

D. Field Investigation:

D1. Boring:

The exploratory boreholes were sunk using shell and auger/wash boring method. Casing was used up to a depth of 3.000 metres to protect the sides of boreholes against collapse. The boring was conducted as per the guidelines and provisions of IS: 1892. Standard Penetration Test was conducted in the boreholes at all the strata encountered. Undisturbed soil samples were collected from the boreholes. Disturbed samples were collected from the split spoon sampler at all the test depths and test location of Standard Penetration Test and from different typical strata.

The termination depth of the borehole and depth of water table as observed in the boreholes are indicated below:

Table 1

Bore Hole No.	Termination Depth below EGL (Mtr)	Depth of Water Table Below EGL (Mtr.) Explored during the period March & April 2018.
BH-1	40.000	1.550
BH-2	40.000	1.100
BH-3	40.000	0.600
BH-4	40.000	0.650
BH-5	40.000	0.790
BH-6	40.000	0.830
BH-7	40.000	0.940
BH-8	40.000	0.950
BH-9	40.000	0.900
BH-10	40.000	0.830
BH-11	40.000	0.780
BH-12	40.000	0.400
BH-13	35.000	0.550
BH-14	35.000	1.230
BH-15	40.000	1.500
BH-16	40.000	1.400
BH-17	40.000	2.600



Bore Hole No.	Termination Depth below EGL (Mtr)	Depth of Water Table Below EGL (Mtr.) Explored during the period March & April 2018.
BH-18	40.000	3.200
BH-19	35.000	1.300
BH-20	35.000	0.400
BH-21	35.000	0.950
BH-22	35.000	1.420

D.2. Sampling:

D.2.1 Undisturbed Sampling:

The collection of undisturbed soil sample was done, wherever possible depending on existing soil strata, as per the guidelines of IS: 1892 – Code of Practice for site Investigation for Foundation. The sampling system used was an assembly of sampling tube of 100 mm diameter and 450 mm long, connected with a jarring link. The specification of the tube is as per the provision of IS: 2132, Code of practice for thin walled sampling of soils.

After the samples are collected within the tubes, the tubes are taken out of the borehole. Both the ends of the tube were properly sealed with wax, properly labeled depth-wise and borehole-wise, capped and thus made ready for onward transmission for testing the soil samples in the laboratory.

D.2.2 Disturbed Sampling:

Disturbed samples were collected from cutting shoe and split spoon of the SPT sampler. These samples were collected in polythene bags, properly labeled depth-wise and borehole-wise and were used in the preparation of bore log as well as for general identification & classification purpose of soil as per IS: 1498. The same were then packed and sent to the laboratory for further test.

D3. Standard Penetration Test:

Standard Penetration Test was conducted as per the guidelines and provisions of IS: 2131- Method for standard penetration test for soil, in the borehole at regular intervals or at change of strata with the SPT sampler. In this test, the sampler was driven by falling a weight of 63.5 Kg hammer through a height of 750 mm. The sampler was driven through a depth of 450mm. The number of blows for every 150mm. of penetration was recorded. The first 150



mm. was taken as seating drive, the number of blows for subsequent 300 mm. is the **SPT N-value**. The observed N-values are indicated in the corresponding bore log.

D4. Recording of Ground Water Table:

The field exploration was carried out during the month of March and April 2018.

The recorded ground water table is indicated in Table 1 of the report.

E. Laboratory Testing:

Laboratory tests were conducted on the soil samples collected from the boreholes. The tests were conducted as per provisions and guidelines of Bureau of Indian Standard laid down in their different codes and as per requirements of the client. All disturbed and undisturbed samples were opened up in the laboratory for further identification & classification of soil samples.

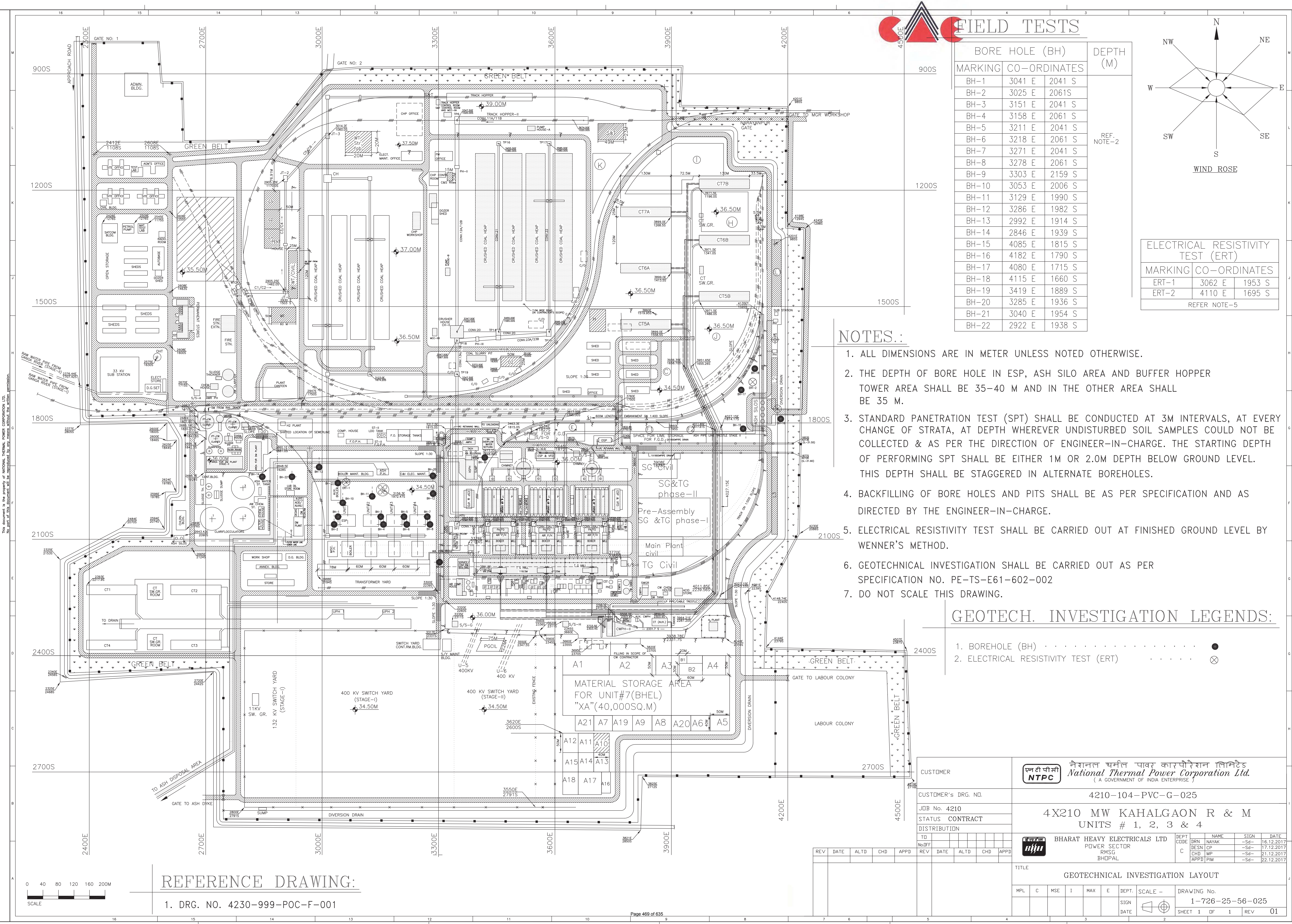
Various tests were conducted for ascertaining the following engineering and physical properties of the sub-soil:

-  Natural Moisture Content
-  Bulk & Dry Density
-  Specific Gravity.
-  Liquid Limit & Plastic Limit.
-  Shrinkage Limit
-  Grain Size Analysis (Sieve & Hydrometer)
-  Unconfined Compressive Strength.
-  Tri-axial Shear Strength (UU, CU & CD.)
-  Consolidation Properties.
-  Swelling Pressure.
-  Shrinkage Limit.
-  Standard Proctor Compaction Test.
-  Chemical Test on Soil Sample.
-  Chemical Test of Water Sample.



F. Discussion and Recommendation:-

In general the top soil is suitable to rest foundation for structures with light to medium pressure. Shallow foundation have been recommended zone wise in following chapters for foundation of different sizes and shapes of foundations resting at different foundation depth. Moreover, pile foundations have been recommended for structures with heavy load on foundations. Recommended pile capacities have been indicated for different zones in their corresponding chapters.





ASH SILOS

Total four (4) boreholes were sunk in this area, viz borehole marked BH-15, BH-16, BH-17 and BH-18. From the general sub soil profile it has been observed that the top soil is filled up followed by the first layer (i.e. Layer-I) consisting medium to stiff brownish grey clayey silt/ silty clay. The second layer (i.e. Layer-II) is very stiff to hard brownish grey clayey silt/ silty clay with traces of kankar and the third layer (i.e. Layer-III) as encountered up to the explored depth is dense to very dense yellowish grey silty sand.

Discussion and Recommendation:

From the general profile of the subsoil it has been observed that the maximum thickness of top layer as observed at the location of BH-17 is 18.5m and minimum thickness is 11.00m as observed at the location of BH-15. For lightly to medium loaded structures, shallow foundation has been proposed to rest in layer-I i.e. medium to stiff brownish grey clayey silt/ silty clay. Table-2A may be referred for adopting safe bearing capacity.

Table 2A
Recommended Bearing Capacity from Shear and Settlement Criteria

Depth of Foundation below NGL (Mtr)	Net Allowable Bearing Pressure (T/Sqm)		
	Isolated / Strip for a permissible settlement of 40 mm		Rafts (width > & = 6m) for a permissible settlement of 75mm
	width upto 3.0m	width >3 & < 6m	
2.50	10.00	6.00	7.00
3.00	10.00	6.00	7.00
4.00	12.00	6.00	8.00
5.00	14.00	7.00	8.00



Pile foundation has also been recommended for foundation system of heavily loaded structures. Pile capacities in compression, pull-out and horizontal shear for different diameter of pile are indicated in the Table-2B. It is further recommended to check the Settlement of the pile groups during design of structure and carry out initial pile load test for load under compression, pull-out and horizontal shear, in order to confirm the recommended pile capacities and to take corrective measures, if required.

Table-2B
Recommended Pile Capacity

Sl.No	Pile Dia , D	Total Length of Pile, L	Cut-off Level	Recommended Pile Capacity in Compression	Recommended Pile Capacity in Pull-Out	Recommended Pile Capacity in Horizontal Shear
	Mtr	Mtr.	Mtr.	T	T	T
2	0.600	29.000	2.000	106	49	5.89
3	0.760	29.000	2.000	139	63	8.25

Recommended pile capacity in pull-out for 600mm dia pile has been restricted up to 20T as per the technical specification.



BORE LOG SHEET		Centre for Advanced Engineering						Bore Hole No.: BH-15 (Sheet 1)	
Project: SOIL_BHEL_NTPC-KAHALGAON_ASH SILO								Job No.: Soil - 1582	
Co-ord: E= 4083.80, S= 1818.70		E.G.L.: 37.11		Unit:		Bore Hole Dia. : 150 MM.			
Type of Boring	Shell & Auger	FIELDTEST	NOS.	SAMPLES	NOS.	SAMPLES	NOS.	Commenced on : 01.03.2018	
Depth of Boring	40.000 M.	SPT	21	UDS	8	WS		Completed on : 03.03.2018	
Type of Drilling		DCPT		DS	24	RCS		Water Struck At : 1.60 M.	
Depth of Drilling		VST		SCPT				Standing Water Table : 1.50 M.	

D E S C R I P T I O N	SYMBOL	DEPTH	N-V A L U E	S A M P L E					
				NO.	DEPTH				
Medium to stiff brownish grey clayey silt/ silty clay.			N = 7	DS1	0.50 M				
				DS2	1.00M				
				DS3	1.50M				
				UDS1	2.00-2.45M				
				SPT1	3.00-3.45M				
				DS4	3.00-3.45M				
				UDS2	4.00-4.45M				
				SPT2	5.00-5.45M				
				DS5	5.00-5.45M				
				UDS3	6.00-6.45M				
			N = 6	SPT3	7.00-7.45M				
				DS6	7.00-7.45M				
				UDS4	8.00-8.45M				
				SPT4	9.00-9.45M				
				DS7	9.00-9.45M				
				UDS5	10.00-10.45M				
							N = 12	SPT5	11.50-11.95M
								DS8	11.50-11.95M
								UDS6	13.00-13.45M
								SPT6	14.50-14.95M
DS9	14.50-14.95M								
UDS7	16.00-16.45M								
			N = 26					SPT7	17.50-17.95M
								DS10	17.50-17.95M
								UDS8	19.00-19.45M
								SPT8	20.50-20.95M
				DS11	20.50-20.95M				
				SPT9	22.00-22.45M				
				DS12	22.00-22.45M				
				SPT10	23.50-23.95M				
				DS13	23.50-23.95M				
							N = 21	SPT11	24.50-24.95M
DS14	24.50-24.95M								
UDS9	26.00-26.45M								
SPT12	27.50-27.95M								
DS15	27.50-27.95M								
UDS10	29.00-29.45M								
			N = 25					SPT13	30.50-30.95M
								DS16	30.50-30.95M
								UDS11	32.00-32.45M
								SPT14	33.50-33.95M
				DS17	33.50-33.95M				
				UDS12	35.00-35.45M				
							N = 28	SPT15	36.50-36.95M
								DS18	36.50-36.95M
								UDS13	38.00-38.45M
								SPT16	39.50-39.95M
DS19	39.50-39.95M								
UDS14	41.00-41.45M								
			N = 24					SPT17	42.50-42.95M
								DS20	42.50-42.95M
								UDS15	44.00-44.45M
								SPT18	45.50-45.95M
				DS21	45.50-45.95M				
				UDS16	47.00-47.45M				
							N = 24	SPT19	48.50-48.95M
								DS22	48.50-48.95M
								UDS17	50.00-50.45M
								SPT20	51.50-51.95M
DS23	51.50-51.95M								
UDS18	53.00-53.45M								
			N = 24					SPT21	54.50-54.95M
								DS24	54.50-54.95M
								UDS19	56.00-56.45M
								SPT22	57.50-57.95M
				DS25	57.50-57.95M				
				UDS20	59.00-59.45M				
							N = 24	SPT23	60.50-60.95M
								DS26	60.50-60.95M
								UDS21	62.00-62.45M
								SPT24	63.50-63.95M
DS27	63.50-63.95M								
UDS22	65.00-65.45M								
			N = 24					SPT25	66.50-66.95M
								DS28	66.50-66.95M
								UDS23	68.00-68.45M
								SPT26	69.50-69.95M
				DS29	69.50-69.95M				
				UDS24	71.00-71.45M				
							N = 24	SPT27	72.50-72.95M
								DS30	72.50-72.95M
								UDS25	74.00-74.45M
								SPT28	75.50-75.95M
DS31	75.50-75.95M								
UDS26	77.00-77.45M								
			N = 24					SPT29	78.50-78.95M
								DS32	78.50-78.95M
								UDS27	80.00-80.45M
								SPT30	81.50-81.95M
				DS33	81.50-81.95M				
				UDS28	83.00-83.45M				
							N = 24	SPT31	84.50-84.95M
								DS34	84.50-84.95M
								UDS29	86.00-86.45M
								SPT32	87.50-87.95M
DS35	87.50-87.95M								
UDS30	89.00-89.45M								
			N = 24					SPT33	90.50-90.95M
								DS36	90.50-90.95M
								UDS31	92.00-92.45M
								SPT34	93.50-93.95M
				DS37	93.50-93.95M				
				UDS32	95.00-95.45M				
							N = 24	SPT35	96.50-96.95M
								DS38	96.50-96.95M
								UDS33	98.00-98.45M
								SPT36	99.50-99.95M
DS39	99.50-99.95M								
UDS34	101.00-101.45M								
			N = 24					SPT37	102.50-102.95M
								DS40	102.50-102.95M
								UDS35	104.00-104.45M
								SPT38	105.50-105.95M
				DS41	105.50-105.95M				
				UDS36	107.00-107.45M				
							N = 24	SPT39	108.50-108.95M
								DS42	108.50-108.95M
								UDS37	110.00-110.45M
								SPT40	111.50-111.95M
DS43	111.50-111.95M								
UDS38	113.00-113.45M								
			N = 24					SPT41	114.50-114.95M
								DS44	114.50-114.95M
								UDS39	116.00-116.45M
								SPT42	117.50-117.95M
				DS45	117.50-117.95M				
				UDS40	119.00-119.45M				
							N = 24	SPT43	120.50-120.95M
								DS46	120.50-120.95M
								UDS41	122.00-122.45M
								SPT44	123.50-123.95M
DS47	123.50-123.95M								
UDS42	125.00-125.45M								
			N = 24					SPT45	126.50-126.95M
								DS48	126.50-126.95M
								UDS43	128.00-128.45M
								SPT46	129.50-129.95M
				DS49	129.50-129.95M				
				UDS44	131.00-131.45M				
							N = 24	SPT47	132.50-132.95M
								DS50	132.50-132.95M
								UDS45	134.00-134.45M
								SPT48	135.50-135.95M
DS51	135.50-135.95M								
UDS46	137.00-137.45M								
			N = 24					SPT49	138.50-138.95M
								DS52	138.50-138.95M
								UDS47	140.00-140.45M
								SPT50	141.50-141.95M
				DS53	141.50-141.95M				
				UDS48	143.00-143.45M				
							N = 24	SPT51	144.50-144.95M
								DS54	144.50-144.95M
								UDS49	146.00-146.45M
								SPT52	147.50-147.95M
DS55	147.50-147.95M								
UDS50	149.00-149.45M								
			N = 24					SPT53	150.50-150.95M
								DS56	150.50-150.95M
								UDS51	152.00-152.45M
								SPT54	153.50-153.95M
				DS57	153.50-153.95M				
				UDS52	155.00-155.45M				
							N = 24	SPT55	156.50-156.95M
								DS58	156.50-156.95M
								UDS53	158.00-158.45M
								SPT56	159.50-159.95M
DS59	159.50-159.95M								
UDS54	161.00-161.45M								
			N = 24					SPT57	162.50-162.95M
								DS60	162.50-162.95M
								UDS55	164.00-164.45M
								SPT58	165.50-165.95M
				DS61	165.50-165.95M				
				UDS56	167.00-167.45M				
							N = 24	SPT59	168.50-168.95M
								DS62	168.50-168.95M
								UDS57	170.00-170.45M
								SPT60	171.50-171.95M
DS63	171.50-171.95M								
UDS58	173.00-173.45M								
			N = 24					SPT61	174.50-174.95M
								DS64	174.50-174.95M
								UDS59	176.00-176.45M
								SPT62	177.50-177.95M
				DS65	177.50-177.95M				
				UDS60	179.00-179.45M				
							N = 24	SPT63	180.50-180.95M
								DS66	180.50-180.95M
								UDS61	182.00-182.45M
								SPT64	183.50-183.95M
DS67	183.50-183.95M								
UDS62	185.00-185.45M								
			N = 24					SPT65	186.50-186.95M
								DS68	186.50-186.95M
								UDS63	188.00-188.45M
								SPT66	189.50-189.95M
				DS69	189.50-189.95M				
				UDS64	191.00-191.45M				
							N = 24	SPT67	192.50-192.95M
								DS70	192.50-192.95M
								UDS65	194.00-194.45M
								SPT68	195.50-195.95M
DS71	195.50-195.95M								
UDS66	197.00-197.45M								
			N = 24					SPT69	198.50-198.95M
								DS72	198.50-198.95M
								UDS67	200.00-200.45M
								SPT70	201.50-201.95M
				DS73	201.50-201.95M				
				UDS68	203.00-203.45M				
							N = 24	SPT71	204.50-204.95M
								DS74	204.50-204.95M
								UDS69	206.00-206.45M
								SPT72	207.50-207.95M
DS75	207.50-207.95M								
UDS70	209.00-209.45M								
			N = 24					SPT73	210.50-210.95M
								DS76	210.50-210.95M
								UDS71	212.00-212.45M
								SPT74	213.50-213.95M
				DS77	213.50-213.95M				
				UDS72	215.00-215.45M				
							N = 24	SPT75	216.50-216.95M
								DS78	216.50-216.95M
								UDS73	218.00-218.45M
								SPT76	219.50-219.95M
DS79	219.50-219.95M								
UDS74	221.00-221.45M								
			N = 24					SPT77	222.50-222.95M
								DS80	222.50-222.95M
								UDS75	224.00-224.45M
								SPT78	225.50-225.95M
				DS81	225.50-225.95M				
				UDS76	227.00-227.45M				
							N = 24	SPT79	228.50-228.95M
								DS82	228.50-228.95M
								UDS77	230.00-230.45M
								SPT80	231.50-231.95M
DS83	231.50-231.95M								
UDS78	233.00-233.45M								
			N = 24					SPT81	234.50-234.95M
								DS84	234.50-234.95M
								UDS79	236.00-236.45M
								SPT82	237.50-237.95M
				DS85	237.50-237.95M				
				UDS80	239.00-239.45M				
							N = 24	SPT83	240.50-240.95M
								DS86	240.50-240.95M
								UDS81	242.00-242.45M
								SPT84	243.50-243.95M
DS87	243.50-243.95M								
UDS82	245.00-245.45M								
			N = 24					SPT85	246.50-246.95M
								DS88	246.50-246.95M
								UDS83	248.00-248.45M
								SPT86	249.50-249.95M
				DS89	249.50-249.95M				
				UDS84	251.00-251.45M				
							N = 24	SPT87	252.50-252.95M
								DS90	252.50-252.95M
								UDS85	254.00-254.45M
								SPT88	255.50-255.95M
DS91	255.50-255.95M								
UDS86	257.00-257.45M								
			N = 24					SPT89	258.50-258.95M
								DS92	258.50-258.95M
								UDS87	260.00-260.45M
								SPT90	261.50-261.95M
				DS93	261.50-261.95M				
				UDS88	263.00-263.45M				
							N = 24	SPT91	264.50-264.95M



BORE LOG SHEET		Centre for Advanced Engineering						Bore Hole No.:BH-15 (Sheet 2)
Project: SOIL_BHEL_NTPC-KAHALGAON_ASH SILO								Job No.: Soil - 1582
Co-ord: E= 4083.80, S= 1818.70		E.G.L.: 37.11		Unit:				Bore Hole Dia. :150 MM.
Type of Boring	Shell & Auger	FIELDTEST	NOS.	SAMPLES	NOS.	SAMPLES	NOS.	Commenced on : 01.03.2018
Depth of Boring	40.000 M.	SPT	21	UDS	8	WS		Completed on : 03.03.2018
Type of Drilling		DCPT		DS	24	RCS		Water Struck At :1.60 M.
Depth of Drilling		VST		SCPT				Standing Water Table : 1.50 M.

DESCRIPTION	SYMBOL	DEPTH	N-V A L U E	S A M P L E	
				NO.	DEPTH
Very stiff to hard brownish grey clayey silt/ silty clay with traces of kankar.		26	N = 25	SPT11	25.00-25.45M
				DS14	25.00-25.45M
		27	N = 27	SPT12	26.50-26.95M
				DS15	26.50-26.95M
		28	N = 31	SPT13	28.00-28.45M
				DS16	28.00-28.45M
		29	N = 36	SPT14	29.50-29.95M
				DS17	29.50-29.95M
Dense to very dense yellowish grey silty sand.		30	N = 35	SPT15	31.00-31.45M
				DS18	31.00-31.45M
		31	N = 40	SPT16	32.50-32.95M
				DS19	32.50-32.95M
		32	N = 41	SPT17	34.00-34.45M
				DS20	34.00-34.45M
		33	N = 43	SPT18	35.50-35.95M
				DS21	35.50-35.95M
Termination Depth 40.000 Mtr.		34	N = 46	SPT19	37.00-37.45M
				DS22	37.00-37.45M
		35	N = 48	SPT20	38.50-38.95M
				DS23	38.50-38.95M
		36	N = 52	SPT21	39.55-40.00M
				DS24	39.55-40.00M
		37			
		38			
		39			
		40			
		41			
		42			
		43			
		44			
		45			
		46			
		47			
		48			
		49			

SPT - Standard Penetration Test	VST- Vane Shear Test	DS - Disturbed Sample	WS - Water Sample
DCPT - Dynamic Cone Penetration Test.	UDS - Undisturbed Sample	SCPT-Static Cone Penetration Test.	RCS - Rock Core Sample



BORE LOG SHEET		Centre for Advanced Engineering						Bore Hole No.:BH-16 (Sheet 1)	
Project: SOIL_BHEL_NTPC-KAHALGAON_ASH SILO								Job No.: Soil - 1582	
Co-ord: E=4182.00, S= 1793.10		E.G.L.: 37.01		Unit:		Bore Hole Dia. : 150 MM.			
Type of Boring	Shell & Auger	FIELDTEST	NOS.	SAMPLES	NOS.	SAMPLES	NOS.	Commenced on : 10.03.2018	
Depth of Boring	40.000 M.	SPT	21	UDS	8	WS		Completed on : 14.03.2018	
Type of Drilling		DCPT		DS	24	RCS		Water Struck At : 1.50 M.	
Depth of Drilling		VST		SCPT				Standing Water Table : 1.40 M.	

D E S C R I P T I O N	SYMBOL	DEPTH	N-V A L U E	S A M P L E	
				NO.	DEPTH
Filled up soil with clayey silt, fly ash, sand, brick bats etc.		01		DS1	0.50 M
		02		DS2	1.00M
Medium to stiff brownish grey clayey silt/ silty clay.		03		DS3	1.50M
		04	N = 7	UDS1	2.00-2.45M
		05		SPT1	3.00-3.45M
		06	N = 7	DS4	3.00-3.45M
		07		UDS2	4.00-4.45M
		08	N = 10	SPT2	5.00-5.45M
		09		DS5	5.00-5.45M
		10	N = 12	UDS3	6.00-6.45M
		11		SPT3	7.00-7.45M
		12	N = 16	DS6	7.00-7.45M
		13		UDS4	8.00-8.45M
		14	N = 16	SPT5	11.50-11.95M
		15		DS8	11.50-11.95M
		16		UDS6	13.00-13.45M
		17	N = 20	SPT7	17.50-17.95M
		18		DS10	17.50-17.95M
		19		UDS8	19.00-19.45M
		20	N = 23	SPT8	20.50-20.95M
		21		DS11	20.50-20.95M
		22	N = 24	SPT9	22.00-22.45M
		23		DS12	22.00-22.45M
		24	N = 26	SPT10	23.50-23.95M
				DS13	23.50-23.95M
Contd.....					

SPT - Standard Penetration Test	VST- Vane Shear Test	DS - Disturbed Sample	WS - Water Sample
DCPT - Dynamic Cone Penetration Test.	UDS - Undisturbed Sample	SCPT-Static Cone Penetration Test.	RCS - Rock Core Sample



BORE LOG SHEET		Centre for Advanced Engineering				Bore Hole No.: BH-16 (Sheet 2)	
Project: SOIL_BHEL_NTPC-KAHALGAON_ASH SILO						Job No.: Soil - 1582	
Co-ord: E=4182.00, S= 1793.10		E.G.L.: 37.01		Unit:		Bore Hole Dia. : 150 MM.	
Type of Boring	Shell & Auger	FIELDTEST	NOS.	SAMPLES	NOS.	SAMPLES	NOS.
Depth of Boring	40.000 M.	SPT	21	UDS	8	WS	
Type of Drilling		DCPT		DS	24	RCS	
Depth of Drilling		VST		SCPT			
						Commenced on : 10.03.2018	
						Completed on : 14.03.2018	
						Water Struck At : 1.50 M.	
						Standing Water Table : 1.40 M.	

D E S C R I P T I O N	SYMBOL	DEPTH	N - V A L U E	S A M P L E	
				NO.	DEPTH
Very stiff to hard brownish grey clayey silt/ silty clay with traces of kankar.			N = 28	SPT11	25.00-25.45M
				DS14	25.00-25.45M
			N = 29	SPT12	26.50-26.95M
				DS15	26.50-26.95M
			N = 33	SPT13	28.00-28.45M
				DS16	28.00-28.45M
			N = 34	SPT14	29.50-29.95M
				DS17	29.50-29.95M
			N = 35	SPT15	31.00-31.45M
				DS18	31.00-31.45M
			N = 40	SPT16	32.50-32.95M
				DS19	32.50-32.95M
			N = 41	SPT17	34.00-34.45M
				DS20	34.00-34.45M
			N = 44	SPT18	35.50-35.95M
				DS21	35.50-35.95M
N = 46	SPT19	37.00-37.45M			
	DS22	37.00-37.45M			
N = 49	SPT20	38.50-38.95M			
Very dense yellowish grey silty sand.			N = 55	DS23	38.50-38.95M
				SPT21	39.55-40.00M
Termination Depth 40.000 Mtr.				DS24	39.55-40.00M

SPT - Standard Penetration Test	VST- Vane Shear Test	DS - Disturbed Sample	WS - Water Sample
DCPT - Dynamic Cone Penetration Test.	UDS - Undisturbed Sample	SCPT-Static Cone Penetration Test.	RCS - Rock Core Sample



BORE LOG SHEET		Centre for Advanced Engineering						Bore Hole No.:BH-17 (Sheet 1)
Project: SOIL_BHEL_NTPC-KAHALGAON_ASH SILO								Job No.: Soil - 1582
Co-ord: E=4077.10, S= 1713.80		E.G.L.: 37.08		Unit:			Bore Hole Dia. :150 MM.	
Type of Boring	Shell & Auger	FIELDTEST	NOS.	SAMPLES	NOS.	SAMPLES	NOS.	Commenced on : 03.03.2018
Depth of Boring	40.000 M.	SPT	21	UDS	8	WS		Completed on : 07.03.2018
Type of Drilling		DCPT		DS	24	RCS		Water Struck At :2.70 M.
Depth of Drilling		VST		SCPT				Standing Water Table : 2.60 M.

D E S C R I P T I O N	SYMBOL	DEPTH	N-V A L U E	S A M P L E	
				NO.	DEPTH
Filled up soil with clayey silt, fly ash, sand, brick bats etc.		01		DS1	0.50 M
				DS2	1.00M
Medium to stiff brownish grey clayey silt/ silty clay.		02		DS3	1.50M
		03	G.W.T	UDS1	2.00-2.45M
		04	N = 8	SPT1	3.00-3.45M
		05		DS4	3.00-3.45M
		06	N = 10	UDS2	4.00-4.45M
		07		SPT2	5.00-5.45M
		08	N = 11	DS5	5.00-5.45M
		09		UDS3	6.00-6.45M
		10	N = 14	SPT3	7.00-7.45M
		11		DS6	7.00-7.45M
		12	N = 19	UDS4	8.00-8.45M
		13		SPT4	9.00-9.45M
		14	N = 14	DS7	9.00-9.45M
		15		UDS5	10.00-10.45M
		16	N = 19	SPT5	11.50-11.95M
		17		DS8	11.50-11.95M
		18	N = 14	UDS6	13.00-13.45M
		19		SPT6	14.50-14.95M
		20	N = 16	DS9	14.50-14.95M
		21		UDS7	16.00-16.45M
		22	N = 18	SPT7	17.50-17.95M
		23	N = 20	DS10	17.50-17.95M
		24	N = 23	UDS8	19.00-19.45M
Very stiff to hard brownish grey clayey silt/ silty clay with traces of kankar.				SPT8	20.50-20.95M
				DS11	20.50-20.95M
				SPT9	22.00-22.45M
				DS12	22.00-22.45M
				SPT10	23.50-23.95M
				DS13	23.50-23.95M
Contd.....					

SPT - Standard Penetration Test	VST- Vane Shear Test	DS - Disturbed Sample	WS - Water Sample
DCPT - Dynamic Cone Penetration Test.	UDS - Undisturbed Sample	SCPT-Static Cone Penetration Test.	RCS - Rock Core Sample



BORE LOG SHEET		Centre for Advanced Engineering						Bore Hole No.:BH-17 (Sheet 2)	
								Job No.: Soil - 1582	
Project: SOIL_BHEL_NTPC-KAHALGAON_ASH SILO									
Co-ord: E=4077.10, S= 1713.80		E.G.L.: 37.08		Unit:			Bore Hole Dia. :150 MM.		
Type of Boring	Shell & Auger	FIELDTEST	NOS.	SAMPLES	NOS.	SAMPLES	NOS.	Commenced on : 03.03.2018	
Depth of Boring	40.000 M.	SPT	21	UDS	8	WS		Completed on : 07.03.2018	
Type of Drilling		DCPT		DS	24	RCS		Water Struck At :2.70 M.	
Depth of Drilling		VST		SCPT				Standing Water Table : 2.60 M.	

D E S C R I P T I O N	SYMBOL	DEPTH	N-V A L U E	S A M P L E	
				NO.	DEPTH
Very stiff to hard brownish grey clayey silt/ silty clay with traces of kankar.		26	N = 24	SPT11	25.00-25.45M
				DS14	25.00-25.45M
			N = 29	SPT12	26.50-26.95M
				DS15	26.50-26.95M
			N = 31	SPT13	28.00-28.45M
				DS16	28.00-28.45M
			N = 28	SPT14	29.50-29.95M
				DS17	29.50-29.95M
			N = 26	SPT15	31.00-31.45M
				DS18	31.00-31.45M
Dense yellowish grey silty sand.		32	N = 24	SPT16	32.50-32.95M
				DS19	32.50-32.95M
			N = 26	SPT17	34.00-34.45M
				DS20	34.00-34.45M
			N = 28	SPT18	35.50-35.95M
				DS21	35.50-35.95M
			N = 33	SPT19	37.00-37.45M
				DS22	37.00-37.45M
			N = 37	SPT20	38.50-38.95M
				DS23	38.50-38.95M
Termination Depth 40.000 Mtr.		40	N = 43	SPT21	39.55-40.00M
				DS24	39.55-40.00M

SPT - Standard Penetration Test	VST- Vane Shear Test	DS - Disturbed Sample	WS - Water Sample
DCPT - Dynamic Cone Penetration Test.	UDS - Undisturbed Sample	SCPT-Static Cone Penetration Test.	RCS - Rock Core Sample



BORE LOG SHEET		Centre for Advanced Engineering						Bore Hole No.:BH-18 (Sheet 1)	
Project: SOIL_BHEL_NTPC-KAHALGAON_ASH SILO								Job No.: Soil - 1582	
Co-ord: E=4115.00, S= 1660.00		E.G.L.: 37.15		Unit:		Bore Hole Dia. : 150 MM.			
Type of Boring	Shell & Auger	FIELDTEST	NOS.	SAMPLES	NOS.	SAMPLES	NOS.	Commenced on : 07.03.2018	
Depth of Boring	40.000 M.	SPT	21	UDS	8	WS		Completed on : 10.03.2018	
Type of Drilling		DCPT		DS	24	RCS		Water Struck At : 3.30 M.	
Depth of Drilling		VST		SCPT				Standing Water Table : 3.20 M.	

D E S C R I P T I O N	SYMBOL	DEPTH	N-V A L U E	S A M P L E	
				NO.	DEPTH
Filled up soil with clayey silt, fly ash, sand, brick bats etc.		01		DS1	0.50 M
				DS2	1.00M
Medium to stiff brownish grey clayey silt/ silty clay.		02		DS3	1.50M
				UDS1	2.00-2.45M
		03	N = 6	SPT1	3.00-3.45M
		04		DS4	3.00-3.45M
				UDS2	4.00-4.45M
		05	N = 6	SPT2	5.00-5.45M
		06		DS5	5.00-5.45M
				UDS3	6.00-6.45M
		07	N = 10	SPT3	7.00-7.45M
		08		DS6	7.00-7.45M
				UDS4	8.00-8.45M
		09	N = 12	SPT4	9.00-9.45M
		10		DS7	9.00-9.45M
				UDS5	10.00-10.45M
		11			
		12	N = 15	SPT5	11.50-11.95M
				DS8	11.50-11.95M
		13		UDS6	13.00-13.45M
		14			
Very stiff to hard brownish grey clayey silt/ silty clay with traces of kankar.		15	N = 17	SPT6	14.50-14.95M
				DS9	14.50-14.95M
		16		UDS7	16.00-16.45M
		17			
		18	N = 21	SPT7	17.50-17.95M
				DS10	17.50-17.95M
		19		UDS8	19.00-19.45M
		20			
		21	N = 23	SPT8	20.50-20.95M
				DS11	20.50-20.95M
		22	N = 25	SPT9	22.00-22.45M
				DS12	22.00-22.45M
		23			
		24	N = 26	SPT10	23.50-23.95M
				DS13	23.50-23.95M
Contd.....					

SPT - Standard Penetration Test	VST- Vane Shear Test	DS - Disturbed Sample	WS - Water Sample
DCPT - Dynamic Cone Penetration Test.	UDS - Undisturbed Sample	SCPT-Static Cone Penetration Test.	RCS - Rock Core Sample

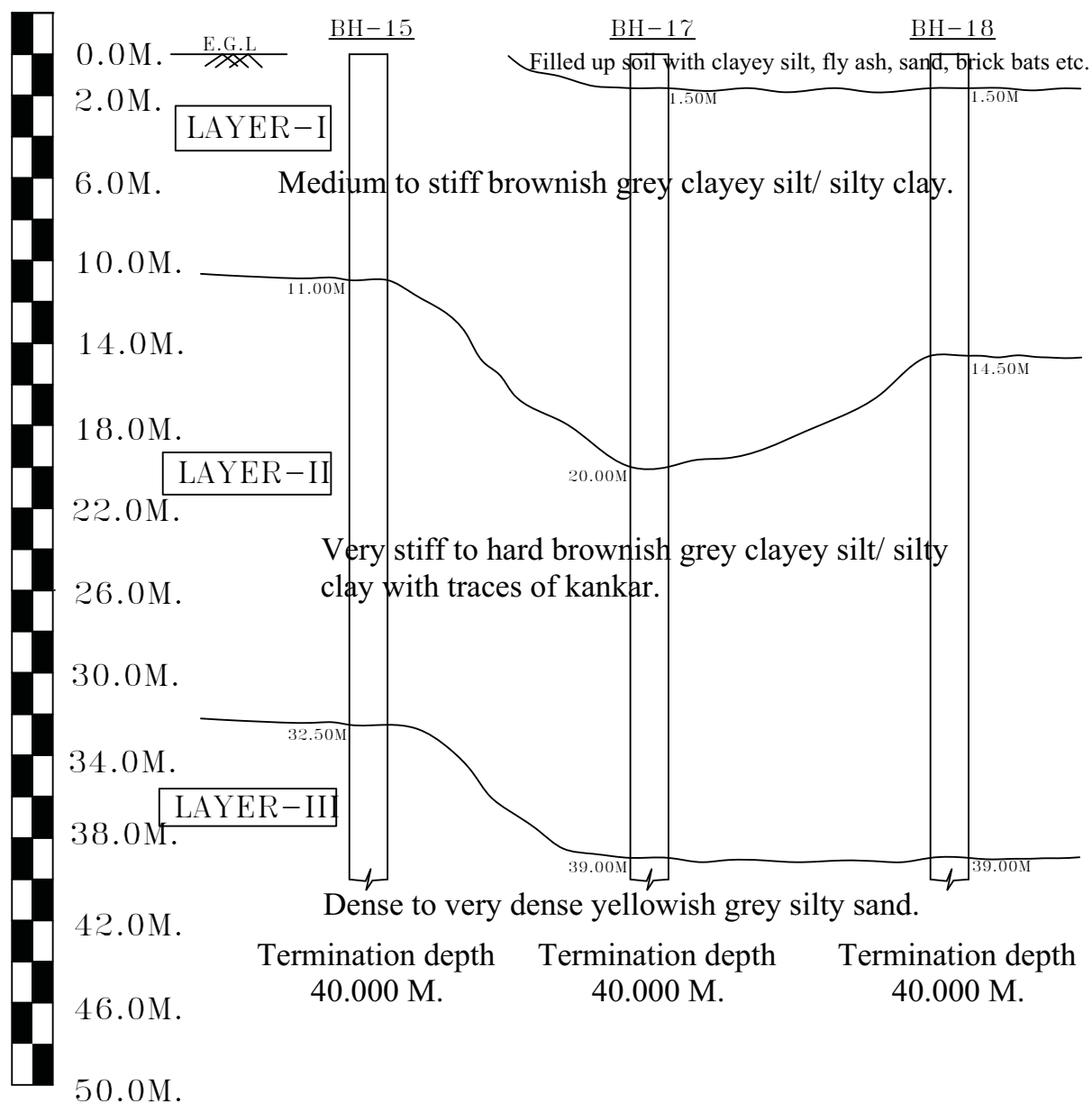
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BORE LOG SHEET		Centre for Advanced Engineering				Bore Hole No.: BH-18 (Sheet 1)	
Project: SOIL_BHEL_NTPC-KAHALGAON_ASH SILO						Job No.: Soil - 1582	
Co-ord: E=4115.00, S= 1660.00		E.G.L.: 37.15		Unit:		Bore Hole Dia. : 150 MM.	
Type of Boring	Shell & Auger	FIELDTEST	NOS.	SAMPLES	NOS.	SAMPLES	NOS.
Depth of Boring	40.000 M.	SPT	21	UDS	8	WS	
Type of Drilling		DCPT		DS	24	RCS	
Depth of Drilling		VST		SCPT			
						Commenced on : 07.03.2018	
						Completed on : 10.03.2018	
						Water Struck At : 3.30 M.	
						Standing Water Table : 3.20 M.	

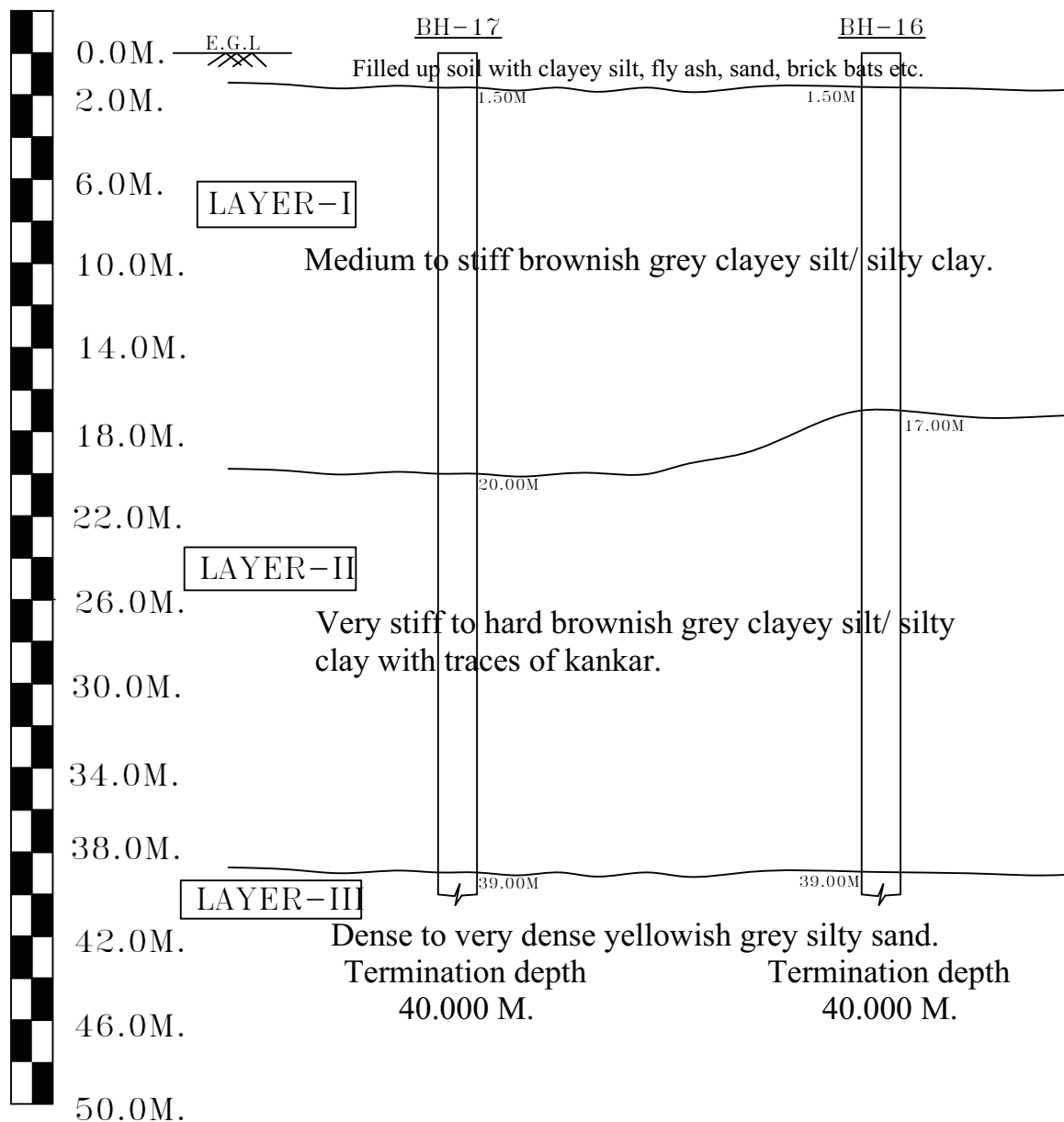
D E S C R I P T I O N	SYMBOL	DEPTH	N-V A L U E	S A M P L E	
				NO.	DEPTH
Very stiff to hard brownish grey clayey silt/ silty clay with traces of kankar.		26	N = 30	SPT11	25.00-25.45M
				DS14	25.00-25.45M
			N = 32	SPT12	26.50-26.95M
				DS15	26.50-26.95M
			N = 35	SPT13	28.00-28.45M
				DS16	28.00-28.45M
			N = 37	SPT14	29.50-29.95M
				DS17	29.50-29.95M
			N = 39	SPT15	31.00-31.45M
				DS18	31.00-31.45M
N = 41	SPT16	32.50-32.95M			
	DS19	32.50-32.95M			
N = 44	SPT17	34.00-34.45M			
	DS20	34.00-34.45M			
N = 46	SPT18	35.50-35.95M			
	DS21	35.50-35.95M			
N = 39	SPT19	37.00-37.45M			
	DS22	37.00-37.45M			
N = 52	SPT20	38.50-38.95M			
	DS23	38.50-38.95M			
N = 55	SPT21	39.55-40.00M			
	DS24	39.55-40.00M			
Very dense yellowish grey silty sand.		40			
Termination Depth 40.450 Mtr.		41			
		42			
		43			
		44			
		45			
		46			
		47			
		48			
		49			

SPT - Standard Penetration Test	VST- Vane Shear Test	DS - Disturbed Sample	WS - Water Sample
DCPT - Dynamic Cone Penetration Test.	UDS - Undisturbed Sample	SCPT-Static Cone Penetration Test.	RCS - Rock Core Sample



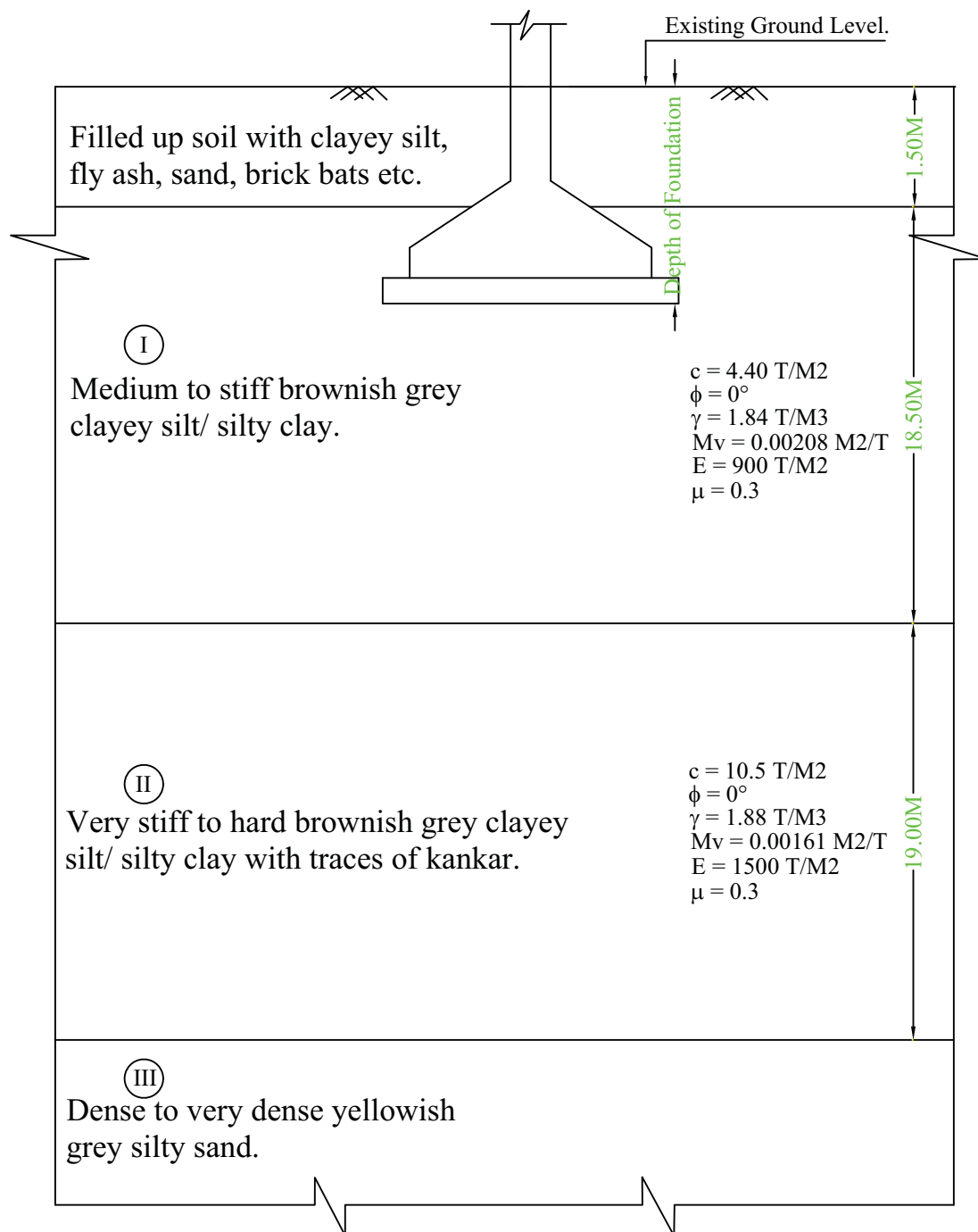
Sub-Soil Profile through BH-15, BH-17 & BH-18

Sketch No.-SK/BHEL-NTPC-KAHALGAON/ASH SILO/1582/02/1 of 2



Sub-Soil Profile through BH-17 & BH-16

Sketch No.-SK/BHEL-NTPC-KAHALGAON/ASH SILO 1582 02 2 of 2



Foundation Model

Scale :- N.T.S.

Sketch No.-SK/BHEL-NTPC-KAHALGAON/ASH SILO 1582 03 1 of 2



DETERMINATION OF BEARING CAPACITY:-

The Net Ultimate Bearing Capacity is given by:

$$q_{ult} = C.N_c.sc.dc.ic + q.(N_q-1).sq.dq.iq + 0.5\gamma.B.N_\gamma.s_\gamma.d_\gamma.i_\gamma.W'$$

[Ref. Clause 5.1.2(a), IS 6403:1981 (2002)]

Where,

N_c , N_q and N_γ are bearing capacity factors,

sc , sq and s_γ are shape factors,

dc , dq and d_γ are depth factors,

ic , iq and i_γ are inclination factors,

C = Cohesion

q = Overburden pressure,

γ = Effective density below foundation.

B = Width of foundation,

W' = Water Table Correction Factor.

Size of Footing = 3.00M X 3.00M

Cohesion, C = 4.40 t/sqm

Density, γ = 1.84 t/sqm

Bearing Capacity Factor

For ϕ = 0 degree, the bearing capacity factors are:

$$\left. \begin{array}{l} N_c = 5.14 \\ N_q = 1.00 \\ N_\gamma = 0.00 \end{array} \right\} \text{Ref: Table-1 of IS: 6403-1981 (2002)}$$

Foundation Dimensions

Depth of Foundation= D_f = 2.50 M (below EGL)

Width of Foundation= B = 3.00 M

Length of Foundation= L = 3.00 M

Now $q = (\gamma - 1) \times D_f = 0.84 \times 2.5 = 2.1$ t/sqm

Shape factors are [IS:6403 - 1981]

$$sc = 1.30 \quad sq = 1.20 \quad s_\gamma = 0.80$$

Depth factors are [IS:6403 - 1981]

$$dc = 1.17 \quad dq = 1.00 \quad d_\gamma = 1.00$$

Computed Net Ultimate Bearing Capacity = 34.39 t/sqm

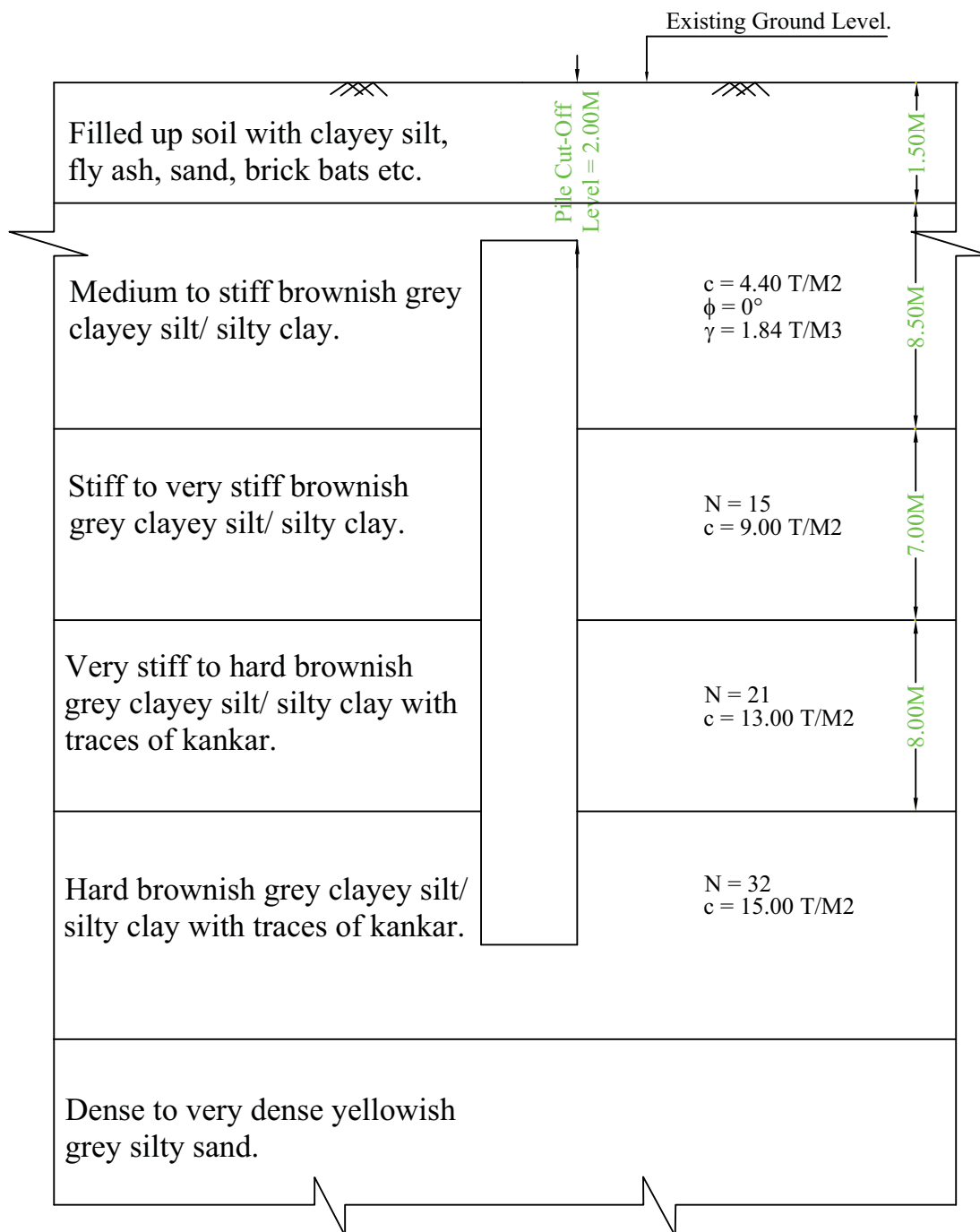
Using a factor of safety of 2.5, Net Safe Bearing Capacity = 13.75 t/sqm



SETTLEMENT CALCULATION:-

Depth of Foundation= Df = 2.50 M (below EGL)
 Width of Foundation= B = 3.00 M
 Length of Foundation= L = 3.00 M
 Net base Pressure, P = 13.75 t/sqm

Strata	From	To (M)	Thickness of compressible	Mid depth below Founding	ΔP	Young's Modulus	Poisson's Ratio μ	Mvc	Influence Factor I	Elastic settlement	Consolidation Settlement	Pore Water Pressure Factor	Corrected Consolidation Settlement	Total Corrected Settlement
	(m)	(m)	(m)	(m)	t/sqm	t/sqm		sqm/t		mm	mm		mm	mm
I	2.50	8.50	6.00	3.00	3.44	900	0.3	0.00208	0.95	39.62	42.90	0.70	30.03	69.65
Total Settlement														69.65
Depth Correction Factor														0.77
Rigidity Correction Factor														1.00
Hence, corrected Total Settlement =														53.69
The calculated settlement is beyond the settlement limit of 40mm														
Hence, Recommended bearing capacity for 40mm settlement is = 10.24 t/sqm														



Pile Model

Scale :- N.T.S.

Sketch No.-SK/BHEL-NTPC-KAHALGAON/ ASH SILO 1582 03 2 of 2



Ultimate Skin Friction Capacity

Project: Geo-technical investigation pertaining to associated civil works for retrofitting of ESPs for ESP R & M 4X210 MW (U#1,2,3&4) Kahalgaon STPP, NTPC, Bhagalpur, Bihar.

Location: Kahalgaon STPP, NTPC, Bhagalpur, Bihar.

Layer No: 1

Soil Description Medium to stiff brownish grey clayey silt/ silty clay.

Sl.No	Pile Dia , D	Pile-Depth of termination wrt FGL	Depth of layer top from EGL	Depth of layer bottom from EGL	Reduction factor, α (Note1 IS 2911(Part1/Sec2)	Average Cohesion along the length of the pile in this layer, C	Surface area of the pile shaft in this layer, A_s	Ultimate Skin friction capacity of the shaft in this layer, $Q_{su} = \alpha * C * A_s$
	m	m	m	m		T/m ²	m ²	
1	0.600	29.000	2.000	10.000	0.98	4.4	15.080	65.023
2	0.760	29.000	2.000	10.000	0.98	4.4	19.101	82.363



Ultimate Skin Friction Capacity

Project: Geo-technical investigation pertaining to associated civil works for retrofitting of ESPs for ESP R & M 4X210 MW (U#1,2,3&4) Kahalgaon STPP, NTPC, Bhagalpur, Bihar.

Location: Kahalgaon STPP, NTPC, Bhagalpur, Bihar.

Layer No:

2

Soil Description

Stiff to very stiff brownish grey clayey silt/ silty clay with traces of kankar.

Sl.No	Pile Dia , D	Pile-Depth of termination wrt FGL	Depth of layer top from EGL	Depth of layer bottom from EGL	Reduction factor, α (Note 1 IS 2911 (Part1/Sec2)	Average Cohesion along the length of the pile in this layer, C	Surface area of the pile shaft in this layer, A_s	Ultimate Skin friction capacity of the shaft in this layer, $Q_{su} = \alpha * C * A_s$
	m	m	m	m		T/m ²	m ²	
1	0.600	29.000	10.000	17.000	0.5	9.0	13.195	59.376
2	0.760	29.000	10.000	17.000	0.5	9.0	16.713	75.210



Ultimate Skin Friction Capacity

Project: Geo-technical investigation pertaining to associated civil works for retrofitting of ESPs for ESP R & M 4X210 MW (U#1,2,3&4) Kahalgaon STPP, NTPC, Bhagalpur, Bihar.

Location: Kahalgaon STPP, NTPC, Bhagalpur, Bihar.

Layer No: **3**

Soil Description Very stiff to hard brownish grey clayey silt/ silty clay with traces of kankar.

Sl.No	Pile Dia , D	Pile-Depth of termination wrt FGL	Depth of layer top from EGL	Depth of layer bottom from EGL	Reduction factor, α (Note 1 IS 2911(Part1/Sec2)	Average Cohesion along the length of the pile in this layer, C	Surface area of the pile shaft in this layer, A_s	Ultimate Skin friction capacity of the shaft in this layer, $Q_{su} = \alpha * C * A_s$
	m	m	m	m		T/m ²	m ²	
1	0.600	29.000	17.000	25.000	0.35	13.0	15.080	68.612
2	0.760	29.000	17.000	25.000	0.35	13.0	19.101	86.909



Ultimate Skin Friction Capacity

Project: Geo-technical investigation pertaining to associated civil works for retrofitting of ESPs for ESP R & M 4X210 MW (U#1,2,3&4) Kahalgaon STPP, NTPC, Bhagalpur, Bihar.

Location: Kahalgaon STPP, NTPC, Bhagalpur, Bihar.

Layer No:

4

Soil Description

Hard brownish grey clayey silt/ silty clay with traces of kankar.

Sl.No	Pile Dia , D	Pile-Depth of termination wrt FGL	Depth of layer top from EGL	Depth of layer bottom from EGL	Reduction factor, α (Note 1 IS 2911 (Part1/Sec2)	Average Cohesion along the length of the pile in this layer, C	Surface area of the pile shaft in this layer, A_s	Ultimate Skin friction capacity of the shaft in this layer, $Q_{su} = \alpha * C * A_s$
	m	m	m	m		T/m ²	m ²	
1	0.600	29.000	25.000	29.000	0.3	15.0	7.540	33.929
2	0.760	29.000	25.000	29.000	0.3	15.0	9.550	42.977



Ultimate End Bearing capacity

Project: Geo-technical investigation pertaining to associated civil works for retrofitting of ESPs for ESP R & M 4X210 MW (U#1,2,3&4) Kahalgaon STPP, NTPC, Bhagalpur, Bihar.

Location: Kahalgaon STPP, NTPC, Bhagalpur, Bihar.

Layer No: 4

Soil Description Hard brownish grey clayey silt/ silty clay with traces of kankar.

Sl.No	Pile Dia , D	Total Length of Pile, L	Depth of layer top from EGL	Depth of layer bottom from EGL	Average Cohesion at the pile tip, C_p	Cross sectional area of the pile tip, A_p	Bearing capacity factor, N_c	UltimateEnd bearing capacityat pile tip, $Q_{BU} = A_p * N_c * C_p$
	m	m	m	m	T/m ²	m ²		T
1	0.600	29.000	25.000	29.000	15.0	0.283	9.000	38.170
2	0.760	29.000	25.000	29.000	15.0	0.454	9.000	61.242



Horizontal Shear Capacity of Pile

Sample Calculation:-

$$C \text{ Value} = 0.44 \text{ Kg/cm}^2$$

$$\text{Pile-Depth of termination wrt FGL} = 29.00 \text{ m}$$

$$\text{Cut-off Level of Pile} = 2.00 \text{ m}$$

$$\text{Dia of Pile (D)} = 0.600 \text{ m}$$

$$f_{ck}, \text{ for M25 grade of concrete} = 25 \text{ N/mm}^2$$

$$E_p = E_{conc} = \text{Young's modulus} = 25000 \text{ MN/m}^2$$

$$I_p \text{ (Moment of inertia of the pile cross-section)} = 0.00636 \text{ m}^4$$

$$\text{Neglecting the effect of steel we get } E_p I_p = 159 \text{ MN.m}^2$$

$$\eta_h = \text{Modulus of Subgrade Reaction} = 1.200 \text{ MN/m}^3$$

From Reese and Matlock (1956) for fixed head pile deflection ρ_z is given as

$$\rho_z = (A_p - 0.93B_p) \times [(Q_h \times T^3) / E_p I_p] \dots \dots \dots (A)$$

Where, ρ_z is deflection

A_p and B_p are co-efficients given by Matlock and Reese for different Z values

$$Z = (z/T) \dots \dots \dots (B)$$

z = depth of pile top

$$T \text{ is given as } T = (E_p I_p / \eta_h)^{1/5} \dots \dots \dots (C)$$

Q_h = Horizontal Force at depth z

$$\text{Therefore, } T = 2.657 \text{ m, From equation (C)}$$

$$\text{For cut-off length of pile of 2M, } z = 2.000 \text{ m}$$

$$\text{Therefore, } z/T = 0.752639 \text{ From equation (B)}$$

So, For $Z = 0.7526$ we get, from the table proposed by Matlock and Reese

$$A_p = 1.284$$

$$B_p = 0.591$$

$$\text{From equation A, we get } Q_h = (\rho_z \times E_p \cdot I_p) / [(A_p - 0.93B_p) \cdot T^3]$$

For an allowable deflection of 5mm we get allowable horizontal capacity as

$$Q_h = 0.05769294 \text{ MN}$$

$$= 5.89 \text{ T}$$