Booking No JP/ETTL/24-25/85074961114 -2-L2 Date of Report: - 19.11.2024
Location: - Viroli Bridge

TC- 12743

E.T.T.L.

ENGINEERING TRAINING TESTING AND CALIBRATION LABORATORY

(AN ISO 9001:2015 CERTIFIED CO.) NABL Accredited Laboratory as per 17025: 2017

Geotechnical Investigation Report

Report No. JP/ETTL/24-25/TE-8507496114-2--L2			
ULR No. TC-12743230000007496F			
Issued To:	**Executive Engineer PWD Div Chittorgarh Distt Chittorgarh**	Sample ID:	07496-2
		Date of Receiving:	14.11.2024
		Date of test start:	14.11.2024
		Date of test Completion:	19.11.2024
		Date of Report:	19.11.2024
Name of Work:	**Itali Bhadsora 0/00-36/00 (Viroli Bridge)**		

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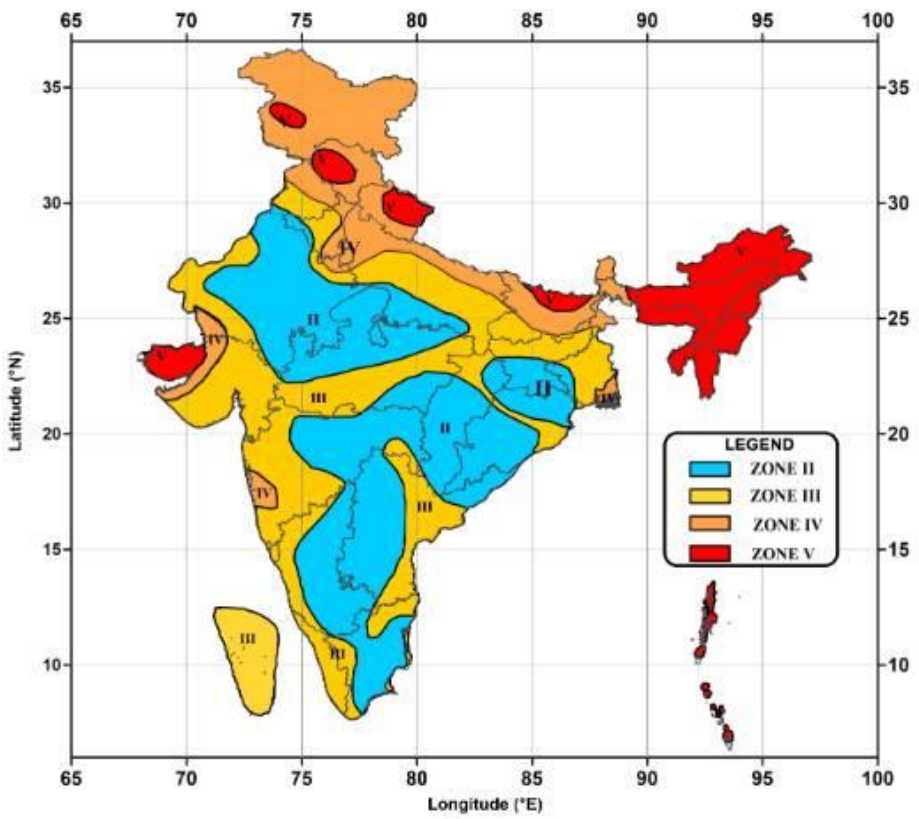
1. INTRODUCTION:

This report deals with Geo-Technical Investigation for Itali Bhadsora 0/00-36/00. The work of conducting the detailed Geotechnical Investigation has been awarded to us who includes investigation in field, laboratory testing of bulk samples collected from the site and submission of the test report.

This report includes the detail of Methodology of investigation, collection of samples, field and laboratory test result including their interpretation/ analysis, recommendations on the properties of soils required for design of foundation and suggesting suitable type of foundation and safe allowable bearing capacity for safe and strong foundation for various structures.

2. SITE DESCRIPTION:

From the study of the district seismic profile map of **India** it is evident that, project line comes Under the Damage Risk Zone-III.



Seismic Map of India

Source: National Disaster Management Authority

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3. FIELD INVESTIGATION:

The field investigation work at the sites under consideration of this part of the report was carried out, boreholes of diameter 150 mm, the boreholes were progressed by using power driven rotary drilling machines. In disintegrated rock strata boreholes were progressed using NX size (75 mm diameter) double tube barrel with diamond bit. As rock was encountered from top the drilling of rock was done. Standard Penetration Tests were conducted at 1.50-meter interval up to the depth as per the procedure laid in IS: 2131-1981 in all the bore holes whereas possible. For conducting the test, the bottom of the borehole was properly cleaned and split spoon sampler was properly seated in position in the borehole. The split spoon sampler resting on the bottom of borehole was allowed to sink under its own weight; then the sampler was allowed to penetrate 15 cm with the blows of the hammer 63.50 kg weight falling free through 75 cm, thereafter the split spoon sampler was further driven by another 15 cm. For the 3rd and final drive, the sampler was further allowed to penetrate 15 cm. The number of blows required to affect each 15 cm of penetration was recorded. The first 15 cm of drive is considered to be seating drive.

Structure of SPT Sampler

The total blows of penetration for the second and third 15 cm of penetration is termed the penetration resistance N. The N' values are indicative of the compactness/ relative density of cohesion less soils and consistency of cohesive soils.

In case the blows count of SPT in soil (including the number of blows of seating) exceeds 100, the corresponding penetration was recorded and this particular test at that depth stopped. If the total penetration is more than the seating penetration of 15 cm, then breakup of blows count for 15 cm seating penetration and for remaining portion of penetration is also given.

SPT 'N' values are correlated with relative of non-cohesive stratum as per BS: 5930 (1999) - for sandy strata and with consistency of cohesive stratum.

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CORRELATION FOR CLAY/PLASTIC SILT		CORRELATION FOR SAND/NON-PLASTIC SILT	
Consistency of clays	Penetration Value	Relative Density of sand	Penetration Value
Very Soft	0 to 2 Blows	Very loose	0 to 4 Blows
Soft	3 to 4 Blows	Loose	5 to 10 Blows
Medium Stiff	5 to 8 Blows	Medium	11 to 30 Blows
Stiff	9 to 16 Blows	Dense	31 to 50 Blows
Very Stiff	17 to 32 Blows	Very Dense	Above 50
Hard	Above 32		

In this method, the sampler acts as a probe and the driving energy is supplied by the fall of the drop weight. The values of 'N' depend on the compactness or relative density of the materiel. In hard formations, the testing is discontinued if 'N' value is found to be more than 100. It is termed as refusal.

'N' value depends upon degree of saturation and over burden pressure of the formation. Silty fine sand and fine sand below the water table develop pore water pressure. Depending on the in-situ void ratio which in turn affects the effective stress. This change in effective stress influences the 'N' value considerably. Soil sample obtained from standard spoon sampler for all above standard penetration tests were collected in the polythene bags of suitable size. These samples were property seal, labelled, record and carefully transported to the laboratory for testing.

3.1 **Disturbed soil samples** were tried to be collected at 1.50-meter interval and at significant change of stratum. Soil from cutting edge of SPT samplers and retained in split spoon sampler, used for Standard Penetration Tests was taken as disturbed samples as well as from boring water. These samples were placed without delay in adequately sealed polythene bags. The laboratory tests were conducted on the collected soil samples and reported

3.2 **Undisturbed soil samples** were tried to be collected in accordance with IS: 2132-1986. Since strata is of rock it was not collected. In general Undisturbed soil samples (UDS) is obtained in 100 mm diameter MS tubes of length 450 mm at 3.00 meter interval in all the bore holes.

3.3 **Rock** Drilling and core samples: Drilling was advanced by rotary core drilling method using double tube core barrels as per the guidelines of IS: 6926-1996. A double tube core barrel and Nx sized bits are used

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for drilling and recovering rock cores. Core Samples were extracted by the application of a continuous pressure at one end of the core with the barrel held horizontally without vibration Immediately after withdrawal from the core barrel, the cores were placed in a tray and transferred into boxes specially prepared for the purpose. The boxes are made of seasoned timber. Recovered rock cores were numbered serially as specified in IS: 4078-1980. Rock core recovery and Rock Quality Designation were computed for every run length drilled. The description of the core samples was recorded. Rock core recovered during the NX size rock drilling have been measured, numbered and packed in wooden core boxes. The core recovery and RQD information have been reported

3.4 IF the **water table** at this site was encountered during the boring operation. Depth of water table was recorded as per IS 6935-1973. Recorded depth of water table in different bore holes are reported below.

Location	Depth of Bore (m)	Water table (m)
BH-1	6m	0.5
BH-2	6m	0.5
BH-3	6m	0.5

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4. LABORATORY INVESTIGATION:

4.1 Field moisture contents are determined by oven drying method as per IS 2720 (part II)-1997. The results have been reported in Table under the title "Laboratory Test Result".

4.2 Bulk density of soil strata was obtained using density ring method. The results have been reported in Table under the title "Laboratory Test Result".

4.3 Mechanical sieve analysis test was performed in accordance with IS 2720 (Part IV) - 1985, for the purpose of identification by grain size analysis, on coarse part of the soil Samples and the results have been reported in Table under the title "Laboratory Test Result"

4.4 Particle size analysis test by **hydrometer** method are performed in accordance with IS 2720 (Part IV) - 1995 on the part of soil samples obtained after the sieve analysis. The results have been reported in Table under the title "Laboratory Test Result".

4.5 Atterberg's limits tests are performed in accordance with IS 2720 (part V)-1985 and results have been reported in Table under the title "Laboratory Test Result".

4.6 Specific gravity tests are performed in accordance with IS 2720 (part III-sec. 1) -1980 and the results have been reported in Table under the title "Laboratory Test Result".

4.7 Direct shear tests are performed as per IS 2720 (part XII)-1971, on the undisturbed soil samples obtained during the field investigation. The results have been reported in Table under the title "Laboratory Test Result".

4.8 Point Load of Rock are performed as per IS 8764, on the rock samples obtained during the field investigation. The results have been reported in Table under the title "Laboratory Test Result".

4.9 Water Absorption are performed as per IS 2386, on the rock samples obtained during the field investigation. The results have been reported in Table under the title "Laboratory Test Result".

4.10 UCS are performed as per IS 9143, on the rock samples obtained during the field investigation. The results have been reported in Table under the title "Laboratory Test Result".

4.11 Rock classification in terms of weathering and state of fractures and strength is carried out in the following manner. Tabulations given in below explain it briefly.

Note: Tests are performed as per requirement, importance and availability of sample and Results of test have been shown in Summary sheet (Laboratory Test Results) in Appendix-A whichever applicable.

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5. CLASSIFICATION CRITERIA OF ROCK MASSES:

Rock classification in terms of weathering and state of fractures and strength is carried out in the following manner. Tabulations given in below explain it briefly.

TERMS	DESCRIPTION	GRADE	RDSO/2023/GE: G-2 Revision-1 02/2023 Table 2.3 RQD %	Graphical Representation
Fresh Rock	No visible sign of rock material weathering; perhaps slight coloration on major discontinuity surfaces	W_1	91 to 100 %	
Slightly Weathered Rock/Hard Rock	Discoloration indicates weathering of rock material and discontinuity surfaces. All the rock material may be discoloured by weathering.	W_2	76 to 90 %	
Moderately Weathered Rock	Less than half of the rock material is decomposed or disintegrated to a soil. Fresh or discoloured rock is present either as a continuous framework or as core-stones.	W_3	51 % to 75 %	
Highly Weathered Rock	More than half of the rock material is decomposed or disintegrated to a soil. Fresh or discoloured rock is present either as a discontinuous framework or as core-stones.	W_4	25 % to 50 %	
Completely weathered Rock	All rock material is decomposed and / or disintegrated to soil. The original mass structure is still largely intact.	W_5	< 25 %	
Residual Soil	All rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume, but the soil has not been significantly transported.	-	CR = Zero % But N > 50	

As per IS: 4464, It should be understood that all grades of weathering may not be seen in a given rock mass and that in some cases a particular grade may be present to a very small extent. Distribution of the various weathering grades of rock material in the rock mass may be related to the porosity of the rock material and the presence of open discontinuities of all types in the rock mass.

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6. COMPUTATION OF BEARING CAPACITY:

The safe allowable bearing capacity of the foundation for the proposed structure has been calculated on the shear failure criteria suggested as per IS 6403-1981 and settlement criteria as per IS: 8009 (part-I)-1976. Looking at the site condition, sub soil stratification and type of proposed structure, calculations have been done for Isolated Footing.

6.1 ISOLATED FOOTING:

IS: 6403-1981

(a) In case of general shear failure –

$q_d = cN_c s_c d_c i_c + q(N_q - 1) s_q d_q i_q + 0.5 B\gamma N_\gamma S_\gamma d_\gamma i_\gamma w'$

(b) In case of local shear failure –

$q'_d = 0.67cN'_c s_c d_c i_c + q(N'_q - 1) s_q d_q i_q + 0.5 B\gamma N'_\gamma S_\gamma d_\gamma i_\gamma w'$

Where,

N_c, N'_c, N_q, N'_q, N_γ, N'_γ = Bearing capacity factors

C = Unit Cohesion

B = Width of Footing

γ = Bulk Density

$q = \gamma d$

S_c, S_q, S_γ = Shape factors

d_c, d_q, d_γ = Depth factors

i_c, i_q, i_γ = Inclination factors

W' = Correction factor for location for location of water table

Φ = Angle of internal resistance of soil

$\Phi' = \tan^{-1}(0.67 \tan \phi)$

Note: - If the void ratio is less than 0.55, the shear failure is considered as General shear failure. On the other hand, if the relative density is smaller than 20% and the void ratio is greater than 0.75, the failure is local shear failure. For relative density between 20% and 70% and the void ratio 0.55 to 0.75, the bearing capacity factors are obtained by interpolation between the general shear failure and local shear failure.

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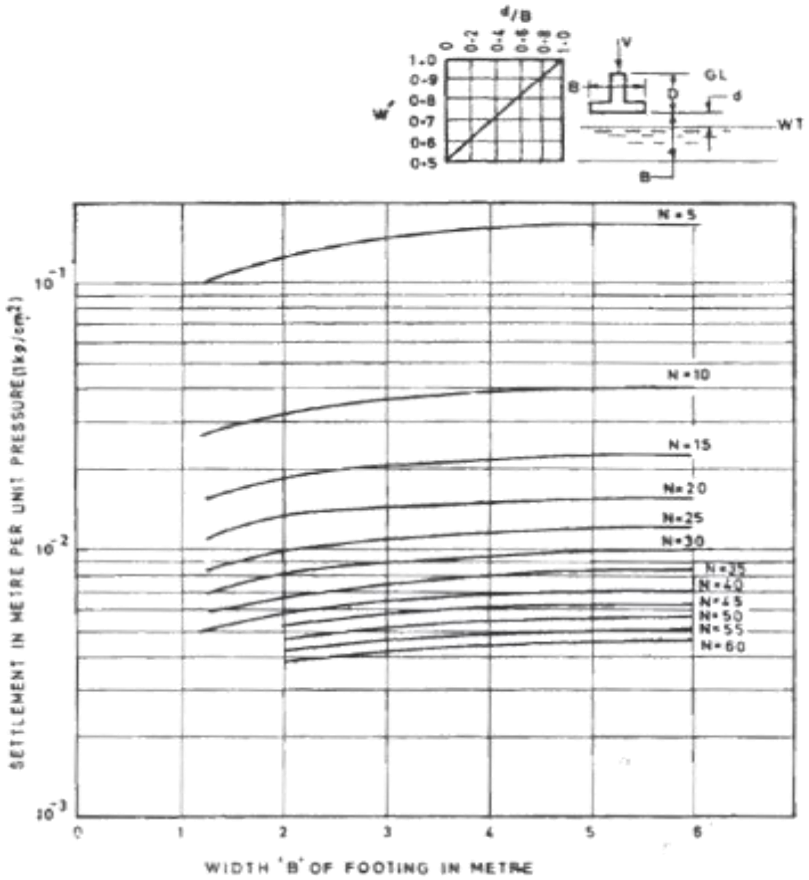
6.2 SETTLEMENTCRITERIA:



GL = Ground level. WT = Water table.

FIG. 9 SETTLEMENT PER UNIT PRESSURE FROM STANDARD PENETRATION RESISTANCE

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6.3 CALCULATION OF SAFE BEARING PRESSURE OF ROCK (SBC):

The safe allowable bearing capacity of the rock Strata for the proposed structure has been calculated on the bed rock approach criteria suggested as per IS 12070-1987 and no settlement criteria is considered in rock mass.

i. Estimate of Safe Bearing Pressure from the Core Strength:

The safe bearing pressure should be estimated from the equation:

Qs = Qc x Nj…….. (IS 12070)

Where

Qs = Safe Bearing Pressure (Gross)
Qc = Avg. Uniaxial Strength Of Rock Core
Nj= Emperical Coefficient (Table 4 , Fig 1)

Uniaxial Compressive Strength (Is 8764)

The uniaxial compressive strength of rock may beredicted from the following correlation:

$$Qc = 22\ Is(50)$$

where

Qc = uniaxial compressive strength inMN/m2 (kgf/cm*), and
Is(50) = Corrected point load strength.

$$Is(50) = \frac{P}{D\ ^{1.5}\sqrt{D_{50}}}$$

Where

Is(50) = Point load Strength Index in MPa
P = Failure Load in N
D = Dia of core in mm
D_{50} = Standard Core Dia (50mm)

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7. RESULT/ RECOMMENDATIONS:

- Based on drilling data the rock strata found at the point of drilling is completely weathered in nature in entire running depth with nil or very low core revery upto 6.0 m depth further as reported in clause 8.0
- Raft/Isolated footings can be provided for the foundation of the proposed structures.
- Water table was encountered from top.
- The report is subjected to sample found during site investigation in presence of customer/customer's representative.
- Settlement analysis is done for 50mm permissible settlement.
- Since core recovery is very less the calculation is done as per following guidelines of RDSO/Text book.

BH-1

Depth m	Type of foundation	Size of foundation (M)	General Shear Failure Criteria T / m²	Local Shear Failure Criteria T / m²	Interpolated Value from Column 4 &5 (As per IS 6403-1981) T / m²	Settlement Criteria T / m²	Recommended Safe Bearing Capacity (T / m²) (Lower of columns 7 & 6 & rounded down)
1.50	Raft/ Isolated Footing	5.00	17.01	5.61	11.88	56.61	**11.5**
3.00		5.00	32.25	10.55	22.48	63.51	**22.0**
4.50		5.00	46.20	15.25	36.92	69.44	**36.5**
6.00		5.00	57.50	19.04	53.65	75.48	**53.5**

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BH-2

Depth m	Type of foundation	Size of foundation (M)	General Shear Failure Criteria T / m²	Local Shear Failure Criteria T / m²	Interpolated Value from Column 4 &5 (As per IS 6403-1981) T / m²	Settlement Criteria T / m²	Recommended Safe Bearing Capacity (T / m²) (Lower of columns 7 & 6 & rounded down)
1.50	Raft/ Isolated Footing	5.00	15.03	5.13	11.07	56.61	**11.0**
3.00		5.00	28.53	9.65	22.87	63.51	**22.5**
4.50		5.00	46.48	15.35	38.70	69.44	**38.5**
6.00		5.00	65.36	20.94	54.25	75.48	**54.0**

BH-3

Depth m	Type of foundation	Size of foundation (M)	General Shear Failure Criteria T / m²	Local Shear Failure Criteria T / m²	Interpolated Value from Column 4 &5 (As per IS 6403-1981) T / m²	Settlement Criteria T / m²	Recommended Safe Bearing Capacity (T / m²) (Lower of columns 7 & 6 & rounded down)
1.50	Raft/ Isolated Footing	5.00	16.81	5.54	10.61	56.61	**10.5**
3.00		5.00	31.86	10.43	22.21	63.51	**22.0**
4.50		5.00	51.91	16.58	37.78	69.44	**37.5**
6.00		5.00	65.36	20.94	49.81	75.48	**49.5**

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8. FIELD TEST RESULT

Location /Chainage: BH -01												Method of drilling: Rotary
Diameter of Bore hole: 150 mm/NX												
FIELD TEST RESULT												
Depth Below NGL (Meter)		Nature of Sample	Sample Reference No.	SPT Test Result				Rock Sample Details		Description of soil	Soil Classification	Graphical representation
				N1 (Seating Drive)	N2 (First Drive)	N3 (Second Drive)	Observed SPT N(N2+N3)	Core Recovery %	R.Q.D %			
0.0	1.5	DS	1	100	-	-	100	0	0	Completely weathered	CWR	
1.5	3.0	DS	2	100	-	-	100	0	0	Completely weathered	CWR	
3.0	4.5	DS	3	100	-	-	100	0	0	Completely weathered	CWR	
4.5	6.0	DS	4	100	-	-	100	0	0	Completely weathered	CWR	

Location /Chainage: BH -02												Method of drilling: Rotary
Diameter of Bore hole: 150 mm/NX												
FIELD TEST RESULT												
Depth Below NGL (Meter)		Nature of Sample	Sample Reference No.	SPT Test Result				Rock Sample Details		Description of soil	Soil Classification	Graphical representation
				N1 (Seating Drive)	N2 (First Drive)	N3 (Second Drive)	Observed SPT N(N2+N3)	Core Recovery %	R.Q.D %			
0.0	1.5	DS	1	100	-	-	100	0	0	Completely weathered	CWR	
1.5	3.0	DS	2	100	-	-	100	0	0	Completely weathered	CWR	
3.0	4.5	C	3	100	-	-	100	0	0	Completely weathered	CWR	
4.5	6.0	C	4	100	-	-	100	0	0	Completely weathered	CWR	

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Location: - Viroli Bridge

Location /Chainage: BH -03										**Method of drilling: Rotary**		
Diameter of Bore hole: 150 mm/NX												
FIELD TEST RESULT												
Depth Below NGL (Meter)		**Nature of Sample**	**Sample Reference No.**	**SPT Test Result**				**Rock Sample Details**		**Description of soil**	**Soil Classification**	**Graphical representation**
				N1 (Seating Drive)	**N2 (First Drive)**	**N3 (Second Drive)**	**Observed SPT N(N2+N3)**	**Core Recovery %**	**R.Q.D %**			
0.0	1.5	DS	1	100	-	-	100	0	0	Completely weathered	CWR	
1.5	3.0	DS	2	100	-	-	100	0	0	Completely weathered	CWR	
3.0	4.5	C	3	-	-	-	-	13.00	0	Completely weathered	CWR	
4.5	6.0	C	4	-	-	-	-	15.00	0	Completely weathered	CWR	

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9. LABORATORY TEST RESULT

BH -01																			Method of drilling: Rotary					
Diameter of Bore hole: NX						Water Table: 0.5 m																		
Depth Below NGL (Meter)	Nature of Sample	Index Property				Grain Size Analysis					Index Property				Shear Strength Parameters			Swelling Parameters		Test on Rock Specimen					
		Bulk Density (gm/cc)	Moisture Content (%)	Void Ratio	Specific Gravity (Gs)	Gravel (%)	Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Silt & Clay (%)	Liquid Limit (%)	Plastic Limit (%)	Plastic Index (%)	Soil Classification	Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (Degree) Φ	Swelling Pressure kn/m^2	Free Swell Index	Core Recovery %	R.Q.D %	Water absorption (%)	Density(gm/cc).	UNSOCKED UCC(N/MM2)	Point Load Index (Is)
1.50	**DS**	1.80	9.45	0.64	2.69	45.56	13.56	11.14	10.78	18.96	21.5	NPL	0.00	DST	0.00	29	21.5	-	-	-	-	-	-	-	-
3.00	**DS**	1.84	11.67	0.64	2.70	47.87	12.15	11.66	12.87	15.45	22.1	NPL	0.00	DST	0.00	30	22.1	-	-	-	-	-	-	-	-
4.50	**DS**	1.88	11.78	0.61	2.71	51.24	11.66	12.44	11.32	13.34	22.5	NPL	0.00	DST	0.00	30	22.5	-	-	-	-	-	-	-	-
6.00	**DS**	1.93	12.15	0.57	2.71	51.76	10.34	13.14	10.56	14.20	22.6	NPL	0.00	DST	0.00	30	22.6	-	-	-	-	-	-	-	-

C- Core, CW- Completely Weathered, HW- Highly Weathered, D-Disturbed , MW-Moderately Weathered, SW-Weathered, FR-Fresh Rock, SM- Silty Sand, DS/DST Direct Shear, S/D- SPT/Disturbed , RS- Residual Soil

Note : The rockey strata is non coreable in nature , so considered as per gradation for calculation purpose .

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Location: - Viroli Bridge

BH -02																			Method of drilling: Rotary					
Diameter of Bore hole: NX											Water Table: 0.5m													
Depth Below NGL (Meter)	Nature of Sample	Index Property				Grain Size Analysis					Index Property				Shear Strength Parameters			Swelling Parameters		Test on Rock Specimen					
		Bulk Density (gm/cc)	Moisture Content (%)	Void Ratio	Specific Gravity (Gs)	Gravel (%)	Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Silt & Clay (%)	Liquid Limit (%)	Plastic Limit (%)	Plastic Index (%)	Soil Classification	Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (Degree) Φ	Swelling Pressure kn/m^2	Free Swell Index	Core Recovery %	R.Q.D %	Water absorption (%)	Density(gm/cc).	UNSOCKED UCC(N/MM2)	Point Load Index (Is)
1.50	DS	1.82	10.12	0.63	2.69	42.54	14.44	12.21	12.54	18.27	21.7	NPL	0.00	DST	0.00	28	21.7	-	-	-	-	-	-	-	-
3.00	DS	1.86	11.56	0.61	2.69	43.65	11.76	12.87	13.12	18.60	22.0	NPL	0.00	DST	0.00	29	22.0	-	-	-	-	-	-	-	-
4.50	C	1.89	12.24	0.60	2.70	49.62	12.23	12.67	12.44	13.04	22.1	NPL	0.00	DST	0.00	30	22.1	-	-	-	-	-	-	-	-
6.00	C	1.92	13.14	0.60	2.71	50.76	11.56	12.22	11.82	13.64	22.9	NPL	0.00	DST	0.00	31	22.9	-	-	-	-	-	-	-	-

C- Core, CW- Completely Weathered, HW- Highly Weathered, D-Disturbed , MW-Moderately Weathered, SW-Weathered, FR-Fresh Rock, SM- Silty Sand, DS/DST Direct Shear, S/D- SPT/Disturbed , RS- Residual Soil

Note : The rockey strata is non coreable in nature , so considered as per gradation for calculation purpose

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Location: - Viroli Bridge

BH -03																			Method of drilling: Rotary					
Diameter of Bore hole: NX						Water Table: 0.5																		
Depth Below NGL (Meter)	Nature of Sample	Index Property				Grain Size Analysis					Index Property				Shear Strength Parameters			Swelling Parameters		Test on Rock Specimen					
		Bulk Density (gm/cc)	Moisture Content (%)	Void Ratio	Specific Gravity (Gs)	Gravel (%)	Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Silt & Clay (%)	Liquid Limit (%)	Plastic Limit (%)	Plastic Index (%)	Soil Classification	Type of Test	Cohesion C (kg/cm^2)	Angle of Friction (Degree) Φ	Swelling Pressure kn/m^2	Free Swell Index	Core Recovery %	R.Q.D %	Water absorption (%)	Density(gm/cc).	UNSOCKED UCC(N/MM2)	Point Load Index (Is)
1.5	**DS**	1.80	10.87	0.66	2.69	43.26	12.54	11.67	11.87	20.66	21.0	NPL	0.00	DST	0.00	29	21.0	-	-	-	-	-	-	-	-
3.0	**DS**	1.84	11.43	0.64	2.70	45.66	13.18	13.44	12.23	15.49	22.2	NPL	0.00	DST	0.00	30	22.2	-	-	-	-	-	-	-	-
4.50	**C**	1.87	13.16	0.63	2.70	48.84	13.77	11.78	13.12	12.49	22.7	NPL	0.00	DST	0.00	31	22.7	-	-	-	-	-	-	-	-
6.00	**C**	1.89	13.29	0.62	2.71	51.25	12.66	10.23	12.66	13.20	23.5	NPL	0.00	DST	0.00	31	23.5	-	-	-	-	-	-	-	-

C- Core, CW- Completely Weathered, HW- Highly Weathered, D-Disturbed , MW-Moderately Weathered, SW-Weathered, FR-Fresh Rock, SM- Silty Sand, DS/DST Direct Shear, S/D- SPT/Disturbed , RS- Residual Soil

Note : The rockey strata is non coreable in nature , so considered as per gradation for calculation purpose

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10. TEST RESULT AND CALCULATION

BH-01 (Local Shear Failure)

Calculation of Net Safe Bearing Capacity Based on Shear Parameters C-Φ
Qns=1/FS[2/3*C*NcScdcic + q(Nq-1)Sqdqiq + 0.5*B*γ*Nγ*WqSydyiy] ; Qs=Qns+γd
FS=3.0, Water Table as per clause No.-2.2.

Sr.No	Size of Foundation		Depth of Foundation m	Shear Parameter			Bearing Capacity Factors			Unit Weight (γ) (gm/cc)	Overburden q	Water Table Correction		Shape Factor			Net Safe Bearing Capacity t/m2 (Qns)	Gross Safe Bearing Capacity t/m2 (Qs)
	Length m	Width m		C (kg/cm^2)	Φ	Φ'	N_c	N_q	N_y			Wq	Wγ	Sc	Sq	Sy		
1	5.00	5.00	1.50	0.00	29	20.29	15.11	6.59	5.61	1.80	1.546	1	0.50	1.3	1.2	0.8	5.61	8.31
2	5.00	5.00	3.00	0.00	30	21.06	15.88	7.11	6.25	1.84	3.091	1	0.50	1.3	1.2	0.8	10.55	16.07
3	5.00	5.00	4.50	0.00	30	21.06	15.88	7.11	6.25	1.88	4.637	1	0.50	1.3	1.2	0.8	15.25	23.71
4	5.00	5.00	6.00	0.00	30	21.06	15.88	7.11	6.25	1.93	5.802	1	0.50	1.3	1.2	0.8	19.04	30.62

BH-01 (General Shear Failure)

Calculation of Net Safe Bearing Capacity Based on Shear Parameters C-Φ
Qns=1/FS[C*NcScdcic + q(Nq-1)Sqdqiq + 0.5*B*γ*Nγ*WqSydyiy] ; Qs=Qns+γd
FS=3, Water Table as per clause No.-2.2.

S.NO	Size of Foundation		Depth of Foundation m	Shear Parameter		Bearing Capacity Factors			Unit Weight (γ) (gm/cc)	Overburden q	Water Table Correction		Shape Factor			Net Safe Bearing Capacity t/m2 (Qns)	Gross Safe Bearing Capacity t/m2 (Qs)
	Length m	Width m		C (kg/cm^2)	Φ	N_c	N_q	N_y			Wq	Wγ	Sc	Sq	Sy		
1	5.00	5.00	1.50	0.00	29	27.86	16.44	19.33	1.80	1.546	1	0.50	1.3	1.2	0.8	17.01	19.71
2	5.00	5.00	3.00	0.00	30	30.13	18.40	22.40	1.84	3.091	1	0.50	1.3	1.2	0.8	32.25	37.77
3	5.00	5.00	4.50	0.00	30	30.13	18.40	22.40	1.88	4.637	1	0.50	1.3	1.2	0.8	46.20	54.66
4	5.00	5.00	6.00	0.00	30	30.13	18.40	22.40	1.93	5.802	1	0.50	1.3	1.2	0.8	57.50	69.08

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Location: - Viroli Bridge

BH-02 (Local Shear Failure)

Calculation of Net Safe Bearing Capacity Based on Shear Parameters C-Φ
Qns=1/FS[2/3*C*NcScdcic + q(Nq-1)Sqdqiq + 0.5*B*γ*Nγ*WqSydyiy| ; Qs=Qns+γd
FS=3, Water Table as per clause No.-2.2.

Sr.No	Size of Foundation		Depth of Foundation m	Shear Parameter			Bearing Capacity Factors			Unit Weight (γ) (gm/cc)	Overburden q	Water Table Correction		Shape Factor			Net Safe Bearing Capacity t/m2 (Qns)	Gross Safe Bearing Capacity t/m2 (Qs)
	Length m	Width m		C (kg/cm^2)	Φ	Φ'	N_c	N_q	N_y			Wq	Wγ	Sc	Sq	Sy		
1	5.00	5.00	1.50	0.00	28	19.53	14.40	6.11	5.04	1.82	1.555	1	0.50	1.3	1.2	0.8	5.13	7.86
2	5.00	5.00	3.00	0.00	29	20.29	15.11	6.59	5.61	1.86	3.110	1	0.50	1.3	1.2	0.8	9.65	15.23
3	5.00	5.00	4.50	0.00	30	21.06	15.88	7.11	6.25	1.89	4.666	1	0.50	1.3	1.2	0.8	15.35	23.85
4	5.00	5.00	6.00	0.00	31	21.84	16.70	7.69	6.97	1.92	5.802	1	0.50	1.3	1.2	0.8	20.94	32.46

BH-02 (General Shear Failure)

Calculation of Net Safe Bearing Capacity Based on Shear Parameters C-Φ
Qns=1/FS[C*NcScdcic + q(Nq-1)Sqdqiq + 0.5*B*γ*Nγ*WqSydyiy| ; Qs=Qns+γd
FS=3, Water Table as per clause No.-2.2.

S.NO	Size of Foundation		Depth of Foundation m	Shear Parameter		Bearing Capacity Factors			Unit Weight (γ) (gm/cc)	Overburden q	Water Table Correction		Shape Factor			Net Safe Bearing Capacity t/m2 (Qns)	Gross Safe Bearing Capacity t/m2 (Qs)
	Length m	Width m		C (kg/cm^2)	Φ	N_c	N_q	N_y			Wq	Wγ	Sc	Sq	Sy		
1	5.00	5.00	1.50	0.00	28	25.80	14.72	16.71	1.82	1.555	1	0.50	1.3	1.2	0.8	15.03	17.76
2	5.00	5.00	3.00	0.00	29	27.86	16.44	19.33	1.86	3.110	1	0.50	1.3	1.2	0.8	28.53	34.11
3	5.00	5.00	4.50	0.00	30	30.13	18.40	22.40	1.89	4.666	1	0.50	1.3	1.2	0.8	46.48	54.99
4	5.00	5.00	6.00	0.00	31	32.66	20.63	25.99	1.92	5.802	1	0.50	1.3	1.2	0.8	65.36	76.88

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Location: - Viroli Bridge

BH-03 (Local Shear Failure)

Calculation of Net Safe Bearing Capacity Based on Shear Parameters C-Φ
Qns=1/FS[2/3*C*NcScdcic + q(Nq-1)Sqdqiq + 0.5*B*γ*Nγ*WqSydyiy| ; Qs=Qns+γd
FS=3, Water Table as per clause No.-2.2.

Sr.No	Size of Foundation		Depth of Foundation m	Shear Parameter			Bearing Capacity Factors			Unit Weight (γ) (gm/cc)	Overburden q	Water Table Correction		Shape Factor			Net Safe Bearing Capacity t/m2 (Qns)	Gross Safe Bearing Capacity t/m2 (Qs)
	Length m	Width m		C (kg/cm^2)	Φ	Φ'	N_c	N_q	N_y			Wq	Wγ	Sc	Sq	Sy		
1	5.00	5.00	1.50	0.00	29	20.29	15.11	6.59	5.61	1.80	1.527	1	0.50	1.3	1.2	0.8	5.54	8.24
2	5.00	5.00	3.00	0.00	30	21.06	15.88	7.11	6.25	1.84	3.054	1	0.50	1.3	1.2	0.8	10.43	15.95
3	5.00	5.00	4.50	0.00	31	21.84	16.70	7.69	6.97	1.87	4.581	1	0.50	1.3	1.2	0.8	16.58	24.99
4	5.00	5.00	6.00	0.00	31	21.84	16.70	7.69	6.97	1.89	5.802	1	0.50	1.3	1.2	0.8	20.94	32.28

BH-03 (General Shear Failure)

Calculation of Net Safe Bearing Capacity Based on Shear Parameters C-Φ
Qns=1/FS[C*NcScdcic + q(Nq-1)Sqdqiq + 0.5*B*γ*Nγ*WqSydyiy| ; Qs=Qns+γd
FS=3, Water Table as per clause No.-2.2.

S.NO	Size of Foundation		Depth of Foundation m	Shear Parameter		Bearing Capacity Factors			Unit Weight (γ) (gm/cc)	Overburden q	Water Table Correction		Shape Factor			Net Safe Bearing Capacity t/m2 (Qns)	Gross Safe Bearing Capacity t/m2 (Qs)
	Length m	Width m		C (kg/cm^2)	Φ	N_c	N_q	N_y			Wq	Wγ	Sc	Sq	Sy		
1	5.00	5.00	1.50	0.00	29	27.86	16.44	19.33	1.80	1.527	1	0.50	1.3	1.2	0.8	16.81	19.51
2	5.00	5.00	3.00	0.00	30	30.13	18.40	22.40	1.84	3.054	1	0.50	1.3	1.2	0.8	31.86	37.38
3	5.00	5.00	4.50	0.00	31	32.66	20.63	25.99	1.87	4.581	1	0.50	1.3	1.2	0.8	51.91	60.32
4	5.00	5.00	6.00	0.00	31	32.66	20.63	25.99	1.89	5.802	1	0.50	1.3	1.2	0.8	65.36	76.70

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Location: - Viroli Bridge

BH-1

Depth(m)	width(m)	Length(m)	corrected N	Weighted average corrected 'N' value	from Figure 12 of IS:8009 part -1, depth factor	Settlement in 'm' per unit pressure (reading from graph)	Recommended allowable bearing pressure for 25 mm
1.50	5.00	5.00	57	57	0.920	0.005	56.61
3.00	5.00	5.00	57	57	0.820	0.005	63.51
4.50	5.00	5.00	57	57	0.750	0.005	69.44
6.00	5.00	5.00	57	57	0.690	0.005	75.48

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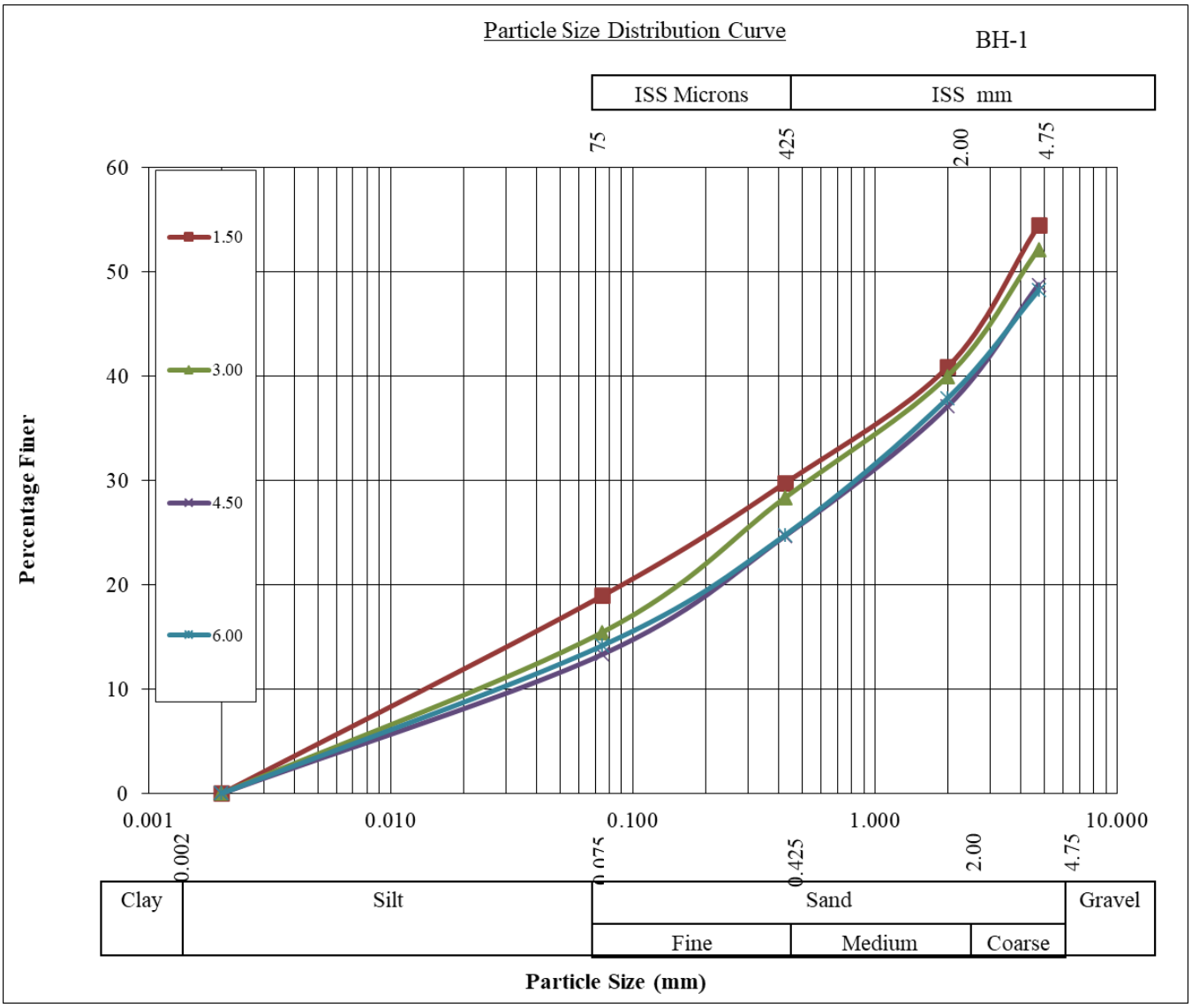
Location: - Viroli Bridge

11. Grain Size Distribution Curve



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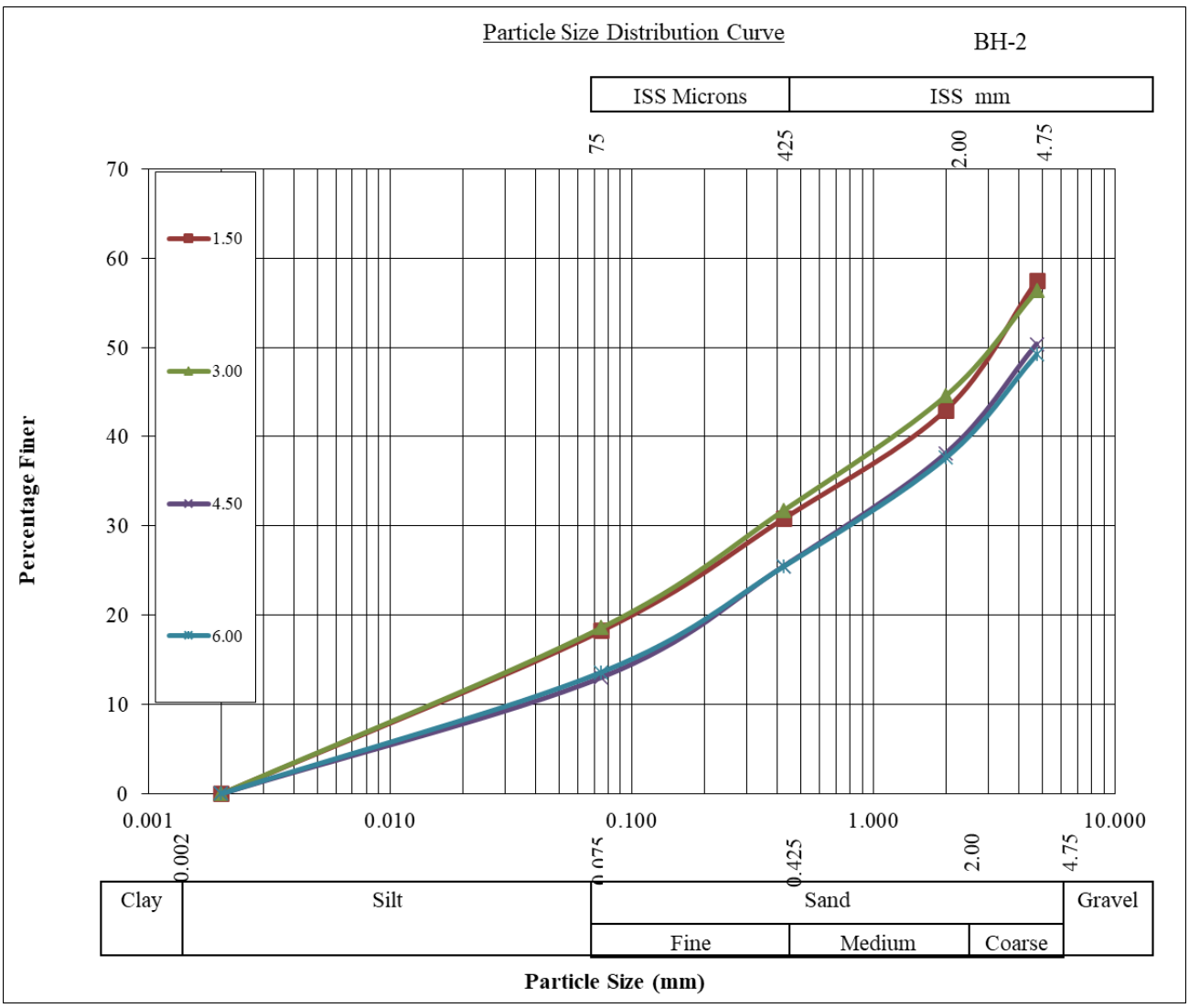

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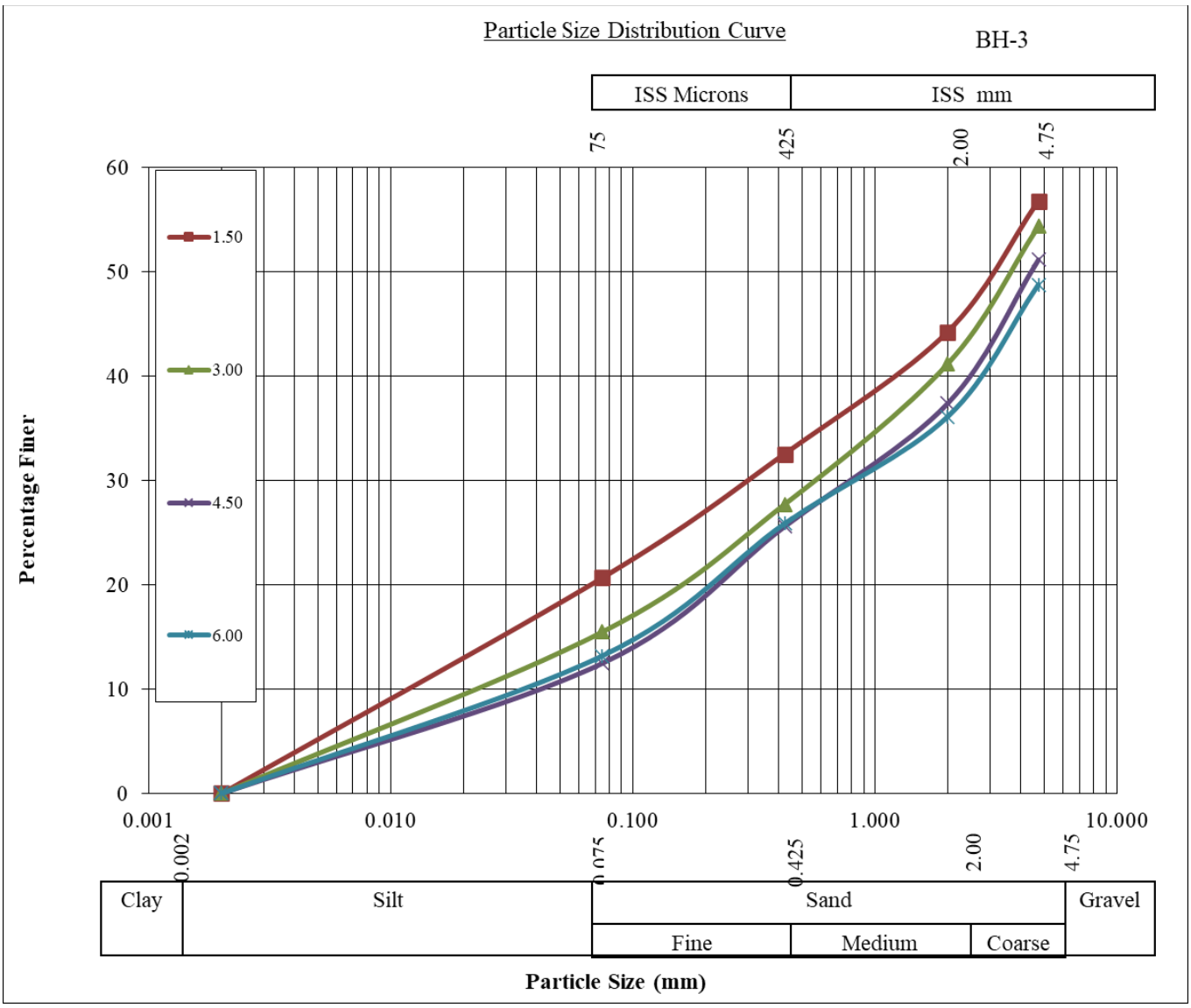
Location: - Viroli Bridge



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12. PHOTOGRAPHS

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13. SAMPLE CALCULATION :

SAFE BEARING CAPACITY OF SOIL - Based on IS: 6403

Square

Depth of footing, D	1.50		Cohesion, C, kg/sq.cm		0.000
Width of footing, B	5.00		Angle of Int.Friction, f		29.00
	5.00		Specific Gravity, g		2.690
			Bulk Density, Y_d, gm/cc		1.800
Depth of Water Table,m	0.00		Sat. Density, Ysat, gm/cc		2.030
Ratio d/B	0.300		Sub. Density, Y', gm/cc		1.030
Water Table Factor	0.50		Inclination Angle a		0
Effective Surcharge over EGL, m	0.00	m	Factor of Safety		3.0
			Surcharge Density Assumed, gm/cc		1.000
Dry Density, Y_d, gm/cc	1.645	9.45			
Overburden Pressure,	1.546	t/m^2	Void Ratio, e_o =	$\frac{G \times Y_w}{Y_d} - 1$	
Shear Zone, H	4.51	= 0.5 B tan (45+ϕ/2)			
			=	0.640	

Mode of Failure = ***Intermediate Shear Failure***

F' =	Tan^{-1} (0.67 tan F)	Nc'' =	22.123	27.86	15.11
=	20.37	Nq'' =	12.006	16.44	6.59
		Ng'' =	13.159	19.33	5.61
			Inter	**General**	**Local**

For general shear failure i.e. Void Ratio < 0.55

qu = cNcScdcic + q(Nq-1) Sqdqiq + 0.5 BgNgSgdgig W'

= 51.04 qs = 17.01 t/m^2

For local shear failure i.e. Void Ratio > 0.75

qu = 0.67cN'cScdcic + q(N'q-1) Sqdqiq + 0.5 BgN'gSgdgig W'

= 16.84 5.61 t/m^2

For intermediate shear failure i.e. Void Ratio < 0.55 and > 0.75

Void Ratio	*e <= 0.55*	*e >= 0.75*	*0.55 < e < 0.75*
e	*0.55*	*0.75*	*0.64*
qu = Net Safe Bearing Capacity, t/m2	***17.01***	***5.61***	***11.88***

Factors- Tan-1(0.67 tan F)

d, s, i	Depth factor	Shape factor	Inclination factor
dc, sc, ic	1.086	1.300	1.000
dq, sq, iq	1.043	1.200	1.000
dg,sg,ig	1.043	0.800	1.000

Factors- tan F

d, s, i	Depth factor	Shape factor	Inclination factor
dc, sc, ic	1.102	1.300	1.000
dq, sq, iq	1.051	1.200	1.000
dg,sg,ig	1.051	0.800	1.000

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Location: - Viroli Bridge

SETTLEMEMT ANALYSIS FOR SHALLOW FOUNDATIONS BASED ON N - VALUES						
Analysis as per IS:8009(Part 1)-1976 , Clause 9.1.4						
Width of footing		B	=	5.00	m	
Length of footing		L	=	5.00	m	
Depth of foundation		D_f	=	1.50	m	
Depth of Influence			=	7.50	m	
CORRECTED'N' VALUE=NVALUE*	**N` = (0.77 log 10 20/ρ) N**			**(ρ= Overburden Pressu**		
Weighted average 'N' value Calculation						
Weighted average corrected 'N' value		**N**	**=**	**57.00**		
Design Depth of water table		d	=	0.00	m	
Water Table Correction		W'	=	0.50		
from Figure 12 of IS:8009 part -1, depth factor			=	0.920		
Settlement in 'm' per unit pressure (reading from graph)						
			=	0.0048	m/kg/sq cm	
Settlement after applying water table correction for 1 unit pressure						
	=0.92*0.0048/ (0.5*100)		=	0.00008832	$m/kN/m^2$	
Bearing Pressure for 50 mm settlement	=50/(0.00008832*1000)		=	566.1	kN/m^2	
Recommended allowable bearing pressure for 50 mm settlement			=	566.1	kN/m^2	
			=	56.61	t/m^2	

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