_o)$ H = 2 cm	Applied force (kg/cm^2)	Settlement (cm)	Total Settlement (cm)	Ht. of Sample (cm)	Void ratio	Mv (cm^2/kg)
5	6.5	0.79	1.117	0.1	0.008	0.008	1.992	0.783	0.040
				0.25	0.014	0.016	1.984	0.776	0.027
				0.5	0.032	0.054	1.946	0.742	0.077
				1	0.049	0.103	1.897	0.698	0.050
				2	0.066	0.169	1.831	0.639	0.035
				4	0.072	0.241	1.759	0.574	0.020
				8	0.078	0.319	1.681	0.504	0.011
6	3.5	0.9	1.053	0.1	0.008	0.008	1.992	0.892	0.040
				0.2	0.011	0.019	1.981	0.882	0.055
				0.5	0.026	0.045	1.955	0.857	0.044
				1	0.038	0.083	1.917	0.821	0.039
				2	0.055	0.138	1.862	0.769	0.029
				4	0.067	0.205	1.795	0.705	0.018
				8	0.077	0.282	1.718	0.632	0.011
6	5.0	0.90	1.053	0.1	0.007	0.007	1.993	0.893	0.035
				0.2	0.013	0.020	1.980	0.881	0.065
				0.5	0.022	0.042	1.958	0.860	0.037
				1	0.033	0.075	1.925	0.829	0.034
				2	0.051	0.126	1.874	0.780	0.026
				4	0.069	0.195	1.805	0.715	0.018
				8	0.075	0.270	1.730	0.644	0.010



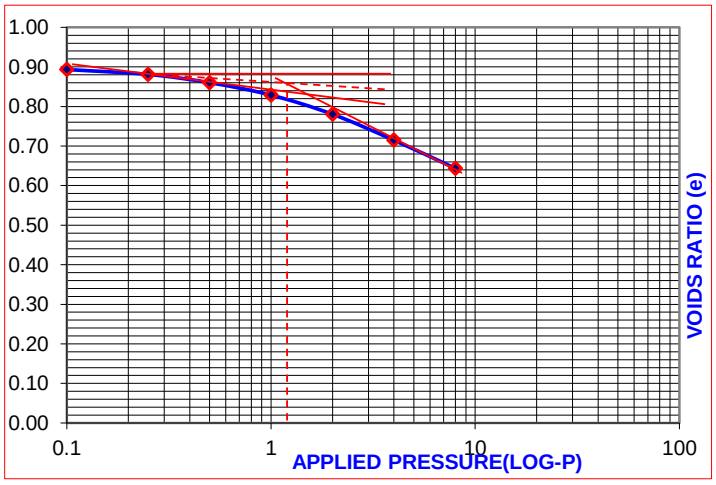
Pre consolidation pressure, $P_{c=}$ 0.60 kg/cm^2

B.H No.	5
Depth (m)	6.5



Pre consolidation pressure, $P_{c=}$ 1.0 kg/cm^2

B.H No.	6
Depth (m)	3.5

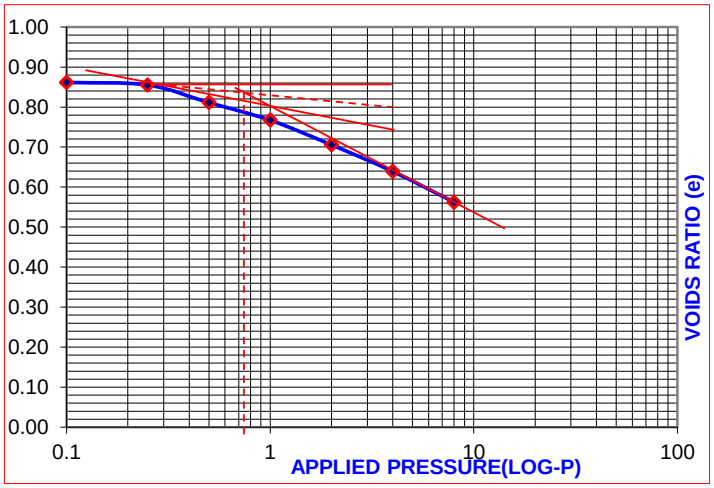


Pre consolidation pressure, $P_{c=}$ 1.20 kg/cm^2

B.H No.	6
Depth (m)	5.0

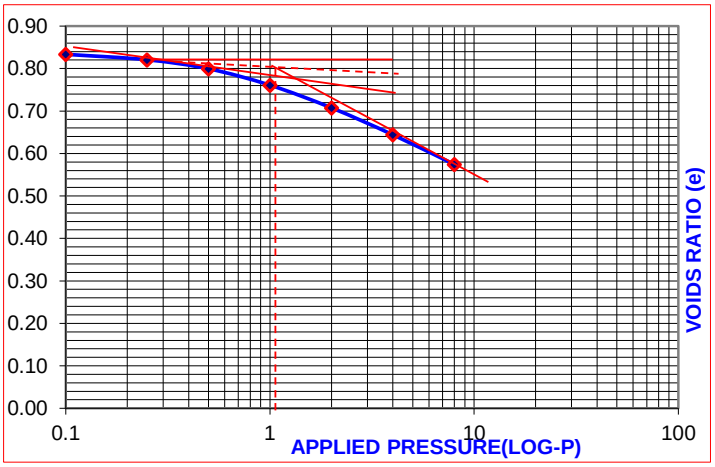
CONSOLIDATION PARAMETERS

Bore Hole No.	Depth (m)	Field void ratio e_o	Ht. of solid = $H/(1 + e_o)$ H = 2 cm	Applied force (kg/cm^2)	Settlement (cm)	Total Settlement (cm)	Ht. of Sample (cm)	Void ratio	Mv (cm^2/kg)
7	3.5	0.87	1.070	0.1	0.009	0.009	1.991	0.862	0.045
				0.25	0.016	0.016	1.984	0.855	0.023
				0.5	0.038	0.063	1.937	0.811	0.095
				1	0.047	0.110	1.890	0.767	0.049
				2	0.066	0.176	1.824	0.705	0.035
				4	0.071	0.247	1.753	0.639	0.019
				8	0.082	0.329	1.671	0.562	0.012
7	5.0	0.84	1.087	0.1	0.007	0.007	1.993	0.834	0.035
				0.2	0.014	0.021	1.979	0.821	0.070
				0.5	0.023	0.044	1.956	0.800	0.039
				1	0.042	0.086	1.914	0.761	0.043
				2	0.058	0.144	1.856	0.708	0.030
				4	0.069	0.213	1.787	0.644	0.019
				8	0.076	0.289	1.711	0.574	0.011



Pre consolidation pressure, $P_{c} =$ 0.72 kg/cm^2

B.H No.	7
Depth (m)	3.5



Pre consolidation pressure, $P_{c} =$ 1.10 kg/cm^2

B.H No.	7
Depth (m)	5.0

Annexure-I

ELECTRICAL RESISTIVITY TEST

ELECTRICAL RESISTIVITY TEST

Introduction:

The electrical resistivity method is based on the measurement and recording of changes in the resistivity or apparent specific resistance of various soils.The resistivity, ρ is usually defined as the resistance between the opposite faces of unit cube of the material.Significant variations in resistivity can be detected between different types of soil strata,above and below the water table,between unfissured rocks and soils,between voids and and soil/rock.

Test location:

In the evaluation of earth resistivity for a location ,at least eight test directions shall be chosen from the centre of the station to cover the whole site.this number shall be increased for very large station sites of it , the test results obtained at various locations show a significant difference,indicating variation in soil formation.

Principle of test:

Wenners four electrode method is recommended for these type of field investigations.In this method , four electrodes are driven in to the earth along a straight line at equal intervals.A current I is passed through the two outer electrodes and the earth and the voltage and the voltage difference $\boldsymbol{V}$,observed between the two inner electrodes.the current I flowing in to the earth produces an electric field proportional to its density and to the resistivity of the soil.The voltage $\boldsymbol{V}$ measured between the inner electrodes is,therefore,proportional to the field.Consequently,the resistivity will be proportional to the ratio of the voltage to current.

The earth testers normally used for these tests comprise the current source and meter in a single instrument and directly read the resistance.The most frequently used earth tester is the four terminal megger.When using such megger,the resistivity may be evaluated from the modified equation as given below:

$$\rho = 2\pi X S R$$

Where,

ρ = Resistivity of soil in ohm-metres

$\boldsymbol{S}$ = Distance between successive electrodes in metres

$\boldsymbol{R}$ = Megger reading in ohms.

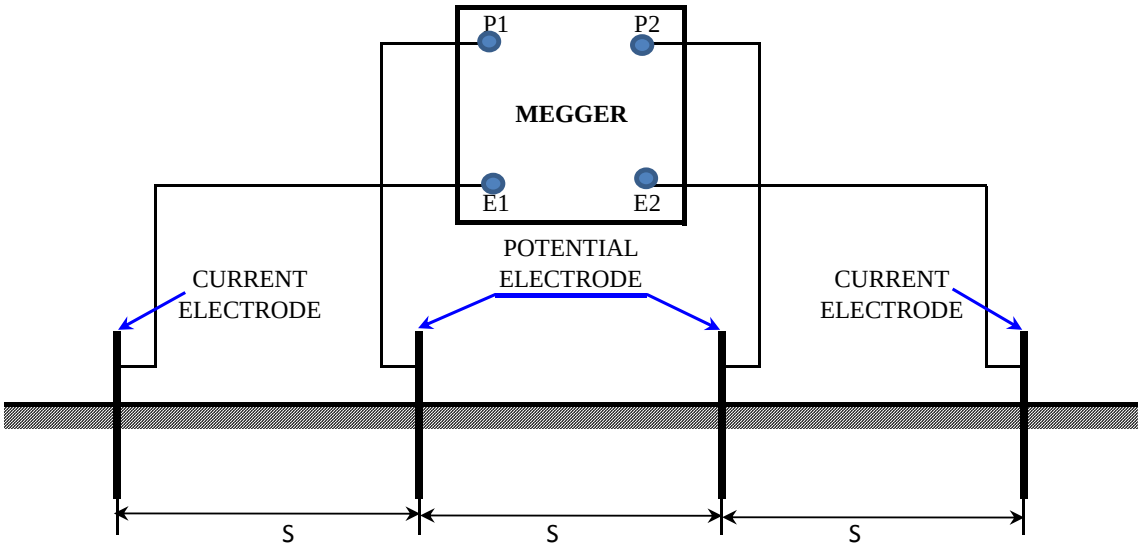
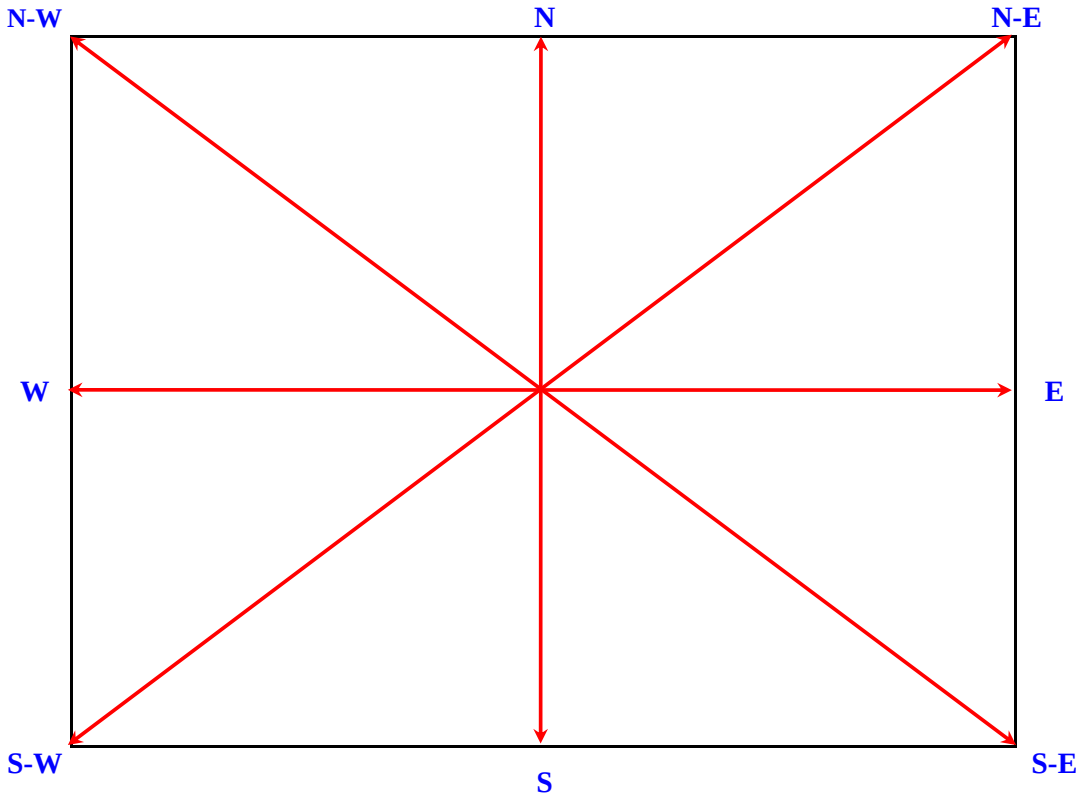


Fig : CONNECTIONS FOR A FOUR TERMINAL MEGGER



Direction of Test

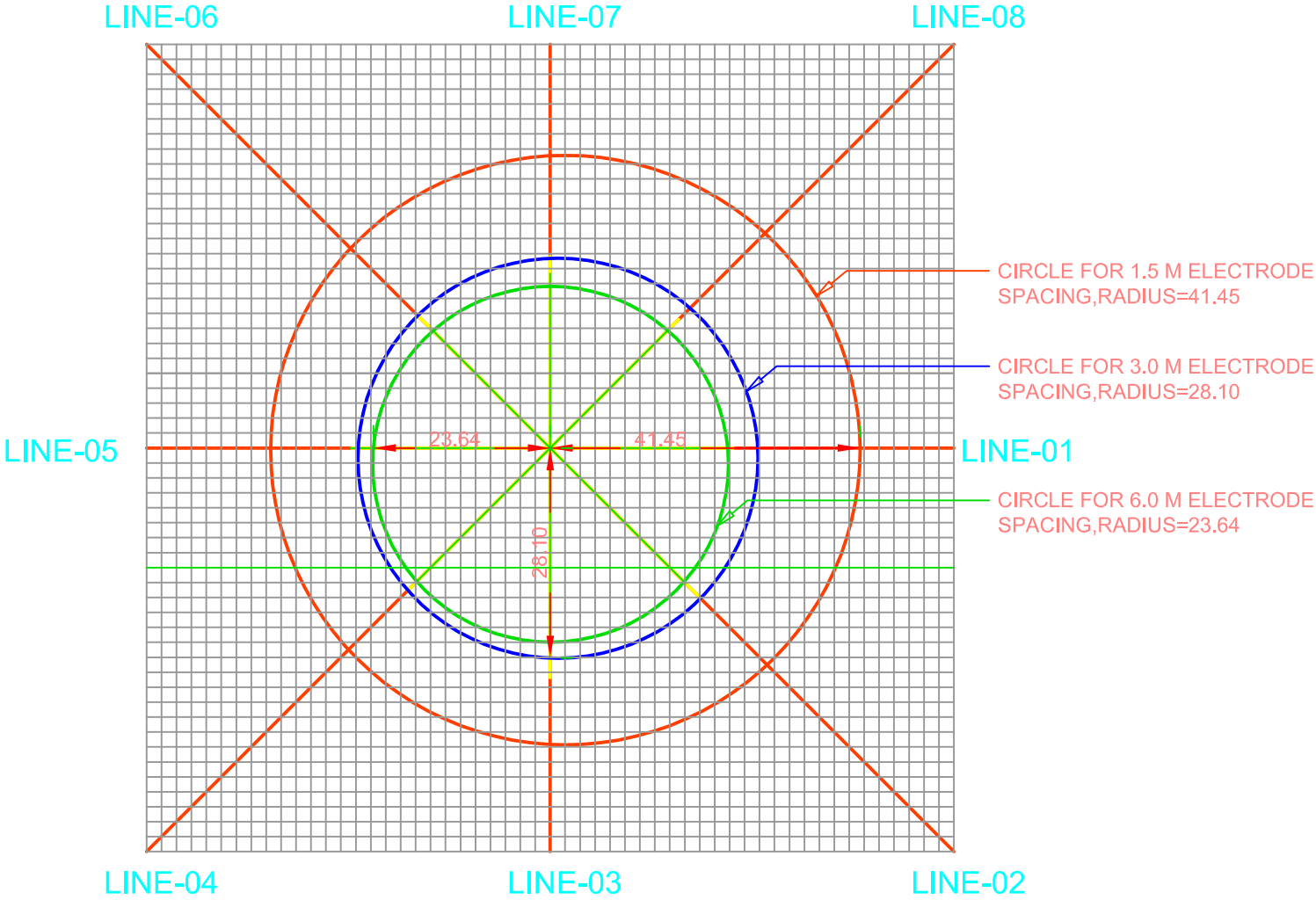
ERT No. 01

ELECTRICAL RESISTIVITY TEST RECORD

Direction	Spacing (S) (m)	K ($2\pi S$)	V (Voltage)	I (Current)	R Resistance Ω	ε Resistivity Ω -m
1	1.5	9.42	100 V	1A	4.40	41.45
	3.0	18.84	100 V	1A	1.30	24.49
	6.0	37.68	100 V	1A	0.63	23.74
2	1.5	9.42	100 V	1A	3.20	30.14
	3.0	18.84	100 V	1A	1.29	24.30
	6.0	37.68	100 V	1A	0.59	22.23
3	1.5	9.42	100 V	1A	3.87	36.46
	3.0	18.84	100 V	1A	1.36	25.62
	6.0	37.68	100 V	1A	0.62	23.36
4	1.5	9.42	100 V	1A	4.01	37.77
	3.0	18.84	100 V	1A	1.33	25.06
	6.0	37.68	100 V	1A	0.58	21.85
5	1.5	9.42	101 V	1A	3.96	37.30
	3.0	18.84	102 V	1A	1.41	26.56
	6.0	37.68	103 V	1A	0.71	26.75
6	1.5	9.42	104 V	1A	4.49	42.30
	3.0	18.84	105 V	1A	1.43	26.94
	6.0	37.68	106 V	1A	0.67	25.25
7	1.5	9.42	107 V	1A	4.21	39.66
	3.0	18.84	108 V	1A	1.63	30.71
	6.0	37.68	109 V	1A	0.70	26.38
8	1.5	9.42	110 V	1A	3.94	37.11
	3.0	18.84	111 V	1A	1.51	28.45
	6.0	37.68	112 V	1A	0.68	25.62

From polar Curve,The average resistivity of soil is as follows:

Spacing (m)	ε Resistivity Ω -m
1.5	41.45
3.0	28.10
6.0	23.64


LINE-06
LINE-07
LINE-08
LINE-05
LINE-01
LINE-04
LINE-03
LINE-02
23.64
41.45
28.10
CIRCLE FOR 1.5 M ELECTRODE SPACING,RADIUS=41.45
CIRCLE FOR 3.0 M ELECTRODE SPACING,RADIUS=28.10
CIRCLE FOR 6.0 M ELECTRODE SPACING,RADIUS=23.64

POLAR CURVE

Annexure-II

PROCTOR,CBR & VANE SHEAR TEST

Data sheet for the Compaction Test of Soil(IS:2720(Part-7)-1983)
(Proctor Density)

Sample No.	LCBR-01
Weight of dry soil	2500 gm
Type of Test	Standard Proctor
Weight of Mould W_1	2540 gm
Volume of Mould V	1000 cc

Sl.No.	Weight of mould + Compacted Soil W2 (gm)	Weight of wet soil W_2-W_1 in gm	Wet Density (gm/cc)	Moisture Content Determination							
				Container No.	Weight of Container (gm)	Weight of Container + wet soil (gm)	Weight of Container + dry soil (gm)	Weight of water Ww (gm)	Weight of dry soil Ws (gm)	Moisture Content (w) %	Dry Density (gm/cc)
1	4186.00	1646.00	1.65	C2	14.56	33.75	32.82	0.93	18.25	5.09	1.57
2	4326.40	1786.40	1.79	C14	13.68	29.82	28.09	1.72	14.41	11.96	1.60
3	4414.80	1874.80	1.87	C21	13.03	30.65	28.08	2.56	15.05	17.03	1.60
4	4472.00	1932.00	1.93	C10	17.60	37.76	33.83	3.93	16.23	24.23	1.56

Weight Density of compacted soil γ_m= [(W2-W1)/Vm) gm/cc

Where

W_2 = Weight of mould + soil (gms)

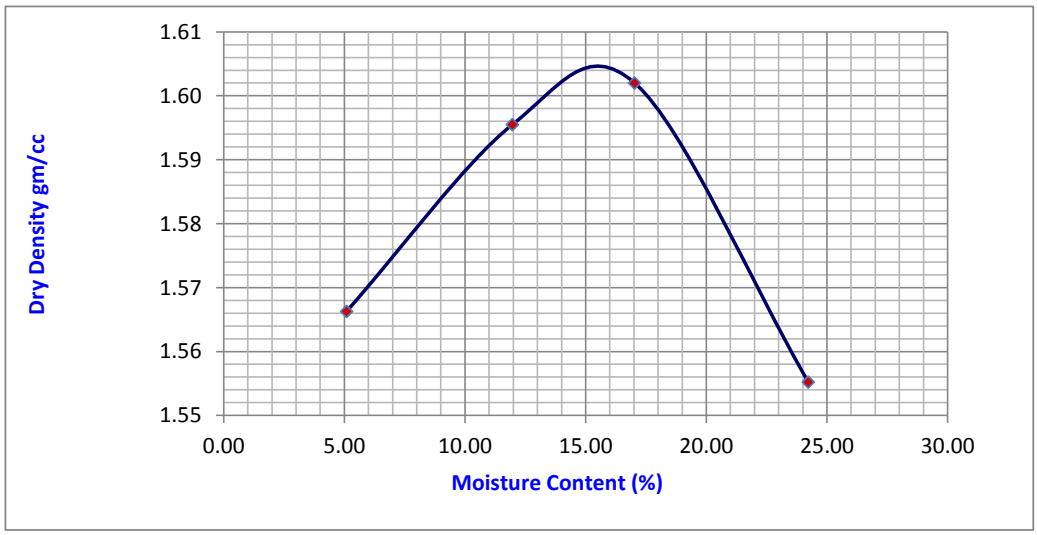
W_1 = Weight of mould(gms)

V_m = Volume of mould (gms)

Dry density of compacted soil γ_d = 100/(100+W) X V_m gm/cc

Where W = moisture content

OMC (%)	=	15.500
MDD (gm/cc)	=	1.605



Data sheet for the Compaction Test of Soil(IS:2720(Part-7)-1983)
(Proctor Density)

Sample No.	LCBR-02
Sample No.	
Weight of dry soil	2500 gm
Type of Test	Standard Proctor
Weight of Mould W_1	2540 gm
Volume of Mould V	1000 cc

Sl.No.	Weight of mould + Compacted Soil W2 (gm)	Weight of wet soil W_2-W_1 in gm	Wet Density (gm/cc)	Moisture Content Determination							
				Container No.	Weight of Container (gm)	Weight of Container + wet soil (gm)	Weight of Container + dry soil (gm)	Weight of water Ww (gm)	Weight of dry soil Ws (gm)	Moisture Content (w) %	Dry Density (gm/cc)
1	3987.52	1447.52	1.45	D25	17.20	49.44	48.28	1.16	31.08	3.73	1.395
2	4079.24	1539.24	1.54	D21	14.40	36.79	35.45	1.34	21.05	6.37	1.447
3	4204.75	1664.75	1.66	D3	17.47	43.73	41.14	2.59	23.67	10.94	1.501
4	4262.68	1722.68	1.72	D23	17.40	42.53	38.06	4.47	20.66	21.64	1.416

Weight Density of compacted soil γ_m= [(W2-W1)/Vm) gm/cc

Where

W_2 = Weight of mould + soil (gms)

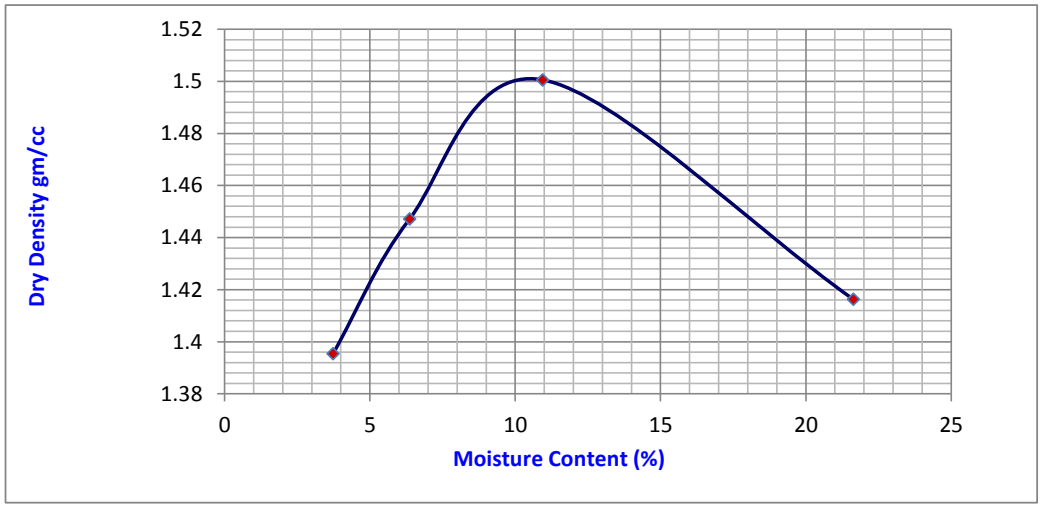
W_1 = Weight of mould(gms)

V_m = Volume of mould (gms)

Dry density of compacted soil γ_d = 100/(100+W) X V_m gm/cc

Where W = moisture content

OMC (%)	=	10.250
MDD (gm/cc)	=	1.500



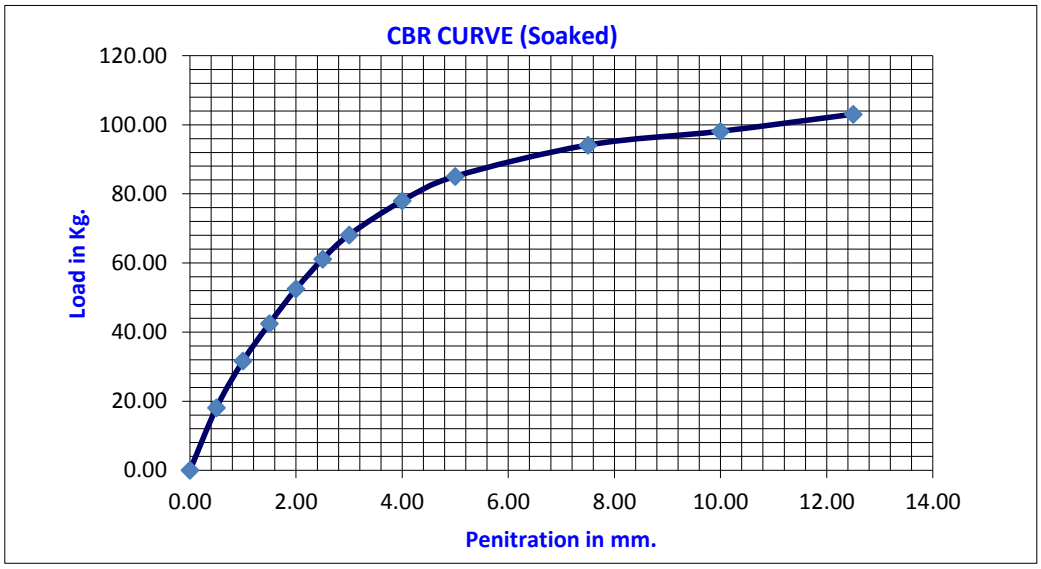
C.B.R Test Soil (Soaked) IS :2720 (Part-16)

Sample No.LCBR-01(N = 2895759.340,E = 0374816.408),Depth-1.5 m

(i) Rammer (a) Weight = 2.60 kg
(b) Length = 31 cm
(ii) No of Layers = 3
(iii) Blows per layer = 55 55
(iv) Proving Ring constant = 2.5 kg
(v) Plunger dia. = 5 cm

Penetration in mm	Providing Ring Reading	load on Plunger =(A) x Proving Ring constant	Corrected Load Intensity in Kg/cm2	Standard Load (Kg.)	Soaked CBR
	(A)	(B)	(C)	(D)	(E)
0.00	0.00	0.00	0.00		
0.50	7.25	18.13	18.13		
1.00	12.65	31.63	31.63		
1.50	17.00	42.50	42.50		
2.00	21.00	52.50	52.50		
2.50	**24.44**	**61.10**	**61.10**	**1370**	**4.46**
3.00	27.25	68.13	68.13		
4.00	31.20	78.00	78.00		
5.00	**34.03**	**85.08**	**85.08**	**2055**	**4.14**
7.50	37.65	94.13	94.13		
10.00	39.25	98.13	98.13		
12.50	41.22	103.05	103.05		

CBR at 2.5mm = (61.102/1370)x100 4.46
CBR at 5mm = (85.077/2055)x100 4.14



C.B.R Test Soil (Soaked) IS :2720 (Part-16)

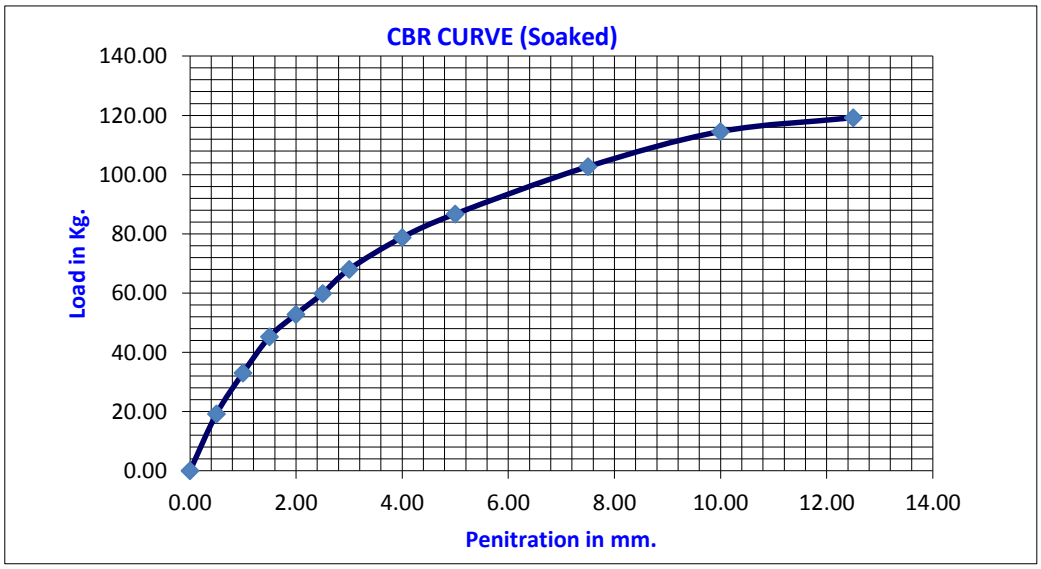
Sample No.LCBR-02 (N = 2895273.140,E = 0374589.350),Depth-1.5 m

(i) Rammer (a) Weight = 2.60 kg
(b) Length = 31 cm
(ii) No of Layers = 3

(iii) Blows per layer = 55 55
(iv) Proving Ring constant = 2.5 kg
(v) Plunger dia. = 5 cm

Penetration in mm	Providing Ring Reading	load on Plunger =(A) x Proving Ring constant	Corrected Load Intensity in Kg/cm2	Standard Load (Kg.)	Shoaked CBR
	(A)	(B)	(C)	(D)	(E)
0.00	0.00	0.00	0.00		
0.50	7.69	19.23	19.23		
1.00	13.20	33.00	33.00		
1.50	18.09	45.23	45.23		
2.00	21.13	52.83	52.83		
2.50	**23.95**	**59.87**	**59.87**	**1370**	**4.37**
3.00	27.21	68.03	68.03		
4.00	31.52	78.80	78.80		
5.00	**34.69**	**86.72**	**86.72**	**2055**	**4.22**
7.50	41.08	102.70	102.70		
10.00	45.82	114.55	114.55		
12.50	47.69	119.23	119.23		

CBR at 2.5mm = (59.869/1370)x100 4.37
CBR at 5mm = (86.721/2055)x100 4.22



Dynamic Cone Penetration:

Description:

This method describes the test used to evaluate the thickness and bearing capacity of the subbase and subgrade using the Dynamic Cone Penetrometer (DCP).

Application Of Test:

The DCP is used as a rapid means of assessing the sequence, thickness and in-situ bearing capacity of the unbound layers and underlying subgrade that comprise the pavement structure.

Units Of Measure:

Readings are taken in mm for each blow of the hammer and read directly from the graduated steel rule attached to the instrument.

APPARATUS AND MATERIALS

Equipment Required

A Dynamic Cone Penetrometer complete with replacement tips, two 25 cm spanner wrenches, a 10 mm x 250 mm breaking rod and one 6 mm (1/4") allan wrench.
A tool or sturdy box for the person responsible for holding the instrument perpendicular to the surface. The end gate of a vehicle may be used instead. A jack designed to retrieve the rod after the test. If testing paved sections, a coring machine, a bar and a tamping tool for removal and replacement of asphalt and/or base coarse materials.

PROCEDURE

Description of Equipment Preparation:

The equipment is assembled. It is important that all the screwed joints be kept tight during testing. The joints should be secured with wrenches before beginning each test. It may be necessary to use a non-hardening thread locking compound. Operating the DCP with loose joints will reduce the life of the instrument. The threaded portions may occasionally require repair with a tap and die set.

Sample Preparation:

No preparation is necessary if the test is to start from surface. The instrument is held in an perpendicular position. The weight of the drop hammer seats the cone before the test begins.

The DCP is capable of penetrating through asphalt and base course materials. Tests in these materials causes additional wear on the instrument. Asphalt should be removed by coring. An area large enough to accommodate the base of the instrument is removed and the base course materials excavated to the subbase or subgrade. Before recording the zero reading of DCP, the drop hammer should be released once, to seat the cone in any disturbed material that may be present after excavation.

Test Procedure:

Normally three people are needed to complete the test. One person stands on the tool and holds the apparatus by the handle while the second person lifts the drop weight. The third observes the readings and records them on the appropriate form. The steel rule attached to the guide foot is placed through the slot in the hand guard. The foot is placed on the surface to be tested and the cone tip passed through the guide hole. The entire apparatus is then held by the handle perpendicular to the surface. The technician observes the reading on the rule at the top of the hand guard and records this as the Zero Reading of DCP.
The drop weight is then raised to its maximum height and released. It is extremely important to gain maximum height for each drop but care must be taken not to strike the weight gainst the handle. Doing so would cause the instrument to withdraw and results would be in question. The readings are taken with each blow of the weight. If the penetration rate is below 20 mm/blow, the frequency of readings may be decreased to:

· one for every two blows with readings from 10-20 mm
· one for every five blows with readings from 5-9 mm
· one for every ten blows with readings from 2-4 mm.
· Penetration depth less than 1 mm and exceeding 20 blows is considered as refusal.

The test depth is determined by the engineer. Normally, readings are taken to 1.0 m below the contact with the subgrade. No test should be less than 1.0 m from surface. Upon reaching the desired depth or refusal, the instrument is withdrawn. The forked part of the modified jack is placed under the anvil during extraction. An alternative method would be to strike the drop weight against the bottom of the handle, reversing the entry procedure. This is sually time consuming and adds additional stress to the threaded components, reducing instrument life.

RESULTS AND CALCULATIONS:

Collection of Test Results:

Calculations:

Log CBR = 2.628 - 1.273 log(DCP)
where DCP = penetration mm/blow.

Table : Results of Field CBR from DCP Tests

SL.No.	Test Location	Layer 1			Layer 2			Layer 3			Layer 4			Layer 5			Layer 6			Layer 7			Overall CBR
		Thickness	No.of Blows	DCP-CBR	Thickness	No.of Blows	DCP-CBR	Thickness	No.of Blows	DCP-CBR	Thickness	No.of Blows	DCP-CBR	Thickness	No.of Blows	DCP-CBR	Thickness	No.of Blows	DCP-CBR	Thickness	No.of Blows	DCP-CBR	
1	FCBR-01	150	2	1.74	150	1	0.72	150	1	0.72	150	1	0.72	150	2	1.74	150	2	0.72	150	2	1.74	1.09
2	FCBR-02	150	2	1.74	150	2	1.74	150	2	1.74	150	1	0.72	150	1	0.72	150	2	0.72	150	2	1.74	1.23

FIELD VANE SHEAR TEST:

The equipments meets the requirements of IS:4434-78 and it is used for determining the in place shearing resistance in saturated cohesive deposits. This instrument is for testing from bottom of bore hole.

Description of the equipment:

Torque applicator assembly contains a sturdy ring which has a section cut from it and it will deform as torque is applied. The deformation is indicated by a dial gauge. The assembly is calibrated in kgf/cm torque. A gear wheel which holds the torque ring is geared to a crank handle which can be operated at controlled speed. The gear wheel is marked in degrees and has a rotation indicator for registering rotation. The wheel assembly is fixed on a base and can be mounted on the stand. The stand is provided with an adjustable (in height) clamp to hold the string of rods. For clamping, press the handle down. Insert the rod and then release the handle T.R. Clamp is mounted on holding plate. Three spikes are provided to anchor the stand with torque applicator assembly on to the ground.

Van Rod System consists of a torque rod of square cross-section passing through the torque applicator, a center section made of quick coupling type rods and a lower vane. Vanes are of two different sizes 37.5 mm dia and 50 mm dia. Rods are of uniform diameter, one meter and half meter long. These rods have tapered male and female threads. One of the rods meant for fixing the vane has however tapered female and straight female threads.

Two dummy rods corresponding to vane rods are supplied for determine the friction between the soil and rods. Two spanners are also supplied to tighten the rods. A chart for converting the dial gauge reading to kgf.cm torque is supplied.

Sink the bore hole upto the depth required and extend the casting (not supplied) upto the full depth. If the casing is loose secure it so that it does not move during the test. Fix the torque applicator on the stand and anchor the stand with the help of spikes. Connect the vane of suitable size to the rod having same female thread as on the vane rod and lower it to the bottom of the bore hole putting guides (not supplied) at suitable intervals but not more than about 5.0 meter as the rods are expended. The vane size selected should be the the largest size suitable for general soil conditions. The 100 mm dia vane (not supplied) is limited to obtaining shear value from 0 to 0.55 kgf/cm2 and is recommended for very soft saturated soils. The 75 mm diameter vane (not supplied) is limited to obtaining shear values from 0 to 1.3 kgf/ cm2 and is recommended for soft moderately firm saturated soils. The 50 mm dia vane is intended for firm saturated soils.

Push the vane with a moderate steady force upto a depth of four times the diameter of the bore hole or 50 mm whichever is more, below the bottom of the bore hole. Ensure that no torque is applied to the torque rods during the thrust. No hammering shall be permitted.

Set the initial dial gauge reading. Allow a minimum period of five minutes after insertion of the vane. Turn the gear handle so that the vane is rotated at the rate of $0.1^{o}/S$. To get this turn the crank at a uniform rate of 12 turns per minute; this corresponds to $0.1^{o}/S$ rotation of the vane rod. The maximum torque reading attained. If necessary note the torque indicator dial gauge readings at half-minute intervals and continue rotating the vane until the reading drops appreciably from the maximum.

Rotate the vane completely ten times to disturb the soil. Stop further rotation for about ten minutes and repeat the test as above to determine the remoulded strength after failure.

Friction in the clamping arrangement (if any) can be found out by turning the crank handle before pushing the vane in the soil. Remove the vane testing assembly , continue boring and collect soil sample from the level of the vane testing for laboratory analysis to ascertain whether the deposit will behave as a purely cohesive soil. For a rectangular vane, calculate the shear strength of the soil usuing the following formula:

$$S = \frac{T}{\pi(D^2H/2 + D^3/6)}$$

Where,

S = Shear strength in kg/cm^2

T = Torque in kg-cm

D = Overall diameter of vane in cm = 5 cm

H = Height of Vane in cm = 10 cm

k = $\pi(D^2H/2 + D^3/6)$

TABLE: VANE SHEAR TEST RESULTS

BH NO.	DEPTH (M)	Torque (kg-cm)	k constant	Shear strength (kg/cm^2)
1	3.50	59.00	457.92	0.129
	5.00	61.00	457.92	0.133
2	3.50	52.00	457.92	0.114
	5.00	61.00	457.92	0.133
	6.50	65.00	457.92	0.142
3	3.50	52.00	457.92	0.114
	5.00	60.50	457.92	0.132

Annexure-III

STATIC CONE PENETRATION TEST

Methodology for Static Cone Penetration Test:

The equipment used for this test shall conform to the requirments of **IS:4968 (Part-III)**

The capacity of the equipment to be used for test shall not be less than 3.0 tones but preferably 20.0 tones.

The test shall not be carried out on gravelly soils and for soils with standard penetration value 'N' greater than 50.

Test Procedure shall meet the requirments of IS:4968 (Part-III). Some of the important points of the test procedure are given below:

(a) The cone is pushed through a distance in accordance with the design of the equipment and the need for the sub-starta and the cone resistance noted. The cone and the friction jacket are pushed togethere subsequently for a distance depending upon, the design of the cone and friction jacket assembly and the combined value of cone and friction resistance noted. This procedure is repeted at predetermined intervales.

(b) Equipment shall be securely anchored to the ground at the test point for obtaining the required reaction.

(c) The rod and the driving mechanism shall be brought to the top most position. The cone-friction jecket assembly shall be connected to the first sounding rod and the mantle tube. The assembly shall be positioned over the test point through the mentle tube guided and held vertically. The plunger of the driving mechanism shall be brought down so as to rest against the protruding sounding rod.

(d) To obtain the con eresistance, this sounding rod only shall be pushed. Switching the gear clutch to the slow position, the drive handle shall be operated at a steady rate of 1 cm per sec approximately, so as to advance the cone only to a depth which is possible with the cone assembly available. During the pushing, the mean value of resistance as indicated by pressure gauses shall be noted ignoring erratic changes.

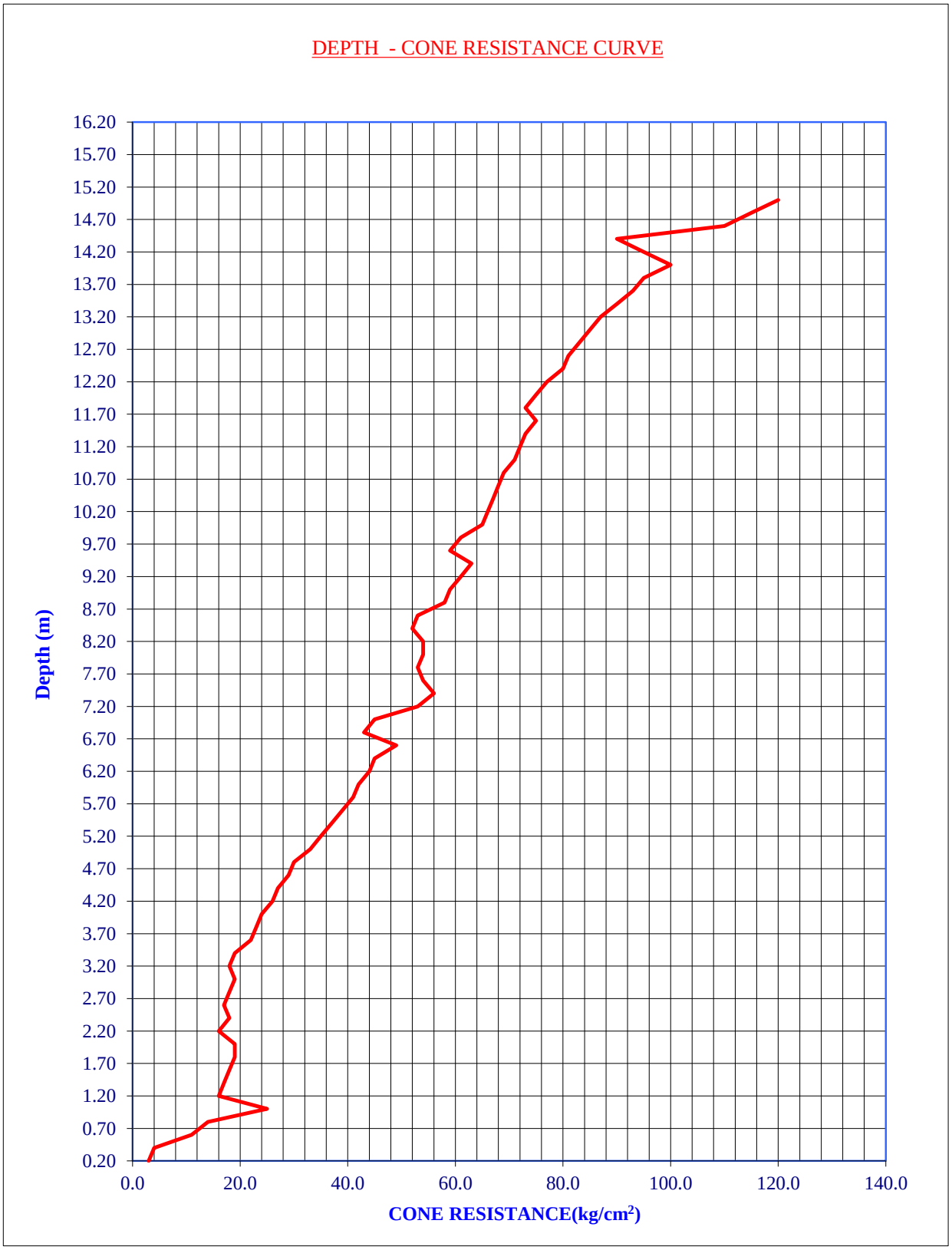
(e) For finding combined cone and resistance of the soil, the sounding rod shall be pushed to the extent, the cone has been pushed at the rate of 1 cm per sec noting mean resistance on the gauges.

(f) Above procedure shall be repeted after pushing the combined cone-friction jacket and mentle tube assembly to the next depth at which the test is to be performed.

TEST REPORT ON STATIC CONE PENETRATION TEST

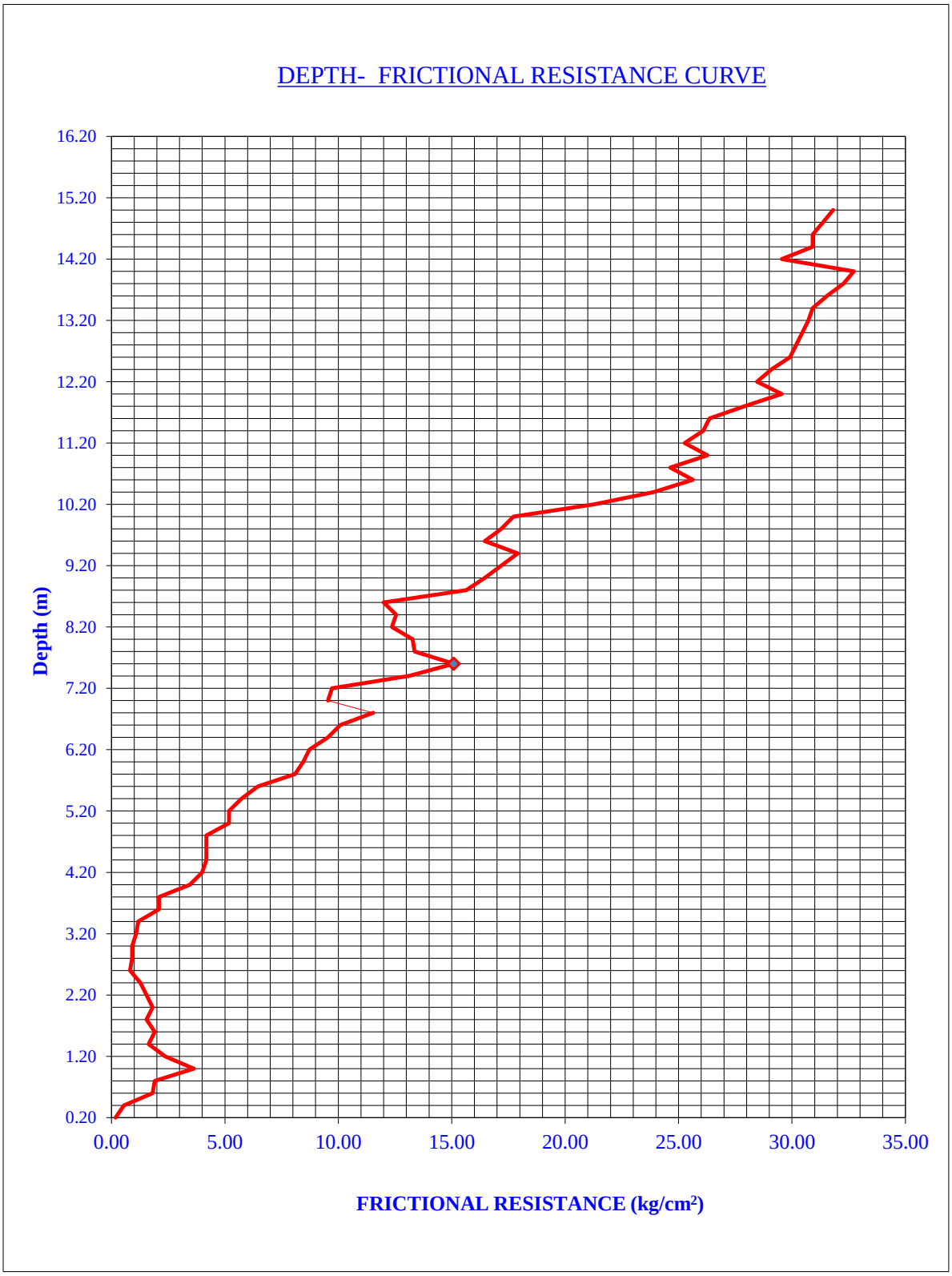
Test point No: 01 **Date of Testing:** 11/5/2017

Depth below ground level (m)	Gauge Reading (Kg/cm^2)	Corrected value of cone Penetration resistance (Kg/cm^2)	Depth below ground level (m)	Gauge Reading (Kg/cm^2)	Corrected value of cone Penetration resistance (Kg/cm^2)
0.20	3.00	3.26	8.20	54.00	56.34
0.40	4.00	4.26	8.40	52.00	54.34
0.60	11.00	11.26	8.60	53.00	55.34
0.80	14.00	14.26	8.80	58.00	60.34
1.00	25.00	25.26	9.00	59.00	61.34
1.20	16.00	16.52	9.20	61.00	63.60
1.40	17.00	17.52	9.40	63.00	65.60
1.60	18.00	18.52	9.60	59.00	61.60
1.80	19.00	19.52	9.80	61.00	63.60
2.00	19.00	19.52	10.00	65.00	67.60
2.20	16.00	16.78	10.20	66.00	68.86
2.40	18.00	18.78	10.40	67.00	69.86
2.60	17.00	17.78	10.60	68.00	70.86
2.80	18.00	18.78	10.80	69.00	71.86
3.00	19.00	19.78	11.00	71.00	73.86
3.20	18.00	19.04	11.20	72.00	75.12
3.40	19.00	20.04	11.40	73.00	76.12
3.60	22.00	23.04	11.60	75.00	78.12
3.80	23.00	24.04	11.80	73.00	76.12
4.00	24.00	25.04	12.00	75.00	78.12
4.20	26.00	27.30	12.20	77.00	80.38
4.40	27.00	28.30	12.40	80.00	83.38
4.60	29.00	30.30	12.60	81.00	84.38
4.80	30.00	31.30	12.80	83.00	86.38
5.00	33.00	34.30	13.00	85.00	88.38
5.20	35.00	36.56	13.20	87.00	90.64
5.40	37.00	38.56	13.40	90.00	93.64
5.60	39.00	40.56	13.60	93.00	96.64
5.80	41.00	42.56	13.80	95.00	98.64
6.00	42.00	43.56	14.00	100.00	103.64
6.20	44.00	45.82	14.20	95.00	98.90
6.40	45.00	46.82	14.40	90.00	93.90
6.60	49.00	50.82	14.60	110.00	113.90
6.80	43.00	44.82	14.80	115.00	118.90
7.00	45.00	46.82	15.00	120.00	123.90
7.20	53.00	55.08			
7.40	56.00	58.08			
7.60	54.00	56.08			
7.80	53.00	55.08			
8.00	54.00	56.08			


DEPTH - CONE RESISTANCE CURVE
Depth (m)
16.20
15.70
15.20
14.70
14.20
13.70
13.20
12.70
12.20
11.70
11.20
10.70
10.20
9.70
9.20
8.70
8.20
7.70
7.20
6.70
6.20
5.70
5.20
4.70
4.20
3.70
3.20
2.70
2.20
1.70
1.20
0.70
0.20
0.0
20.0
40.0
60.0
80.0
100.0
120.0
140.0
CONE RESISTANCE(kg/cm2)

Depth below ground level (m)	Total Resistance (Kg/cm^2)	Cone resistance (uncorrected) (Kg/cm^2)	Total resistance Minus cone resistance(Kg/cm^2)	Frictional resistance (Kg/cm^2)	Corrected Frictional resistance (Kg/cm^2)
0.20	5.00	3.00	2.00	0.18	0.19
0.40	10.00	4.00	6.00	0.55	0.56
0.60	31.00	11.00	20.00	1.82	1.83
0.80	35.00	14.00	21.00	1.91	1.92
1.00	65.00	25.00	40.00	3.64	3.65
1.20	42.00	16.00	26.00	2.36	2.37
1.40	35.00	17.00	18.00	1.64	1.65
1.60	39.00	18.00	21.00	1.91	1.92
1.80	36.00	19.00	17.00	1.55	1.56
2.00	39.00	19.00	20.00	1.82	1.83
2.20	33.00	16.00	17.00	1.55	1.56
2.40	32.00	18.00	14.00	1.27	1.28
2.60	26.00	17.00	9.00	0.82	0.83
2.80	28.00	18.00	10.00	0.91	0.92
3.00	29.00	19.00	10.00	0.91	0.92
3.20	30.00	18.00	12.00	1.09	1.10
3.40	32.00	19.00	13.00	1.18	1.19
3.60	45.00	22.00	23.00	2.09	2.10
3.80	46.00	23.00	23.00	2.09	2.10
4.00	62.00	24.00	38.00	3.45	3.46
4.20	70.00	26.00	44.00	4.00	4.01
4.40	73.00	27.00	46.00	4.18	4.19
4.60	75.00	29.00	46.00	4.18	4.19
4.80	76.00	30.00	46.00	4.18	4.19
5.00	90.00	33.00	57.00	5.18	5.19
5.20	92.00	35.00	57.00	5.18	5.19
5.40	100.00	37.00	63.00	5.73	5.74
5.60	110.00	39.00	71.00	6.45	6.46
5.80	130.00	41.00	89.00	8.09	8.10
6.00	135.00	42.00	93.00	8.45	8.46
6.20	140.00	44.00	96.00	8.73	8.74
6.40	150.00	45.00	105.00	9.55	9.56
6.60	160.00	49.00	111.00	10.09	10.10
6.80	170.00	43.00	127.00	11.55	11.56
7.00	150.00	45.00	105.00	9.55	9.56
7.20	160.00	53.00	107.00	9.73	9.74
7.40	200.00	56.00	144.00	13.09	13.10
7.60	220.00	54.00	166.00	15.09	15.10
7.80	200.00	53.00	147.00	13.36	13.37
8.00	200.00	54.00	146.00	13.27	13.28
8.20	190.00	54.00	136.00	12.36	12.37
8.40	190.00	52.00	138.00	12.55	12.56
8.60	185.00	53.00	132.00	12.00	12.01
8.80	230.00	58.00	172.00	15.64	15.65
9.00	240.00	59.00	181.00	16.45	16.46

Depth below ground level (m)	Total resistance (Kg/cm^2)	Cone resistance (uncorrected) (Kg/cm^2)	Total resistance Minus cone Resistance(Kg/cm^2)	Frictional Resistance (Kg/cm^2)	Corrected Frictional Resistance (Kg/cm^2)
9.20	250.00	61.00	189.00	17.18	17.19
9.40	260.00	63.00	197.00	17.91	17.92
9.60	240.00	59.00	181.00	16.45	16.46
9.80	250.00	61.00	189.00	17.18	17.19
10.00	260.00	65.00	195.00	17.73	17.74
10.20	300.00	66.00	234.00	21.27	21.28
10.40	330.00	67.00	263.00	23.91	23.92
10.60	350.00	68.00	282.00	25.64	25.65
10.80	340.00	69.00	271.00	24.64	24.65
11.00	360.00	71.00	289.00	26.27	26.28
11.20	350.00	72.00	278.00	25.27	25.28
11.40	360.00	73.00	287.00	26.09	26.10
11.60	365.00	75.00	290.00	26.36	26.37
11.80	380.00	73.00	307.00	27.91	27.92
12.00	400.00	75.00	325.00	29.55	29.56
12.20	390.00	77.00	313.00	28.45	28.46
12.40	400.00	80.00	320.00	29.09	29.10
12.60	410.00	81.00	329.00	29.91	29.92
12.80	415.00	83.00	332.00	30.18	30.19
13.00	420.00	85.00	335.00	30.45	30.46
13.20	425.00	87.00	338.00	30.73	30.74
13.40	430.00	90.00	340.00	30.91	30.92
13.60	440.00	93.00	347.00	31.55	31.56
13.80	450.00	95.00	355.00	32.27	32.28
14.00	460.00	100.00	360.00	32.73	32.74
14.20	420.00	95.00	325.00	29.55	29.56
14.40	430.00	90.00	340.00	30.91	30.92
14.60	450.00	110.00	340.00	30.91	30.92
14.80	460.00	115.00	345.00	31.36	31.37
15.00	470.00	120.00	350.00	31.82	31.83



Type of strata based on SCPT result:

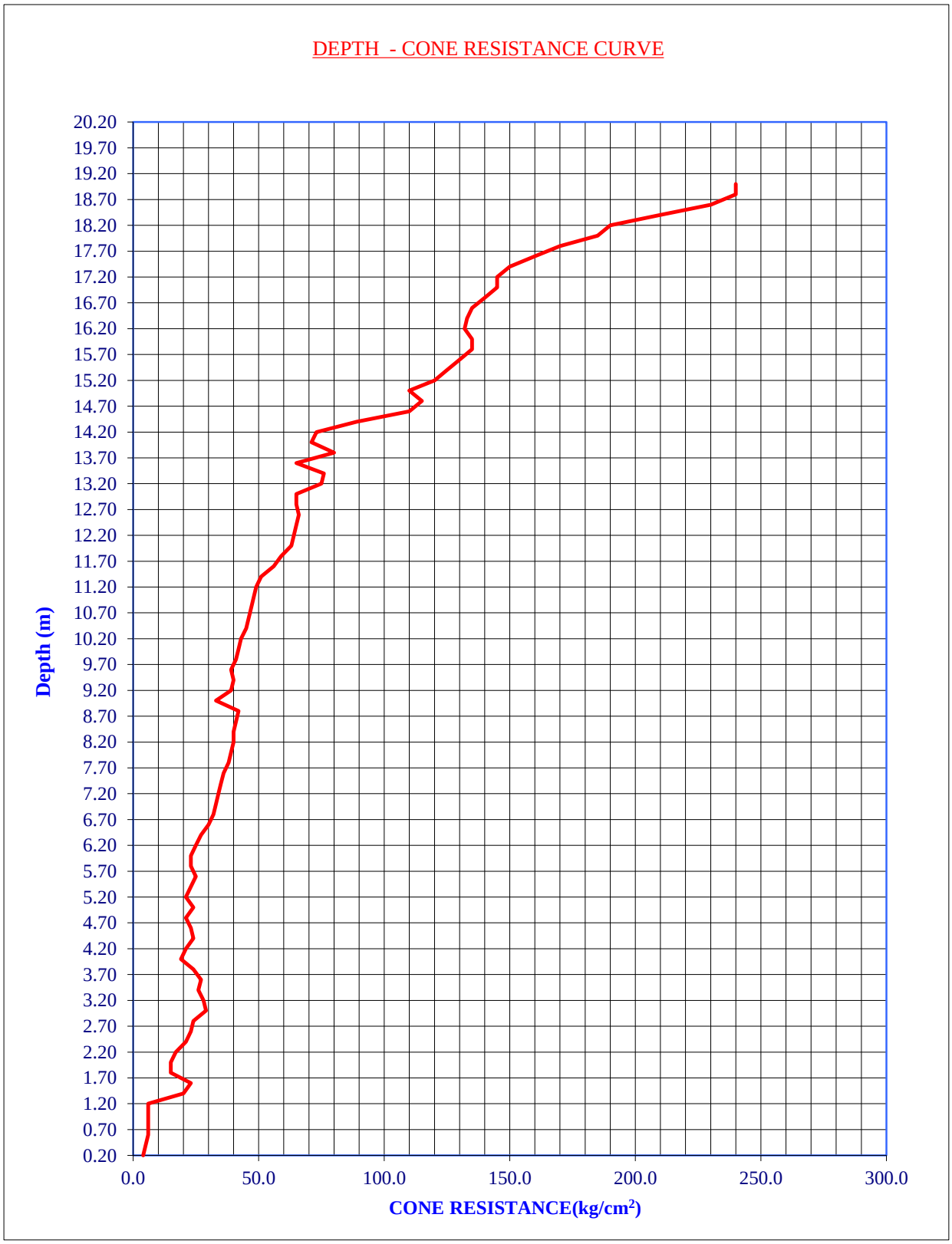
i) From 0.0 to 8.0 m the soil is clay
ii) From 8.0 to 15.0 m sand layer is indicated

TEST REPORT ON STATIC CONE PENETRATION TEST

Test point No: 02 **Date of Testing:** 10/5/2017

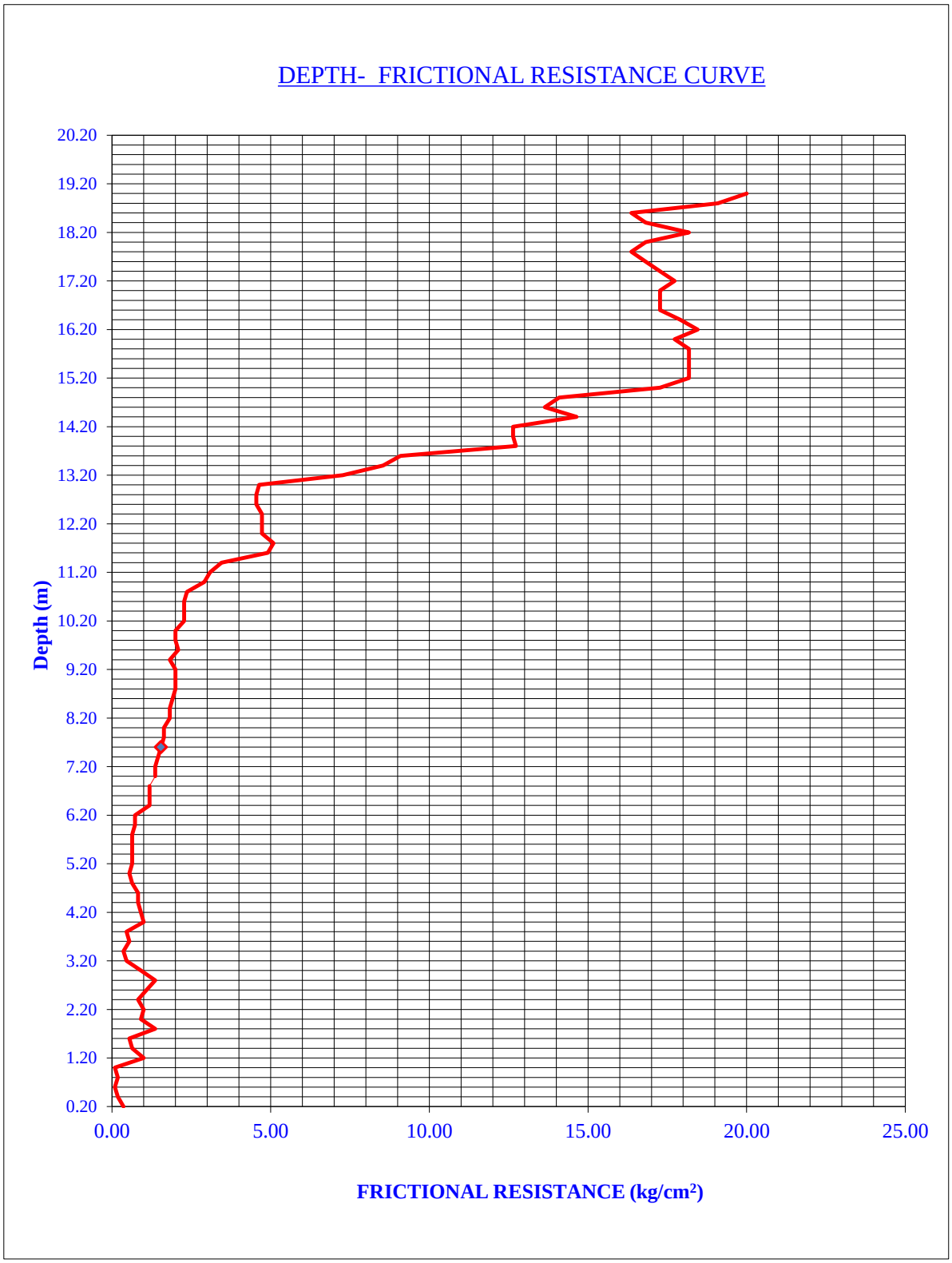
Depth below ground level (m)	Gauge Reading (Kg/cm^2)	Corrected value of cone Penetration resistance (Kg/cm^2)	Depth below ground level (m)	Gauge Reading (Kg/cm^2)	Corrected value of cone Penetration resistance (Kg/cm^2)
0.20	4.00	4.26	8.20	40.00	42.34
0.40	5.00	5.26	8.40	40.00	42.34
0.60	6.00	6.26	8.60	41.00	43.34
0.80	6.00	6.26	8.80	42.00	44.34
1.00	6.00	6.26	9.00	33.00	35.34
1.20	6.00	6.52	9.20	39.00	41.60
1.40	20.00	20.52	9.40	40.00	42.60
1.60	23.00	23.52	9.60	39.00	41.60
1.80	15.00	15.52	9.80	41.00	43.60
2.00	15.00	15.52	10.00	42.00	44.60
2.20	17.00	17.78	10.20	43.00	45.86
2.40	21.00	21.78	10.40	45.00	47.86
2.60	23.00	23.78	10.60	46.00	48.86
2.80	24.00	24.78	10.80	47.00	49.86
3.00	29.00	29.78	11.00	48.00	50.86
3.20	28.00	29.04	11.20	49.00	52.12
3.40	26.00	27.04	11.40	51.00	54.12
3.60	27.00	28.04	11.60	56.00	59.12
3.80	24.00	25.04	11.80	59.00	62.12
4.00	19.00	20.04	12.00	63.00	66.12
4.20	21.00	22.30	12.20	64.00	67.38
4.40	24.00	25.30	12.40	65.00	68.38
4.60	23.00	24.30	12.60	66.00	69.38
4.80	21.00	22.30	12.80	65.00	68.38
5.00	24.00	25.30	13.00	65.00	68.38
5.20	21.00	22.56	13.20	75.00	78.64
5.40	23.00	24.56	13.40	76.00	79.64
5.60	25.00	26.56	13.60	65.00	68.64
5.80	23.00	24.56	13.80	80.00	83.64
6.00	23.00	24.56	14.00	71.00	74.64
6.20	25.00	26.82	14.20	73.00	76.90
6.40	27.00	28.82	14.40	89.00	92.90
6.60	30.00	31.82	14.60	110.00	113.90
6.80	32.00	33.82	14.80	115.00	118.90
7.00	33.00	34.82	15.00	110.00	113.90
7.20	34.00	36.08	15.20	120.00	124.16
7.40	35.00	37.08	15.40	125.00	129.16
7.60	36.00	38.08	15.60	130.00	134.16
7.80	38.00	40.08	15.80	135.00	139.16
8.00	39.00	41.08	16.00	135.00	139.16

Depth below ground level (m)	Gauge Reading (Kg/cm^2)	Corrected value of cone Penetration resistance (Kg/cm^2)	Depth below ground level (m)	Gauge Reading (Kg/cm^2)	Corrected value of cone Penetration resistance (Kg/cm^2)
16.20	132.00	136.42			
16.40	133.00	137.42			
16.60	135.00	139.42			
16.80	140.00	144.42			
17.00	145.00	149.42			
17.20	145.00	149.68			
17.40	150.00	154.68			
17.60	160.00	164.68			
17.80	170.00	174.68			
18.00	185.00	189.68			
18.20	190.00	194.94			
18.40	210.00	214.94			
18.60	230.00	234.94			
18.80	240.00	244.94			
19.00	240.00	244.94			


DEPTH - CONE RESISTANCE CURVE
Depth (m)
20.20
19.70
19.20
18.70
18.20
17.70
17.20
16.70
16.20
15.70
15.20
14.70
14.20
13.70
13.20
12.70
12.20
11.70
11.20
10.70
10.20
9.70
9.20
8.70
8.20
7.70
7.20
6.70
6.20
5.70
5.20
4.70
4.20
3.70
3.20
2.70
2.20
1.70
1.20
0.70
0.20
0.0
50.0
100.0
150.0
200.0
250.0
300.0
CONE RESISTANCE(kg/cm2)

Depth below ground level (m)	Total Resistance (Kg/cm^2)	Cone resistance (uncorrected) (Kg/cm^2)	Total resistance Minus cone resistance(Kg/cm^2)	Frictional resistance (Kg/cm^2)	Corrected Frictional resistance (Kg/cm^2)
0.20	8.00	4.00	4.00	0.36	0.37
0.40	7.00	5.00	2.00	0.18	0.19
0.60	7.00	6.00	1.00	0.09	0.10
0.80	8.00	6.00	2.00	0.18	0.19
1.00	7.00	6.00	1.00	0.09	0.10
1.20	17.00	6.00	11.00	1.00	1.01
1.40	27.00	20.00	7.00	0.64	0.65
1.60	29.00	23.00	6.00	0.55	0.56
1.80	30.00	15.00	15.00	1.36	1.37
2.00	25.00	15.00	10.00	0.91	0.92
2.20	28.00	17.00	11.00	1.00	1.01
2.40	30.00	21.00	9.00	0.82	0.83
2.60	35.00	23.00	12.00	1.09	1.10
2.80	39.00	24.00	15.00	1.36	1.37
3.00	39.00	29.00	10.00	0.91	0.92
3.20	33.00	28.00	5.00	0.45	0.46
3.40	30.00	26.00	4.00	0.36	0.37
3.60	33.00	27.00	6.00	0.55	0.56
3.80	29.00	24.00	5.00	0.45	0.46
4.00	30.00	19.00	11.00	1.00	1.01
4.20	31.00	21.00	10.00	0.91	0.92
4.40	33.00	24.00	9.00	0.82	0.83
4.60	32.00	23.00	9.00	0.82	0.83
4.80	28.00	21.00	7.00	0.64	0.65
5.00	30.00	24.00	6.00	0.55	0.56
5.20	28.00	21.00	7.00	0.64	0.65
5.40	30.00	23.00	7.00	0.64	0.65
5.60	32.00	25.00	7.00	0.64	0.65
5.80	30.00	23.00	7.00	0.64	0.65
6.00	31.00	23.00	8.00	0.73	0.74
6.20	33.00	25.00	8.00	0.73	0.74
6.40	40.00	27.00	13.00	1.18	1.19
6.60	43.00	30.00	13.00	1.18	1.19
6.80	45.00	32.00	13.00	1.18	1.19
7.00	48.00	33.00	15.00	1.36	1.37
7.20	49.00	34.00	15.00	1.36	1.37
7.40	51.00	35.00	16.00	1.45	1.46
7.60	53.00	36.00	17.00	1.55	1.56
7.80	56.00	38.00	18.00	1.64	1.65
8.00	57.00	39.00	18.00	1.64	1.65
8.20	60.00	40.00	20.00	1.82	1.83
8.40	60.00	40.00	20.00	1.82	1.83
8.60	62.00	41.00	21.00	1.91	1.92
8.80	64.00	42.00	22.00	2.00	2.01
9.00	55.00	33.00	22.00	2.00	2.01

Depth below ground level (m)	Total resistance (Kg/cm^2)	Cone resistance (uncorrected) (Kg/cm^2)	Total resistance Minus cone Resistance(Kg/cm^2)	Frictional Resistance (Kg/cm^2)	Corrected Frictional Resistance (Kg/cm^2)
9.20	61.00	39.00	22.00	2.00	2.01
9.40	60.00	40.00	20.00	1.82	1.83
9.60	62.00	39.00	23.00	2.09	2.10
9.80	63.00	41.00	22.00	2.00	2.01
10.00	64.00	42.00	22.00	2.00	2.01
10.20	68.00	43.00	25.00	2.27	2.28
10.40	70.00	45.00	25.00	2.27	2.28
10.60	71.00	46.00	25.00	2.27	2.28
10.80	73.00	47.00	26.00	2.36	2.37
11.00	80.00	48.00	32.00	2.91	2.92
11.20	83.00	49.00	34.00	3.09	3.10
11.40	89.00	51.00	38.00	3.45	3.46
11.60	110.00	56.00	54.00	4.91	4.92
11.80	115.00	59.00	56.00	5.09	5.10
12.00	115.00	63.00	52.00	4.73	4.74
12.20	116.00	64.00	52.00	4.73	4.74
12.40	117.00	65.00	52.00	4.73	4.74
12.60	116.00	66.00	50.00	4.55	4.56
12.80	115.00	65.00	50.00	4.55	4.56
13.00	116.00	65.00	51.00	4.64	4.65
13.20	155.00	75.00	80.00	7.27	7.28
13.40	170.00	76.00	94.00	8.55	8.56
13.60	165.00	65.00	100.00	9.09	9.10
13.80	220.00	80.00	140.00	12.73	12.74
14.00	210.00	71.00	139.00	12.64	12.65
14.20	212.00	73.00	139.00	12.64	12.65
14.40	250.00	89.00	161.00	14.64	14.65
14.60	260.00	110.00	150.00	13.64	13.65
14.80	270.00	115.00	155.00	14.09	14.10
15.00	300.00	110.00	190.00	17.27	17.28
15.20	320.00	120.00	200.00	18.18	18.19
15.40	325.00	125.00	200.00	18.18	18.19
15.60	330.00	130.00	200.00	18.18	18.19
15.80	335.00	135.00	200.00	18.18	18.19
16.00	330.00	135.00	195.00	17.73	17.74
16.20	335.00	132.00	203.00	18.45	18.46
16.40	330.00	133.00	197.00	17.91	17.92
16.60	325.00	135.00	190.00	17.27	17.28
16.80	330.00	140.00	190.00	17.27	17.28
17.00	335.00	145.00	190.00	17.27	17.28
17.20	340.00	145.00	195.00	17.73	17.74
17.40	340.00	150.00	190.00	17.27	17.28
17.60	345.00	160.00	185.00	16.82	16.83
17.80	350.00	170.00	180.00	16.36	16.37
18.00	370.00	185.00	185.00	16.82	16.83
18.20	390.00	190.00	200.00	18.18	18.19
18.40	395.00	210.00	185.00	16.82	16.83
18.60	410.00	230.00	180.00	16.36	16.37
18.80	450.00	240.00	210.00	19.09	19.10
19.00	460.00	240.00	220.00	20.00	20.01



Type of strata based on SCPT result:

i) From 0.0 to 13.0 m the soil is clay
ii) From 13.0 to 19.0 m sand layer is indicated