GEOTECHNICAL INVESTIGATIONS FOR PREPARATION OF DETAILED PROJECT REPORT (DPR) FOR CONSTRUCTION OF IWT TERMINAL AT SAHIBGANJ IN JHARKHAND (INDIA) ON RIVER GANGA NATIONAL WATERWAY-1

Client :

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CHAPTER - I

1.0 INTRODUCTION

- Detailed Geotechnical Investigations for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1 was entrusted to Fargo Consultants Pvt. Ltd., CF-394, Sector-I, Salt Lake City, Kolkata- 700064 by HOWE Engineering Projects (India) Pvt. Ltd., HOWE India House, 81, Nehru Place, New Delhi – 110 019.

- The scope of the soil investigation work consisted of conducting soil investigation at the proposed facility. Seven (7) boreholes were included collection of undisturbed / disturbed soil samples and conducting Standard Penetration Tests.

- The formation at the site is to be reported for various layers present at their respective depths along with their thickness. As ground water table location influences the method of construction of foundation at a site its location also needs to be found out.

- During sinking of bore holes soil samples both in disturbed and undisturbed conditions were to be collected for laboratory tests. The disturbed samples would be subjected to tests to obtain soil index properties. The undisturbed soil samples, however, would be used mainly for conducting tests to obtain shear strength parameters as well as consolidation characteristics of the soil representing the strata.

CHAPTER - II

2.0 FIELD INVESTIGATION

This report contains details of investigation for the borehole locations at Sahibganj in Jharkhand.

- The details of field work like, location, borehole no., termination depth, static water level and the dates of commencement and completion are furnished below. Location of the boreholes are presented in a site plan provided in Annexure-A.

Borehole No.	Termination Depth of Hole	**D.T.W. (m)	Commencement Date	Completion Date
BH-1	41.00	3.00	31.07.2015	04.08.2015
BH-2	45.00	3.75	19.07.2015	26.07.2015
BH-3	18.00	2.75	06.08.2015	08.08.2015
BH-4	23.00	N.E.	08.08.2015	11.08.2015
BH-5	40.45	11.60	27.07.2015	29.07.2015
BH-6	13.00	16.54*	16.08.2015	17.08.2015
BH-7	30.50	10.74*	21.08.2015	23.08.2015
Note: **D.T.W. - Depth to water from borehole top * - Above bed Level N.E. - Not Encountered				

- Groundwater was not encountered in BH-4. However, due to the fractured condition of the rocks encountered, water loss was observed in some boreholes.

- The boreholes of 150 mm diameter were explored with the help of auger and mud rotary circulation as per IS 1892 - 1979. Here the auger was turned in the bottom of the hole through auger pipes. Due to this the soil cuttings were held in the auger and were drawn to the surface by pulling the auger out of the hole each time the auger was filled. In continuation to auger boring mud rotary boring method was employed. In

this method the boring was advanced by a cutter fixed to drill pipes, which were rotated by means of pipe wrenches. Bentonite was pushed simultaneously by a mechanical pump. The slurry flowing out of cutter bottom mixes up with the cut soil and flows up to the ground surface, and slurry tank after passing through setting pits and back to the slurry tank. The process was continuous and the same slurry can be used several times. The cutting tool was lowered slowly with the help of a double pulley system fixed on a tripod. This method of boring was followed upto the explored depth in each bore hole.

- Seamless flush jointed steel casing of 200mm internal diameter was used to prevent any caving of bore holes and it was inserted simultaneously with the advancement of boring operation whenever required.

- The undisturbed samples were collected from the bore holes wherever possible, with the help of a thin walled sampler, as per the IS:2132-1986 "Code of practice for thin walled tube sampling of soils". The area ratio of the sampler was of the order of twelve percent and the inside clearance was around two percent. The sample tube about 450mm long and 100mm inner diameter, was coupled with the sampler with a drive head, vent holes and ball check valve to complete the sampling assembly. While sampling below the water table inside the borehole, the entrapped water has the opportunity to escape through this valve at the top. The sampling assembly was then lowered inside the boreholes by connecting a string of 'A' / 'AW' size drill rods to it. The assembly was driven to a predetermined depth with the help of jarring link. On completion of sampling operation, the sampler was first rotated (so that the soil would shear off on a horizontal plane at the cutting shoe edge) and then raised to the surface. The undisturbed sample was waxed at both ends with proper identification mark on the tube sampler.

- Standard Penetration Tests were conducted inside the bore holes at 3.0m intervals as per IS:2131-1981 "Method of Standard Penetration Tests for soils". The split spoon sampler used was of standard design and dimension. The spoon was advanced by driving with a drop hammer weighing 63.5 kg. falling freely through a height of 75cm. A record of the number of blows required to penetrate every 15cm. to a depth of 45cm. was kept. The number of blows required for the last 30cm penetration of the split spoon sampler was recorded as 'N' - value. On completion of the test, the sampler was lifted to the ground, opened and the specimen of the soil sample was stored in double polythene bags with the proper identification mark. The penetration number, 'N', has been shown against the corresponding depths in the field bore logs. The distributions of field and corrected 'N' values with RL at different locations are shown in the attached figures.

- Representative disturbed samples were collected regularly and wherever the stratum changed. These samples were taken from the cutting edge of undisturbed samples and the split spoon samplers after standard penetration tests. These samples were labelled depth wise and used in the preparation of borehole log and for general identification and classification purposes.

- The boreholes were then extended to the termination depth by rotary core drilling technique using diamond bits. Drilling was done with standard G.O. type rotary drilling machine as per IS: 6926-1973. In this method the hole is advanced by rotating a system consisting of a series of hollow drill roads to the bottom of which is attached a double tube core barrel with diamond coring bit, by means of a diesel operated engine. When the rod with the coring bit is rotated, downward pressure is applied to the system for penetration in the rocky strata and water under pressure is introduced into the bottom of the hole through the hollow drill rods. Water comes up through the annular space between the drill rods the borehole and is collected in the water sump, from where it is re-circulated. Water served the dual function of cooling the bit as it enters

the hole and carrying the cuttings from the bottom of the hole on its return journey to the surface.

- Seamless flush jointed steel casing of NX sizes were used to prevent any caving and water loss from holes and they were inserted simultaneously with the advancement of drilling operation. Rocky core samples were collected in standard NX size barrel and stored as per IS: 4464-1967 and IS: 4078-1967.

- The field investigation work commenced on 19th July 2015 and was completed on 23rd August 2015. The depth of water level in the borehole was determined 24 hours after the completion of boring so that the water in the borehole could come to equilibrium with the water table. No artesian condition was encountered in any borehole.

CHAPTER - III

3.0 LABORATORY TESTING

The following laboratory tests were carried out to ascertain the properties of the sub-soil.

- **Grain size analysis**

The particle size distribution of various soil samples collected from different subsoil deposits were determined by sieve analysis (dry method) or hydrometer analysis (wet method) or a combination of both, as was found necessary. From the test results, grain size distribution curves were generated to ascertain percentage of sand, silt, clay etc in each sample.

- **Natural Moisture Content**

The natural moisture content (N. M. C) or water content of the samples were obtained by oven drying a quantity of soil for at least 24 hours at 105^{0}C and recording their weights before and after drying.

- **Atterberg Limits**

The Atterberg limits of the soil samples were determined by adopting standard procedure. The liquid limit was determined with the help of Cassagrande's apparatus. The plastic limit was ascertained by rolling the soil samples into threads.

- **Specific Gravity**

The Specific Gravity of the soil samples was determined by adopting standard procedure. The soil sample was dried in oven dried for 24 hours and pulverished. The sample was then poured into a specific gravity bottle and topped up with distilled water. The specific

gravity bottle was stirred and heated to eliminate air bubbles. The weight of the specific gravity bottle was recorded along with the temperature of the sample.

- **Triaxial Test (Unconfined Compression)**

The triaxial test unconfined compression test was carried as per IS Code. Three samples were tested and the average value was reported.

- **One Dimensional Consolidation Test**

The One dimensional consolidation test was carried as per IS Code. The sample was loaded upto 8kg/cm incrementally and then unloaded. The data was used to evaluate the m_v values. These values will be used for settlement calculations.

All these tests were conducted as per relevant I.S. Codes and the test results are tabulated in Tables enclosed herewith.

CHAPTER - IV

4.0 DISCUSSION AND RECOMMENDATION

4.1 LAND BOREHOLES

4.1.1 The sub-soil formation in this area has been investigated by sinking four (4) boreholes explored upto maximum depth of 45.45m below the existing ground level. The field investigation data and the results of laboratory test conducted on samples collected from the borehole indicate the presence of six (6) layers.

The details of layer like layer no. description of layer and the thickness of each layer as encountered in the borehole are furnished below.

Layer No.	Description	Layer thickness (m)			
		BH-1	BH-2	BH-4	BH-5
I	Stiff to very stiff yellow grey silty clay/clayey silt with varying % of kankars and gravels	13.00	7.00	-	7.00
II	Hard greyish yellow/yellowish brown silty clay/clayey silt with little % of kankars	3.00	4.50	4.00	4.00
III	Very stiff greyish yellow clayey silt with varying % of kankar	-	3.50	6.00	8.00
III (A)	Highly decomposed product of rock	1.50	-	-	-
IV	Hard greyish yellow/brown silty clay with traces of kankars & calcarious nodules	7.50	7.50	7.80	21.45*
V	Hard reddish brown silty clay with gravels (compacted high % of silt)	15.12*	22.57*	-	-
VI	Completely weathered silty sand			5.20*	-
* - Upto termination depth					

4.1.2 The bore hole location plan, bore logs, graphical representation of field 'N' values with R.L., soil profile, laboratory test results, laboratory test curves & sample calculations are provided in Annexure A through Annexure F.

4.1.3 On close scrutiny of field and laboratory test results and based on experience and judgement, necessary soil parameters for the purpose of design of foundation are tabulated in the following table.

Layer No.	Description	Thickness (m)	Average Range of N-Value	Bulk Density (t/m^3)	Shear Strength Parameter
I	Stiff to very stiff yellow grey silty clay/clayey silt with varying % of kankars and gravels	7.00	21	1.93#	$c=11.0t/m^2$
II	Hard greyish yellow/yellowish brown silty clay/clayey silt with little % of kankars	4.00	48	2.05#	$c=24.0t/m^2$
III	Very stiff greyish yellow clayey silt with varying % of kankar	8.00	28	1.98#	$c=14.0t/m^2$
III (A)	Highly decomposed product of rock	-	>100	-	-
IV	Hard greyish yellow/brown silty clay with traces of kankars & calcarious nodules	21.45*	58	2.07#	$c=29.0t/m^2$
V	Hard reddish brown silty clay with gravels (compacted high % of silt)	-	>63	2.10#	$c=31.0t/m^2$
VI	Completely to highly weathered sand stone	-	>36+	1.99#	$\phi = 36^{o\#}$
* = Upto termination depth #=Suggested value + = Corrected N-value					

4.1.4 Pile load capacities were calculated as per IS Code 2911 (Part-I Sec 2). Spacing between piles will be 3"D" where "D" is the diameter of the pile. The pile load capacities will require to be checked by conducting pile load test as per IS Code.

Pile Dia.	Founding Depth below GL	Cut-off Depth below GL	Vertical Load Capacity	Lateral Load Capacity (Fixed Head)	Uplift Load Capacity
(mm)	(m)	(m)	(t)	(t)	(t)
1000	17.0	1..5	129.0	30	73.5
	20.5		196.0	30	93.0
	24.0		230.0	30	118.5
1200	20.5	1.5	253.0	45	113.5
	24.0		293.0	45	144.5
1500	24.0	1.5	400.0	70	185.0

4.1.5 Proper care shall also be taken during construction, particularly during excavation and casting of pile caps. The sides of excavation shall be protected against possible collapse or caving in. The bottom of excavation shall be checked against any heaving. The stagnating water from the excavated pit shall be conveniently drained out.

4.2 RIVER BOREHOLES

4.2.1 The sub-soil formation in this area has been investigated by sinking one (1) borehole explored upto maximum depth of 18.0m below the existing ground level. The field investigation data and the results of laboratory test conducted on samples collected from the borehole indicate the presence of three (3) layers.

The details of layer like layer no. description of layer and the thickness of each layer as encountered in the borehole are furnished below.

Layer No.	Description	Layer thickness (m)		
		BH-3	BH-6	BH-7
I	Very soft yellowish grey silty clay	1.00	1.30	1.50
II	Very loose to loose yellowish grey silty sand/sandy silt	12.00	6.75	24.00
III	Completely to highly weathered sand stone	5.00*	4.95*	5.00*
* - Upto termination depth				

4.2.2 The bore hole location plan, bore log, graphical representation of field 'N' values with R.L., soil profile, laboratory test results, laboratory test curves & sample calculations are provided in Annexure A through Annexure F.

4.2.3 On close scrutiny of field and laboratory test results and based on experience and judgement, necessary soil parameters for the purpose of design of foundation are tabulated in the following table.

Layer No.	Description	Thickness (m)	Average Range of N-Value	Bulk Density (t/m^3)	Shear Strength Parameter
I	Very soft yellowish grey silty clay	1.00	4	1.75#	-
II	Very loose to loose yellowish grey silty sand/sandy silt	12.00	4+	1.75#	$\phi = 28^{o\#}$
III	Completely to highly weathered sand stone	5.00*	54+	2.07#	$\phi = 36^{o\#}$
* = Upto termination depth #=Suggested value + = Corrected N-value					

4.2.4 In the absence of hydraulic particulars the depth of scour could not be evaluated. The suggested pile load capacities have been provided for assumed scour depth of 2.0m below ground level/bed level and a cut-off height of 2.0m above ground level/bed level. Pile load capacities were calculated as per IS Code 2911 (Part-I Sec 2). Spacing between piles will be 3"D" where "D" is the diameter of the pile. The pile load capacities will require to be checked by conducting pile load test as per IS Code.

Pile Dia.	Founding Depth below GL	Cut-off Depth above GL	Scour Depth below GL / Bed Level	Vertical Load Capacity	Lateral Load Capacity (Fixed Head)	Uplift Load Capacity
(mm)	(m)	(m)	(m)	(t)	(t)	(t)
1000	25.0	2.0	2.0	350.0	3.7	130
1200	29.0			650.0	6.5	230
1500	34..0			1200.0	12.9	410
Note: 1) It is assumed that the last layer extends to a depth of 10m beyond the founding depth. 2) The founding depths provided are equal to the minimum depth required for the pile to be considered as long pile.						

4.2.5 Proper care shall also be taken during construction, particularly during excavation and casting of pile caps. The sides of excavation shall be protected against possible collapse or caving in. The bottom of excavation shall be checked against any heaving. The stagnating water from the excavated pit shall be conveniently drained out.

4.2.6 Prior to construction confirmatory boreholes needs to be carried out at the proposed locations as per relevant IS Codes. Pile load capacities will require to be evaluated after hydraulic particulars are available and the cut-off level is fixed.

for **FARGO CONSULTANTS PVT. LTD.**

(P. BRAHMA)
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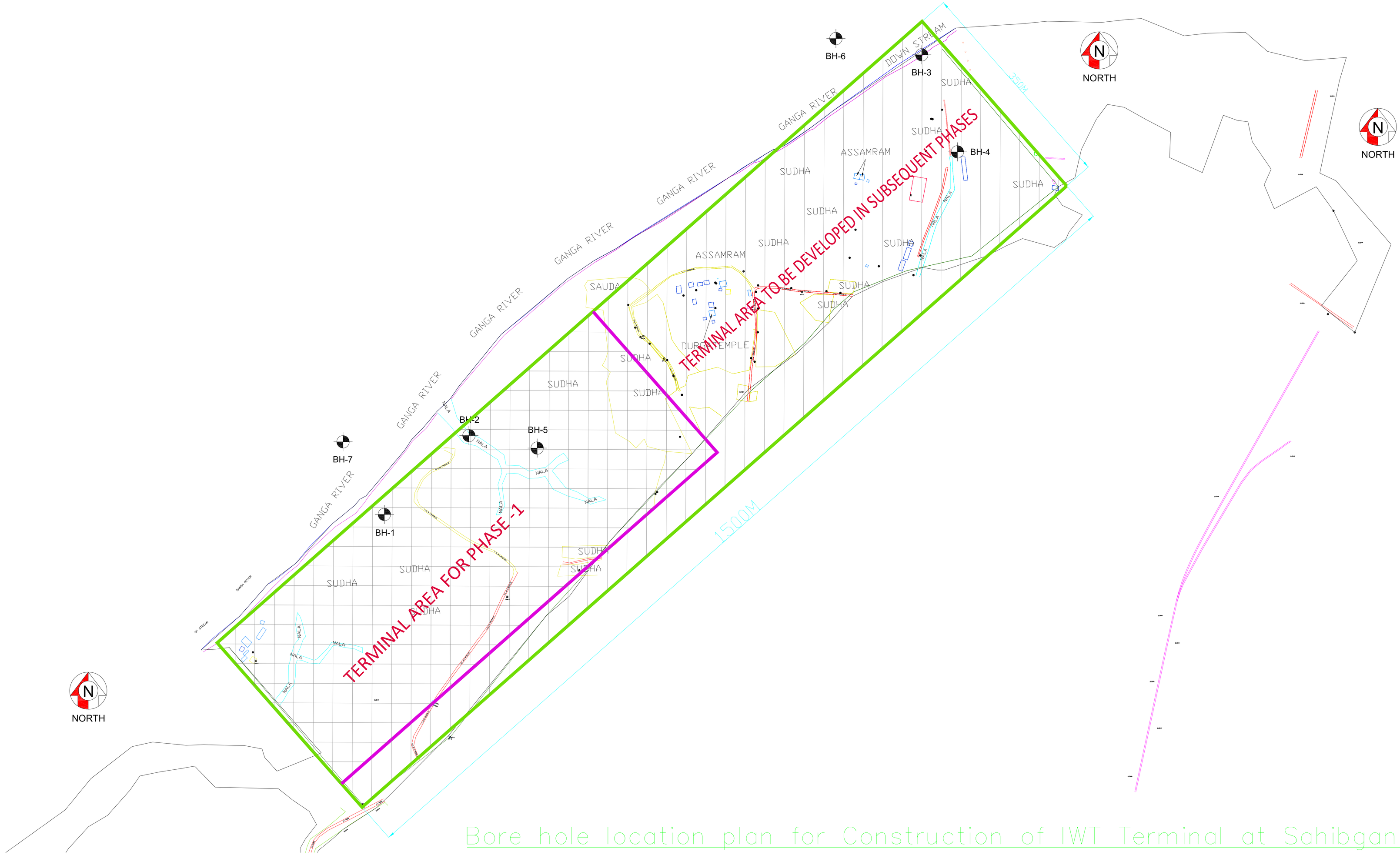
B. Tech (Hons.), M.S. (USA), MIGS

ANNEXURE - A

SITE PLAN



Bore hole location plan for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga

Note: All measurements are in metres

CLENT:	SCALE:	PROJECT:	CONSULTANT: Mailing Address:	FIG NO: 1
HOWE Engineering Projects (India) Pvt. Ltd. HOWE India House, 81, Nehru Place, New Delhi – 110 019	Not to scale	Geotechnical Investigations for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway–1	FARGO CONSULTANTS PVT. LTD. CF–394, SALT LAKE CITY, SECTOR– I, KOLKATA – 700 064 PHONE: (033)6454 4560(O) FAX: 033–2337 3775 e–mail: fargoconsultants@gmail.com	Sheet No.: A–1

ANNEXURE - B

BORELOG

FARGO CONSULTANTS PVT. LTD.

BORE / DRILL LOG

Project : Geotechnical Investigations for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1

Project No. : 2015258J

Bore Hole No. : BH-1

Location : Sahibganj (45R E-570640, N-2792953)

Ground Elevation : +30.550m

Method of Boring / Drilling : R.M.C

Dia. of Boring/Drilling : 150mm

Boring / Drilling Equipment : Mechanical Winch / GO

Casing Lowered : 13.50m

Water Level (Static) : 3.00 bgl.

Date : 31.07.2015 to 04.08.2015

Date	Sample and in-situ Test: Time (Min)	DEPTH/RUN (m): From	To	Length (m)	Sample/Test Code	SPT: 0cm-15cm	15cm-30cm	30cm-45cm	N' Value	Core Recovered (m)	Recovery (%)	R.Q.D. (%)	Description
31.07.2015		1.50	1.95	0.45	P	7	9	11	20				Stiff to very stiff yellow grey silty clay with varying % of kankars.
		3.00	3.45	0.45	U	-	-	-	-				
		4.50	4.95	0.45	P	4	6	9	15				
		6.00	6.45	0.45	U	-	-	-	-				
		7.50	7.95	0.45	P	5	14	15	29				
		9.00	9.45	0.45	P	7	12	21	33				
		10.50	10.95	0.45	P	8	10	13	23				
		12.00	12.45	0.45	P	9	11	13	24				
													13.00m
		13.50	13.95	0.45	P	15	27	31	58				Hard greyish yellow silty clay with little % of kankars.
		15.00	15.45	0.45	P	31	36	43	79				
													16.00m
		16.00	16.02	0.02	P	20 (2cm)	-	-	>100				Highly decomposed product of rock
		16.00	16.30	0.30	C	-	-	-	-	0.10	33	Nil	
													17.50m
		18.00	18.45	0.45	P	13	26	32	58				Hard greyish yellow silty clay with traces of kankars & calcarious nodules.
		19.50	19.95	0.45	P	14	23	24	47				
		21.00	21.45	0.45	P	16	25	28	53				
		22.50	22.95	0.45	P	13	27	41	68				
		24.00	24.45	0.45	P	16	32	47	79				
													25.00m
		25.50	25.95	0.45	P	14	25	45	70				Hard reddish brown silty clay with gravels (compacted high % of silt).
		27.00	27.45	0.45	P	17	27	54	81				
		28.50	28.95	0.45	P	13	25	35	60				
		30.00	30.45	0.45	P	15	27	42	69				
		31.50	31.95	0.45	P	16	24	34	58				
		33.00	33.45	0.45	P	17	26	38	64				
		34.50	34.95	0.45	P	16	29	40	69				

Sample Code: U-Undisturbed, C-Core, D-Disturbed, W-Water

Test Code P-Standard Penetration, V-Vane Shear

FARGO CONSULTANTS PVT. LTD.

BORE / DRILL LOG

Project : Geotechnical Investigations for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1

Project No.	: 2015258J	Bore Hole No.	: BH-1
Location	: Sahibganj (45R E-570640, N-2792953)	Ground Elevation	: +30.550m
Method of Boring / Drilling	: R.M.C	Dia. of Boring/Drilling	: 150mm
Boring / Drilling Equipment	: Mechanical Winch / GO	Casing Lowered	: 13.50m
Water Level (Static)	: 3.00 bgl.	Date :	31.07.2015 to 04.08.2015

Date	Sample and in-situ Test			Length (m)	Sample/Test Code	SPT			N' Value	Core Recovered (m)	Recovery (%)	R.Q.D. (%)	Description
	Time (Min)	DEPTH/RUN (m) From	DEPTH/RUN (m) To			0cm-15cm	15cm-30cm	30cm-45cm					
													Continued from previous page
		36.00	36.40	0.40	P	20	48	39 (10cm)	>100				Hard reddish brown silty clay with gravels (compacted high % of silt).
		37.00	37.38	0.38	P	29	46	43 (8cm)	>100				
		38.00	38.25	0.25	P	35	40 (10cm)	-	>100				
		39.00	39.23	0.23	P	43	55 (8cm)	-	>100				
		40.00	40.38	0.38	P	39	37	50 (8cm)	>100				
		41.00	41.12	0.12	P	52 (2cm)	-	-	>100				
		Borehole Termination Depth = 41.12m											

Sample Code: U-Undisturbed, C-Core, D-Disturbed, W-Water

Test Code P-Standard Penetration, V-Vane Shear

FARGO CONSULTANTS PVT. LTD.

BORE / DRILL LOG

Project : Geotechnical Investigations for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1

Project No. : 2015258J

Bore Hole No. : BH-2

Location : Sahibganj (45R E-570775, N-2793079)

Ground Elevation : +28.470m

Method of Boring / Drilling : R.M.C

Dia. of Boring/Drilling : 150mm

Boring / Drilling Equipment : Mechanical Winch / GO

Casing Lowered : 13.50m

Water Level (Static) : 3.75 bgl.

Date : 19.07.2015 to 26.07.2015

Date	Sample and in-situ Test			Length (m)	Sample/Test Code	SPT			N' Value	Core Recovered (m)	Recovery (%)	R.Q.D. (%)	Description
	Time (Min)	DEPTH/RUN (m) From	DEPTH/RUN (m) To			0cm-15cm	15cm-30cm	30cm-45cm					
19.07.2015		1.50	1.95	0.45	U	-	-	-	-				Stiff to very stiff yellowish grey silty clay/silty clay with kankars and gravels.
		3.00	3.45	0.45	P	3	5	7	12				
		4.50	4.95	0.45	P	7	5	8	13				
		6.00	6.45	0.45	P	7	8	9	17				
													7.00m
		7.50	7.95	0.45	U	-	-	-	-				Hard yellowish grey clayey silt.
		9.00	9.45	0.45	P	9	13	19	32				
		10.50	10.95	0.45	P	12	22	30	52				
													11.50m
		12.00	12.45	0.45	P	6	14	14	28				Very stiff greyish yellow clayey silt with varying % of kankar.
		13.50	13.95	0.45	P	9	13	16	29				
													15.00m
		15.00	15.45	0.45	P	11	14	24	38				Hard greyish brown silty clay with varying % of kankar.
		16.50	16.95	0.45	P	12	19	23	42				
		18.00	18.45	0.45	P	15	25	30	55				
		19.50	19.95	0.45	P	18	27	35	62				
		21.00	21.45	0.45	P	21	29	44	73				
		22.50	22.95	0.45	P	18	27	41	68				
													22.50m
		24.00	24.45	0.45	P	21	30	48	78				Hard greyish yellow - bluish grey silty clay/clayey silt with calcarious nodules and kankars (compacted high % of silt).
		25.50	25.95	0.45	P	16	23	33	56				
		27.00	27.45	0.45	P	14	27	37	64				
		28.50	28.95	0.45	P	10	21	29	50				
		30.00	30.45	0.45	P	13	24	27	51				
		31.50	31.95	0.45	P	11	19	23	42				
		33.00	33.45	0.45	P	15	22	25	47				
		34.50	34.95	0.45	P	14	24	30	54				
		36.00	36.45	0.45	P	17	28	33	61				

Sample Code: U-Undisturbed, C-Core, D-Disturbed, W-Water

Test Code P-Standard Penetration, V-Vane Shear

FARGO CONSULTANTS PVT. LTD.

BORE / DRILL LOG

Project : Geotechnical Investigations for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1

Project No. : 2015258J

Bore Hole No. : BH-2

Location : Sahibganj (45R E-570775, N-2793079)

Ground Elevation : +28.470m

Method of Boring / Drilling : R.M.C

Dia. of Boring/Drilling : 150mm

Boring / Drilling Equipment : Mechanical Winch / GO

Casing Lowered : 13.50m

Water Level (Static) : 3.75 bgl.

Date : 19.07.2015 to 26.07.2015

Date	Sample and in-situ Test			Length (m)	Sample/Test Code	SPT			N' Value	Core Recovered (m)	Recovery (%)	R.Q.D. (%)	Description
	Time (Min)	DEPTH/RUN (m) From	DEPTH/RUN (m) To			0cm-15cm	15cm-30cm	30cm-45cm					
		37.50	37.95	0.45	P	15	25	31	56				Continued from previous page
		39.00	39.38	0.38	P	25	45	40 (8 cm)	>100				Hard greyish yellow - bluish grey silty clay/clayey silt with calcarious nodules and kankars (compacted high % of silt)..
		40.00	40.35	0.35	P	30	51	31 (5cm)	>100				
		41.00	41.25	0.25	P	36	48 (1 0cm)	-	>100				
		42.00	42.23	0.23	P	82	43 (8cm)	-	>100				
		43.00	43.26	0.26	P	41	50 (11cm)	-	>100				
		44.00	44.24	0.24	P	45	52 (9cm)	70	>100				
		45.00	45.07	0.07	P	49 (7cm)	-	-	>100				
		Borehole Termination Depth = 45.07m											

Sample Code: U-Undisturbed, C-Core, D-Disturbed, W-Water

Test Code P-Standard Penetration, V-Vane Shear

FARGO CONSULTANTS PVT. LTD.

BORE / DRILL LOG

Project : Geotechnical Investigations for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1

Project No. : 2015258J

Bore Hole No. : BH-3

Location : Sahibganj (45R E-571498, N-2793687)

Ground Elevation : +26.370m

Method of Boring / Drilling : R.M.C

Dia. of Boring/Drilling : 150mm

Boring / Drilling Equipment : Mechanical Winch / GO

Casing Lowered : 13.00m

Water Level (Static) : 2.70 bgl.

Date : 06.08.2015 to 08.08.2015

Date	Sample and in-situ Test: Time (Min)	DEPTH/RUN (m): From	To	Length (m)	Sample/Test Code	SPT: 0cm-15cm	15cm-30cm	30cm-45cm	N' Value	Core Recovered (m)	Recovery (%)	R.Q.D. (%)	Description
06.08.2015		0.00	1.00	1.00	D	-	-	-	-				Very soft yellowish grey silty clay.
													1.00m
		1.50	1.95	0.45	P	1	2	2	4				Very loose to loose yellowish grey silty sand/sandy silt.
		3.00	3.45	0.45	U	-	-	-	-				
		4.50	4.95	0.45	P	1	1	1	2				
		6.00	6.45	0.45	P	2	2	3	5				
		7.50	7.95	0.45	P	2	2	3	5				
		9.00	9.45	0.45	P	3	5	3	8				
		10.50	10.95	0.45	P	1	2	1	3				
		12.00	12.45	0.45	P	2	1	2	3				
													13.00m
07.08.2015		13.00	13.04	0.04	P	34 (4cm)	-	-	>100				Completely to highly weathered sand stone.
	20	13.00	14.00	1.00	C	-	-	-	-	0.25	25	10	
	24	14.00	15.00	1.00	C	-	-	-	-	0.24	24	18	
	30	15.00	16.00	1.00	C	-	-	-	-	0.28	28	Nil	
08.08.2015	27	16.00	17.00	1.00	C	-	-	-	-	0.25	25	Nil	
	31	17.00	18.00	1.00	C	-	-	-	-	0.26	26	Nil	

Borehole Termination Depth = 18.00m

Sample Code: U-Undisturbed, C-Core, D-Disturbed, W-Water

Test Code P-Standard Penetration, V-Vane Shear

FARGO CONSULTANTS PVT. LTD.

BORE / DRILL LOG

Project : Geotechnical Investigations for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1

Project No. : 2015258J

Bore Hole No. : BH-4

Location : Sahibganj (45R E-571555, N-2793532)

Ground Elevation : +45.780m

Method of Boring / Drilling : R.M.C

Dia. of Boring/Drilling : 150mm

Boring / Drilling Equipment : Mechanical Winch / GO

Casing Lowered : 13.00m

Water Level (Static) : Not Encountered

Date : 08.08.2015 to 11.08.2015

Date	Sample and in-situ Test: Time (Min)	DEPTH/RUN (m): From	DEPTH/RUN (m): To	Length (m)	Sample/Test Code	SPT: 0cm-15cm	SPT: 15cm-30cm	SPT: 30cm-45cm	N' Value	Core Recovered (m)	Recovery (%)	R.Q.D. (%)	Description
08.08.2015		1.50	1.95	0.45	U	-	-	-	-				Hard yellowish brown silty clay / clayey silt with traces of kankars, gravel etc.
		3.00	3.45	0.45	P	12	19	20	39				
		4.50	4.95	0.45	P	12	15	16	31				
		6.00	6.45	0.45	P	10	12	13	25				4.00m
		7.50	7.95	0.45	P	11	18	23	41				Very stiff to hard greyish yellow clayey silt with traces of kankars.
		9.00	9.45	0.45	P	14	22	25	47				
		10.50	10.95	0.45	P	12	20	27	47				10.00m
		12.00	12.45	0.45	P	10	17	24	41				Hard greyish brown silty cay with traces of kankars, gravel.
10.08.2015		13.50	13.95	0.45	P	17	29	33	62				
		15.00	15.45	0.45	P	32	35	43	78				
		16.50	16.95	0.45	P	34	38	53	91				17.80m
		18.00	18.05	0.05	P	35 (5cm)	-	-	>100				Completely to highly weathered sand stone.
	15	18.00	19.00	1.00	C	-	-	-	-	Nil	Nil	Nil	
		19.00	19.04	0.04	P	25 (4cm)	-	-	>100				
	17	19.00	20.00	1.00	C					Nil	Nil	Nil	
		20.00	20.05	0.05	P	31 (5cm)	-	-	>100				
	20	20.00	21.00	1.00	C					Nil	Nil	Nil	
		21.00	21.05	0.05	P	35 (5cm)	-	-	>100				
11.08.2015	16	21.00	22.00	1.00	C					Nil	Nil	Nil	
		22.00	22.04	0.04	P	27 (4cm)	-	-	>100				
	30	22.00	23.00	1.00	C					0.30	30	Nil	

Borehole Termination Depth = 23.00m

Sample Code: U-Undisturbed, C-Core, D-Disturbed, W-Water

Test Code P-Standard Penetration, V-Vane Shear

FARGO CONSULTANTS PVT. LTD.

BORE / DRILL LOG

Project : Geotechnical Investigations for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1

Project No. : 2015258J

Bore Hole No. : BH-5

Location : Sahibganj (45R E-570884, N-2793059)

Ground Elevation : +37.750m

Method of Boring / Drilling : R.M.C

Dia. of Boring/Drilling : 150mm

Boring / Drilling Equipment : Mechanical Winch / GO

Casing Lowered : 13.00m

Water Level (Static) : 11.60 bgl.

Date : 27.07.2015 to 29.07.2015

Date	Sample and in-situ Test			Length (m)	Sample/Test Code	SPT			N' Value	Core Recovered (m)	Recovery (%)	R.Q.D. (%)	Description
	Time (Min)	DEPTH/RUN (m) From	DEPTH/RUN (m) To			0cm-15cm	15cm-30cm	30cm-45cm					
27.07.2015		1.50	1.95	0.45	P	3	5	7	12				Stiff to very stiff brownish yellow/yellowish grey silty clay with little % of kankars.
		3.00	3.45	0.45	U	-	-	-	-				
		4.50	4.95	0.45	P	6	9	12	21				
		6.00	6.45	0.45	P	8	12	18	30				
													7.00m
		7.50	7.95	0.45	P	7	15	21	36				Hard yellowish brown silty clay/clayey silt with little % of kankars.
		9.00	9.45	0.45	P	9	18	24	42				
		10.50	10.95	0.45	P	15	22	25	47				
													11.00m
		12.00	12.45	0.45	P	10	12	13	25				Very stiff yellowish grey silty clay with varying % of kankars.
		13.50	13.95	0.45	P	8	10	15	25				
		15.00	15.45	0.45	P	9	13	16	29				
28.07.2015		16.50	16.95	0.45	P	11	12	14	26				
		18.00	18.45	0.45	P	12	14	17	31				
													19.00m
		19.50	19.95	0.45	P	21	31	35	66				Hard greyish brown silty clay/ clayey silt with gravels, pebbles and kankars etc.
		21.00	21.45	0.45	P	10	16	25	41				
		22.50	22.95	0.45	P	12	18	24	42				
		24.00	24.45	0.45	P	14	24	29	53				
		25.50	25.95	0.45	P	17	28	36	64				
		27.00	27.45	0.45	P	20	30	41	71				
		28.50	28.95	0.45	P	16	24	38	62				
		30.00	30.45	0.45	P	21	33	44	77				
		31.50	31.95	0.45	P	17	26	39	65				
		33.00	33.45	0.45	P	15	24	31	55				
		34.50	34.95	0.45	P	13	21	28	49				
		36.00	36.45	0.45	P	18	23	33	56				

Sample Code: U-Undisturbed, C-Core, D-Disturbed, W-Water

Test Code P-Standard Penetration, V-Vane Shear

FARGO CONSULTANTS PVT. LTD.

BORE / DRILL LOG

Project : Geotechnical Investigations for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1

Project No. : 2015258J

Bore Hole No. : BH-5

Location : Sahibganj (45R E-570884, N-2793059)

Ground Elevation : +37.750m

Method of Boring / Drilling : R.M.C

Dia. of Boring/Drilling : 150mm

Boring / Drilling Equipment : Mechanical Winch / GO

Casing Lowered : 13.00m

Water Level (Static) : 11.60 bgl.

Date : 27.07.2015 to 29.07.2015

Date	Sample and in-situ Test			Length (m)	Sample/Test Code	SPT			N' Value	Core Recovered (m)	Recovery (%)	R.Q.D. (%)	Description
	Time (Min)	DEPTH/RUN (m) From	DEPTH/RUN (m) To			0cm-15cm	15cm-30cm	30cm-45cm					
		38.00	38.45	0.45	P	16	28	32	60				Continued from previous page
		40.00	40.45	0.45	P	15	30	38	68				
		Borehole Termination Depth = 40.45m											

Sample Code: U-Undisturbed, C-Core, D-Disturbed, W-Water

Test Code P-Standard Penetration, V-Vane Shear

FARGO CONSULTANTS PVT. LTD.

BORE / DRILL LOG

Project : Geotechnical Investigations for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1

Project No.	: 2015258J	Bore Hole No.	: BH-6
Location	: Sahibganj (45R E-571361, N-2793713)	Ground Elevation	: +7.660m
Method of Boring / Drilling	: R.M.C	Dia. of Boring/Drilling	: 150/75mm
Boring / Drilling Equipment	: Mechanical Winch / GO	Casing Lowered	: 25.0m
Water Level (Static)	: 16.54m abl	Date :	16.08.2015 to 17.08.2015

Date	Sample and in-situ Test: Time (Min)	DEPTH/RUN (m): From	To	Length (m)	Sample/Test Code	SPT: 0cm-15cm	15cm-30cm	30cm-45cm	N' Value	Core Recovered (m)	Recovery (%)	R.Q.D. (%)	Description
16.08.2015		0.00	1.30	1.00	D	-	-	-	-				Very soft yellowish grey silty clay.
													1.30m
		1.50	1.95	0.45	P	4	3	6	9				Loose to medium dense yellowish grey silty sand/sandy silt.
		3.00	3.45	0.45	P	5	3	7	10				
		4.50	4.95	0.45	P	4	10	7	17				
		6.00	6.45	0.45	P	6	9	8	17				
		7.50	7.95	0.45	P	8	6	8	14				
													8.05m
		8.05	8.10	0.05	P	25 (5cm)	-	-	>100				Completely to highly weathered sand stone.
	20	8.00	9.00	1.00	C	-	-	-	-	0.20	20	Nil	
17.08.2015	24	9.00	10.00	1.00	C	-	-	-	-	0.18	18	Nil	
	30	10.00	11.00	1.00	C	-	-	-	-	0.26	26	Nil	
	27	11.00	12.00	1.00	C	-	-	-	-	0.19	19	Nil	
	31	12.00	13.00	1.00	C	-	-	-	-	0.22	22	Nil	
		Borehole Termination Depth = 13.00m											

Sample Code: U-Undisturbed, C-Core, D-Disturbed, W-Water

Test Code P-Standard Penetration, V-Vane Shear

FARGO CONSULTANTS PVT. LTD.

BORE / DRILL LOG

Project : Geotechnical Investigations for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1

Project No. : 2015258J

Bore Hole No. : BH-7

Location : Sahibganj (45R E-570574, N-2793069)

Ground Elevation : +13.460m

Method of Boring / Drilling : R.M.C

Dia. of Boring/Drilling : 150mm

Boring / Drilling Equipment : Mechanical Winch / GO

Casing Lowered : 37.0m

Water Level (Static) : 10.74m abl

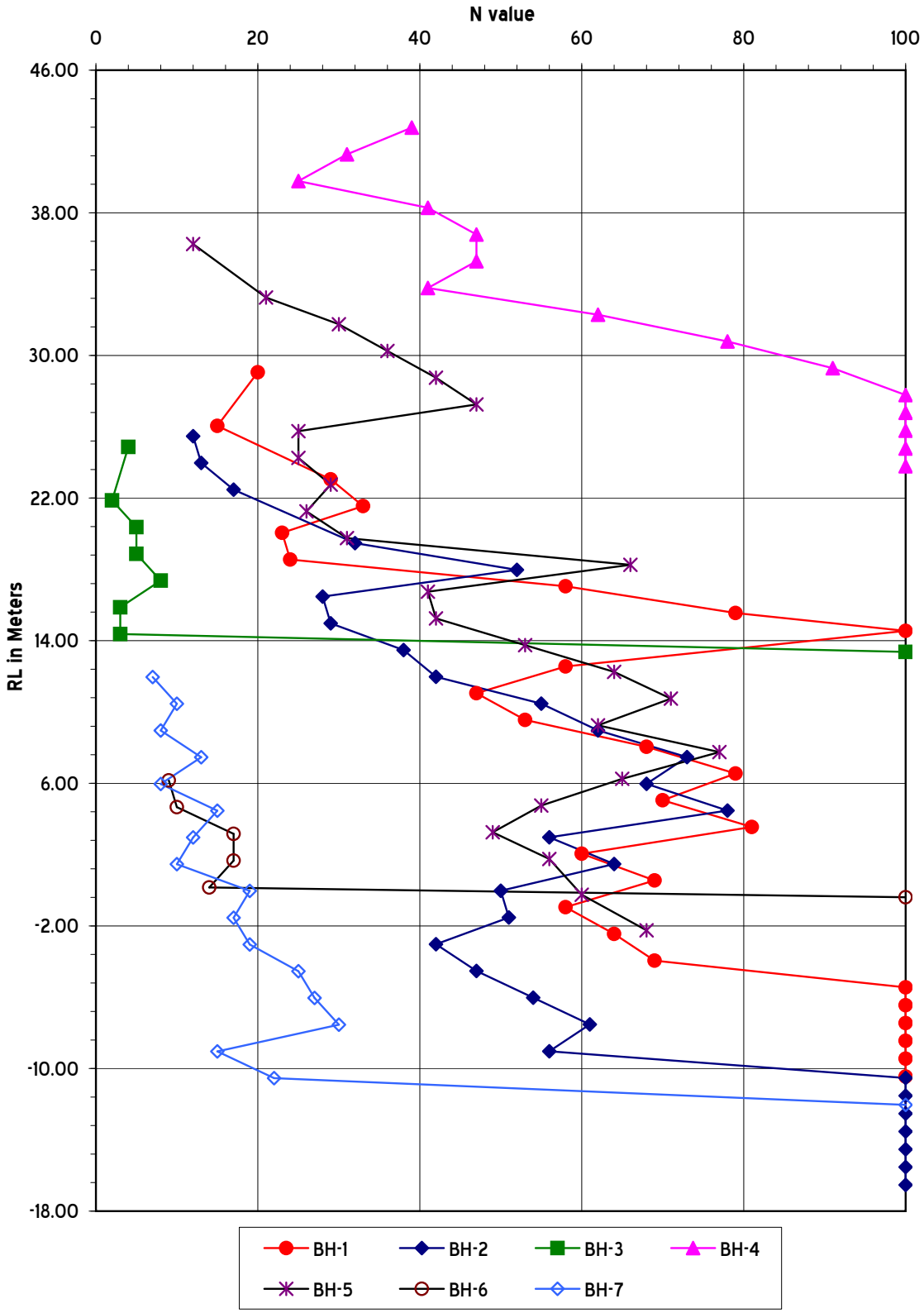
Date : 21.08.2015 to 23.08.2015

Date	Sample and in-situ Test: Time (Min)	DEPTH/RUN (m): From	To	Length (m)	Sample/Test Code	SPT: 0cm-15cm	15cm-30cm	30cm-45cm	N' Value	Core Recovered (m)	Recovery (%)	R.Q.D. (%)	Description
21.08.2015		0.00	1.50	1.00	D	-	-	-	-				Very soft yellowish grey silty clay.
													1.50m
		1.50	1.95	0.45	P	1	2	5	7				Loose to medium dense yellowish grey silty sand/sandy silt.
		3.00	3.45	0.45	P	4	6	4	10				
		4.50	4.95	0.45	P	4	4	4	8				
		6.00	6.45	0.45	P	4	6	7	13				
		7.50	7.95	0.45	P	4	4	4	8				
		9.00	9.45	0.45	P	5	6	9	15				
		10.50	10.95	0.45	P	3	6	6	12				
		12.00	12.45	0.45	P	4	5	5	10				
		13.50	13.95	0.45	P	6	9	10	19				
22.08.2015		15.00	15.45	0.45	P	4	7	10	17				
		16.50	16.95	0.45	P	7	8	11	19				
		18.00	18.45	0.45	P	11	12	13	25				
		19.50	19.95	0.45	P	12	12	15	27				
		21.00	21.45	0.45	P	14	15	15	30				
		22.50	22.95	0.45	P	7	7	8	15				
		24.00	24.45	0.45	P	9	11	11	22				
													25.50m
23.08.2015		25.50	25.62	0.12	P	45 (12cm)	-	-	>100				Completely to highly weathered sand stone.
	30	25.50	27.00	1.50	C	-	-	-	-	0.29	29	Nil	
	28	27.00	28.50	1.50	C	-	-	-	-	0.28	28	Nil	
	20	28.50	29.50	1.00	C	-	-	-	-	0.30	30	Nil	
	23	29.50	30.50	1.00	C	-	-	-	-	0.23	23	Nil	
		Borehole Termination Depth = 30.50m											

Sample Code: U-Undisturbed, C-Core, D-Disturbed, W-Water

Test Code P-Standard Penetration, V-Vane Shear

GRAPHICAL REPRESENTATION OF FIELD N-VALUE WITH RL AT IWT TERMINAL AT SAHIBGANJ IN JHARKHAND

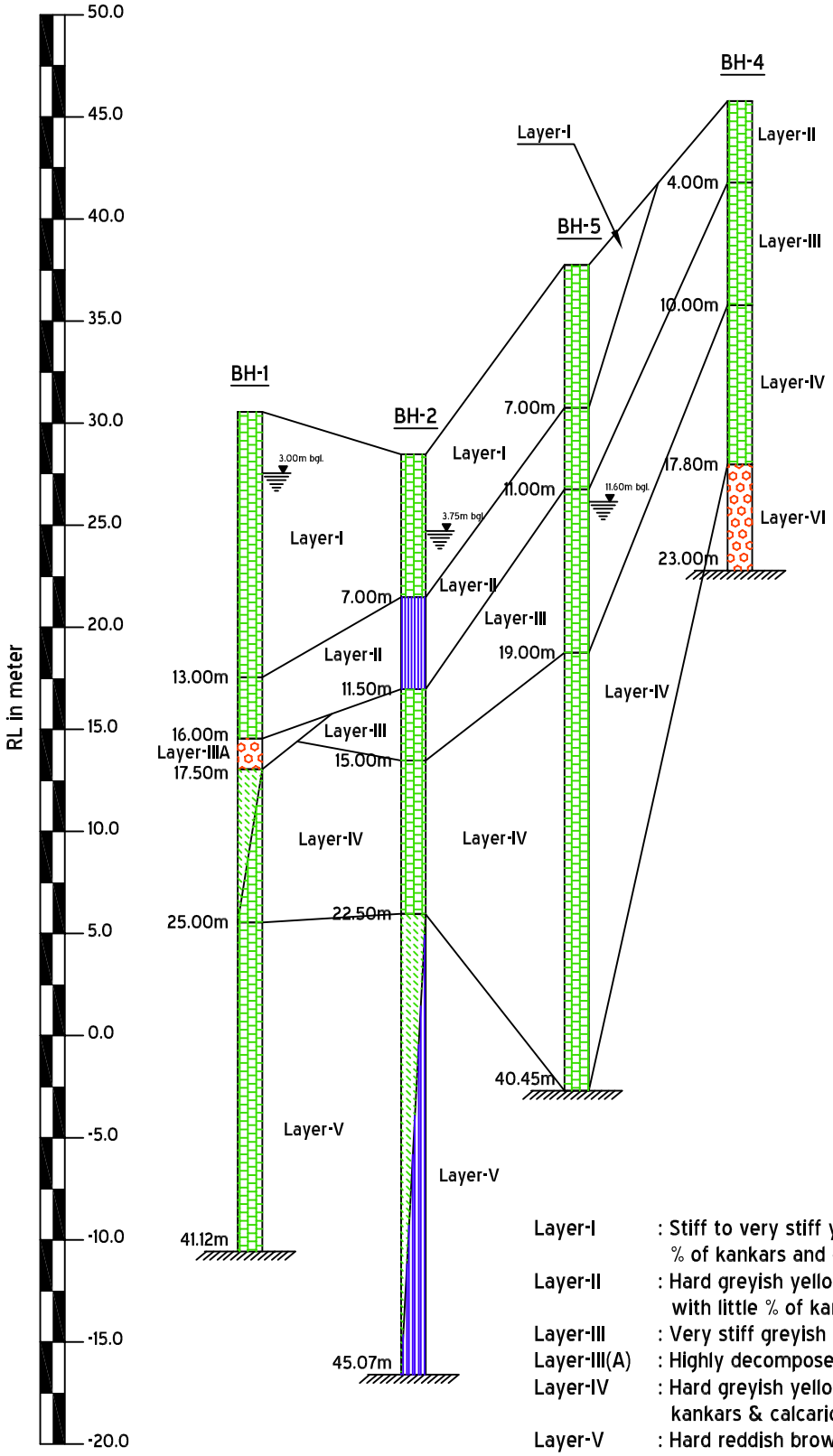


Project :	Geotechnical Investigations for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1	Job No.:	2015258J
		Fig No.:	2

FARGO CONSULTANTS PVT. LTD., KOLKATA

ANNEXURE - C

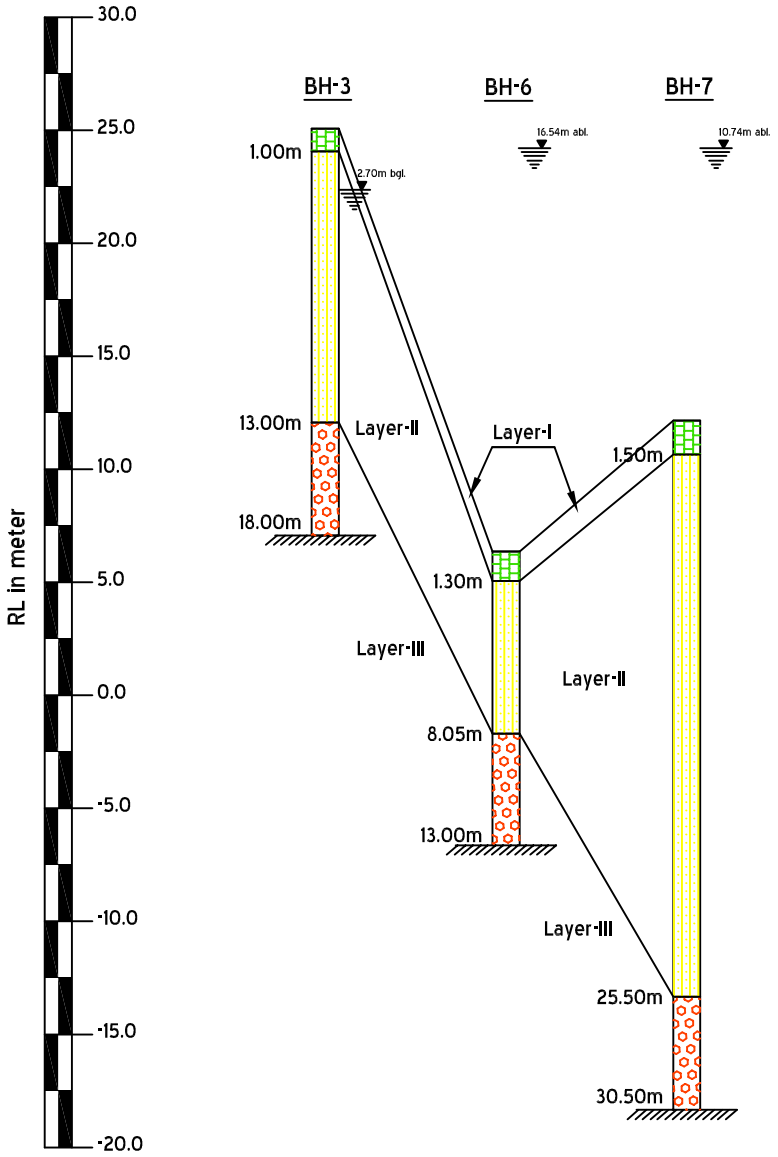
SOIL PROFILE



Layer-I	: Stiff to very stiff yellow grey silty clay/clayey silt with varying % of kankars and gravels.
Layer-II	: Hard greyish yellow/yellowish brown silty clay/clayey silt with little % of kankars.
Layer-III	: Very stiff greyish yellow clayey silt with varying % of kankar.
Layer-III(A)	: Highly decomposed product of rock.
Layer-IV	: Hard greyish yellow/brown silty clay with traces of kankars & calcarious nodules.
Layer-V	: Hard reddish brown silty clay with gravels (compacted high % of silt)
Layer-VI	: Completely to highly weathered sand stone

Generalized soil profile for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga

CLIENT:	SCALE:	
HOWE Engineering Projects (India) Pvt. Ltd. HOWE India House, 81, Nehru Place, New Delhi - 110 019	Not to scale	
PROJECT:	**CONSULTANT:**	**FIG. NO.**
Geotechnical Investigations for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1	FARGO CONSULTANTS PVT. LTD. Mailing Address: CF-394, SALT LAKE CITY, SECTOR- I, KOLKATA - 700 064 PHONE:(033)6454 4560(O) FAX:033-2337 3775 e-mail:fargoconsultants@gmail.com	3



Layer-I : Very soft yellowish grey silty clay
Layer-II : Very loose to loose yellowish grey silty sand/sandy silt
Layer-III : Completely to highly weathered sand stone

Generalized soil profile for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga

CLIENT:	SCALE:	
HOWE Engineering Projects (India) Pvt. Ltd. HOWE India House, 81, Nehru Place, New Delhi - 110 019	Not to scale	
PROJECT:	**CONSULTANT:**	**FIG. NO.**
Geotechnical Investigations for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1	FARGO CONSULTANTS PVT. LTD. Mailing Address: CF-394, SALT LAKE CITY, SECTOR- I, KOLKATA - 700 064 PHONE:(033)6454 4560(O) FAX:033-2337 3775 e-mail:fargoconsultants@gmail.com	4

ANNEXURE - D

LABORATORY RESULTS

FARGO CONSULTANTS PVT. LTD.

LABORATORY TEST RESULTS

Project Name & Bore Hole No.	Layer ID	Depth (m)	Sample Type	'N' value	Corrected "N" Value	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Natural Moisture Content (%)	Bulk Density (gm/cc)	Dry density (gm/cc)	Liquid Limit(%)	Plastic Limit (%)	Plasticity Index (%)	Type of Test	Cohesion (kg/cm^2)	Angle of Friction (degree)	Sp.Gravity	e_0	P_0 (kg/cm^2)	P_c (kg/cm^2)	C_c	C_r
G.I. works for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1 Location:National water way at Sahibganj in Jharkhand , BH - 1	I	1.50	P	20	-	2.2	6.8	82.3	8.7	-	-	-	27.6	18.0	9.6	-	-	-	-	-	-	-	-	-
		3.00	U	-	-	0.0	2.7	87.8	9.5	17.9	1.928	1.635	28.7	17.7	11.0	UU	1.09	0.0	-	-	-	-	-	-
		4.50	P	15	-	7.1	8.2	74.6	10.1	-	-	-	28.2	17.5	10.7	-	-	-	-	-	-	-	-	-
		6.00	U	-	-	43.5	6.9	49.6*		21.1	1.997	1.649	-	-	-	-	-	-	-	-	-	-	-	-
		7.50	P	29	-	0.0	2.5	88.0	9.5	-	-	-	27.8	17.6	10.2	-	-	-	-	-	-	-	-	-
		9.00	P	33	-	0.0	2.9	87.6	9.5	-	-	-	27.9	18.8	9.1	-	-	-	-	-	-	-	-	-
		10.50	P	23	-	0.7	4.5	85.5	9.3	-	-	-	28.4	17.5	10.9	-	-	-	-	-	-	-	-	-
		12.00	P	24	-	0.7	4.5	85.5	9.3	-	-	-	28.1	16.7	11.4	-	-	-	-	-	-	-	-	-
	II	13.50	P	58	-	0.2	3.5	86.7	9.6	-	-	-	28.1	16.7	11.4	-	-	-	-	-	-	-	-	-
		15.00	P	79	-	0.2	3.3	88.8	7.7	-	-	-	29.1	17.2	11.9	-	-	-	-	-	-	-	-	-
	IIIA	16.00	P	>100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	IV	18.00	P	58	-	10.2	6.4	73.8	9.6	-	-	-	27.5	16.3	11.2	-	-	-	-	-	-	-	-	-
		19.50	P	47	-	11.0	7.6	73.2	8.2	-	-	-	27.6	15.8	11.8	-	-	-	-	-	-	-	-	-
		21.00	P	53	-	8.9	8.1	69.9	13.1	-	-	-	36.6	17.0	19.6	-	-	-	-	-	-	-	-	-
		22.50	P	68	-	8.3	7.0	71.4	13.3	-	-	-	36.6	14.9	21.7	-	-	-	-	-	-	-	-	-
		24.00	P	79	-	0.0	3.1	78.9	18.0	-	-	-	37.2	16.6	20.6	-	-	-	-	-	-	-	-	-
	V	25.50	P	70	-	10.8	49.9	39.3*		-	-	-	Non Plastic			-	-	-	-	-	-	-	-	-
		27.00	P	81	-	10.8	51.2	38.0*		-	-	-	Non Plastic			-	-	-	-	-	-	-	-	-
		28.50	P	60	-	21.4	3.8	66.9	7.9	-	-	-	28.3	16.8	11.5	-	-	-	-	-	-	-	-	-
		30.00	P	69	-	19.4	5.4	66.8	8.4	-	-	-	27.8	16.9	10.9	-	-	-	-	-	-	-	-	-
		31.50	P	58	-	19.1	3.6	68.6	8.7	-	-	-	28.2	17.9	10.3	-	-	-	-	-	-	-	-	-
		33.00	P	64	-	20.2	4.2	67.4	8.2	-	-	-	27.9	17.4	10.5	-	-	-	-	-	-	-	-	-
		34.50	P	69	-	16.7	3.2	70.9	9.2	-	-	-	28.6	17.3	11.3	-	-	-	-	-	-	-	-	-
		36.00	P	>100	-	16.0	5.0	70.1	8.9	-	-	-	28.6	16.8	11.8	-	-	-	-	-	-	-	-	-

Note :

1. U-Undisturbed Sample
2. D-Disturbed Sample
3. P-Standard Penetration Test
4. UU : Unconsolidated Undrained Triaxial Test
5. UC : Unconfined Compression Test
6. CU : Consolidated Un-drained Test
7. CD : Consolidated Drained Test
8. DS : Direct Shear Test
9. * Combined % of Silt & Clay.

Sheet No.: D-1

FARGO CONSULTANTS PVT. LTD.

LABORATORY TEST RESULTS

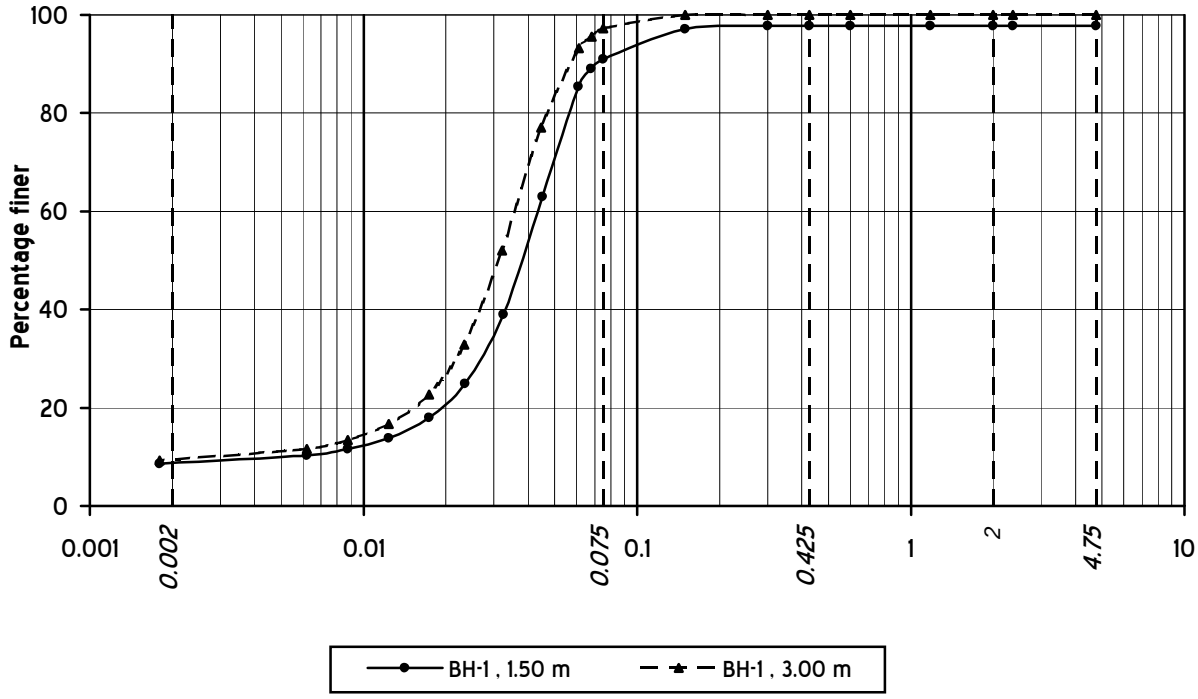
Project Name & Bore Hole No.	G.I. works for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1 Location:National water way at Sahibganj in Jharkhand , BH - 1					
Layer ID	V					
Depth (m)	37.00	38.00	39.00	40.00	41.00	
Sample Type	P	P	P	P	P	
'N' value	>100	>100	>100	>100	>100	
Corrected "N" Value	.	.	.	.	.	
Gravel (%)	.	.	.	.	.	
Sand (%)	.	.	.	.	.	
Silt (%)	.	.	.	.	.	
Clay (%)	.	.	.	.	.	
Natural Moisture Content (%)	.	.	.	.	.	
Bulk Density (gm/cc)	.	.	.	.	.	
Dry density (gm/cc)	.	.	.	.	.	
Liquid Limit(%)	.	.	.	.	.	
Plastic Limit (%)	.	.	.	.	.	
Plasticity Index (%)	.	.	.	.	.	
Type of Test	.	.	.	.	.	
Cohesion (kg/cm^2)	.	.	.	.	.	
Angle of Friction (degree)	.	.	.	.	.	
Sp.Gravity	.	.	.	.	.	
e_0	.	.	.	.	.	
P_0 (kg/cm^2)	.	.	.	.	.	
P_c (kg/cm^2)	.	.	.	.	.	
C_c	.	.	.	.	.	
C_r	.	.	.	.	.	. . . . .

Note :

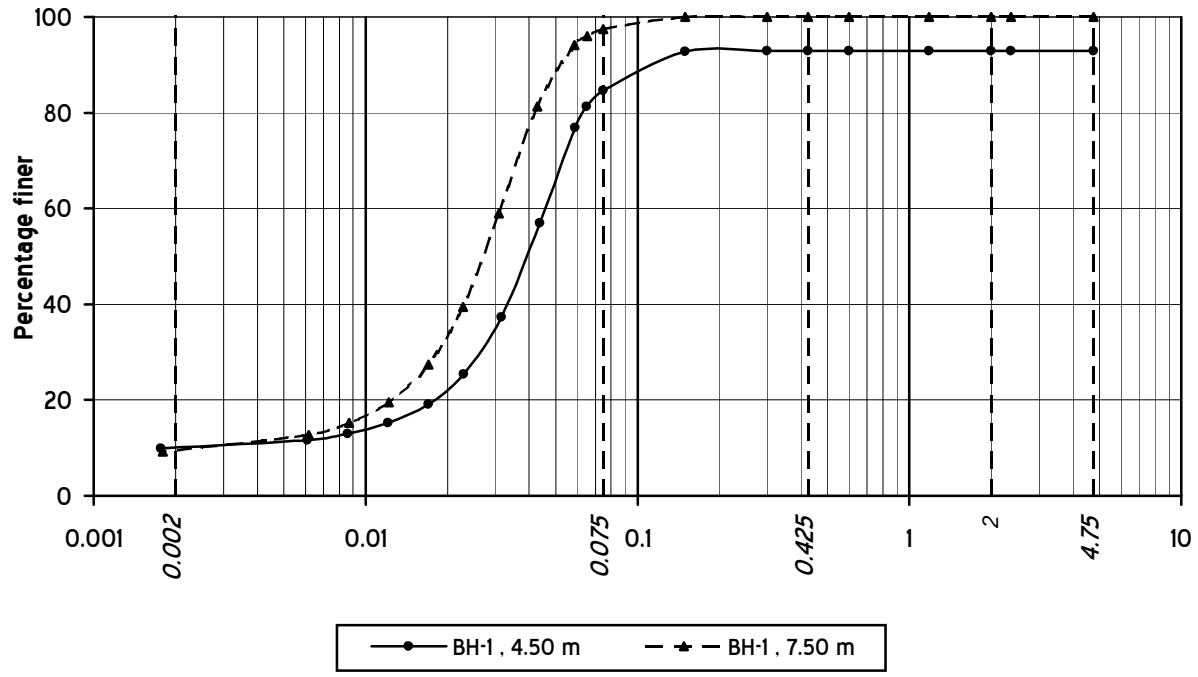
1. U-Undisturbed Sample
2. D-Disturbed Sample
3. P-Standard Penetration Test
4. UU : Unconsolidated Undrained Triaxial Test
5. UC : Unconfined Compression Test
6. CU : Consolidated Un-drained Test
7. CD : Consolidated Drained Test
8. DS : Direct Shear Test
9. * Combined % of Silt & Clay.

Sheet No.: D-2

GRAIN SIZE DISTRIBUTION CURVES



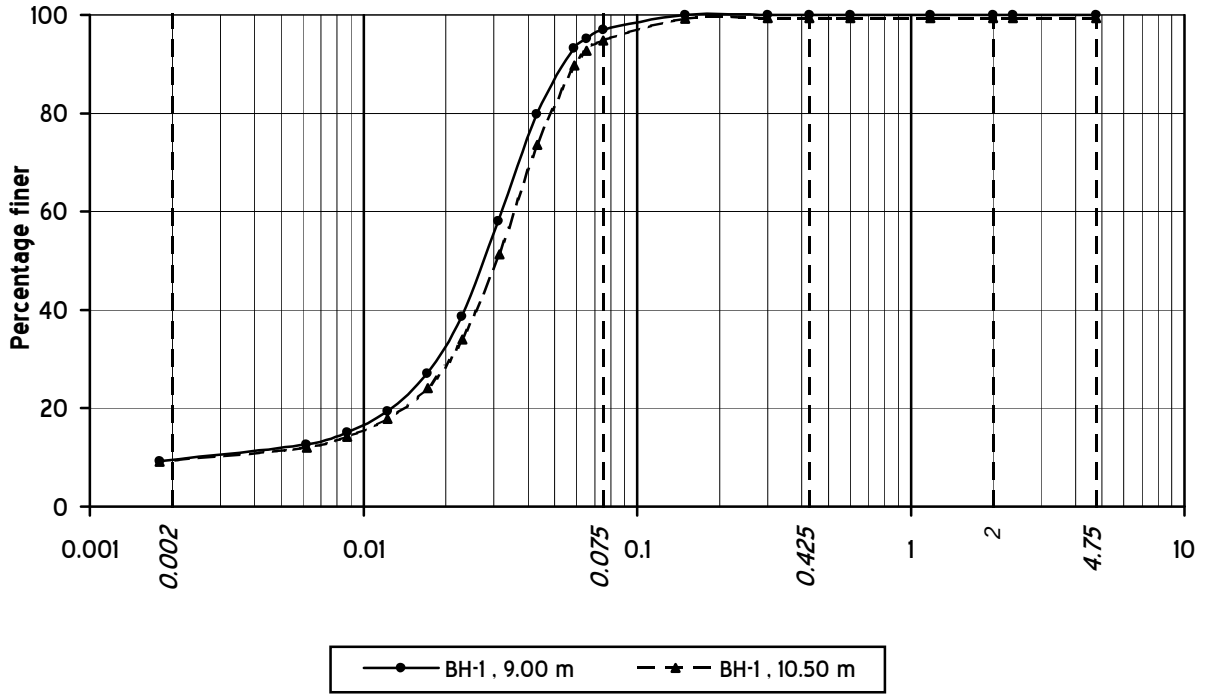
Grain size (mm) / Sample No.	*< 0.002* Clay (%)	*0.002-0.075* Silt (%)	*0.075-0.425* Fine sand (%)	*0.425-2.0* Medium sand (%)	*2.0-4.75* Coarse sand (%)	*> 4.75* Gravel (%)
BH-1 , 1.50 m	8.7	82.3	6.8	0.0	0.0	2.2
BH-1 , 3.00 m	9.5	87.8	2.7	0.0	0.0	0.0



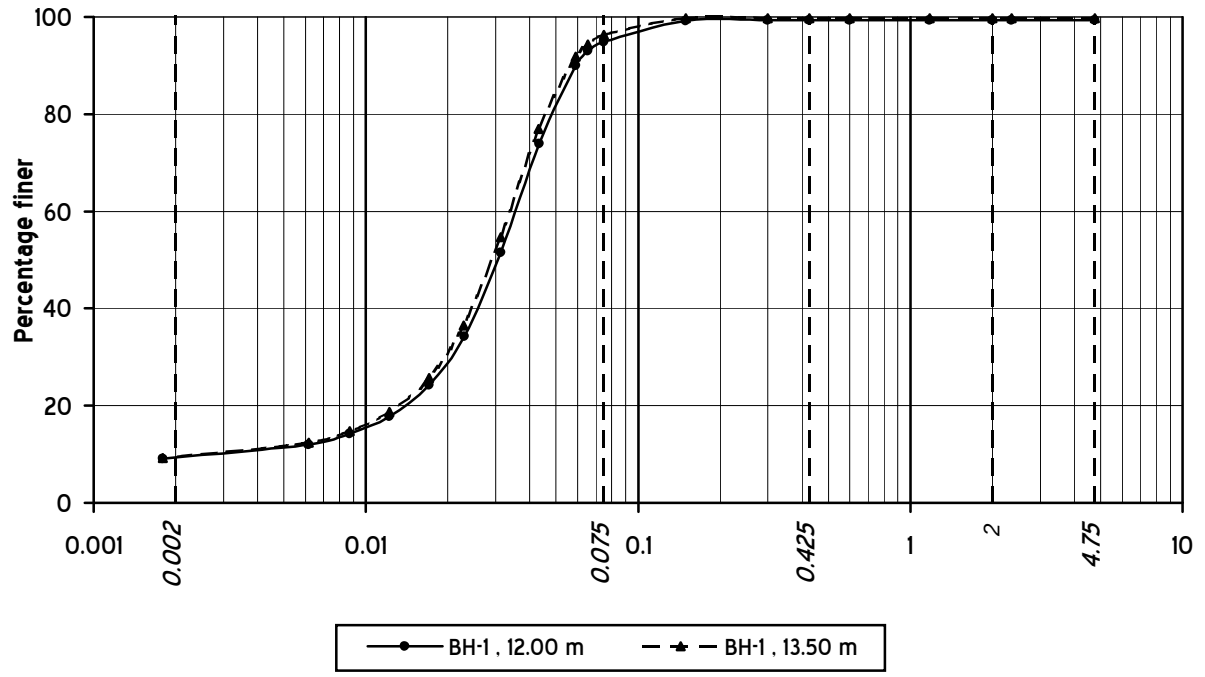
Grain size (mm) / Sample No.	*< 0.002* Clay (%)	*0.002-0.075* Silt (%)	*0.075-0.425* Fine sand (%)	*0.425-2.0* Medium sand (%)	*2.0-4.75* Coarse sand (%)	*> 4.75* Gravel (%)
BH-1 , 4.50 m	10.1	74.6	8.2	0.0	0.0	7.1
BH-1 , 7.50 m	9.5	88.0	2.5	0.0	0.0	0.0

Project:G.I. works for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1	Job No. 2015258J	Fig. No. 5

GRAIN SIZE DISTRIBUTION CURVES



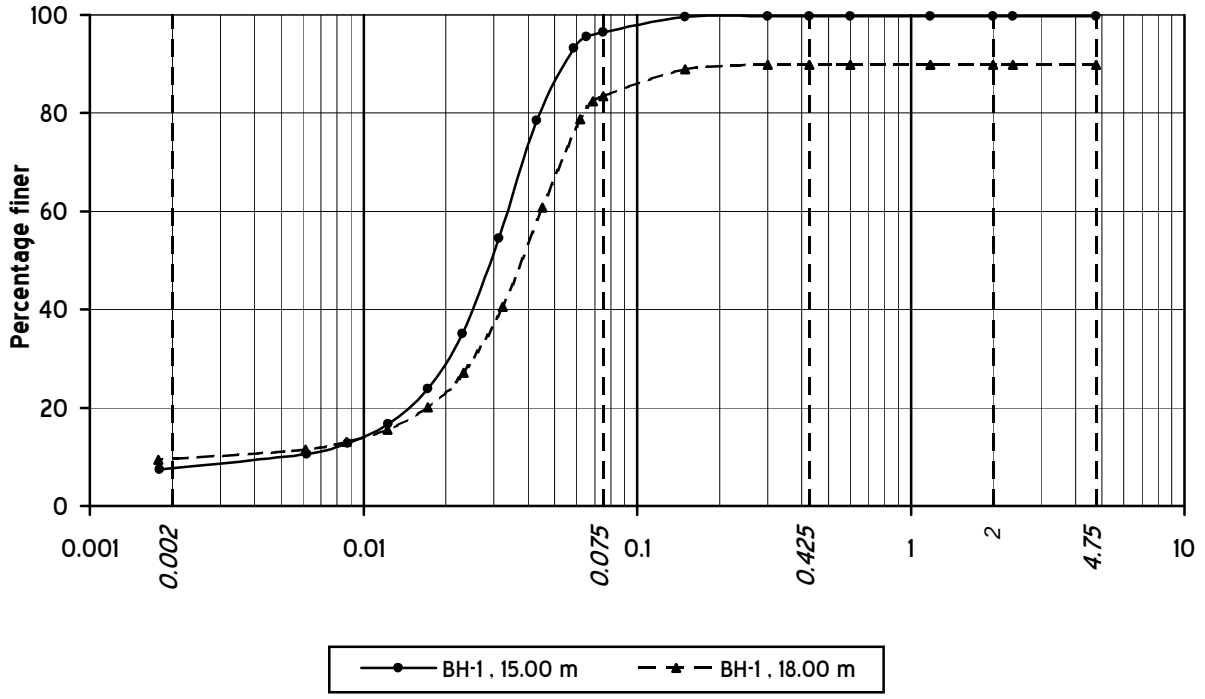
Grain size (mm) / Sample No.	< 0.002 Clay (%)	0.002-0.075 Silt (%)	0.075-0.425 Fine sand (%)	0.425-2.0 Medium sand (%)	2.0-4.75 Coarse sand (%)	> 4.75 Gravel (%)
BH-1 , 9.00 m	9.5	87.6	2.9	0.0	0.0	0.0
BH-1 , 10.50 m	9.3	85.5	4.5	0.0	0.0	0.7



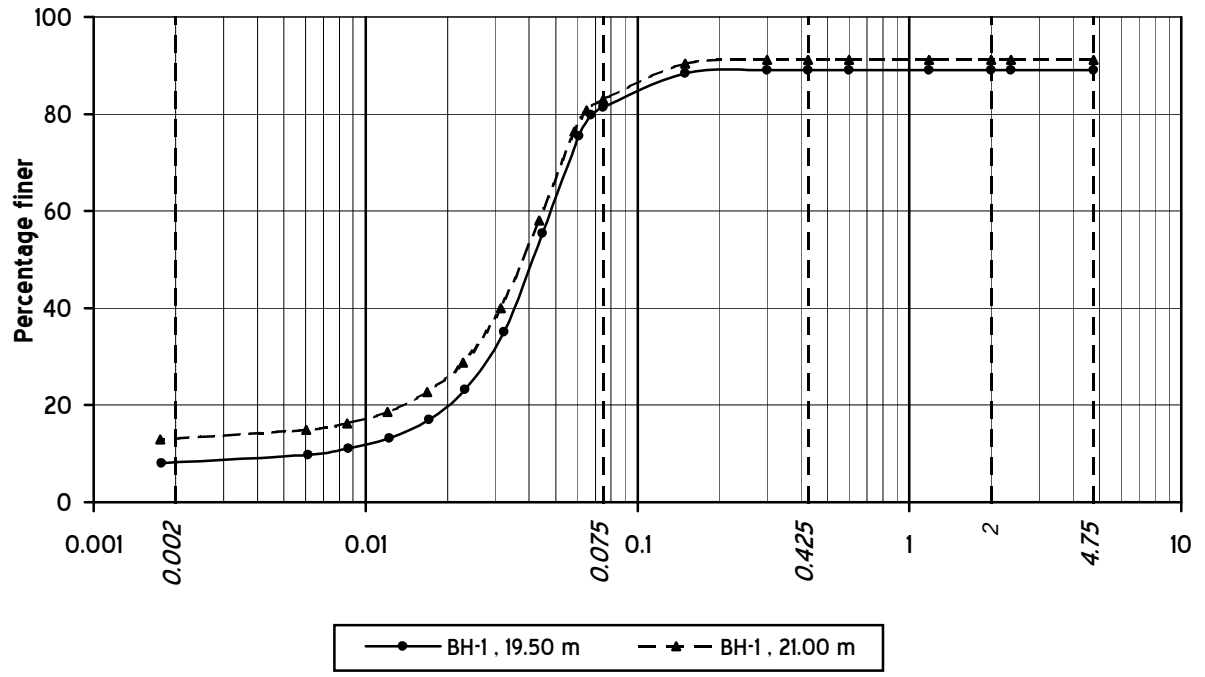
Grain size (mm) / Sample No.	< 0.002 Clay (%)	0.002-0.075 Silt (%)	0.075-0.425 Fine sand (%)	0.425-2.0 Medium sand (%)	2.0-4.75 Coarse sand (%)	> 4.75 Gravel (%)
BH-1 , 12.00 m	9.3	85.5	4.5	0.0	0.0	0.7
BH-1 , 13.50 m	9.6	86.7	3.5	0.0	0.0	0.2

Project:G.I. works for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1	Job No. 2015258J	Fig. No. 6

GRAIN SIZE DISTRIBUTION CURVES



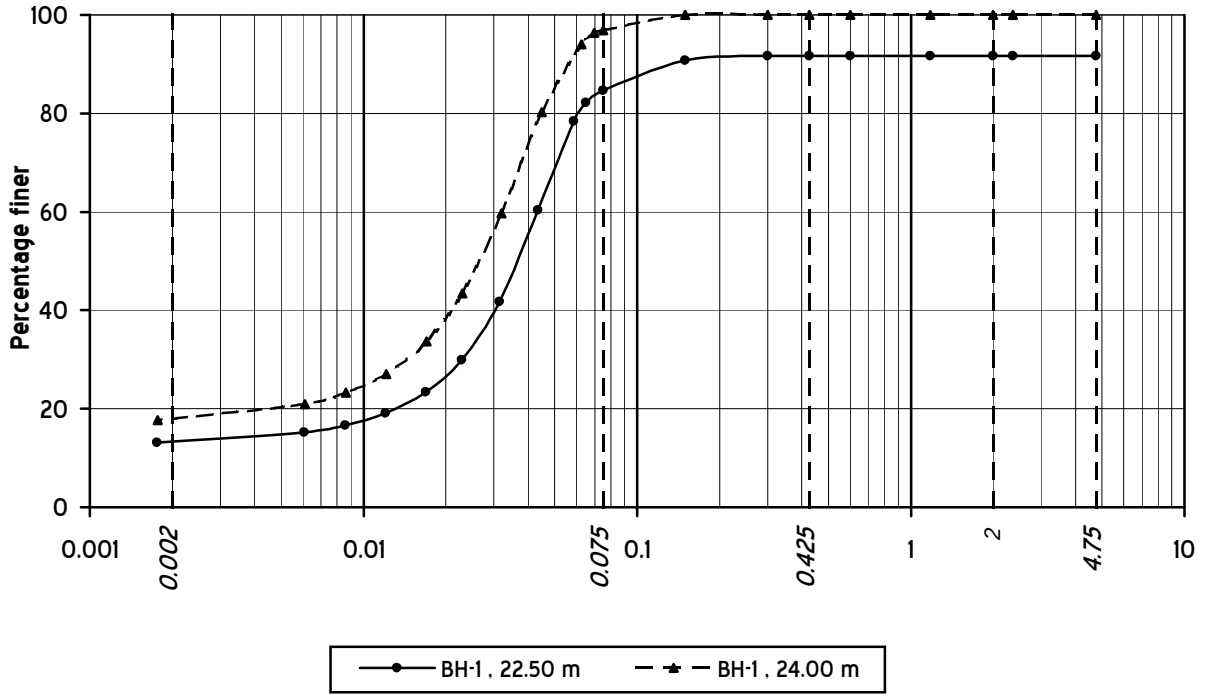
Grain size (mm) / Sample No.	*< 0.002* Clay (%)	*0.002-0.075* Silt (%)	*0.075-0.425* Fine sand (%)	*0.425-2.0* Medium sand (%)	*2.0-4.75* Coarse sand (%)	*> 4.75* Gravel (%)
BH-1 , 15.00 m	7.7	88.8	3.3	0.0	0.0	0.2
BH-1 , 18.00 m	9.6	73.8	6.4	0.0	0.0	10.2



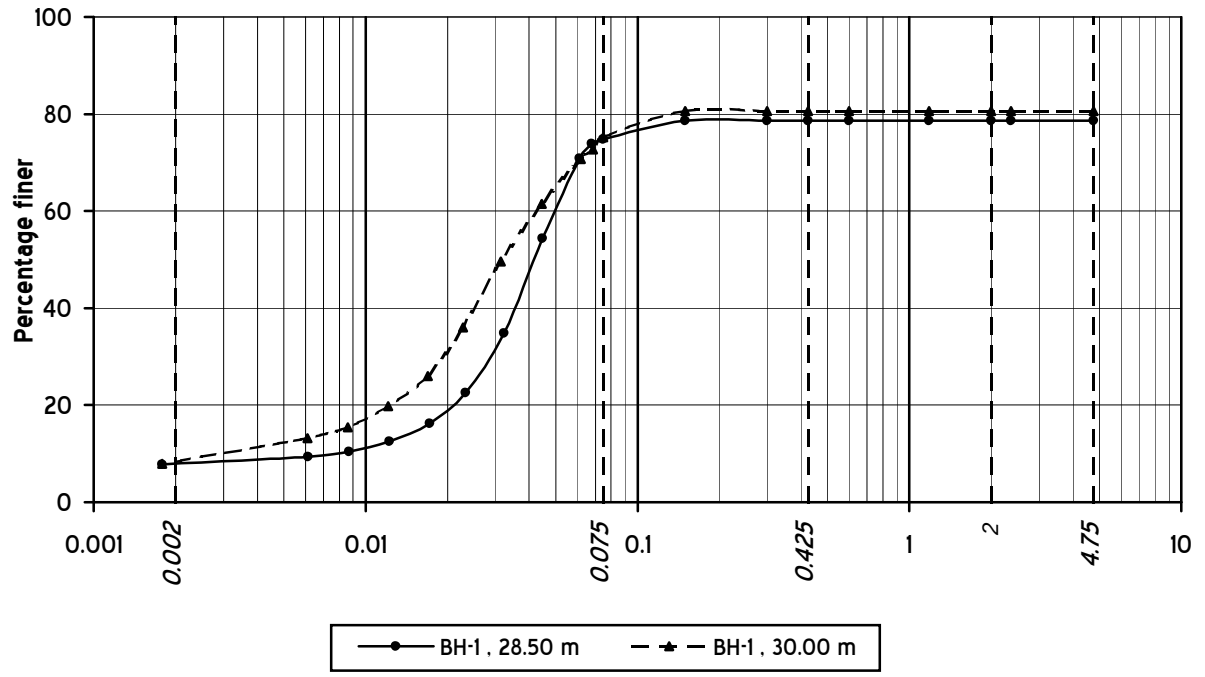
Grain size (mm) / Sample No.	*< 0.002* Clay (%)	*0.002-0.075* Silt (%)	*0.075-0.425* Fine sand (%)	*0.425-2.0* Medium sand (%)	*2.0-4.75* Coarse sand (%)	*> 4.75* Gravel (%)
BH-1 , 19.50 m	8.2	73.2	7.6	0.0	0.0	11.0
BH-1 , 21.00 m	13.1	69.9	8.1	0.0	0.0	8.9

Project:G.I. works for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1	Job No. 2015258J	Fig. No. 7

GRAIN SIZE DISTRIBUTION CURVES



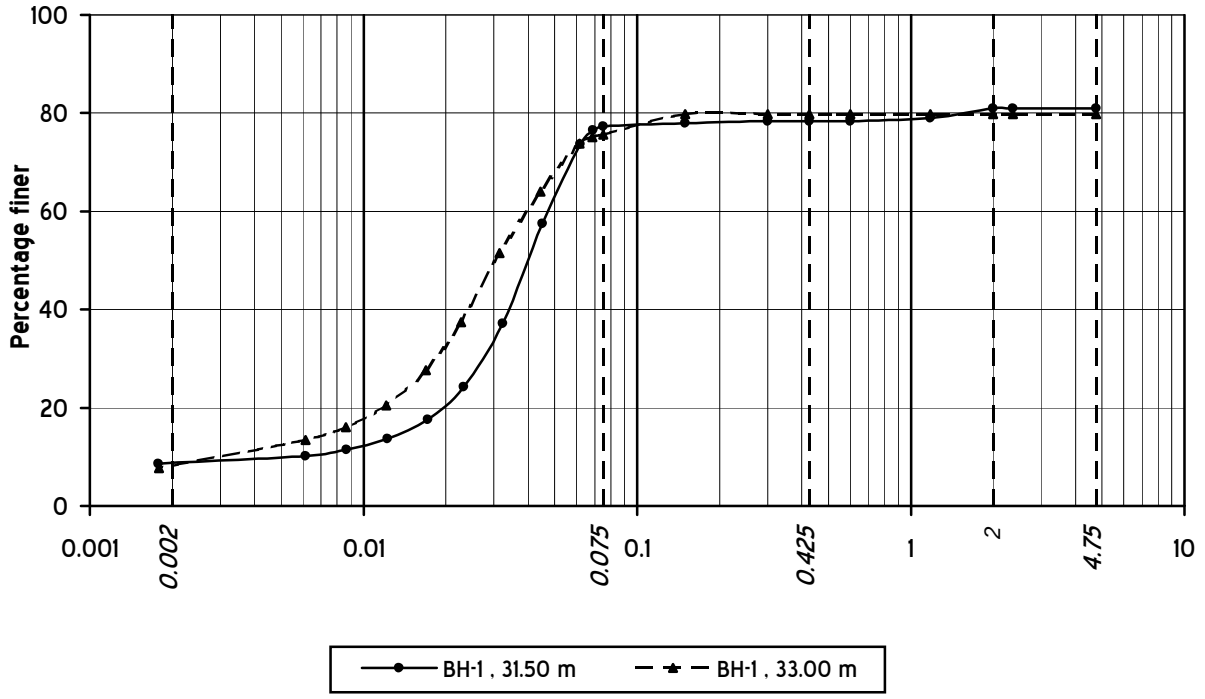
Grain size (mm) / Sample No.	*< 0.002* Clay (%)	*0.002-0.075* Silt (%)	*0.075-0.425* Fine sand (%)	*0.425-2.0* Medium sand (%)	*2.0-4.75* Coarse sand (%)	*> 4.75* Gravel (%)
BH-1 , 22.50 m	13.3	71.4	7.0	0.0	0.0	8.3
BH-1 , 24.00 m	18.0	78.9	3.1	0.0	0.0	0.0



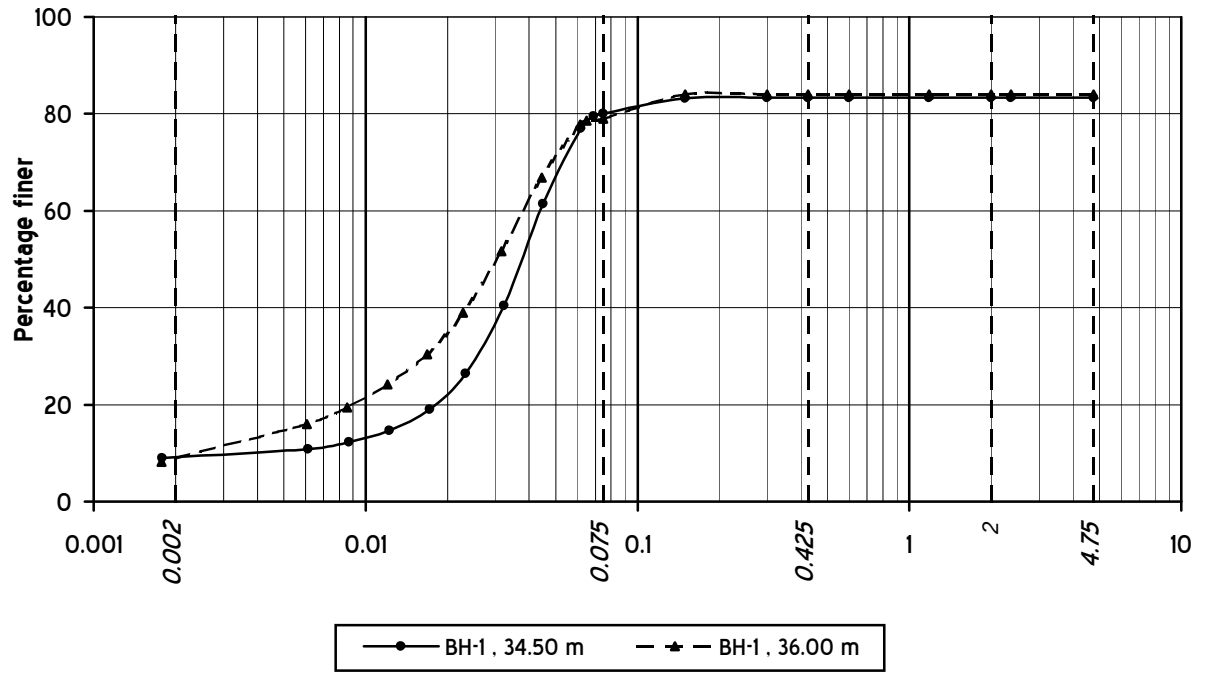
Grain size (mm) / Sample No.	*< 0.002* Clay (%)	*0.002-0.075* Silt (%)	*0.075-0.425* Fine sand (%)	*0.425-2.0* Medium sand (%)	*2.0-4.75* Coarse sand (%)	*> 4.75* Gravel (%)
BH-1 , 28.50 m	7.9	66.9	3.8	0.0	0.0	21.4
BH-1 , 30.00 m	8.4	66.8	5.4	0.0	0.0	19.4

Project:G.I. works for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1	Job No. 2015258J	Fig. No. 8

GRAIN SIZE DISTRIBUTION CURVES

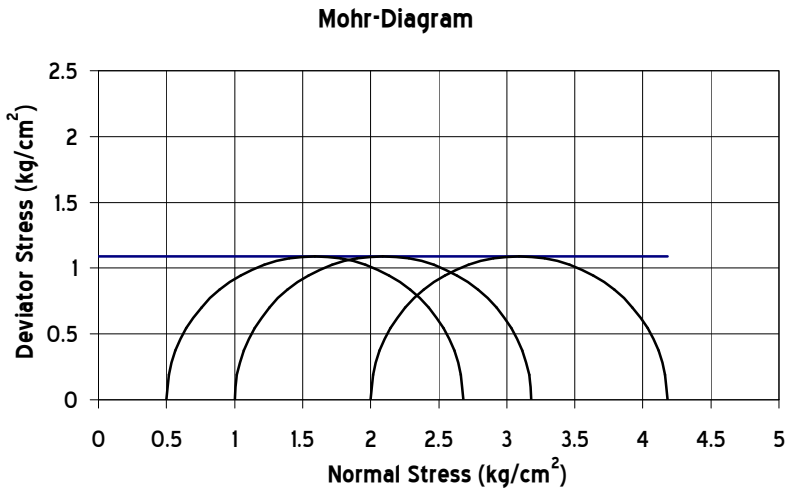


Grain size (mm) / Sample No.	*< 0.002* Clay (%)	*0.002-0.075* Silt (%)	*0.075-0.425* Fine sand (%)	*0.425-2.0* Medium sand (%)	*2.0-4.75* Coarse sand (%)	*> 4.75* Gravel (%)
BH-1 , 31.50 m	8.7	68.6	1.1	2.5	0.0	19.1
BH-1 , 33.00 m	8.2	67.4	4.2	0.0	0.0	20.2

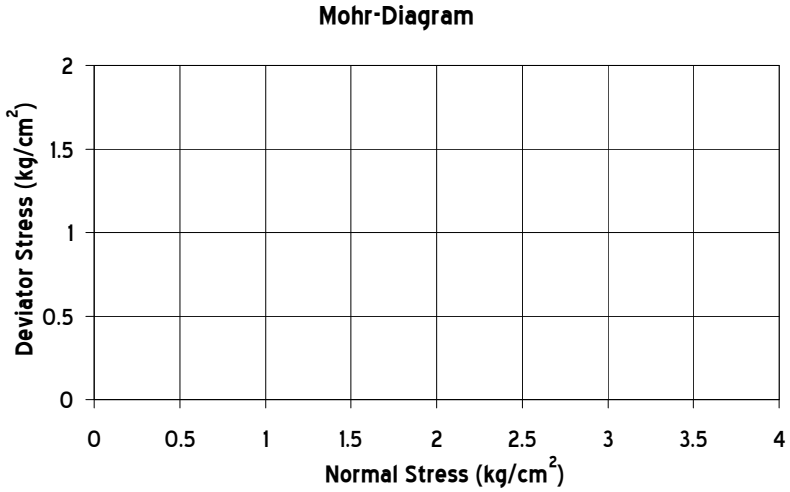


Grain size (mm) / Sample No.	*< 0.002* Clay (%)	*0.002-0.075* Silt (%)	*0.075-0.425* Fine sand (%)	*0.425-2.0* Medium sand (%)	*2.0-4.75* Coarse sand (%)	*> 4.75* Gravel (%)
BH-1 , 34.50 m	9.2	70.9	3.2	0.0	0.0	16.7
BH-1 , 36.00 m	8.9	70.1	5.0	0.0	0.0	16.0

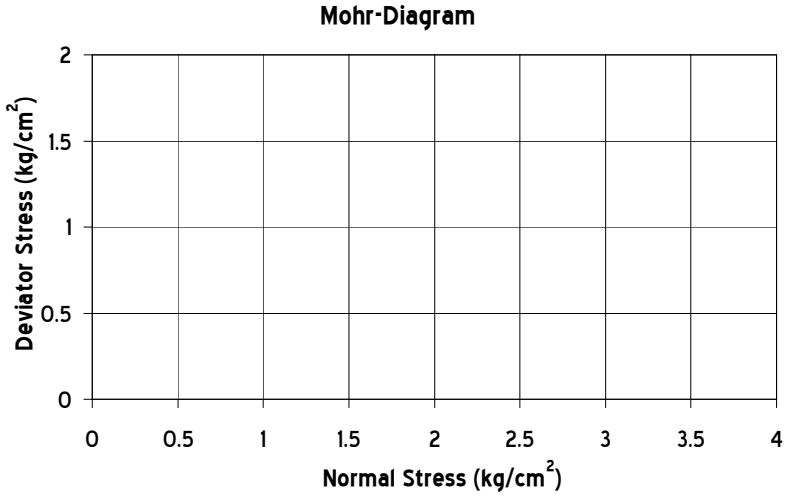
Project:G.I. works for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1	Job No. 2015258J	Fig. No. 9



BH No.:	BH-1		c : 1.09 kg/sq. cm
Depth:	3.00m	Test Type: UU	ϕ : 0 degree



BH No.:			c :
Depth:		Test Type:	ϕ :



BH No.:			c :
Depth:		Test Type:	ϕ :

Geotechnical Investigations for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1	**Job No.**	**Fig. No.**
	2015258J	10

FARGO CONSULTANTS PVT. LTD.

LABORATORY TEST RESULTS

Project Name & Bore Hole No.	Layer ID	Depth (m)	Sample Type	'N' value	Corrected "N" Value	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Natural Moisture Content (%)	Bulk Density (gm/cc)	Dry density (gm/cc)	Liquid Limit(%)	Plastic Limit (%)	Plasticity Index (%)	Type of Test	Cohesion (kg/cm^2)	Angle of Friction (degree)	Sp.Gravity	e_0	P_0 (kg/cm^2)	P_c (kg/cm^2)	C_c	C_r
G.I. works for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1 Location:National water way at Sahibganj in Jharkhand , BH - 2	I	1.50	U	-	-	0.0	6.1	68.5	25.4	23.4	1.820	1.475	34.6	16.4	18.2	UU	0.75	0.5	-	-	-	-	-	-
		3.00	P	12	-	28.2	31.3	35.0	5.5	-	-	-	21.3	17.5	3.8	-	-	-	-	-	-	-	-	-
		4.50	P	13	-	32.9	23.0	36.6	7.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		6.00	P	17	-	0.0	3.0	87.2	9.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	II	7.50	U	-	-	0.0	3.0	90.4	6.6	23.7	1.951	1.577	32.8	23.6	9.2	UU	1.53	0.0	-	-	-	-	-	-
		9.00	P	32	-	0.0	2.9	91.0	6.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10.50	P	52	-	0.0	3.8	90.1	6.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	III	12.00	P	28	-	0.8	3.9	85.1	10.2	-	-	-	29.0	15.7	13.3	-	-	-	-	-	-	-	-	-
		13.50	P	29	-	23.9	13.9	54.6	7.6	-	-	-	27.6	15.6	12.0	-	-	-	-	-	-	-	-	-
	iV	15.00	P	38	-	23.7	13.2	55.1	8.0	-	-	-	26.5	16.5	10.0	-	-	-	-	-	-	-	-	-
		16.50	P	42	-	0.0	3.9	81.4	14.7	-	-	-	28.3	16.0	12.3	-	-	-	-	-	-	-	-	-
		18.00	P	55	-	0.0	3.4	81.4	15.2	-	-	-	27.4	15.5	11.9	-	-	-	-	-	-	-	-	-
		19.50	P	62	-	0.0	4.6	79.6	15.8	-	-	-	31.0	14.7	16.3	-	-	-	-	-	-	-	-	-
		21.00	P	73	-	0.0	3.9	80.1	16.0	-	-	-	30.5	14.4	16.1	-	-	-	-	-	-	-	-	-
	V	22.50	P	68	-	28.4	7.9	57.4	6.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		24.00	P	78	-	33.3	10.8	50.3	5.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		25.50	P	56	-	4.5	3.9	71.0	20.6	-	-	-	40.6	16.5	24.1	-	-	-	-	-	-	-	-	-
		27.00	P	64	-	2.4	5.7	69.3	22.6	-	-	-	38.4	16.6	21.8	-	-	-	-	-	-	-	-	-
		28.50	P	50	-	10.7	4.6	71.4	13.3	-	-	-	32.3	14.2	18.1	-	-	-	-	-	-	-	-	-
		30.00	P	51	-	11.1	6.9	70.7	11.3	-	-	-	35.3	15.8	19.5	-	-	-	-	-	-	-	-	-
		31.50	P	42	-	5.2	13.2	81.6*		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		33.00	P	47	-	14.9	10.5	62.2	12.4	-	-	-	52.8	38.6	14.2	-	-	-	-	-	-	-	-	-
		34.50	P	54	-	15.4	10.6	62.6	11.4	-	-	-	59.3	38.7	20.6	-	-	-	-	-	-	-	-	-
		36.00	P	61	-	9.2	5.6	71.0	14.2	-	-	-	62.0	41.6	20.4	-	-	-	-	-	-	-	-	-

Note :

1. U-Undisturbed Sample
2. D-Disturbed Sample
3. P-Standard Penetration Test
4. UU : Unconsolidated Undrained Triaxial Test
5. UC : Unconfined Compression Test
6. CU : Consolidated Un-drained Test
7. CD : Consolidated Drained Test
8. DS : Direct Shear Test
9. * Combined % of Silt & Clay.

Sheet No.: D-9

FARGO CONSULTANTS PVT. LTD.

LABORATORY TEST RESULTS

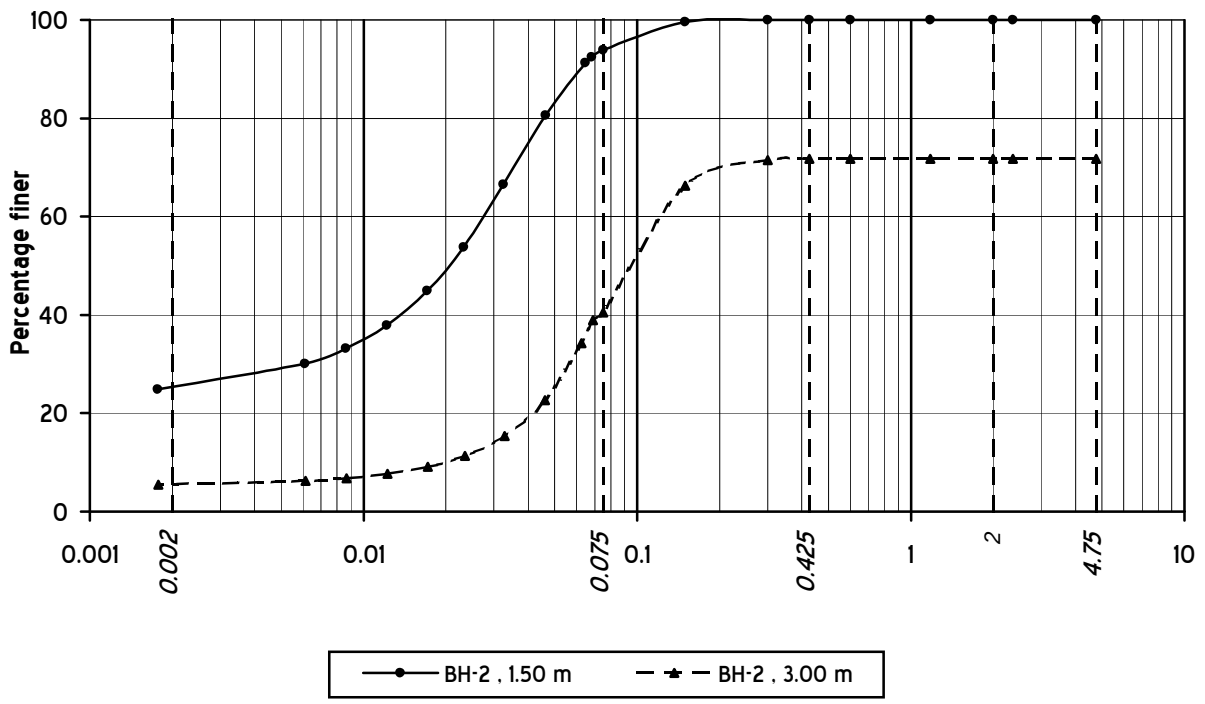
Project Name & Bore Hole No.	Layer ID	Depth (m)	Sample Type	'N' value	Corrected "N" Value	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Natural Moisture Content (%)	Bulk Density (gm/cc)	Dry density (gm/cc)	Liquid Limit(%)	Plastic Limit (%)	Plasticity Index (%)	Type of Test	Cohesion (kg/cm^2)	Angle of Friction (degree)	Sp.Gravity	e_0	P_0 (kg/cm^2)	P_c (kg/cm^2)	C_c	C_r
G.I. works for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1 Location:National water way at Sahibganj in Jharkhand , BH - 2	V	37.50	P	56	-	10.5	6.1	68.8	14.6	-	-	-	58.2	41.1	17.1	-	-	-	-	-	-	-	-	-
		39.00	P	>100	-	25.8	13.5	60.7*		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		40.00	P	>100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		41.00	P	>100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		42.00	P	>100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		43.00	P	>100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		44.00	P	>100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		45.00	P	>100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Note :

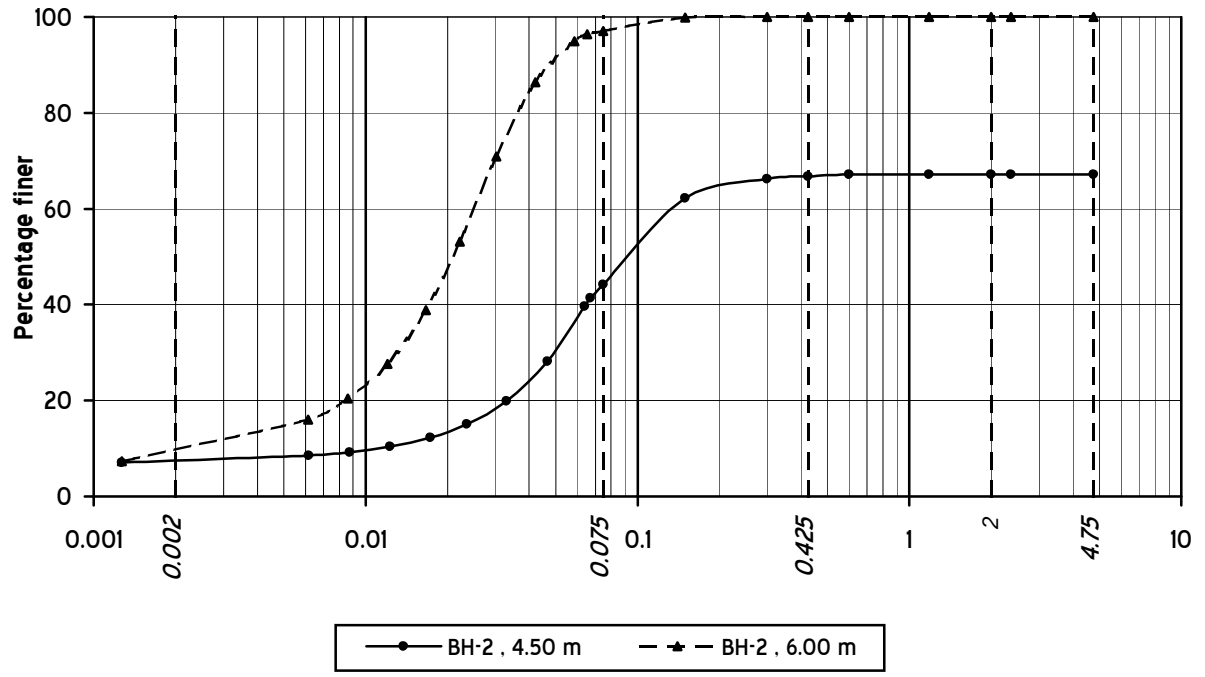
1. U-Undisturbed Sample
2. D-Disturbed Sample
3. P-Standard Penetration Test
4. UU : Unconsolidated Undrained Triaxial Test
5. UC : Unconfined Compression Test
6. CU : Consolidated Un-drained Test
7. CD : Consolidated Drained Test
8. DS : Direct Shear Test
9. * Combined % of Silt & Clay.

Sheet No.: D-10

GRAIN SIZE DISTRIBUTION CURVES



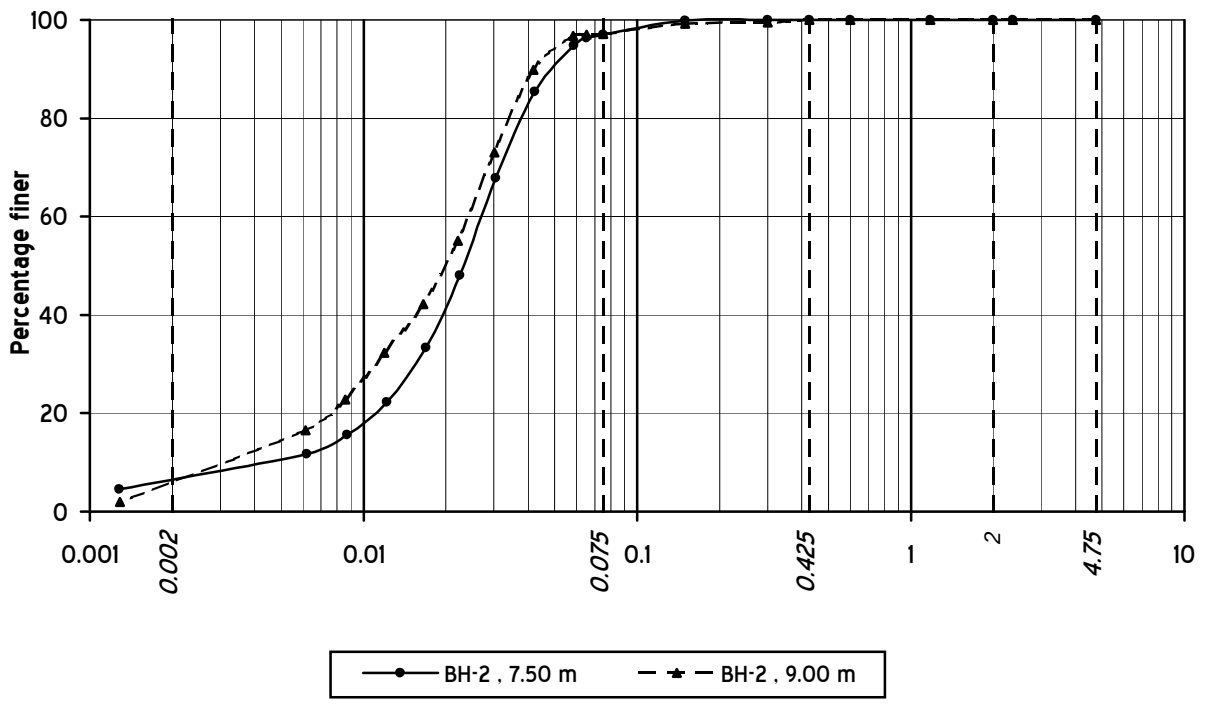
Grain size (mm) / Sample No.	*< 0.002* Clay (%)	*0.002-0.075* Silt (%)	*0.075-0.425* Fine sand (%)	*0.425-2.0* Medium sand (%)	*2.0-4.75* Coarse sand (%)	*> 4.75* Gravel (%)
BH-2 , 1.50 m	25.4	68.5	6.1	0.0	0.0	0.0
BH-2 , 3.00 m	5.5	35.0	31.3	0.0	0.0	28.2



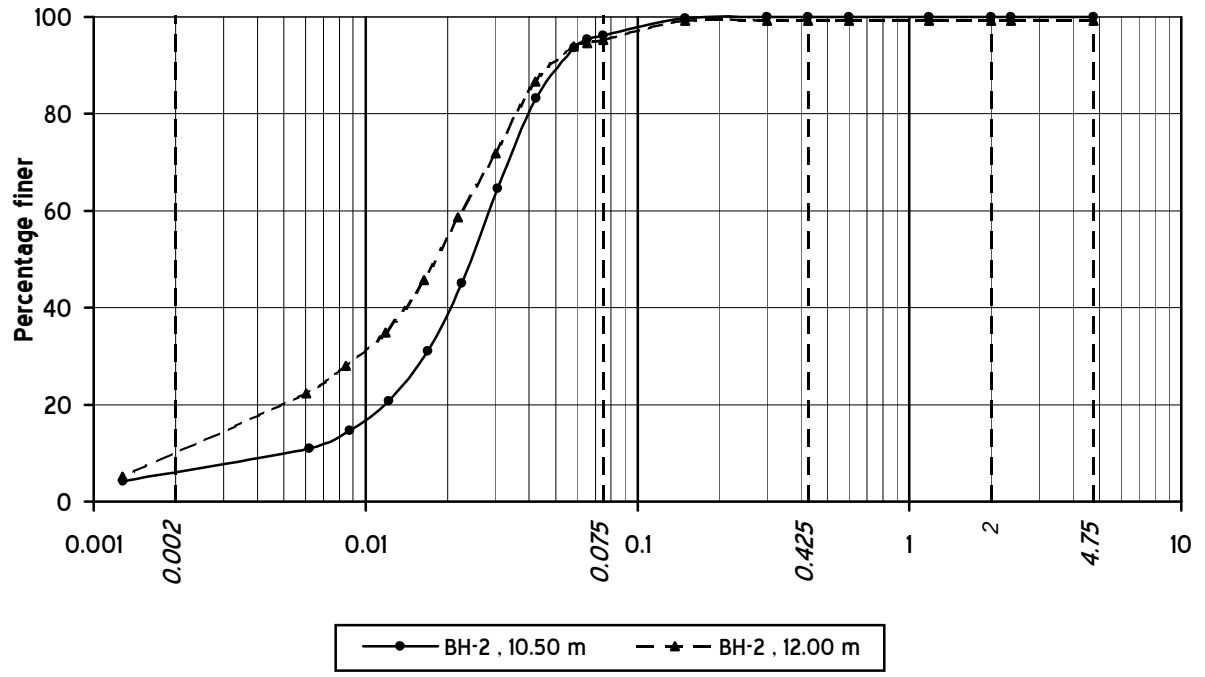
Grain size (mm) / Sample No.	*< 0.002* Clay (%)	*0.002-0.075* Silt (%)	*0.075-0.425* Fine sand (%)	*0.425-2.0* Medium sand (%)	*2.0-4.75* Coarse sand (%)	*> 4.75* Gravel (%)
BH-2 , 4.50 m	7.5	36.6	22.7	0.3	0.0	32.9
BH-2 , 6.00 m	9.8	87.2	3.0	0.0	0.0	0.0

Project:G.I. works for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1	Job No. 2015258J	Fig. No. 11

GRAIN SIZE DISTRIBUTION CURVES



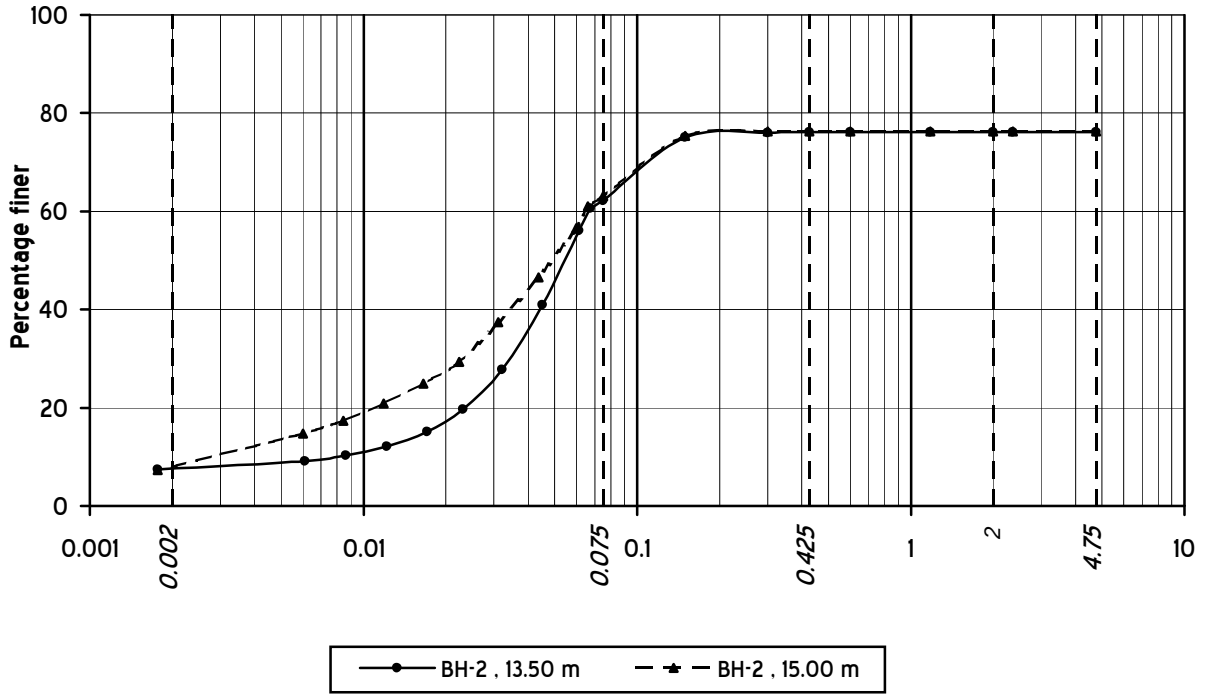
Grain size (mm) / Sample No.	< 0.002 Clay (%)	0.002-0.075 Silt (%)	0.075-0.425 Fine sand (%)	0.425-2.0 Medium sand (%)	2.0-4.75 Coarse sand (%)	> 4.75 Gravel (%)
BH-2 , 7.50 m	6.6	90.4	3.0	0.0	0.0	0.0
BH-2 , 9.00 m	6.1	91.0	2.9	0.0	0.0	0.0



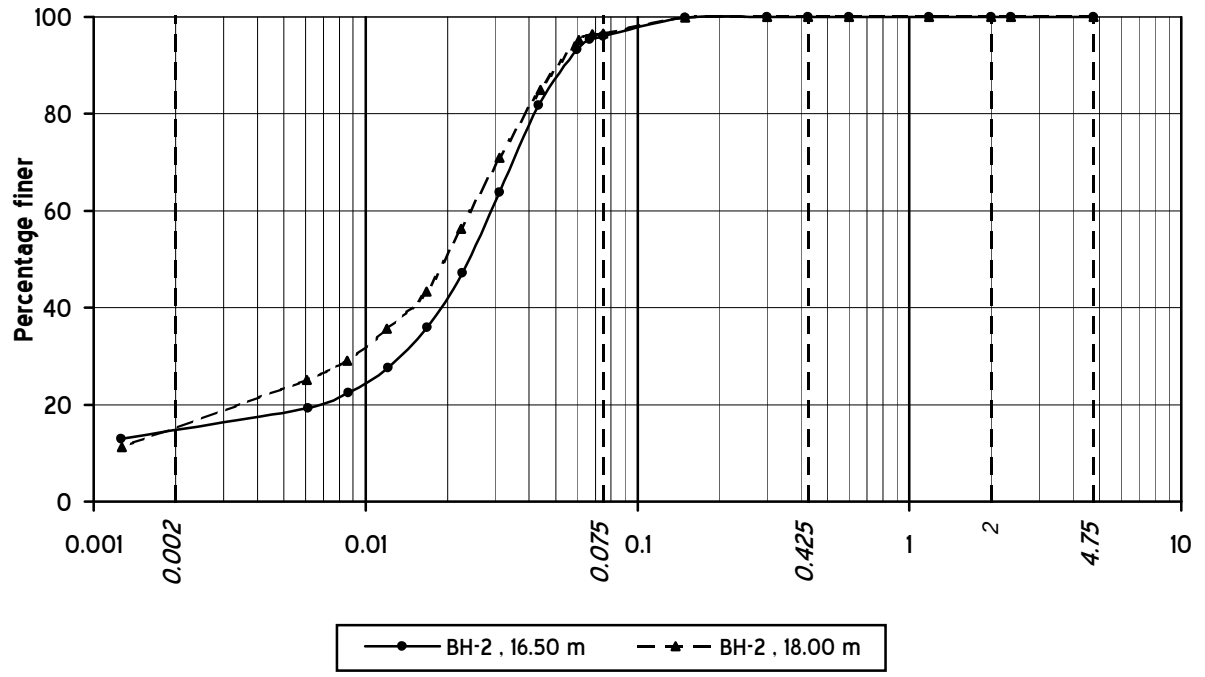
Grain size (mm) / Sample No.	< 0.002 Clay (%)	0.002-0.075 Silt (%)	0.075-0.425 Fine sand (%)	0.425-2.0 Medium sand (%)	2.0-4.75 Coarse sand (%)	> 4.75 Gravel (%)
BH-2 , 10.50 m	6.1	90.1	3.8	0.0	0.0	0.0
BH-2 , 12.00 m	10.2	85.1	3.9	0.0	0.0	0.8

Project:G.I. works for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1	Job No. 2015258J	Fig. No. 12

GRAIN SIZE DISTRIBUTION CURVES



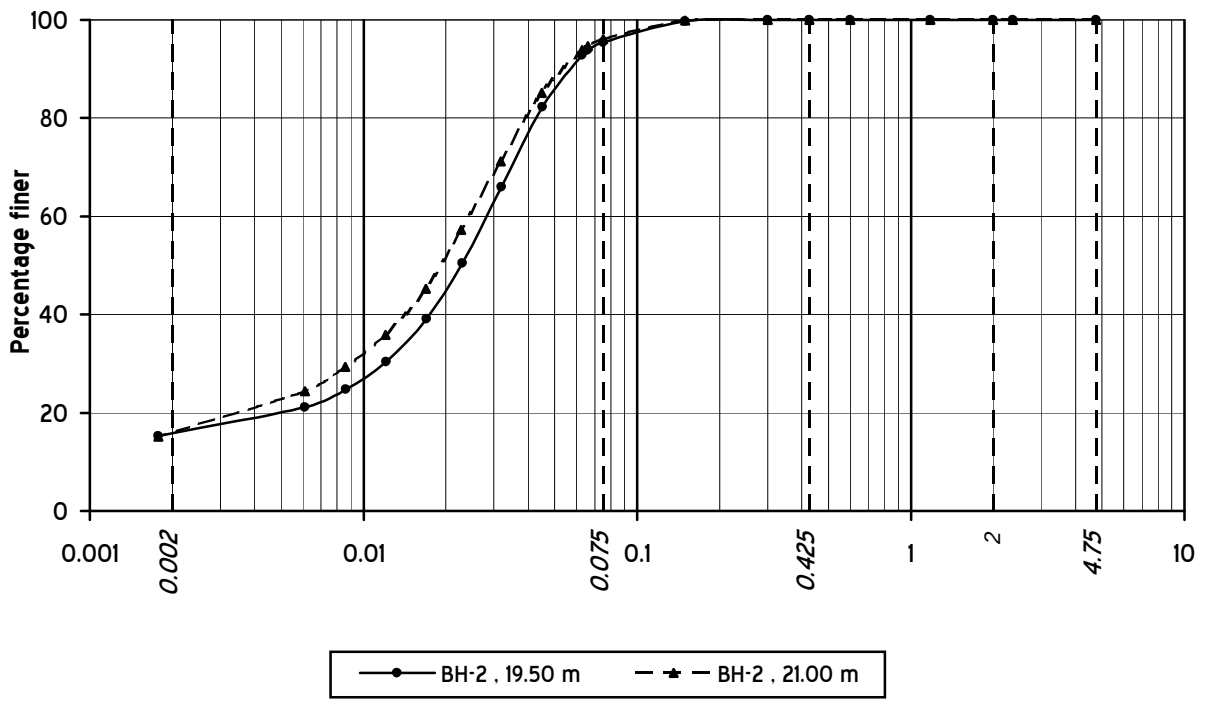
Grain size (mm) / Sample No.	*< 0.002* Clay (%)	*0.002-0.075* Silt (%)	*0.075-0.425* Fine sand (%)	*0.425-2.0* Medium sand (%)	*2.0-4.75* Coarse sand (%)	*> 4.75* Gravel (%)
BH-2 , 13.50 m	7.6	54.6	13.9	0.0	0.0	23.9
BH-2 , 15.00 m	8.0	55.1	13.2	0.0	0.0	23.7



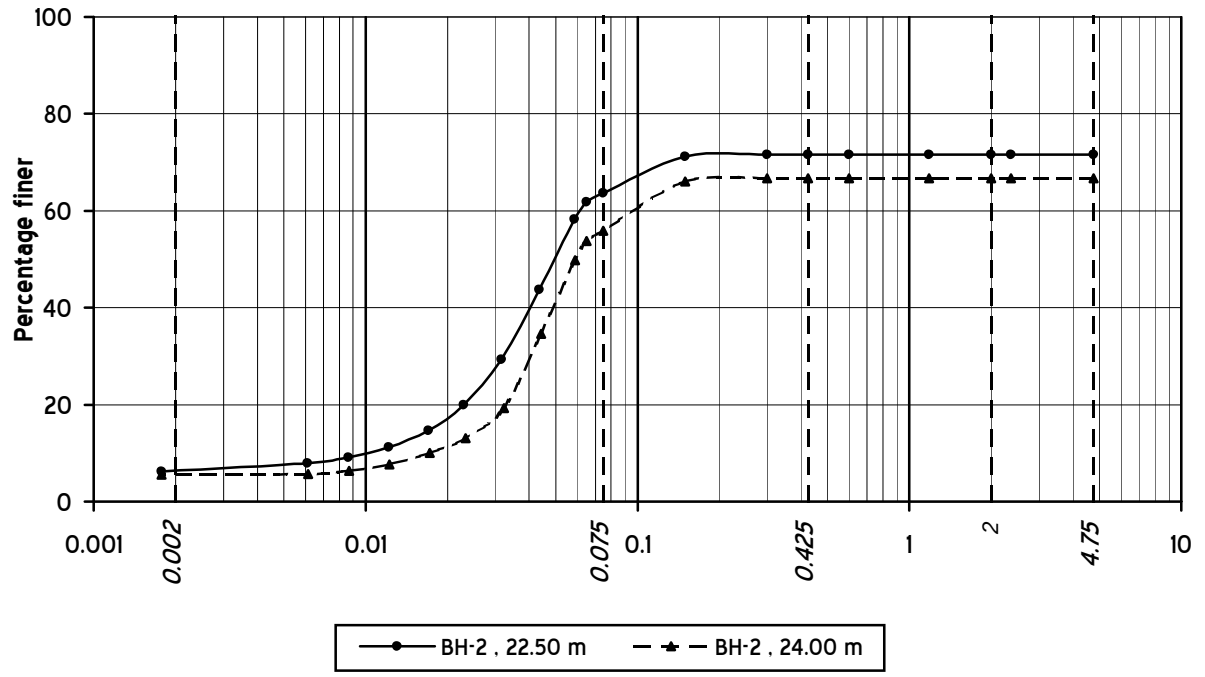
Grain size (mm) / Sample No.	*< 0.002* Clay (%)	*0.002-0.075* Silt (%)	*0.075-0.425* Fine sand (%)	*0.425-2.0* Medium sand (%)	*2.0-4.75* Coarse sand (%)	*> 4.75* Gravel (%)
BH-2 , 16.50 m	14.7	81.4	3.9	0.0	0.0	0.0
BH-2 , 18.00 m	15.2	81.4	3.4	0.0	0.0	0.0

Project:G.I. works for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1	Job No. 2015258J	Fig. No 13

GRAIN SIZE DISTRIBUTION CURVES



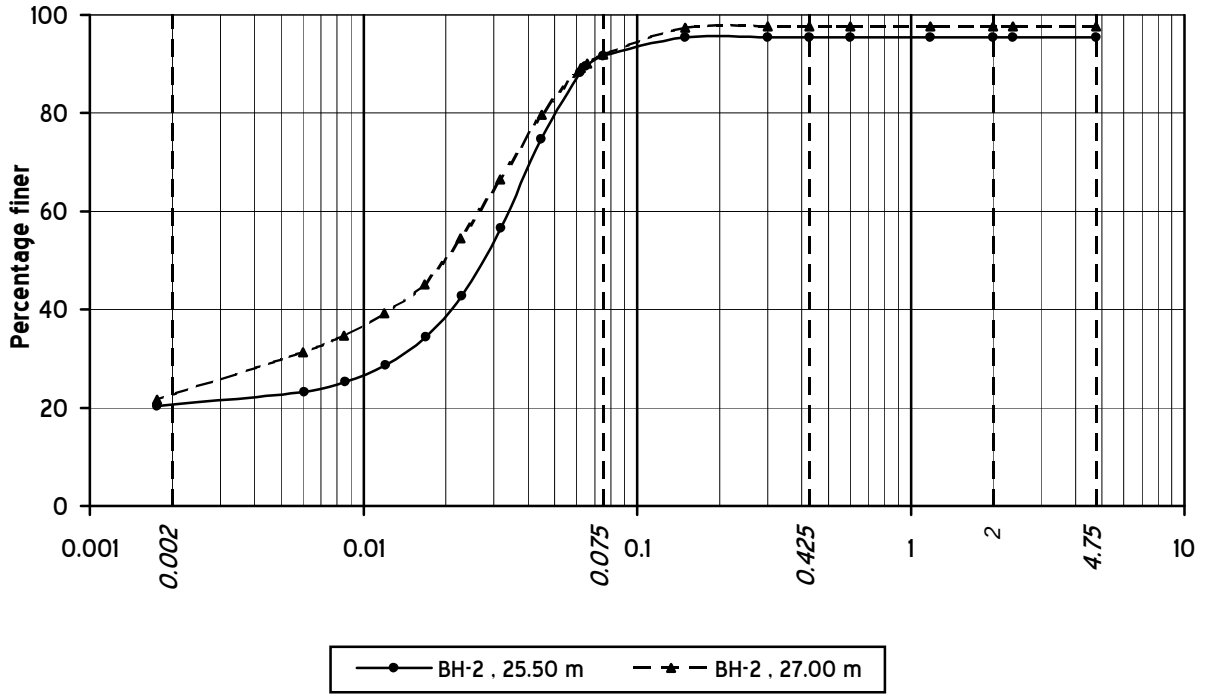
Grain size (mm) / Sample No.	*< 0.002* Clay (%)	*0.002-0.075* Silt (%)	*0.075-0.425* Fine sand (%)	*0.425-2.0* Medium sand (%)	*2.0-4.75* Coarse sand (%)	*> 4.75* Gravel (%)
BH-2 , 19.50 m	15.8	79.6	4.6	0.0	0.0	0.0
BH-2 , 21.00 m	16.0	80.1	3.9	0.0	0.0	0.0



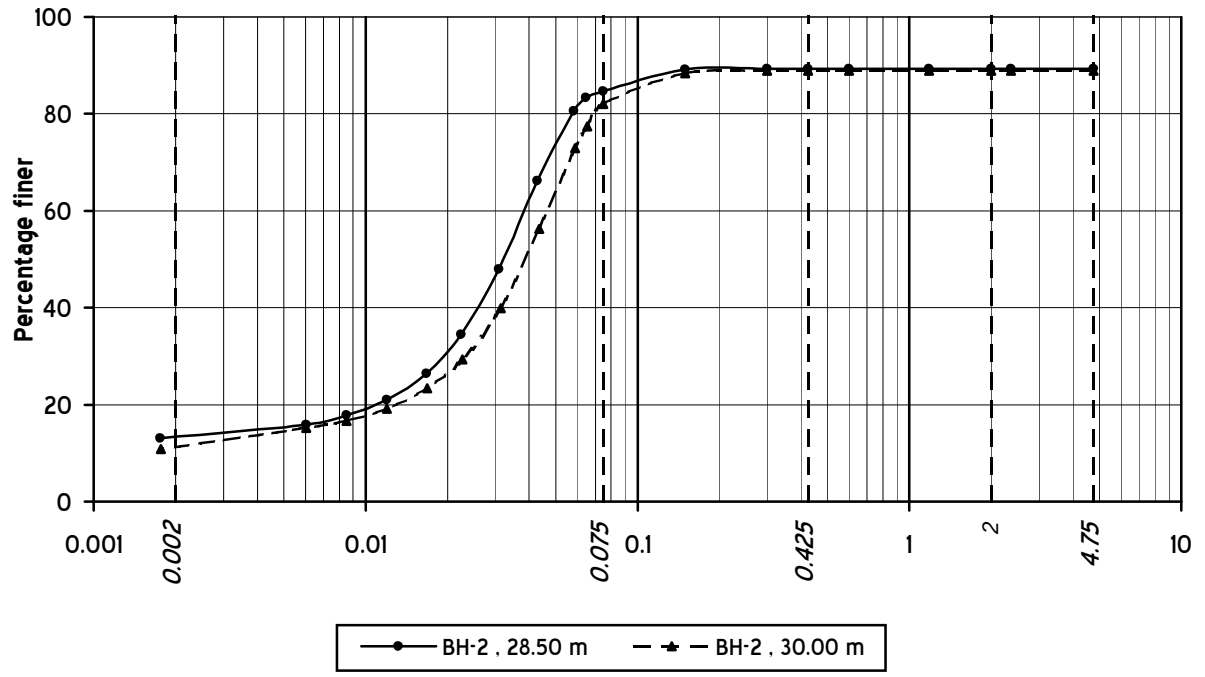
Grain size (mm) / Sample No.	*< 0.002* Clay (%)	*0.002-0.075* Silt (%)	*0.075-0.425* Fine sand (%)	*0.425-2.0* Medium sand (%)	*2.0-4.75* Coarse sand (%)	*> 4.75* Gravel (%)
BH-2 , 22.50 m	6.3	57.4	7.9	0.0	0.0	28.4
BH-2 , 24.00 m	5.6	50.3	10.8	0.0	0.0	33.3

Project:G.I. works for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1	Job No. 2015258J	Fig. No. 14

GRAIN SIZE DISTRIBUTION CURVES



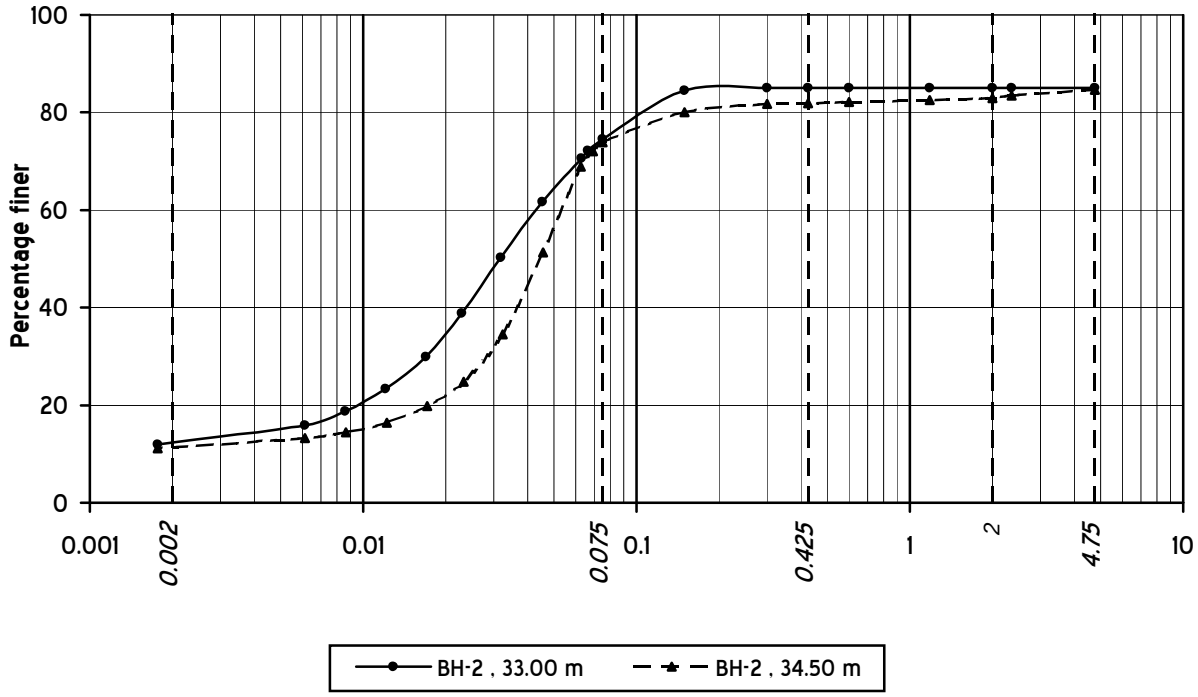
Grain size (mm) / Sample No.	*< 0.002* Clay (%)	*0.002-0.075* Silt (%)	*0.075-0.425* Fine sand (%)	*0.425-2.0* Medium sand (%)	*2.0-4.75* Coarse sand (%)	*> 4.75* Gravel (%)
BH-2 , 25.50 m	20.6	71.0	3.9	0.0	0.0	4.5
BH-2 , 27.00 m	22.6	69.3	5.7	0.0	0.0	2.4



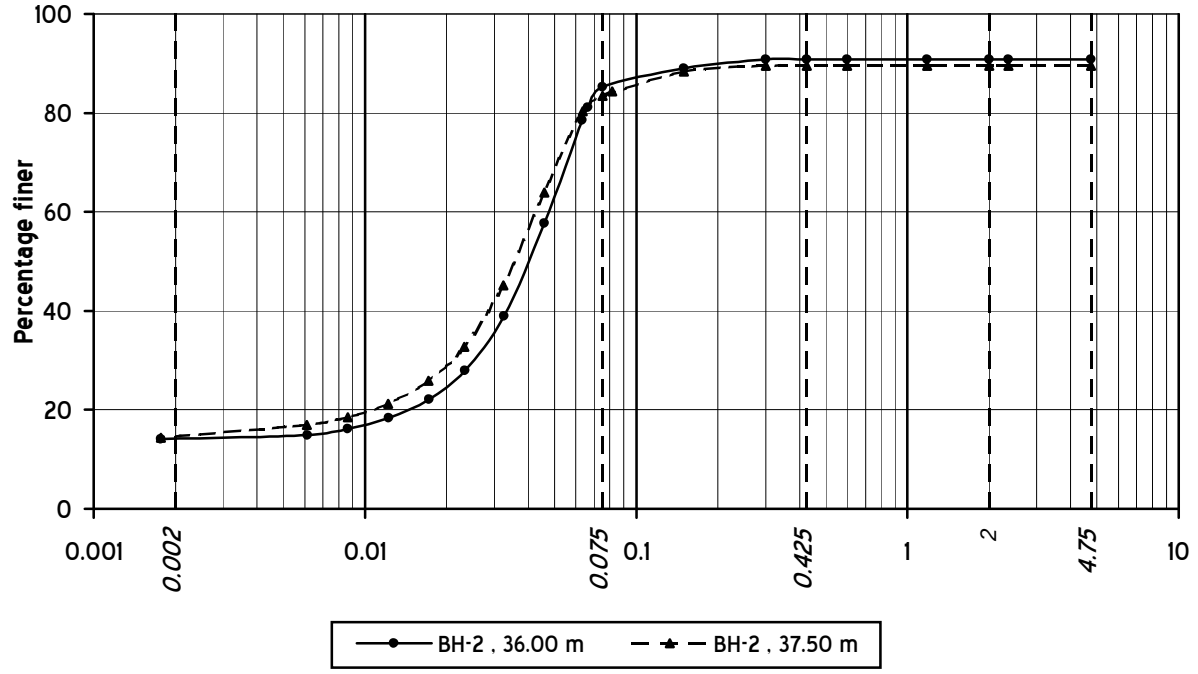
Grain size (mm) / Sample No.	*< 0.002* Clay (%)	*0.002-0.075* Silt (%)	*0.075-0.425* Fine sand (%)	*0.425-2.0* Medium sand (%)	*2.0-4.75* Coarse sand (%)	*> 4.75* Gravel (%)
BH-2 , 28.50 m	13.3	71.4	4.6	0.0	0.0	10.7
BH-2 , 30.00 m	11.3	70.7	6.9	0.0	0.0	11.1

Project:G.I. works for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1	Job No. 2015258J	Fig. No. 15

GRAIN SIZE DISTRIBUTION CURVES

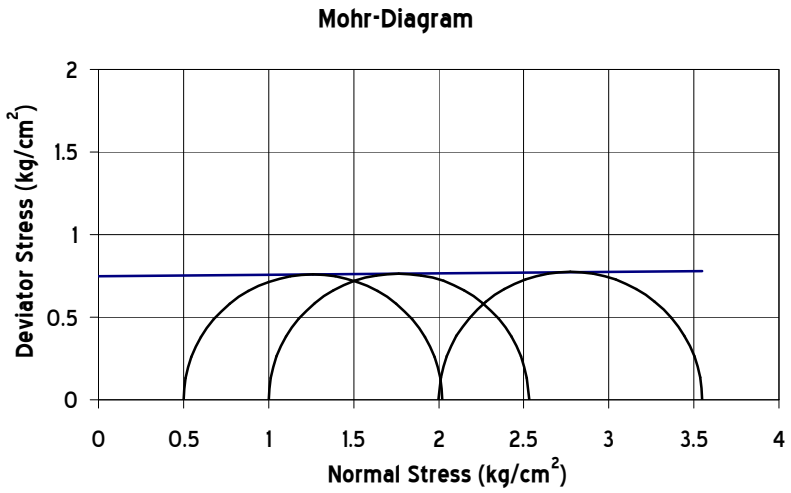


Grain size (mm) / Sample No.	< 0.002 Clay (%)	0.002-0.075 Silt (%)	0.075-0.425 Fine sand (%)	0.425-2.0 Medium sand (%)	2.0-4.75 Coarse sand (%)	> 4.75 Gravel (%)
BH-2 , 33.00 m	12.4	62.2	10.5	0.0	0.0	14.9
BH-2 , 34.50 m	11.4	62.6	7.9	1.1	1.6	15.4

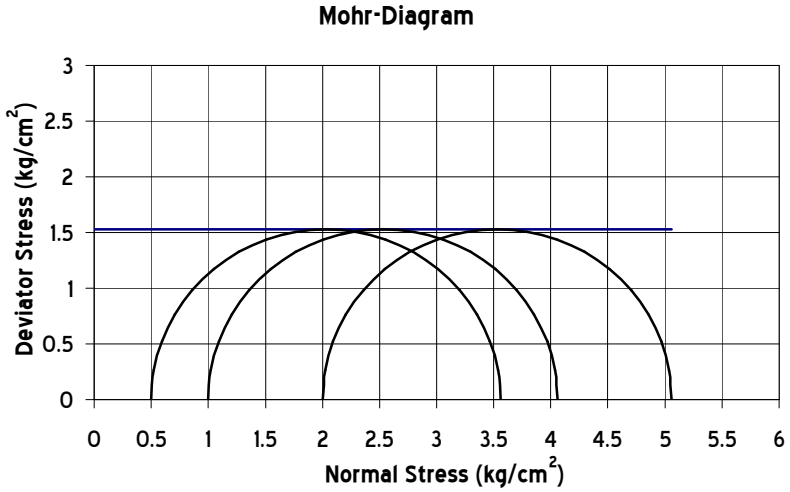


Grain size (mm) / Sample No.	< 0.002 Clay (%)	0.002-0.075 Silt (%)	0.075-0.425 Fine sand (%)	0.425-2.0 Medium sand (%)	2.0-4.75 Coarse sand (%)	> 4.75 Gravel (%)
BH-2 , 36.00 m	14.2	71.0	5.6	0.0	0.0	9.2
BH-2 , 37.50 m	14.6	68.8	6.1	0.0	0.0	10.5

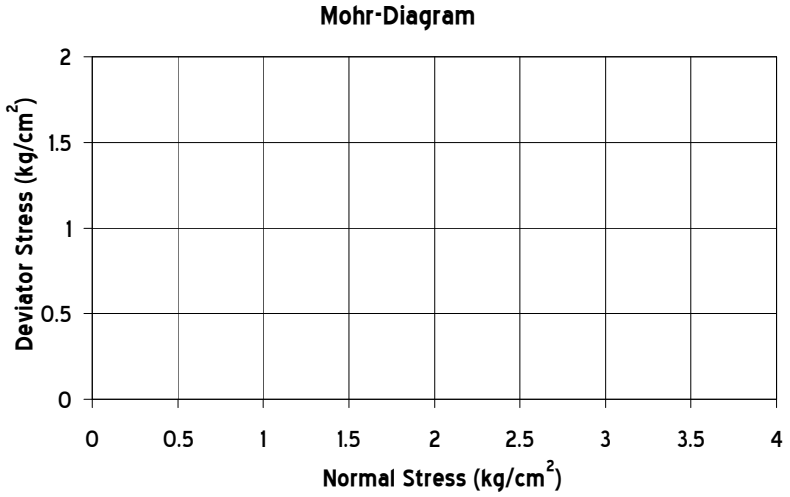
Project:G.I. works for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1	Job No. 2015258J	Fig. No. 16



BH No.:	BH-2		c : 0.75 kg/sq. cm
Depth:	+1.50 m	Test Type: UU	ϕ : 0.5 degree



BH No.:	BH-2		c : 1.53 kg/sq. cm
Depth:	+7.50 m	Test Type: UU	ϕ : 0 degree



BH No.:			c :
Depth:		Test Type:	ϕ :

Geotechnical Investigations for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1	**Job No.**	**Fig. No.**
	2015258J	17

FARGO CONSULTANTS PVT. LTD.

LABORATORY TEST RESULTS

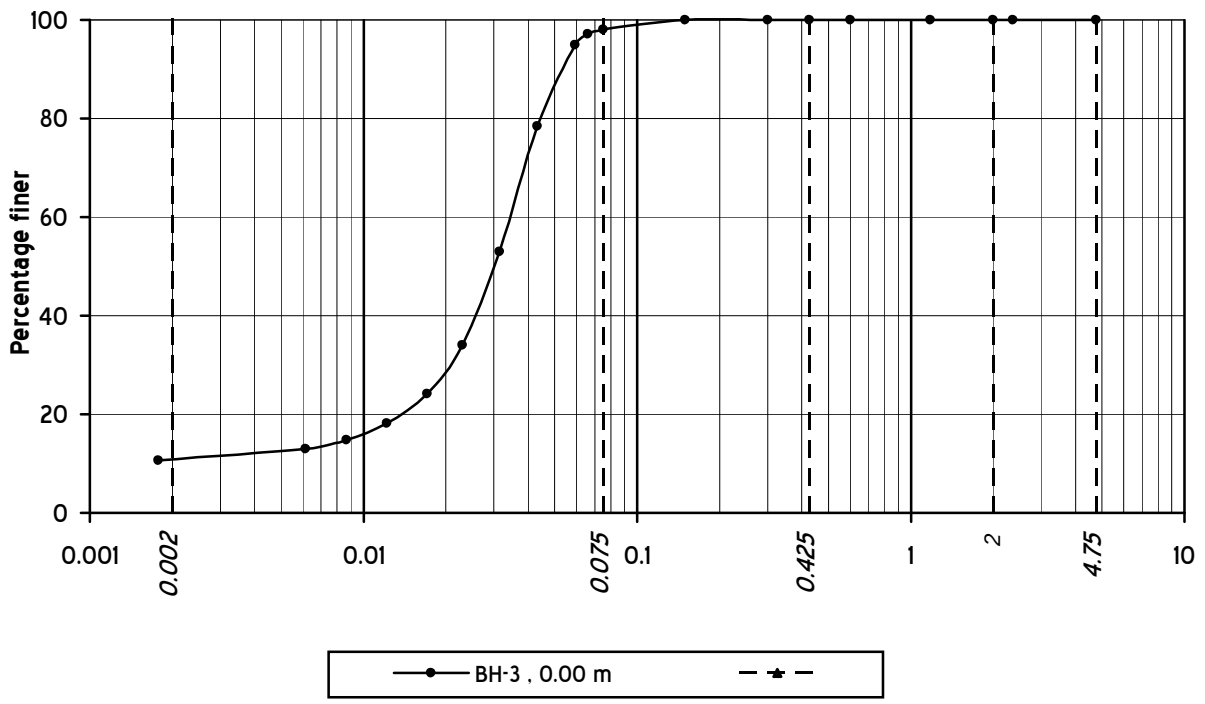
Project Name & Bore Hole No.	Layer ID	Depth (m)	Sample Type	'N' value	Corrected "N" Value	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Natural Moisture Content (%)	Bulk Density (gm/cc)	Dry density (gm/cc)	Liquid Limit(%)	Plastic Limit (%)	Plasticity Index (%)	Type of Test	Cohesion (kg/cm^2)	Angle of Friction (degree)	Sp.Gravity	e_0	P_0 (kg/cm^2)	P_c (kg/cm^2)	C_c	C_r
G.I. works for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1 Location : National water way at Sahibganj in Jharkhand , BH - 3	I	0.00	D	-	-	0.0	2.0	87.2	10.8	-	-	-	30.8	20.5	10.3	-	-	-	-	-	-	-	-	-
	II	1.50	P	4	5	0.0	78.2	21.8*		-	-	-	Non Plastic			-	-	-	-	-	-	-	-	-
		3.00	U	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4.50	P	2	2	0.0	79.9	20.1*		-	-	-	Non Plastic			-	-	-	-	-	-	-	-	-
		6.00	P	5	5	0.0	74.6	25.4*		-	-	-	Non Plastic			-	-	-	-	-	-	-	-	-
		7.50	P	5	5	0.0	68.1	31.9*		-	-	-	Non Plastic			-	-	-	-	-	-	-	-	-
		9.00	P	8	8	0.0	70.2	29.8*		-	-	-	Non Plastic			-	-	-	-	-	-	-	-	-
		10.50	P	3	3	0.0	27.0	65.8	7.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		12.00	P	3	2	0.0	71.6	28.4*		-	-	-	Non Plastic			-	-	-	-	-	-	-	-	-
	III	13.00	P	>100	>54	1.1	78.4	20.5*		-	-	-	Non Plastic			-	-	-	-	-	-	-	-	-

Note :

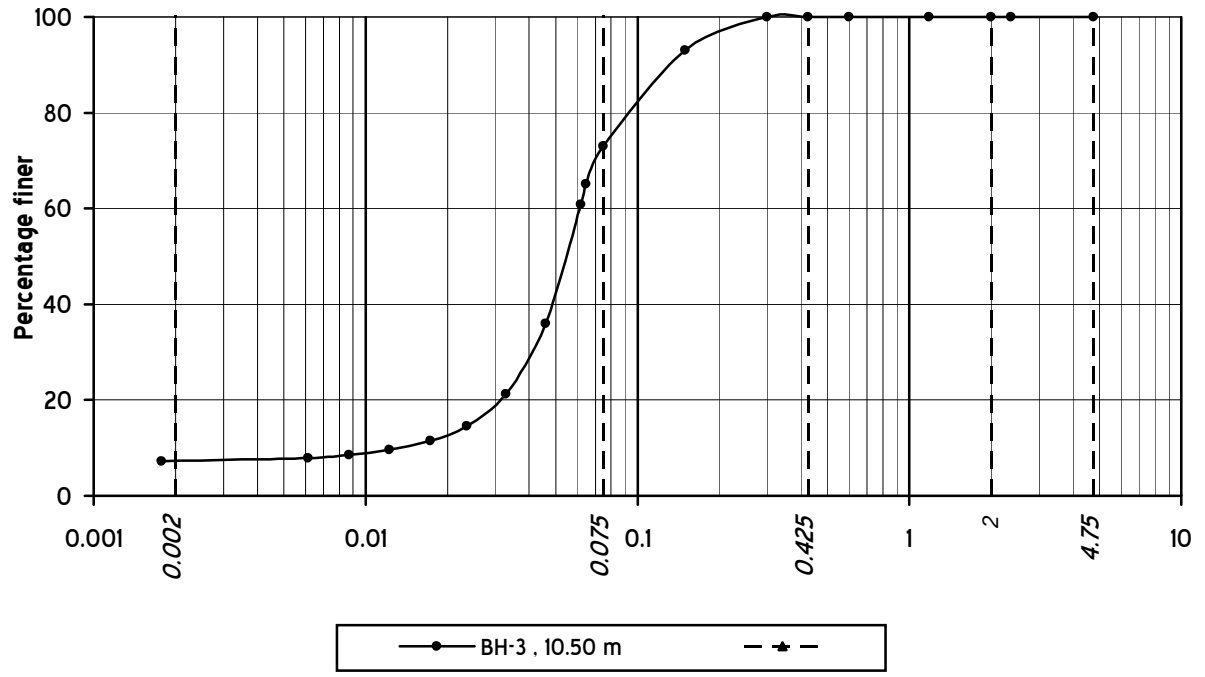
1. U-Undisturbed Sample
2. D-Disturbed Sample
3. P-Standard Penetration Test
4. UU : Unconsolidated Undrained Triaxial Test
5. UC : Unconfined Compression Test
6. CU : Consolidated Un-drained Test
7. CD : Consolidated Drained Test
8. DS : Direct Shear Test
9. * Combined % of Silt & Clay.

Sheet No.: D-18

GRAIN SIZE DISTRIBUTION CURVES



Grain size (mm) / Sample No.	< 0.002 Clay (%)	0.002-0.075 Silt (%)	0.075-0.425 Fine sand (%)	0.425-2.0 Medium sand (%)	2.0-4.75 Coarse sand (%)	> 4.75 Gravel (%)
BH-3 , 0.00 m	10.8	87.2	2.0	0.0	0.0	0.0



Grain size (mm) / Sample No.	< 0.002 Clay (%)	0.002-0.075 Silt (%)	0.075-0.425 Fine sand (%)	0.425-2.0 Medium sand (%)	2.0-4.75 Coarse sand (%)	> 4.75 Gravel (%)
BH-3 , 10.50 m	7.2	65.8	27.0	0.0	0.0	0.0

Project:G.I. works for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1	Job No. 2015258J	Fig. No. 18

FARGO CONSULTANTS PVT. LTD.

LABORATORY TEST RESULTS

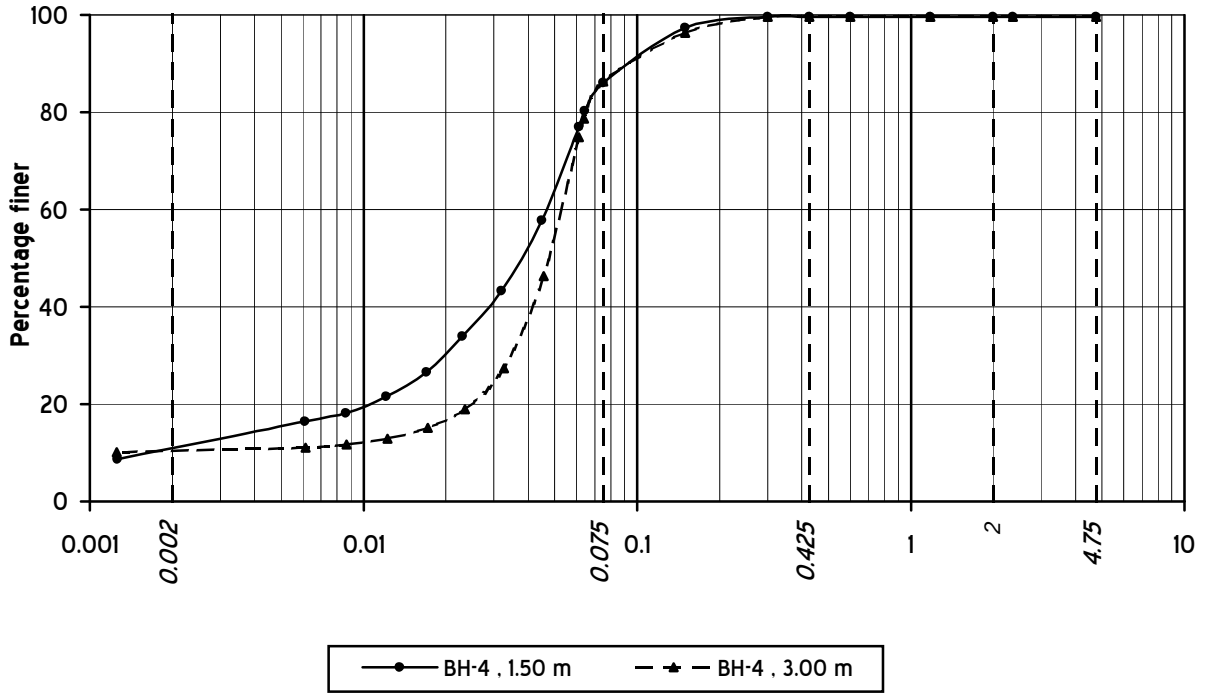
Project Name & Bore Hole No.	Layer ID	Depth (m)	Sample Type	'N' value	Corrected "N" Value	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Natural Moisture Content (%)	Bulk Density (gm/cc)	Dry density (gm/cc)	Liquid Limit(%)	Plastic Limit (%)	Plasticity Index (%)	Type of Test	Cohesion (kg/cm^2)	Angle of Friction (degree)	Sp.Gravity	e_0	P_0 (kg/cm^2)	P_c (kg/cm^2)	C_c	C_r
G.I. works for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1 Location : National water way at Sahibganj in Jharkhand , BH - 4	II	1.50	U	-	-	0.4	13.6	75.1	10.9	19.5	1.703	1.425	26.6	17.3	9.3	UU	2.40	10.0	-	-	-	-	-	-
		3.00	P	39	-	0.4	13.3	75.9	10.4	-	-	-	26.6	18.4	8.2	-	-	-	-	-	-	-	-	-
	III	4.50	P	31	-	0.0	3.8	84.6	11.6	-	-	-	29.4	19.4	10.0	-	-	-	-	-	-	-	-	-
		6.00	P	25	-	0.0	3.6	85.1	11.3	-	-	-	27.6	17.5	10.1	-	-	-	-	-	-	-	-	-
	IV	7.50	P	41	-	0.0	8.8	83.2	8.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		9.00	P	47	-	0.0	8.3	81.9	9.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		10.50	P	47	-	17.6	16.9	49.7	15.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		12.00	P	41	-	17.8	16.2	53.1	12.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		13.50	P	62	-	3.1	37.6	51.4	7.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		15.00	P	78	-	3.2	38.6	49.1	9.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		16.50	P	91	-	0.0	45.5	35.8	18.7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	VI	18.00	P	>100	>38	6.6	76.8	16.6*		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Note :

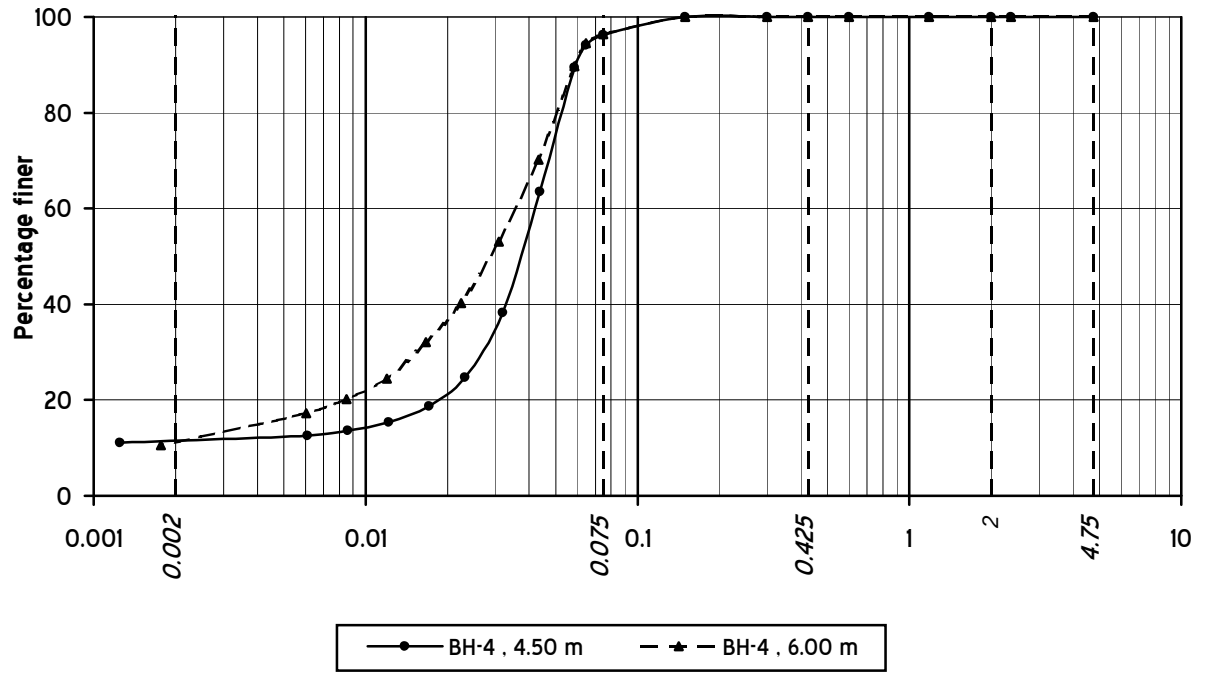
1. U-Undisturbed Sample
2. D-Disturbed Sample
3. P-Standard Penetration Test
4. UU : Unconsolidated Undrained Triaxial Test
5. UC : Unconfined Compression Test
6. CU : Consolidated Un-drained Test
7. CD : Consolidated Drained Test
8. DS : Direct Shear Test
9. * Combined % of Silt & Clay.

Sheet No.: D-20

GRAIN SIZE DISTRIBUTION CURVES



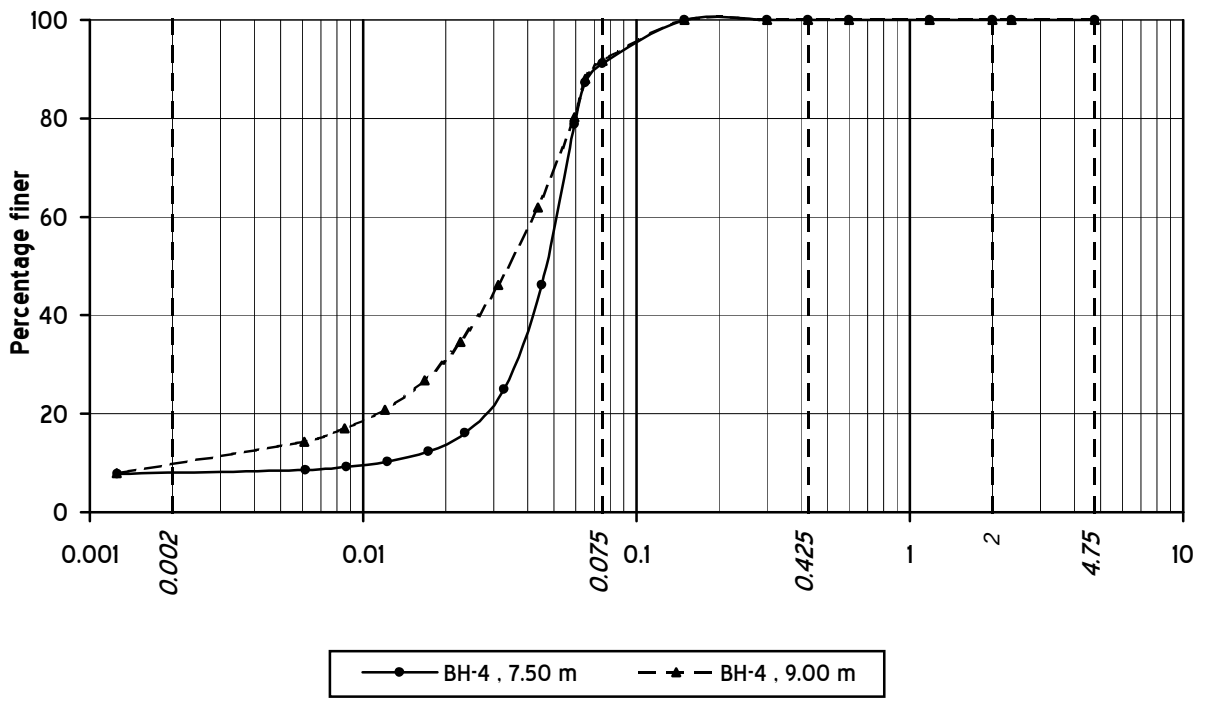
Grain size (mm) / Sample No.	*< 0.002* Clay (%)	*0.002-0.075* Silt (%)	*0.075-0.425* Fine sand (%)	*0.425-2.0* Medium sand (%)	*2.0-4.75* Coarse sand (%)	*> 4.75* Gravel (%)
BH-4 , 1.50 m	10.9	75.1	13.6	0.0	0.0	0.4
BH-4 , 3.00 m	10.4	75.9	13.3	0.0	0.0	0.4



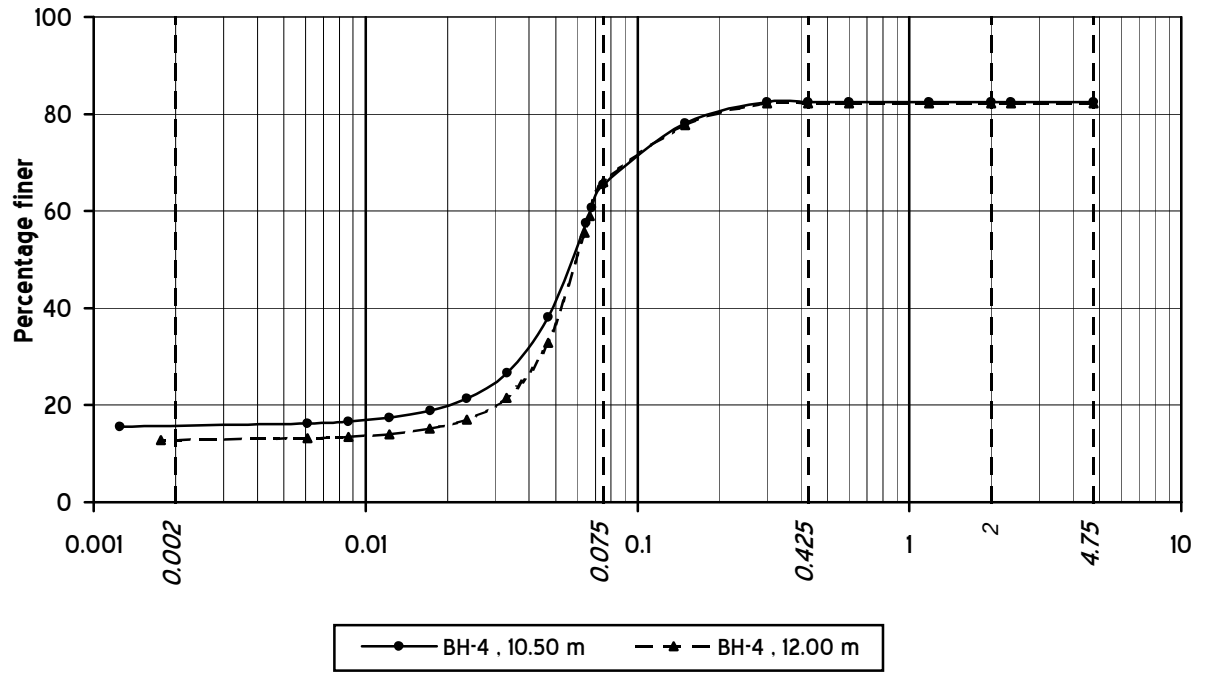
Grain size (mm) / Sample No.	*< 0.002* Clay (%)	*0.002-0.075* Silt (%)	*0.075-0.425* Fine sand (%)	*0.425-2.0* Medium sand (%)	*2.0-4.75* Coarse sand (%)	*> 4.75* Gravel (%)
BH-4 , 4.50 m	11.6	84.6	3.8	0.0	0.0	0.0
BH-4 , 6.00 m	11.3	85.1	3.6	0.0	0.0	0.0

Project:G.I. works for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1	Job No. 2015258J	Fig. No. 19

GRAIN SIZE DISTRIBUTION CURVES



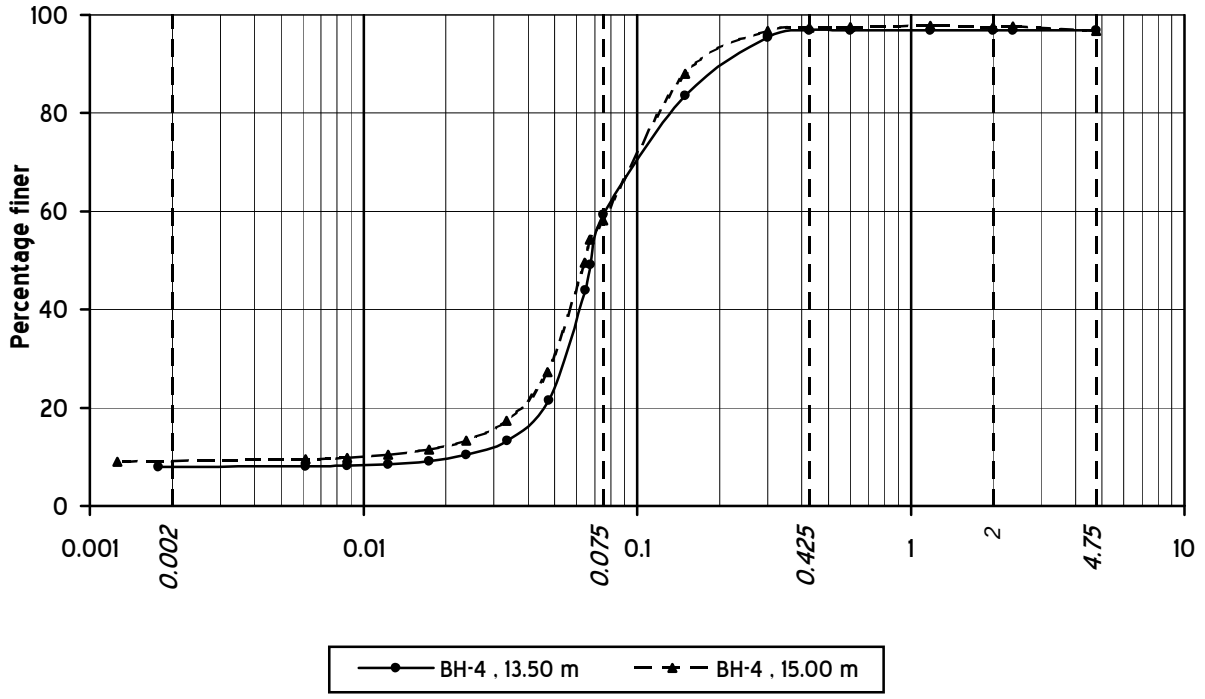
Grain size (mm) / Sample No.	*< 0.002* Clay (%)	*0.002-0.075* Silt (%)	*0.075-0.425* Fine sand (%)	*0.425-2.0* Medium sand (%)	*2.0-4.75* Coarse sand (%)	*> 4.75* Gravel (%)
BH-4 , 7.50 m	8.0	83.2	8.8	0.0	0.0	0.0
BH-4 , 9.00 m	9.8	81.9	8.3	0.0	0.0	0.0



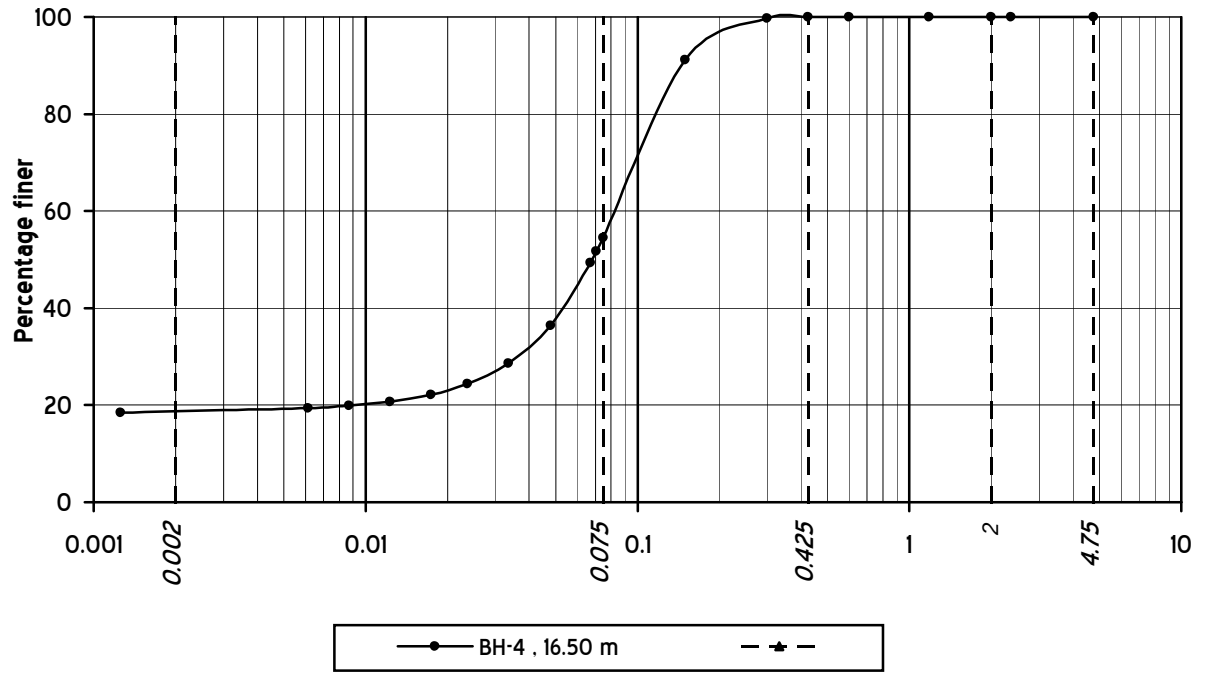
Grain size (mm) / Sample No.	*< 0.002* Clay (%)	*0.002-0.075* Silt (%)	*0.075-0.425* Fine sand (%)	*0.425-2.0* Medium sand (%)	*2.0-4.75* Coarse sand (%)	*> 4.75* Gravel (%)
BH-4 , 10.50 m	15.8	49.7	16.9	0.0	0.0	17.6
BH-4 , 12.00 m	12.9	53.1	16.2	0.0	0.0	17.8

Project:G.I. works for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1	Job No. 2015258J	Fig. No. 20

GRAIN SIZE DISTRIBUTION CURVES

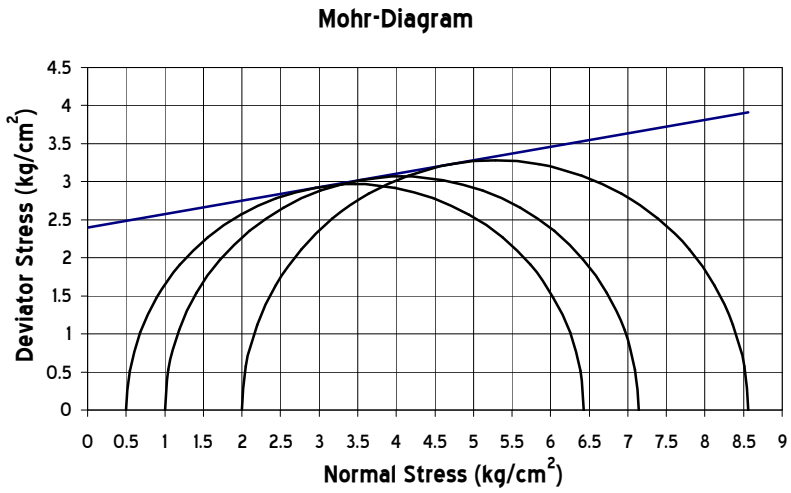


Grain size (mm) / Sample No.	< 0.002 Clay (%)	0.002-0.075 Silt (%)	0.075-0.425 Fine sand (%)	0.425-2.0 Medium sand (%)	2.0-4.75 Coarse sand (%)	> 4.75 Gravel (%)
BH-4 , 13.50 m	7.9	51.4	37.6	0.0	0.0	3.1
BH-4 , 15.00 m	9.1	49.1	39.2	0.1	-0.7	3.2

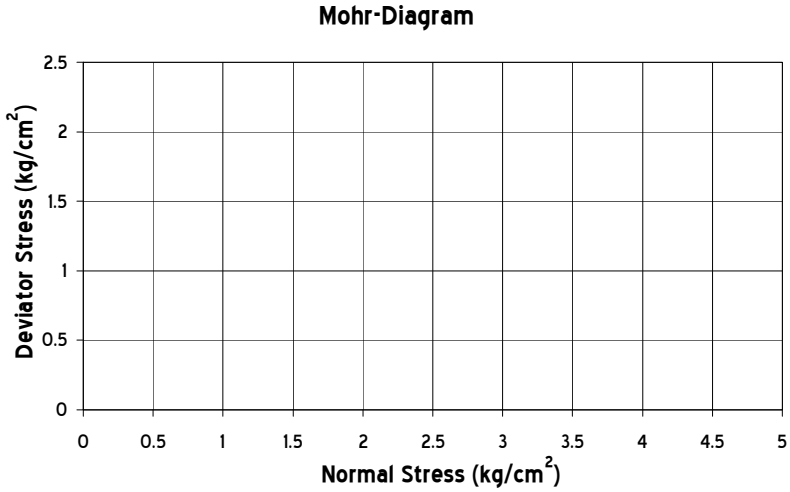


Grain size (mm) / Sample No.	< 0.002 Clay (%)	0.002-0.075 Silt (%)	0.075-0.425 Fine sand (%)	0.425-2.0 Medium sand (%)	2.0-4.75 Coarse sand (%)	> 4.75 Gravel (%)
BH-4 , 16.50 m	18.7	35.8	45.5	0.0	0.0	0.0

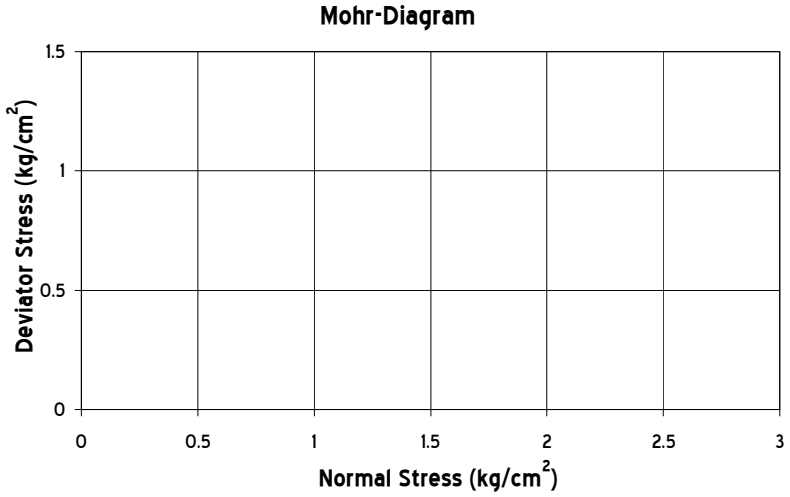
Project:G.I. works for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1	Job No. 2015258J	Fig. No. 21



BH No.:	BH-4		c : 2.40 kg/sq. cm
Depth:	+1.50 m	Test Type: UU	ϕ : 10 degree



BH No.:			c :
Depth:		Test Type:	ϕ :



BH No.:			c :
Depth:		Test Type:	ϕ :

Geotechnical Investigations for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1	Job No.	Fig. No.
	2015258J	22

FARGO CONSULTANTS PVT. LTD.

LABORATORY TEST RESULTS

Project Name & Bore Hole No.	Layer ID	Depth (m)	Sample Type	'N' value	Corrected "N" Value	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Natural Moisture Content (%)	Bulk Density (gm/cc)	Dry density (gm/cc)	Liquid Limit(%)	Plastic Limit (%)	Plasticity Index (%)	Type of Test	Cohesion (kg/cm^2)	Angle of Friction (degree)	Sp.Gravity	e_0	P_0 (kg/cm^2)	P_c (kg/cm^2)	C_c	C_r
G.I. works for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1 Location : National water way at Sahibganj in Jharkhand , BH - 5	I	1.50	P	12	-	0.8	5.8	82.5	10.9	-	-	-	27.5	19.3	8.2	-	-	-	-	-	-	-	-	-
		3.00	U	-	-	0.8	4.2	83.9	11.1	19.4	1.892	1.585	27.3	18.4	8.9	UU	1.02	2.5	-	-	-	-	-	-
		4.50	P	21	-	0.5	7.7	84.4	7.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		6.00	P	30	-	0.7	8.7	82.7	7.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	II	7.50	P	36	-	0.9	4.5	83.5	11.1	-	-	-	25.3	17.1	8.2	-	-	-	-	-	-	-	-	-
		9.00	P	42	-	0.1	4.3	84.4	11.2	-	-	-	24.7	17.1	7.6	-	-	-	-	-	-	-	-	-
		10.50	P	47	-	3.5	2.2	81.3	13.0	-	-	-	26.7	15.2	11.5	-	-	-	-	-	-	-	-	-
	III	12.00	P	25	-	12.5	4.3	73.3	9.9	-	-	-	22.0	9.3	12.7	-	-	-	-	-	-	-	-	-
		13.50	P	25	-	13.6	4.8	70.5	11.1	-	-	-	23.0	11.4	11.6	-	-	-	-	-	-	-	-	-
		15.00	P	29	-	14.3	4.3	71.7	9.7	-	-	-	21.9	11.9	10.0	-	-	-	-	-	-	-	-	-
		16.50	P	26	-	23.0	8.4	60.6	8.0	-	-	-	22.8	11.2	11.6	-	-	-	-	-	-	-	-	-
		18.00	P	31	-	25.1	9.5	57.6	7.8	-	-	-	24.0	11.9	12.1	-	-	-	-	-	-	-	-	-
	IV	19.50	P	66	-	22.6	10.1	62.0	5.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		21.00	P	41	-	22.6	10.5	61.5	5.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		22.50	P	42	-	14.2	5.1	74.4	6.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		24.00	P	53	-	14.5	6.7	71.8	7.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		25.50	P	64	-	53.3	4.3	38.1	4.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		27.00	P	71	-	53.9	4.1	38.0	4.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		28.50	P	62	-	51.8	2.9	40.1	5.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		30.00	P	77	-	54.1	4.0	36.4	5.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		31.50	P	65	-	51.8	2.8	39.5	5.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		33.00	P	55	-	52.1	3.0	38.3	6.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		34.50	P	49	-	32.2	4.6	56.1	7.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		36.00	P	56	-	32.3	5.4	54.7	7.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Note :

1. U-Undisturbed Sample
2. D-Disturbed Sample
3. P-Standard Penetration Test
4. UU : Unconsolidated Undrained Triaxial Test
5. UC : Unconfined Compression Test
6. CU : Consolidated Un-drained Test
7. CD : Consolidated Drained Test
8. DS : Direct Shear Test
9. * Combined % of Silt & Clay.

Sheet No.: D-25

FARGO CONSULTANTS PVT. LTD.

LABORATORY TEST RESULTS

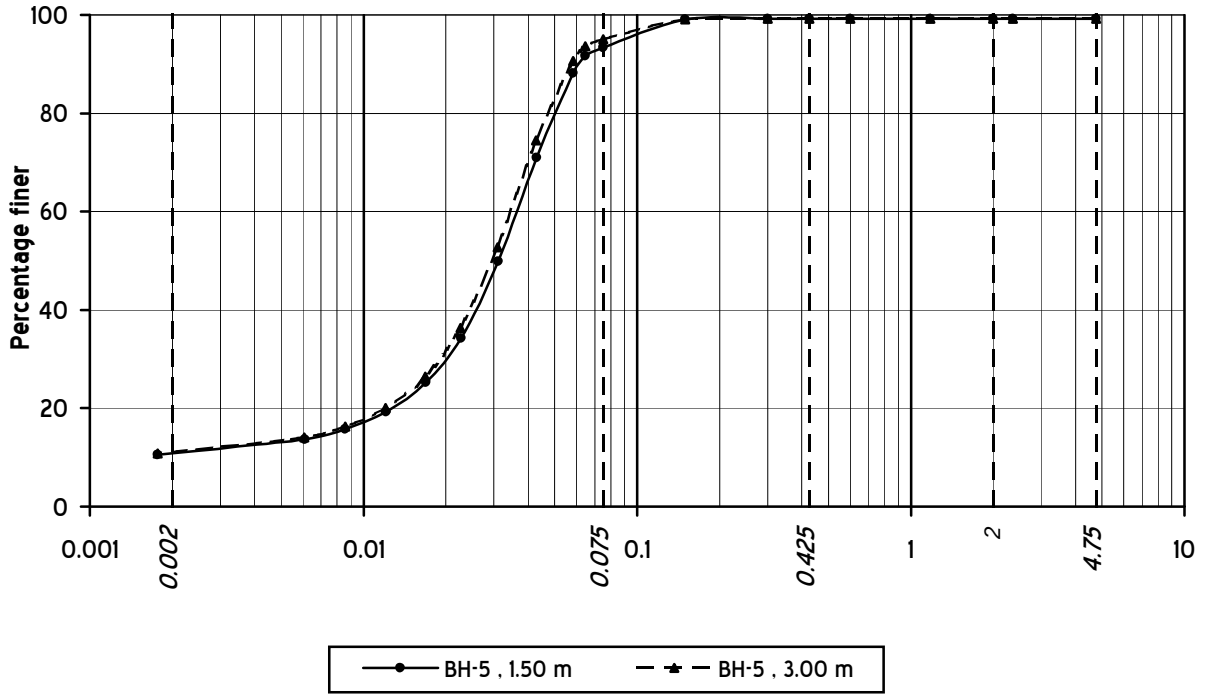
Project Name & Bore Hole No.	Layer ID	Depth (m)	Sample Type	'N' value	Corrected "N" Value	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Natural Moisture Content (%)	Bulk Density (gm/cc)	Dry density (gm/cc)	Liquid Limit(%)	Plastic Limit (%)	Plasticity Index (%)	Type of Test	Cohesion (kg/cm^2)	Angle of Friction (degree)	Sp.Gravity	e_0	P_0 (kg/cm^2)	P_c (kg/cm^2)	C_c	C_r
G.I. works for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1 Location : National water way at Sahibganj in Jharkhand , BH - 5	IV	38.00	P	60	-	44.7	4.3	46.2	4.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		40.00	P	68	-	44.8	4.6	45.6	5.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Note :

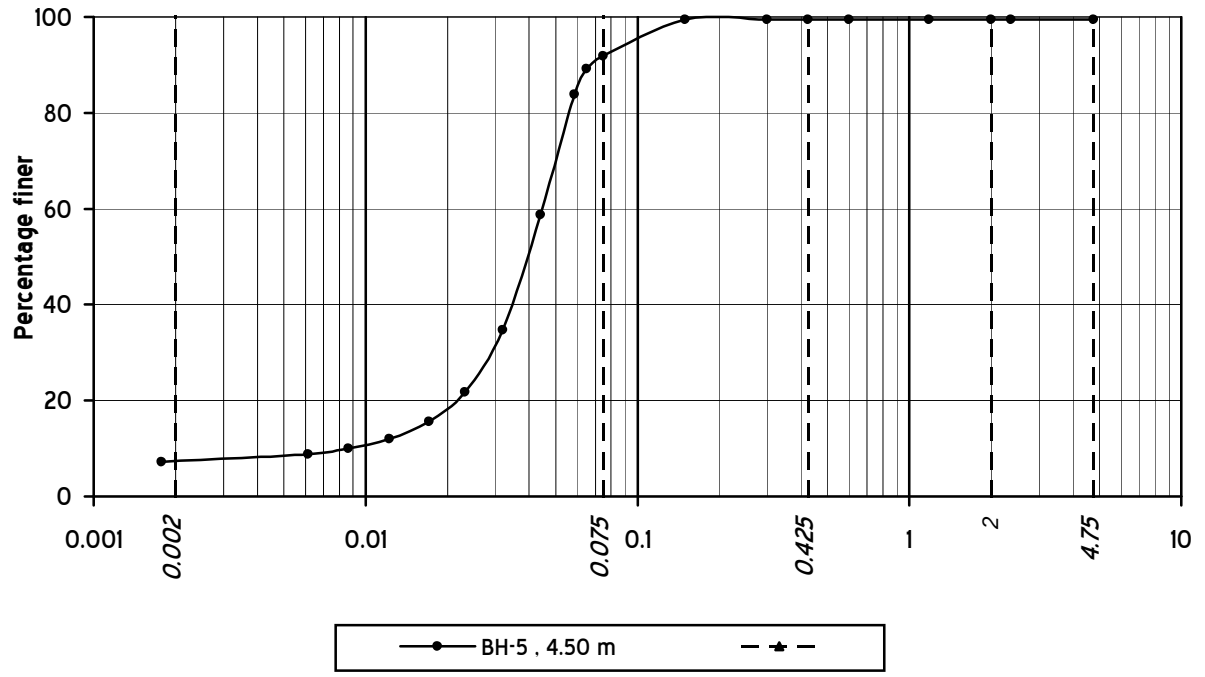
1. U-Undisturbed Sample
2. D-Disturbed Sample
3. P-Standard Penetration Test
4. UU : Unconsolidated Undrained Triaxial Test
5. UC : Unconfined Compression Test
6. CU : Consolidated Un-drained Test
7. CD : Consolidated Drained Test
8. DS : Direct Shear Test
9. * Combined % of Silt & Clay.

Sheet No.: D-26

GRAIN SIZE DISTRIBUTION CURVES



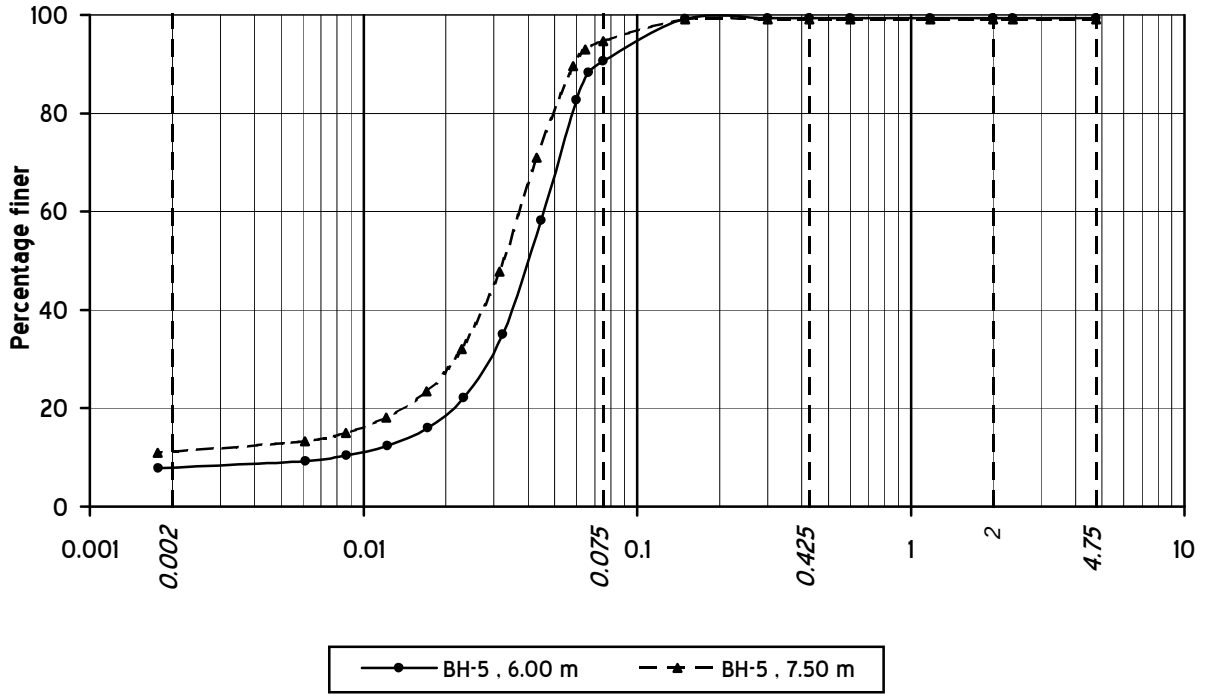
Grain size (mm) / Sample No.	< 0.002 Clay (%)	0.002-0.075 Silt (%)	0.075-0.425 Fine sand (%)	0.425-2.0 Medium sand (%)	2.0-4.75 Coarse sand (%)	> 4.75 Gravel (%)
BH-5 , 1.50 m	10.9	82.5	5.8	0.0	0.0	0.8
BH-5 , 3.00 m	11.1	83.9	4.2	0.0	0.0	0.8



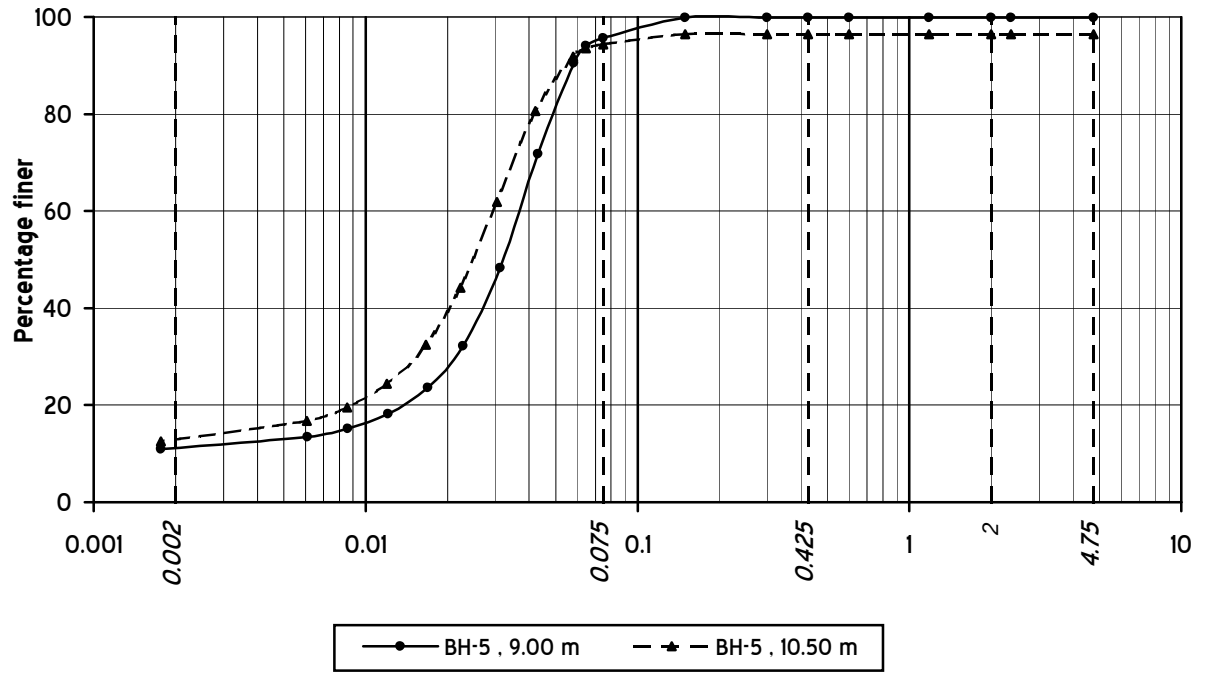
Grain size (mm) / Sample No.	< 0.002 Clay (%)	0.002-0.075 Silt (%)	0.075-0.425 Fine sand (%)	0.425-2.0 Medium sand (%)	2.0-4.75 Coarse sand (%)	> 4.75 Gravel (%)
BH-5 , 4.50 m	7.4	84.4	7.7	0.0	0.0	0.5

Project:G.I. works for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1	Job No. 2015258J	Fig. No. 23

GRAIN SIZE DISTRIBUTION CURVES



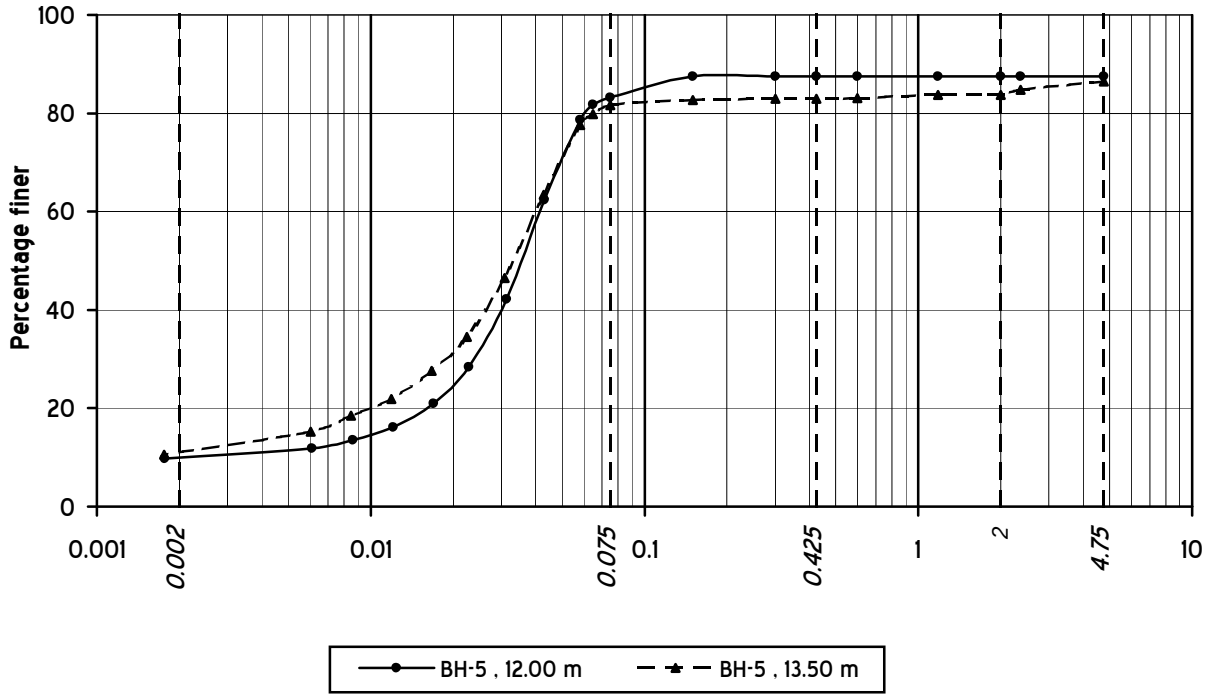
Grain size (mm) / Sample No.	*< 0.002* Clay (%)	*0.002-0.075* Silt (%)	*0.075-0.425* Fine sand (%)	*0.425-2.0* Medium sand (%)	*2.0-4.75* Coarse sand (%)	*> 4.75* Gravel (%)
BH-5 , 6.00 m	7.9	82.7	8.7	0.0	0.0	0.7
BH-5 , 7.50 m	11.1	83.5	4.5	0.0	0.0	0.9



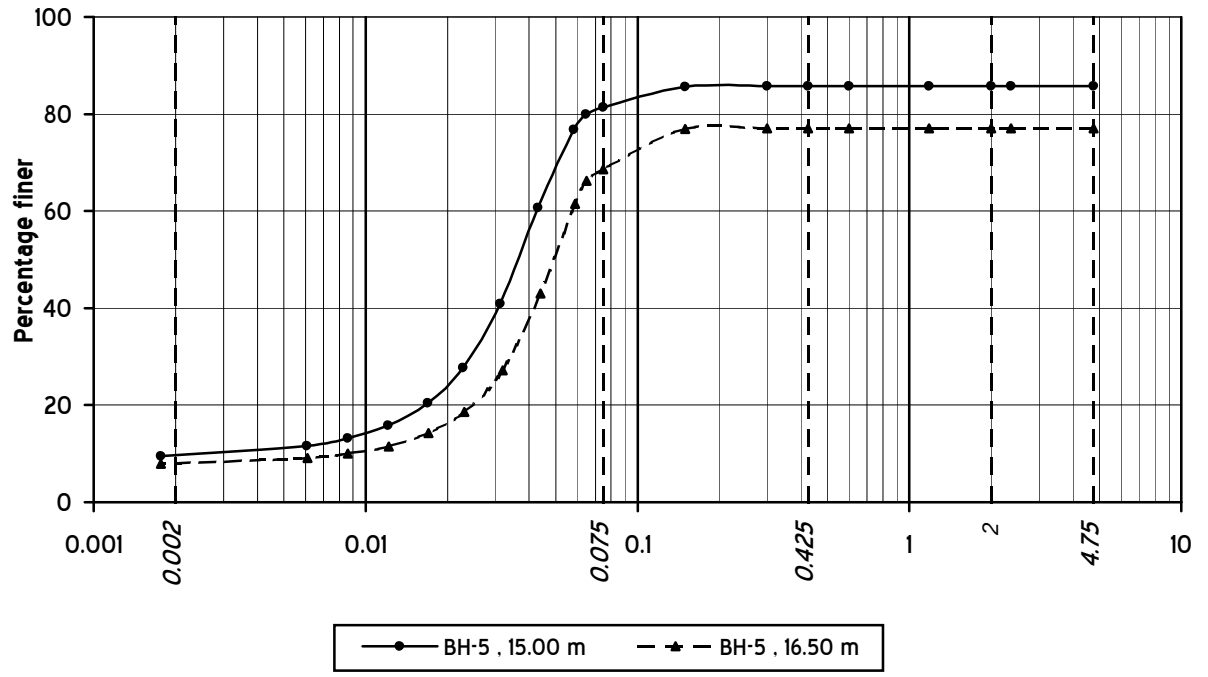
Grain size (mm) / Sample No.	*< 0.002* Clay (%)	*0.002-0.075* Silt (%)	*0.075-0.425* Fine sand (%)	*0.425-2.0* Medium sand (%)	*2.0-4.75* Coarse sand (%)	*> 4.75* Gravel (%)
BH-5 , 9.00 m	11.2	84.4	4.3	0.0	0.0	0.1
BH-5 , 10.50 m	13.0	81.3	2.2	0.0	0.0	3.5

Project:G.I. works for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1	Job No. 2015258J	Fig. No. 24

GRAIN SIZE DISTRIBUTION CURVES



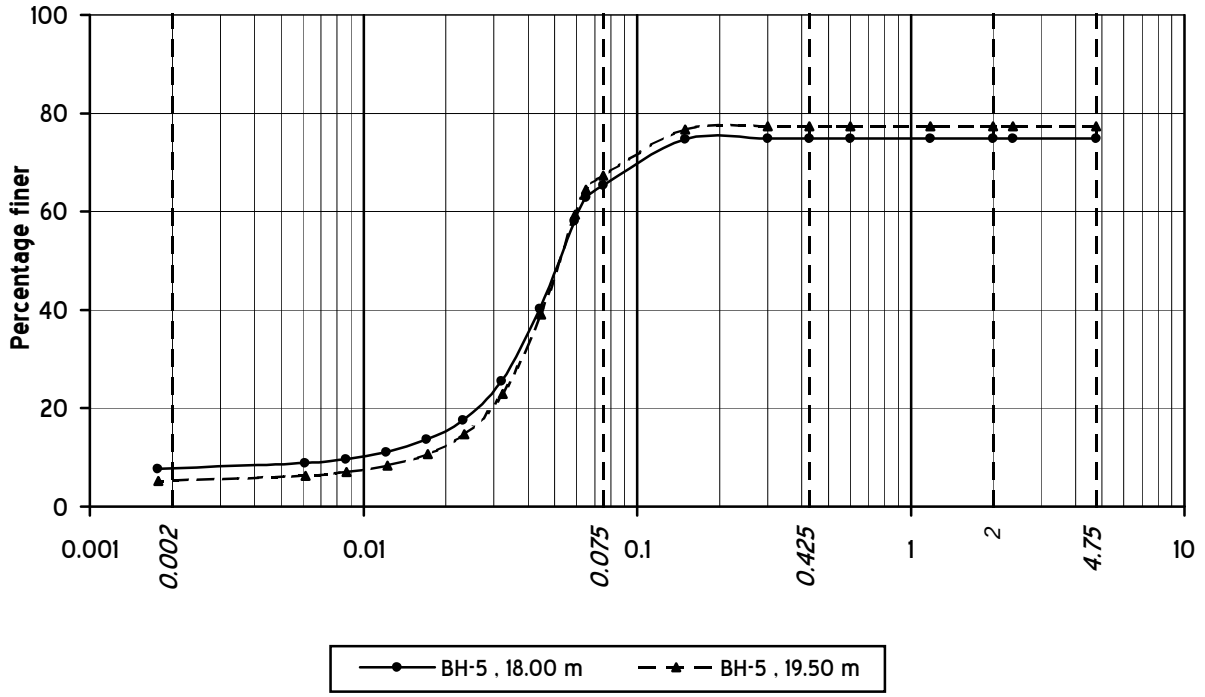
Grain size (mm) / Sample No.	*< 0.002* Clay (%)	*0.002-0.075* Silt (%)	*0.075-0.425* Fine sand (%)	*0.425-2.0* Medium sand (%)	*2.0-4.75* Coarse sand (%)	*> 4.75* Gravel (%)
BH-5 , 12.00 m	9.9	73.3	4.3	0.0	0.0	12.5
BH-5 , 13.50 m	11.1	70.5	1.3	0.8	2.7	13.6



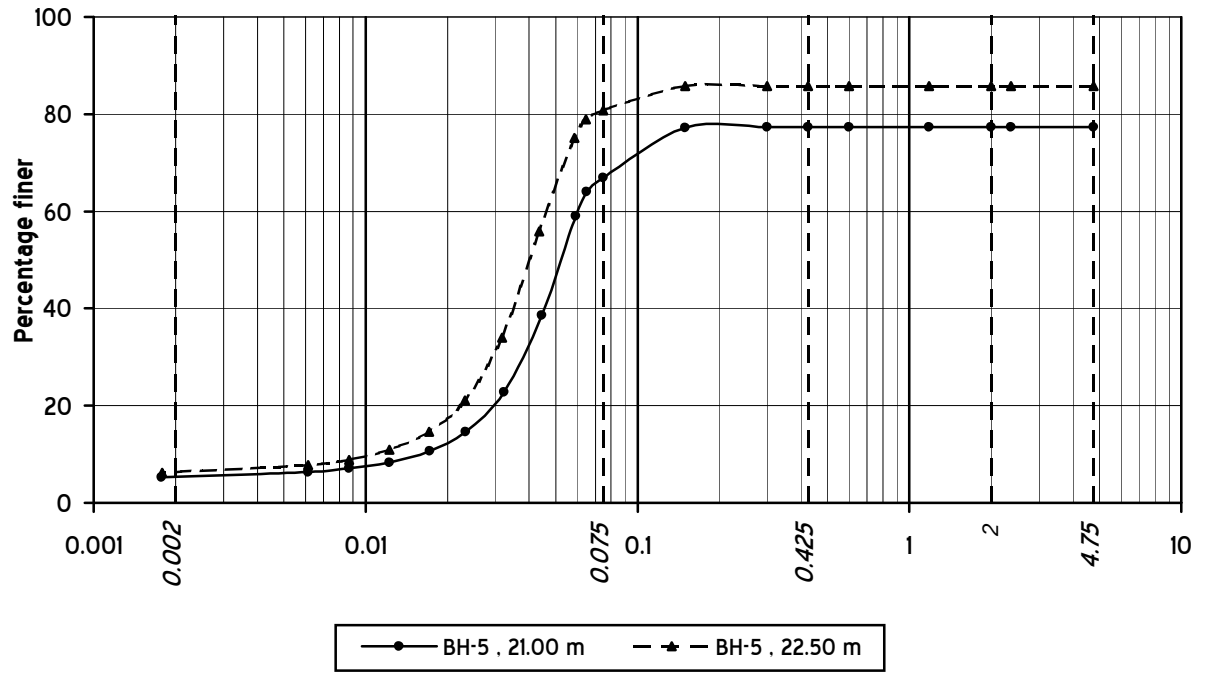
Grain size (mm) / Sample No.	*< 0.002* Clay (%)	*0.002-0.075* Silt (%)	*0.075-0.425* Fine sand (%)	*0.425-2.0* Medium sand (%)	*2.0-4.75* Coarse sand (%)	*> 4.75* Gravel (%)
BH-5 , 15.00 m	9.7	71.7	4.3	0.0	0.0	14.3
BH-5 , 16.50 m	8.0	60.6	8.4	0.0	0.0	23.0

Project:G.I. works for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1	Job No. 2015258J	Fig. No. 25

GRAIN SIZE DISTRIBUTION CURVES



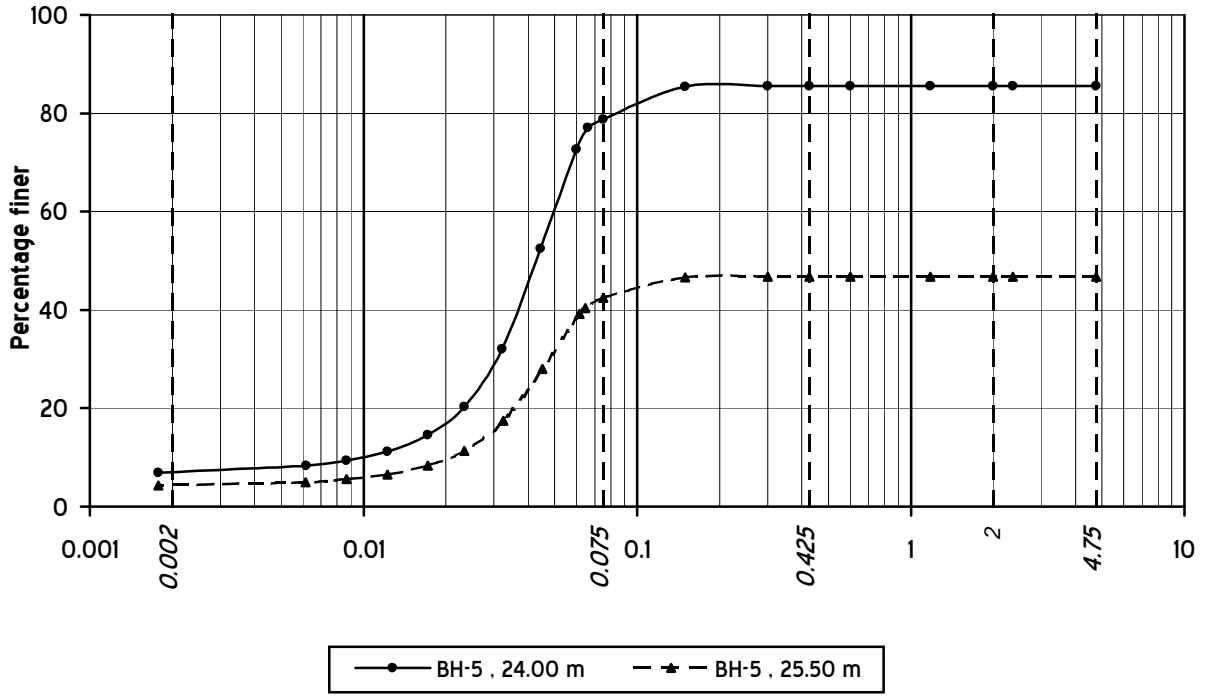
Grain size (mm) / Sample No.	< 0.002 Clay (%)	0.002-0.075 Silt (%)	0.075-0.425 Fine sand (%)	0.425-2.0 Medium sand (%)	2.0-4.75 Coarse sand (%)	> 4.75 Gravel (%)
BH-5 , 18.00 m	7.8	57.6	9.5	0.0	0.0	25.1
BH-5 , 19.50 m	5.3	62.0	10.1	0.0	0.0	22.6



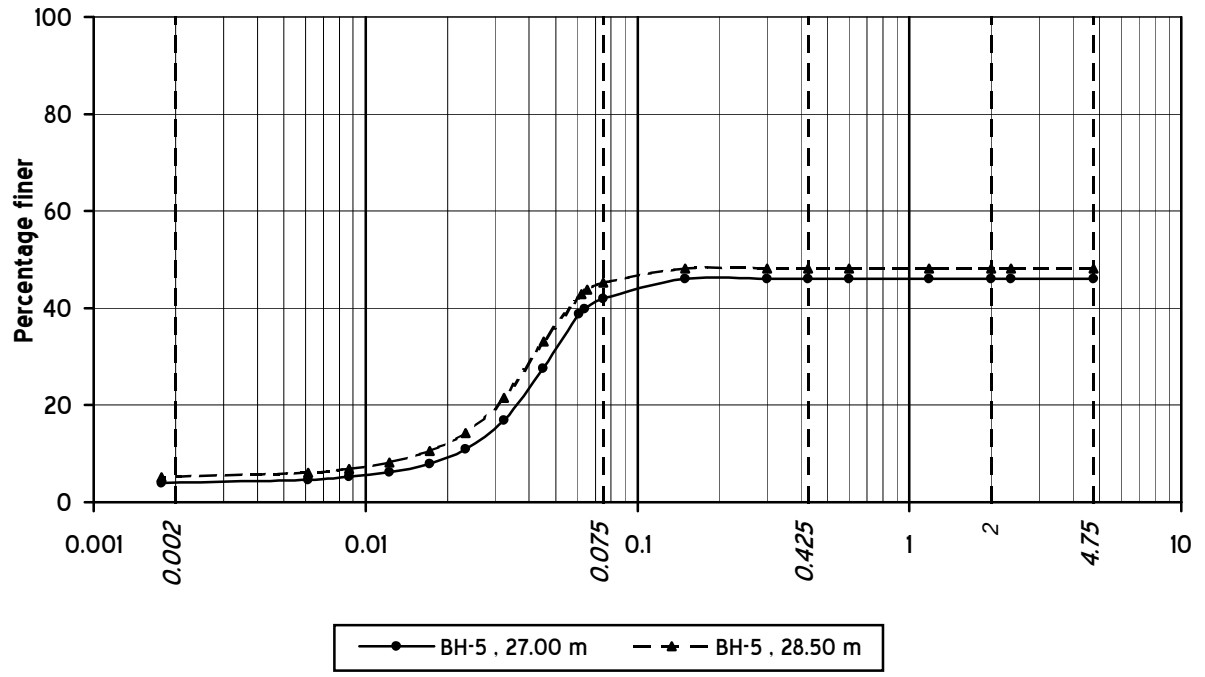
Grain size (mm) / Sample No.	< 0.002 Clay (%)	0.002-0.075 Silt (%)	0.075-0.425 Fine sand (%)	0.425-2.0 Medium sand (%)	2.0-4.75 Coarse sand (%)	> 4.75 Gravel (%)
BH-5 , 21.00 m	5.4	61.5	10.5	0.0	0.0	22.6
BH-5 , 22.50 m	6.3	74.4	5.1	0.0	0.0	14.2

Project:G.I. works for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1	Job No. 2015258J	Fig. No. 26

GRAIN SIZE DISTRIBUTION CURVES



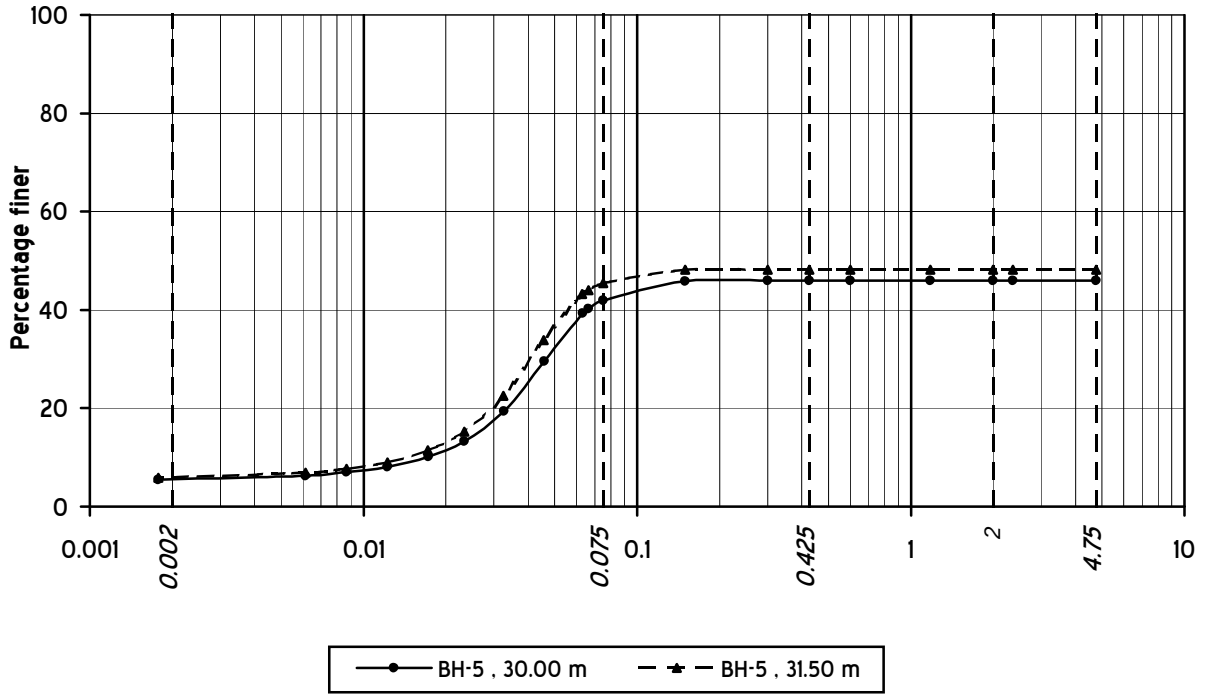
Grain size (mm) / Sample No.	< 0.002 Clay (%)	0.002-0.075 Silt (%)	0.075-0.425 Fine sand (%)	0.425-2.0 Medium sand (%)	2.0-4.75 Coarse sand (%)	> 4.75 Gravel (%)
BH-5 , 24.00 m	7.0	71.8	6.7	0.0	0.0	14.5
BH-5 , 25.50 m	4.3	38.1	4.3	0.0	0.0	53.3



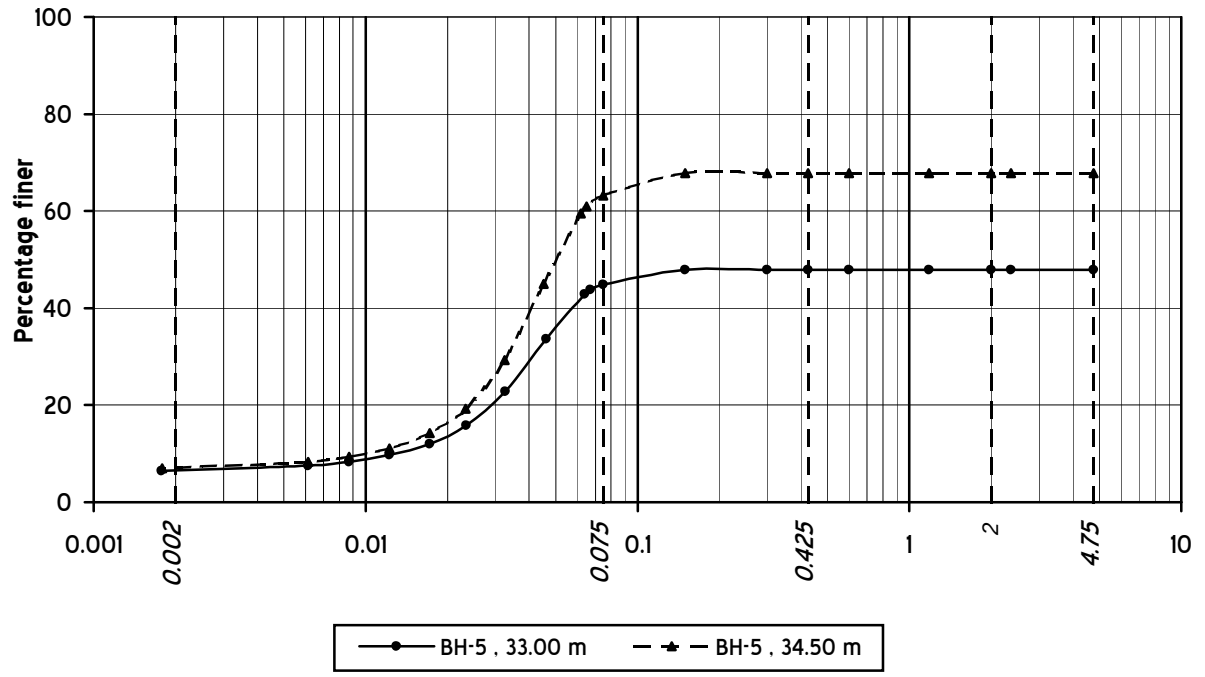
Grain size (mm) / Sample No.	< 0.002 Clay (%)	0.002-0.075 Silt (%)	0.075-0.425 Fine sand (%)	0.425-2.0 Medium sand (%)	2.0-4.75 Coarse sand (%)	> 4.75 Gravel (%)
BH-5 , 27.00 m	4.0	38.0	4.1	0.0	0.0	53.9
BH-5 , 28.50 m	5.2	40.1	2.9	0.0	0.0	51.8

Project:G.I. works for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1	Job No. 2015258J	Fig. No. 27

GRAIN SIZE DISTRIBUTION CURVES



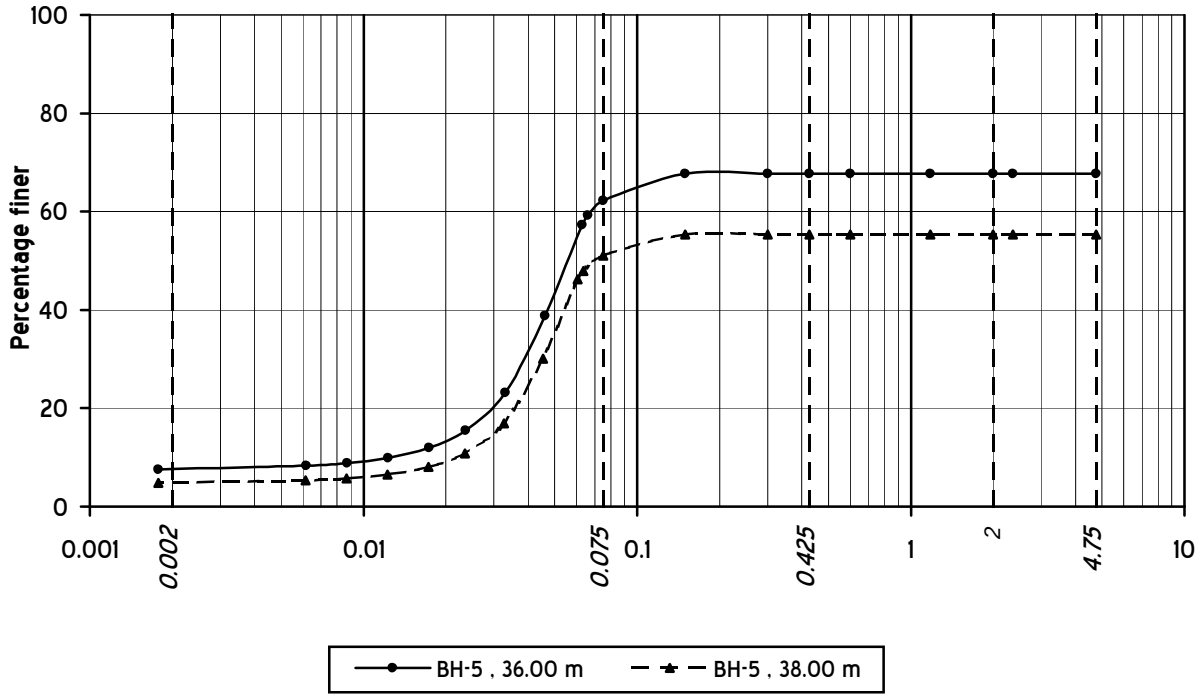
Grain size (mm) / Sample No.	*< 0.002* Clay (%)	*0.002-0.075* Silt (%)	*0.075-0.425* Fine sand (%)	*0.425-2.0* Medium sand (%)	*2.0-4.75* Coarse sand (%)	*> 4.75* Gravel (%)
BH-5 , 30.00 m	5.5	36.4	4.0	0.0	0.0	54.1
BH-5 , 31.50 m	5.9	39.5	2.8	0.0	0.0	51.8



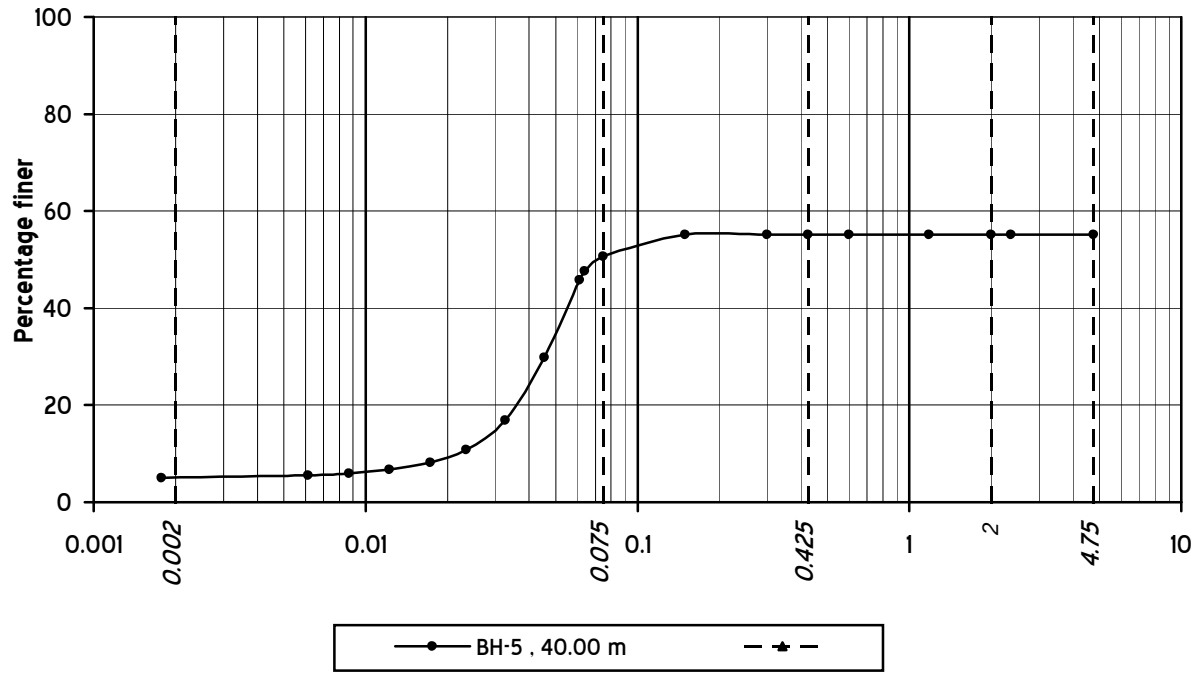
Grain size (mm) / Sample No.	*< 0.002* Clay (%)	*0.002-0.075* Silt (%)	*0.075-0.425* Fine sand (%)	*0.425-2.0* Medium sand (%)	*2.0-4.75* Coarse sand (%)	*> 4.75* Gravel (%)
BH-5 , 33.00 m	6.6	38.3	3.0	0.0	0.0	52.1
BH-5 , 34.50 m	7.1	56.1	4.6	0.0	0.0	32.2

Project:G.I. works for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1	Job No. 2015258J	Fig. No. 28

GRAIN SIZE DISTRIBUTION CURVES

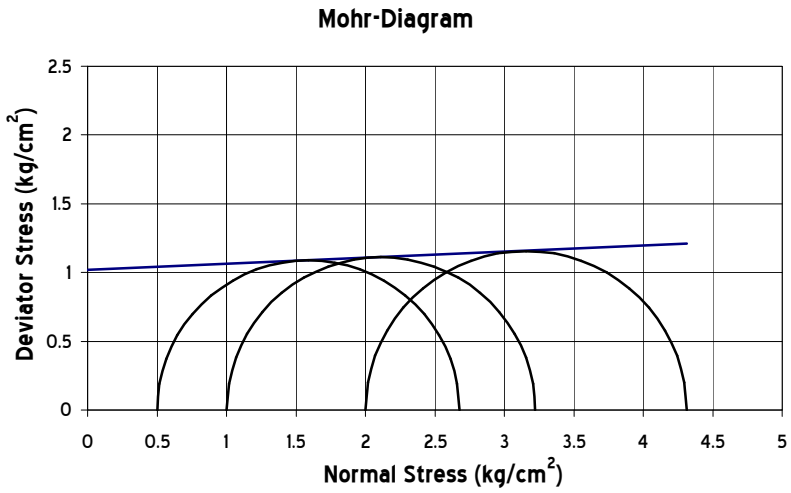


Grain size (mm) / Sample No.	*< 0.002* Clay (%)	*0.002-0.075* Silt (%)	*0.075-0.425* Fine sand (%)	*0.425-2.0* Medium sand (%)	*2.0-4.75* Coarse sand (%)	*> 4.75* Gravel (%)
BH-5 , 36.00 m	7.6	54.7	5.4	0.0	0.0	32.3
BH-5 , 38.00 m	4.8	46.2	4.3	0.0	0.0	44.7

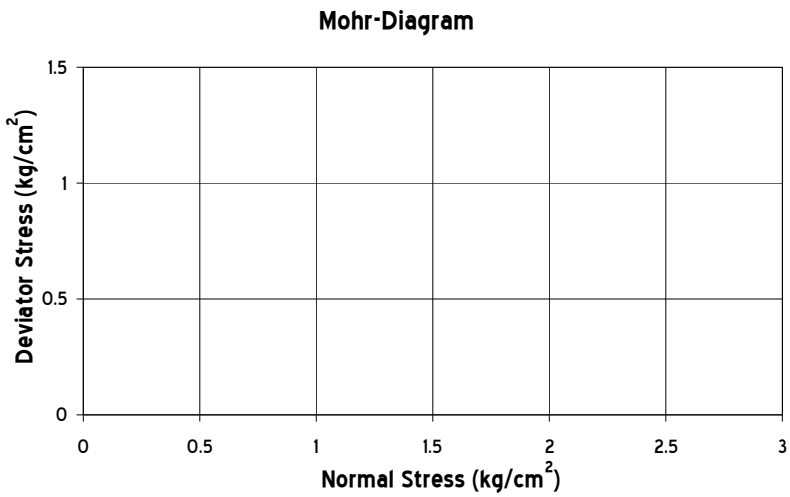


Grain size (mm) / Sample No.	*< 0.002* Clay (%)	*0.002-0.075* Silt (%)	*0.075-0.425* Fine sand (%)	*0.425-2.0* Medium sand (%)	*2.0-4.75* Coarse sand (%)	*> 4.75* Gravel (%)
BH-5 , 40.00 m	5.0	45.6	4.6	0.0	0.0	44.8

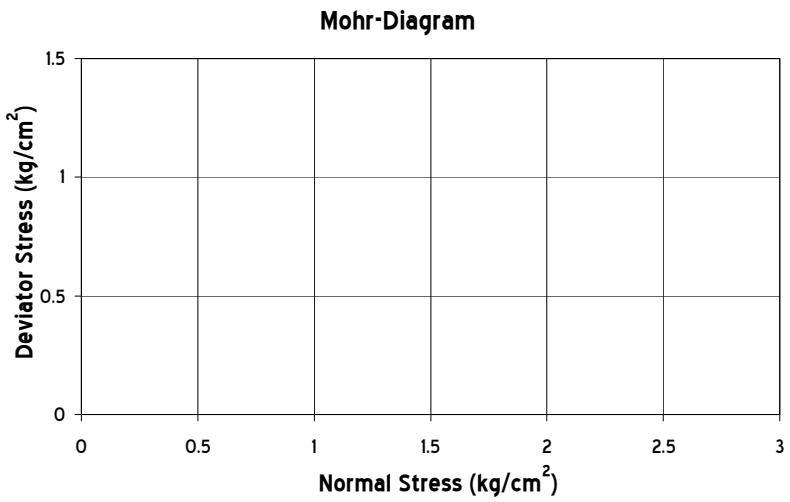
Project:G.I. works for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1	Job No. 2015258J	Fig. No. 29



BH No.:	BH-5		c : 1.02 kg/sq. cm
Depth:	+3.00 m	Test Type: UU	ϕ : 2.5 degree



BH No.:			c :
Depth:		Test Type:	ϕ :



BH No.:			c :
Depth:		Test Type:	ϕ :

Geotechnical Investigations for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1	Job No.	Fig. No.
	2015258J	30

FARGO CONSULTANTS PVT. LTD.

LABORATORY TEST RESULTS

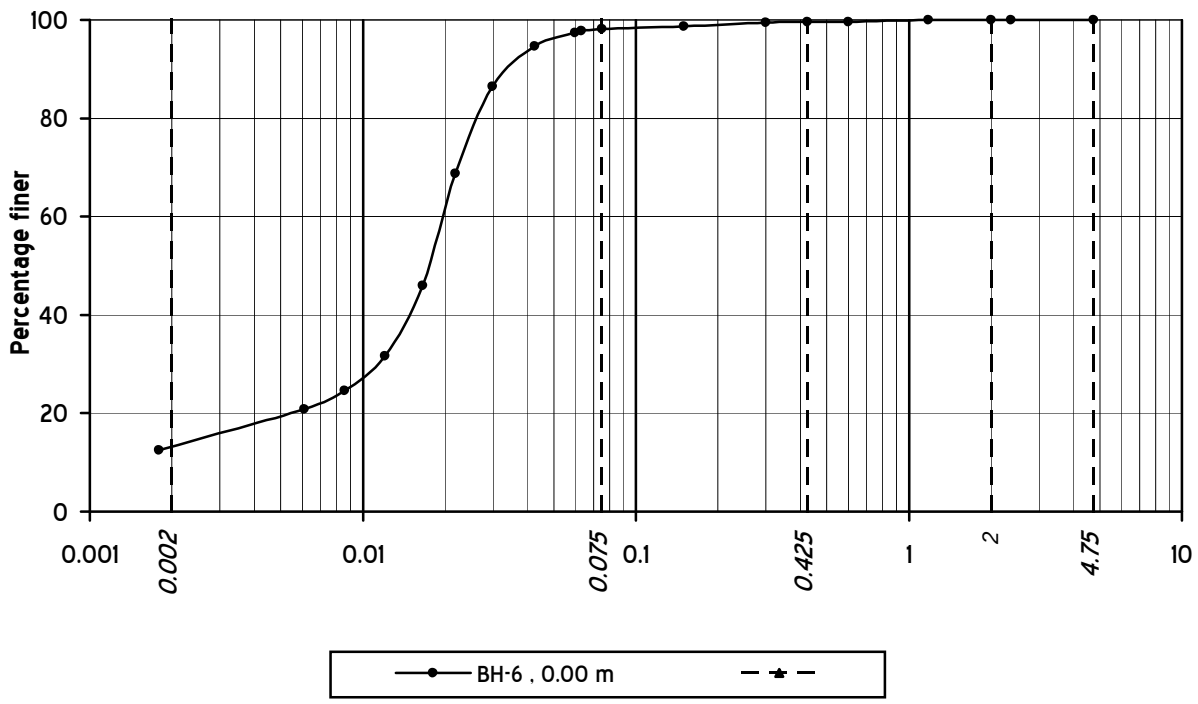
Project Name & Bore Hole No.	Layer ID	Depth (m)	Sample Type	'N' value	Corrected "N" Value	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Natural Moisture Content (%)	Bulk Density (gm/cc)	Dry density (gm/cc)	Liquid Limit(%)	Plastic Limit (%)	Plasticity Index (%)	Type of Test	Cohesion (kg/cm^2)	Angle of Friction (degree)	Sp.Gravity	e_0	P_0 (kg/cm^2)	P_c (kg/cm^2)	C_c	C_r
Topographical survey for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Location : National water way at Sahibganj in Jharkhand , BH - 6	I	0.00	D	-	-	0.0	1.8	84.9	13.3	-	-	-	32.1	18.7	13.4	-	-	-	-	-	-	-	-	-
	II	1.50	P	9	15	0.3	73.4	26.3*		-	-	-	Non Plastic			-	-	-	-	-	-	-	-	-
		3.00	P	10	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		4.50	P	17	19	0.7	79.2	20.1*		-	-	-	Non Plastic			-	-	-	-	-	-	-	-	-
		6.00	P	17	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		7.50	P	14	16	0.9	77.1	22.0*		-	-	-	Non Plastic			-	-	-	-	-	-	-	-	-
	III	8.05	P	>100	>67	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Note :

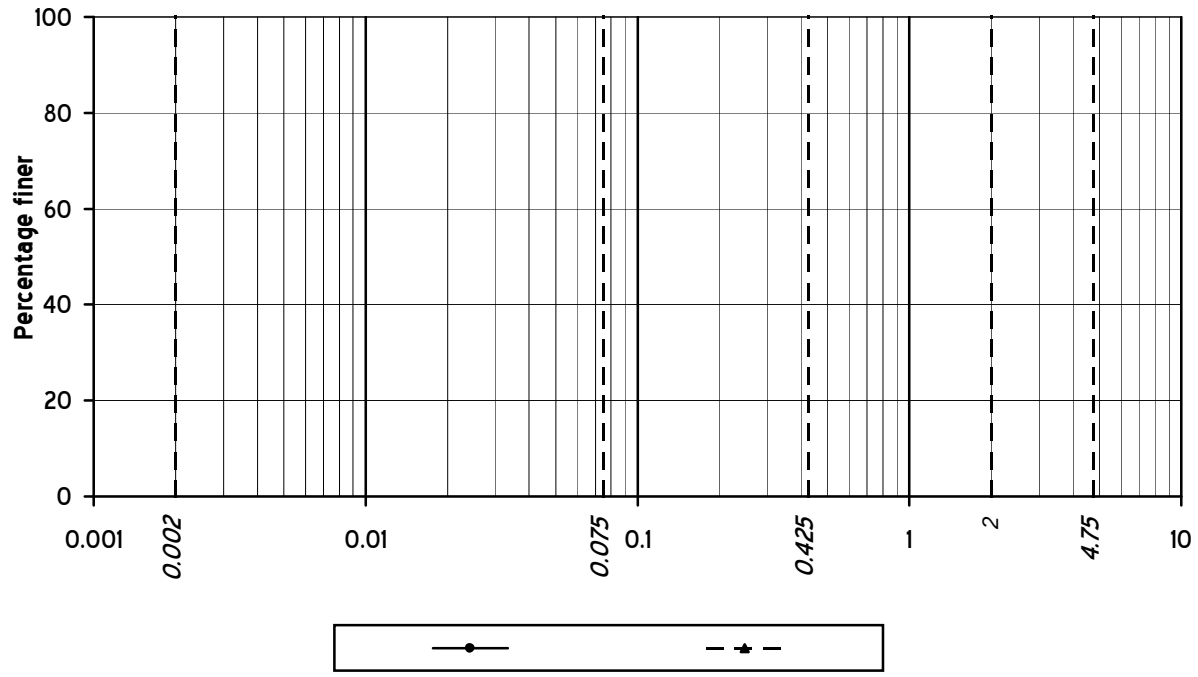
1. U-Undisturbed Sample
2. D-Disturbed Sample
3. P-Standard Penetration Test
4. UU : Unconsolidated Undrained Triaxial Test
5. UC : Unconfined Compression Test
6. CU : Consolidated Un-drained Test
7. CD : Consolidated Drained Test
8. DS : Direct Shear Test
9. * Combined % of Silt & Clay.

Sheet No.: D-35

GRAIN SIZE DISTRIBUTION CURVES



Grain size (mm) / Sample No.	< 0.002 Clay (%)	0.002-0.075 Silt (%)	0.075-0.425 Fine sand (%)	0.425-2.0 Medium sand (%)	2.0-4.75 Coarse sand (%)	> 4.75 Gravel (%)
BH-6 , 0.00 m	13.3	84.9	1.4	0.4	0.0	0.0



Grain size (mm) / Sample No.	< 0.002 Clay (%)	0.002-0.075 Silt (%)	0.075-0.425 Fine sand (%)	0.425-2.0 Medium sand (%)	2.0-4.75 Coarse sand (%)	> 4.75 Gravel (%)

Project:G.I. works for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1	Job No. 2015258J	Fig. No. 26

FARGO CONSULTANTS PVT. LTD.

LABORATORY TEST RESULTS

Project Name & Bore Hole No.: Topographical survey for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Location : National water way at Sahibganj in Jharkhand , BH - 7

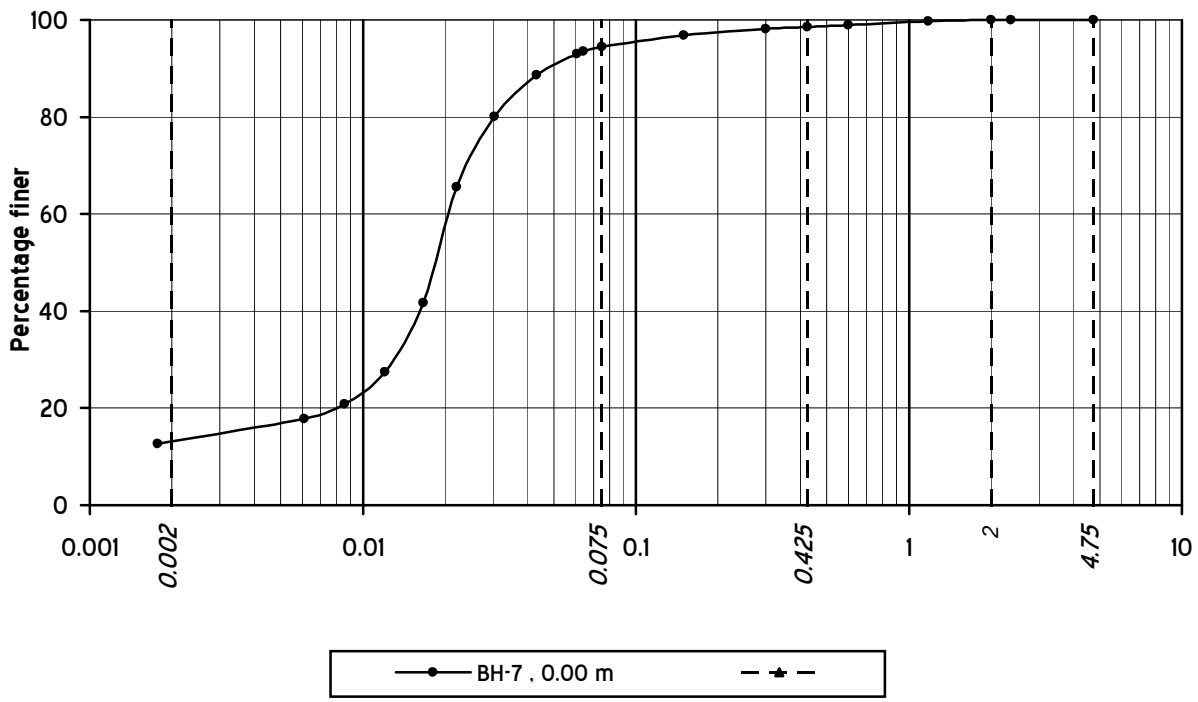
Layer ID	Depth (m)	Sample Type	'N' value	Corrected "N" Value	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Natural Moisture Content (%)	Bulk Density (gm/cc)	Dry density (gm/cc)	Liquid Limit(%)	Plastic Limit (%)	Plasticity Index (%)	Type of Test	Cohesion (kg/cm^2)	Angle of Friction (degree)	Sp.Gravity	e_0	P_0 (kg/cm^2)	P_c (kg/cm^2)	C_c	C_r
I	0.00	D	-	-	0.0	5.6	81.2	13.2	-	-	-	32.1	19.9	12.2	-	-	-	-	-	-	-	-	-
II	1.50	P	7	12	0.4	78.9	20.7*		-	-	-	Non Plastic			-	-	-	-	-	-	-	-	-
	3.00	U	10	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	4.50	P	8	11	0.6	72.5	26.9*		-	-	-	Non Plastic			-	-	-	-	-	-	-	-	-
	6.00	P	13	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	7.50	P	8	9	1.0	69.9	29.1*		-	-	-	Non Plastic			-	-	-	-	-	-	-	-	-
	9.00	P	15	16	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	10.50	P	12	13	0.2	69.7	30.1*		-	-	-	Non Plastic			-	-	-	-	-	-	-	-	-
	12.00	P	10	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	13.50	P	19	17	0.1	68.8	31.1*		-	-	-	Non Plastic			-	-	-	-	-	-	-	-	-
	15.00	P	17	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	16.50	P	19	16	0.0	74.7	25.3*		-	-	-	Non Plastic			-	-	-	-	-	-	-	-	-
	18.00	P	25	19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	19.50	P	27	19	1.1	70.3	28.6*		-	-	-	Non Plastic			-	-	-	-	-	-	-	-	-
	21.00	P	30	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	22.50	P	15	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	24.00	P	22	16	0.6	71.9	27.5*		-	-	-	Non Plastic			-	-	-	-	-	-	-	-	-
III	25.50	P	>100	>47	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Note :

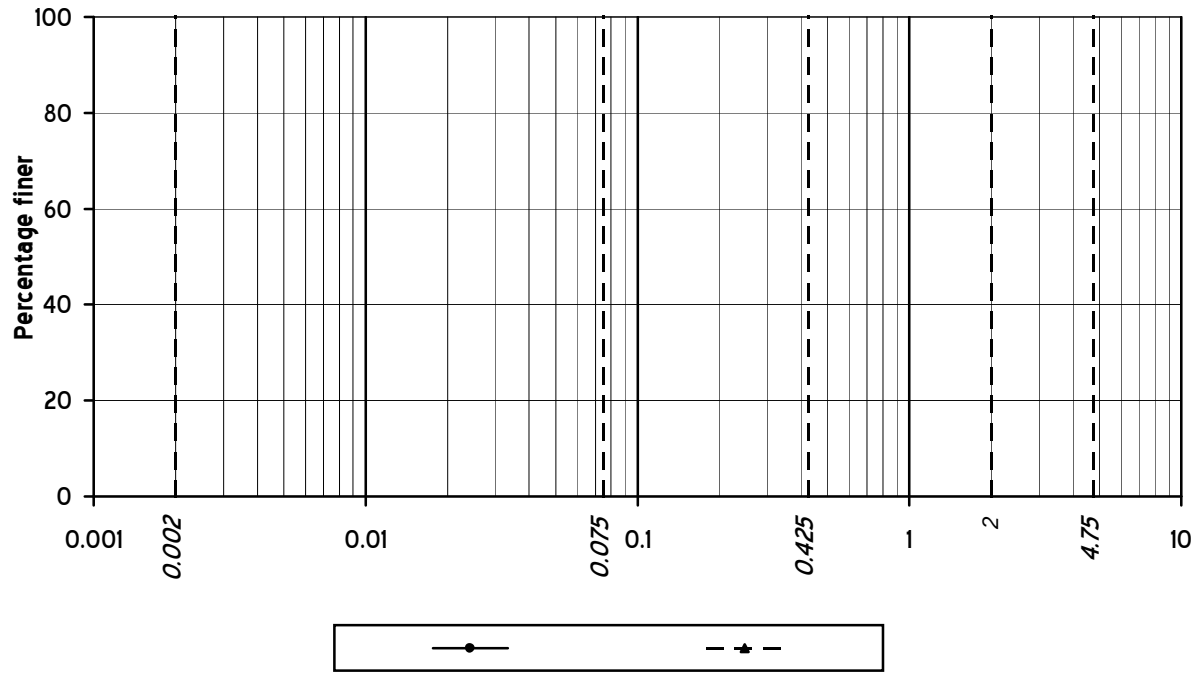
1. U-Undisturbed Sample
2. D-Disturbed Sample
3. P-Standard Penetration Test
4. UU : Unconsolidated Undrained Triaxial Test
5. UC : Unconfined Compression Test
6. CU : Consolidated Un-drained Test
7. CD : Consolidated Drained Test
8. DS : Direct Shear Test
9. * Combined % of Silt & Clay.

Sheet No.: D-37

GRAIN SIZE DISTRIBUTION CURVES



Grain size (mm) / Sample No.	< 0.002 Clay (%)	0.002-0.075 Silt (%)	0.075-0.425 Fine sand (%)	0.425-2.0 Medium sand (%)	2.0-4.75 Coarse sand (%)	> 4.75 Gravel (%)
BH-7 , 0.00 m	13.2	81.2	4.1	1.5	0.0	0.0



Grain size (mm) / Sample No.	< 0.002 Clay (%)	0.002-0.075 Silt (%)	0.075-0.425 Fine sand (%)	0.425-2.0 Medium sand (%)	2.0-4.75 Coarse sand (%)	> 4.75 Gravel (%)

Project:G.I. works for Preparation of Detailed Project Report (DPR) for Construction of IWT Terminal at Sahibganj in Jharkhand (India) on River Ganga National Waterway-1	Job No. 2015258J	Fig. No. 27

ANNEXURE - E

CALCULATIONS

SAMPLE CALCULATIONS FOR PILE LOAD CAPACITY

Location:IWT-1 Sahibganj Terminal
Borehole No. :BH-5
Existing Ground Level :+0.0 m
Scour Level -1.5 m
Groundwater Level :+0.0 m

Pile Diameter :+1.00 m
Pile Cut-Off Level -1.5 m
Pile Founding Level -17.0 m
Pile Type : Bored
Earth Pressure Coefficient,K : 1.0

LAYER INFORMATION

Layer	Design Sub-Layer	Starting Elevation (m)	Ending Elevation (m)	Length (m)	SPT Value	Angle of Friction (ϕ) Degrees	Cohesion (KN/m^2)	Bulk Density (KN/m^3)
	1	-1.5	-7	5.5	21	0	110	19.3
	2	-7	-11	4	48	0	240	20.5
	3	-11	-19	8	28	0	140	19.8
	4	-19	-40	21	58	0	290	20.7

EFFECTIVE OVERBURDEN PRESSURE CALCULATIONS

$P_{-7.0}$ = 5.5 x 9.300 = 51.1 KN/m²

$P_{-11.0}$ = 51.1 + 4.0 x 10.500 = 93.1 KN/m²

$P_{-17.0}$ = 93.1 + 6.0 x 9.800 = 152.0 KN/m²

$P_{-19.0}$ = 152.0 + 2.0 x 9.800 = 171.6 KN/m²

$P_{-40.0}$ = 171.6 + 21.0 x 10.700 = 396.3 KN/m²

SKIN FRICTION CALCULATIONS

Formula for skin friction calculation is $Q_s = \Sigma\ K\ P_{di} \tan\delta\ A_s + \alpha\ C\ A_s$

Qs_1 = 0.4 x 110.0 x (3.14159 x 1 x 5.5) = 764.2 KN

Qs_2 = 0.3 x 240.0 x (3.14159 x 1 x 4.0) = 821.7 KN

Qs_3 = 0.3 x 140.0 x (3.14159 x 1 x 6.0) = 833.9 KN

Total Skin Friction =764.2 + 821.7 + 833.9 = 2419.9KN

END BEARING CAPACITY CALCULATIONS

Formula for end bearing capacity is $Q_b = A_p\ (0.5\ D\ \gamma\ N_\gamma + P_d\ N_q + N_c\ C)$

End Bearing capacity of founding layer

Qbc = 140.0x 9 x(3.1415 x1.0 x 1.0)/4 = 989.6 KN

CALCULATIONS FOR SELF WEIGHT OF PILE

Self Weight of Pile = 3.14159x(1.0x1.0)/4 x[5.5x(25.0-19.300)+4.0x(25.0-20.500)+
6.0x(25.0-19.800)]=63.3 KN

VERTICAL LOAD CAPACITY OF PILE

Design Load Capacity = ((2419.9+989.6)/2.5) - 63.3 = 1300.5 KN

UPLIFT CAPACITY OF PILE

Total frictional resistance = (764.2 + 821.7 + 833.9) = 2419.9 KN

Design Uplift Capacity = ((2419.9)*0.7/2.5) + 63.3 = 740.8 KN

Pile Lateral Load Capacity Calculations

Location: **IWT-1 Terminal at Sahibganj**
Land Location

Input data

Grade of Concrete	M-25	
Diameter (d)	1.5	m
E	2.50E+07	kN/m^2
I	0.248505	m^4
Length above Scour Level (L1)	0	m
Embedment Length (Le) (below Scour)	22	m
Overburden Material Type *	C	
Unconfined Compression,qu	220	kN/m^2
Modulus of Subgrade Reaction	39.6	$kN/m^3 \times 10^3$
Stiffness Factor R	5.3	m
Le/R (-)	4.2	

Long Pile (Le/R > 4)	Fixed	Free
L1/R (-)	0.000	0.000
Lf/R (-)	2.190	1.925
Lf (m)	11.6	10.2
Q_{lat} for 1% of PileDia deflection (kN)	718.50	179.63

Short Pile (Le/R < 2)	Fixed	Free
Q_{lat} for 1% of PileDia deflection (kN)	-	-

Note: * NC-Non cohesive soil : C-Normally consolidated cohesive soil : PC-Preconsolidated cohesive soil
Calculations for long pile are as per IS Code. Calculations for short pile has been done as per methods outlined "Soil Mechanics and Foundation Engg, V.N.S. Murthy, 2nd Ed. pp. 691-692"

Constants as provided in IS Code

Table 3 Modulus of Subgrade Reaction for Granular Soils, η_h, in kN/m^3

Category	Description	N (Blow/30 cm)	Submerged
1	Very Loose	0-4	<0.2
2	Loose sand	4-10	0.2-1.4
3	Medium sand	10-35	1.4-5.0
4	Dense sand	>35	5.0-12.0

Table 4 Modulus of Subgrade Reaction for Cohesive Soil, k_1 in kN/m^3

Category	Soil Consistency	q_u (i.e. =2c) (kN/m^2)	Range of k1 $kN/m^3 \times 10^3$
1	Soft	25-50	4.5-9.0
2	Medium Stiff	50-100	9.0-18.0
3	Stiff	100-200	18.0-36.0
4	Very Stiff	200-400	36.0-72.0
5	Hard	>400	>72.0

SAMPLE CALCULATIONS FOR PILE LOAD CAPACITY

Location:IWT-1 Sahibganj Terminal		Pile Diameter	:+1.00 m
Borehole No.	:BH-3	Pile Cut-Off Level	:+2.0 m
Existing Ground Level	:+0.0 m	Pile Founding Level	-25.0 m
Scour Level	-2.0 m	Pile Type	: Bored
Groundwater Level	:+2.0 m	Earth Pressure Coefficient,K	: 1.0

LAYER INFORMATION

Layer	Design Sub-Layer	Starting Elevation (m)	Ending Elevation (m)	Length (m)	SPT Value	Angle of Friction (ϕ) Degrees	Cohesion (KN/m^2)	Bulk Density (KN/m^3)
	1	-2	-13	11	4	25	0	17.5
	2	-13	-35	22	54	33	0	20.7

EFFECTIVE OVERBURDEN PRESSURE CALCULATIONS

$P_{-13.0}$ = 11.0 x 7.500 = 82.5 KN/m²

$P_{-25.0}$ = 82.5 + 12.0 x 10.700 = 210.9 KN/m²

SKIN FRICTION CALCULATIONS

Formula for skin friction calculation is $Q_s = \Sigma K P_{di} \tan \delta A_s + \alpha C A_s$

Qs_1 = 1.00 x 0.5(0.0+82.5) x (3.14159 x 1.0 x 11.0) x tan(25.0) = 664.7 KN

Qs_2 = 1.00 x 0.5(82.5+210.9) x (3.14159 x 1.0 x 12.0) x tan(33.0) = 3591.5 KN

Total Skin Friction =664.7 + 3591.5 = 4256.2KN

END BEARING CAPACITY CALCULATIONS

Formula for end bearing capacity is $Q_b = A_p (0.5 D \gamma N_\gamma + P_d N_q + N_c C)$

Length of pile in this layer is 12.m which is less than 15D. Therefore, no reduction of overburden pressure will be done.

End Bearing capacity of founding layer

Qbc = [210.9 x 34.7 + 0.5 x 1.0 x 10.700 x 35.2]x(3.1415 x1.0 x 1.0)/4 = 5903.6 KN

CALCULATIONS FOR SELF WEIGHT OF PILE

Length of pile below water level and above ground level [m]= 4.0

Self Weight of Pile = 3.14159x(1.0x1.0)/4 x[4.0x(25.0-10.0) +11.0x(25.0-17.500)+ 12.0x(25.0-20.700)]=152.4 KN

VERTICAL LOAD CAPACITY OF PILE

Design Load Capacity = ((4256.2+5903.6)/2.5) - 152.4 = 3911.5 KN

UPLIFT CAPACITY OF PILE

Total frictional resistance = (664.7 + 3591.5) = 4256.2 KN

Design Uplift Capacity = ((4256.2)*0.7/2.5) + 152.4 = 1344.2 KN

Pile Lateral Load Capacity Calculations

Location: **IWT-1 Terminal at Sahibganj River Location**

Input data

Grade of Concrete	M-25	
Diameter (d)	1.5	m
E	2.50E+07	kN/m^2
I	0.248505	m^4
Length above Scour Level (L1)	4	m
Embedment Length (Le) (below Scour)	32	m
Overburden Material Type *	NC	
N-Value	4	
Modulus of Subgrade Reaction	0.20	$kN/m^3 \times 10^3$
Stiffness Factor T	7.9	m
Le/T (-)	4.0	

Long Pile (Le/T > 4)	Fixed	Free
L1/T (-)	0.505	0.505
Lf/T (-)	2.089	1.883
Lf (m)	16.5	14.9
Q_{lat} for 1% of PileDia deflection (kN)	129.09	32.27

Short Pile (Le/T < 2)	Fixed	Free
Q_{lat} for 1% of PileDia deflection (kN)	-	-

Note: * NC-Non cohesive soil : C-Normally consolidated cohesive soil : PC-Preconsolidated cohesive soil
Calculations for long pile are as per IS Code. Calculations for short pile has been done as per methods outlined "Soil Mechanics and Foundation Engg, V.N.S. Murthy, 2nd Ed. pp. 691-692"

Constants as provided in IS Code

Table 3 Modulus of Subgrade Reaction for Granular Soils, η_h, in kN/m^3

Category	Description	N (Blow/30 cm)	Submerged
1	Very Loose	0-4	<0.2
2	Loose sand	4-10	0.2-1.4
3	Medium sand	10-35	1.4-5.0
4	Dense sand	>35	5.0-12.0

Table 4 Modulus of Subgrade Reaction for Cohesive Soil, k_1 in kN/m^3

Category	Soil Consistency	q_u (i.e. =2c) (kN/m^2)	Range of k1 $kN/m^3 \times 10^3$
1	Soft	25-50	4.5-9.0
2	Medium Stiff	50-100	9.0-18.0
3	Stiff	100-200	18.0-36.0
4	Very Stiff	200-400	36.0-72.0
5	Hard	>400	>72.0

Test Results for Ground Water & Surface Water Sample at Project Site

The test results for ground water and surface water at project site location are given below:

The sample locations for ground water and surface water are shown in Drawing No.I-521/ST/1003.

Test Results for Ground Water Sample at Project Site

S.N.	Parameters	Qty.in mg/l
1.	Chloride as Cl	18
2.	Sulphates as SO_4	8

Test Results for Surface Water Sample at Project Site

S.N.	Parameters	Qty.in mg/l	
		SW-1	SW-2
1.	Chloride as Cl	14	16