

PROJECT	SUBJECT	DOCUMENT NO.	REV.	SECTION
NLC India Limited NLC Talabira Thermal Power Project- 3x800 MW Jharsuguda, Odisha	Geotechnical Investigation Report Part-1 (BTG Area)	PE-DC-511-602-C001	3	
				SHEET NO.
				1



**NLC India Limited
NLC Talabira Thermal
Power Project- 3x800 MW
Jharsuguda, Odisha**

**GEOTECHNICAL INVESTIGATION REPORT
PART-1 (BTG AREA)**

BHEL DOCUMENT NO. PE-DC-511-602-C001

(REVISION R3)

**BHARAT HEAVY ELECTRICALS LIMITED
NEW DELHI**



Bharat Heavy Electricals Limited (B H E L)

**Technical Report of Geotechnical Investigation for
Proposed Structures in Phase 1 of 3 x 800 MW NLC
Talabira Thermal Power Project (NTTPP) at village
Hirma, Talabira, Odisha**

PART – 1

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Geotechnical Investigation Report of 3x800 MW NLC Talabira TPS has been divided in following parts as detailed below:

S. No.	Description	Area covered
1	Part-1	BTG area (Transformer yard to Chimney including FGD)
2	Part-2A & 2B	Compound wall
3	Part-3	Thermal project office building, Main gate complex, security & time office, gates, parking lots, watch towers, rain water collection ponds & rain water pump houses (outside plant boundary) etc.
4	Part-4	BOP area (Switchyard, PT Plant, ETP, STP, WTP, IDCT, CW system, Raw water system, Chlorination system, Miscellaneous. Buildings, Raw water reservoir etc.)
5	Part-5	CHP & AHP area
6	Part-6	Field test results of all areas (DCPT, SCPT, SRT, Pressure meter test, Cross hole shear test, PLT, CPLT, BVT, Pump in & pump out type field permeability etc.)

This is Geotechnical Investigation Report, Part-1 (BTG Area)



3 X 800 MW NLC Talabira Thermal Power Project
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COMMENT RESOLUTION SHEET

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		Approval Category : -		Approval Category : Cat- 3			Approval Category : 2	
Section-B Comments								
1	General	BHEL shall mention the details of proposed number of parts/volumes for Soil investigation report including detailed list of tests / list of areas being covered in each Soil report part/volume. Accordingly, for the recommendations with respect to particular area corresponding Soil report part/volume shall be referred.	This is part-1 of the report. Geotechnical investigation is already in process at site. Based on the report for BTG area, capacity of pile and bearing capacity in case of open foundation can be finalised. The requirement as commented will be executed for complete report.	As informed by BHEL, Soil investigation reports will be submitted in multiple parts for approval. Each part will have a separate document number and title. Hence, BHEL shall be dividing the boreholes in multiple parts instead of submitting whatever boreholes are completed at site in a document. This will help in detailed engineering. If Part-I is confined to BTG area, all BTG area related boreholes and test shall be included in part-1 itself after completion at site.	BHEL agreed to incorporate details of Boreholes & Tests covered in each volume and shall be grouped areawise. For example, all BTG area Boreholes shall be included in Part-1 report only. BHEL also confirmed that after completion of pending boreholes, respective Borelogs, lab test results recommendations shall be included in the respective volumes. NLCIL Noted.	Incorporated in revised report R2.	Noted. BHEL is aware that there are still additional boreholes which are to be completed in BTG area. Hence, this report shall be approved in Cat-II only till the completion of all the boreholes corresponding to BTG area..	All the bore holes of BTG area have been completed and updated in revised report R3.
2	General	It is observed that the all the considered number of boreholes for a particular area/system as per approved Geotechnical investigation layout are not completed in full in many cases. For example, 5 Nos boreholes (BH-35, BH-79, BH-84, BH-93 & BH-94) are considered in Boiler-Unit-2 area. However, BH-94 is only presented in this report and recommendation for Boiler - Unit-2 foundations are being made. Similarly, ESP-1 recommendation is submitted without data corresponding to BH-51. Switchyard recommendation is submitted based on only one BH-89. This practice is not acceptable.	Please note that geotechnical investigation works is in progress. BHEL will submit the complete report as per approved geotechnical investigation layout only. BHEL submitted the report to expedite the approval of test pile drawing at site after finalization of pile capacity. This is part-1 report in which borelog attached which were already executed at site.	BHEL has submitted recommendations for particular area/system without completion of all corresponding Boreholes. BHEL shall clarify the method to be adopted if any incomplete borehole turns out to be critical one. Hence, for the areas where the investigation is completed, the report can also be approved if it is provided as unitwise instead of combining units.	See reply to Point 1 above.	Incorporated in revised report R2.	Ok. Noted.	All the bore holes of BTG area have been completed and updated in revised report R3.
3	General	Recommendations for particular area shall be submitted based on all the Test reports corresponding to that area including plate load tests, penetration tests, dynamic soil properties, etc.						
4	General	Table of contents with page numbers shall be included for easy reference.	Noted and incorporated.	Noted. Point closed.	-	-	-	-
5	Report	In page 1 of 196, it is mentioned that submitted document is an interim report. Part-I report shall be mentioned. BHEL shall ensure that recommendations corresponding to a particular area shall not be modified after approval of that soil report part/volume.	Noted	Noted. BHEL shall ensure the same.	BHEL confirmed. Point closed.	-	-	-
6	Report	In 2.1 exploratory drilling, details like planned termination depth as per approved geotechnical investigation layout and reasons/remarks for early Borehole termination shall be included in the table.	Table is prepared as mention here and it is add in section 2.1. of report.	Noted. Point closed.	-	-	-	-
7	Layout	Locations of Boreholes BH-81, BH-92, BH-94 and BH-115 as per submitted investigation report is not matching with approved Geotechnical investigation layout. For example BH-115 is away from its approved location by 900m. Hence, BHEL shall reconfirm the actual locations of Boreholes executed at NTTPP site to avoid any erroneous recommendations.	Coordinate of the BH-81, BH-92, BH-94 & BH-115 in the written in the report has writing error. These boreholes checked with field borelog and corrected in the report. These boreholes were investigated on the location as per the geotechnical investigation layout. Mismatch of location is observed is only due to writing error.	Noted that mismatch of location is due to writing error. However, the location co-ordinates are yet to be corrected in the resubmitted document.	BHEL informed that certain Borehole locations are slightly modified from approved layout due to site constraints. Revised co-ordinates will be incorporated during resubmission in-line with actual execution at site. NLCIL Noted.	Incorporated in revised report R2.	Ok. Noted.	-
8	Report	In 4.0 results, bore log details and laboratory results are not available in reported locations.	We have reviewed the comments. Details are already available.	Page numbers related to Borelogs and lab test results are corrected in this revision. Point closed.	-	-	-	-
9	Report	As per specification, GWT shall be considered at FGL for all designs. Accordingly, 5.1 and 8.0 (2) of soil report shall be modified.	Noted and incorporated.	In line with the comment, 5.1 of report is corrected. But 8.0 (2) of the report is yet to be corrected. BHEL to check.	BHEL confirmed that report will be corrected in line with the comments. NLCIL noted.	Incorporated in revised report R2.	Ok. Noted.	-
10	Report	In 7.0 Computation of Safe bearing Capacity, it was recommended that filled up soil between NGL and FGL shows SPT N value of at least 22. Fill soil properties and compaction measures to ensure the same shall be suggested. M/s BHEL shall ensure compliance to the recommendations at site.	Noted.	BHEL has not submitted any suggestions for Fill soil properties and compaction measures. BHEL to check.	BHEL informed that fill soil details and compaction measures will be excluded from this report as pile cutoff levels of different areas is considered at or below NGL. NLCIL Noted.	Fill soil details and compaction measures are deleted in revised report R2.	Ok. Noted.	-
11	Report	In S. No. 4 of 8.0 Conclusions, detailed analysis corresponding to liquefaction shall be included in final report. BHEL shall include the same in this report.	This site is non-liquefiable. However, as suggested the same shall be incorporated.	Noted. Point closed.	-	-	-	-
12	Report	BHEL shall include detailed sample calculation for obtaining pile lateral capacity.	Please refer clause no 6 of appendix 11 to 21 for the same.	BHEL to note that sample calculation is included in page 90/215 in line with the comment.	BHEL Noted. Point closed.	-	-	-



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13	Report	BHEL shall include detailed sample calculation for obtaining bearing capacities of one open foundation instead of tabulation.	Please refer appendix 1 to 10 for the same.	BHEL to note that sample calculation is included in page 94/215 in line with the comment.	BHEL Noted. Point closed.	-	-	-
14	General	As per clause 2.00.00, Section-II, Volume-II-G1, Bearing capacities of open foundations and Pile capacities based on contractor's soil investigation shall be compared with recommendations of nearest boreholes as per Owner's soil report and design shall be based on conservative values. Hence, BHEL shall include summary of conservative values to be considered for design of structures area-wise.	This shall be finalised as per the discussion with NLC	Noted. BHEL shall ensure the same.	BHEL confirmed that recommended pile capacities shall be finalised after considering the nearest borehole as per owner's soil investigation report also. NLCIL Noted.	Suitably incorporated in revised report R2.	Noted. However, the finalised pile capacities shall be reviewed after completion of all the boreholes in BTG area if required.	Noted.
15	Calculation	Since the pile is founded on rock, the reason for not following IS 14593 guidelines for pile capacity calculation (IS-14593-Design & Construction of Bored cast-in-situ piles founded on rocks) may be clarified by BHEL.	pile is founded on the soft rock. Hence, safe load carrying capacity was worked out based on IS 2911 instead of IS 14893	Noted. Point closed.	-	-	-	-
16	Report	Permissible settlement shall be limited to 25mm for plant buildings and 40mm for non-plant buildings as per specification for all types of open foundations. Revise the recommendations for open foundation accordingly.	In the geotechnical investigation report, bearing capacities were furnished for both 25mm and 40mm. Structure engineer will take the bearing capacity based on permissible settlement as specified in specification.	Bearing capacity recommendations for 75mm is available in Summary of allowable capacities in page 7/215 which are not relevant to this project. For foundations of width greater than 6m, recommendations are available for 40mm and 75mm only. Refer Appendix 3 and 6. BHEL to clarify the methodology for adopting bearing capacities for 25mm settlement for open foundations of width above 6m.	BHEL agreed to incorporate bearing capacity recommendations for only 25mm and 40 mm permissible settlement in all the locations. Details corresponding to 75mm settlement shall be deleted as the same is not permitted as per technical specification. NLCIL Noted.	Incorporated in revised report R2.	Ok. Noted.	-
17	General	BHEL to confirm that socketing length has been provided below availability of rock as per Bore log data for all bore hole/ pile location.	Socketing length shall be inside rocky strata only.	Noted. Point closed.	-	-	-	-
18	Report	Since recommendations are provided for fixed head condition, BHEL shall confirm that only fixed head pile condition will be used for the detail engineering.	Fixed head pile condition will be on all job piles. However, free head piles condition will be in test piles.	Noted. Point closed.	-	-	-	-
19	Calculation	For piles, Lateral capacity shall be restricted to 5% of vertical capacity as per specification. Revise lateral pile capacities accordingly.	This shall be finalised as per the discussion with NLC	Noted. BHEL shall ensure the same.	BHEL agreed to restrict lateral capacity to 5% of vertical capacity. NLCIL Noted.	Incorporated in revised report R2.	Ok. Noted.	-
20	Calculation	Uplift capacity shall be restricted to 25% of vertical capacity+ buoyant weight of pile as per specification. Revise uplift capacities accordingly.	This shall be finalised as per the discussion with NLC	Noted. BHEL shall ensure the same.	BHEL agreed to restrict uplift capacity to 25% of vertical capacity. NLCIL Noted.	Incorporated in revised report R2.	Ok. Noted.	-
21	Report	In summary of design parameters (from page 10/196), soil properties are presented depth wise from NGL. In pile capacity calculations from Appendix 11 to 21, soil properties used are at depths from FGL. These soil properties are not matching. BHEL to clarify the same.	Please note that cut off level is considered as 2m below FGL wherein pile capacity were worked out considering the remaining fill wherever applicable.	Noted. Point closed.	-	-	-	-
22	Report	In pile capacity calculation for ESP-1 in appendix-13, soil properties are used for depth 2m to 5m from FGL 202.5M in calculations. However, NGL is around 197M. BHEL clarify the considered properties. BHEL shall check for other bore holes also regarding the same.	This shall be suitably corrected.	Noted. Point closed.	-	-	-	-
23	Calculation	Whenever pile cut off level is considered above NGL and filling in encountered, negative skin friction to be accounted in pile capacity calculation.	In case of fill, Negative skin friction need not to apply for non-sensitive soil. However, for pile capacity calculation, skin friction can be ignored.	Noted. Point closed.	-	-	-	-
24	Calculation	In pile capacity calculations under appendix 11 to 20, as per 7.0 Notes, Required set as suggested in pile termination criteria may be indicated.	Clause no 7 shall be modified as per discussion with NLC	Noted. Point closed.	-	-	-	-
25	Lab results	In laboratory test results, UCS for Point load index for rock values are for saturated condition or unsaturated condition? Whether these values are considered in pile capacity calculation? BHEL may clarify.	UCS for Point load index for rock values are for saturated condition and the same is being used for pile capacity calculation.	Noted. Point closed.	-	-	-	-



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26	Report	For piles terminating in Soil Strata, recommendations are submitted for all areas based on single borehole BH-50. Reasons for the same may be clarified. For each area, separate recommendation shall be provided considering variation in soil strata. For piles terminating in Soil Strata, termination criteria shall be indicated.	Pile length/capacites are based on the different bore log areawise. Please refer the summary of design parameters in the report.	BHEL reply is not clear. Please refer Appendix 17 of resubmitted document. Based on BH-50, recommendation is provided for piles terminating in soil strata for all areas. Reasons for the same may be clarified. For each area, separate recommendation shall be provided considering variation in soil strata. For piles terminating in Soil Strata, termination criteria shall be indicated.	BHEL informed that recommendations corresponding to piles terminating in soil strata shall be given areawise as per respective borehole. NLCIL Noted.	Incorporated in revised report R2.	Ok. Noted.	-
27	General	For open foundation depth of footing shall be not less than 1.0m below virgin soil. Accordingly, SBC recommendation table may be revised for open foundations.	This shall be suitably corrected.	For Power house area, based on BHs-50, 61, 66, 108 & 123, Average EGL is arrived as 201.2M. However, Average Egl was found to be 200.64M. Further, SBC recommendations are provided upto 4m below FGL 202.5M i.e, upto 198.5M. However, as per BH-123, EGL is at 198.42M. BHEL shall revisit the methodology adopted and ensure that SBC recommendations are available for maintaining the condition that depth of footing shall be not less than 1.0m below virgin soil.	BHEL agreed that recommendations shall be revised based on lowest NGL level for a particular area to avoid such issues. NLCIL Noted.	Incorporated in revised report R2.	Ok. Noted.	-
28	Report	In summary of design parameters (from page 10/196), shear strength Qc is provided without mention of assumed N value based on extrapolation. The same shall be included in the design parameter tables for clarity.	Shear strength Qc is worked out based on the lab test and SPT N both.	Noted. Point closed.	-	-	-	-
29	Report	In pile capacity calculations under appendix 11 to 20, as per 3.0 Design Considerations, It is suggested to keep socket length of at least 4 D in to foliate shale. As per Bore log data, few boreholes encountered foliated shale as topmost rock. BHEL shall review recommended socketing length for such boreholes.	The socketing length is as per specification and required pile capacity. Hence OK.	Noted. Point closed.	-	-	-	-
30	General	BHEL shall submit recommendation center to center distance of piles based on soil profile at site.	Noted and incorporated.	Not incorporated. BHEL may inform the clause/ page number if incorporated.	BHEL informed that pile spacing details shall be submitted in detailed piling drawing by following IS Codal provisions. NLCIL Noted.	-	-	-
31	Report	NGL reduced levels for BH-94 is not mentioned in Laboratory test results and NGL reduced levels for BH-68, BH-82 & IBH-36 are not mentioned in bore log data.	NGL reduced level of BH-94 in laboratory test result and in borelog BH-68, BH-82, IBH-36 included in report.	Noted. Point closed.	-	-	-	-
32	General	Site photographs may be added.	Site photograph included in the report.	Noted. Point closed.	-	-	-	-
Section-A Comments								
33	Section A	It is noted that details and recommendations for Boreholes pertaining to Section A works as per Approved Geotechnical investigation layout PE-DG-511-602-C001 R2 has not been included in report. To be reviewed and incorporated.	Please note that geotechnical investigation works is in progress. BHEL will submit the complete report as per approved geotechnical investigation layout only. BHEL submitted the report to expedite the approval of test pile drawing at site after finalization of pile capacity. This is part-1 report in which borelog attached which were already executed at site.	Noted. It is understood that M/s BHEL will be submitting remaining soil report subsequently.	BHEL confirmed. Point closed.	-	-	-
34	Section A	As per Cl. 6.1, General, it is mentioned that water logging with present topographical levels is imminent and raising of GL is required. FGL for Plant area is 202.5 and cooling tower area is 202.0. It is suggested to review water logging hazard mentioned w.r.t FGL of 202.5/202.00	It is planned to raise the FGL up to RL 202.5 which is above the flood level and therefore in that circumstances water logging at that site may not take place	Cooling tower area grading is proposed at +202.00 as per site grading layout. Cl. 6.1, General may be reviewed w.r.t +202.00 as well.	BHEL confirmed. Point closed.	-	-	-
35	Section A	It is noted that assumptions such as SPT value of atleast 22 has been mentioned for filled up soil in Cl. 7.0. Moreover, characteristic of soil in filling is not known at this stage as mentioned in Cl. 7.0. It is suggested that on completion of site grading, confirmatory soil investigation shall be done to ensure the same. Further, for light weight buildings/ small structures (e.g., Watch towers, Security buildings etc.), possibility of supporting structures in filled up earth may be reviewed based on revised soil investigation after site grading.	While Filling above NGL to FGL in layers, necessary compaction test is to be done to assess the quality of fill	M/s BHEL to ensure SPT value of 22 to match the assumption. Further, as per Cl. 8.0 (1) Initial and routine pile load tests shall be carried out on the piles at site as per IS: 2911 Part 4. M/s BHEL to ensure same.	BHEL confirmed. Point closed.	-	-	-
36	Section A	Further it is noted that, properties for fill material is mentioned in Cl. 8.0 (5). As per Cl. 1.1 of Ch II, Part II, Vol IB (Section A), suitability of available earth for grading shall be tested and approval shall be obtained by contractor from IIT/IISc/NIT. M/s BHEL is requested to identify the source for fill material and conduct necessary tests to ensure the suitability of available earth for fill material.	Noted	-	-	-	-	-



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37	Section A	As per Cl. 7.0, it is proposed to fill up entire plot premises to RL 202.50. However, as per site grading layout, Plant area and coal handling area is proposed to be graded to 202.5 and cooling tower area is proposed to be graded to 202.00. To be reviewed and corrected.	This shall be suitably corrected.	Noted.	BHEL Noted. Point closed.	-	-	-
38	General	In summary of Allowable bearing pressure for various structures (Pg 7), SBC for foundation size 1.50 m width may also be added.	This is already marked in the range of width in recommendation part.	Noted.	BHEL Noted. Point closed.	-	-	-
39	General	In summary of Pile capacity recommendation (Pg 8), pile capacity for 450 mm dia may also be added to table apart from 600 mm and 760 mm/ 900mm.	450MM is used only in boundary wall. 600mm and 760 mm is used in case plant area.	Noted. It is understood that pile capacity for 450 mm dia pile will be submitted separately.	BHEL confirmed that pile capacities for 450mm dia for boundary wall will be submitted separately. Point closed.	-	-	-
40	General	In Page 14, in table, depth of foundation is mentioned from NGL. However, in page 7 & in footnote of page 14, depth of foundation is mentioned as below FGL (RL 202.5m). In general, it is suggested to indicate depth of foundation for all structures from FGL. FGL to be taken as 202.5 for Main plant area/Coal Handling area and 202 for Cooling tower area.	This shall be suitably corrected.	Noted.	BHEL Noted. Point closed.	-	-	-
41	General	Typical calculations for arriving at SBC shall added in report indicating equations/formula adopted as per IS 6403 for shear criteria and as per IS 8009 for settlement criteria as well.	The same were already adopted.	Noted.	BHEL Noted. Point closed.	-	-	-
42	General	Chemical analysis of Ground water sample shall be conducted and shall be enclosed.	Noted	Noted.	BHEL Noted. Point closed.	-	-	-
43	General	As per Cl. 6.2 of report, Factors that influence soil corrosivity include pH, electrical resistivity, and chemical constituents (chloride, sulfate, etc.) and based on the test results, soil is classified as Class I. The test results of chemical analysis of soil sample is not enclosed in the report. The same shall be furnished to ensure that deleterious chemicals are not present.	This will be covered in other part of the report.	Noted.	BHEL Noted. Point closed.	-	-	-
44	General	It is suggested to include core box photos of soil samples.	Photographs of core boxes of soil sample is included in the report.	Noted.	BHEL Noted. Point closed.	-	-	-
		Section-B Comments						
45				Recommendations for pile capacities of Bored Cast-in-situ RCC piles socketed inside rock are available in Page 8/215 and 9/215 with different values for Later capacities (fixed head) and uplift capacities. BHEL shall clarify.	BHEL confirmed that report will be corrected in line with the comments. NLCIL noted.	Incorporated in revised report R2.	Ok. Noted.	-
46				For Boiler & Mill Bunker UNIT-3, recommended pile capacities have been increased in R1 document on comparison with R0 document and corresponding calculations have been deleted in R1 document. IBH36 is the governing borehole for Boiler area. BHEL shall clarify.	BHEL informed that pile capacities for Boiler & Mill Bunker UNIT-3 area were wrongly mentioned in R0 document and revised calculations shall be submitted in R2 document. NLCIL noted.	Incorporated in revised report R2.	Ok. Noted.	-
47				In appendix 9 & 13, 11 cm penetration (average) in 50 blows during SPT. However, in N value calculations 6cm and 7cm penetration is used erroneously. Accordingly, N values of 250 and 214 are to be reduced.	BHEL noted the errors and confirmed that report will be corrected in line with the comments. NLCIL noted.	Incorporated in revised report R2.	Ok. Noted.	-

Table of Contents

SR No.	Contents	Page No.
1	Introduction	1
2	Field Investigation	1
3	Laboratory investigation	4
4	General geology of site	5
5	Subsurface Soil Conditions	5
6	Computation of safe bearing capacity	6
7	Conclusions	6
8	Limitation	7
9	Summary of allowable bearing pressure	8
10	Recommendations & summary for RCC Bored cast-in-situ Pile Capacity for piles socketed inside rock	10
11	Recommendations & summary for RCC Bored cast-in-situ Pile Capacity for piles terminating in soil strata	14
12	Summary of design parameter	18
13	Appendix -1 to 21	39
14	Appendix -1 to 18"(Revision 03)	124
15	Sample liquefaction analysis	200
16	Sample calculation for allowable bearing pressure	202
17	Sample calculation for lateral capacity of pile	206
18	Notations	208
19	References	209
20	Results of laboratory tests	215
21	Investigation Layout Plan	282
22	Bore log data sheets	283
23	Core box photographs	350
24	Field photographs	353

Report on Geotechnical Investigation for Proposed Structures in Phase 1 of 3 x 800 MW of NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

1.0 Introduction

This report is presented based on limited numbers of geotechnical investigation locations. The detailed scope of work for entire of investigation work was decided by officials of BHEL. A complete geotechnical investigation was undertaken by us to obtain the required subsurface information to study and to indicate the nature and behavior of soil/rock under the application of load of proposed Structures in Phase 1 of 3 x 800 MW of NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha.

For foundation analysis of the structure on the site, it is necessary to determine the soil/rock profile of the site and to know physical properties and strength characteristics of soil/rock at various depths. For this purpose, BHEL entrusted the geotechnical investigation to us.

A report was required to be submitted as per the instructions of the client's officials. This report contains following,

1. Details of 68 Nos. of exploratory bore holes for BTG area
2. Details of standard penetration tests at regular interval of 1 m and even closer.
3. Results of tests on disturbed samples and undisturbed samples collected at regular intervals in soils and continuous sampling in rock.
4. Physical properties and strength characteristics of undisturbed and disturbed samples.
5. Interpretation of results, analysis and Conclusions
6. Locating ground water table

Based on the above points the detailed Geotechnical Investigation Program included the following:

(A) Field Investigation

1. Drilling of exploratory bore holes.
2. Collection of soil/rock samples (Disturbed and Undisturbed)
3. Conducting Standard Penetration Test.

(B) Laboratory Investigation

1. Bulk Density and moisture content of soil and rock
2. Grain size analysis and Index properties in soil
3. Shear tests (Triaxial shear test) in soil
4. Consolidation tests in cohesive soil
5. Uniaxial Compressive Test in rock
6. Point load Index in rock

(C) Recommendations

Based on above investigations, the results were obtained. The findings are based on interpretation of results, analysis and computations as per relevant Indian standards.

2.0 Field Investigation

2.1 Exploratory drilling

The exploratory boreholes of 150mm diameter in soils and 76mm diameter (Nx size) in rocks were drilled by rotary drilling method with mud circulation. Drilling was carried out using hydraulic feed drilling machine fitted with soil saw tooth and NX size bit. The locations of boreholes were dictated by client. The bore holes were terminated following the tender specifications and instruction of clients EIC. The details of the exploratory bore holes are as under:

SR No.	Borehole Number	Structure	R.L.	Co-Ordinate	Depth Investigated from ground level	Depth Planned to investigate	Reasoned for early termination
1	53	Boiler area Unit-1	199.40	E 1171 N 3260	25.00	30.00	*
2	56	Boiler area Unit-1	198.42	E 1152 N 3231	26.50	30.00	*
3	58	Mill Bunker Unit-1	200.20	E 1217 N 3229	23.00	30.00	*
4	63	Boiler area Unit-1	199.12	E 1178 N 3201	27.00	30.00	*

SR No.	Borehole Number	Structure	R.L.	Co-Ordinate	Depth Investigated from ground level	Depth Planned to investigate	Reasoned for early termination
5	64	Boiler area Unit-1	197.40	E 1128 N 3195	21.50	30.00	*
6	IBH-34	Boiler area Unit-1	198.51	E 1131 N 3266	25.00	25.00	-
7	94	Boiler area Unit-2	199.89	E 1109 N 3047	25.00	25.00	-
8	116	Boiler area Unit-3	200.69	E 1154 N 2913	21.50	30.00	*
9	126	Boiler area Unit-3	200.68	E 1180 N 2881	26.00	30.00	*
10	129	Boiler area Unit-3	200.45	E 1128 N 2880	19.00	25.00	*
11	109	Boiler area Unit-3	200.77	E 1177 N 2943	14.00	30.00	*
12	IBH-36	Boiler area Unit-3	200.53	E 1132 N 2951	17.50	25.00	*
13	135	Boiler area Unit-3	200.55	E 1150 N 2851	20.50	25.00	*
14	115	Mill Bunker Unit-3	200.71	E 1217 N 2918	14.50	25.00	*
15	134	Mill Bunker Unit-3	200.95	E 1209 N 2839	26.50	30.00	*
16	IBH-19	Mill Bunker Unit-3	200.35	E 1218 N 2964	18.00	25.00	*
17	50	Power house Unit-1	201.55	E 1281 N 3254	23.00	25.00	*
18	61	Power house Unit-1	201.10	E 1265 N 3214	23.00	30.00	*
19	66	Power house Unit-1	200.86	E 1280 N 3169	23.00	30.00	*
20	108	Power house Unit-3	201.17	E 1278 N 2950	18.00	30.00	*
21	123	Power house Unit-3	201.20	E 1265 N 2898	22.00	30.00	*
22	65	Transformer yard Unit-1	201.95	E 1335 N 3190	18.50	20.00	*
23	92	Transformer yard Unit-2	200.70	E 1348 N 3034	18.50	30.00	*
24	111	Transformer yard Unit-3	200.98	E 1305 N 2930	17.00	20.00	*
25	131	ESP cum FGD control room Unit-3	197.80	E 912 N 2848	19.00	25.00	*
26	137	Boiler area - Toilet Block	198.35	E 952 N 2825	20.00	25.00	*
27	120	FGD area (Absorber, RC	197.30	E 884 N 2920	17.00	20.00	*
28	124		197.52	E 860 N 2885	14.50	25.00	*
29	98	Pump house, Aux Absorbent tank etc)	197.45	E 912 N 3024	22.00	30.00	*
30	113		197.55	E 908 N 2941	24.50	30.00	*
31	90		197.10	E 884 N 3039	24.50	30.00	*
32	75	Chimney Unit-1	197.60	E 917 N 3123	15.50	25.00	*
33	103	Chimney Unit-2 & 3	197.10	E 856 N 2994	18.00	25.00	*
34	105	Chimney Unit-2 & 3	197.67	E 916 N 2986	20.50	30.00	*
35	57	ESP Unit-1	196.65	E 1077 N 3230	23.00	30.00	*
36	68	ESP Unit-1	197.40	E 1050 N 3179	17.50	25.00	*
37	82	ESP Unit-2	199.38	E 1011 N 3100	20.00	20.00	-
38	101	ESP Unit-2	199.53	E 1047 N 3016	25.00	25.00	-
39	104	ESP Unit-3	200.00	E 1082 N 2970	25.00	25.00	-
40	121	ID Fan Unit-3	198.42	E 967 N 2897	19.00	30.00	*
41	112	ESP Unit-3	199.05	E 1009 N 2928	20.00	20.00	-
42	73	Chimney Unit-1	196.39	E 886 N 3136	14.50	20.00	*

Sr. No.	Bore hole nos.	Structure	R.L.	Co-ordinates		Depth Planned to investigate	Depth Investigated from ground level	Reason for early termination
				E	N			
43	BH-26	CST tanks & pump house	203.10	1350	3255	25.00	25.00	-
44	BH-49	Piperack	197.50	1081	3296	25.00	19.50	*
45	BH-104		200.00	1082	2970	25.00	25.00	-
46	BH-60	ESP cum FGD control room Unit-1	196.25	909	3227	30.00	14.50	*
47	BH-59	ID fan Unit-1	197.60	967	3209	30.00	24.50	*
48	BH-67	Absorber & RC pump house Unit-1	196.50	900	3182	25.00	18.00	*
49	BH-51	ESP Unit-1	196.05	1007	3246	25.00	18.00	*
50	BH-87	ESP cum FGD control room Unit-2	197.43	902	3074	30.00	21.00	*
51	BH-91	ID fan Unit-2	198.53	978	3061	30.00	19.00	*
52	BH-106	ID fan Unit-3	197.10	888	2972	25.00	25.00	-
53	IBH-18	Mill & Bunker Unit-1	200.34	1218	3266	25.00	25.00	-
54	BH-70		201.82	1216	3170	30.00	18.50	*
55	BH-71	MRS silo	197.88	1175	3163	20.00	20.00	-
56	IBH-35	Boiler Unit-2	198.78	1132	3102	25.00	23.50	*
57	BH-24		195.77	1176	3017	25.00	15.00	*
58	BH-79		198.70	1172	3104	30.00	17.00	*
59	BH-84		198.70	1152	3073	20.00	18.00	*
60	BH-93		198.96	1172	3048	20.00	18.00	*
61	BH-86	Mill & Bunker Unit-2	198.98	1217	3081	30.00	17.50	*
62	BH-76	Power hose Unit-1	198.89	1204	3137	25.00	24.00	*
63	BH-78	Power hose Unit-2	199.07	1253	3105	30.00	18.00	*
64	BH-88		197.20	1266	3062	25.00	17.50	*
65	BH-100		199.00	1248	3017	20.00	14.00	*
66	BH-130	Power hose Unit-3	201.08	1248	2855	30.00	21.00	*
67	BH-127	Transformer yard Unit-3	202.28	1349	2868	25.00	24.50	*
68	BH-139		202.56	1337	2828	20.00	20.00	-

* As per the note no 2 of approved drawing vide no. PE-DG-511-602-C001, borehole shall be drilled up to the depth indicated against each borehole or up to the depth where more than 75% core recovery is encountered, whichever is earlier.

2.2 Sampling

2.2.1 Disturbed samples

Disturbed samples were collected during boring and from split spoon samplers in SPT. The samples recovered were logged, labeled and placed in polyethylene bags and sent to laboratory for testing.

2.2.2 Undisturbed samples

Undisturbed soil samples were collected in thin walled Shelby tubes as per IS 2132 in overburden. The samples thus collected were sealed with wax, labeled and transported with utmost care.

In rocky stratum, undisturbed samples were collected in rock core form. Sampling was carried out to get continuous samples. The rock core samples from different depths were numbered chronologically and marked with direction of drilling and were stored in core boxes. All this samples were labeled and transported to our laboratory at Gota, Ahmedabad for testing at the earliest.

2.2.3 Standard penetration test

The standard penetration tests is conducted in accordance with IS:2131-1981. The test results show N Value, the blow counts of last 30 cm penetration of split spoon sampler with 63.5 kg hammer falling from 76 cm height. Tests were carried out using the auto-hammer fitted on each drilling rig. The ER (energy ratio) has been maintained at 60 % to get N60. The numbers of blows / minute was maintained as 25 to 30 blows / minute. This test is the most appropriate in sandy soils. In clays the same indicates the consistency. While SPT is one of the important tests in soils, in rock the same is not of much significance as the N values are more than 100 i.e. refusal. In soft and laminated rock SPT was conducted to be utilized for analysis of the deep foundations.

2.2.4 Rock Quality designation

From the cores samples recovered, % core recovery and Rock quality designation RQD were determined on cores having length more than 10cm. Based on the RQD; the rock can be classified from stand point of spacing of discontinuities.

RQD (%)	Rock Classification
100-90	Very good
90-75	Good
75-50	Medium
50-25	Poor
25-0	Very poor

3.0 Laboratory investigation

The following laboratory tests were conducted on undisturbed and disturbed soil samples collected from various depths to find physical properties and strength characteristics.

Tests	Recommended procedure	Type Samples
1. Sample Preparation	IS 2720 Pt 1	DS / UDS
2. Moisture Content	IS 2720 Pt 2	DS / UDS
3. Dry Unit Weight	IS 2720 Pt 29	UDS
4. Specific Gravity	IS 2720 Pt 3	DS
5. Atterberg's Limit	IS 2720 Pt 5	DS
6. Grain Size Analysis	IS 2720 Pt 4	DS
7. Soil Classification	IS 1498	DS / UDS
8. Consolidation	IS 2720 Pt 15	UDS
9. Unconfined Compression Strength	IS 2720 Pt 10	UDS
10. Triaxial Compression Test	IS 2720 Pt 11	UDS
11. Direct Shear Test	IS 2720 Pt 13	

The following tests were conducted on rock sample

Tests	Recommended procedure	Type Samples
1. Sample Preparation	IS 4464	Rock Core
2. Moisture Content	IS 2720 Pt 2	Rock Core
3. Bulk and Dry Unit Weight	IS 13030	Rock Core
4. Specific Gravity	IS 2720 Pt 3	Rock Core
5. Uniaxial Compressive Strength	IS 9143	Rock Core
6. Point load index test	IS 10785	Rock Core
7. Water absorption test	IS 1124	Rock Core

4.0 General Geology of Site

The Sambalpur district houses a wide variety of rock types of different ages. They can broadly be classified into Eastern Ghat Supergroup, Bonai Group, Gangpur Group, Chattisgarh Group, intrusive nepheline syenite, Gondwana Supergroup and Quaternary sediment. The rocks belonging to Gondwana Supergroup are hosted in the fault bounded basins occupying the central portion of the district with a NW-SE trend. They are represented by Talchir Formation, Barakar Formation and Mahadeva Formation.

Quaternary sediments are sporadically distributed in district. They occur as 5-20 m thick medium- to finegrained soil/alluvium in the pediplains and flood plains followed by Barakar formation shale and sandstone which alternate with one another within individual bodies.

5.0 Subsurface Soil Conditions

At this stage of investigation exact sub soil profiling may not be narrated correctly based on only few bore hole results especially in a very vast project site area as in present case. However it can be said that there exists four characterized strata up to the depth investigated i.e. 25 m from NGL.

A superficial clayey sandy soil layer exists up to around 1 m from NGL. Underlying layer comprises of fully saturated silty Clay of intermediate plasticity of stiff to very stiff and even hard consistency. This layer was observed to extend up to 2.5 to 4 m. A very fine grained fully saturated, very stiff to hard clays of high plasticity exists under the second layer and extends up to 3.5 to 8.5 m in different land parcels. These soils are adjudged to be expensive in nature. Below expansive clays, a thick layer of fully saturated, dense sandy soils are encountered. Again this layer also varies in depth between 9.5 to 14.5 m. below all these layers, very weak, laminated and foliated shale is encountered.

5.1 Groundwater Conditions

Ground water table was encountered on an average at 2 m depth from NGL. The ground water can rise up to GL immediately post monsoon. Practically the GWT shall be considered at FGL for all designs.

5.2 Strong Ground Motion

The site is located within a seismically active region (Zone 3; ref IS 1893). Liquefaction is unlikely owing to the cohesive soils of stiff to very stiff and hard consistency and dense sandy soils. Hence, soil is not likely to undergo shear strength loss in seismic event.

6.0 Computation of Safe Bearing Capacity

It is proposed to fill up the entire plot premises up to 202.5 m RL. The filling would on an average about 4 to 5m. At this stage character of soil for filling is not known. Again, foundation for all important structures may not be kept in filling. Shallow depth of water table from NGL would be another constraint for taking down foundation below NGL. So from all such considerations pile foundations shall be necessary for all important plant structures.

In this report, safe load on piles is calculated which would be the primary foundation option and allowable bearing pressure of open foundation is also calculated. In situations where overburden offering low bearing pressure is followed by rock at relatively shallower depths, end bearing piles is the suitable foundation option. Piles in rocks and weathered rocks of varying degree of weathering derive their capacity by end bearing and socket side resistance.

In situations, where, rock strata comprises of highly fragmented rock, as in present case, where RQD is nil or $(CR+RQD)/2$ is less than 30 % or when the crushing strength is less than 10 MPa, the appropriate approach would be of that suggested by Cole & Stroud. In present site overburden soils overlay fractured / laminated / foliated weak shale. The founding stratum having highly fragmented rock with nil RQD and $(CR+RQD)/2$ to be less than 30 %, the approach suggested by Cole and Stroud as per Annex B under clause 6.3.1.1 and 6.3.2 of IS 2911 Pa/S2 has been used for safe load calculations.

Allowable bearing capacity and safe load on end bearing piles in compression, uplift and lateral direction is calculated area wise and appended in Appendix 1 to 22 (as per revision 02) and Appendix 1 to 16 (as per revision 03) for different areas represented by the boreholes covered in BTG area portion.

7.0 Conclusions

- 1) General stratifications are as described in section 5.0 and as shown in respective borelogs.

In situations where overburden offering low bearing pressure is followed by rock at relatively shallower depths, end bearing piles is the most suitable foundation option. Safe load on end bearing piles in compression, uplift and lateral direction is calculated and appended for different structures by the boreholes covered in BTG area. Pile shall be terminated after socketing atleast up to 3D. Initial and routine pile load tests shall be carried out on the piles at site as per IS: 2911 Part 4. For design and construction, specification of IS: 2911, P1/S2, IS: 456, 2000 and IS: 14593 shall strictly be followed.

- 2) Ground water table was encountered on an average at 2 m depth from NGL. The ground water can rise up to GL immediately post monsoon. Practically the GWT shall be considered at FGL for all designs.
- 3) Based on the test results the soil can be classified in class-1 as per Table-4 of IS 456: 2000. Therefore, from the standpoint of sulphite (SO_3) and Chlorides content specific precautions are not required.
- 4) The site is located within a seismically region (Zone 3). Shear strength loss (liquefaction) is unlikely based on screening criteria. Though detailed analysis shall be included in final report.
- 5) Considering chemical analysis test results of sub soil samples, existing soil is suitable for filling/backfilling purposes.
- 6) The filling for raising FGL will be a controlled fill assuming that the soil used for raising the EGL to FGL are from local sources and of similar character than the soil would be mostly cohesive in nature and after 95% compaction have very stiff consistency as well. Not with standing very stiff consistency, the safe bearing capacity may safely be assume to be 5 t/m^2 as suggested in presumptive safe bearing capacity of soil in various credible documents. For the ready reference the document suggesting 5 t/m^2 published by Indian railway standard “Code of practice for the design of sub-structures and foundations of bridges”, second revision 2013 may be referred which is also attached in report as Reference-e for your ready reference. From that table, we have considered the minimum presumptive safe bearing capacity among all types of soil, which is 5 t/m^2 .

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8.0 Limitations

We have prepared this report for the exclusive use of clients and as per the scope and specification instructed by them verbally or in writing. No other use is anticipated or authorized by clients. The report shall be used only by the client for the project and purposes described herein at the locations shown by him and explored by us. The finding and recommendations are valid when the onsite and offsite conditions affecting the structures in project are not changed due to the actions of man or nature.

Professional judgments presented in this report are based on evaluations of the technical information gathered, understanding of the proposed construction, and general experience in the geotechnical field. We have performed according to generally accepted geotechnical engineering practices followed in the project area at the time the services were provided. No warranty is expressed or implied. The report is issued with the understanding that the owner and client choose the risk they decide to incur by the expenditures involved in the engineering and construction.

The findings and recommendations presented in this report are based upon soil conditions inferred from site explorations, interpolation of the soil conditions between exploration locations, and extrapolation of these conditions throughout the proposed site area. The extent of investigation as well as specific exploration locations were dictated by the clients. The findings and recommendations are further based on the assumption that the subsurface conditions do not deviate appreciably from those reported and those assumed. The potential for encountering conditions different from those assumed can never be discounted.

If different subsurface conditions are encountered if any, must be brought to our attention before execution & in a timely manner so that the need for revised recommendations can be evaluated. In the event of changes in design loads or structural characteristics or in location of the structure, clients should review its design based on our recommendation and their applicability to the revision he made in a timely manner.

Summary of Allowable Bearing Pressure for Various Structures

							Allowable Bearing Prssure (in T/m ²) for given below permissible settlement	
SR.No.	Building/Structure/Area	Applicable bore hole nos.	Lowest EGL in RL (m)	FGL in RL (m)	Depth of foundation below EGL (in m)	Width of foundation (in m)	Isolated & strip foundation	
							25 mm	40 mm
1	Powe house area	50,61,66,108 and 123	200.86	202.5	1.00	1.5 m	12	12
						>1.5 to ≤ 3 m	10	11
						>3 to ≤ 6 m	5	8
						>6 to ≤ 10 m	3	5
					1.50	1.5 m	12	12
						Up to 3 m	11	11
						>3 to ≤ 6 m	5	8
						>6 to ≤ 10 m	3	5
					2.00	1.5 m	13	13
						Up to 3 m	11	12
						>3 to ≤ 6 m	5	8
						>6 to ≤ 10 m	3	5
					2.50	1.5 m	14	14
						Up to 3 m	12	12
						>3 to ≤ 6 m	5	8
						>6 to ≤ 10 m	3	5
2	Transformer yard area	65, 92, 111, 127, 139	201.69	202.5	1.00	1.5 m	19	19
						>1.5 to ≤ 3 m	18	18
						>3 to ≤ 6 m	9	14
						>6 to ≤ 10 m	6	10
					1.50	1.5 m	20	20
						Up to 3 m	18	18
						>3 to ≤ 6 m	9	15
						>6 to ≤ 10 m	6	10
					2.00	1.5 m	21	21
						Up to 3 m	19	19
						>3 to ≤ 6 m	9	15
						>6 to ≤ 10 m	7	11
					2.50	1.5 m	22	22
						Up to 3 m	19	19
						>3 to ≤ 6 m	10	16
						>6 to ≤ 10 m	7	11

Summary of Allowable Bearing Pressure for Various Structures (Revision 03)

SR.No.	Building/Structure/Area	Applicable bore hole nos.	Average EGL in RL (m)	FGL in RL (m)	Foundation level adopted (in RL)	Width of foundation (in m)	Allowable Bearing Prssure (in T/m ²) for given below permissible settlement
							In case of Rock
							12 mm
3	Mill & Bunker Unit-2	BH-86	198.98	202.50	193.00	1.5 m	45.00
						>1.5 to ≤ 3 m	45.00
						>3 to ≤ 6 m	45.00
						>6 to ≤ 10 m	45.00
4	Power house Unit-2 & TG	BH-78,100	199.04	202.50	193.50	1.5 m	45.00
						Up to 3 m	45.00
						>3 to ≤ 6 m	45.00
						>6 to ≤ 10 m	45.00
		BH-88	197.20	202.50	191.00	1.5 m	45.00
						Up to 3 m	45.00
						>3 to ≤ 6 m	45.00
						>6 to ≤ 10 m	45.00

Recommendation for RCC Bored cast-in-situ Pile Capacity for piles socketed inside rock as per technical specification

ST/21/09/19094

SR.No.	Building/Structure/ Area	Applicable bore hole nos.	Average EGL in RL (m)	FGL in RL (m)	Pile cut off level below FGL (in m)	Diameter of pile (in m)	Safe pile capacity (in T)			Remarks
							Vertical compression	Lateral (in fixed head condition)	Uplift	
1	Power House & TG UNIT 1	50, 61, 66	201.17	202.5	4m or below	0.60	140.00	7.00	35.00	Pile length includes 3D socketing inside rock
						0.76	250.00	12.50	62.50	
2	Power House & TG UNIT 2 & 3	123, 108	201.19	202.5	4m or below	0.60	150.00	7.50	37.50	
						0.76	250.00	12.50	62.50	
3	ESP UNIT-1	57, 68	197.03	202.5	5m or below	0.60	150.00	7.50	37.50	
						0.76	250.00	12.50	62.50	
4	ESP UNIT-2 & 3	82, 101, 104, 112	199.49	202.5	3m or below	0.60	150.00	7.50	37.50	
						0.76	250.00	12.50	62.50	
5	Boiler & Mill Bunker UNIT-1	53, 56, 58, 63, 64 and IBH-34	198.84	202.5	4m or below	0.60	140.00	7.00	35.00	
						0.76	250.00	12.50	62.50	
6	Boiler & Mill Bunker UNIT-2 & 3	116, 126, 129, 109, 135, 115, 134, IBH-19, IBH-36	200.63	202.5	4m or below	0.60	150.00	7.50	37.50	
						0.76	250.00	12.50	62.50	
7	Chimney Unit 1, 2 & 3	75,103, 105, 73	197.19	202.5	5m or below	0.60	150.00	7.50	37.50	
						0.76	250.00	12.50	62.50	
8	FGD area	120, 124, 98, 113, 90	197.38	202.5	5m or below	0.60	150.00	7.50	37.50	
						0.76	250.00	12.50	62.50	

*Note: Since rock level is varying from transformer yard to chimney area, pile lengths will also vary as 3D socketing inside rock is to be ensured for each pile.

Recommendation for RCC Bored cast-in-situ piles socketed inside rock as per technical specification (Revision 03)

Sr No	Building/ Structure/ Area	Applicable bore hole nos.	Average EGL in RL (m)	FGL in RL (m)	Pile cut off level below FGL (in m)	Diameter of pile (in m)	Safe pile capacity (in T)			Remarks
							Vertical compression	Lateral (in fixed head condition)	Uplift	
9	CST tanks & pump house	BH-26	203.1	202.5	1.00m or below	0.60	150.00	7.50	37.50	Pile length includes 3D socketing inside rock
						0.76	250.00	12.50	62.50	
10	ESP cum FGD control room Unit-1	BH-60	196.3	202.5	6.50m or below	0.60	150.00	7.50	37.50	
						0.76	250.00	12.50	62.50	
11	ID fan Unit-1	BH-59	197.6	202.5	5.00m or below	0.60	150.00	7.50	37.50	
						0.76	250.00	12.50	62.50	
12	Absorber & RC pump house Unit-1	BH-67	196.5	202.5	6.00m or below	0.60	150.00	7.50	37.50	
						0.76	250.00	12.50	62.50	
13	ESP Unit-1	BH-51	196.05	202.5	6.50m or below	0.60	150.00	7.50	37.50	
						0.76	250.00	12.50	62.50	
14	ESP cum FGD control room Unit-2	BH-87	197.43	202.5	5.00m or below	0.60	150.00	7.50	37.50	
						0.76	250.00	12.50	62.50	
15	ID fan Unit-2	BH-91	198.53	202.5	4.00m or below	0.60	150.00	7.50	37.50	
						0.76	250.00	12.50	62.50	
19	ID fan Unit-3	BH-106	197.1	202.5	5.50m or below	0.60	150.00	7.50	37.50	
						0.76	250.00	12.50	62.50	
17	Mill & Bunker Unit-1	IBH-18, BH-70	201.08	202.5	3.00m or below	0.60	150.00	7.50	37.50	
						0.76	250.00	12.50	62.50	
18	MRS silo	BH-71	197.88	202.5	5.00m or below	0.60	150.00	7.50	37.50	
						0.76	250.00	12.50	62.50	
19	Boiler Unit-2	IBH-35, BH-24,79,84,93	198.18	202.5	4.00m or below	0.60	150.00	7.50	37.50	
						0.76	250.00	12.50	62.50	
20	Power hose Unit-1 Control room	BH-76	198.89	202.5	4.00m or below	0.60	150.00	7.50	37.50	
						0.76	250.00	12.50	62.50	
21	Power hose Unit-3	BH-130	201.08	202.5	1.50m or below	0.60	150.00	7.50	37.50	
						0.76	250.00	12.50	62.50	
22	Mill & Bunker Unit-2	BH-86	198.98	202.5	3.50m or below	0.60	150.00	7.50	37.50	
						0.76	250.00	12.50	62.50	
23	Power house Unit-2	BH-78,88,100	199.07	202.5	3.50m or below	0.60	150.00	7.50	37.50	
						0.76	250.00	12.50	62.50	

Summary for RCC Bored cast-in-situ Pile Capacity for piles socketed inside rock ST/24/09/19094

SR.No.	Building/Structure/Area	Applicable bore hole nos.	Average EGL in RL (m)	FGL in RL (m)	Pile cut off level below FGL (in m)	Diameter of pile (in m)	*Length of pile below cut off level (in m)	Safe pile capacity (in T)				Remarks
								Vertical compression	Lateral (in free head condition)	Lateral (in fixed head condition)	Uplift	
1	Power House & TG UNIT 1	50, 61, 66	201.17	202.5	4	0.60	17.00	176.00	3.20	8.30	124.40	Pile length includes 3D socketing inside rock
						0.76	17.50	283.00	4.60	12.20	182.80	
					5	0.60	16.00	176.00	3.60	9.60	120.70	
						0.76	16.50	283.00	5.30	14.00	177.90	
					6	0.60	15.00	176.00	3.80	10.10	117.00	
						0.76	15.50	283.00	5.60	14.70	173.10	
2	Power House & TG UNIT 3	123, 108	201.19	202.5	4	0.60	6.00	170.00	3.20	8.60	78.70	
						0.76	6.50	272.00	4.70	12.60	122.40	
					5	0.60	5.00	170.00	3.50	9.40	77.00	
						0.76	5.50	272.00	5.20	13.70	120.10	
					6	0.60	4.00	170.00	4.40	11.70	73.80	
						0.76	4.50	272.00	6.40	17.00	115.90	
3	ESP UNIT-1	57, 68	197.03	202.5	5	0.60	16.50	176.00	3.20	8.60	123.80	
						0.76	17.00	283.00	4.60	12.50	181.80	
4	ESP UNIT-2 & 3	82, 101, 104, 112	199.49	202.5	3	0.60	19.00	176.00	3.20	8.30	139.90	
						0.76	19.50	283.00	4.60	12.20	202.60	
					4	0.60	18.00	176.00	3.20	8.30	135.70	
						0.76	18.50	283.00	4.60	12.20	197.20	
5	Boiler & Mill Bunker UNIT-1	53, 56, 58, 63, 64 and IBH-34	198.84	202.5	4	0.60	13.00	176.00	3.00	8.10	103.00	
						0.76	13.50	283.00	4.40	11.80	155.00	
					5	0.60	12.00	176.00	3.60	9.60	100.40	
						0.76	12.50	283.00	5.30	14.00	151.50	
					6	0.60	11.00	176.00	3.60	9.60	98.10	
						0.76	11.50	283.00	5.30	14.00	148.50	
6	Boiler & Mill Bunker UNIT-3	116, 126, 129, 109, 135, 115, 134, IBH-19, IBH-36	200.63	202.5	4	0.60	11.50	176.00	3.20	8.60	107.00	
						0.76	12.00	283.00	4.70	12.60	153.60	
					5	0.60	10.50	176.00	3.70	9.80	99.60	
						0.76	11.00	283.00	5.40	14.40	144.10	
					6	0.60	9.50	176.00	3.70	9.80	92.30	
						0.76	10.00	283.00	5.40	14.40	134.60	
7	Chimney Unit 1, 2 & 3	75,103, 105, 73	197.19	202.5	5	0.60	14.00	176.00	3.60	9.60	120.30	
						0.76	14.50	283.00	5.30	14.00	177.10	
					6	0.60	13.00	176.00	3.60	9.60	116.00	
						0.76	13.50	283.00	5.30	14.00	171.50	
					7	0.60	12.00	176.00	3.60	9.60	111.70	
						0.76	12.50	283.00	5.30	14.00	166.00	
8	FGD area	120, 124, 98, 113, 90	197.38	202.5	5	0.60	16.00	176.00	3.40	8.90	125.10	
						0.76	16.50	283.00	4.90	13.10	183.50	

*Note: Since rock level is varying from transformer yard to chimney area, pile lengths will also vary as 3D socketing inside rock is to be ensured for each pile.

Summary of RCC Bored cast-in-situ Pile Capacity for piles socketed inside rock (Revision 03)

Sr No	Building/ Structure/ Area	Applicable bore hole nos.	Average EGL in RL (m)	FGL in RL (m)	Pile cut off level below FGL (in m)	Diameter of pile (in m)	*Length of pile below cut off level (in m)	Safe pile capacity (in T)				Remarks
								Vertical compression	Lateral (in free head condition)	Lateral (in fixed head condition)	Uplift	
9	CST tanks & pump house	BH-26	203.1	202.5	1.00m or below	0.60	18.50	176.00	3.00	8.00	165.00	Pile length includes 3D socketing inside rock
						0.76	19.00	283.00	4.00	12.00	234.00	
10	ESP cum FGD control room Unit-1	BH-60	196.3	202.5	6.50m or below	0.60	7.00	176.00	6.00	16.00	87.00	
						0.76	7.50	283.00	9.00	24.00	134.00	
11	ID fan Unit-1	BH-59	197.6	202.5	5.00m or below	0.60	9.00	176.00	5.00	13.00	93.00	
						0.76	9.50	283.00	7.00	19.00	141.00	
12	Absorber & RC pump house Unit-1	BH-67	196.5	202.5	6.00m or below	0.60	8.50	176.00	5.00	13.00	91.00	
						0.76	9.00	283.00	7.00	19.00	140.00	
13	ESP Unit-1	BH-51	196.05	202.5	6.50m or below	0.60	8.50	176.00	4.00	12.00	91.00	
						0.76	9.00	283.00	7.00	18.00	139.00	
14	ESP cum FGD control room Unit-2	BH-87	197.43	202.5	5.00m or below	0.60	14.00	176.00	9.00	24.00	89.00	
						0.76	14.50	283.00	13.00	35.00	137.00	
15	ID fan Unit-2	BH-91	198.53	202.5	4.00m or below	0.60	17.00	176.00	5.00	13.00	141.00	
						0.76	17.50	283.00	7.00	19.00	204.00	
16	ID fan Unit-3	BH-106	197.1	202.5	5.50m or below	0.60	11.50	176.00	6.00	18.00	126.00	
						0.76	12.00	283.00	10.00	26.00	184.00	
17	Mill & Bunker Unit-1	IBH-18, BH-70	201.08	202.5	3.00m or below	0.60	15.00	176.00	9.00	24.00	120.00	
						0.76	15.50	283.00	13.00	35.00	176.00	
18	MRS silo	BH-71	197.88	202.5	5.00m or below	0.60	13.00	176.00	7.00	19.00	114.00	
						0.76	13.50	283.00	11.00	29.00	169.00	
19	Boiler Unit-2	IBH-35, BH-24,79,84,93	198.18	202.5	4.00m or below	0.60	11.00	176.00	4.00	12.00	102.00	
						0.76	11.50	283.00	7.00	18.00	153.00	
20	Power hose Unit-1 Control room	BH-76	198.89	202.5	4.00m or below	0.60	8.50	176.00	6.00	16.00	96.00	
						0.76	9.00	283.00	9.00	24.00	146.00	
21	Power hose Unit-3	BH-130	201.08	202.5	1.50m or below	0.60	10.50	176.00	8.00	21.00	123.00	
						0.76	11.00	283.00	11.00	31.00	180.00	
22	Mill & Bunker Unit-2	BH-86	198.98	202.5	3.50m or below	0.60	6.00	176.00	5.00	13.00	77.00	
						0.76	6.50	283.00	7.00	19.00	121.00	
23	Power house Unit-2	BH-78,88,100	199.07	202.5	3.50m or below	0.60	5.00	176.00	6.00	16.00	7.00	
						0.76	5.50	283.00	9.00	24.00	122.00	

*Note: Since rock level is varying, pile lengths will also vary as 3D socketing inside rock is to be ensured for each pile

Recommendations for RCC Bored cast-in-situ Pile Terminating in Soil Strata as per technical specification

ST/24/08/1904

SR.No.	Building/Structure/ Area	Applicable bore hole nos.	Average EGL in RL (m)	FGL in RL (m)	Pile cut off level below FGL (in m)	Length of pile below cut off level (in m)	Diameter of pile (in m)	Safe pile capacity (in T)			Remarks
								Vertical compression	Lateral (in fixed head condition)	Uplift	
1	Power House & TG UNIT 1	50, 61, 66	201.17	202.5	2m or below	16.00	0.60	75.00	3.75	18.75	Pile is terminating in soil strata
2	ESP UNIT-1	57, 68	197.03	202.5	5m or below	12.00	0.60	75.00	3.75	18.75	
3	ESP UNIT-2 & 3	82, 101, 104, 112	199.49	202.5	3m or below	14.00	0.60	75.00	3.75	18.75	
4	Boiler & Mill Bunker UNIT-1	53, 56, 58, 63, 64 and IBH-34	198.84	202.5	4m or below	11.00	0.60	75.00	3.75	18.75	
5	Boiler & Mill Bunker UNIT-3	116, 126, 129, 109, 135, 115, 134, IBH-19, IBH-36	200.63	202.5	3m or below	9.50	0.60	75.00	3.75	18.75	
6	Chimney Unit 1, 2 & 3	75,103, 105, 73	197.19	202.5	5m or below	12.00	0.60	75.00	3.75	18.75	
7	FGD area	120, 124, 98, 113, 90	197.38	202.5	5m or below	12.00	0.60	75.00	3.75	18.75	

ST/24/09/19094 Recommendations for RCC Bored cast-in-situ Pile Terminating in Soil Strata as per technical specification (Revision 03)										
Sr No	Building/ Structure/ Area	Applicable bore hole nos.	Average EGL in RL (m)	FGL in RL (m)	Pile cut off level below FGL (in m)	Diameter of pile (in m)	Length of pile below cut off level (in m)	Safe pile capacity (in T)		
								Vertical compression	Lateral (in fixed head condition)	Uplift
8	CST tanks & pump house	BH-26	203.1	202.5	1.00m or below	0.60	11.00	75.00	3.75	18.75
9	ESP cum FGD control room Unit-2	BH-87	197.43	202.5	5.00m or below	0.60	11.00	75.00	3.75	18.75
10	ID fan Unit-2	BH-91	198.53	202.5	4.00m or below	0.60	11.00	75.00	3.75	18.75
11	ID fan Unit-3	BH-106	197.1	202.5	5.5m or below	0.60	9.00	75.00	3.75	18.75
12	Mill & Bunker Unit-1	IBH-18, BH-70	201.08	202.5	3.00m or below	0.60	11.00	75.00	3.75	18.75
13	MRS silo	BH-71	197.88	202.5	5.00m or below	0.60	11.00	75.00	3.75	18.75
14	Power hose Unit-3	BH-130	201.08	202.5	1.50m or below	0.60	8.00	75.00	3.75	18.75

SR.No.	Building/Structure/Area	Applicable bore hole nos.	Average EGL in RL (m)	FGL in RL (m)	Pile cut off level below FGL (in m)	Diameter of pile (in m)	Length of pile below cut off level (in m)	Safe pile capacity (in T)				Remarks
								Vertical compression	Lateral (in free head condition)	Lateral (in fixed head condition)	Uplift	
1	Power House & TG UNIT 1	50, 61, 66	201.17	202.5	2	0.60	16.00	95.94	3.20	8.30	50.53	Pile is terminating in soil strata
2	ESP UNIT-1	57, 68	197.03	202.5	5	0.60	12.00	81.21	3.20	8.60	39.02	
3	ESP UNIT-2 & 3	82, 101, 104, 112	199.49	202.5	3	0.60	14.00	78.42	3.20	8.30	48.49	
4	Boiler & Mill Bunker UNIT-1	53, 56, 58, 63, 64 and IBH-34	198.84	202.5	4	0.60	11.00	74.65	3.00	8.10	32.44	
5	Boiler & Mill Bunker UNIT-3	116, 126, 129, 109, 135, 115, 134, IBH-19, IBH-36	200.63	202.5	3	0.60	9.50	75.41	3.20	8.60	32.69	
6	Chimney Unit 1, 2 & 3	75, 103, 105, 73	197.19	202.5	5	0.60	12.00	77.13	3.60	9.60	53.88	
7	FGD area	120, 124, 98, 113, 90	197.38	202.5	5	0.60	12.00	76.13	3.40	8.90	35.32	

Summary for RCC Bored cast-in-situ Pile Capacity for Piles Terminating in Soil Strata (Revision 03)

Sr No	Building/ Structure/ Area	Applicable bore hole nos.	Average EGL in RL (m)	FGL in RL (m)	Pile cut off level below FGL (in m)	Diameter of pile (in m)	Length of pile below cut off level (in m)	Safe pile capacity (in T)			
								Vertical compression	Lateral (in free head condition)	Lateral (in fixed head condition)	Uplift
8	CST tanks & pump house	BH-26	203.1	202.5	1.00m or below	0.60	11.00	81.00	3.00	8.00	37.00
9	ESP cum FGD control room Unit-2	BH-87	197.43	202.5	5.00m or below	0.60	11.00	75.00	9.00	24.00	32.00
10	ID fan Unit-2	BH-91	198.53	202.5	4.00m or below	0.60	11.00	77.00	5.00	13.00	34.00
11	ID fan Unit-3	BH-106	197.1	202.5	5.5m or below	0.60	9.50	79.00	6.00	18.00	37.00
12	Mill & Bunker Unit-1	IBH-18, BH-70	201.08	202.5	3.00m or below	0.60	11.00	77.00	9.00	24.00	34.00
13	MRS silo	BH-71	197.88	202.5	5.00m or below	0.60	11.00	76.00	7.00	19.00	34.00
14	Power hose Unit-3	BH-130	201.08	202.5	1.50m or below	0.60	8.00	76.00	8.00	21.00	33.00

Summary of Design Parameters

Building/Structure/Area	Depth in m from NGL	Soil Classification	Depth in m from FGL	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Bulk density in gm/cc γ_b	SPT N Value	shear strength q_c kN/m ²
POWER HOUSE UNIT-1	-	Filled up soil	FGL-0.95	1.00	0	1.80	22	NA
	0.00 - 4.90	Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI)	0.95-5.85	1.10	7	2.00	7	
	4.90 - 7.45	Yellowish brown, fine to very fine grained, clays of high plasticity	5.85-8.40	1.39	3	2.03	23	
	7.45 - 10.80	Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI)	8.40-11.75	1.47	5	2.08	30	
	10.80 - 12.20	Yellowish brown, fine to very fine grained, clays of high plasticity (CH)	11.75-13.15	-	-	-	36	
	12.20 - 14.40	Brownish, fine to very fine grained, sandy clays of intermediate plasticity (CI)	13.15-15.35	-	-	-	>100	
	14.40 - 18.57	Dark brownish, fine to very fine grained, clays of high plasticity (CH)	15.35-19.52	-	-	-	>100	
	18.57 - 23.00	Highly weathered, very weak, brownish, fine to very fine grained, thinly bedded rock	19.52-23.95	NA			200	1300

Building/Structure/Area	Depth in m from NGL	Soil Classification	Depth in m from FGL	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Bulk density in gm/cc γ_b	SPT N Value	shear strength q_c kN/m ²
POWER HOUSE UNIT -3	-	Filled up soil	FGL-1.30	1.00	0	1.80	22	NA
	0.00 - 2.80	Yellowish brown, fine to very fine grained, clays of intermediate plasticity with some gravels (CI)	1.30-4.10	0.95	8	1.97	24	
	2.80 - 4.00	Yellowish brown, fine to very fine grained, clayey sand with much gravels (SC)	4.10-5.30	0.03	25	1.98	17	
	4.00 - 5.30	Yellowish brown, very fine grained, clays of high plasticity (CH)	5.30-6.60	-	-	-	23	
	5.30 - 6.80	Brownish, fine to very fine grained, clays of intermediate plasticity (CI)	6.60-8.10	-	-	-	74	
	6.80 - 7.20	Yellowish brown, very fine grained, clays of high plasticity (CH)	8.10-8.50	-	-	-	>100	
	7.20 - 22.00	Highly weathered, weak, dark greyish black, fine to very fine grained, thinly laminated rock	8.50-23.30	NA			160	1250

Building/Structure/Area	Depth in m from NGL	Soil Classification	Depth in m from FGL	Cohesion in kg/cm ²	Angle of Internal Friction, ϕ	Bulk density in gm/cc	SPT N Value	shear strength q_c kN/m ²
ESP UNIT-1)	-	Filled up soil	FGL-5.10	1.00	0	1.80	22	NA
	0.00 - 3.60	Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI)	5.10-8.70	0.72	2	1.95	7	
	3.60 - 5.90	Yellowish brown, very fine grained, clays of high plasticity (CH)	8.70-11.00	0.86	3	2	16	
	5.90 - 6.80	Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI)	11.00-11.90	0.57	4	1.96	19	
	6.80 - 8.70	Yellowish brown, fine to very fine grained, clayey sand (SC)	11.90-13.80	0.08	25	1.98	11	
	8.70 - 13.50	Yellowish brown, fine to medium grained, silty sand with little to some gravels (SM)	13.80-18.60	-	-	-	16	
	13.50 - 14.20	Yellowish brown, fine to medium grained, clayey sand (SC)	18.60-19.30	-	-	-	>100	
	14.20 - 14.60	Brownish, fine to very fine grained, sandy clays of low plasticity (CL)	19.30-19.70	-	-	-	>100	
	14.60 - 17.50	Moderately weathered, weak, brownish grey, fine to medium grained, thinly bedded rock	19.70-22.60	NA			200	1300

Building/Structure/Area	Depth in m from NGL	Soil Classification	Depth in m from FGL	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Bulk density in gm/cc	SPT N Value	shear strength q_c kN/m ²
ESP Unit-2 and 3	-	Filled up soil	FGL-3.12	1.00	0	1.80	22	NA
	0.00 - 0.50	Yellowish brown, fine to very fine grained, clayey sand (SC)	3.12-3.62	-	-	-	-	
	0.50 - 3.50	Yellowish brown, fine to very fine grained, sandy clays of high plasticity (CH)	3.62-6.62	-	-	-	7	
	3.50 - 5.80	Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI)	6.62-8.92	0.87	6	1.97	16	
	5.80 - 7.00	Yellowish brown, fine to medium grained, clayey sand (SC)	8.92-10.12	0.03	27	2	22	
	7.00 - 9.20	Yellowish brown, fine to very fine grained, clays of high plasticity (CH)	10.12-12.32	1.34	5	1.98	21	
	9.20 - 10.50	Yellowish brown, fine to very fine grained, clayey sand (SC)	12.32-13.62	0.06	26	1.99	18	
	10.50 - 11.30	Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI)	13.62-14.42	1.38	5	2.01	-	
	11.30 - 12.00	Yellowish brown, fine to very fine grained, clayey sand (SC)	14.42-15.12	-	-	-	37	
	12.00 - 13.90	Yellowish brown, fine to medium grained, silty sand with some gravels (SM)	15.12-17.02	-	-	-	20	
	13.90 - 17.30	Yellowish brown, fine to very fine grained, clayey sand with little gravels (SC)	17.02-20.42	-	-	-	>100	
	17.30 - 20.00	Highly weathered, very weak, yellowish brown, fine to medium grained, very thinly bedded rock	20.42-23.12	NA			200	1300

Building/Structure/Area	Depth in m from NGL	Soil Classification	Depth in m from FGL	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Bulk density in gm/cc	SPT N Value	shear strength q_c kN/m ²
Boiler Area unit-1 & Mill bunker unit-1 and 2	-	Filled up soil	FGL-2.30	1.00	0	1.80	22	NA
	0.00 - 2.60	Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity with little to some gravels (CI)	2.30-4.90	-	-	-	4	
	2.60 - 7.60	Yellowish brown, fine to very fine grained, clays of high plasticity (CH)	4.90-9.90	0.89	2	1.98	14	
	7.60 - 8.60	Yellowish brown, fine to very fine grained, clayey sand (SC)	9.90-10.90	0.08	25	1.98	14	
	8.60 - 13.10	Yellowish brown, fine to very fine grained, silty sand (SM)	10.90-15.40	0	31	2.02	25	
	13.10 - 17.10	Yellowish brown, fine to medium grained, mud rock and indurated clays	15.40-25.3	NA			200	1300
	17.10 - 23.00	Highly weathered, very weak, dark grey, very fine grained, thinly laminated rock						

Building/Structure/Area	Depth in m from NGL	Soil Classification	Depth in m from FGL	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Bulk density in gm/cc ρ_b	SPT N Value	shear strength q_c kN/m ²
BOILER AREA UNIT-3 & MILL BUNKER UNIT-3	-	Filled up soil	FGL-1.97	1.00	0	1.80	22	NA
	0.00 - 5.70	Yellowish brown, fine to very fine grained, sandy clays of high plasticity (CH)	1.97-7.67	0.93	2	1.96	7	
	5.70 - 7.90	Yellowish brown, fine to medium grained, sandy clays of intermediate plasticity (CI)	7.67-9.87	-	-	-	22	
	7.90 - 11.90	Yellowish brown, fine to very fine grained, clayey sand (SC)	9.87-13.87	0.11	26	2.01	17	
	11.90 - 13.00	Mixture of Highly weathered, weak, completely fractured and disintegrated, dark brownish grey, fine to very fine grained, thinly bedded rock	13.87-19.47	NA			130	930
	13.00 - 17.5	Moderately weathered, weak, yellowish brown, fine to medium grained, moderately thickly laminated rock						

Building/Structure/Area	Depth in m from NGL	Soil Classification	Depth in m from FGL	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Bulk density in gm/cc ρ_b	SPT N Value	shear strength q_c kN/m ²
CHIMNEY UNIT-1,2&3	-	Filled up soil	FGL-4.83	1.00	0	1.80	22	NA
	0.00 - 1.80	Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI)	4.83-6.63	-	-	-	10	
	1.80 - 4.70	Yellowish brown, fine to very fine grained, clays of high plasticity (CH)	6.63-9.53	0.77	2	1.95	12	
	4.70 - 5.70	Yellowish brown, fine to medium grained, sandy clays of intermediate plasticity (CI)	9.53-10.53	-	-	-	22	
	5.70 - 6.95	Yellowish brown, fine to medium grained, clayey sand (SC)	10.53-11.78	0.1	27	2	20	
	6.95 - 11.40	Yellowish brown, fine to very fine grained, silty sand (SM)	11.78-16.23	0	30	2.02	22	
	11.40 - 12.60	Yellowish brown, fine to very fine grained, clayey sand (SC)	16.23-17.43	-	-	-	78	
	12.60 - 20.5	Highly weathered, very weak and friable, dark brownish yellow, fine to medium grained, very thinly laminated rock	17.43-25.33	NA			200	1300

Building/Structure/Area	Depth in m from NGL	Soil Classification	Depth in m from FGL	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Bulk density in gm/cc	SPT N Value	shear strength qc kN/m ²
FGD area	-	Filled up soil	FGL-5.05	1.00	0	1.80	22	NA
	0.00 - 0.70	Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI)	5.05-5.75	-	-	-	-	
	0.70 - 3.00	Yellowish brown, fine to very fine grained, sandy clays of high plasticity (CH)	5.75-8.05	0.47	7	1.91	8	
	3.00 - 4.50	Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI)	8.05-9.55	0.48	5	1.92	9	
	4.50 - 7.90	Yellowish brown, fine to very fine grained, clayey sand (SC)	9.55-12.95	0.11	26	1.95	11	
	7.90 - 10.40	Yellowish brown, fine to medium grained, silty sand with some gravels (SM)	12.95-15.45	-	-	-	12	
	10.40 - 12.20	Yellowish brown, fine to medium grained, clayey sand with much to little gravels (SC)	15.45-17.25	-	-	-	75	
	12.20 - 14.60	Light yellowish brown, medium to coarse grained, poorly graded and silty sand with much gravels (SP-SM)	17.25-19.65	-	-	-	>100	
	14.60 - 22.00	Highly weathered, very weak, medium grained, brownish, fine to medium grained, thinly bedded rock	19.65-27.05	NA			200	1300

Design Parameter '*Tgxkkqp'25+

Design Parameter for Group 1 Applicable structure: CST tanks & pump house Representative Borehole: BH-26							
Depth in m from NGL	Soil Classification	Depth in m from FGL	Cohesion in kg/cm ²	Angle of Internal Friction	Bulk density in gm/cc	SPT N Value	shear strength qc kN/m ²
0.00-0.30	Brownish, fine to medium grained, silty clayey sand with little gravels	Up to 0.60m depth from FGL soil in cutting	-	-	-	-	-
0.30-0.60	Reddish yellow to light brownish, fine to medium grained, clayey sand with occasional to some gravels (SC)		-	-	-	-	
0.60-3.60	Reddish yellow to light brownish, fine to medium grained, clayey sand with occasional to some gravels (SC)	FGL-3.00	0.07	25	1.95	2-9	
3.60-7.30	Reddish yellow, fine to very fine grained, sandy clays of intermediate plasticity with occasional gravels (CI)	3.00-6.70	0.99	8	1.99	9-29	
7.30-7.90	Reddish yellow, fine to medium grained, silty clayey sand (SM-SC)	6.70-7.30	-	-	-	21	
7.90-10.60	Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI)	7.30-10.00	-	-	-	21-40	
10.60-18.60	Yellowish brown, very fine grained, indurated, silty clays of intermediate plasticity (CI) (Silt stone)	10.00-18.00	-	-	-	>100	96.90
18.60-25.00	Highly weathered, weak, brownish, black, very fine grained, fractured laminated to very thinly bedded rock	18.00-24.40	-	-	-	>100	

Design Parameter for Group 2 Applicable structure: Pipe rack Representative Borehole: BH-49							
Depth in m from NGL	Soil Classification	Depth in m from FGL	Cohesion in kg/cm ²	Angle of Internal Friction	Bulk Density in gm/cc	SPT N Value	shear strength qc kN/m ²
-	Filled up soil	FGL- 5.00	-	-	-	-	-
0.00-0.80	Yellowish brown, fine to medium grained, sandy clays of intermediate plasticity (CI)	5.00-5.80	-	-	-	-	
0.80-2.90	Dark brownish and yellowish brown, fine to very fine grained, sandy and silty clays of intermediate plasticity with little to occasional gravels (CI)	5.80-7.90	0.95	2	1.96	14-18	
2.90-3.50	Yellowish brown, fine to very fine grained, silty clays of low plasticity (CL)	7.90-8.50	1.16	5	1.98	22	
3.50-4.00	Yellowish brown, fine to coarse grained, sandy clays of intermediate plasticity with some gravels (CI)	8.50-9.00	-	-	-	-	
4.00-4.50	Yellowish brown, fine to very fine grained, clayey sand (SC)	9.00-9.50	-	-	-	33	
4.50-5.60	Yellowish brown, fine to very fine grained, indurated silty clays of low plasticity (CL) (silty stone)	9.50-10.60	-	-	-	>100	
5.60-7.00	Boulderous formation of highly weathered, completely fractured, gravels, pebbles, cobbles size fragments with lightly yellowish brown, fine to very fine grained, indurated silty clays of low plasticity	10.60-12.00	-	-	-	>100	40.60
7.00 - 14.00	Highly weathered, very weak, light yellowish brown and dark brownish, fine to very fine grained, very thinly laminated rock	12.00-19.00	-	-	-	-	
14.00 – 16.80	Highly weathered, weak, dark brownish grey, fine to very fine grained, rock with moderately closely spaced discontinuities	19.00-21.80	-	-	-	-	
16.80 – 19.50	Slightly weathered, weak, light greyish brown, fine to medium grained, rock with moderately widely spaced discontinuities	21.80-24.50	-	-	-	-	99.10

Design Parameter for Group 3 Applicable structure: ESP cum FGD control room Unit-1 Representative Borehole: BH-60							
Depth in m from NGL	Soil Classification	Depth in m from FGL	Cohesion in kg/cm ²	Angle of Internal Friction	Bulk Density in gm/cc	SPT N Value	shear strength qc kN/m ²
-	Filled up soil	FGL- 6.25	-	-	-	-	-
0.00-0.10	Yellowish brown, fine to medium grained, sandy clays of low plasticity (CL)	6.25-6.35	-	-	-	-	
0.10-2.70	Brownish yellow, fine to medium grained, sandy clays of intermediate plasticity with little to some gravels (CI)	6.35-8.95	0.52	6	1.95	6-10	
2.70-3.60	Brownish yellow, fine to coarse grained, clayey sand with some to much gravels (SC)	8.95-9.85	0.08	25	1.97	16	
3.60-5.20	Yellowish brown, fine to medium grained, cemented silty clayey sand with some to much gravels (SM-SC)	9.85-11.45	-	-	-	56- >100	
5.20-5.70	Yellowish brown, fine to coarse grained, cemented, silty sand with much gravels (SM)	11.45-11.95	-	-	-	>100	
5.70-8.50	Highly weathered, weak, yellowish brown, fine to coarse grained, fractured rock	11.95-14.75	-	-	-	-	121.80
8.50-10.00	Highly weathered, very weak, yellowish brown, fine to medium grained, fractured rock	14.75-16.25	-	-	-	-	89.40
10.00-11.50	Highly weathered, very weak, yellowish brown, fine to medium grained, rock with close spacing of discontinuities	16.25-17.75	-	-	-	-	60.30
11.50-14.50	Moderately weathered, moderately weak, light brownish grey, fine to medium grained, fractured rock	17.75-20.75	-	-	-	-	126.70

Design Parameter for Group 4 Applicable structure: ID fan Unit-1 Representative Borehole: BH-59							
Depth in m from NGL	Soil Classification	Depth in m from FGL	Cohesion in kg/cm ²	Angle of Internal Friction	Bulk Density in gm/cc	SPT N Value	shear strength qc kN/m ²
-	Filled up soil	FGL-4.90	-	-	-	-	-
0.00-0.20	Brownish yellow, fine to very fine grained, sandy clays of low plasticity with occasional gravels (CL)	4.90-5.10	-	-	-	-	
0.20-3.60	Brownish yellow, fine to coarse grained, sandy clays of intermediate plasticity with some gravels (CI)	5.10-8.50	0.36	6	1.94	4-7	
3.60-6.30	Brownish yellow, fine to very fine grained, clayey sand with some gravels (SC)	8.50-11.20	0.06	28	2.03	10-54	
6.30-7.30	Light brownish yellow, fine to very fine grained, cemented silty clayey sand (SMSC)	11.20-12.20	-	-	-	>100	
7.30-8.50	Highly weathered, very weak and friable yellowish brown, fine to medium grained, fractured rock	12.20-13.40	-	-	-	-	39.90
8.50-14.50	Highly weathered, weak, yellowish brown, fine to medium grained, fractured rock	13.40-19.40	-	-	-	-	125.60
14.50-16.00	Highly weathered, weak, brownish grey, fine to medium grained, rock with close spacing of discontinuities	19.40-20.90	-	-	-	-	-
16.00-17.00	Highly weathered, very weak and friable yellowish brown, fine to coarse grained, fractured rock	20.90-21.90	-	-	-	-	50.40
17.00-21.00	Highly weathered, very weak, dark blackish grey, very fine grained, very thinly bedded rock	21.90-25.90	-	-	-	-	41.50
21.00-24.00	Highly weathered, weak, dark greyish black, fine to medium grained, rock with close spacing of discontinuities	25.90-28.90	-	-	-	-	54.10
24.00-24.50	Slightly weathered, weak, dark greyish black, fine to medium grained, rock with close spacing of discontinuities	28.90-29.40	-	-	-	-	143.50

Design Parameter for Group 5 Applicable structure: Absorber & RC pump house Unit-1 Representative Borehole: BH-67							
Depth in m from NGL	Soil Classification	Depth in m from FGL	Cohesion in kg/cm ²	Angle of Internal Friction	Bulk Density in gm/cc	SPT N Value	shear strength qc kN/m ²
-	Filled up soil	FGL-6.00	-	-	-	-	-
0.00-0.10	Yellowish brown, fine to very fine grained, sandy clays of low plasticity with some gravels (CL)	6.00-6.10	-	-	-	-	
0.10-2.60	Reddish yellow, fine to very fine grained, sandy clays of intermediate plasticity with some gravels (CI)	6.10-8.60	0.31	7	1.95	4-6	
2.60-5.40	Brownish yellow, fine to coarse grained, clayey sand with some to much gravels (SC)	8.60-10.40	0.05	26	2.00	12-23	
5.40-7.10	Yellowish brown, fine to medium grained, cemented silty clayey sand (SM-SC)	10.40-13.10	-	-	-	>100	
7.10-9.00	Highly weathered, weak, light brownish yellow, fine to medium grained, fractured rock	13.10-15.00	-	-	-	-	79.60
9.00-13.50	Slightly weathered, moderately weak, yellowish brown, fine to medium grained, rock with wide spacing of discontinuities	15.00-19.50	-	-	-	-	89.60
13.50-18.00	Slightly weathered, moderately weak, light brownish grey, fine to medium grained, massive rock	19.50-24.00	-	-	-	-	138.50

Design Parameter for Group 6 Applicable structure: ESP Unit-1 Representative Borehole: BH-51							
Depth in m from NGL	Soil Classification	Depth in m from FGL	Cohesion in kg/cm ²	Angle of Internal Friction	Bulk Density in gm/cc	SPT N Value	shear strength qc kN/m ²
-	Filled up soil	FGL-6.45	-	-	-	-	-
0.00-0.75	Yellowish brown, fine to medium grained, sandy clays of low plasticity (CL)	6.45-7.20	-	-	-	-	
0.75-2.70	Yellowish brown, fine to medium grained, clayey sand with occasional gravels (SC)	4.20-9.15	0.30	8	1.99	4-6	
2.70-3.70	Yellowish brown, very fine grained, silty clays of intermediate plasticity (CI)	9.15-10.15	0.88	3	1.98	16	
3.70-4.90	Yellowish brown, very fine grained, Clays of intermediate plasticity (CI)	10.15-11.35	0.98	2	2.01	19	
4.90-7.00	Brownish, very fine grained, clays of intermediate plasticity (CI)	11.35-13.45	-	-	-	47	
7.00-9.00	Highly weathered, very weak, greyish brown, fine to very fine grained, fractured rock	13.45-15.45	-	-	-	-	47.90
9.00-10.50	Moderately weathered, weak, light brownish yellow, fine to very fine grained, rock with very close spacing of discontinuities	15.45-16.95	-	-	-	-	83.40
10.50-12.00	Moderately weathered, weak, dark brownish yellow, fine to medium grained, rock with wide spacing of discontinuities	16.95-18.45	-	-	-	-	92.20
12.00-15.00	Moderately weathered, weak, dark greyish, fine to medium grained, rock with very close spacing of discontinuities	18.45-21.45	-	-	-	-	72.50
15.00-16.50	Slightly weathered, weak, greyish black, fine to medium grained, rock with moderately close spacing of discontinuities	21.45-22.95	-	-	-	-	121.40
16.50-18.00	Slightly weathered, weak, greyish black, fine to medium grained, massive rock	22.95-24.45	-	-	-	-	162.30

Design Parameter for Group 7 Applicable structure: ESP cum FGD control room Unit-2 Representative Borehole: BH-87							
Depth in m from NGL	Soil Classification	Depth in m from FGL	Cohesion in kg/cm ²	Angle of Internal Friction	Bulk Density in gm/cc	SPT N Value	shear strength qc kN/m ²
-	Filled up soil	FGL- 5.07	-	-	-	-	-
0.00-0.80	Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI)	5.07-5.87	-	-	-	-	
0.80-3.90	Dark Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI)	5.87-8.97	1.02	8	2.00	11-21	
3.90-7.30	Dark Yellowish brown, fine to very fine grained, clayey sand with occasional gravels (SC)	8.97-12.37	0.08	27	2.00	15-22	
7.30-8.40	Light yellowish brown, fine to very fine grained, clayey sand (SC)	12.37-13.47	0.05	28	1.99	16	
8.40-9.40	Yellowish brown, fine to medium grained, silty sand (SM)	13.47-14.47	0.00	29	2.02	29	
9.40-12.30	Yellowish brown, fine to very fine grained, clayey sand with some gravels (SC)	14.47-17.37	-	-	-	33- >100	40.10
12.30-15.00	Highly weathered, very weak and friable, brownish yellow, fine to medium grained, interlocking fragments of fractured rock	17.37-20.07	-	-	-	-	
15.00-18.00	Highly weathered, completely fractured and disintegrated, brownish yellow, fine to medium grained, very weak and friable rock with very close spacing of discontinuities	20.07-23.07	-	-	-	-	
18.00-19.50	Moderately weathered, very weak, fine to medium grained, fractured rock	23.07-24.57	-	-	-	-	
19.50-20.00	Moderately weathered, moderately weak, brownish yellow, fine to very fine grained, rock with wide spacing discontinuities	24.57-25.07	-	-	-	-	
20.00-21.00	Slightly weathered, weak, brownish grey, fine to very fine grained, rock with very close spacing of discontinuities	25.07-26.07	-	-	-	-	

Design Parameter for Group 8 Applicable structure: ID fan Unit-2 Representative Borehole: BH-91							
Depth in m from NGL	Soil Classification	Depth in m from FGL	Cohesion in kg/cm ²	Angle of Internal Friction	Bulk Density in gm/cc	SPT N Value	shear strength qc kN/m ²
-	Filled up soil	FGL- 3.97	-	-	-	-	-
0.00-0.50	Yellowish brown, fine to very fine grained, clayey sand (SC)	3.97-4.47	-	-	-	-	
0.50-4.70	Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI)	4.47-8.67	0.62	4	1.97	4-20	
4.70-6.30	Yellowish brown, fine to very fine grained, clayey sand (SC)	8.67-10.27	0.07	27	2.02	17-20	
6.30-7.60	Yellowish brown, fine to very fine grained, sandy clays of low plasticity with little gravels (CL)	10.27-11.57	0.80	7	1.99	14	
7.60-13.30	Yellowish brown, fine to very fine grained, clayey sand (SC)	11.57-17.27	0.06	27	2.03	18- >100	
13.30-15.60	Dark brownish, fine to very fine grained, clays of high plasticity (CH)	17.27-19.57	-	-	-	>100	76.20
15.60-17.50	Moderately weathered, weak, dark blackish grey, fractured rock	19.57-21.47	-	-	-	-	
17.50-19.00	Fresh, moderately weak, brownish grey, fine to medium grained, massive rock	21.47-22.97	-	-	-	-	

Design Parameter for Group 9 Applicable structure: ID fan Unit-3 Representative Borehole: BH-106							
Depth in m from NGL	Soil Classification	Depth in m from FGL	Cohesion in kg/cm ²	Angle of Internal Friction	Bulk Density in gm/cc	SPT N Value	shear strength qc kN/m ²
-	Filled up soil	FGL-5.40	-	-	-	-	-
0.00-2.40	Yellowish brown, fine to medium grained, sandy clays of intermediate plasticity with some gravels (CI)	5.40-7.80	-	-	-	7-11	
2.40-3.30	Yellowish brown, fine to coarse grained, clayey sand with much gravels (SC)	7.80-8.70	0.07	25	1.67	10	
3.30-5.80	Reddish yellow, fine to medium grained, clayey sand with little to some gravels (SC)	8.70-11.20	0.08	27	2.00	11-18	
5.80-6.90	Light yellowish brown and greyish, fine to very fine grained, sandy clays of intermediate plasticity (CI)	11.20-12.30	1.65	6	2.00	12	
6.90-7.80	Reddish yellow, fine to very fine grained, clayey sand with occasional gravels (SC)	12.30-13.20	0.07	29	2.12	42	
7.80-9.30	Brownish, fine to very fine grained, cemented sandy clays of low plasticity- mud stone	13.20-14.70	-	-	-	>100	
9.30-10.30	Yellowish brown, fine to very fine grained, cemented, sandy clays of low plasticity -mud stone	14.70-15.70	-	-	-	>100	76.10
10.30-15.50	Highly weathered, weak light yellowish brown to reddish brown, fine to very fine grained, fractured rock	15.70-20.90	-	-	-	-	
15.50-18.50	Highly weathered, moderately weak light yellowish brown to reddish brown, fine to medium grained, fractured rock	20.90-23.90	-	-	-	-	
18.50-21.50	Highly weathered, strong, light greyish, fine to very fine grained, fractured rock	23.90-26.90	-	-	-	-	
21.50-24.00	Highly weathered, weak, dark reddish brown, fine to coarse grained, rock with moderately close spacing of discontinuities	26.90-29.40	-	-	-	-	
24.00-25.00	Slightly weathered, weak, Light greyish, fine to medium grained, rock with moderately close spacing of discontinuities	29.40-30.40	-	-	-	-	

Design Parameter for Group 10 Applicable structure: Mill & Bunker Unit-1 Representative Borehole: IBH-18							
Depth in m from NGL	Soil Classification	Depth in m from FGL	Cohesion in kg/cm ²	Angle of Internal Friction	Bulk Density in gm/cc	SPT N Value	shear strength qc kN/m ²
-	Filled up soil	FGL- 2.16	-	-	-	-	-
0.00-0.50	Brownish, fine to very fine grained, clayey sand with occasional gravels(SC)	2.16-2.66	-	-	-	-	-
0.50-3.70	Pinkish yellow, fine to very fine grained, sandy clays of intermediate plasticity with occasional gravels(CI)	2.66-5.86	0.90	5	1.97	11-17	-
3.70-8.50	Brownish yellow, very fine grained, clays of high plasticity with little gravels (CH)	5.86-10.66	1.12	3	2.00	19-24	-
8.50-9.50	Brownish yellow, fine to very fine grained, sandy clays of low plasticity (CL)	10.66-11.66	0.96	8	2.00	21	-
9.50-10.50	Light brownish yellow and greyish, fine to medium grained, clayey sand with little plastic fines (SC)	11.66-12.66	0.09	27	2.02	22	-
10.50-14.20	Light brownish yellow and greyish, fine to medium grained, silty sand with little plastic fines (SM)	12.66-16.36	0	29	2.05	18-22	-
14.20-16.00	Highly weathered, very weak, dark greenish grey, very fine grained, very weak, very thinly laminated, foliated SHALE	16.36-18.16	-	-	-	>100	-
16.00-19.00	Highly weathered, dark greenish grey, very fine grained, very weak, very thinly laminated, foliated SHALE	18.16-21.16	-	-	2.17	-	30.4
19.00-20.50	Moderately weathered, dark greenish grey, very fine grained, very weak, very thinly laminated, foliated SHALE	21.16-22.66	-	-	2.21	-	29.6
20.50-25.00	Slightly weathered, dark greenish grey, very fine grained, very weak, very thinly laminated foliated SHALE	22.66-27.16	-	-	2.29	-	39.4

Design Parameter for Group 11 Applicable structure: MRS Silo Representative Borehole: BH-71							
Depth in m from NGL	Soil Classification	Depth in m from FGL	Cohesion in kg/cm ²	Angle of Internal Friction	Bulk Density in gm/cc	SPT N Value	shear strength qc kN/m ²
-	Filled up soil	FGL- 4.62	-	-	-	-	-
0.00-0.80	Brownish, fine to medium grained, clayey sand (SC)	4.62-5.42	-	-	-	-	
0.80-2.60	Yellowish brown, fine to medium grained, sandy clays of intermediate plasticity (CI)	5.42-7.22	0.53	6	1.95	8-10	
2.60-5.60	Yellowish brown, very fine grained, clays of high plasticity (CH)	7.22-10.22	0.47	4	1.93	7-12	
5.60-11.90	Brownish yellow, fine to very fine grained, silty clayey sand (SM-SC)	10.22-16.52	0.04	28	2.03	14-53	
11.90-14.50	Moderately weathered, weak, dark brownish, fine to medium grained, rock with close spacing of discontinuities	16.52-19.12	-	-	-	-	125.30
14.50-16.00	Highly weathered, moderately weak, brownish grey, fine to medium grained, rock with moderately close spacing of discontinuities	19.12-20.62	-	-	-	-	218.30
16.00-20.00	Moderately weathered, moderately weak, greyish black, fine to medium grained, massive rock	20.62-24.62	-	-	-	-	183.40

Design Parameter for Group 12 Applicable structure: Boiler Unit-2 Representative Borehole: BH-79							
Depth in m from NGL	Soil Classification	Depth in m from FGL	Cohesion in kg/cm ²	Angle of Internal Friction	Bulk Density in gm/cc	SPT N Value	shear strength qc kN/m ²
-	Filled up soil	FGL- 3.80	-	-	-	-	-
0.00-1.50	Yellowish brown, fine to medium grained, clayey sand (SC)	3.80-5.30	-	-	-	4	
1.50-4.30	Yellowish brown, fine to medium grained, sandy clays of intermediate plasticity with occasional gravels (CI)	5.30-8.10	0.33	6	1.92	6-7	
4.30-5.50	Brownish yellow, fine to very fine grained, clays of intermediate plasticity (CI)	8.10-9.30	0.67	6	1.95	10-13	
5.50-8.40	Brownish yellow, fine to very fine grained, sandy clays of intermediate plasticity (CI)	9.30-12.20	0.66	6	1.96	11-30	
8.40-9.80	Brownish yellow, very fine grained, silts of intermediate plasticity (MI)	12.20-13.60	-	-	-	34-71	
9.80-12.50	Highly weathered, very weak and friable, light brownish yellow, fine to very fine grained, fractured rock	13.60-16.30	-	-	-	-	107.80
12.50-14.00	Highly weathered, moderate weak, yellowish brown, fine to very fine grained, rock with close spacing of discontinuities	16.30-17.80	-	-	-	-	146.30
14.00-15.50	Moderately weathered, moderately weak, light brownish, fine to very fine grained, rock with wide spacing of discontinuities	17.80-19.30	-	-	-	-	197.20
15.50-16.00	Moderately weathered, moderately strong, light brownish, fine to very fine grained, rock with close spacing of discontinuities	19.30-19.80	-	-	-	-	197.20
16.00-17.00	Slightly weathered, weak, greyish black, fine to very fine grained, very wide spacing of discontinuities	19.80-20.80	-	-	-	-	422.60

Design Parameter for Group 13 Applicable structure: Mill & Bunker Unit-2 Representative Borehole: BH-86							
Depth in m from NGL	Soil Classification	Depth in m from FGL	Cohesion in kg/cm ²	Angle of Internal Friction	Bulk Density in gm/cc	SPT N Value	shear strength qc kN/m ²
-	Filled up soil	FGL- 6.79	-	-	-	-	-
0.00-0.60	Yellowish brown, fine to medium grained, clayey sand (SC)	6.79-7.39	-	-	-	-	
0.60-2.40	Light brownish yellow, fine to very fine grained, silty clays of intermediate plasticity (CI)	7.39-9.19	-	-	-	4-40	
2.40-4.20	Brownish yellow, very fine grained, silts of intermediate plasticity (MI)	9.19-10.99	-	-	-	53- >100	
4.20-8.50	Highly weathered, very weak, greyish brown, fine to very fine grained, fractured rock	10.99-15.29	-	-	-	-	39.10
8.50-11.50	Highly weathered, very weak, dark grey, fine to very fine grained, rock with close spacing of discontinuities	15.29-18.29	-	-	-	-	49.60
11.50-14.50	Moderately weathered, weak, yellowish brown to greyish, fine to medium grained, rock with moderately wide spacing of discontinuities	18.29-21.29	-	-	-	-	100.60
14.50-16.00	Moderately weathered, weak, light greyish brown, fine to medium grained, fractured rock	21.29-22.79	-	-	-	-	94.90
16.00-17.00	Moderately weathered, moderately weak, light greyish, fine to medium grained, rock with wide spacing of discontinuities	22.79-23.79	-	-	-	-	246.60
17.00-18.00	Slightly weathered, weak, greyish black, fine to very fine grained, massive rock	23.79-24.79	-	-	-	-	156.40

Design Parameter for Group 14 Applicable structure: Power house Unit-1 Representative Borehole: BH-76							
Depth in m from NGL	Soil Classification	Depth in m from FGL	Cohesion in kg/cm ²	Angle of Internal Friction	Bulk Density in gm/cc	SPT N Value	shear strength qc kN/m ²
-	Filled up soil	FGL-4.50	-	-	-	-	-
0.00-0.40	Yellowish brown, fine to medium grained, sandy clays of intermediate plasticity with occasional gravels (CI)	4.50-4.90	-	-	-	-	
0.40-3.00	Brownish yellow, fine to medium grained, sandy clays of intermediate plasticity with occasional gravels (CI)	4.90-7.50	0.30	7	1.93	6	
3.00-6.50	Brownish yellow, very fine grained, clays of intermediate plasticity (CI)	7.50-11.00	2.34	4	2.03	35-70	
6.50-9.00	Moderately weathered, weak, dark greyish, fine to very fine grained, rock with wide spacing of discontinuities	11.00-13.50	-	-	-	-	100.50
9.00-10.50	Moderately weathered, weak, yellowish brown, fine to medium grained, rock with moderately wide spacing of discontinuities	13.50-15.00	-	-	-	-	153.40
10.50-12.00	Moderately weathered, moderately weak, light brownish grey, fine to medium grained, rock with moderately wide spacing of discontinuities	15.00-16.50	-	-	-	-	186.20
12.00-16.50	Moderately weathered, moderately weak, light brownish grey, fine to medium grained, rock with very wide spacing of discontinuities	16.50-21.00	-	-	-	-	173.90
16.50-18.00	Slightly weathered, moderately weak, greyish black, fine to medium grained, rock with very wide spacing of discontinuities	21.00-22.50	-	-	-	-	194.20
18.00-20.00	Slightly weathered, moderately weak, greyish black, fine to medium grained, massive rock	22.50-24.50	-	-	-	-	195.20
20.00-24.00	Slightly weathered, moderately strong, greyish black, fine to medium grained, massive rock	24.50-28.50	-	-	-	-	394.60

Design Parameter for Group 15 Applicable structure: Power house Unit-2 Representative Borehole: BH-78							
Depth in m from NGL	Soil Classification	Depth in m from FGL	Cohesion in kg/cm ²	Angle of Internal Friction	Bulk Density in gm/cc	SPT N Value	shear strength qc kN/m ²
-	Filled up soil	FGL- 3.43	-	-	-	-	-
0.00-1.30	Yellowish brown and dark brownish, fine to very fine grained, sandy clays of intermediate plasticity (CI)	3.43-4.73	-	-	-	6	
1.30-3.50	Brownish yellow to light brownish, very fine grained, silts of intermediate plasticity (MI)	4.73-6.93	0.83	10	1.99	48	
3.50-7.50	Highly weathered, weak, light brownish yellow, fine to very fine grained, rock with moderately close spacing of discontinuities	6.93-10.93	-	-	-	-	83.40
7.50-9.00	Slightly weathered, weak, dark brownish, fine to medium grained, rock with moderately close spacing of discontinuities	10.93-12.43	-	-	-	-	108.30
9.00-10.50	Highly weathered, weak, dark brownish, fine to medium grained, fractured rock	12.43-13.93	-	-	-	-	136.20
10.50-12.00	Highly weathered, moderately weak, greyish brown, fine to very fine grained, fractured rock	13.93-15.43	-	-	-	-	169.40
12.00-15.00	Moderately weathered, moderately strong, greyish brown, fine to medium grained, rock with moderately close spacing of discontinuities	15.43-18.43	-	-	-	-	337.40
15.00-18.00	Moderately weathered, moderately strong, dark greyish black, fine to medium grained, rock with wide spacing of discontinuities	18.43-21.43	-	-	-	-	435.10

Design Parameter for Group 16 Applicable structure: Power house Unit-3 Representative Borehole: BH-130							
Depth in m from NGL	Soil Classification	Depth in m from FGL	Cohesion in kg/cm ²	Angle of Internal Friction	Bulk Density in gm/cc	SPT N Value	shear strength qc kN/m ²
-	Filled up soil	FGL- 1.42	-	-	-	-	-
0.00-0.80	Brownish yellow, fine to very fine grained, sandy clays of low plasticity (CL)	1.42-2.22	-	-	-	-	
0.80-1.50	Yellowish brown, fine to medium grained, sandy clays of intermediate plasticity with occasional gravels (CI)	2.22-2.92	-	-	-	9	
1.50-3.10	Brownish to yellowish brown, fine to coarse grained, clayey sand with much gravels (SC)	2.92-4.52	0.08	27	2.02	18	
3.10-4.70	Brownish yellow, fine to very fine grained, sandy clays of intermediate plasticity with much gravels (CI)	4.52-6.12	1.59	2.05	9	41	
4.70-6.60	Yellowish brown, fine to very fine grained, cemented clayey sand (SC)	6.12-8.02	0.18	30	2.13	>100	
6.60-7.80	Yellowish brown, fine to very fine grained, cemented, silty clays of low plasticity –mud stone	8.02-9.22	-	-	-	>100	
7.80-9.10	Greyish brown, fine to very fine grained, cemented sandy clays of low plasticity –mud stone	9.22-10.52	-	-	-	>100	
9.10-12.00	Highly weathered, weak, yellowish brown, fine to medium grained, fractured rock	10.52-13.42	-	-	-	-	126.30
12.00-13.50	Highly weathered, moderately weak, yellowish brown, fine to medium grained, rock with close spacing of discontinuities	13.42-14.92	-	-	-	-	111.70
13.50-15.00	Moderately weathered, moderately weak, yellowish brown, fine to medium grained, rock with moderately wide spacing of discontinuities	14.9-16.42	-	-	-	-	126.90
15.00-16.50	Slightly weathered, moderately weak, yellowish brown and blackish brown, fine to very fine grained, rock with close spacing of discontinuities	16.42-17.92	-	-	-	-	189.90
16.50-18.00	Slightly weathered, weak, light greyish, fine to medium grained, rock with moderately close spacing of discontinuities	17.92-19.42	-	-	-	-	164.60
18.00-21.00	Slightly weathered, weak, dark brownish black, fine to medium grained, massive rock	19.42-22.42	-	-	-	-	209.70

KCT Consultancy Services LLP, Ahmedabad

APPENDIX - 1 (Power House)

SUMMARY OF ALLOWABLE BEARING PRESSURE BASED ON SHEAR AND SETTLEMENT CRITERION**Project :** Proposed Structures in Phase 1 of 3 x 800 MW NLC Talabira, Thermal Power Project (NTTPP) at village- Hirma, Talabira, Odisha

Depth of Foundation from N.G.L.	R.L. of Foundation	Length of Foundation	Width of Foundation	Safe Bearing Capacities calculated based on Shear Criteria (See Appendix 1.1)	Safe Bearing Pressures calculated based on Settlement Criteria (See Appendix 1.2)		Allowable Bearing Pressure suggested (Min. of Shear and Settlement Criterion)	
					For 25 mm Settlement	For 40 mm Settlement	For 25 mm Settlement	For 40 mm Settlement
(m)	(m)	(m)	(m)	(t / m ²)	(t / m ²)	(t / m ²)	(t / m ²)	(t / m ²)
1.00	199.86	1.50	1.50	12	22	36	12	12
1.00	199.86	2.00	2.00	11	16	26	11	11
1.00	199.86	2.50	2.50	11	12	20	11	11
1.00	199.86	3.00	3.00	11	10	16	10	11
1.50	199.36	1.50	1.50	12	24	38	12	12
1.50	199.36	2.00	2.00	12	17	27	12	12
1.50	199.36	2.50	2.50	12	13	21	12	12
1.50	199.36	3.00	3.00	11	11	17	11	11
2.00	198.86	1.50	1.50	13	24	38	13	13
2.00	198.86	2.00	2.00	12	18	29	12	12
2.00	198.86	2.50	2.50	12	14	22	12	12
2.00	198.86	3.00	3.00	12	11	18	11	12

Notes :

- 1) The factor of safety of 2.5 is considered.
- 2) The depth of foundation is considered from the R.L. 200.86m.
- 3) Calculations are considering the effect of water table at F.G.L.

KCT Consultancy Services LLP, Ahmedabad

APPENDIX - 1.1 (Power House)

Calculation of Net Safe Bearing Capacity Based on Shear Parameters C - ϕ

$$q_u = 1 / FS [2 / 3 C N_c d_c S_c i_c + \gamma d (N_q - 1) S_q d_q i_q W_q + 0.5 \gamma B N_\gamma S_\gamma d_\gamma i_\gamma W_\gamma]$$

Project : Proposed Structures in Phase 1 of 3 x 800 MW NLC Talabira, Thermal Power Project (NTTPP) at village- Hirma, Talabira, Odisha**For Square Isolated Foundation**

Sr. No.	Size of Foundation		Depth of Foundation m	R.L. of Foundation m	Shear Parameter		Bearing Capacity Factors			Shape Factors			Depth Factors			Inclination Factors			Unit Weight		Water Table Correction		Safe Bearing Capacity t / m ²
	Length	Width			C	ϕ	N _c	N _q - 1	N _γ	S _c	S _q	S _γ	d _c	d _q	d _γ	i _c	i _q	i _γ	γ	0.5 γ			
	m	m			Kg/cm ²	degree													gm/cc		W _q	W _γ	
1	1.50	1.50	1.00	199.9	0.47	5	5.99	0.35	0.27	1.30	1.20	0.80	1.14	1.00	1.00	1.00	1.00	1.00	1.67	0.84	0.50	0.50	12
2	2.00	2.00	1.00	199.9	0.47	5	5.99	0.35	0.27	1.30	1.20	0.80	1.11	1.00	1.00	1.00	1.00	1.00	1.67	0.84	0.50	0.50	11
3	2.50	2.50	1.00	199.9	0.47	5	5.99	0.35	0.27	1.30	1.20	0.80	1.08	1.00	1.00	1.00	1.00	1.00	1.67	0.84	0.50	0.50	11
4	3.00	3.00	1.00	199.9	0.47	5	5.99	0.35	0.27	1.30	1.20	0.80	1.07	1.00	1.00	1.00	1.00	1.00	1.67	0.84	0.50	0.50	11
5	1.50	1.50	1.50	199.4	0.47	5	5.99	0.35	0.27	1.30	1.20	0.80	1.21	1.00	1.00	1.00	1.00	1.00	1.67	0.84	0.50	0.50	12
6	2.00	2.00	1.50	199.4	0.47	5	5.99	0.35	0.27	1.30	1.20	0.80	1.16	1.00	1.00	1.00	1.00	1.00	1.67	0.84	0.50	0.50	12
7	2.50	2.50	1.50	199.4	0.47	5	5.99	0.35	0.27	1.30	1.20	0.80	1.13	1.00	1.00	1.00	1.00	1.00	1.67	0.84	0.50	0.50	12
8	3.00	3.00	1.50	199.4	0.47	5	5.99	0.35	0.27	1.30	1.20	0.80	1.11	1.00	1.00	1.00	1.00	1.00	1.67	0.84	0.50	0.50	11
9	1.50	1.50	2.00	198.9	0.47	5	5.99	0.35	0.27	1.30	1.20	0.80	1.28	1.00	1.00	1.00	1.00	1.00	1.67	0.84	0.50	0.50	13
10	2.00	2.00	2.00	198.9	0.47	5	5.99	0.35	0.27	1.30	1.20	0.80	1.21	1.00	1.00	1.00	1.00	1.00	1.67	0.84	0.50	0.50	12
11	2.50	2.50	2.00	198.9	0.47	5	5.99	0.35	0.27	1.30	1.20	0.80	1.17	1.00	1.00	1.00	1.00	1.00	1.67	0.84	0.50	0.50	12
12	3.00	3.00	2.00	198.9	0.47	5	5.99	0.35	0.27	1.30	1.20	0.80	1.14	1.00	1.00	1.00	1.00	1.00	1.67	0.84	0.50	0.50	12

Note :-

- 1) The factor of safety of 2.5 is considered.
- 2) The depth of foundation is considered from the R.L. 200.86m.
- 3) Calculations are considering the effect of water table at F.G.L.
- 4) 2.95 T/m² overburden of filling considered in calculation.

KCT Consultancy Services LLP, Ahmedabad

APPENDIX - 1.2 (Power House)

Calculation of Safe Bearing Pressure for Settlement of 25 and 40 mm

Project :- Proposed Structures in Phase 1 of 3 x 800 MW NLC Talabira, Thermal Power Project (NTTPP) at village- Hirma, Talabira, Odisha

Sr. No.	Foundation Details				Immediate Settlement				Consolidation Settlement					Safe Bearing Pressure	
	Depth D	R.L. of Foundation	Width B	Length L	Poissons ratio μ	Modulus of Elasticity E	Factor Cd	Rigidity Factor	Coefficient of Volume Compressibility	Depth of Compressible Stratum H from N.G.L.	λ factor related to pore pressure parameter	Depth Factor df	Rigidity Factor	For 25 mm Settlement	For 40 mm Settlement
	m	m	m	m		kg/cm ²			cm ² /kg	m				T / m ²	T / m ²
1	1.00	199.9	1.50	1.50	0.40	183	1.12	0.80	0.0170	3.00	1.00	0.80	0.80	22	36
2	1.00	199.9	2.00	2.00	0.40	183	1.12	0.80	0.0170	4.00	1.00	0.85	0.80	16	26
3	1.00	199.9	2.50	2.50	0.40	183	1.12	0.80	0.0170	5.00	1.00	0.88	0.80	12	20
4	1.00	199.9	3.00	3.00	0.40	183	1.12	0.80	0.0170	6.00	1.00	0.91	0.80	10	16
5	1.50	199.4	1.50	1.50	0.40	183	1.12	0.80	0.0170	3.00	1.00	0.73	0.80	24	38
6	1.50	199.4	2.00	2.00	0.40	183	1.12	0.80	0.0170	4.00	1.00	0.77	0.80	17	27
7	1.50	199.4	2.50	2.50	0.40	183	1.12	0.80	0.0170	5.00	1.00	0.82	0.80	13	21
8	1.50	199.4	3.00	3.00	0.40	183	1.12	0.80	0.0170	6.00	1.00	0.85	0.80	11	17
9	2.00	198.86	1.50	1.50	0.40	183	1.09	0.80	0.0170	3.00	1.00	0.73	0.80	24	38
10	2.00	198.86	2.00	2.00	0.40	183	1.12	0.80	0.0170	4.00	1.00	0.73	0.80	18	29
11	2.00	198.86	2.50	2.50	0.40	183	1.12	0.80	0.0170	5.00	1.00	0.76	0.80	14	22
12	2.00	198.86	3.00	3.00	0.40	183	1.12	0.80	0.0170	6.00	1.00	0.80	0.80	11	18

Note: - Coefficient of volume compressibility has been taken by weighted average of the values within the compressible layer.

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APPENDIX - 1.3 (Power House)

SUMMARY OF ALLOWABLE BEARING PRESSURE BASED ON SHEAR AND SETTLEMENT CRITERION**Project :** Proposed Structures in Phase 1 of 3 x 800 MW NLC Talabira, Thermal Power Project (NTTPP) at village- Hirma, Talabira, Odisha

Depth of Foundation from N.G.L.	R.L. of Foundation	Length of Foundation	Width of Foundation	Safe Bearing Capacities calculated based on Shear Criteria (See Appendix 1.4)	Safe Bearing Pressures calculated based on Settlement Criteria (See Appendix 1.5)		Allowable Bearing Pressure suggested (Min. of Shear and Settlement Criterion)	
					For 25 mm Settlement	For 40 mm Settlement	For 25 mm Settlement	For 40 mm Settlement
(m)	(m)	(m)	(m)	(t / m ²)	(t / m ²)	(t / m ²)	(t / m ²)	(t / m ²)
2.50	198.36	1.50	1.50	14	24	39	14	14
2.50	198.36	2.00	2.00	13	18	29	13	13
2.50	198.36	2.50	2.50	13	14	23	13	13
2.50	198.36	3.00	3.00	12	12	19	12	12

Notes :

- 1) The factor of safety of 2.5 is considered.
- 2) The depth of foundation is considered from the R.L. 200.86m.
- 3) Calculations are considering the effect of water table at F.G.L.

KCT Consultancy Services LLP, Ahmedabad

APPENDIX - 1.4 (Power House)

Calculation of Net Safe Bearing Capacity Based on Shear Parameters C - ϕ

$$q_u = 1 / FS [2 / 3 C N_c d_c S_c i_c + \gamma d (N_q - 1) S_q d_q i_q W_q + 0.5 \gamma B N_\gamma S_\gamma d_\gamma i_\gamma W_\gamma]$$

Project : Proposed Structures in Phase 1 of 3 x 800 MW NLC Talabira, Thermal Power Project (NTTTP) at village- Hirma, Talabira, Odisha**For Square Isolated Foundation**

Sr. No.	Size of Foundation		Depth of Foundation m	R.L. of Foundation m	Shear Parameter		Bearing Capacity Factors			Shape Factors			Depth Factors			Inclination Factors			Unit Weight		Water Table Correction		Safe Bearing Capacity t / m ²
	Length	Width			C	ϕ	N _c	N _q - 1	N _γ	S _c	S _q	S _γ	d _c	d _q	d _γ	i _c	i _q	i _γ	γ	0.5 γ			
	m	m			Kg/cm ²	degree													gm/cc		W _q	W _γ	
1	1.50	1.50	2.50	198.4	0.47	5	5.99	0.35	0.27	1.30	1.20	0.80	1.35	1.00	1.00	1.00	1.00	1.00	1.67	0.84	0.50	0.50	14
2	2.00	2.00	2.50	198.4	0.47	5	5.99	0.35	0.27	1.30	1.20	0.80	1.27	1.00	1.00	1.00	1.00	1.00	1.67	0.84	0.50	0.50	13
3	2.50	2.50	2.50	198.4	0.47	5	5.99	0.35	0.27	1.30	1.20	0.80	1.21	1.00	1.00	1.00	1.00	1.00	1.67	0.84	0.50	0.50	13
4	3.00	3.00	2.50	198.4	0.47	5	5.99	0.35	0.27	1.30	1.20	0.80	1.18	1.00	1.00	1.00	1.00	1.00	1.67	0.84	0.50	0.50	12

Note :-

- 1) The factor of safety of 2.5 is considered.
- 2) The depth of foundation is considered from the R.L. 200.86m.
- 3) Calculations are considering the effect of water table at F.G.L.
- 4) 2.95 T/m² overburden of filling considered in calculation.

KCT Consultancy Services LLP, Ahmedabad

APPENDIX - 1.5 (Power House)

Calculation of Safe Bearing Pressure for Settlement of 25 and 40 mm

Project :- Proposed Structures in Phase 1 of 3 x 800 MW NLC Talabira, Thermal Power Project (NTTPP) at village- Hirma, Talabira, Odisha

Sr. No.	Foundation Details				Immediate Settlement				Consolidation Settlement					Safe Bearing Pressure	
	Depth D	R.L. of Foundation	Width B	Length L	Poissons ratio μ	Modulus of Elasticity E	Factor Cd	Rigidity Factor	Coefficient of Volume Compressibility	Depth of Compressible Stratum H from N.G.L.	λ factor related to pore pressure parameter	Depth Factor df	Rigidity Factor	For 25 mm Settlement	For 40 mm Settlement
	m	m	m	m		kg/cm ²			cm ² /kg	m				T / m ²	T / m ²
1	2.50	198.4	1.50	1.50	0.40	183	1.04	0.80	0.0170	3.00	1.00	0.73	0.80	24	39
2	2.50	198.4	2.00	2.00	0.40	183	1.11	0.80	0.0170	4.00	1.00	0.73	0.80	18	29
3	2.50	198.4	2.50	2.50	0.40	183	1.12	0.80	0.0170	5.00	1.00	0.73	0.80	14	23
4	2.50	198.4	3.00	3.00	0.40	183	1.12	0.80	0.0170	6.00	1.00	0.75	0.80	12	19

Note: - Coefficient of volume compressibility has been taken by weighted average of the values within the compressible layer.

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APPENDIX - 2 (Power House)

SUMMARY OF ALLOWABLE BEARING PRESSURE BASED ON SHEAR AND SETTLEMENT CRITERION**Project :** Proposed Structures in Phase 1 of 3 x 800 MW NLC Talabira, Thermal Power Project (NTTPP) at village- Hirma, Talabira, Odisha

Depth of Foundation from N.G.L.	R.L. of Foundation	Length of Foundation	Width of Foundation	Safe Bearing Capacities calculated based on Shear Criteria (See Appendix 2.1)	Safe Bearing Pressures calculated based on Settlement Criteria (See Appendix 2.2)		Allowable Bearing Pressure suggested (Min. of Shear and Settlement Criterion)	
					For 25 mm Settlement	For 40 mm Settlement	For 25 mm Settlement	For 40 mm Settlement
(m)	(m)	(m)	(m)	(t / m ²)	(t / m ²)	(t / m ²)	(t / m ²)	(t / m ²)
1.00	199.86	3.50	3.50	11	9	14	9	11
1.00	199.86	4.00	4.00	11	7	12	7	11
1.00	199.86	5.00	5.00	11	6	9	6	9
1.00	199.86	6.00	6.00	11	5	8	5	8
1.50	199.36	3.50	3.50	11	9	14	9	11
1.50	199.36	4.00	4.00	11	8	12	8	11
1.50	199.36	5.00	5.00	11	6	10	6	10
1.50	199.36	6.00	6.00	11	5	8	5	8
2.00	198.86	3.50	3.50	12	9	15	9	12
2.00	198.86	4.00	4.00	12	8	13	8	12
2.00	198.86	5.00	5.00	11	6	10	6	10
2.00	198.86	6.00	6.00	11	5	8	5	8

Notes :

- 1) The factor of safety of 2.5 is considered.
- 2) The depth of foundation is considered from the R.L. 200.86m.
- 3) Calculations are considering the effect of water table at F.G.L.

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APPENDIX - 2.1 (Power House)

Calculation of Net Safe Bearing Capacity Based on Shear Parameters C - ϕ

$$q_u = 1 / FS [2 / 3 C N_c d_c S_c i_c + \gamma d (N_q - 1) S_q d_q i_q W_q + 0.5 \gamma B N_\gamma S_\gamma d_\gamma i_\gamma W_\gamma]$$

Project : Proposed Structures in Phase 1 of 3 x 800 MW NLC Talabira, Thermal Power Project (NTTPP) at village- Hirma, Talabira, Odisha**For Square Isolated Foundation**

Sr. No.	Size of Foundation		Depth of Foundation m	R.L. of Foundation m	Shear Parameter		Bearing Capacity Factors			Shape Factors			Depth Factors			Inclination Factors			Unit Weight		Water Table Correction		Safe Bearing Capacity t / m ²
	Length	Width			C	ϕ	N _c	N _q - 1	N _γ	S _c	S _q	S _γ	d _c	d _q	d _γ	i _c	i _q	i _γ	γ	0.5 γ			
	m	m			Kg/cm ²	degree													gm/cc		W _q	W _γ	
1	3.50	3.50	1.00	199.9	0.47	5	5.99	0.35	0.27	1.30	1.20	0.80	1.06	1.00	1.00	1.00	1.00	1.00	1.67	0.84	0.50	0.50	11
2	4.00	4.00	1.00	199.9	0.47	5	5.99	0.35	0.27	1.30	1.20	0.80	1.05	1.00	1.00	1.00	1.00	1.00	1.67	0.84	0.50	0.50	11
3	5.00	5.00	1.00	199.9	0.47	5	5.99	0.35	0.27	1.30	1.20	0.80	1.04	1.00	1.00	1.00	1.00	1.00	1.67	0.84	0.50	0.50	11
4	6.00	6.00	1.00	199.9	0.47	5	5.99	0.35	0.27	1.30	1.20	0.80	1.04	1.00	1.00	1.00	1.00	1.00	1.67	0.84	0.50	0.50	11
5	3.50	3.50	1.50	199.4	0.47	5	5.99	0.35	0.27	1.30	1.20	0.80	1.09	1.00	1.00	1.00	1.00	1.00	1.67	0.84	0.50	0.50	11
6	4.00	4.00	1.50	199.4	0.47	5	5.99	0.35	0.27	1.30	1.20	0.80	1.08	1.00	1.00	1.00	1.00	1.00	1.67	0.84	0.50	0.50	11
7	5.00	5.00	1.50	199.4	0.47	5	5.99	0.35	0.27	1.30	1.20	0.80	1.06	1.00	1.00	1.00	1.00	1.00	1.67	0.84	0.50	0.50	11
8	6.00	6.00	1.50	199.4	0.47	5	5.99	0.35	0.27	1.30	1.20	0.80	1.05	1.00	1.00	1.00	1.00	1.00	1.67	0.84	0.50	0.50	11
9	3.50	3.50	2.00	198.9	0.47	5	5.99	0.35	0.27	1.30	1.20	0.80	1.12	1.00	1.00	1.00	1.00	1.00	1.67	0.84	0.50	0.50	12
10	4.00	4.00	2.00	198.9	0.47	5	5.99	0.35	0.27	1.30	1.20	0.80	1.11	1.00	1.00	1.00	1.00	1.00	1.67	0.84	0.50	0.50	12
11	5.00	5.00	2.00	198.9	0.47	5	5.99	0.35	0.27	1.30	1.20	0.80	1.08	1.00	1.00	1.00	1.00	1.00	1.67	0.84	0.50	0.50	11
12	6.00	6.00	2.00	198.9	0.47	5	5.99	0.35	0.27	1.30	1.20	0.80	1.07	1.00	1.00	1.00	1.00	1.00	1.67	0.84	0.50	0.50	11

Note :-

- 1) The factor of safety of 2.5 is considered.
- 2) The depth of foundation is considered from the R.L. 200.86m.
- 3) Calculations are considering the effect of water table at F.G.L.
- 4) 2.95 T/m² overburden of filling considered in calculation.

KCT Consultancy Services LLP, Ahmedabad

APPENDIX - 2.2 (Power House)

Calculation of Safe Bearing Pressure for Settlement of 25 and 40 mm

Project :- Proposed Structures in Phase 1 of 3 x 800 MW NLC Talabira, Thermal Power Project (NTTPP) at village- Hirma, Talabira, Odisha

Sr. No.	Foundation Details				Immediate Settlement				Consolidation Settlement					Safe Bearing Pressure	
	Depth D	R.L. of Foundation	Width B	Length L	Poissons ratio μ	Modulus of Elasticity E	Factor Cd	Rigidity Factor	Coefficient of Volume Compressibility	Depth of Compressible Stratum H from N.G.L.	λ factor related to pore pressure parameter	Depth Factor df	Rigidity Factor	For 25 mm Settlement	For 40 mm Settlement
	m	m	m	m		kg/cm ²			cm ² /kg	m				T / m ²	T / m ²
1	1.00	199.9	3.50	3.50	0.40	183	1.12	0.80	0.0170	7.00	1.00	0.92	0.80	9	14
2	1.00	199.9	4.00	4.00	0.40	183	1.12	0.80	0.0170	8.00	1.00	0.93	0.80	7	12
3	1.00	199.9	5.00	5.00	0.40	183	1.12	0.80	0.0170	10.00	1.00	0.95	0.80	6	9
4	1.00	199.9	6.00	6.00	0.40	183	1.12	0.80	0.0170	12.00	1.00	0.96	0.80	5	8
5	1.50	199.4	3.50	3.50	0.40	183	1.12	0.80	0.0170	7.00	1.00	0.87	0.80	9	14
6	1.50	199.4	4.00	4.00	0.40	183	1.12	0.80	0.0170	8.00	1.00	0.89	0.80	8	12
7	1.50	199.4	5.00	5.00	0.40	183	1.12	0.80	0.0170	10.00	1.00	0.92	0.80	6	10
8	1.50	199.4	6.00	6.00	0.40	183	1.12	0.80	0.0170	12.00	1.00	0.93	0.80	5	8
9	2.00	198.86	3.50	3.50	0.40	183	1.12	0.80	0.0170	7.00	1.00	0.83	0.80	9	15
10	2.00	198.86	4.00	4.00	0.40	183	1.12	0.80	0.0170	8.00	1.00	0.85	0.80	8	13
11	2.00	198.86	5.00	5.00	0.40	183	1.12	0.80	0.0170	10.00	1.00	0.88	0.80	6	10
12	2.00	198.86	6.00	6.00	0.40	183	1.12	0.80	0.0170	12.00	1.00	0.91	0.80	5	8

Note: - Coefficient of volume compressibility has been taken by weighted average of the values within the compressible layer.

KCT Consultancy Services LLP, Ahmedabad

APPENDIX - 2.3 (Power House)

SUMMARY OF ALLOWABLE BEARING PRESSURE BASED ON SHEAR AND SETTLEMENT CRITERION**Project :** Proposed Structures in Phase 1 of 3 x 800 MW NLC Talabira, Thermal Power Project (NTTPP) at village- Hirma, Talabira, Odisha

Depth of Foundation from N.G.L.	R.L. of Foundation	Length of Foundation	Width of Foundation	Safe Bearing Capacities calculated based on Shear Criteria (See Appendix 2.4)	Safe Bearing Pressures calculated based on Settlement Criteria (See Appendix 2.5)		Allowable Bearing Pressure suggested (Min. of Shear and Settlement Criterion)	
					For 25 mm Settlement	For 40 mm Settlement	For 25 mm Settlement	For 40 mm Settlement
(m)	(m)	(m)	(m)	(t / m ²)	(t / m ²)	(t / m ²)	(t / m ²)	(t / m ²)
2.50	198.36	3.50	3.50	12	10	15	10	12
2.50	198.36	4.00	4.00	12	8	13	8	12
2.50	198.36	5.00	5.00	12	6	10	6	10
2.50	198.36	6.00	6.00	12	5	8	5	8

Notes :

- 1) The factor of safety of 2.5 is considered.
- 2) The depth of foundation is considered from the R.L. 200.86m.
- 3) Calculations are considering the effect of water table at F.G.L.

KCT Consultancy Services LLP, Ahmedabad

APPENDIX - 2.4 (Power House)

Calculation of Net Safe Bearing Capacity Based on Shear Parameters C - ϕ

$$q_u = 1 / FS [2 / 3 C N_c d_c S_c i_c + \gamma d (N_q - 1) S_q d_q i_q W_q + 0.5 \gamma B N_\gamma S_\gamma d_\gamma i_\gamma W_\gamma]$$

Project : Proposed Structures in Phase 1 of 3 x 800 MW NLC Talabira, Thermal Power Project (NTTTP) at village- Hirma, Talabira, Odisha**For Square Isolated Foundation**

Sr. No.	Size of Foundation		Depth of Foundation m	R.L. of Foundation m	Shear Parameter		Bearing Capacity Factors			Shape Factors			Depth Factors			Inclination Factors			Unit Weight		Water Table Correction		Safe Bearing Capacity t / m ²
	Length	Width			C	ϕ	N _c	N _q - 1	N _γ	S _c	S _q	S _γ	d _c	d _q	d _γ	i _c	i _q	i _γ	γ	0.5 γ			
	m	m			Kg/cm ²	degree													gm/cc		W _q	W _γ	
1	3.50	3.50	2.50	198.4	0.47	5	5.99	0.35	0.27	1.30	1.20	0.80	1.15	1.00	1.00	1.00	1.00	1.00	1.67	0.84	0.50	0.50	12
2	4.00	4.00	2.50	198.4	0.47	5	5.99	0.35	0.27	1.30	1.20	0.80	1.13	1.00	1.00	1.00	1.00	1.00	1.67	0.84	0.50	0.50	12
3	5.00	5.00	2.50	198.4	0.47	5	5.99	0.35	0.27	1.30	1.20	0.80	1.11	1.00	1.00	1.00	1.00	1.00	1.67	0.84	0.50	0.50	12
4	6.00	6.00	2.50	198.4	0.47	5	5.99	0.35	0.27	1.30	1.20	0.80	1.09	1.00	1.00	1.00	1.00	1.00	1.67	0.84	0.50	0.50	12

Note :-

- 1) The factor of safety of 2.5 is considered.
- 2) The depth of foundation is considered from the R.L. 200.86m.
- 3) Calculations are considering the effect of water table at F.G.L.
- 4) 2.95 T/m² overburden of filling considered in calculation.

KCT Consultancy Services LLP, Ahmedabad

APPENDIX - 2.5 (Power House)

Calculation of Safe Bearing Pressure for Settlement of 25 and 40 mm

Project :- Proposed Structures in Phase 1 of 3 x 800 MW NLC Talabira, Thermal Power Project (NTTPP) at village- Hirma, Talabira, Odisha

Sr. No.	Foundation Details				Immediate Settlement				Consolidation Settlement					Safe Bearing Pressure	
	Depth D	R.L. of Foundation	Width B	Length L	Poissons ratio μ	Modulus of Elasticity E	Factor Cd	Rigidity Factor	Coefficient of Volume Compressibility	Depth of Compressible Stratum H from N.G.L.	λ factor related to pore pressure parameter	Depth Factor df	Rigidity Factor	For 25 mm Settlement	For 40 mm Settlement
	m	m	m	m		kg/cm ²			cm ² /kg	m				T / m ²	T / m ²
1	2.50	198.4	3.50	3.50	0.40	183	1.12	0.80	0.0170	7.00	1.00	0.78	0.80	10	15
2	2.50	198.4	4.00	4.00	0.40	183	1.12	0.80	0.0170	8.00	1.00	0.81	0.80	8	13
3	2.50	198.4	5.00	5.00	0.40	183	1.12	0.80	0.0170	10.00	1.00	0.85	0.80	6	10
4	2.50	198.4	6.00	6.00	0.40	183	1.12	0.80	0.0170	12.00	1.00	0.88	0.80	5	8

Note: - Coefficient of volume compressibility has been taken by weighted average of the values within the compressible layer.

KCT Consultancy Services LLP, Ahmedabad

APPENDIX - 3 (Power House)

SUMMARY OF ALLOWABLE BEARING PRESSURE BASED ON SHEAR AND SETTLEMENT CRITERION**Project :** Proposed Structures in Phase 1 of 3 x 800 MW NLC Talabira, Thermal Power Project (NTTPP) at village- Hirma, Talabira, Odisha

Depth of Foundation from N.G.L.	R.L. of Foundation	Length of Foundation	Width of Foundation	Safe Bearing Capacities calculated based on Shear Criteria (See Appendix 3.1)	Safe Bearing Pressures calculated based on Settlement Criteria (See Appendix 3.2)		Allowable Bearing Pressure suggested (Min. of Shear and Settlement Criterion)	
					For 25 mm Settlement	For 40 mm Settlement	For 25 mm Settlement	For 40 mm Settlement
(m)	(m)	(m)	(m)	(t / m ²)	(t / m ²)	(t / m ²)	(t / m ²)	(t / m ²)
1.00	199.86	7.00	7.00	11	4	7	4	7
1.00	199.86	8.00	8.00	11	4	6	4	6
1.00	199.86	9.00	9.00	11	3	5	3	5
1.00	199.86	10.00	10.00	11	3	5	3	5
1.50	199.36	7.00	7.00	11	4	7	4	7
1.50	199.36	8.00	8.00	11	4	6	4	6
1.50	199.36	9.00	9.00	11	3	5	3	5
1.50	199.36	10.00	10.00	11	3	5	3	5
2.00	198.86	7.00	7.00	11	4	7	4	7
2.00	198.86	8.00	8.00	11	4	6	4	6
2.00	198.86	9.00	9.00	11	3	5	3	5
2.00	198.86	10.00	10.00	11	3	5	3	5

Notes :

- 1) The factor of safety of 2.5 is considered.
- 2) The depth of foundation is considered from the R.L. 200.86m.
- 3) Calculations are considering the effect of water table at F.G.L.

KCT Consultancy Services LLP, Ahmedabad

APPENDIX - 3.1 (Power House)

Calculation of Net Safe Bearing Capacity Based on Shear Parameters C - ϕ

$$q_u = 1 / FS [2 / 3 C N_c d_c S_c i_c + \gamma d (N_q - 1) S_q d_q i_q W_q + 0.5 \gamma B N_\gamma S_\gamma d_\gamma i_\gamma W_\gamma]$$

Project : Proposed Structures in Phase 1 of 3 x 800 MW NLC Talabira, Thermal Power Project (NTTPP) at village- Hirma, Talabira, Odisha**For Raft Foundation**

Sr. No.	Size of Foundation		Depth of Foundation m	R.L. of Foundation m	Shear Parameter		Bearing Capacity Factors			Shape Factors			Depth Factors			Inclination Factors			Unit Weight		Water Table Correction		Safe Bearing Capacity t / m ²
	Length	Width			C	ϕ	N _c	N _q - 1	N _γ	S _c	S _q	S _γ	d _c	d _q	d _γ	i _c	i _q	i _γ	γ	0.5 γ			
	m	m			Kg/cm ²	degree													gm/cc		W _q	W _γ	
1	7.00	7.00	1.00	199.9	0.47	5	5.99	0.35	0.27	1.30	1.20	0.80	1.03	1.00	1.00	1.00	1.00	1.00	1.67	0.84	0.50	0.50	11
2	8.00	8.00	1.00	199.9	0.47	5	5.99	0.35	0.27	1.30	1.20	0.80	1.03	1.00	1.00	1.00	1.00	1.00	1.67	0.84	0.50	0.50	11
3	9.00	9.00	1.00	199.9	0.47	5	5.99	0.35	0.27	1.30	1.20	0.80	1.02	1.00	1.00	1.00	1.00	1.00	1.67	0.84	0.50	0.50	11
4	10.00	10.00	1.00	199.9	0.47	5	5.99	0.35	0.27	1.30	1.20	0.80	1.02	1.00	1.00	1.00	1.00	1.00	1.67	0.84	0.50	0.50	11
5	7.00	7.00	1.50	199.4	0.47	5	5.99	0.35	0.27	1.30	1.20	0.80	1.05	1.00	1.00	1.00	1.00	1.00	1.67	0.84	0.50	0.50	11
6	8.00	8.00	1.50	199.4	0.47	5	5.99	0.35	0.27	1.30	1.20	0.80	1.04	1.00	1.00	1.00	1.00	1.00	1.67	0.84	0.50	0.50	11
7	9.00	9.00	1.50	199.4	0.47	5	5.99	0.35	0.27	1.30	1.20	0.80	1.04	1.00	1.00	1.00	1.00	1.00	1.67	0.84	0.50	0.50	11
8	10.00	10.00	1.50	199.4	0.47	5	5.99	0.35	0.27	1.30	1.20	0.80	1.03	1.00	1.00	1.00	1.00	1.00	1.67	0.84	0.50	0.50	11
9	7.00	7.00	2.00	198.9	0.47	5	5.99	0.35	0.27	1.30	1.20	0.80	1.06	1.00	1.00	1.00	1.00	1.00	1.67	0.84	0.50	0.50	11
10	8.00	8.00	2.00	198.9	0.47	5	5.99	0.35	0.27	1.30	1.20	0.80	1.05	1.00	1.00	1.00	1.00	1.00	1.67	0.84	0.50	0.50	11
11	9.00	9.00	2.00	198.9	0.47	5	5.99	0.35	0.27	1.30	1.20	0.80	1.05	1.00	1.00	1.00	1.00	1.00	1.67	0.84	0.50	0.50	11
12	10.00	10.00	2.00	198.9	0.47	5	5.99	0.35	0.27	1.30	1.20	0.80	1.04	1.00	1.00	1.00	1.00	1.00	1.67	0.84	0.50	0.50	11

Note :-

- 1) The factor of safety of 2.5 is considered.
- 2) The depth of foundation is considered from the R.L. 200.86m.
- 3) Calculations are considering the effect of water table at F.G.L.
- 4) 2.95 T/m² overburden of filling considered in calculation.

KCT Consultancy Services LLP, Ahmedabad

APPENDIX - 3.2 (Power House)

Calculation of Safe Bearing Pressure for Settlement of 25 and 40 mm

Project :- Proposed Structures in Phase 1 of 3 x 800 MW NLC Talabira, Thermal Power Project (NTTPP) at village- Hirma, Talabira, Odisha

Sr. No.	Foundation Details				Immediate Settlement				Consolidation Settlement					Safe Bearing Pressure	
	Depth D	R.L. of Foundation	Width B	Length L	Poissons ratio μ	Modulus of Elasticity E	Factor Cd	Rigidity Factor	Coefficient of Volume Compressibility	Depth of Compressible Stratum H from N.G.L.	λ factor related to pore pressure parameter	Depth Factor df	Rigidity Factor	For 25 mm Settlement	For 40 mm Settlement
	m	m	m	m		kg/cm ²			cm ² /kg	m				T / m ²	T / m ²
1	1.00	199.9	7.00	7.00	0.40	183	1.12	0.80	0.0170	14.00	1.00	0.97	0.80	4	7
2	1.00	199.9	8.00	8.00	0.40	183	1.12	0.80	0.0170	16.00	1.00	0.97	0.80	4	6
3	1.00	199.9	9.00	9.00	0.40	183	1.12	0.80	0.0170	16.50	1.00	0.97	0.80	3	5
4	1.00	199.9	10.00	10.00	0.40	183	1.12	0.80	0.0170	16.50	1.00	0.98	0.80	3	5
5	1.50	199.4	7.00	7.00	0.40	183	1.12	0.80	0.0170	14.00	1.00	0.94	0.80	4	7
6	1.50	199.4	8.00	8.00	0.40	183	1.12	0.80	0.0170	16.00	1.00	0.95	0.80	4	6
7	1.50	199.4	9.00	9.00	0.40	183	1.12	0.80	0.0170	16.00	1.00	0.96	0.80	3	5
8	1.50	199.4	10.00	10.00	0.40	183	1.12	0.80	0.0170	16.00	1.00	0.96	0.80	3	5
9	2.00	198.86	7.00	7.00	0.40	183	1.12	0.80	0.0170	14.00	1.00	0.92	0.80	4	7
10	2.00	198.86	8.00	8.00	0.40	183	1.12	0.80	0.0170	15.50	1.00	0.93	0.80	4	6
11	2.00	198.86	9.00	9.00	0.40	183	1.12	0.80	0.0170	15.50	1.00	0.94	0.80	3	5
12	2.00	198.86	10.00	10.00	0.40	183	1.12	0.80	0.0170	15.50	1.00	0.95	0.80	3	5

Note: - Coefficient of volume compressibility has been taken by weighted average of the values within the compressible layer.

KCT Consultancy Services LLP, Ahmedabad

APPENDIX - 3.3 (Power House)

SUMMARY OF ALLOWABLE BEARING PRESSURE BASED ON SHEAR AND SETTLEMENT CRITERION**Project :** Proposed Structures in Phase 1 of 3 x 800 MW NLC Talabira, Thermal Power Project (NTTPP) at village- Hirma, Talabira, Odisha

Depth of Foundation from N.G.L.	R.L. of Foundation	Length of Foundation	Width of Foundation	Safe Bearing Capacities calculated based on Shear Criteria (See Appendix 3.4)	Safe Bearing Pressures calculated based on Settlement Criteria (See Appendix 3.5)		Allowable Bearing Pressure suggested (Min. of Shear and Settlement Criterion)	
					For 25 mm Settlement	For 40 mm Settlement	For 25 mm Settlement	For 40 mm Settlement
(m)	(m)	(m)	(m)	(t / m ²)	(t / m ²)	(t / m ²)	(t / m ²)	(t / m ²)
2.50	198.36	7.00	7.00	11	4	7	4	7
2.50	198.36	8.00	8.00	11	4	6	4	6
2.50	198.36	9.00	9.00	11	3	5	3	5
2.50	198.36	10.00	10.00	11	3	5	3	5

Notes :

- 1) The factor of safety of 2.5 is considered.
- 2) The depth of foundation is considered from the R.L. 200.86m.
- 3) Calculations are considering the effect of water table at F.G.L.

KCT Consultancy Services LLP, Ahmedabad

APPENDIX - 3.4 (Power House)

Calculation of Net Safe Bearing Capacity Based on Shear Parameters C - ϕ

$$q_u = 1 / FS [2 / 3 C N_c d_c S_c i_c + \gamma d (N_q - 1) S_q d_q i_q W_q + 0.5 \gamma B N_\gamma S_\gamma d_\gamma i_\gamma W_\gamma]$$

Project : Proposed Structures in Phase 1 of 3 x 800 MW NLC Talabira, Thermal Power Project (NTTTP) at village- Hirma, Talabira, Odisha**For Raft Foundation**

Sr. No.	Size of Foundation		Depth of Foundation m	R.L. of Foundation m	Shear Parameter		Bearing Capacity Factors			Shape Factors			Depth Factors			Inclination Factors			Unit Weight		Water Table Correction		Safe Bearing Capacity t / m ²
	Length	Width			C	ϕ	N _c	N _q - 1	N _γ	S _c	S _q	S _γ	d _c	d _q	d _γ	i _c	i _q	i _γ	γ	0.5 γ			
	m	m			Kg/cm ²	degree													gm/cc		W _q	W _γ	
1	7.00	7.00	2.50	198.4	0.47	5	5.99	0.35	0.27	1.30	1.20	0.80	1.08	1.00	1.00	1.00	1.00	1.00	1.67	0.84	0.50	0.50	11
2	8.00	8.00	2.50	198.4	0.47	5	5.99	0.35	0.27	1.30	1.20	0.80	1.07	1.00	1.00	1.00	1.00	1.00	1.67	0.84	0.50	0.50	11
3	9.00	9.00	2.50	198.4	0.47	5	5.99	0.35	0.27	1.30	1.20	0.80	1.06	1.00	1.00	1.00	1.00	1.00	1.67	0.84	0.50	0.50	11
4	10.00	10.00	2.50	198.4	0.47	5	5.99	0.35	0.27	1.30	1.20	0.80	1.05	1.00	1.00	1.00	1.00	1.00	1.67	0.84	0.50	0.50	11

Note :-

- 1) The factor of safety of 2.5 is considered.
- 2) The depth of foundation is considered from the R.L. 200.86m.
- 3) Calculations are considering the effect of water table at F.G.L.
- 4) 2.95 T/m² overburden of filling considered in calculation.

KCT Consultancy Services LLP, Ahmedabad

APPENDIX - 3.5 (Power House)

Calculation of Safe Bearing Pressure for Settlement of 25 and 40 mm

Project :- Proposed Structures in Phase 1 of 3 x 800 MW NLC Talabira, Thermal Power Project (NTTPP) at village- Hirma, Talabira, Odisha

Sr. No.	Foundation Details				Immediate Settlement				Consolidation Settlement					Safe Bearing Pressure	
	Depth D	R.L. of Foundation	Width B	Length L	Poissons ratio μ	Modulus of Elasticity E	Factor Cd	Rigidity Factor	Coefficient of Volume Compressibility	Depth of Compressible Stratum H from N.G.L.	λ factor related to pore pressure parameter	Depth Factor df	Rigidity Factor	For 25 mm Settlement	For 40 mm Settlement
	m	m	m	m		kg/cm ²			cm ² /kg	m				T / m ²	T / m ²
1	2.50	198.4	7.00	7.00	0.40	183	1.12	0.80	0.0170	14.00	1.00	0.90	0.80	4	7
2	2.50	198.4	8.00	8.00	0.40	183	1.12	0.80	0.0170	15.00	1.00	0.91	0.80	4	6
3	2.50	198.4	9.00	9.00	0.40	183	1.12	0.80	0.0170	15.00	1.00	0.92	0.80	3	5
4	2.50	198.4	10.00	10.00	0.40	183	1.12	0.80	0.0170	15.00	1.00	0.93	0.80	3	5

Note: - Coefficient of volume compressibility has been taken by weighted average of the values within the compressible layer.

KCT Consultancy Services LLP, Ahmedabad

APPENDIX - 4 (Transformer Yard)

SUMMARY OF ALLOWABLE BEARING PRESSURE BASED ON SHEAR AND SETTLEMENT CRITERION**Project :** Proposed Structures in Phase 1 of 3 x 800 MW NLC Talabira, Thermal Power Project (NTTPP) at village- Hirma, Talabira, Odisha

Depth of Foundation from N.G.L.	R.L. of Foundation	Length of Foundation	Width of Foundation	Safe Bearing Capacities calculated based on Shear Criteria (See Appendix 4.1)	Safe Bearing Pressures calculated based on Settlement Criteria (See Appendix 4.2)		Allowable Bearing Pressure suggested (Min. of Shear and Settlement Criterion)	
					For 25 mm Settlement	For 40 mm Settlement	For 25 mm Settlement	For 40 mm Settlement
(m)	(m)	(m)	(m)	(t / m ²)	(t / m ²)	(t / m ²)	(t / m ²)	(t / m ²)
1.00	199.70	1.50	1.50	19	40	64	19	19
1.00	199.70	2.00	2.00	18	29	46	18	18
1.00	199.70	2.50	2.50	18	22	36	18	18
1.00	199.70	3.00	3.00	18	18	29	18	18
1.50	199.20	1.50	1.50	20	42	68	20	20
1.50	199.20	2.00	2.00	19	31	49	19	19
1.50	199.20	2.50	2.50	19	24	38	19	19
1.50	199.20	3.00	3.00	18	19	31	18	18
2.00	198.70	1.50	1.50	21	43	68	21	21
2.00	198.70	2.00	2.00	20	32	51	20	20
2.00	198.70	2.50	2.50	19	25	39	19	19
2.00	198.70	3.00	3.00	19	20	32	19	19

Notes :

- 1) The factor of safety of 2.5 is considered.
- 2) The depth of foundation is considered from the R.L. 200.7m.
- 3) Calculations are considering the effect of water table at F.G.L.

KCT Consultancy Services LLP, Ahmedabad

APPENDIX - 4.1 (Transformer Yard)

Calculation of Net Safe Bearing Capacity Based on Shear Parameters C - ϕ

$$q_u = 1 / FS [2 / 3 C N_c d_c S_c i_c + \gamma d (N_q - 1) S_q d_q i_q W_q + 0.5 \gamma B N_\gamma S_\gamma d_\gamma i_\gamma W_\gamma]$$

Project : Proposed Structures in Phase 1 of 3 x 800 MW NLC Talabira, Thermal Power Project (NTTPP) at village- Hirma, Talabira, Odisha**For Square Isolated Foundation**

Sr. No.	Size of Foundation		Depth of Foundation m	R.L. of Foundation m	Shear Parameter		Bearing Capacity Factors			Shape Factors			Depth Factors			Inclination Factors			Unit Weight		Water Table Correction		Safe Bearing Capacity t / m ²
	Length	Width			C	ϕ	N _c	N _q - 1	N _γ	S _c	S _q	S _γ	d _c	d _q	d _γ	i _c	i _q	i _γ	γ	0.5 γ			
	m	m			Kg/cm ²	degree													gm/cc		W _q	W _γ	
1	1.50	1.50	1.00	199.70	0.81	3	5.71	0.23	0.18	1.30	1.20	0.80	1.14	1.00	1.00	1.00	1.00	1.00	1.95	0.98	0.50	0.50	19
2	2.00	2.00	1.00	199.70	0.81	3	5.71	0.23	0.18	1.30	1.20	0.80	1.10	1.00	1.00	1.00	1.00	1.00	1.95	0.98	0.50	0.50	18
3	2.50	2.50	1.00	199.70	0.81	3	5.71	0.23	0.18	1.30	1.20	0.80	1.08	1.00	1.00	1.00	1.00	1.00	1.95	0.98	0.50	0.50	18
4	3.00	3.00	1.00	199.70	0.81	3	5.71	0.23	0.18	1.30	1.20	0.80	1.07	1.00	1.00	1.00	1.00	1.00	1.95	0.98	0.50	0.50	18
5	1.50	1.50	1.50	199.20	0.81	3	5.71	0.23	0.18	1.30	1.20	0.80	1.21	1.00	1.00	1.00	1.00	1.00	1.95	0.98	0.50	0.50	20
6	2.00	2.00	1.50	199.20	0.81	3	5.71	0.23	0.18	1.30	1.20	0.80	1.16	1.00	1.00	1.00	1.00	1.00	1.95	0.98	0.50	0.50	19
7	2.50	2.50	1.50	199.20	0.81	3	5.71	0.23	0.18	1.30	1.20	0.80	1.12	1.00	1.00	1.00	1.00	1.00	1.95	0.98	0.50	0.50	19
8	3.00	3.00	1.50	199.20	0.81	3	5.71	0.23	0.18	1.30	1.20	0.80	1.10	1.00	1.00	1.00	1.00	1.00	1.95	0.98	0.50	0.50	18
9	1.50	1.50	2.00	198.70	0.81	3	5.71	0.23	0.18	1.30	1.20	0.80	1.28	1.00	1.00	1.00	1.00	1.00	1.95	0.98	0.50	0.50	21
10	2.00	2.00	2.00	198.70	0.81	3	5.71	0.23	0.18	1.30	1.20	0.80	1.21	1.00	1.00	1.00	1.00	1.00	1.95	0.98	0.50	0.50	20
11	2.50	2.50	2.00	198.70	0.81	3	5.71	0.23	0.18	1.30	1.20	0.80	1.17	1.00	1.00	1.00	1.00	1.00	1.95	0.98	0.50	0.50	19
12	3.00	3.00	2.00	198.70	0.81	3	5.71	0.23	0.18	1.30	1.20	0.80	1.14	1.00	1.00	1.00	1.00	1.00	1.95	0.98	0.50	0.50	19

Note :-**1) The factor of safety of 2.5 is considered.****2) The depth of foundation is considered from the R.L. 200.7m.****3) Calculations are considering the effect of water table at F.G.L.**

KCT Consultancy Services LLP, Ahmedabad

APPENDIX - 4.2 (Transformer Yard)

Calculation of Safe Bearing Pressure for Settlement of 25 and 40 mm

Project :- Proposed Structures in Phase 1 of 3 x 800 MW NLC Talabira, Thermal Power Project (NTTPP) at village- Hirma, Talabira, Odisha

Sr. No.	Foundation Details				Immediate Settlement				Consolidation Settlement					Safe Bearing Pressure	
	Depth D	R.L. of Foundation	Width B	Length L	Poissons ratio μ	Modulus of Elasticity E	Factor Cd	Rigidity Factor	Coefficient of Volume Compressibility	Depth of Compressible Stratum H from N.G.L.	λ factor related to pore pressure parameter	Depth Factor df	Rigidity Factor	For 25 mm Settlement	For 40 mm Settlement
	m	m	m	m		kg/cm ²			cm ² /kg	m				T / m ²	T / m ²
1	1.00	199.70	1.50	1.50	0.40	248	1.12	0.80	0.0119	3.00	0.70	0.80	0.80	40	64
2	1.00	199.70	2.00	2.00	0.40	248	1.12	0.80	0.0119	4.00	0.70	0.85	0.80	29	46
3	1.00	199.70	2.50	2.50	0.40	248	1.12	0.80	0.0119	5.00	0.70	0.88	0.80	22	36
4	1.00	199.70	3.00	3.00	0.40	248	1.12	0.80	0.0119	6.00	0.70	0.91	0.80	18	29
5	1.50	199.20	1.50	1.50	0.40	248	1.12	0.80	0.0119	3.00	0.70	0.73	0.80	42	68
6	1.50	199.20	2.00	2.00	0.40	248	1.12	0.80	0.0119	4.00	0.70	0.77	0.80	31	49
7	1.50	199.20	2.50	2.50	0.40	248	1.12	0.80	0.0119	5.00	0.70	0.82	0.80	24	38
8	1.50	199.20	3.00	3.00	0.40	248	1.12	0.80	0.0119	6.00	0.70	0.85	0.80	19	31
9	2.00	198.70	1.50	1.50	0.40	248	1.09	0.80	0.0119	3.00	0.70	0.73	0.80	43	68
10	2.00	198.70	2.00	2.00	0.40	248	1.12	0.80	0.0119	4.00	0.70	0.73	0.80	32	51
11	2.00	198.70	2.50	2.50	0.40	248	1.12	0.80	0.0119	5.00	0.70	0.76	0.80	25	39
12	2.00	198.70	3.00	3.00	0.40	248	1.12	0.80	0.0119	6.00	0.70	0.80	0.80	20	32

Note: - Coefficient of volume compressibility has been taken by weighted average of the values within the compressible layer.

KCT Consultancy Services LLP, Ahmedabad

APPENDIX - 4.3 (Transformer Yard)

SUMMARY OF ALLOWABLE BEARING PRESSURE BASED ON SHEAR AND SETTLEMENT CRITERION**Project :** Proposed Structures in Phase 1 of 3 x 800 MW NLC Talabira, Thermal Power Project (NTTPP) at village- Hirma, Talabira, Odisha

Depth of Foundation from N.G.L.	R.L. of Foundation	Length of Foundation	Width of Foundation	Safe Bearing Capacities calculated based on Shear Criteria (See Appendix 4.4)	Safe Bearing Pressures calculated based on Settlement Criteria (See Appendix 4.5)		Allowable Bearing Pressure suggested (Min. of Shear and Settlement Criterion)	
					For 25 mm Settlement	For 40 mm Settlement	For 25 mm Settlement	For 40 mm Settlement
(m)	(m)	(m)	(m)	(t / m ²)	(t / m ²)	(t / m ²)	(t / m ²)	(t / m ²)
2.50	198.20	1.50	1.50	22	43	69	22	22
2.50	198.20	2.00	2.00	21	32	51	21	21
2.50	198.20	2.50	2.50	20	25	41	20	20
2.50	198.20	3.00	3.00	19	21	33	19	19

Notes :

- 1) The factor of safety of 2.5 is considered.
- 2) The depth of foundation is considered from the R.L. 200.7m.
- 3) Calculations are considering the effect of water table at F.G.L.

KCT Consultancy Services LLP, Ahmedabad

APPENDIX - 4.4 (Transformer Yard)

Calculation of Net Safe Bearing Capacity Based on Shear Parameters C - ϕ

$$q_u = 1 / FS [2 / 3 C N_c d_c S_c i_c + \gamma d (N_q - 1) S_q d_q i_q W_q + 0.5 \gamma B N_\gamma S_\gamma d_\gamma i_\gamma W_\gamma]$$

Project : Proposed Structures in Phase 1 of 3 x 800 MW NLC Talabira, Thermal Power Project (NTTTP) at village- Hirma, Talabira, Odisha**For Square Isolated Foundation**

Sr. No.	Size of Foundation		Depth of Foundation m	R.L. of Foundation m	Shear Parameter		Bearing Capacity Factors			Shape Factors			Depth Factors			Inclination Factors			Unit Weight		Water Table Correction		Safe Bearing Capacity t / m ²
	Length	Width			C	ϕ													γ	0.5γ			
	m	m			Kg/cm ²	degree	N _c	N _q - 1	N _γ	S _c	S _q	S _γ	d _c	d _q	d _γ	i _c	i _q	i _γ	gm/cc		W _q	W _γ	
1	1.50	1.50	2.50	198.20	0.81	3	5.71	0.23	0.18	1.30	1.20	0.80	1.35	1.00	1.00	1.00	1.00	1.00	1.95	0.98	0.50	0.50	22
2	2.00	2.00	2.50	198.20	0.81	3	5.71	0.23	0.18	1.30	1.20	0.80	1.26	1.00	1.00	1.00	1.00	1.00	1.95	0.98	0.50	0.50	21
3	2.50	2.50	2.50	198.20	0.81	3	5.71	0.23	0.18	1.30	1.20	0.80	1.21	1.00	1.00	1.00	1.00	1.00	1.95	0.98	0.50	0.50	20
4	3.00	3.00	2.50	198.20	0.81	3	5.71	0.23	0.18	1.30	1.20	0.80	1.17	1.00	1.00	1.00	1.00	1.00	1.95	0.98	0.50	0.50	19

Note :-

- 1) The factor of safety of 2.5 is considered.
- 2) The depth of foundation is considered from the R.L. 200.7m.
- 3) Calculations are considering the effect of water table at F.G.L.

KCT Consultancy Services LLP, Ahmedabad

APPENDIX - 4.5 (Transformer Yard)

Calculation of Safe Bearing Pressure for Settlement of 25 and 40 mm

Project :- Proposed Structures in Phase 1 of 3 x 800 MW NLC Talabira, Thermal Power Project (NTTPP) at village- Hirma, Talabira, Odisha

Sr. No.	Foundation Details				Immediate Settlement				Consolidation Settlement					Safe Bearing Pressure	
	Depth D	R.L. of Foundation	Width B	Length L	Poissons ratio μ	Modulus of Elasticity E	Factor Cd	Rigidity Factor	Coefficient of Volume Compressibility	Depth of Compressible Stratum H from N.G.L.	λ factor related to pore pressure parameter	Depth Factor df	Rigidity Factor	For 25 mm Settlement	For 40 mm Settlement
	m	m	m	m		kg/cm ²			cm ² /kg	m				T / m ²	T / m ²
1	2.50	198.20	1.50	1.50	0.40	248	1.04	0.80	0.0119	3.00	0.70	0.73	0.80	43	69
2	2.50	198.20	2.00	2.00	0.40	248	1.11	0.80	0.0119	4.00	0.70	0.73	0.80	32	51
3	2.50	198.20	2.50	2.50	0.40	248	1.12	0.80	0.0119	5.00	0.70	0.73	0.80	25	41
4	2.50	198.20	3.00	3.00	0.40	248	1.12	0.80	0.0119	6.00	0.70	0.75	0.80	21	33

Note: - Coefficient of volume compressibility has been taken by weighted average of the values within the compressible layer.

KCT Consultancy Services LLP, Ahmedabad

APPENDIX - 5 (Transformer Yard)

SUMMARY OF ALLOWABLE BEARING PRESSURE BASED ON SHEAR AND SETTLEMENT CRITERION**Project :** Proposed Structures in Phase 1 of 3 x 800 MW NLC Talabira, Thermal Power Project (NTTPP) at village- Hirma, Talabira, Odisha

Depth of Foundation from N.G.L.	R.L. of Foundation	Length of Foundation	Width of Foundation	Safe Bearing Capacities calculated based on Shear Criteria (See Appendix 5.1)	Safe Bearing Pressures calculated based on Settlement Criteria (See Appendix 5.2)		Allowable Bearing Pressure suggested (Min. of Shear and Settlement Criterion)	
					For 25 mm Settlement	For 40 mm Settlement	For 25 mm Settlement	For 40 mm Settlement
(m)	(m)	(m)	(m)	(t / m ²)	(t / m ²)	(t / m ²)	(t / m ²)	(t / m ²)
1.00	199.70	3.50	3.50	17	16	25	16	17
1.00	199.70	4.00	4.00	17	14	22	14	17
1.00	199.70	5.00	5.00	17	11	17	11	17
1.00	199.70	6.00	6.00	17	9	14	9	14
1.50	199.20	3.50	3.50	18	16	26	16	18
1.50	199.20	4.00	4.00	18	14	22	14	18
1.50	199.20	5.00	5.00	18	11	18	11	18
1.50	199.20	6.00	6.00	17	9	15	9	15
2.00	198.70	3.50	3.50	18	17	27	17	18
2.00	198.70	4.00	4.00	18	14	23	14	18
2.00	198.70	5.00	5.00	18	11	18	11	18
2.00	198.70	6.00	6.00	18	9	15	9	15

Notes :

- 1) The factor of safety of 2.5 is considered.
- 2) The depth of foundation is considered from the R.L. 200.7m.
- 3) Calculations are considering the effect of water table at F.G.L.

KCT Consultancy Services LLP, Ahmedabad

APPENDIX - 5.1 (Transformer Yard)

Calculation of Net Safe Bearing Capacity Based on Shear Parameters C - ϕ

$$q_u = 1 / FS [2 / 3 C N_c d_c S_c i_c + \gamma d (N_q - 1) S_q d_q i_q W_q + 0.5 \gamma B N_\gamma S_\gamma d_\gamma i_\gamma W_\gamma]$$

Project : Proposed Structures in Phase 1 of 3 x 800 MW NLC Talabira, Thermal Power Project (NTTPP) at village- Hirma, Talabira, Odisha**For Square Isolated Foundation**

Sr. No.	Size of Foundation		Depth of Foundation m	R.L. of Foundation m	Shear Parameter		Bearing Capacity Factors			Shape Factors			Depth Factors			Inclination Factors			Unit Weight		Water Table Correction		Safe Bearing Capacity t / m ²
	Length	Width			C	ϕ	N _c	N _q - 1	N _γ	S _c	S _q	S _γ	d _c	d _q	d _γ	i _c	i _q	i _γ	γ	0.5 γ			
	m	m			Kg/cm ²	degree													gm/cc		W _q	W _γ	
1	3.50	3.50	1.00	199.70	0.81	3	5.71	0.23	0.18	1.30	1.20	0.80	1.06	1.00	1.00	1.00	1.00	1.00	1.95	0.98	0.50	0.50	17
2	4.00	4.00	1.00	199.70	0.81	3	5.71	0.23	0.18	1.30	1.20	0.80	1.05	1.00	1.00	1.00	1.00	1.00	1.95	0.98	0.50	0.50	17
3	5.00	5.00	1.00	199.70	0.81	3	5.71	0.23	0.18	1.30	1.20	0.80	1.04	1.00	1.00	1.00	1.00	1.00	1.95	0.98	0.50	0.50	17
4	6.00	6.00	1.00	199.70	0.81	3	5.71	0.23	0.18	1.30	1.20	0.80	1.03	1.00	1.00	1.00	1.00	1.00	1.95	0.98	0.50	0.50	17
5	3.50	3.50	1.50	199.20	0.81	3	5.71	0.23	0.18	1.30	1.20	0.80	1.09	1.00	1.00	1.00	1.00	1.00	1.95	0.98	0.50	0.50	18
6	4.00	4.00	1.50	199.20	0.81	3	5.71	0.23	0.18	1.30	1.20	0.80	1.08	1.00	1.00	1.00	1.00	1.00	1.95	0.98	0.50	0.50	18
7	5.00	5.00	1.50	199.20	0.81	3	5.71	0.23	0.18	1.30	1.20	0.80	1.06	1.00	1.00	1.00	1.00	1.00	1.95	0.98	0.50	0.50	18
8	6.00	6.00	1.50	199.20	0.81	3	5.71	0.23	0.18	1.30	1.20	0.80	1.05	1.00	1.00	1.00	1.00	1.00	1.95	0.98	0.50	0.50	17
9	3.50	3.50	2.00	198.70	0.81	3	5.71	0.23	0.18	1.30	1.20	0.80	1.12	1.00	1.00	1.00	1.00	1.00	1.95	0.98	0.50	0.50	18
10	4.00	4.00	2.00	198.70	0.81	3	5.71	0.23	0.18	1.30	1.20	0.80	1.10	1.00	1.00	1.00	1.00	1.00	1.95	0.98	0.50	0.50	18
11	5.00	5.00	2.00	198.70	0.81	3	5.71	0.23	0.18	1.30	1.20	0.80	1.08	1.00	1.00	1.00	1.00	1.00	1.95	0.98	0.50	0.50	18
12	6.00	6.00	2.00	198.70	0.81	3	5.71	0.23	0.18	1.30	1.20	0.80	1.07	1.00	1.00	1.00	1.00	1.00	1.95	0.98	0.50	0.50	18

Note :-**1) The factor of safety of 2.5 is considered.****2) The depth of foundation is considered from the R.L. 200.7m.****3) Calculations are considering the effect of water table at F.G.L.**

KCT Consultancy Services LLP, Ahmedabad

APPENDIX - 5.2 (Transformer Yard)

Calculation of Safe Bearing Pressure for Settlement of 25 and 40 mm

Project :- Proposed Structures in Phase 1 of 3 x 800 MW NLC Talabira, Thermal Power Project (NTTPP) at village- Hirma, Talabira, Odisha

Sr. No.	Foundation Details				Immediate Settlement				Consolidation Settlement					Safe Bearing Pressure	
	Depth D	R.L. of Foundation	Width B	Length L	Poissons ratio μ	Modulus of Elasticity E	Factor Cd	Rigidity Factor	Coefficient of Volume Compressibility	Depth of Compressible Stratum H from N.G.L.	λ factor related to pore pressure parameter	Depth Factor df	Rigidity Factor	For 25 mm Settlement	For 40 mm Settlement
	m	m	m	m		kg/cm ²			cm ² /kg	m				T / m ²	T / m ²
1	1.00	199.70	3.50	3.50	0.40	248	1.12	0.80	0.0119	7.00	0.70	0.92	0.80	16	25
2	1.00	199.70	4.00	4.00	0.40	248	1.12	0.80	0.0119	8.00	0.70	0.93	0.80	14	22
3	1.00	199.70	5.00	5.00	0.40	248	1.12	0.80	0.0119	9.00	0.70	0.95	0.80	11	17
4	1.00	199.70	6.00	6.00	0.40	248	1.12	0.80	0.0119	9.00	0.70	0.96	0.80	9	14
5	1.50	199.20	3.50	3.50	0.40	248	1.12	0.80	0.0119	7.00	0.70	0.87	0.80	16	26
6	1.50	199.20	4.00	4.00	0.40	248	1.12	0.80	0.0119	8.00	0.70	0.89	0.80	14	22
7	1.50	199.20	5.00	5.00	0.40	248	1.12	0.80	0.0119	8.50	0.70	0.92	0.80	11	18
8	1.50	199.20	6.00	6.00	0.40	248	1.12	0.80	0.0119	8.50	0.70	0.93	0.80	9	15
9	2.00	198.70	3.50	3.50	0.40	248	1.12	0.80	0.0119	7.00	0.70	0.83	0.80	17	27
10	2.00	198.70	4.00	4.00	0.40	248	1.12	0.80	0.0119	8.00	0.70	0.85	0.80	14	23
11	2.00	198.70	5.00	5.00	0.40	248	1.12	0.80	0.0119	8.00	0.70	0.88	0.80	11	18
12	2.00	198.70	6.00	6.00	0.40	248	1.12	0.80	0.0119	8.00	0.70	0.91	0.80	9	15

Note: - Coefficient of volume compressibility has been taken by weighted average of the values within the compressible layer.

KCT Consultancy Services LLP, Ahmedabad

APPENDIX - 5.3 (Transformer Yard)

SUMMARY OF ALLOWABLE BEARING PRESSURE BASED ON SHEAR AND SETTLEMENT CRITERION**Project :** Proposed Structures in Phase 1 of 3 x 800 MW NLC Talabira, Thermal Power Project (NTTPP) at village- Hirma, Talabira, Odisha

Depth of Foundation from N.G.L.	R.L. of Foundation	Length of Foundation	Width of Foundation	Safe Bearing Capacities calculated based on Shear Criteria (See Appendix 5.4)	Safe Bearing Pressures calculated based on Settlement Criteria (See Appendix 5.5)		Allowable Bearing Pressure suggested (Min. of Shear and Settlement Criterion)	
					For 25 mm Settlement	For 40 mm Settlement	For 25 mm Settlement	For 40 mm Settlement
(m)	(m)	(m)	(m)	(t / m ²)	(t / m ²)	(t / m ²)	(t / m ²)	(t / m ²)
2.50	198.20	3.50	3.50	19	17	28	17	19
2.50	198.20	4.00	4.00	19	15	24	15	19
2.50	198.20	5.00	5.00	18	12	19	12	18
2.50	198.20	6.00	6.00	18	10	16	10	16

Notes :

- 1) The factor of safety of 2.5 is considered.
- 2) The depth of foundation is considered from the R.L. 200.7m.
- 3) Calculations are considering the effect of water table at F.G.L.

KCT Consultancy Services LLP, Ahmedabad

APPENDIX - 5.4 (Transformer Yard)

Calculation of Net Safe Bearing Capacity Based on Shear Parameters C - ϕ

$$q_u = 1 / FS [2 / 3 C N_c d_c S_c i_c + \gamma d (N_q - 1) S_q d_q i_q W_q + 0.5 \gamma B N_\gamma S_\gamma d_\gamma i_\gamma W_\gamma]$$

Project : Proposed Structures in Phase 1 of 3 x 800 MW NLC Talabira, Thermal Power Project (NTTTP) at village- Hirma, Talabira, Odisha**For Square Isolated Foundation**

Sr. No.	Size of Foundation		Depth of Foundation m	R.L. of Foundation m	Shear Parameter		Bearing Capacity Factors			Shape Factors			Depth Factors			Inclination Factors			Unit Weight		Water Table Correction		Safe Bearing Capacity t / m ²
	Length	Width			C	ϕ	N _c	N _q - 1	N _γ	S _c	S _q	S _γ	d _c	d _q	d _γ	i _c	i _q	i _γ	γ	0.5 γ			
	m	m			Kg/cm ²	degree													gm/cc		W _q	W _γ	
1	3.50	3.50	2.50	198.20	0.81	3	5.71	0.23	0.18	1.30	1.20	0.80	1.15	1.00	1.00	1.00	1.00	1.00	1.95	0.98	0.50	0.50	19
2	4.00	4.00	2.50	198.20	0.81	3	5.71	0.23	0.18	1.30	1.20	0.80	1.13	1.00	1.00	1.00	1.00	1.00	1.95	0.98	0.50	0.50	19
3	5.00	5.00	2.50	198.20	0.81	3	5.71	0.23	0.18	1.30	1.20	0.80	1.10	1.00	1.00	1.00	1.00	1.00	1.95	0.98	0.50	0.50	18
4	6.00	6.00	2.50	198.20	0.81	3	5.71	0.23	0.18	1.30	1.20	0.80	1.09	1.00	1.00	1.00	1.00	1.00	1.95	0.98	0.50	0.50	18

Note :-

- 1) The factor of safety of 2.5 is considered.
- 2) The depth of foundation is considered from the R.L. 200.7m.
- 3) Calculations are considering the effect of water table at F.G.L.

KCT Consultancy Services LLP, Ahmedabad

APPENDIX - 5.5 (Transformer Yard)

Calculation of Safe Bearing Pressure for Settlement of 25 and 40 mm

Project :- Proposed Structures in Phase 1 of 3 x 800 MW NLC Talabira, Thermal Power Project (NTTPP) at village- Hirma, Talabira, Odisha

Sr. No.	Foundation Details				Immediate Settlement				Consolidation Settlement					Safe Bearing Pressure	
	Depth D	R.L. of Foundation	Width B	Length L	Poissons ratio μ	Modulus of Elasticity E	Factor Cd	Rigidity Factor	Coefficient of Volume Compressibility	Depth of Compressible Stratum H from N.G.L.	λ factor related to pore pressure parameter	Depth Factor df	Rigidity Factor	For 25 mm Settlement	For 40 mm Settlement
	m	m	m	m		kg/cm ²			cm ² /kg	m				T / m ²	T / m ²
1	2.50	198.20	3.50	3.50	0.40	248	1.12	0.80	0.0119	7.00	0.70	0.78	0.80	17	28
2	2.50	198.20	4.00	4.00	0.40	248	1.12	0.80	0.0119	7.50	0.70	0.81	0.80	15	24
3	2.50	198.20	5.00	5.00	0.40	248	1.12	0.80	0.0119	7.50	0.70	0.85	0.80	12	19
4	2.50	198.20	6.00	6.00	0.40	248	1.11	0.80	0.0119	7.50	0.70	0.88	0.80	10	16

Note: - Coefficient of volume compressibility has been taken by weighted average of the values within the compressible layer.

KCT Consultancy Services LLP, Ahmedabad

APPENDIX - 6 (Transformer Yard)

SUMMARY OF ALLOWABLE BEARING PRESSURE BASED ON SHEAR AND SETTLEMENT CRITERION**Project :** Proposed Structures in Phase 1 of 3 x 800 MW NLC Talabira, Thermal Power Project (NTTPP) at village- Hirma, Talabira, Odisha

Depth of Foundation from N.G.L.	R.L. of Foundation	Length of Foundation	Width of Foundation	Safe Bearing Capacities calculated based on Shear Criteria (See Appendix 6.1)	Safe Bearing Pressures calculated based on Settlement Criteria (See Appendix 6.2)		Allowable Bearing Pressure suggested (Min. of Shear and Settlement Criterion)	
					For 25 mm Settlement	For 40 mm Settlement	For 25 mm Settlement	For 40 mm Settlement
(m)	(m)	(m)	(m)	(t / m ²)	(t / m ²)	(t / m ²)	(t / m ²)	(t / m ²)
1.00	199.70	7.00	7.00	17	8	12	8	12
1.00	199.70	8.00	8.00	17	7	11	7	11
1.00	199.70	9.00	9.00	17	7	11	7	11
1.00	199.70	10.00	10.00	17	6	10	6	10
1.50	199.20	7.00	7.00	17	8	13	8	13
1.50	199.20	8.00	8.00	17	7	12	7	12
1.50	199.20	9.00	9.00	17	7	11	7	11
1.50	199.20	10.00	10.00	17	6	10	6	10
2.00	198.70	7.00	7.00	18	8	13	8	13
2.00	198.70	8.00	8.00	18	8	12	8	12
2.00	198.70	9.00	9.00	17	7	11	7	11
2.00	198.70	10.00	10.00	17	7	11	7	11

Notes :

- 1) The factor of safety of 2.5 is considered.
- 2) The depth of foundation is considered from the R.L. 200.7m.
- 3) Calculations are considering the effect of water table at F.G.L.

KCT Consultancy Services LLP, Ahmedabad

APPENDIX - 6.1 (Transformer Yard)

Calculation of Net Safe Bearing Capacity Based on Shear Parameters C - ϕ

$$q_u = 1 / FS [2 / 3 C N_c d_c S_c i_c + \gamma d (N_q - 1) S_q d_q i_q W_q + 0.5 \gamma B N_\gamma S_\gamma d_\gamma i_\gamma W_\gamma]$$

Project : Proposed Structures in Phase 1 of 3 x 800 MW NLC Talabira, Thermal Power Project (NTTPP) at village- Hirma, Talabira, Odisha**For Raft Foundation**

Sr. No.	Size of Foundation		Depth of Foundation m	R.L. of Foundation m	Shear Parameter		Bearing Capacity Factors			Shape Factors			Depth Factors			Inclination Factors			Unit Weight		Water Table Correction		Safe Bearing Capacity t / m ²
	Length	Width			C	ϕ	N _c	N _q - 1	N _γ	S _c	S _q	S _γ	d _c	d _q	d _γ	i _c	i _q	i _γ	γ	0.5 γ			
	m	m			Kg/cm ²	degree													gm/cc		W _q	W _γ	
1	7.00	7.00	1.00	199.70	0.81	3	5.71	0.23	0.18	1.30	1.20	0.80	1.03	1.00	1.00	1.00	1.00	1.00	1.95	0.98	0.50	0.50	17
2	8.00	8.00	1.00	199.70	0.81	3	5.71	0.23	0.18	1.30	1.20	0.80	1.03	1.00	1.00	1.00	1.00	1.00	1.95	0.98	0.50	0.50	17
3	9.00	9.00	1.00	199.70	0.81	3	5.71	0.23	0.18	1.30	1.20	0.80	1.02	1.00	1.00	1.00	1.00	1.00	1.95	0.98	0.50	0.50	17
4	10.00	10.00	1.00	199.70	0.81	3	5.71	0.23	0.18	1.30	1.20	0.80	1.02	1.00	1.00	1.00	1.00	1.00	1.95	0.98	0.50	0.50	17
5	7.00	7.00	1.50	199.20	0.81	3	5.71	0.23	0.18	1.30	1.20	0.80	1.04	1.00	1.00	1.00	1.00	1.00	1.95	0.98	0.50	0.50	17
6	8.00	8.00	1.50	199.20	0.81	3	5.71	0.23	0.18	1.30	1.20	0.80	1.04	1.00	1.00	1.00	1.00	1.00	1.95	0.98	0.50	0.50	17
7	9.00	9.00	1.50	199.20	0.81	3	5.71	0.23	0.18	1.30	1.20	0.80	1.03	1.00	1.00	1.00	1.00	1.00	1.95	0.98	0.50	0.50	17
8	10.00	10.00	1.50	199.20	0.81	3	5.71	0.23	0.18	1.30	1.20	0.80	1.03	1.00	1.00	1.00	1.00	1.00	1.95	0.98	0.50	0.50	17
9	7.00	7.00	2.00	198.70	0.81	3	5.71	0.23	0.18	1.30	1.20	0.80	1.06	1.00	1.00	1.00	1.00	1.00	1.95	0.98	0.50	0.50	18
10	8.00	8.00	2.00	198.70	0.81	3	5.71	0.23	0.18	1.30	1.20	0.80	1.05	1.00	1.00	1.00	1.00	1.00	1.95	0.98	0.50	0.50	18
11	9.00	9.00	2.00	198.70	0.81	3	5.71	0.23	0.18	1.30	1.20	0.80	1.05	1.00	1.00	1.00	1.00	1.00	1.95	0.98	0.50	0.50	17
12	10.00	10.00	2.00	198.70	0.81	3	5.71	0.23	0.18	1.30	1.20	0.80	1.04	1.00	1.00	1.00	1.00	1.00	1.95	0.98	0.50	0.50	17

Note :-

- 1) The factor of safety of 2.5 is considered.
- 2) The depth of foundation is considered from the R.L. 200.7m.
- 3) Calculations are considering the effect of water table at F.G.L.

KCT Consultancy Services LLP, Ahmedabad

APPENDIX - 6.2 (Transformer Yard)

Calculation of Safe Bearing Pressure for Settlement of 25 and 40 mm

Project :- Proposed Structures in Phase 1 of 3 x 800 MW NLC Talabira, Thermal Power Project (NTTPP) at village- Hirma, Talabira, Odisha

Sr. No.	Foundation Details				Immediate Settlement				Consolidation Settlement					Safe Bearing Pressure	
	Depth D	R.L. of Foundation	Width B	Length L	Poissons ratio μ	Modulus of Elasticity E	Factor Cd	Rigidity Factor	Coefficient of Volume Compressibility	Depth of Compressible Stratum H from N.G.L.	λ factor related to pore pressure parameter	Depth Factor df	Rigidity Factor	For 25 mm Settlement	For 40 mm Settlement
	m	m	m	m		kg/cm ²			cm ² /kg	m				T / m ²	T / m ²
1	1.00	199.70	7.00	7.00	0.40	248	1.12	0.80	0.0119	9.00	0.70	0.97	0.80	8	12
2	1.00	199.70	8.00	8.00	0.40	248	1.05	0.80	0.0119	9.00	0.70	0.97	0.80	7	11
3	1.00	199.70	9.00	9.00	0.40	248	0.98	0.80	0.0119	9.00	0.70	0.97	0.80	7	11
4	1.00	199.70	10.00	10.00	0.40	248	0.91	0.80	0.0119	9.00	0.70	0.98	0.80	6	10
5	1.50	199.20	7.00	7.00	0.40	248	1.10	0.80	0.0119	8.50	0.70	0.94	0.80	8	13
6	1.50	199.20	8.00	8.00	0.40	248	1.02	0.80	0.0119	8.50	0.70	0.95	0.80	7	12
7	1.50	199.20	9.00	9.00	0.40	248	0.94	0.80	0.0119	8.50	0.70	0.96	0.80	7	11
8	1.50	199.20	10.00	10.00	0.40	248	0.88	0.80	0.0119	8.50	0.70	0.96	0.80	6	10
9	2.00	198.70	7.00	7.00	0.40	248	1.06	0.80	0.0119	8.00	0.70	0.92	0.80	8	13
10	2.00	198.70	8.00	8.00	0.40	248	0.98	0.80	0.0119	8.00	0.70	0.93	0.80	8	12
11	2.00	198.70	9.00	9.00	0.40	248	0.91	0.80	0.0119	8.00	0.70	0.94	0.80	7	11
12	2.00	198.70	10.00	10.00	0.40	248	0.84	0.80	0.0119	8.00	0.70	0.95	0.80	7	11

Note: - Coefficient of volume compressibility has been taken by weighted average of the values within the compressible layer.

KCT Consultancy Services LLP, Ahmedabad

APPENDIX - 6.3 (Transformer Yard)

SUMMARY OF ALLOWABLE BEARING PRESSURE BASED ON SHEAR AND SETTLEMENT CRITERION**Project :** Proposed Structures in Phase 1 of 3 x 800 MW NLC Talabira, Thermal Power Project (NTTPP) at village- Hirma, Talabira, Odisha

Depth of Foundation from N.G.L.	R.L. of Foundation	Length of Foundation	Width of Foundation	Safe Bearing Capacities calculated based on Shear Criteria (See Appendix 6.4)	Safe Bearing Pressures calculated based on Settlement Criteria (See Appendix 6.5)		Allowable Bearing Pressure suggested (Min. of Shear and Settlement Criterion)	
					For 25 mm Settlement	For 40 mm Settlement	For 25 mm Settlement	For 40 mm Settlement
(m)	(m)	(m)	(m)	(t / m ²)	(t / m ²)	(t / m ²)	(t / m ²)	(t / m ²)
2.50	198.20	7.00	7.00	18	9	14	9	14
2.50	198.20	8.00	8.00	18	8	13	8	13
2.50	198.20	9.00	9.00	18	7	12	7	12
2.50	198.20	10.00	10.00	18	7	11	7	11

Notes :

- 1) The factor of safety of 2.5 is considered.
- 2) The depth of foundation is considered from the R.L. 200.7m.
- 3) Calculations are considering the effect of water table at F.G.L.

KCT Consultancy Services LLP, Ahmedabad

APPENDIX - 6.4 (Transformer Yard)

Calculation of Net Safe Bearing Capacity Based on Shear Parameters C - ϕ

$$q_u = 1 / FS [2 / 3 C N_c d_c S_c i_c + \gamma d (N_q - 1) S_q d_q i_q W_q + 0.5 \gamma B N_\gamma S_\gamma d_\gamma i_\gamma W_\gamma]$$

Project : Proposed Structures in Phase 1 of 3 x 800 MW NLC Talabira, Thermal Power Project (NTTTP) at village- Hirma, Talabira, Odisha**For Raft Foundation**

Sr. No.	Size of Foundation		Depth of Foundation m	R.L. of Foundation m	Shear Parameter		Bearing Capacity Factors			Shape Factors			Depth Factors			Inclination Factors			Unit Weight		Water Table Correction		Safe Bearing Capacity t / m ²
	Length	Width			C	ϕ	N _c	N _q - 1	N _γ	S _c	S _q	S _γ	d _c	d _q	d _γ	i _c	i _q	i _γ	γ	0.5 γ			
	m	m			Kg/cm ²	degree													gm/cc		W _q	W _γ	
1	7.00	7.00	2.50	198.20	0.81	3	5.71	0.23	0.18	1.30	1.20	0.80	1.07	1.00	1.00	1.00	1.00	1.00	1.95	0.98	0.50	0.50	18
2	8.00	8.00	2.50	198.20	0.81	3	5.71	0.23	0.18	1.30	1.20	0.80	1.06	1.00	1.00	1.00	1.00	1.00	1.95	0.98	0.50	0.50	18
3	9.00	9.00	2.50	198.20	0.81	3	5.71	0.23	0.18	1.30	1.20	0.80	1.06	1.00	1.00	1.00	1.00	1.00	1.95	0.98	0.50	0.50	18
4	10.00	10.00	2.50	198.20	0.81	3	5.71	0.23	0.18	1.30	1.20	0.80	1.05	1.00	1.00	1.00	1.00	1.00	1.95	0.98	0.50	0.50	18

Note :-

- 1) The factor of safety of 2.5 is considered.
- 2) The depth of foundation is considered from the R.L. 200.7m.
- 3) Calculations are considering the effect of water table at F.G.L.

KCT Consultancy Services LLP, Ahmedabad

APPENDIX - 6.5 (Transformer Yard)

Calculation of Safe Bearing Pressure for Settlement of 25 and 40 mm

Project :- Proposed Structures in Phase 1 of 3 x 800 MW NLC Talabira, Thermal Power Project (NTTPP) at village- Hirma, Talabira, Odisha

Sr. No.	Foundation Details				Immediate Settlement				Consolidation Settlement					Safe Bearing Pressure	
	Depth D	R.L. of Foundation	Width B	Length L	Poissons ratio μ	Modulus of Elasticity E	Factor Cd	Rigidity Factor	Coefficient of Volume Compressibility	Depth of Compressible Stratum H from N.G.L.	λ factor related to pore pressure parameter	Depth Factor df	Rigidity Factor	For 25 mm Settlement	For 40 mm Settlement
	m	m	m	m		kg/cm ²			cm ² /kg	m				T / m ²	T / m ²
1	2.50	198.20	7.00	7.00	0.40	248	1.02	0.80	0.0119	7.50	0.70	0.90	0.80	9	14
2	2.50	198.20	8.00	8.00	0.40	248	0.94	0.80	0.0119	7.50	0.70	0.91	0.80	8	13
3	2.50	198.20	9.00	9.00	0.40	248	0.86	0.80	0.0119	7.50	0.70	0.92	0.80	7	12
4	2.50	198.20	10.00	10.00	0.40	248	0.80	0.80	0.0119	7.50	0.70	0.93	0.80	7	11

Note: - Coefficient of volume compressibility has been taken by weighted average of the values within the compressible layer.

Appendix – 7

Calculation of Safe Load carrying capacity of piles socketed inside rock (Near BH 50, 61, 66) (POWER HOUSE UNIT-1)

Project Name: - Proposed structures of thermal power project of NTPP at Hirma, Talabira

1.0 Introduction

In situations where overburden offering low bearing pressure is followed by rock at relatively shallower depths, end bearing piles is the suitable foundation option. Piles in rocks and weathered rocks of varying degree of weathering derive their capacity by end bearing and socket side resistance.

In situations, where, rock strata comprises of highly fragmented rock, as in present case, where RQD is nil or $(CR+RQD)/2$ is less than 30 % or when the crushing strength is less than 10 MPa, the appropriate approach would be of that suggested by Cole & Stroud.

In present site overburden soils overlay fractured / laminated / foliated rock. The founding stratum having highly fragmented rock with nil RQD and $(CR+RQD)/2$ to be less than 30 %, the approach suggested by Cole and Stroud as per Annex B under clause 6.3.1.1 and 6.3.2 of IS 2911 Pa/S2 has been used for safe load calculations.

An illustrative calculation of safe load on pile and summary of pile capacities is as follows,

2.0 Sub soil strata Characterization

Out of four boreholes in given area, BH 50 happens to be the weakest. General stratification at the location of boreholes 50 show primarily three characterized layers,

1. Overburden comprising of fine to very fine grained clays upto 18.57m (i.e. RL 182.98 m). The RL of NGL is 201.55 m.
2. Second characterized layer below the overburden soils consists Highly weathered, very weak, thinly bedded rock, up to 22.00 m (i.e. RL 179.55 m). Though, rock is not very sound but can be considered for socketing if the pile capacity obtained thereby is adequate against imposed loads.
3. Third layer comprises of Slightly weathered, weak, massive rock up to 23.0 m (i.e. RL 178.55m).

3.0 Design Considerations

1. Length of socket considered 3D from depth of rock encountered.
2. The pile is considered to have socket length below 18.57 m below NGL (i.e. RL 182.98 m) depth.
3. For present case of pile terminating in highly weathered rock. SPT at depths between 18.57 to 22.00 m (between RL 184.32 to 178.12 m) is > 100 with just 7 cm penetration (average) in 50 blows. SPT can be extrapolated for 30 cm i.e. $60 * 30 / 7 = 257.1$.

Based on recommendation of fig no. 3 in B 8 in Annex B under clause 6.3.1.1 and 6.3.2 of IS 2911 P1/S2, average shear strength q_c corresponding to assumed SPT of 200 may be taken as 1300 kN/m^2

4. Allowable Capacity of pile socketed into rock $Q_a = R_e + R_{sf} = C_{u1} N_c \pi B^2 / 4 (F_s = 3) + \alpha C_{u2} \pi BL / (F_s = 6)$

4.0 Safe Load on Pile in Compression

Where,

End bearing component, $R_e = C_{u1} N_c \pi B^2 / 4 F_s$,

C_{u1} = Shear strength below base of pile = 1300 kN/m^2

B = diameter of the pile = d

F_s = Factor of Safety = 3

$N_c = 9$

Therefore, **$R_e = 3061.5 d^2$**

Skin friction component of socketed length of pile, $R_{sf} = \alpha C_{u2} \pi BL / F_s$

$\alpha = 0.9$ (recommended value in IS 2911 P1/S2)

L = length of the socket = $3 D$

C_{u2} = Ultimate shear strength along socket length which shall be restricted to shear capacity of concrete of the pile = 1300 kN/m²

F_s = Factor of Safety = 6

Therefore, $R_{sf} = 1836.9 \text{ d}^2$

Thus,

$$Q_a = c_{u1} N_c \cdot \frac{\pi B^2}{4 F_s} + \alpha c_{u2} \cdot \frac{\pi B L}{F_s}$$

$$= 3061.5 \text{ d}^2 + 1836.9 \text{ d}^2 = 4898.4 \text{ d}^2$$

Substituting the values of various diameters and socket lengths equal to 3 times diameter, allowable load on single pile can be summarized as follows,

Summary of the Safe load calculation in Compression

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	21.32	21.80	22.22
Termination level RL in m	181.18	180.70	180.28
End Bearing Component in kN	1102.1	1768.3	2479.8
Friction Component in kN	661.3	1060.9	1487.9
Safe load in Compression in kN	1763.4	2829.3	3967.7
Safe load in Compression in T	176	283	397

5.0 Safe Load on Pile in uplift

5.1 For 4.0m cutoff from FGL

The overburden soils, though, will not contribute in compression capacity would offer resistance in uplift capacity. The parameters of BH 50 are considered for calculation of uplift resistance as summarized below,

Depth in m from RL 202.5 m	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Submerged density in gm/cc γ_{sub}	Reduction Factor α	Earth pressure coefficient K	Angle of wall friction $\delta = \phi$	SPT N Value
0.00 to 4.00	Pile cutoff level – No pile						
4.00 to 19.52	1.32 ^{\$}	5 ^{\$} ~0(Ignored)	1.03 ^{\$}	0.33	NA	NA	19
19.52 to 23.95	Rock strata – Resistance would be as per skin friction capacity in socket as already calculated in compression capacity						

Note - ^{\$} Weighted average data considered. NA means not applicable.

Ultimate load in skin friction,

$$Q_{uf} = \alpha_i C_{ai} A_{si} + K_i P D_i \tan \delta_i A_{si}$$

First Layer – No contribution considered – (Within Cutoff Level).

$$\text{Second Layer} - \alpha_2 C_{a2} A_{s2} = 0.33 * 13.20 * \pi d * 15.52 = 212.39 \text{ d}$$

Third Layer – 1836.9 d² in rock socket

$$\text{Substituting, ultimate load } q_{uf} = 2123.9 \text{ d} + 1836.9 \text{ d}^2$$

The safe load in uplift is worked out (considering the safety factor of 2.50 for overburden soils) and summarized below,

Safe Load on Piles in Uplift (in Ton)

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	21.32	21.80	22.22
Termination level RL in m	181.18	180.70	180.28
Safe load in Uplift in kN	1171.02	1706.7	2252.5
Self-weight of Pile in kN	73.42	121.1	173.8
Safe load in Uplift in T (Considering Self weight of Pile)	124.4	182.8	242.6

5.2 For 5.0m cutoff from FGL

The overburden soils, though, will not contribute in compression capacity would offer resistance in uplift capacity. The parameters of BH 50 are considered for calculation of uplift resistance as summarized below,

Depth in m from RL 202.5 m	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Submerged density in gm/cc γ_{sub}	Reduction Factor α	Earth pressure coefficient K	Angle of wall friction $\delta = \phi$	SPT N Value
0.00 to 5.00	Pile cutoff level – No pile						
5.00 to 19.52	1.32 ^{\$}	5 ^{\$} ~0(Ignored)	1.03 ^{\$}	0.33	NA	NA	24
19.52 to 23.95	Rock strata – Resistance would be as per skin friction capacity in socket as already calculated in compression capacity						

Note - ^{\$} Weighted average data considered. NA means not applicable.

Ultimate load in skin friction,

$$Q_{uf} = \alpha_i C_{ai} A_{si} + K_i P D_i \tan \delta_i A_{si}$$

First Layer – No contribution considered – (Within Cutoff Level).

$$\text{Second Layer} - \alpha_2 C_{a2} A_{s2} = 0.33 * 13.20 * \pi d * 14.52 = 198.71 d$$

Third Layer – 1836.9 d² in rock socket

$$\text{Substituting, ultimate load } q_{uf} = 1987.1 d + 1836.9 d^2$$

The safe load in uplift is worked out (considering the safety factor of 2.50 for overburden soils) and summarized below,

Safe Load on Piles in Uplift (in Ton)

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	21.32	21.80	22.22
Termination level RL in m	181.18	180.70	180.28
Safe load in Uplift in kN	1138.2	1665.1	2203.2
Self-weight of Pile in kN	69.2	114.3	164.2
Safe load in Uplift in T (Considering Self weight of Pile)	120.7	177.9	236.7

5.3 For 6.0m cutoff from FGL

The overburden soils, though, will not contribute in compression capacity would offer resistance in uplift capacity. The parameters of BH 50 are considered for calculation of uplift resistance as summarized below,

Depth in m from RL 202.5 m	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Submerged density in gm/cc γ_{sub}	Reduction Factor α	Earth pressure coefficient K	Angle of wall friction $\delta = \phi$	SPT N Value
0.00 to 6.00	Pile cutoff level – No pile						
6.00 to 19.52	1.32 ^s	5 ^s ~0(Ignored)	1.03 ^s	0.33	NA	NA	26
19.52 to 23.95	Rock strata – Resistance would be as per skin friction capacity in socket as already calculated in compression capacity						

Note - ^s Weighted average data considered. NA means not applicable.

Ultimate load in skin friction,

$$Q_{uf} = \alpha_i C_{ai} A_{si} + K_i P D_i \tan \delta_i A_{si}$$

First Layer – No contribution considered – (Within Cutoff Level).

$$\text{Second Layer} - \alpha_2 C_{a2} A_{s2} = 0.33 * 13.20 * \pi d * 13.52 = 185.02 d$$

Third Layer – 1836.9 d² in rock socket

$$\text{Substituting, ultimate load } q_{uf} = 1850.2 d + 1836.9 d^2$$

The safe load in uplift is worked out (considering the safety factor of 2.50 for overburden soils) and summarized below,

Safe Load on Piles in Uplift (in Ton)

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	21.32	21.80	22.22
Termination level RL in m	181.18	180.70	180.28
Safe load in Uplift in kN	1105.3	1623.5	2153.9
Self-weight of Pile in kN	64.9	107.5	154.7
Safe load in Uplift in T (Considering Self weight of Pile)	117.0	173.1	230.9

6.0 Lateral Pile Capacity

6.1 For 4.0m cutoff from FGL

Pile would be long and elastic (i.e. $L > 4T$). For a prescribed deflection of 5mm and with M 30 grade of concrete, the lateral load and moment were worked out as follows,

Diameters in m		0.60	0.76	0.90
Subgrade reaction in MN/m ³		2.70	2.70	2.70
Stiffness factor T in m		2.31	2.79	3.20
Depth of fixity in m	Free Head	4.40	5.30	6.10
	Fixed Head	5.00	6.10	7.00
Allowable Horizontal Force in T	Free Head	3.20	4.60	6.00
	Fixed Head	8.30	12.20	16.00
Allowable Moment capacity in Tm	Free Head	4.84	8.54	12.81
	Fixed Head	17.23	30.38	45.58

6.2 For 5.0m cutoff from FGL

Pile would be long and elastic (i.e. $L > 4T$). For a prescribed deflection of 5mm and with M 30 grade of concrete, the lateral load and moment were worked out as follows,

Diameters in m		0.60	0.76	0.90
Subgrade reaction in MN/m ³		3.42	3.42	3.42
Stiffness factor T in m		2.20	2.66	3.05
Depth of fixity in m	Free Head	4.20	5.10	5.80
	Fixed Head	4.80	5.80	6.60
Allowable Horizontal Force in T	Free Head	3.60	5.30	6.90
	Fixed Head	9.60	14.00	18.40
Allowable Moment capacity in Tm	Free Head	5.32	9.38	14.08
	Fixed Head	18.93	33.39	50.10

6.3 For 6.0m cutoff from FGL

Pile would be long and elastic (i.e. $L > 4T$). For a prescribed deflection of 5mm and with M 30 grade of concrete, the lateral load and moment were worked out as follows,

Diameters in m		0.60	0.76	0.90
Subgrade reaction in MN/m ³		3.70	3.70	3.70
Stiffness factor T in m		2.17	2.62	3.00
Depth of fixity in m	Free Head	4.10	5.00	5.70
	Fixed Head	4.70	5.70	6.50
Allowable Horizontal Force in T	Free Head	3.80	5.60	7.30
	Fixed Head	10.10	14.70	19.30
Allowable Moment capacity in Tm	Free Head	5.49	9.68	14.53
	Fixed Head	19.54	34.46	51.71

7.0 Notes

1. Pile shall be terminated after socketing 3D inside rock.
2. Initial and routine pile load test is required to verify the actual carrying capacity of pile in compression, uplift and lateral loads.
3. For design and construction, specification of IS: 2911, P1/S2, IS: 456, 2000 shall strictly be followed.

(Dr. K. K. Thaker)

Appendix – 8

Calculation of Safe Load carrying capacity of piles socketed inside rock (Near BH 123 and 108) (Power house Unit -3)

Project Name: - Proposed structures of thermal power project of NTTTP at Hirma, Talabira

1.0 Introduction

In situations where overburden offering low bearing pressure is followed by rock at relatively shallower depths, end bearing piles is the suitable foundation option. Piles in rocks and weathered rocks of varying degree of weathering derive their capacity by end bearing and socket side resistance.

In situations, where, rock strata comprises of highly fragmented rock, as in present case, where RQD is nil or $(CR+RQD)/2$ is less than 30 % or when the crushing strength is less than 10 MPa, the appropriate approach would be of that suggested by Cole & Stroud.

In present site overburden soils overlay fractured / laminated / foliated rock. The founding stratum having highly fragmented rock with nil RQD and $(CR+RQD)/2$ to be less than 30 %, the approach suggested by Cole and Stroud as per Annex B under clause 6.3.1.1 and 6.3.2 of IS 2911 Pa/S2 has been used for safe load calculations.

An illustrative calculation of safe load on pile and summary of pile capacities is as follows,

2.0 Sub soil strata Characterization

Out of two boreholes in given area, BH 123 happens to be the weakest. General stratification at the location of boreholes 123 show primarily three characterized layers,

1. Overburden comprising of fine to very fine-grained clays and fine to very fine grained clayey and silty sand upto 7.20m (i.e. RL 194.00 m). The RL of NGL is 201.20 m.
2. Second characterized layer below the overburden soils consists Highly weathered, weak, fine to very fine grained thinly laminated rock, up to 19.50 m (i.e. RL 181.70 m). Though, rock is not very sound but can be considered for socketing if the pile capacity obtained thereby is adequate against imposed loads.
3. Third layer comprises of Moderately weathered, weak, dark greyish brown, fine to medium grained, massive rock up to 22.0 m (i.e. RL 179.20 m).

3.0 Design Considerations

1. Length of socket considered 3D from depth of rock encountered.
2. The pile is considered to have socket length below 7.20 m below NGL (i.e. RL 194.00 m) depth.
3. For present case of pile terminating in highly weathered rock. SPT at depths between 17.30 to 19.60 m (between RL 182.08 to 179.78 m) is > 100 with just 9 cm penetration (average) in 50 blows. SPT can be extrapolated for 30 cm i.e. $50 * 30 / 9 = 167$.

Based on recommendation of fig no. 3 in B 8 in Annex B under clause 6.3.1.1 and 6.3.2 of IS 2911 P1/S2, average shear strength q_c corresponding to assumed SPT of 160 may be taken as 1250 kN/m^2

4. Allowable Capacity of pile socketed into rock $Q_a = R_e + R_{sf} = C_{u1} N_c \pi B^2 / 4 (F_s = 3) + \alpha C_{u2} \pi BL / (F_s = 6)$

4.0 Safe Load on Pile in Compression

Where,

End bearing component, $R_e = C_{u1} N_c \pi B^2 / 4 F_s$,

C_{u1} = Shear strength below base of pile = 1250 kN/m^2

B = diameter of the pile = d

F_s = Factor of Safety = 3

$N_c = 9$

Therefore, **$R_e = 2945.24 d^2$**

Skin friction component of socketed length of pile, $R_{sf} = \alpha C_{u2} \pi BL / F_s$

$\alpha = 0.9$ (recommended value in IS 2911 P1/S2)

$L =$ length of the socket $= 3 D$

$C_{u2} =$ Ultimate shear strength along socket length which shall be restricted to shear capacity of concrete of the pile $= 1250 \text{ kN/m}^2$

$F_s =$ Factor of Safety $= 6$

Therefore, $R_{sf} = 1767.15 \text{ d}^2$

Thus,

$$Q_a = c_{u1} N_c \cdot \frac{\pi B^2}{4 F_s} + \alpha c_{u2} \cdot \frac{\pi B L}{F_s}$$

$$= 2945.24 \text{ d}^2 + 1767.15 \text{ d}^2 = 4712.39 \text{ d}^2$$

Substituting the values of various diameters and socket lengths equal to 3 times diameter, allowable load on single pile can be summarized as follows,

Summary of the Safe load calculation in Compression

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	10.30	10.78	11.20
Termination level RL in m	192.20	191.72	191.30
End Bearing Component in kN	1060.3	1701.2	2385.6
Friction Component in kN	636.2	1020.7	1431.4
Safe load in Compression in kN	1696.5	2721.9	3817.0
Safe load in Compression in T	170	272	382

5.0 Safe Load on Pile in uplift

5.1 For 4.0m cutoff from FGL

The overburden soils, though, will not contribute in compression capacity would offer resistance in uplift capacity. The parameters of BH 123 are considered for calculation of uplift resistance as summarized below,

Depth in m from RL 202.5 m	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Submerged density in gm/cc γ_{sub}	Reduction Factor α	Earth pressure coefficient K	Angle of wall friction $\delta = \phi$	SPT N Value
0.00 to 4.00	Pile cutoff level – No pile						
4.00 to 5.30	0.03	25	0.98	NA	1.00	25	17
5.30 to 8.50	0.92	0	0.98	0.48	NA	NA	23
8.50 to 23.30	Rock strata – Resistance would be as per skin friction capacity in socket as already calculated in compression capacity						

Ultimate load in skin friction,

$$Q_{uf} = \alpha_i C_{ai} A_{si} + K_i P D_i \tan \delta_i A_{si}$$

First Layer – No contribution considered – (Within Cutoff Level).

$$\text{Second Layer} - K_2 P D_2 \tan \delta_2 A_{s2} = 1.00 * 3.84 * \tan 25 * \pi d * 1.30 = 7.31 \text{ d}$$

$$\text{Third Layer} - \alpha_3 C_{a3} A_{s3} = 0.48 * 9.20 * \pi d * 3.20 = 44.39 \text{ d}$$

Fourth Layer – 1767.15 d^2 in rock socket

$$\text{Substituting, ultimate load } q_{uf} = 517.0 \text{ d} + 1767.15 \text{ d}^2$$

The safe load in uplift is worked out (considering the safety factor of 2.50 for overburden soils) and summarized below,

Safe Load on Piles in Uplift (in Ton)

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	10.30	10.78	11.20
Termination level RL in m	192.20	191.72	191.30
Safe load in Uplift in kN	760.3	1177.9	1617.5
Self-weight of Pile in kN	26.7	46.1	68.7
Safe load in Uplift in T (Considering Self weight of Pile)	78.7	122.4	168.6

5.2 For 5.0m cutoff from FGL

The overburden soils, though, will not contribute in compression capacity would offer resistance in uplift capacity. The parameters of BH 123 are considered for calculation of uplift resistance as summarized below,

Depth in m from RL 202.5 m	Cohesion in kg/cm²	Angle of Internal Friction ϕ	Submerged density in gm/cc γ_{sub}	Reduction Factor α	Earth pressure coefficient K	Angle of wall friction $\delta = \phi$	SPT N Value
0.00 to 5.00	Pile cutoff level – No pile						
5.00 to 5.30	0.03	25	0.98	NA	1.00	25	17
5.30 to 8.50	0.92	0	0.98	0.48	NA	NA	23
8.50 to 23.30	Rock strata – Resistance would be as per skin friction capacity in socket as already calculated in compression capacity						

Ultimate load in skin friction,

$$Q_{uf} = \alpha_i C_{ai} A_{si} + K_i P D_i \tan \delta_i A_{si}$$

First Layer – No contribution considered – (Within Cutoff Level).

$$\text{Second Layer} - K_2 P D_2 \tan \delta_2 A_{s2} = 1.00 * 4.15 * \tan 25^\circ * \pi d * 0.30 = 1.82 d$$

$$\text{Third Layer} - \alpha_3 C_{a3} A_{s3} = 0.48 * 9.20 * \pi d * 3.20 = 44.39 d$$

Fourth Layer – 1767.15 d² in rock socket

$$\text{Substituting, ultimate load } q_{uf} = 462.10 d + 1767.15 d^2$$

The safe load in uplift is worked out (considering the safety factor of 2.50 for overburden soils) and summarized below,

Safe Load on Piles in Uplift (in Ton)

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	10.30	10.78	11.20
Termination level RL in m	192.20	191.72	191.30
Safe load in Uplift in kN	747.1	1161.2	1597.8
Self-weight of Pile in kN	22.5	39.3	59.1
Safe load in Uplift in T (Considering Self weight of Pile)	77.0	120.1	165.7

5.3 For 6.0m cutoff from FGL

The overburden soils, though, will not contribute in compression capacity would offer resistance in uplift capacity. The parameters of BH 123 are considered for calculation of uplift resistance as summarized below,

Depth in m from RL 202.5 m	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Submerged density in gm/cc γ_{sub}	Reduction Factor α	Earth pressure coefficient K	Angle of wall friction $\delta = \phi$	SPT N Value
0.00 to 6.00	Pile cutoff level – No pile						
6.00 to 8.50	0.92	0	0.98	0.48	NA	NA	23
8.50 to 23.30	Rock strata – Resistance would be as per skin friction capacity in socket as already calculated in compression capacity						

Ultimate load in skin friction,

$$Q_{uf} = \alpha_i C_{ai} A_{si} + K_i P D_i \tan \delta_i A_{si}$$

First Layer – No contribution considered – (Within Cutoff Level).

$$\text{Second Layer} - \alpha_2 C_{a2} A_{s2} = 0.48 * 9.20 * \pi d * 2.50 = 34.68 d$$

Third Layer – 1767.15 d² in rock socket

$$\text{Substituting, ultimate load } q_{uf} = 346.80 d + 1767.15 d^2$$

The safe load in uplift is worked out (considering the safety factor of 2.50 for overburden soils) and summarized below,

Safe Load on Piles in Uplift (in Ton)

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	10.30	10.78	11.20
Termination level RL in m	192.20	191.72	191.30
Safe load in Uplift in kN	719.4	1126.1	1556.2
Self-weight of Pile in kN	18.2	32.5	49.6
Safe load in Uplift in T (Considering Self weight of Pile)	73.8	115.9	160.6

6.0 Lateral Pile Capacity

6.1 For 4.00m cutoff

Pile would be long and elastic (i.e. $L > 4T$). For a prescribed deflection of 5mm and with M 30 grade of concrete, the lateral load and moment were worked out as follows,

Diameters in m		0.60	0.76	0.90
Subgrade reaction in MN/m ^{3S}		2.84	2.84	2.84
Stiffness factor T in m		2.29	2.76	3.16
Depth of fixity in m	Free Head	4.30	5.20	6.00
	Fixed Head	5.00	6.00	6.90
Allowable Horizontal Force in T	Free Head	3.20	4.70	6.20
	Fixed Head	8.60	12.60	16.50
Allowable Moment capacity in Tm	Free Head	4.94	8.71	13.07
	Fixed Head	17.58	31.00	46.51

6.2 For 5.00m cutoff

Pile would be long and elastic (i.e. $L > 4T$). For a prescribed deflection of 5mm and with M 30 grade of concrete, the lateral load and moment were worked out as follows,

Diameters in m		0.60	0.76	0.90
Subgrade reaction in MN/m ³		3.27	3.27	3.27
Stiffness factor T in m		2.22	2.69	3.08
Depth of fixity in m	Free Head	4.20	5.10	5.80
	Fixed Head	4.80	5.90	6.70
Allowable Horizontal Force in T	Free Head	3.50	5.20	6.80
	Fixed Head	9.40	13.70	17.90
Allowable Moment capacity in Tm	Free Head	5.23	9.21	13.83
	Fixed Head	18.60	32.80	49.21

6.3 For 6.00m cutoff

Pile would be long and elastic (i.e. $L > 4T$). For a prescribed deflection of 5mm and with M 30 grade of concrete, the lateral load and moment were worked out as follows,

Diameters in m		0.60	0.76	0.90
Subgrade reaction in MN/m ³		4.71	4.71	4.71
Stiffness factor T in m		2.07	2.50	2.86
Depth of fixity in m	Free Head	3.90	4.70	5.40
	Fixed Head	4.50	5.40	6.20
Allowable Horizontal Force in T	Free Head	4.40	6.40	8.40
	Fixed Head	11.70	17.00	22.30
Allowable Moment capacity in Tm	Free Head	6.05	10.66	16.00
	Fixed Head	21.52	37.95	56.95

7.0 Notes

1. Pile shall be terminated after socketing 3D inside Rock.
2. Initial and routine pile load test is required to verify the actual carrying capacity of pile in compression, uplift and lateral loads.
3. For design and construction, specification of IS: 2911, P1/S2, IS: 456, 2000 shall strictly be followed.

(Dr. K. K. Thaker)

Appendix – 9

Calculation of Safe Load carrying capacity of piles socketed inside rock (Near BH 57 & 68) (ESP UNIT-1)

Project Name: - Proposed structures of thermal power project of NTTTP at Hirma, Talabira

1.0 Introduction

In situations where overburden offering low bearing pressure is followed by rock at relatively shallower depths, end bearing piles is the suitable foundation option. Piles in rocks and weathered rocks of varying degree of weathering derive their capacity by end bearing and socket side resistance.

In situations, where, rock strata comprises of highly fragmented rock, as in present case, where RQD is nil or $(CR+RQD)/2$ is less than 30 % or when the crushing strength is less than 10 MPa, the appropriate approach would be of that suggested by Cole & Stroud.

In present site overburden soils overlay fractured / laminated / foliated rock. The founding stratum having highly fragmented rock with nil RQD and $(CR+RQD)/2$ to be less than 30 %, the approach suggested by Cole and Stroud as per Annex B under clause 6.3.1.1 and 6.3.2 of IS 2911 Pa/S2 has been used for safe load calculations.

An illustrative calculation of safe load on pile and summary of pile capacities is as follows,

2.0 Sub soil strata Characterization

Out of two boreholes in given area, BH-68 happens to be the weakest. General stratification at the location of boreholes 68 show primarily two characterized layers,

1. Overburden comprising of fine to very fine grained, sandy clays of high/low plasticity upto 6.80 m (i.e. RL 190.60 m) followed by clayey and silty sand upto 14.60m (i.e. RL 182.80 m). The RL of NGL is 197.40 m.
2. Second layer comprises of Moderately weathered, weak, brownish grey, fine to medium grained, thinly bedded rock up to 17.50 m (i.e. RL 179.90 m).

3.0 Design Considerations

1. Length of socket considered 3D from depth of rock encountered.
2. The pile is considered to have socket length below 14.60 m below NGL (i.e. RL 182.80 m) depth.
3. For present case of pile terminating in highly weathered rock. SPT at depths between 14.60 to 17.50 m (between RL 182.80 to 179.90 m) is > 100 with just 6 cm penetration in 50 blows. SPT can be extrapolated for 30 cm i.e. $50 * 30 / 6 = 250$.

Based on recommendation of fig no. 3 in B 8 in Annex B under clause 6.3.1.1 and 6.3.2 of IS 2911 P1/S2, average shear strength q_c corresponding to assumed SPT of 250 may be taken as 1300 kN/m²

4. Allowable Capacity of pile socketed into rock $Q_a = R_e + R_{sf} = C_{u1} N_c \pi B^2 / 4 (F_s = 3) + \alpha C_{u2} \pi BL / (F_s = 6)$

4.0 Safe Load on Pile in Compression

Where,

End bearing component, $R_e = C_{u1} N_c \pi B^2 / 4 F_s$,

C_{u1} = Shear strength below base of pile = 1300 kN/m²

B = diameter of the pile = d

F_s = Factor of Safety = 3

$N_c = 9$

Therefore, **$R_e = 3061.5 d^2$**

Skin friction component of socketed length of pile, $R_{sf} = \alpha C_{u2} \pi BL / F_s$

$\alpha = 0.9$ (recommended value in IS 2911 P1/S2)

L = length of the socket = $3 D$

C_{u2} = Ultimate shear strength along socket length which shall be restricted to shear capacity of concrete of the pile = 1300 kN/m²

F_s = Factor of Safety = 6
 Therefore, $R_{sf} = 1836.9 d^2$
 Thus,

$$Q_a = c_{u1} N_c \cdot \frac{\pi B^2}{4 F_s} + \alpha c_{u2} \cdot \frac{\pi B L}{F_s}$$

$$= 3061.5 d^2 + 1836.9 d^2 = 4898.4 d^2$$

Substituting the values of various diameters and socket lengths equal to 3 times diameter, allowable load on single pile can be summarized as follows,

Summary of the Safe load calculation in Compression

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	21.50	21.98	22.40
Termination level RL in m	181.00	180.52	180.10
End Bearing Component in kN	1102.1	1768.3	2479.8
Friction Component in kN	661.3	1060.9	1487.9
Safe load in Compression in kN	1763.4	2829.3	3967.7
Safe load in Compression in T	176	283	397

5.0 Safe Load on Pile in uplift

5.1 For 5.0m cutoff from FGL

The overburden soils, though, will not contribute in compression capacity would offer resistance in uplift capacity. The parameters of BH 68 are considered for calculation of uplift resistance as summarized below,

Depth in m from RL 202.5 m	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Submerged density in gm/cc γ_{sub}	Reduction Factor α	Earth pressure coefficient K	Angle of wall friction $\delta = \phi$	SPT N Value
0.00 to 5.00	Pile cutoff level – No pile						
5.00 to 11.90	0.72	3~0(Ignored)	0.96	0.61	NA	NA	7
11.90 to 19.70	0.08(Ignored)	25	0.98	NA	1.00	25	11
19.70 to 22.60	Rock strata – Resistance would be as per skin friction capacity in socket as already calculated in compression capacity						

Note - & data is assumed for filling soils used for raising the FGL from EGL.

Ultimate load in skin friction,

$$Q_{uf} = \alpha_i c_{ai} A_{si} + K_i P D_i \tan \delta_i A_{si}$$

First Layer – No contribution considered – (Within Cutoff Level).

$$\text{Second Layer} - \alpha_2 c_{a2} A_{s2} = 0.61 * 7.20 * \pi d * 6.90 = 95.21 d$$

$$\text{Third Layer} - K_3 P D_3 \tan \delta_3 A_{s3} = 1.00 * 10.13 * \tan 25 * \pi d * 7.80 = 115.75 d$$

Fifth Layer – 1836.9 d^2 in rock socket

$$\text{Substituting, ultimate load } q_{uf} = 2109.6 d + 1836.9 d^2$$

The safe load in uplift is worked out (considering the safety factor of 2.50 for overburden soils) and summarized below,

Safe Load on Piles in Uplift (in Ton)

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	21.50	21.98	22.40

Termination level RL in m	181.00	180.52	180.10
Safe load in Uplift in kN	1167.59	1702.31	2247.34
Self-weight of Pile in kN	69.94	115.49	165.96
Safe load in Uplift in T (Considering Self weight of Pile)	123.8	181.8	241.3

6.0 Lateral Pile Capacity

Pile would be long and elastic (i.e. $L > 4T$). For a prescribed deflection of 5mm and with M 30 grade of concrete, the lateral load and moment were worked out as follows,

Diameters in m		0.60	0.76	0.90
Subgrade reaction in MN/m ³		2.70	2.70	2.70
Stiffness factor T in m		2.31	2.79	3.20
Depth of fixity in m	Free Head	4.40	5.30	6.10
	Fixed Head	5.00	6.00	6.90
Allowable Horizontal Force in T	Free Head	3.20	4.60	6.00
	Fixed Head	8.60	12.50	16.40
Allowable Moment capacity in Tm	Free Head	4.84	8.54	12.81
	Fixed Head	17.55	30.94	46.43

7.0 Notes

1. Pile shall be terminated after socketing 3D inside rock.
2. Initial and routine pile load test is required to verify the actual carrying capacity of pile in compression, uplift and lateral loads.
3. For design and construction, specification of IS: 2911, P1/S2, IS: 456, 2000 shall strictly be followed.

(Dr. K. K. Thaker)

Appendix – 10

Calculation of Safe Load carrying capacity of piles socketed inside rock (Near BH 82, 101, 104, 112) (ESP Unit-2 & 3)

Project Name: - Proposed structures of thermal power project of NTTTP at Hirma, Talabira

1.0 Introduction

In situations where overburden offering low bearing pressure is followed by rock at relatively shallower depths, end bearing piles is the suitable foundation option. Piles in rocks and weathered rocks of varying degree of weathering derive their capacity by end bearing and socket side resistance.

In situations, where, rock strata comprises of highly fragmented rock, as in present case, where RQD is nil or $(CR+RQD)/2$ is less than 30 % or when the crushing strength is less than 10 MPa, the appropriate approach would be of that suggested by Cole & Stroud.

In present site overburden soils overlay fractured / laminated / foliated rock. The founding stratum having highly fragmented rock with nil RQD and $(CR+RQD)/2$ to be less than 30 %, the approach suggested by Cole and Stroud as per Annex B under clause 6.3.1.1 and 6.3.2 of IS 2911 Pa/S2 has been used for safe load calculations.

An illustrative calculation of safe load on pile and summary of pile capacities is as follows,

2.0 Sub soil strata Characterization

Out of two boreholes in given area, BH 82 happens to be the weakest. General stratification at the location of boreholes 82 show primarily three characterized layers,

1. Overburden comprising of fine to very fine grained clays and fine to very fine grained clayey and silty sand upto 17.30m (i.e. RL 182.08 m). The RL of NGL is 199.38 m.
2. Second characterized layer below the overburden soils consists Highly weathered, very weak, yellowish brown, fine to medium grained, very thinly bedded rock, up to 19.60 m (i.e. RL 179.78 m). Though, rock is not very sound but can be considered for socketing if the pile capacity obtained thereby is adequate against imposed loads.
3. Third layer comprises of Slightly weathered, very weak, dark blackish grey, fine to very fine grained, very thickly bedded rock up to 20.0 m (i.e. RL 179.38 m).

3.0 Design Considerations

1. Length of socket considered 3D from depth of rock encountered.
2. The pile is considered to have socket length below 17.30 m below NGL (i.e. RL 182.08 m) depth.
3. For present case of pile terminating in highly weathered rock. SPT at depths between 17.30 to 19.60 m (between RL 182.08 to 179.78 m) is > 100 with just 7 cm penetration (average) in 50 blows. SPT can be extrapolated for 30 cm i.e. $50 * 30 / 7 = 214$.

Based on recommendation of fig no. 3 in B 8 in Annex B under clause 6.3.1.1 and 6.3.2 of IS 2911 P1/S2, average shear strength q_c corresponding to assumed SPT of 200 may be taken as 1300 kN/m^2

4. Allowable Capacity of pile socketed into rock $Q_a = R_e + R_{sf} = C_{u1} N_c \pi B^2 / 4 (F_s = 3) + \alpha C_{u2} \pi BL / (F_s = 6)$

4.0 Safe Load on Pile in Compression

Where,

End bearing component, $R_e = C_{u1} N_c \pi B^2 / 4 F_s$,

C_{u1} = Shear strength below base of pile = 1300 kN/m^2

B = diameter of the pile = d

F_s = Factor of Safety = 3

$N_c = 9$

Therefore, **$R_e = 3061.5 d^2$**

Skin friction component of socketed length of pile, $R_{sf} = \alpha C_{u2} \pi BL / F_s$

$\alpha = 0.9$ (recommended value in IS 2911 P1/S2)

$L = \text{length of the socket} = 3 D$

$C_{u2} = \text{Ultimate shear strength along socket length which shall be restricted to shear capacity of concrete of the pile} = 1300 \text{ kN/m}^2$

$F_s = \text{Factor of Safety} = 6$

Therefore, $R_{sf} = 1836.9 d^2$

Thus,

$$Q_a = c_{u1} N_c \cdot \frac{\pi B^2}{4 F_s} + \alpha c_{u2} \cdot \frac{\pi B L}{F_s}$$

$$= 3061.5 d^2 + 1836.9 d^2 = 4898.4 d^2$$

Substituting the values of various diameters and socket lengths equal to 3 times diameter, allowable load on single pile can be summarized as follows,

Summary of the Safe load calculation in Compression

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	22.22	22.70	23.12
Termination level RL in m	180.28	179.8	179.38
End Bearing Component in kN	1102.1	1768.3	2479.8
Friction Component in kN	661.3	1060.9	1487.9
Safe load in Compression in kN	1763.4	2829.3	3967.7
Safe load in Compression in T	176	283	397

5.0 Safe Load on Pile in uplift

5.1 For 3.0m cutoff from FGL

The overburden soils, though, will not contribute in compression capacity would offer resistance in uplift capacity. The parameters of BH 82 are considered for calculation of uplift resistance as summarized below,

Depth in m from RL 202.5 m	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Submerged density in gm/cc γ_{sub}	Reduction Factor α	Earth pressure coefficient K	Angle of wall friction $\delta = \phi$	SPT N Value
0.00 to 3.00	Pile cutoff level – No pile						
3.00 to 14.42	1.10	6~0(Ignored)	0.98	0.40	NA	NA	8
14.42 to 20.42	0.0	30	1.01	NA	1.00	30	20
20.42 to 23.12	Rock strata – Resistance would be as per skin friction capacity in socket as already calculated in compression capacity						

Note - & data is assumed for filling soils used for raising the FGL from EGL.

\$ Weighted average data considered. NA means not applicable.

Ultimate load in skin friction,

$$Q_{uf} = \alpha_i C_{ai} A_{si} + K_i P D_i \tan \delta_i A_{si}$$

First Layer – No contribution considered – (Within Cutoff Level).

$$\text{Second Layer} - \alpha_2 C_{a2} A_{s2} = 0.40 * 11.0 * \pi d * 11.42 = 157.86 d$$

$$\text{Third Layer} - K_3 P D_3 \tan \delta_3 A_{s3} = 1.00 * 10.61 * \tan 30 * \pi d * 6.00 = 115.47 d$$

Fourth Layer – 1836.9 d² in rock socket

$$\text{Substituting, ultimate load } q_{uf} = 2733.3 d + 1836.9 d^2$$

The safe load in uplift is worked out (considering the safety factor of 2.50 for overburden soils) and summarized below,

Safe Load on Piles in Uplift (in Ton)

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	22.22	22.70	23.12
Termination level RL in m	180.28	179.8	179.38
Safe load in Uplift in kN	1317.3	1891.9	2471.9
Self-weight of Pile in kN	81.5	134.0	191.9
Safe load in Uplift in T (Considering Self weight of Pile)	139.9	202.6	266.4

5.2 For 4.0m cutoff from FGL

The overburden soils, though, will not contribute in compression capacity would offer resistance in uplift capacity. The parameters of BH 82 are considered for calculation of uplift resistance as summarized below,

Depth in m from RL 202.5 m	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Submerged density in gm/cc γ_{sub}	Reduction Factor α	Earth pressure coefficient K	Angle of wall friction $\delta = \phi$	SPT N Value
0.00 to 4.00	Pile cutoff level – No pile						
4.00 to 14.42	1.10	6~0(Ignored)	0.98	0.40	NA	NA	8
14.42 to 20.42	0.0	30	1.01	NA	1.00	30	20
20.42 to 23.12	Rock strata – Resistance would be as per skin friction capacity in socket as already calculated in compression capacity						

Note - [&] data is assumed for filling soils used for raising the FGL from EGL.

^{\$} Weighted average data considered. NA means not applicable.

Ultimate load in skin friction,

$$Q_{uf} = \alpha_i C_{ai} A_{si} + K_i P D_i \tan \delta_i A_{si}$$

First Layer – No contribution considered – (Within Cutoff Level).

$$\text{Second Layer} - \alpha_2 C_{a2} A_{s2} = 0.40 * 11.0 * \pi d * 10.42 = 144.04 d$$

$$\text{Third Layer} - K_3 P D_3 \tan \delta_3 A_{s3} = 1.00 * 10.45 * \tan 30 * \pi d * 6.00 = 113.73 d$$

Fourth Layer – 1836.9 d² in rock socket

$$\text{Substituting, ultimate load } q_{uf} = 2577.7 d + 1836.9 d^2$$

The safe load in uplift is worked out (considering the safety factor of 2.50 for overburden soils) and summarized below,

Safe Load on Piles in Uplift (in Ton)

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	22.22	22.70	23.12
Termination level RL in m	180.28	179.8	179.38
Safe load in Uplift in kN	1279.9	1844.6	2415.9
Self-weight of Pile in kN	77.2	127.2	182.4
Safe load in Uplift in T (Considering Self weight of Pile)	135.7	197.2	259.8

6.0 Lateral Pile Capacity**6.1 For 3.00 & 4.00m cutoff from FGL**

Pile would be long and elastic (i.e. $L > 4T$). For a prescribed deflection of 5mm and with M 30 grade of concrete, the lateral load and moment were worked out as follows,

Diameters in m		0.60	0.76	0.90
Subgrade reaction in MN/m ³		2.70	2.70	2.70
Stiffness factor T in m		2.31	2.79	3.20
Depth of fixity in m	Free Head	4.40	5.30	6.10
	Fixed Head	5.00	6.10	7.00
Allowable Horizontal Force in T	Free Head	3.20	4.60	6.00
	Fixed Head	8.30	12.20	16.00
Allowable Moment capacity in Tm	Free Head	4.84	8.54	12.81
	Fixed Head	17.23	30.38	45.58

7.0 Notes

1. Pile shall be terminated after socketing 3D inside rock.
2. Initial and routine pile load test is required to verify the actual carrying capacity of pile in compression, uplift and lateral loads.
3. For design and construction, specification of IS: 2911, P1/S2, IS: 456, 2000 shall strictly be followed.

(Dr. K. K. Thaker)

Appendix – 11

Calculation of Safe Load carrying capacity of piles socketed inside rock (Near BH 53, 56, 58, 63, 64, IBH-34) (Boiler Area unit-1 & Mill bunker unit-1)

Project Name: - Proposed structures of thermal power project of NTTTP at Hirma, Talabira

1.0 Introduction

In situations where overburden offering low bearing pressure is followed by rock at relatively shallower depths, end bearing piles is the suitable foundation option. Piles in rocks and weathered rocks of varying degree of weathering derive their capacity by end bearing and socket side resistance.

In situations, where, rock strata comprises of highly fragmented rock, as in present case, where RQD is nil or $(CR+RQD)/2$ is less than 30 % or when the crushing strength is less than 10 MPa, the appropriate approach would be of that suggested by Cole & Stroud.

In present site overburden soils overlay fractured / laminated / foliated rock. The founding stratum having highly fragmented rock with nil RQD and $(CR+RQD)/2$ to be less than 30 %, the approach suggested by Cole and Stroud as per Annex B under clause 6.3.1.1 and 6.3.2 of IS 2911 Pa/S2 has been used for safe load calculations.

An illustrative calculation of safe load on pile and summary of pile capacities is as follows,

2.0 Sub soil strata Characterization

Out of six boreholes in given area, BH 58 happens to be the weakest. General stratification at the location of boreholes 58 show primarily three characterized layers,

1. Overburden comprising of fine to very fine grained clays up to 7.60 m (i.e. RL 192.600 m) followed by fine to very fine grained clayey and silty sand upto 13.10m (i.e. RL 187.100 m). The RL of NGL is 200.20 m.
2. Second characterized layer below the overburden soils consists fine to medium grained mud rock and indurated clays, up to 17.10 m (i.e. RL 183.100 m). Though, rock is not very sound but can be considered for socketing if the pile capacity obtained thereby is adequate against imposed loads.
3. Third layer comprises of highly weathered, thinly laminated rock up to 20.0 m (i.e. RL 180.200 m).
4. Fourth layer comprises of Slightly weathered, very weak, moderately thinly bedded rock. This layer extends below third layer and up to depth of termination of bore i.e. 23 m (i.e. RL 177.200 m). This layer is reasonably suitable for socketing of piles.

3.0 Design Considerations

1. Length of socket considered 3D from depth of rock encountered.
2. The pile is considered to have socket length below 13.10 m below NGL (i.e. RL 187.100 m) depth.
3. For present case of pile terminating in mud rock. SPT at depths between 13.10 to 17.10 m (between RL 187.100 to 183.100 m) is > 100 with just 8 cm penetration (average) in 59 blows. SPT can be extrapolated for 30 cm i.e. $59 * 30 / 8 = 221$.
Based on recommendation of fig no. 3 in B 8 in Annex B under clause 6.3.1.1 and 6.3.2 of IS 2911 P1/S2, average shear strength q_c corresponding to assumed SPT of 200 may be taken as 1300 kN/m²
4. Allowable Capacity of pile socketed into rock $Q_a = R_e + R_{sf} = C_{u1} N_c \pi B^2 / 4 (F_s = 3) + \alpha C_{u2} \pi BL / (F_s = 6)$

4.0 Safe Load on Pile in Compression

Where,

End bearing component, $R_e = C_{u1} N_c \pi B^2 / 4 F_s$,

C_{u1} = Shear strength below base of pile = 1300 kN/m²

B = diameter of the pile = d

F_s = Factor of Safety = 3

$N_c = 9$

Therefore, **$R_e = 3061.5 d^2$**

Skin friction component of socketed length of pile, $R_{sf} = \alpha C_{u2} \pi BL / F_s$

$\alpha = 0.9$ (recommended value in IS 2911 P1/S2)

$L =$ length of the socket $= 3 D$

$C_{u2} =$ Ultimate shear strength along socket length which shall be restricted to shear capacity of concrete of the pile $= 1300 \text{ kN/m}^2$

$F_s =$ Factor of Safety $= 6$

Therefore, $R_{sf} = 1836.9 d^2$

Thus,

$$Q_a = c_{u1} N_c \cdot \frac{\pi B^2}{4 F_s} + \alpha c_{u2} \cdot \frac{\pi BL}{F_s}$$

$$= 3061.5 d^2 + 1836.9 d^2 = 4898.4 d^2$$

Substituting the values of various diameters and socket lengths equal to 3 times diameter, allowable load on single pile can be summarized as follows,

Summary of the Safe load calculation in Compression

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	17.20	17.68	18.10
Termination level RL in m	185.30	184.82	184.40
End Bearing Component in kN	1102.1	1768.3	2479.8
Friction Component in kN	661.3	1060.9	1487.9
Safe load in Compression in kN	1763.4	2829.3	3967.7
Safe load in Compression in T	176	283	397

5.0 Safe Load on Pile in uplift

5.1 For 4.0m cutoff from FGL

The overburden soils, though, will not contribute in compression capacity would offer resistance in uplift capacity. The parameters of BH 58 are considered for calculation of uplift resistance as summarized below,

Depth in m from RL 202.5 m	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Submerged density in gm/cc γ_{sub}	Reduction Factor α	Earth pressure coefficient K	Angle of wall friction $\delta = 0.6 \phi$	SPT N Value
0.00 to 4.00	Pile cutoff level – No pile						
4.00 to 9.90	0.89 [#]	2 [#] ~0(Ignored)	0.98 [#]	0.28	NA	NA	14
9.90 to 15.40	0.08(Ignored)	25	0.98	NA	1.00	25	14
15.40 to 23.00	Rock strata – Resistance would be as per skin friction capacity in socket as already calculated in compression capacity						

Note - [#]Weighted average data considered. NA means not applicable.

Ultimate load in skin friction,

$Q_{uf} = \alpha_i C_{ai} A_{si}$

First Layer – No contribution considered – (Within Cutoff Level).

Second Layer – $\alpha_2 C_{a2} A_{s2} = 0.28 * 8.90 * \pi d * 5.90 = 46.19 d$

Third Layer – $K_3 P D_3 \tan \delta_3 A_{s3} = 1.00 * 10.45 * \tan 25 * \pi d * 5.50 = 84.20 d$

Fourth Layer – $1836.9 d^2$ in rock socket

Substituting, ultimate load **$q_{uf} = 1303.9 d + 1836.9 d^2$**

The safe load in uplift is worked out (considering the safety factor of 2.50 for overburden soils) and summarized below,

Safe Load on Piles in Uplift (in Ton)

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	17.20	17.68	18.10
Termination level RL in m	185.30	184.82	184.40
Safe load in Uplift in kN	974.2	1457.4	1957.3
Self-weight of Pile in kN	56.0	93.0	134.5
Safe load in Uplift in T (Considering Self weight of Pile)	103.0	155.0	209.2

5.2 For 5.0m cutoff from FGL

The overburden soils, though, will not contribute in compression capacity would offer resistance in uplift capacity. The parameters of BH 58 are considered for calculation of uplift resistance as summarized below,

Depth in m from RL 202.5 m	Cohesion in kg/cm²	Angle of Internal Friction ϕ	Submerged density in gm/cc γ_{sub}	Reduction Factor α	Earth pressure coefficient K	Angle of wall friction $\delta = 0.6 \phi$	SPT N Value
0.00 to 5.00	Pile cutoff level – No pile						
5.00 to 9.90	0.89 [#]	2 [#] ~0(Ignored)	0.98 [#]	0.28	NA	NA	14
9.90 to 15.40	0.08(Ignored)	25	0.98	NA	1.00	25	14
15.40 to 23.00	Rock strata – Resistance would be as per skin friction capacity in socket as already calculated in compression capacity						

Note - [#]Weighted average data considered. NA means not applicable.

Ultimate load in skin friction,

$$Q_{uf} = \alpha_i C_{ai} A_{si}$$

First Layer – No contribution considered – (Within Cutoff Level).

$$\text{Second Layer} - \alpha_2 C_{a2} A_{s2} = 0.28 * 8.90 * \pi d * 4.90 = 38.36 d$$

$$\text{Third Layer} - K_3 P D_3 \tan \delta_3 A_{s3} = 1.00 * 10.27 * \tan 25^\circ * \pi d * 5.50 = 82.75 d$$

Fourth Layer – 1836.9 d² in rock socket

$$\text{Substituting, ultimate load } q_{uf} = 1211.1 d + 1836.9 d^2$$

The safe load in uplift is worked out (considering the safety factor of 2.50 for overburden soils) and summarized below,

Safe Load on Piles in Uplift (in Ton)

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	17.20	17.68	18.10
Termination level RL in m	185.30	184.82	184.40
Safe load in Uplift in kN	951.9	1429.2	1923.9
Self-weight of Pile in kN	51.7	86.2	124.9
Safe load in Uplift in T (Considering Self weight of Pile)	100.4	151.5	204.9

5.3 For 6.0m cutoff from FGL

The overburden soils, though, will not contribute in compression capacity would offer resistance in uplift capacity. The parameters of BH 58 are considered for calculation of uplift resistance as summarized below,

Depth in m from RL 202.5 m	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Submerged density in gm/cc γ_{sub}	Reduction Factor α	Earth pressure coefficient K	Angle of wall friction $\delta = 0.6 \phi$	SPT N Value
0.00 to 6.00	Pile cutoff level – No pile						
6.00 to 9.90	0.89 [#]	2 [#] ~0(Ignored)	0.98 [#]	0.28	NA	NA	14
9.90 to 15.40	0.08(Ignored)	25	0.98	NA	1.00	25	14
15.40 to 23.00	Rock strata – Resistance would be as per skin friction capacity in socket as already calculated in compression capacity						

Note - [#]Weighted average data considered. NA means not applicable.

Ultimate load in skin friction,

$$Q_{uf} = \alpha_i C_{ai} A_{si}$$

First Layer – No contribution considered – (Within Cutoff Level).

$$\text{Second Layer} - \alpha_2 C_{a2} A_{s2} = 0.28 * 8.90 * \pi d * 3.90 = 30.53 d$$

$$\text{Third Layer} - K_3 P D_3 \tan \delta_3 A_{s3} = 1.00 * 10.27 * \tan 25 * \pi d * 5.50 = 82.75 d$$

Fourth Layer – 1836.9 d² in rock socket

$$\text{Substituting, ultimate load } Q_{uf} = 1132.8 d + 1836.9 d^2$$

The safe load in uplift is worked out (considering the safety factor of 2.50 for overburden soils) and summarized below,

Safe Load on Piles in Uplift (in Ton)

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	17.20	17.68	18.10
Termination level RL in m	185.30	184.82	184.40
Safe load in Uplift in kN	933.2	1405.4	1895.7
Self-weight of Pile in kN	47.5	79.4	115.4
Safe load in Uplift in T (Considering Self weight of Pile)	98.1	148.5	201.1

6.0 Lateral Pile Capacity

6.1 For 4.0m cutoff from FGL

Pile would be long and elastic (i.e. $L > 4T$). For a prescribed deflection of 5mm and with M 30 grade of concrete, the lateral load and moment were worked out as follows,

Diameters in m		0.60	0.76	0.90
Subgrade reaction in MN/m ³		2.55	2.55	2.55
Stiffness factor T in m		2.34	2.82	3.23
Depth of fixity in m	Free Head	4.40	5.40	6.10
	Fixed Head	5.10	6.20	7.00
Allowable Horizontal Force in T	Free Head	3.00	4.40	5.80
	Fixed Head	8.10	11.80	15.40
Allowable Moment capacity in Tm	Free Head	4.73	8.34	12.52
	Fixed Head	16.84	29.69	44.55

6.2 For 5.0m cutoff from FGL

Pile would be long and elastic (i.e. $L > 4T$). For a prescribed deflection of 5mm and with M 30 grade of concrete, the lateral load and moment were worked out as follows,

Diameters in m		0.60	0.76	0.90
Subgrade reaction in MN/m^3		3.42	3.42	3.42
Stiffness factor T in m		2.20	2.66	3.05
Depth of fixity in m	Free Head	4.20	5.10	5.80
	Fixed Head	4.80	5.80	6.60
Allowable Horizontal Force in T	Free Head	3.60	5.30	6.90
	Fixed Head	9.60	14.00	18.40
Allowable Moment capacity in Tm	Free Head	5.32	9.38	14.08
	Fixed Head	18.93	33.39	50.10

6.3 For 6.0m cutoff from FGL

Pile would be long and elastic (i.e. $L > 4T$). For a prescribed deflection of 5mm and with M 30 grade of concrete, the lateral load and moment were worked out as follows,

Diameters in m		0.60	0.76	0.90
Subgrade reaction in MN/m^3		3.42	3.42	3.42
Stiffness factor T in m		2.20	2.66	3.05
Depth of fixity in m	Free Head	4.20	5.10	5.80
	Fixed Head	4.80	5.80	6.60
Allowable Horizontal Force in T	Free Head	3.60	5.30	6.90
	Fixed Head	9.60	14.00	18.40
Allowable Moment capacity in Tm	Free Head	5.32	9.38	14.08
	Fixed Head	18.93	33.39	50.10

7.0 Notes

1. Pile shall be terminated after socketing 3D inside rock.
2. Initial and routine pile load test is required to verify the actual carrying capacity of pile in compression, uplift and lateral loads.
3. For design and construction, specification of IS: 2911, P1/S2, IS: 456, 2000 shall strictly be followed.

(Dr. K. K. Thaker)

Appendix – 12

Calculation of Safe Load carrying capacity of piles socketed inside rock (Near BH 116, 126, 129, 109, 135, 115, 134, IBH-19 and IBH-36) (BOILER AREA UNIT-3 & MILL BUNKER UNIT-3)

Project Name: - Proposed structures of thermal power project of NTTTP at Hirma, Talabira

1.0 Introduction

In situations where overburden offering low bearing pressure is followed by rock at relatively shallower depths, end bearing piles is the suitable foundation option. Piles in rocks and weathered rocks of varying degree of weathering derive their capacity by end bearing and socket side resistance.

In situations, where, rock strata comprises of highly fragmented rock, as in present case, where RQD is nil or $(CR+RQD)/2$ is less than 30 % or when the crushing strength is less than 10 MPa, the appropriate approach would be of that suggested by Cole & Stroud.

In present site overburden soils overlay fractured / laminated / foliated rock. The founding stratum having highly fragmented rock with nil RQD and $(CR+RQD)/2$ to be less than 30 %, the approach suggested by Cole and Stroud as per Annex B under clause 6.3.1.1 and 6.3.2 of IS 2911 Pa/S2 has been used for safe load calculations.

An illustrative calculation of safe load on pile and summary of pile capacities is as follows,

2.0 Sub soil strata Characterization

Out of nine boreholes in given area, IBH-36 happens to be the weakest. General stratification at the location of boreholes 36 show primarily three characterized layers,

1. Overburden comprising of fine to medium grained, sandy clays of high/low plasticity upto 7.90 m (i.e. RL 192.63 m) followed by fine to very fine grained, clayey sand upto 11.30m (i.e. RL 189.23m). The RL of NGL is 200.53 m.
2. Second characterized layer below the overburden soils consists Mixture of Highly weathered, weak, completely fractured and disintegrated, dark brownish grey, fine to very fine grained, thinly bedded rock up to 13.00 m (i.e. RL 187.53 m).
3. Third layer comprises of Moderately weathered, weak, yellowish brown, fine to medium grained, moderately thickly laminated rock up to 17.50 m (i.e. RL 183.03 m).

3.0 Design Considerations

1. Length of socket considered 3D from depth of rock encountered.
2. The pile is considered to have socket length below 11.30 m below NGL (i.e. RL 189.23 m) depth.
3. For present case of pile terminating in highly weathered rock. Based on recommendation of fig no. 3 in B 8 in Annex B under clause 6.3.1.1 and 6.3.2 of IS 2911 P1/S2, average shear strength q_c corresponding to assumed SPT of 200 may be taken as 1300 kN/m^2
4. Allowable Capacity of pile socketed into rock $Q_a = R_e + R_{sf} = C_{u1} N_c \pi B^2 / 4(F_s=3) + \alpha C_{u2} \pi BL / (F_s=6)$

4.0 Safe Load on Pile in Compression

Where,

End bearing component, $R_e = C_{u1} N_c \pi B^2 / 4F_s$,

C_{u1} = Shear strength below base of pile = 1300 kN/m^2

B = diameter of the pile = d

F_s = Factor of Safety = 3

$N_c = 9$

Therefore, **$R_e = 3061.5 d^2$**

Skin friction component of socketed length of pile, $R_{sf} = \alpha C_{u2} \pi BL / F_s$

$\alpha = 0.9$ (recommended value in IS 2911 P1/S2)

L = length of the socket = 3 D

C_{u2} = Ultimate shear strength along socket length which shall be restricted to shear capacity of concrete of the pile = 1300 kN/m²

F_s = Factor of Safety = 6

Therefore, $R_{sf} = 1836.9 \text{ d}^2$

Thus,

$$Q_a = c_{u1} N_c \cdot \frac{\pi B^2}{4 F_s} + \alpha c_{u2} \cdot \frac{\pi B L}{F_s}$$

$$= 3061.5 \text{ d}^2 + 1836.9 \text{ d}^2 = 4898.4 \text{ d}^2$$

Substituting the values of various diameters and socket lengths equal to 3 times diameter, allowable load on single pile can be summarized as follows,

Summary of the Safe load calculation in Compression

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	15.07	15.55	15.97
Termination level RL in m	187.43	186.95	186.53
End Bearing Component in kN	1102.1	1768.3	2479.8
Friction Component in kN	661.3	1060.9	1487.9
Safe load in Compression in kN	1763.4	2829.3	3967.7
Safe load in Compression in T	176	283	397

5.0 Safe Load on Pile in uplift

5.1 For 4.0m cutoff from FGL

The overburden soils, though, will not contribute in compression capacity would offer resistance in uplift capacity. The parameters of IBH 36 are considered for calculation of uplift resistance as summarized below,

Depth in m from RL 202.5 m	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Submerged density in gm/cc γ_{sub}	Reduction Factor α	Earth pressure coefficient K	Angle of wall friction $\delta = \phi$	SPT N Value
0.00 to 4.00	Pile cutoff level – No pile						
4.00 to 9.87	0.93	2~0(Ignored)	0.96	0.48	NA	NA	10
9.87 to 13.87	0.11(Ignored)	26	1.01	NA	1.00	26	17
13.87 to 19.47	Rock strata – Resistance would be as per skin friction capacity in socket as already calculated in compression capacity						

Ultimate load in skin friction,

$$Q_{uf} = \alpha_i C_{ai} A_{si} + K_i P D_i \tan \delta_i A_{si}$$

First Layer – No contribution considered – (Within Cutoff Level).

$$\text{Second Layer} - \alpha_2 C_{a2} A_{s2} = 0.96 * 9.30 * \pi d * 5.87 = 164.64 \text{ d}$$

$$\text{Third Layer} - K_3 P D_3 \tan \delta_3 A_{s3} = 1.00 * 10.38 * \tan 26 * \pi d * 4.00 = 63.62 \text{ d}$$

Fourth Layer – 1314.10 d² in rock socket

$$\text{Substituting, ultimate load } q_{uf} = 2282.6 \text{ d} + 1314.10 \text{ d}^2$$

The safe load in uplift is worked out (considering the safety factor of 2.50 for overburden soils) and summarized below,

Safe Load on Piles in Uplift (in Ton)

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	15.07	15.55	15.97
Termination level RL in m	187.43	186.95	186.53
Safe load in Uplift in kN	1020.9	1452.9	1886.2
Self-weight of Pile in kN	49.5	82.6	119.9
Safe load in Uplift in T (Considering Self weight of Pile)	107.0	153.6	200.6

5.2 For 5.0m cutoff from FGL

The overburden soils, though, will not contribute in compression capacity would offer resistance in uplift capacity. The parameters of IBH 36 are considered for calculation of uplift resistance as summarized below,

Depth in m from RL 202.5 m	Cohesion in kg/cm²	Angle of Internal Friction ϕ	Submerged density in gm/cc γ_{sub}	Reduction Factor α	Earth pressure coefficient K	Angle of wall friction $\delta = \phi$	SPT N Value
0.00 to 5.00	Pile cutoff level – No pile						
5.00 to 9.87	0.93	2~0(Ignored)	0.96	0.48	NA	NA	10
9.87 to 13.87	0.11(Ignored)	26	1.01	NA	1.00	26	17
13.87 to 19.47	Rock strata – Resistance would be as per skin friction capacity in socket as already calculated in compression capacity						

Ultimate load in skin friction,

$$Q_{uf} = \alpha_i C_{ai} A_{si} + K_i P D_i \tan \delta_i A_{si}$$

First Layer – No contribution considered – (Within Cutoff Level).

$$\text{Second Layer} - \alpha_2 C_{a2} A_{s2} = 0.96 * 9.30 * \pi d * 4.87 = 136.59 d$$

$$\text{Third Layer} - K_3 P D_3 \tan \delta_3 A_{s3} = 1.00 * 10.22 * \tan 26 * \pi d * 4.00 = 62.64 d$$

$$\text{Fourth Layer} - 1314.10 d^2 \text{ in rock socket}$$

$$\text{Substituting, ultimate load } q_{uf} = 1992.3 d + 1314.10 d^2$$

The safe load in uplift is worked out (considering the safety factor of 2.50 for overburden soils) and summarized below,

Safe Load on Piles in Uplift (in Ton)

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	15.07	15.55	15.97
Termination level RL in m	187.43	186.95	186.53
Safe load in Uplift in kN	951.2	1364.7	1781.6
Self-weight of Pile in kN	45.2	75.8	110.4
Safe load in Uplift in T (Considering Self weight of Pile)	99.6	144.1	189.2

5.3 For 6.0m cutoff from FGL

The overburden soils, though, will not contribute in compression capacity would offer resistance in uplift capacity. The parameters of IBH 36 are considered for calculation of uplift resistance as summarized below,

Depth in m from RL 202.5 m	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Submerged density in gm/cc γ_{sub}	Reduction Factor α	Earth pressure coefficient K	Angle of wall friction $\delta = \phi$	SPT N Value
0.00 to 6.00	Pile cutoff level – No pile						
6.00 to 9.87	0.93	2~0(Ignored)	0.96	0.48	NA	NA	10
9.87 to 13.87	0.11(Ignored)	26	1.01	NA	1.00	26	17
13.87 to 19.47	Rock strata – Resistance would be as per skin friction capacity in socket as already calculated in compression capacity						

Ultimate load in skin friction,

$$Q_{uf} = \alpha_i C_{ai} A_{si} + K_i P D_i \tan \delta_i A_{si}$$

First Layer – No contribution considered – (Within Cutoff Level).

$$\text{Second Layer} - \alpha_2 C_{a2} A_{s2} = 0.96 * 9.30 * \pi d * 3.87 = 108.55 d$$

$$\text{Third Layer} - K_3 P D_3 \tan \delta_3 A_{s3} = 1.00 * 10.06 * \tan 26^\circ * \pi d * 4.00 = 61.66 d$$

Fourth Layer – 1314.10 d² in rock socket

$$\text{Substituting, ultimate load } q_{uf} = 1702.1 d + 1314.10 d^2$$

The safe load in uplift is worked out (considering the safety factor of 2.50 for overburden soils) and summarized below,

Safe Load on Piles in Uplift (in Ton)

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	15.07	15.55	15.97
Termination level RL in m	187.43	186.95	186.53
Safe load in Uplift in kN	881.6	1276.5	1677.2
Self-weight of Pile in kN	41.0	69.0	100.8
Safe load in Uplift in T (Considering Self weight of Pile)	92.3	134.6	177.8

6.0 Lateral Pile Capacity

6.1 For 4.00m cutoff

Pile would be long and elastic (i.e. $L > 4T$). For a prescribed deflection of 5mm and with M 30 grade of concrete, the lateral load and moment were worked out as follows,

Diameters in m		0.60	0.76	0.90
Subgrade reaction in MN/m ³		2.84	2.84	2.84
Stiffness factor T in m		2.29	2.76	3.16
Depth of fixity in m	Free Head	4.30	5.20	6.00
	Fixed Head	5.00	6.00	6.90
Allowable Horizontal Force in T	Free Head	3.20	4.70	6.20
	Fixed Head	8.60	12.60	16.50
Allowable Moment capacity in Tm	Free Head	4.94	8.71	13.07
	Fixed Head	17.58	31.00	46.51

6.2 For 5.00 & 6.00m cutoff

Pile would be long and elastic (i.e. $L > 4T$). For a prescribed deflection of 5mm and with M 30 grade of concrete, the lateral load and moment were worked out as follows,

Diameters in m		0.60	0.76	0.90
Subgrade reaction in MN/m ³		3.56	3.56	3.56
Stiffness factor T in m		2.19	2.64	3.02
Depth of fixity in m	Free Head	4.20	5.00	5.70
	Fixed Head	4.80	5.80	6.60
Allowable Horizontal Force in T	Free Head	3.70	5.40	7.10
	Fixed Head	9.80	14.40	18.80
Allowable Moment capacity in Tm	Free Head	5.41	9.53	14.30
	Fixed Head	19.24	33.93	50.91

7.0 Notes

1. Pile shall be terminated after socketing 3D inside rock.
2. Initial and routine pile load test is required to verify the actual carrying capacity of pile in compression, uplift and lateral loads.
3. For design and construction, specification of IS: 2911, P1/S2, IS: 456, 2000 shall strictly be followed.

(Dr. K. K. Thaker)

Appendix – 13

Calculation of Safe Load carrying capacity of piles socketed inside rock (Near BH- 75, 73, 103 & 105) (CHIMNEY UNIT-1,2&3)

Project Name: - Proposed structures of thermal power project of NTTTP at Hirma, Talabira

1.0 Introduction

In situations where overburden offering low bearing pressure is followed by rock at relatively shallower depths, end bearing piles is the suitable foundation option. Piles in rocks and weathered rocks of varying degree of weathering derive their capacity by end bearing and socket side resistance.

In situations, where, rock strata comprises of highly fragmented rock, as in present case, where RQD is nil or $(CR+RQD)/2$ is less than 30 % or when the crushing strength is less than 10 MPa, the appropriate approach would be of that suggested by Cole & Stroud.

In present site overburden soils overlay fractured / laminated / foliated rock. The founding stratum having highly fragmented rock with nil RQD and $(CR+RQD)/2$ to be less than 30 %, the approach suggested by Cole and Stroud as per Annex B under clause 6.3.1.1 and 6.3.2 of IS 2911 Pa/S2 has been used for safe load calculations.

An illustrative calculation of safe load on pile and summary of pile capacities is as follows,

2.0 Sub soil strata Characterization

Out of two boreholes in given area, BH-105 happens to be the weakest. General stratification at the location of boreholes 105 show primarily two characterized layers,

1. Overburden comprising of fine to very fine grained, sandy clays of high/low plasticity upto 5.70 m (i.e. RL 191.97 m) followed by clayey and silty sand upto 12.60m (i.e. RL 185.07 m). The RL of NGL is 197.67 m.
2. Second layer comprises of Highly weathered, very weak and friable, dark brownish yellow, fine to medium grained, very thinly laminated rockup to 20.50 m (i.e. RL 177.17 m).

3.0 Design Considerations

1. Length of socket considered 3D from depth of rock encountered.
2. The pile is considered to have socket length below 12.60 m below NGL (i.e. RL 185.07 m) depth.
3. For present case of pile terminating in highly weathered rock. SPT at depths between 12.60 to 20.50 m (between RL 185.07 to 177.17 m) is > 100 with just 7 cm penetration (average) in 50 blows. SPT can be extrapolated for 30 cm i.e. $50 * 30 / 7 = 214$.
Based on recommendation of fig no. 3 in B 8 in Annex B under clause 6.3.1.1 and 6.3.2 of IS 2911 P1/S2, average shear strength q_c corresponding to assumed SPT of 200 may be taken as 1300 kN/m^2
4. Allowable Capacity of pile socketed into rock $Q_a = R_e + R_{sf} = C_{u1} N_c \pi B^2 / 4 (F_s = 3) + \alpha C_{u2} \pi BL / (F_s = 6)$

4.0 Safe Load on Pile in Compression

Where,

End bearing component, $R_e = C_{u1} N_c \pi B^2 / 4 F_s$,

C_{u1} = Shear strength below base of pile = 1300 kN/m^2

B = diameter of the pile = d

F_s = Factor of Safety = 3

$N_c = 9$

Therefore, **$R_e = 3061.5 d^2$**

Skin friction component of socketed length of pile, $R_{sf} = \alpha C_{u2} \pi BL / F_s$

$\alpha = 0.9$ (recommended value in IS 2911 P1/S2)

L = length of the socket = $3 D$

C_{u2} = Ultimate shear strength along socket length which shall be restricted to shear capacity of concrete of the pile = 1300 kN/m²

F_s = Factor of Safety = 6

Therefore, $R_{sf} = 1836.9 \text{ d}^2$

Thus,

$$Q_a = c_{u1} N_c \cdot \frac{\pi B^2}{4 F_s} + \alpha c_{u2} \cdot \frac{\pi B L}{F_s}$$

$$= 3061.5 \text{ d}^2 + 1836.9 \text{ d}^2 = 4898.4 \text{ d}^2$$

Substituting the values of various diameters and socket lengths equal to 3 times diameter, allowable load on single pile can be summarized as follows,

Summary of the Safe load calculation in Compression

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	19.23	19.71	20.13
Termination level RL in m	183.27	182.79	182.37
End Bearing Component in kN	1102.1	1768.3	2479.8
Friction Component in kN	661.3	1060.9	1487.9
Safe load in Compression in kN	1763.4	2829.3	3967.7
Safe load in Compression in T	176	283	397

5.0 Safe Load on Pile in uplift

5.1 For 5.0m cutoff from FGL

The overburden soils, though, will not contribute in compression capacity would offer resistance in uplift capacity. The parameters of BH 105 are considered for calculation of uplift resistance as summarized below,

Depth in m from RL 202.5 m	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Submerged density in gm/cc γ_{sub}	Reduction Factor α	Earth pressure coefficient K	Angle of wall friction $\delta = \phi$	SPT N Value
0.00 to 5.00	Pile cutoff level – No pile						
5.00 to 10.53	0.77	2~0(Ignored)	0.95	0.59	NA	NA	18
10.53 to 17.43	0.10(Ignored)	29	1.02	NA	1.00	29	20
17.43 to 25.33	Rock strata – Resistance would be as per skin friction capacity in socket as already calculated in compression capacity						

Ultimate load in skin friction,

$$Q_{uf} = \alpha_i C_{ai} A_{si} + K_i P D_i \tan \delta_i A_{si}$$

First Layer – No contribution considered – (Within Cutoff Level).

$$\text{Second Layer} - \alpha_2 C_{a2} A_{s2} = 0.59 * 7.70 * \pi d * 5.53 = 78.93 \text{ d}$$

$$\text{Third Layer} - K_3 P D_3 \tan \delta_3 A_{s3} = 1.00 * 10.13 * \tan 29 * \pi d * 6.90 = 121.72 \text{ d}$$

Fourth Layer – 1836.9 d² in rock socket

$$\text{Substituting, ultimate load } q_{uf} = 2006.5 \text{ d} + 1836.9 \text{ d}^2$$

The safe load in uplift is worked out (considering the safety factor of 2.50 for overburden soils) and summarized below,

Safe Load on Piles in Uplift (in Ton)

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	19.23	19.71	20.13
Termination level RL in m	183.27	182.79	182.37
Safe load in Uplift in kN	1142.84	1670.97	2210.23
Self-weight of Pile in kN	60.3	100.0	144.3
Safe load in Uplift in T (Considering Self weight of Pile)	120.3	177.1	235.5

5.2 For 6.0m cutoff from FGL

The overburden soils, though, will not contribute in compression capacity would offer resistance in uplift capacity. The parameters of BH 105 are considered for calculation of uplift resistance as summarized below,

Depth in m from RL 202.5 m	Cohesion in kg/cm²	Angle of Internal Friction ϕ	Submerged density in gm/cc γ_{sub}	Reduction Factor α	Earth pressure coefficient K	Angle of wall friction $\delta = \phi$	SPT N Value
0.00 to 6.00	Pile cutoff level – No pile						
6.00 to 10.53	0.77	2~0(Ignored)	0.95	0.59	NA	NA	18
10.53 to 17.43	0.10(Ignored)	29	1.02	NA	1.00	29	20
17.43 to 25.33	Rock strata – Resistance would be as per skin friction capacity in socket as already calculated in compression capacity						

Ultimate load in skin friction,

$$Q_{uf} = \alpha_i C_{ai} A_{si} + K_i P D_i \tan \delta_i A_{si}$$

First Layer – No contribution considered – (Within Cutoff Level).

$$\text{Second Layer} - \alpha_2 C_{a2} A_{s2} = 0.59 * 7.70 * \pi d * 4.53 = 64.65 d$$

$$\text{Third Layer} - K_3 P D_3 \tan \delta_3 A_{s3} = 1.00 * 9.98 * \tan 29 * \pi d * 6.90 = 119.92 d$$

Fourth Layer – 1836.9 d² in rock socket

$$\text{Substituting, ultimate load } q_{uf} = 1845.7 d + 1836.9 d^2$$

The safe load in uplift is worked out (considering the safety factor of 2.50 for overburden soils) and summarized below,

Safe Load on Piles in Uplift (in Ton)

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	19.23	19.71	20.13
Termination level RL in m	183.27	182.79	182.37
Safe load in Uplift in kN	1104.25	1622.09	2152.34
Self-weight of Pile in kN	56.1	93.2	134.8
Safe load in Uplift in T (Considering Self weight of Pile)	116.0	171.5	228.7

5.3 For 7.0m cutoff from FGL

The overburden soils, though, will not contribute in compression capacity would offer resistance in uplift capacity. The parameters of BH 105 are considered for calculation of uplift resistance as summarized below,

Depth in m from RL 202.5 m	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Submerged density in gm/cc γ_{sub}	Reduction Factor α	Earth pressure coefficient K	Angle of wall friction $\delta = \phi$	SPT N Value
0.00 to 7.00	Pile cutoff level – No pile						
7.00 to 10.53	0.77	2~0(Ignored)	0.95	0.59	NA	NA	18
10.53 to 17.43	0.10(Ignored)	29	1.02	NA	1.00	29	20
17.43 to 25.33	Rock strata – Resistance would be as per skin friction capacity in socket as already calculated in compression capacity						

Ultimate load in skin friction,

$$Q_{uf} = \alpha_i C_{ai} A_{si} + K_i P D_i \tan \delta_i A_{si}$$

First Layer – No contribution considered – (Within Cutoff Level).

$$\text{Second Layer} - \alpha_2 C_{a2} A_{s2} = 0.59 * 7.70 * \pi d * 3.53 = 50.38 d$$

$$\text{Third Layer} - K_3 P D_3 \tan \delta_3 A_{s3} = 1.00 * 9.83 * \tan 29 * \pi d * 6.90 = 118.11 d$$

Fourth Layer – 1836.9 d² in rock socket

$$\text{Substituting, ultimate load } q_{uf} = 1684.9 d + 1836.9 d^2$$

The safe load in uplift is worked out (considering the safety factor of 2.50 for overburden soils) and summarized below,

Safe Load on Piles in Uplift (in Ton)

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	19.23	19.71	20.13
Termination level RL in m	183.27	182.79	182.37
Safe load in Uplift in kN	1065.66	1573.20	2094.45
Self-weight of Pile in kN	51.8	86.4	125.2
Safe load in Uplift in T (Considering Self weight of Pile)	111.7	166.0	222.0

6.0 Lateral Pile Capacity

Pile would be long and elastic (i.e. $L > 4T$). For a prescribed deflection of 5mm and with M 30 grade of concrete, the lateral load and moment were worked out as follows,

Diameters in m		0.60	0.76	0.90
Subgrade reaction in MN/m ³		3.42	3.42	3.42
Stiffness factor T in m		2.20	2.66	3.05
Depth of fixity in m	Free Head	4.20	5.10	5.80
	Fixed Head	4.80	5.80	6.60
Allowable Horizontal Force in T	Free Head	3.60	5.30	6.90
	Fixed Head	9.60	14.00	18.40
Allowable Moment capacity in Tm	Free Head	5.32	9.38	14.08
	Fixed Head	18.93	33.39	50.10

7.0 Notes

1. Pile shall be terminated after socketing 3D inside rock.
2. Initial and routine pile load test is required to verify the actual carrying capacity of pile in compression, uplift and lateral loads.
3. For design and construction, specification of IS: 2911, P1/S2, IS: 456, 2000 shall strictly be followed.

(Dr. K. K. Thaker)

Appendix – 14

Calculation of Safe Load carrying capacity of piles socketed inside rock (Near BH 120, 124, 98, 113, 90) (FGD area(absorber, RC pump house, aux absorbent tank etc))

Project Name: - Proposed structures of thermal power project of NTTTP at Hirma, Talabira

1.0 Introduction

In situations where overburden offering low bearing pressure is followed by rock at relatively shallower depths, end bearing piles is the suitable foundation option. Piles in rocks and weathered rocks of varying degree of weathering derive their capacity by end bearing and socket side resistance.

In situations, where, rock strata comprises of highly fragmented rock, as in present case, where RQD is nil or $(CR+RQD)/2$ is less than 30 % or when the crushing strength is less than 10 MPa, the appropriate approach would be of that suggested by Cole & Stroud.

In present site overburden soils overlay fractured / laminated / foliated rock. The founding stratum having highly fragmented rock with nil RQD and $(CR+RQD)/2$ to be less than 30 %, the approach suggested by Cole and Stroud as per Annex B under clause 6.3.1.1 and 6.3.2 of IS 2911 Pa/S2 has been used for safe load calculations.

An illustrative calculation of safe load on pile and summary of pile capacities is as follows,

2.0 Sub soil strata Characterization

Out of five boreholes in given area, BH 98 happens to be the weakest. General stratification at the location of boreholes 98 show primarily three characterized layers,

1. Overburden comprising of fine to very fine grained clays and fine to very fine grained clayey and silty sand upto 14.60m (i.e. RL 182.85 m). The RL of NGL is 197.45 m.
2. Second characterized layer below the overburden soils consists Highly weathered, very weak, fine to medium grained, very thinly laminated rock, up to 19.50 m (i.e. RL 177.95 m). Though, rock is not very sound but can be considered for socketing if the pile capacity obtained thereby is adequate against imposed loads.
3. Third layer comprises of Slightly weathered, weak, fine to medium grained, thickly bedded rock up to 22.0 m (i.e. RL 175.45 m).

3.0 Design Considerations

1. Length of socket considered 3D from depth of rock encountered.
2. The pile is considered to have socket length below 14.60 m below NGL (i.e. RL 182.85 m) depth.
3. For present case of pile terminating in highly weathered rock. SPT at depths between 14.60 to 19.50 m (between RL 182.85 to 177.95 m) is > 100 with just 3 cm penetration (average) in 50 blows. SPT can be extrapolated for 30 cm i.e. $50 * 30 / 3 = 500$.

Based on recommendation of fig no. 3 in B 8 in Annex B under clause 6.3.1.1 and 6.3.2 of IS 2911 P1/S2, average shear strength q_c corresponding to assumed SPT of 200 may be taken as 1300 kN/m^2

4. Allowable Capacity of pile socketed into rock $Q_a = R_e + R_{sf} = C_{u1} N_c \pi B^2 / 4 (F_s = 3) + \alpha C_{u2} \pi BL / (F_s = 6)$

4.0 Safe Load on Pile in Compression

Where,

End bearing component, $R_e = C_{u1} N_c \pi B^2 / 4 F_s$,

C_{u1} = Shear strength below base of pile = 1300 kN/m^2

B = diameter of the pile = d

F_s = Factor of Safety = 3

$N_c = 9$

Therefore, **$R_e = 3061.5 d^2$**

Skin friction component of socketed length of pile, $R_{sf} = \alpha C_{u2} \pi BL / F_s$

$\alpha = 0.9$ (recommended value in IS 2911 P1/S2)

$L =$ length of the socket $= 3 D$

$C_{u2} =$ Ultimate shear strength along socket length which shall be restricted to shear capacity of concrete of the pile $= 1300 \text{ kN/m}^2$

$F_s =$ Factor of Safety $= 6$

Therefore, $R_{sf} = 1836.9 \text{ d}^2$

Thus,

$$Q_a = c_{u1} N_c \cdot \frac{\pi B^2}{4 F_s} + \alpha c_{u2} \cdot \frac{\pi B L}{F_s}$$

$$= 3061.5 \text{ d}^2 + 1836.9 \text{ d}^2 = 4898.4 \text{ d}^2$$

Substituting the values of various diameters and socket lengths equal to 3 times diameter, allowable load on single pile can be summarized as follows,

Summary of the Safe load calculation in Compression

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	21.45	21.93	22.35
Termination level RL in m	181.05	180.57	180.15
End Bearing Component in kN	1102.1	1768.3	2479.8
Friction Component in kN	661.3	1060.9	1487.9
Safe load in Compression in kN	1763.4	2829.3	3967.7
Safe load in Compression in T	176	283	397

5.0 Safe Load on Pile in uplift

5.1 For 5.0m cutoff from FGL

The overburden soils, though, will not contribute in compression capacity would offer resistance in uplift capacity. The parameters of BH 98 are considered for calculation of uplift resistance as summarized below,

Depth in m from RL 202.5 m	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Submerged density in gm/cc γ_{sub}	Reduction Factor α	Earth pressure coefficient K	Angle of wall friction $\delta = \phi$	SPT N Value
0.00 to 5.00	Pile cutoff level – No pile						
5.00 to 9.55	0.48 ^{\$}	6 ^{\$} ~0(Ignored)	0.92 ^{\$}	0.91	NA	NA	8
9.55 to 19.65	0.0	26	0.97	NA	1.00	26	11
19.65 to 27.05	Rock strata – Resistance would be as per skin friction capacity in socket as already calculated in compression capacity						

Note - [&] data is assumed for filling soils used for raising the FGL from EGL.

^{\$} Weighted average data considered. NA means not applicable.

Ultimate load in skin friction,

$$Q_{uf} = \alpha_i C_{ai} A_{si} + K_i P D_i \tan \delta_i A_{si}$$

First Layer – No contribution considered – (Within Cutoff Level).

$$\text{Second Layer} - \alpha_2 C_{a2} A_{s2} = 0.91 * 4.80 * \pi d * 4.55 = 62.44 \text{ d}$$

$$\text{Third Layer} - K_3 P D_3 \tan \delta_3 A_{s3} = 1.00 * 9.97 * \tan 26 * \pi d * 10.10 = 154.29 \text{ d}$$

Fourth Layer – 1836.9 d^2 in rock socket

$$\text{Substituting, ultimate load } q_{uf} = 2167.3 \text{ d} + 1836.9 \text{ d}^2$$

The safe load in uplift is worked out (considering the safety factor of 2.50 for overburden soils) and summarized below,

Safe Load on Piles in Uplift (in Ton)

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	21.45	21.93	22.35
Termination level RL in m	181.05	180.57	180.15
Safe load in Uplift in kN	1181.44	1719.85	2268.12
Self-weight of Pile in kN	69.73	115.15	165.48
Safe load in Uplift in T (Considering Self weight of Pile)	125.1	183.5	243.4

6.0 Lateral Pile Capacity

Pile would be long and elastic (i.e. $L > 4T$). For a prescribed deflection of 5mm and with M 30 grade of concrete, the lateral load and moment were worked out as follows,

Diameters in m		0.60	0.76	0.90
Subgrade reaction in MN/m^3		3.03	3.03	3.03
Stiffness factor T in m		2.26	2.73	3.12
Depth of fixity in m	Free Head	4.30	5.20	5.90
	Fixed Head	4.90	5.90	6.80
Allowable Horizontal Force in T	Free Head	3.40	4.90	6.50
	Fixed Head	8.90	13.10	17.10
Allowable Moment capacity in Tm	Free Head	5.07	8.94	13.41
	Fixed Head	18.04	31.81	47.74

7.0 Notes

1. Pile shall be terminated after socketing 3D inside rock.
2. Initial and routine pile load test is required to verify the actual carrying capacity of pile in compression, uplift and lateral loads.
3. For design and construction, specification of IS: 2911, P1/S2, IS: 456, 2000 shall strictly be followed.

(Dr. K. K. Thaker)

Appendix – 15

Calculation of Safe Load on Uniform Diameter Bored Cast in situ Pile terminating in soil strata. (Near BH 50, 61, 66) (POWER HOUSE UNIT-1)

The safe load is calculated as follows,

1) Design Stipulations

- | | |
|---|---|
| 1. Type of pile | - Bored cast in situ uniform diameter pile. |
| 2. Pile diameter considered | - 0.60m |
| 3. Termination depth of pile considered | - 18.00, 19.00m from FGL. |
| 4. Cut off Level | - 2.00m from FGL. |
| 5. Factor of Safety | - 2.50 |
| 6. Depth of Water table | - Encountered at 3.70m but considered at FGL. |
| 7. Ref | - IS 2911 P-I, Sec-II, 2021. |

2) Test Data

The parameters are based on BH 50. For evaluation of safe load on piles following characterized layers are considered as described in table below,

Depth in m from RL 202.5 m	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Submerged density in gm/cc γ_{sub}	Reduction Factor α	Earth pressure coefficient K	Angle of wall friction $\delta = \phi$	SPT N Value
0.00 to 2.00	Pile cutoff level – No pile						
2.00 to 19.52	1.32 [#]	5 [#] ~0	1.03 [#]	0.33	NA	NA	11
19.52 to 23.95	0.00	34 ^{\$}	1.03	NA	1.50	34	>100

Notes: - Layers are characterized based on classification and the state of soil in that stratum.

* - In cohesive soils the contribution of the angle of internal friction being insignificant is ignored.

Shear parameters are the most representative for the layer. NA means not applicable. Characterized N values are considered for each layer.

- Weighted Average of the parameters falling in the same layer has been considered.

\$-Parameters are correlated based on SPT value N.

3) Ultimate Load in Compression

3.1) Ultimate load in Compression by Bearing

Ultimate load on pile in end bearing,

$$q_{ub} = A_p (0.5 \cdot D \cdot \gamma \cdot N_v + P D N_q)$$

$$A_p = \text{Cross section area of Pile stem at toe} = \pi d^2 / 4$$

$$D = \text{Diameter of pile} = d \text{ in m}$$

$$N_v = 42.90$$

$$N_q = 40.0$$

$$q_{ub} = 0.785d^2 (0.5 \cdot d \cdot 1.03 \cdot 42.90 + 9.27 \cdot 40.00) = 17.34d^3 + 291.08d^2$$

$$(\text{For Pile terminating at 18.00 to 19.00m from F.G.L.})$$

Note: As the pile terminating just above rock level, we have considered parameter for end bearing component based on rock strata.

3.2) Ultimate Load in Compression by Skin Friction

Ultimate load in skin friction,

$$q_{uf} = \alpha_i C_{ai} A_i + K_i P D_i \tan \delta_i A_{si}$$

First Layer – No contribution considered – (Within Cutoff Level).

$$\text{Second Layer} - \alpha_2 C_{a2} A_{s2} = 0.33 \cdot 13.20 \cdot \pi \cdot d \cdot (\ell - 2.00) = 13.68d (\ell - 2.00)$$

$$(\text{For Pile terminating at 18.00 to 19.00m from F.G.L.})$$

$$q_{uf} = 13.68 d (\ell - 2.00) \text{ (For Pile terminating at 18.00 to 19.00m from F.G.L.)}$$

Where, ℓ is the pile length and d is diameter of piles, substituting

Ultimate load by both bearing and friction can be as follows for various lengths of piles,

$$q_{uc} = q_{ub} + q_{uf}$$

$$q_{uc} = 17.34d^3 + 291.08d^2 + 13.68 d (\ell - 2.00) \text{ (For Pile terminating at 18.00 to 19.00m from F.G.L.)}$$

By substituting various diameters of piles having various lengths, the safe load is worked out considering the

safety factor of 2.50 and are given in table below,

Safe Load on Piles in Compression (in Ton)

Termination Depth of Pile in m, from FGL	Termination Depth of Pile in m, from cut-off	Diameter of Pile in, m
		0.60
18.00	16.00	95.94
19.00	17.00	99.23

3.3) Ultimate Load in Uplift

Considering skin friction for determination of uplift

Safe Load on Piles in Uplift (in Ton)

Termination Depth of Pile in m, from FGL	Termination Depth of Pile in m, from cut-off	Diameter of Pile in, m
		0.60
18.00	16.00	50.53
19.00	17.00	53.72

Note: Self weight of pile is considered in calculation of ultimate load in uplift.

Self weight of Pile (in Ton)

Termination Depth of Pile in m, from FGL	Termination Depth of Pile in m, from cut-off	Diameter of Pile in, m
		0.60
18.00	16.00	6.79
19.00	17.00	7.21

3.4) Lateral Pile Capacity

Pile would be long and elastic (i.e. $L > 4T$). For a prescribed deflection of 5mm and with M 30 grade of concrete, the lateral load and moment were worked out as follows,

Diameters in m		0.60
Subgrade reaction in MN/m^3		2.70
Stiffness factor T in m		2.31
Depth of fixity in m	Free Head	4.40
	Fixed Head	5.00
Allowable Horizontal Force in T	Free Head	3.20
	Fixed Head	8.30
Allowable Moment capacity in Tm	Free Head	4.84
	Fixed Head	17.23

4) Notes:

1) Initial and Routine pile load tests shall be carried out as per IS 2911, P-4 on the piles to confirm the capacity of pile worked out theoretically. For design and construction, specifications of IS 2911, P-I, S-2, shall strictly be followed. Termination depth of pile shall be from EGL.

Dr. K. K. Thaker

Appendix – 16

Calculation of Safe Load on Uniform Diameter Bored Cast in situ Pile terminating in soil strata (Near BH 57 & 68) (ESP UNIT-1)

The safe load is calculated as follows,

1) Design Stipulations

- | | |
|---|---|
| 1. Type of pile | - Bored cast in situ uniform diameter pile. |
| 2. Pile diameter considered | - 0.60m |
| 3. Termination depth of pile considered | - 17.00, 18.00, 19.50m from FGL. |
| 4. Cut off Level | - 5.00m from FGL. |
| 5. Factor of Safety | - 2.50 |
| 6. Depth of Water table | - Considered at FGL. |
| 7. Ref | - IS 2911 P-I, Sec-II, 2021. |

2) Test Data

The parameters are based on BH 68. For evaluation of safe load on piles following characterized layers are considered as described in table below,

Depth in m from RL 202.5 m	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Submerged density in gm/cc γ_{sub}	Reduction Factor α	Earth pressure coefficient K	Angle of wall friction $\delta = \phi$	SPT N Value
0.00 to 5.00	Pile cutoff level – No pile						
5.00 to 11.90	0.72	3~0*	0.96	0.61	NA	NA	7
11.90 to 19.70	0.08*	25	0.98	NA	1.15	25	11
19.70 to 22.60	0.00	34 ^{\$}	0.98	NA	1.50	34	>100

Notes: - Layers are characterized based on classification and the state of soil in that stratum.

* - In cohesive soils the contribution of the angle of internal friction being insignificant is ignored.

Shear parameters are the most representative for the layer. NA means not applicable. Characterized N values are considered for each layer.

- Weighted Average of the parameters falling in the same layer has been considered

\$ Parameters are correlated based on SPT N value.

3) Ultimate Load in Compression

3.1) Ultimate load in Compression by Bearing

Ultimate load on pile in end bearing,

$$q_{ub} = A_p (0.5 \cdot D \cdot \gamma \cdot N_\gamma + P D N_q)$$

$$A_p = \text{Cross section area of Pile stem at toe} = \pi d^2 / 4$$

$$D = \text{Diameter of pile} = d \text{ in m}$$

$$N_\gamma = 42.90$$

$$N_q = 40.0$$

$$q_{ub} = 0.785d^2 (0.5 \cdot d \cdot 0.98 \cdot 42.90 + 8.64 \cdot 40.00) = 16.50d^3 + 271.30d^2$$

(For Pile terminating at 17.00 to 19.50m from F.G.L.)

Note: As the pile terminating just above rock level, we have considered parameter for end bearing component based on rock strata.

3.2) Ultimate Load in Compression by Skin Friction

Ultimate load in skin friction,

$$q_{uf} = \alpha_i C_{ai} A_i + K_i P D_i \tan \delta_i A_{si}$$

First Layer – No contribution considered – (Within Cutoff Level).

$$\text{Second Layer} - \alpha_2 C_{a2} A_{s2} = 0.61 \cdot 7.20 \cdot \pi d \cdot 6.90 = 95.21 d$$

$$\text{Third Layer} - K_3 P D_3 \tan \delta_3 A_{s3} = 1.15 \cdot 8.64 \cdot \tan 25^\circ \cdot \pi d \cdot (\ell - 11.90) = 14.56 d (\ell - 11.90)$$

Substituting, ultimate load

$$q_{uf} = 95.21 d + 14.56 d (\ell - 11.90) \text{ (For Pile terminating at 17.00 to 19.50m from F.G.L.)}$$

Where, ℓ is the pile length and d is diameter of piles, substituting

Ultimate load by both bearing and friction can be as follows for various lengths of piles,
 $q_{uc} = q_{ub} + q_{uf}$

$$q_{uc} = 16.50d^3 + 271.30d^2 + 95.21 d + 14.56 d (\ell - 11.90)$$

(For Pile terminating at 17.00 to 19.50m from F.G.L.).

By substituting various diameters of piles having various lengths, the safe load is worked out considering the safety factor of 2.50 and are given in table below,

Safe Load on Piles in Compression (in Ton)

Termination Depth of Pile in m, from FGL	Termination Depth of Pile in m, from cut-off	Diameter of Pile in, m
		0.60
17.00	12.00	81.21
18.00	13.00	84.70
19.50	14.50	89.94

3.3) Ultimate Load in Uplift

Considering skin friction for determination of uplift

Safe Load on Piles in Uplift (in Ton)

Termination Depth of Pile in m, from FGL	Termination Depth of Pile in m, from cut-off	Diameter of Pile in, m
		0.60
17.00	12.00	39.02
18.00	13.00	42.35
19.50	14.50	47.36

Note: Self weight of pile is considered in calculation of ultimate load in uplift.

Self weight of Pile (in Ton)

Termination Depth of Pile in m, from FGL	Termination Depth of Pile in m, from cut-off	Diameter of Pile in, m
		0.60
17.00	12.00	5.09
18.00	13.00	5.51
19.50	14.50	6.15

3.4) Lateral Pile Capacity

Pile would be long and elastic (i.e. $L > 4T$). For a prescribed deflection of 5mm and with M 30 grade of concrete, the lateral load and moment were worked out as follows,

Diameters in m		0.60
Subgrade reaction in MN/m ³		2.70
Stiffness factor T in m		2.31
Depth of fixity in m	Free Head	4.40
	Fixed Head	5.00
Allowable Horizontal Force in T	Free Head	3.20
	Fixed Head	8.60
Allowable Moment capacity in Tm	Free Head	4.84
	Fixed Head	17.55

4) Notes:

1) Initial and Routine pile load tests shall be carried out as per IS 2911, P-4 on the piles to confirm the capacity of pile worked out theoretically. For design and construction, specifications of IS 2911, P-I, S-2, shall strictly be followed. Termination depth of pile shall be from EGL.

Appendix – 17

Calculation of Safe Load on Uniform Diameter Bored Cast in situ Pile terminating in soil strata (Near BH 82, 101, 104, 112) (ESP Unit-2 & 3)

The safe load is calculated as follows,

1) Design Stipulations

- | | |
|---|---|
| 1. Type of pile | - Bored cast in situ uniform diameter pile. |
| 2. Pile diameter considered | - 0.60m |
| 3. Termination depth of pile considered | - 17.00, 18.00, 19.00m from FGL. |
| 4. Cut off Level | - 3.00m from FGL. |
| 5. Factor of Safety | - 2.50 |
| 6. Depth of Water table | - Considered at FGL. |
| 7. Ref | - IS 2911 P-I, Sec-II, 2021. |

2) Test Data

The parameters are based on BH 82. For evaluation of safe load on piles following characterized layers are considered as described in table below,

Depth in m from RL 202.5 m	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Submerged density in gm/cc γ_{sub}	Reduction Factor α	Earth pressure coefficient K	Angle of wall friction $\delta = \phi$	SPT N Value
0.00 to 3.00	Pile cutoff level – No pile						
3.00 to 14.42	1.10	6~0*	0.98	0.40	NA	NA	8
14.42 to 20.42	0.0	30	1.01	NA	1.00	30	20

Notes: - Layers are characterized based on classification and the state of soil in that stratum.

* - In cohesive soils the contribution of the angle of internal friction being insignificant is ignored.

Shear parameters are the most representative for the layer. NA means not applicable. Characterized N values are considered for each layer.

- Weighted Average of the parameters falling in the same layer has been considered

3) Ultimate Load in Compression

3.1) Ultimate load in Compression by Bearing

Ultimate load on pile in end bearing,

$$q_{ub} = A_p (0.5 \cdot D \cdot \gamma N_\gamma + P D N_q)$$

A_p = Cross section area of Pile stem at toe = $\pi d^2/4$

D = Diameter of pile = d in m

$N_\gamma = 22.40$

$N_q = 20.00$

$$q_{ub} = 0.785d^2 (0.5 \cdot d \cdot 1.01 \cdot 22.40 + 11.76 \cdot 20.00) = 8.88d^3 + 184.63d^2$$

(For Pile terminating at 17.00 to 19.00m from F.G.L.)

3.2) Ultimate Load in Compression by Skin Friction

Ultimate load in skin friction,

$$q_{uf} = \alpha_i C_{ai} + K_i P D_i \tan \delta_i A_{si}$$

First Layer – No contribution considered – (Within Cutoff Level).

$$\text{Second Layer} - \alpha_2 C_{a2} A_{s2} = 0.40 \cdot 11.0 \cdot \pi d \cdot 11.42 = 157.86 d$$

$$\text{Third Layer} - K_3 P D_3 \tan \delta_3 A_{s3} = 1.00 \cdot 11.76 \cdot \tan 30^\circ \cdot \pi d \cdot (\ell - 14.42) = 21.33 d (\ell - 14.42)$$

Substituting, ultimate load

$$q_{uf} = 157.86 d + 21.33d (\ell - 14.42) \text{ (For Pile terminating at 17.00 to 19.00m from F.G.L.)}$$

Where, ℓ is the pile length and d is diameter of piles, substituting

Ultimate load by both bearing and friction can be as follows for various lengths of piles,

$$q_{uc} = q_{ub} + q_{uf}$$

$$q_{uc} = 8.88d^3 + 184.63d^2 + 157.86d + 21.33d(l - 14.42)$$

(For Pile terminating at 17.00 to 19.00m from F.G.L.).

By substituting various diameters of piles having various lengths, the safe load is worked out considering the safety factor of 2.50 and are given in table below,

Safe Load on Piles in Compression (in Ton)

Termination Depth of Pile in m, from FGL	Termination Depth of Pile in m, from cut-off	Diameter of Pile in, m
		0.60
17.00	14.00	78.42
18.00	15.00	83.54
19.00	16.00	88.66

3.3) Ultimate Load in Uplift

Considering skin friction for determination of uplift

Safe Load on Piles in Uplift (in Ton)

Termination Depth of Pile in m, from FGL	Termination Depth of Pile in m, from cut-off	Diameter of Pile in, m
		0.60
17.00	14.00	48.49
18.00	15.00	53.18
19.00	16.00	57.86

Note: Self weight of pile is considered in calculation of ultimate load in uplift.

Self weight of Pile (in Ton)

Termination Depth of Pile in m, from FGL	Termination Depth of Pile in m, from cut-off	Diameter of Pile in, m
		0.60
17.00	14.00	5.93
18.00	15.00	6.36
19.00	16.00	6.78

3.4) Lateral Pile Capacity

Pile would be long and elastic (i.e. $L > 4T$). For a prescribed deflection of 5mm and with M 30 grade of concrete, the lateral load and moment were worked out as follows,

Diameters in m		0.60
Subgrade reaction in MN/m ³		2.70
Stiffness factor T in m		2.31
Depth of fixity in m	Free Head	4.40
	Fixed Head	5.00
Allowable Horizontal Force in T	Free Head	3.20
	Fixed Head	8.30
Allowable Moment capacity in Tm	Free Head	4.84
	Fixed Head	17.23

4) Notes:

1) Initial and Routine pile load tests shall be carried out as per IS 2911, P-4 on the piles to confirm the capacity of pile worked out theoretically. For design and construction, specifications of IS 2911, P-I, S-2, shall strictly be followed. Termination depth of pile shall be from EGL.

Appendix – 18

Calculation of Safe Load on Uniform Diameter Bored Cast in situ Pile terminating in soil strata (Near BH 53, 56, 58, 63, 64, IBH-34) (Boiler Area unit-1 & Mill bunker unit-1)

The safe load is calculated as follows,

1) Design Stipulations

- | | |
|---|---|
| 1. Type of pile | - Bored cast in situ uniform diameter pile. |
| 2. Pile diameter considered | - 0.60m |
| 3. Termination depth of pile considered | - 13.00, 14.00, 15.00m from FGL. |
| 4. Cut off Level | - 4.00m from FGL. |
| 5. Factor of Safety | - 2.50 |
| 6. Depth of Water table | - Considered at FGL. |
| 7. Ref | - IS 2911 P-I, Sec-II, 2021. |

2) Test Data

The parameters are based on BH 58. For evaluation of safe load on piles following characterized layers are considered as described in table below,

Depth in m from RL 202.5 m	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Submerged density in gm/cc γ_{sub}	Reduction Factor α	Earth pressure coefficient K	Angle of wall friction $\delta = \phi$	SPT N Value
0.00 to 4.00	Pile cutoff level – No pile						
4.00 to 9.90	0.89 [#]	2 [#] ~0*	0.98 [#]	0.28	NA	NA	14
9.90 to 15.40	0.08*	25	0.98	NA	1.50	25	14
15.40 to 23.00	0.00	34 ^{\$}	0.98	NA	1.50	34	>100

Notes: - Layers are characterized based on classification and the state of soil in that stratum.

* - In cohesive soils the contribution of the angle of internal friction being insignificant is ignored.

Shear parameters are the most representative for the layer. NA means not applicable. Characterized N values are considered for each layer.

- Weighted Average of the parameters falling in the same layer has been considered

\$ Parameters are correlated based on SPT N value.

3) Ultimate Load in Compression

3.1) Ultimate load in Compression by Bearing

Ultimate load on pile in end bearing,

$$q_{ub} = A_p (0.5 \cdot D \cdot \gamma \cdot N_\gamma + P D N_q)$$

$$A_p = \text{Cross section area of Pile stem at toe} = \pi d^2 / 4$$

$$D = \text{Diameter of pile} = d \text{ in m}$$

$$N_\gamma = 42.90$$

$$N_q = 40.0$$

$$q_{ub} = 0.785d^2 (0.5 \cdot d \cdot 0.98 \cdot 42.90 + 10.78 \cdot 40.00) = 16.50d^3 + 338.49d^2$$

(For Pile terminating at 13.00 to 15.00m from F.G.L.)

Note: As the pile terminating just above rock level, we have considered parameter for end bearing component based on rock strata.

3.2) Ultimate Load in Compression by Skin Friction

Ultimate load in skin friction,

$$q_{uf} = \alpha_i C_{ai} A_i + K_i P D_i \tan \delta_i A_{si}$$

First Layer – No contribution considered – (Within Cutoff Level).

$$\text{Second Layer} - \alpha_2 C_{a2} A_{s2} = 0.28 \cdot 8.90 \cdot \pi d \cdot 5.90 = 46.19 d$$

$$\text{Third Layer} - K_3 P D_3 \tan \delta_3 A_{s3} = 1.50 \cdot 7.30 \cdot \tan 25^\circ \cdot \pi d \cdot (\ell - 9.90) = 16.04 d (\ell - 9.90)$$

Substituting, ultimate load

$$q_{uf} = 46.19 d + 16.04 d (\ell - 9.90) \text{ (For Pile terminating at 13.00 to 15.00m from F.G.L.)}$$

Where, ℓ is the pile length and d is diameter of piles, substituting

Ultimate load by both bearing and friction can be as follows for various lengths of piles,
 $q_{uc} = q_{ub} + q_{uf}$

$$q_{uc} = 16.50d^3 + 338.49d^2 + 46.19d + 16.04d(l - 9.90) \text{ (For Pile terminating at 13.00 to 15.00m from F.G.L.)}$$

By substituting various diameters of piles having various lengths, the safe load is worked out considering the safety factor of 2.50 and are given in table below,

Safe Load on Piles in Compression (in Ton)

Termination Depth of Pile in m, from FGL	Termination Depth of Pile in m, from cut-off	Diameter of Pile in, m
		0.60
13.00	9.00	64.32
14.00	10.00	69.22
15.00	11.00	74.65

3.3) Ultimate Load in Uplift

Considering skin friction for determination of uplift

Safe Load on Piles in Uplift (in Ton)

Termination Depth of Pile in m, from FGL	Termination Depth of Pile in m, from cut-off	Diameter of Pile in, m
		0.60
13.00	9.00	23.00
14.00	10.00	27.50
15.00	11.00	32.44

Note: Self weight of pile is considered in calculation of ultimate load in uplift.

Self weight of Pile (in Ton)

Termination Depth of Pile in m, from FGL	Termination Depth of Pile in m, from cut-off	Diameter of Pile in, m
		0.60
13.00	9.00	3.82
14.00	10.00	4.24
15.00	11.00	4.66

3.4) Lateral Pile Capacity

Pile would be long and elastic (i.e. $L > 4T$). For a prescribed deflection of 5mm and with M 30 grade of concrete, the lateral load and moment were worked out as follows,

Diameters in m		0.60
Subgrade reaction in MN/m ³		2.55
Stiffness factor T in m		2.34
Depth of fixity in m	Free Head	4.40
	Fixed Head	5.10
Allowable Horizontal Force in T	Free Head	3.00
	Fixed Head	8.10
Allowable Moment capacity in Tm	Free Head	4.73
	Fixed Head	16.84

4) Notes:

1) Initial and Routine pile load tests shall be carried out as per IS 2911, P-4 on the piles to confirm the capacity of pile worked out theoretically. For design and construction, specifications of IS 2911, P-I, S-2, shall strictly be followed. Termination depth of pile shall be from EGL.

Appendix – 19

Calculation of Safe Load on Uniform Diameter Bored Cast in situ Pile terminating in soil strata. (Near BH 116, 126, 129, 109, 135, 115, 134, IBH-19 and IBH-36) (BOILER AREA UNIT-3 & MILL BUNKER UNIT-3)

The safe load is calculated as follows,

1) Design Stipulations

- | | |
|---|---|
| 1. Type of pile | - Bored cast in situ uniform diameter pile. |
| 2. Pile diameter considered | - 0.60m |
| 3. Termination depth of pile considered | - 12.50, 13.50m from FGL. |
| 4. Cut off Level | - 3.00m from FGL. |
| 5. Factor of Safety | - 2.50 |
| 6. Depth of Water table | - Considered at FGL. |
| 7. Ref | - IS 2911 P-I, Sec-II, 2021. |

2) Test Data

The parameters are based on IBH 36. For evaluation of safe load on piles following characterized layers are considered as described in table below,

Depth in m from RL 202.5 m	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Submerged density in gm/cc γ_{sub}	Reduction Factor α	Earth pressure coefficient K	Angle of wall friction $\delta = \phi$	SPT N Value
0.00 to 3.00	Pile cutoff level – No pile						
3.00 to 9.87	0.93	2*~0	0.96	0.48	NA	NA	10
9.87 to 13.87	0.11*	26	1.01	NA	1.50	26	17
13.87 to 19.47	0.00	34 ^{\$}	1.01	NA	1.50	34	>100

Notes: - Layers are characterized based on classification and the state of soil in that stratum.

* - In cohesive soils the contribution of the angle of internal friction being insignificant is ignored.

Shear parameters are the most representative for the layer. NA means not applicable. Characterized N values are considered for each layer.

- Weighted Average of the parameters falling in the same layer has been considered

\$ Parameters are correlated based on SPT N value

3) Ultimate Load in Compression

3.1) Ultimate load in Compression by Bearing

Ultimate load on pile in end bearing,

$$q_{ub} = A_p (0.5 \cdot D \cdot \gamma \cdot N_\gamma + P D N_q)$$

$$A_p = \text{Cross section area of Pile stem at toe} = \pi d^2 / 4$$

$$D = \text{Diameter of pile} = d \text{ in m}$$

$$N_\gamma = 42.90$$

$$N_q = 40.0$$

$$q_{ub} = 0.785 d^2 (0.5 \cdot d \cdot 1.01 \cdot 42.90 + 8.75 \cdot 40.00) = 17.00 d^3 + 274.75 d^2$$

(For Pile terminating at 12.50 to 13.50m from F.G.L.)

Note: As the pile terminating just above rock level, we have considered parameter for end bearing component based on rock strata.

3.2) Ultimate Load in Compression by Skin Friction

Ultimate load in skin friction,

$$q_{uf} = \alpha_i C_{ai} A_i + K_i P D_i \tan \delta_i A_{si}$$

First Layer – No contribution considered – (Within Cutoff Level).

$$\text{Second Layer} - \alpha_2 C_{a2} A_{s2} = 0.48 \cdot 9.30 \cdot \pi d \cdot 6.87 = 96.35 d$$

$$\text{Third Layer} - K_3 P D_3 \tan \delta_3 A_{s3} = 1.50 \cdot 7.94 \cdot \tan 26^\circ \cdot \pi d \cdot (\ell - 9.87) = 18.25 d (\ell - 9.87)$$

Substituting, ultimate load

$$q_{uf} = 96.35 d + 18.25 d (\ell - 9.87) \text{ (For Pile terminating at 12.50 to 13.50m from F.G.L.)}$$

Where, ℓ is the pile length and d is diameter of piles, substituting

Ultimate load by both bearing and friction can be as follows for various lengths of piles,
 $q_{uc} = q_{ub} + q_{uf}$

$q_{uc} = 17.00d^3 + 274.75d^2 + 96.35d + 18.25d(l - 9.87)$ (For Pile terminating at 12.50 to 13.50m from F.G.L.).

By substituting various diameters of piles having various lengths, the safe load is worked out considering the safety factor of 2.50 and are given in table below,

Safe Load on Piles in Compression (in Ton)

Termination Depth of Pile in m, from FGL	Termination Depth of Pile in m, from cut-off	Diameter of Pile in, m
		0.60
12.50	9.50	75.41
13.50	10.50	80.79

3.3) Ultimate Load in Uplift

Considering skin friction for determination of uplift

Safe Load on Piles in Uplift (in Ton)

Termination Depth of Pile in m, from FGL	Termination Depth of Pile in m, from cut-off	Diameter of Pile in, m
		0.60
12.50	9.50	32.69
13.50	10.50	37.60

Note: Self weight of pile is considered in calculation of ultimate load in uplift.

Self weight of Pile (in Ton)

Termination Depth of Pile in m, from FGL	Termination Depth of Pile in m, from cut-off	Diameter of Pile in, m
		0.60
12.50	9.50	4.03
13.50	10.50	4.45

3.4) Lateral Pile Capacity

Pile would be long and elastic (i.e. $L > 4T$). For a prescribed deflection of 5mm and with M 30 grade of concrete, the lateral load and moment were worked out as follows,

Diameters in m		0.60
Subgrade reaction in MN/m ³		2.84
Stiffness factor T in m		2.29
Depth of fixity in m	Free Head	4.30
	Fixed Head	5.00
Allowable Horizontal Force in T	Free Head	3.20
	Fixed Head	8.60
Allowable Moment capacity in Tm	Free Head	4.94
	Fixed Head	17.58

4) Notes:

1) Initial and Routine pile load tests shall be carried out as per IS 2911, P-4 on the piles to confirm the capacity of pile worked out theoretically. For design and construction, specifications of IS 2911, P-I, S-2, shall strictly be followed. Termination depth of pile shall be from EGL.

Appendix – 20

Calculation of Safe Load on Uniform Diameter Bored Cast in situ Pile terminating in soil strata (Near BH- 75, 73, 103 & 105) (CHIMNEY UNIT-1,2&3)

The safe load is calculated as follows,

1) Design Stipulations

- | | |
|---|---|
| 1. Type of pile | - Bored cast in situ uniform diameter pile. |
| 2. Pile diameter considered | - 0.60m |
| 3. Termination depth of pile considered | - 15.00, 16.00, 17.00m from FGL. |
| 4. Cut off Level | - 5.00m from FGL. |
| 5. Factor of Safety | - 2.50 |
| 6. Depth of Water table | - Considered at FGL. |
| 7. Ref | - IS 2911 P-I, Sec-II, 2021. |

2) Test Data

The parameters are based on BH 105. For evaluation of safe load on piles following characterized layers are considered as described in table below,

Depth in m from RL 202.5 m	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Submerged density in gm/cc γ_{sub}	Reduction Factor α	Earth pressure coefficient K	Angle of wall friction $\delta =$ ϕ	SPT N Value
0.00 to 5.00	Pile cutoff level – No pile						
5.00 to 10.53	0.77	2~0*	0.95	0.59	NA	NA	18
10.53 to 17.43	0.10	29	1.02	NA	1.50	29	20

Notes: - Layers are characterized based on classification and the state of soil in that stratum.

* - In cohesive soils the contribution of the angle of internal friction being insignificant is ignored.

Shear parameters are the most representative for the layer. NA means not applicable. Characterized N values are considered for each layer.

- Weighted Average of the parameters falling in the same layer has been considered

3) Ultimate Load in Compression

3.1) Ultimate load in Compression by Bearing

Ultimate load on pile in end bearing,

$$q_{ub} = A_p (0.5 \cdot D \cdot \gamma \cdot N_\gamma + PDN_q)$$

$$A_p = \text{Cross section area of Pile stem at toe} = \pi d^2 / 4$$

$$D = \text{Diameter of pile} = d \text{ in m}$$

$$N_\gamma = 20.10$$

$$N_q = 18.00$$

$$q_{ub} = 0.785d^2 (0.5 \cdot d \cdot 1.02 \cdot 20.10 + 8.79 \cdot 18.00) = 8.05d^3 + 124.20d^2$$

(For Pile terminating at 15.00 to 17.00m from F.G.L.)

3.2) Ultimate Load in Compression by Skin Friction

Ultimate load in skin friction,

$$q_{uf} = \alpha_i C_{ai} A_i + K_i P D_i \tan \delta_i A_{si}$$

First Layer – No contribution considered – (Within Cutoff Level).

$$\text{Second Layer} - \alpha_2 C_{a2} A_{s2} = 0.59 \cdot 7.70 \cdot \pi d \cdot 5.53 = 78.93 d$$

$$\begin{aligned} \text{Third Layer} - \alpha_3 C_{a3} A_{s3} + K_3 P D_3 \tan \delta_3 A_{s3} &= 1.00 \cdot 1.00 \cdot \pi d \cdot (\ell - 10.53) + 1.00 \cdot 7.53 \cdot \tan 29^\circ \cdot \pi d \cdot (\ell - 10.53) \\ &= 16.25 d (\ell - 10.53) \end{aligned}$$

Substituting, ultimate load

$$q_{uf} = 78.93d + 13.11d (\ell - 10.53) \text{ (For Pile terminating at 15.00 to 17.00m from F.G.L.)}$$

Where, ℓ is the pile length and d is diameter of piles, substituting

Ultimate load by both bearing and friction can be as follows for various lengths of piles,

$$q_{uc} = q_{ub} + q_{uf}$$

$$q_{uc} = 8.05d^3 + 124.20d^2 + 78.93d + 16.25d (l - 10.53)$$

(For Pile terminating at 15.00 to 17.00m from F.G.L.).

By substituting various diameters of piles having various lengths, the safe load is worked out considering the safety factor of 2.50 and are given in table below,

Safe Load on Piles in Compression (in Ton)

Termination Depth of Pile in m, from FGL	Termination Depth of Pile in m, from cut-off	Diameter of Pile in, m
		0.60
15.00	10.00	62.05
16.00	11.00	69.27
17.00	12.00	77.13

3.3) Ultimate Load in Uplift

Considering skin friction for determination of uplift

Safe Load on Piles in Uplift (in Ton)

Termination Depth of Pile in m, from FGL	Termination Depth of Pile in m, from cut-off	Diameter of Pile in, m
		0.60
15.00	10.00	40.46
16.00	11.00	46.90
17.00	12.00	53.88

Note: Self weight of pile is considered in calculation of ultimate load in uplift.

Self weight of Pile (in Ton)

Termination Depth of Pile in m, from FGL	Termination Depth of Pile in m, from cut-off	Diameter of Pile in, m
		0.60
15.00	10.00	4.24
16.00	11.00	4.66
17.00	12.00	5.09

3.4) Lateral Pile Capacity

Pile would be long and elastic (i.e. $L > 4T$). For a prescribed deflection of 5mm and with M 30 grade of concrete, the lateral load and moment were worked out as follows,

Diameters in m		0.60
Subgrade reaction in MN/m ³		3.42
Stiffness factor T in m		2.20
Depth of fixity in m	Free Head	4.20
	Fixed Head	4.80
Allowable Horizontal Force in T	Free Head	3.60
	Fixed Head	9.60
Allowable Moment capacity in Tm	Free Head	5.32
	Fixed Head	18.93

4) Notes:

1) Initial and Routine pile load tests shall be carried out as per IS 2911, P-4 on the piles to confirm the capacity of pile worked out theoretically. For design and construction, specifications of IS 2911, P-I, S-2, shall strictly be followed. Termination depth of pile shall be from EGL.

Dr. K. K. Thaker

Appendix – 21

Calculation of Safe Load on Uniform Diameter Bored Cast in situ Pile terminating in soil strata (Near BH 120, 124, 98, 113, 90) (FGD area(absorber, RC pump house, aux absorbent tank etc))

The safe load is calculated as follows,

1) Design Stipulations

- | | |
|---|---|
| 1. Type of pile | - Bored cast in situ uniform diameter pile. |
| 2. Pile diameter considered | - 0.60m |
| 3. Termination depth of pile considered | - 17.00, 18.00, 19.00m from FGL. |
| 4. Cut off Level | - 5.00m from FGL. |
| 5. Factor of Safety | - 2.50 |
| 6. Depth of Water table | - Considered at FGL. |
| 7. Ref | - IS 2911 P-I, Sec-II, 2021. |

2) Test Data

The parameters are based on BH 98. For evaluation of safe load on piles following characterized layers are considered as described in table below,

Depth in m from RL 202.5 m	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Submerged density in gm/cc γ_{sub}	Reduction Factor α	Earth pressure coefficient K	Angle of wall friction $\delta =$ ϕ	SPT N Value
0.00 to 5.00	Pile cutoff level – No pile						
5.00 to 9.55	0.48 ^{\$}	6 ^{\$} ~0*	0.92 ^{\$}	0.91	NA	NA	8
9.55 to 19.65	0.0	26	0.97	NA	1.00	26	11
19.65 to 27.05	0.00	34 ^{\$}	0.97	NA	1.50	34	>100

Notes: - Layers are characterized based on classification and the state of soil in that stratum.

* - In cohesive soils the contribution of the angle of internal friction being insignificant is ignored.

Shear parameters are the most representative for the layer. NA means not applicable. Characterized N values are considered for each layer.

- Weighted Average of the parameters falling in the same layer has been considered

\$-Parameters are correlated based on SPT value N.

3) Ultimate Load in Compression

3.1) Ultimate load in Compression by Bearing

Ultimate load on pile in end bearing,

$$q_{ub} = A_p (0.5 \cdot D \cdot \gamma \cdot N_v + P D N_q)$$

A_p = Cross section area of Pile stem at toe = $\pi d^2/4$

D = Diameter of pile = d in m

N_v = 42.90

N_q = 40.00

$$q_{ub} = 0.785d^2 (0.5 \cdot d \cdot 0.97 \cdot 42.90 + 8.50 \cdot 40.00) = 16.33d^3 + 266.90d^2$$

(For Pile terminating at 17.00 to 19.00m from F.G.L.)

Note: As the pile terminating just above rock level, we have considered parameter for end bearing component based on rock strata.

3.2) Ultimate Load in Compression by Skin Friction

Ultimate load in skin friction,

$$q_{uf} = \alpha_i C_{ai} A_i + K_i P D_i \tan \delta_i A_{si}$$

First Layer – No contribution considered – (Within Cutoff Level).

$$\text{Second Layer} - \alpha_2 C_{a2} A_{s2} = 0.91 \cdot 4.80 \cdot \pi d \cdot 4.55 = 62.44 d$$

$$\text{Third Layer} - K_3 P D_3 \tan \delta_3 A_{s3} = 1.00 \cdot 7.80 \cdot \tan 26^\circ \cdot \pi d \cdot (\ell - 9.55) = 11.95 d (\ell - 9.55)$$

Substituting, ultimate load

$$q_{uf} = 62.44 d + 11.95 d (\ell - 9.55) \text{ (For Pile terminating at 17.00 to 19.00m from F.G.L.)}$$

Where, ℓ is the pile length and d is diameter of piles, substituting

Ultimate load by both bearing and friction can be as follows for various lengths of piles,
 $q_{uc} = q_{ub} + q_{uf}$

$q_{uc} = 16.33d^3 + 266.90d^2 + 62.44 d + 11.95 d (\ell - 9.55)$ (For Pile terminating at 17.00 to 19.00m from F.G.L.).

By substituting various diameters of piles having various lengths, the safe load is worked out considering the safety factor of 2.50 and are given in table below,

Safe Load on Piles in Compression (in Ton)

Termination Depth of Pile in m, from FGL	Termination Depth of Pile in m, from cut-off	Diameter of Pile in, m
		0.60
17.00	12.00	76.13
18.00	13.00	80.50
19.00	14.00	82.53

3.3) Ultimate Load in Uplift

Considering skin friction for determination of uplift

Safe Load on Piles in Uplift (in Ton)

Termination Depth of Pile in m, from FGL	Termination Depth of Pile in m, from cut-off	Diameter of Pile in, m
		0.60
17.00	12.00	35.32
18.00	13.00	39.38
19.00	14.00	42.33

Note: Self weight of pile is considered in calculation of ultimate load in uplift.

Self weight of Pile (in Ton)

Termination Depth of Pile in m, from FGL	Termination Depth of Pile in m, from cut-off	Diameter of Pile in, m
		0.60
17.00	12.00	5.09
18.00	13.00	5.51
19.00	14.00	5.93

3.4) Lateral Pile Capacity

Pile would be long and elastic (i.e. $L > 4T$). For a prescribed deflection of 5mm and with M 30 grade of concrete, the lateral load and moment were worked out as follows,

Diameters in m		0.60
Subgrade reaction in MN/m ³		3.03
Stiffness factor T in m		2.26
Depth of fixity in m	Free Head	4.30
	Fixed Head	4.90
Allowable Horizontal Force in T	Free Head	3.40
	Fixed Head	8.90
Allowable Moment capacity in Tm	Free Head	5.07
	Fixed Head	18.04

4) Notes:

1) Initial and Routine pile load tests shall be carried out as per IS 2911, P-4 on the piles to confirm the capacity of pile worked out theoretically. For design and construction, specifications of IS 2911, P-I, S-2, shall strictly be followed. Termination depth of pile shall be from EGL.

Revision 03

Appendix – 1A

Calculation of Safe Load carrying capacity of piles socketed inside rock (Near BH-26) (CST tanks & pump house)

Project Name: - Proposed structures of thermal power project of NTTTP at Hirma, Talabira

1.0 Introduction

In situations where overburden offering low bearing pressure is followed by rock at relatively shallower depths, end bearing piles is the suitable foundation option. Piles in rocks and weathered rocks of varying degree of weathering derive their capacity by end bearing and socket side resistance.

In situations, where, rock strata comprises of highly fragmented rock, as in present case, where RQD is nil or $(CR+RQD)/2$ is less than 30 % or when the crushing strength is less than 10 MPa, the appropriate approach would be of that suggested by Cole & Stroud.

In present site overburden soils overlay fractured / laminated / foliated rock. The founding stratum having highly fragmented rock with nil RQD and $(CR+RQD)/2$ to be less than 30 %, the approach suggested by Cole and Stroud as per Annex B under clause 6.3.1.1 and 6.3.2 of IS 2911 P1/S2 has been used for safe load calculations.

An illustrative calculation of safe load on pile and summary of pile capacities is as follows,

2.0 Sub soil strata Characterization

General stratification at the location of boreholes BH 26 show primarily two characterized layers,

1. Overburden comprising of fine to medium grained, silty clayey sand with little gravels followed by fine to medium grained, clayey sand with occasional to some gravels followed by fine to very fine grained, sandy clays of intermediate plasticity with occasional gravels followed by fine to medium grained, silty clayey sand followed by fine to very fine grained, sandy clays of intermediate plasticity followed by very fine grained, indurated, silty clays of intermediate plasticity upto 18.60m (i.e. RL 184.50m).
2. Second characterized layer below the overburden soils comprises of Highly weatheerd, weak, brownish, black, very fine grained, fractured laminated to very thinly bedded rock upto 25.00m (i.e. RL 178.10m).

3.0 Design Considerations

1. Length of socket considered 3D from depth of rock encountered.
2. The pile is considered to have socket length below 18.60 m below NGL (i.e. RL 184.50 m) depth.
3. For present case of pile terminating in highly weathered rock. SPT at depths between 18.60 to 25.00m (between RL 184.50 to 178.10 m) is > 100 with just 3.0 cm penetration in 50 blows. SPT can be extrapolated for 30 cm i.e. $50 * 30 / 3.00 = 500$.
Based on recommendation of fig no. 3 in B 8 in Annex B under clause 6.3.1.1 and 6.3.2 of IS 2911 P1/S2, average shear strength q_c corresponding to assumed SPT of 200 may be taken as 1300 kN/m^2
4. Allowable Capacity of pile socketed into rock $Q_a = R_e + R_{sf} = C_{u1} N_c \pi B^2 / 4 (F_s = 3) + \alpha C_{u2} \pi BL / (F_s = 6)$

4.0 Safe Load on Pile in Compression

Where,

End bearing component, $R_e = C_{u1} N_c \pi B^2 / 4 F_s$,

C_{u1} = Shear strength below base of pile = 1300 kN/m^2

B = diameter of the pile = d

F_s = Factor of Safety = 3

$N_c = 9$

Therefore, **$R_e = 3061.5 d^2$**

Skin friction component of socketed length of pile, $R_{sf} = \alpha C_{u2} \pi BL / F_s$

$\alpha = 0.9$ (recommended value in IS 2911 P1/S2)

L = length of the socket = $3 D$

C_{u2} = Ultimate shear strength along socket length which shall be restricted to shear capacity of concrete of the pile = 1300 kN/m^2

F_s = Factor of Safety = 6

Therefore, $R_{sf} = 1836.9 d^2$

Thus,

$$Q_a = c_{u1} N_c \cdot \frac{\pi B^2}{4 F_s} + \alpha c_{u2} \cdot \frac{\pi B L}{F_s}$$

$$= 3061.5 d^2 + 1836.9 d^2 = 4898.4 d^2$$

Substituting the values of various diameters and socket lengths equal to 3 times diameter, allowable load on single pile can be summarized as follows,

Summary of the Safe load calculation in Compression

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	19.80	20.28	20.70
Termination level RL in m	182.70	182.22	181.80
End Bearing Component in kN	1102.1	1768.3	2479.8
Friction Component in kN	661.3	1060.9	1487.9
Safe load in Compression in kN	1763.4	2829.3	3967.7
Safe load in Compression in T	176	283	397

5.0 Safe Load on Pile in uplift

At 1.00m FGL

The overburden soils, though, will not contribute in compression capacity would offer resistance in uplift capacity. The parameters of BH 26 are considered for calculation of uplift resistance as summarized below,

Depth in m from RL 202.5 m	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Submerged density in gm/cc γ_{sub}	Reduction Factor α	Earth pressure coefficient K	Angle of wall friction $\delta = \phi$	SPT N Value
FGL to 1.00	No contribution considered - Cut off level						
1.00 to 3.00	0.07(ignored)	25	0.95	NA	1.00	25	2-9
3.00 to 6.70	0.99 [#]	7 [#] (ignored)	0.99	0.43	NA	NA	9-29
6.70 to 7.30	0	30 ^s	1.01	NA	1.00	30	21
7.30 to 10.00	0.96 ^s	0	1.01	0.45	NA	NA	>100
10.00 to 18.00	4.00 ^s	0	1.01	0.28	NA	NA	24
14.00 to 17.10	Rock strata – Resistance would be as per skin friction capacity in socket as already calculated in compression capacity						

Ultimate load in skin friction,

$$Q_{uf} = \alpha_i C_{ai} A_{si} + K_i P D_i \tan \delta_i A_{si}$$

First Layer – Cut off level

$$\text{Second Layer} - K_2 P D_2 \tan \delta_2 A_{s2} = 1.00 * 1.75 * \tan 25 * \pi d * 2.00 = 5.13 d$$

$$\text{Third Layer} - \alpha_3 C_{a3} A_{s3} = 0.43 * 9.90 * \pi d * 3.70 = 49.48 d$$

$$\text{Fourth Layer} - K_4 P D_4 \tan \delta_4 A_{s4} = 1.00 * 6.67 * \tan 30 * \pi d * 0.60 = 7.26 d$$

$$\text{Fifth Layer} - \alpha_5 C_{a5} A_{s5} = 0.45 * 9.60 * \pi d * 2.70 = 36.64 d$$

$$\text{Sixth Layer} - \alpha_6 C_{a6} A_{s6} = 0.28 * 40.00 * \pi d * 8.00 = 281.49 d$$

Seventh Layer – $1836.90 d^2$ in rock socket

Substituting, ultimate load $q_{uf} = 3800 d + 1836.9 d^2$

The safe load in uplift is worked out (considering the safety factor of 2.50 for overburden soils) and summarized below,

Safe Load on Piles in Uplift (in Ton)

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	19.80	20.28	20.70
Termination level RL in m	182.70	182.22	181.80
Safe load in Uplift in kN	1573.28	2216.19	2855.89
Self-weight of pile in kN	79.69	131.13	187.89
Safe load in Uplift in T (Considering self-weight of pile)	165.30	234.73	304.38

6.0 Lateral Pile Capacity

Pile would be long and elastic (i.e. $L > 4T$). For a prescribed deflection of 5mm and with M 30 grade of concrete, the lateral load and moment were worked out as follows,

Diameters in m		0.60	0.76	0.90
Subgrade reaction in MN/m ³		2.88	2.88	2.88
Stiffness factor T in m		2.28	2.76	3.15
Depth of fixity in m	Free Head	4.30	5.20	6.00
	Fixed Head	5.00	6.00	6.90
Allowable Horizontal Force in T	Free Head	3.30	4.80	6.30
	Fixed Head	8.70	12.70	16.60
Allowable Moment capacity in Tm	Free Head	4.97	8.76	13.14
	Fixed Head	17.68	31.17	46.78

7.0 Notes

1. Pile shall be terminated after socketing 3D inside rock.
2. Initial and routine pile load test is required to verify the actual carrying capacity of pile in compression, uplift and lateral loads.
3. For design and construction, specification of IS: 2911, P1/S2, IS: 456, 2000 shall strictly be followed.

(Dr. K. K. Thaker)

Appendix – 1B

Calculation of Safe Load on Uniform Diameter Bored Cast in situ Pile. (Near BH-26) (CST tanks & pump house)

The safe load is calculated as follows,

1) Design Stipulations

- | | |
|---|---|
| 1. Type of pile | - Bored cast in situ uniform diameter pile. |
| 2. Pile diameter considered | - 0.60m |
| 3. Termination depth of pile considered | - 12.00m from FGL. |
| 4. Cut off Level | - At 1.00m from FGL. |
| 5. Factor of Safety | - 2.50 |
| 6. Depth of Water table | - Considered at FGL. |
| 7. Ref | - IS 2911 P-I, Sec-II, 2021. |

2) Test Data

The parameters are based on BH 26. For evaluation of safe load on piles following characterized layers are considered as described in table below,

Depth in m from RL 202.5 m	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Submerged density in gm/cc γ_{sub}	Reduction Factor α	Earth pressure coefficient K	Angle of wall friction $\delta = \phi$	SPT N Value
FGL to 1.00	No contribution considered - Cut off level						
1.00 to 3.00	0.07(ignored)	25	0.95	NA	1.00	25	2-9
3.00 to 6.70	0.99 [#]	7 [#] (ignored)	0.99	0.43	NA	NA	9-29
6.70 to 7.30	0	30 ^{\$}	1.01	NA	1.00	30	21
7.30 to 10.00	0.96 ^{\$}	0	1.01	0.45	NA	NA	>100
10.00 to 18.00	4.00 ^{\$}	0	1.01	0.28	NA	NA	24
14.00 to 17.10	Rock strata – Resistance would be as per skin friction capacity in socket as already calculated in compression capacity						

Notes: - Layers are characterized based on classification and the state of soil in that stratum.

* - In cohesive soils the contribution of the angle of internal friction being insignificant is ignored.

Shear parameters are the most representative for the layer. NA means not applicable. Characterized N values are considered for each layer.

- Weighted Average of the parameters falling in the same layer has been considered

\$-Parameters are correlated based on SPT value N.

3) Ultimate Load in Compression

3.1) Ultimate load in Compression by Bearing

Ultimate load on pile in end bearing,

$$q_{ub} = A_p (0.5 \cdot D \cdot \gamma \cdot N_\gamma + P D N_q)$$

A_p = Cross section area of Pile stem at toe = $\pi d^2/4$

D = Diameter of pile = d in m

N_γ = 42.90

N_q = 40.00

$$q_{ub} = 0.785d^2 (0.5 \cdot d \cdot 1.01 \cdot 42.90 + 8.90 \cdot 40.00) = 17.01d^3 + 279.46d^2$$

(For Pile terminating at 12.00m from F.G.L.)

Note: As the pile terminating just above rock level, we have considered parameter for end bearing component based on rock strata.

3.2) Ultimate Load in Compression by Skin Friction

Ultimate load in skin friction,

$$q_{uf} = \alpha_i C_{ai} A_i + K_i P D_i \tan \delta_i A_{si}$$

First Layer – No contribution considered due to cut off level

Second Layer – $K_2 P D_2 \tan \delta_2 A_{s2} = 1.00 \cdot 0.95 \cdot \tan 25^\circ \cdot \pi \cdot d \cdot 2.00 = 2.78 d$

Third Layer – $\alpha_3 C_{a3} A_{s3} = 0.43 \cdot 9.90 \cdot \pi \cdot d \cdot 3.70 = 49.48 d$

Fourth Layer – $K_4 PD_4 \tan \delta_4 A_{s4} = 1.00 * 5.87 * \tan 30^\circ * \pi d * 0.60 = 6.96 d$

Fifth Layer – $\alpha_5 Ca_5 A_{s5} = 0.45 * 9.60 * \pi d * 2.70 = 36.64 d$

Sixth Layer – $\alpha_6 Ca_6 A_{s6} = 0.28 * 40.00 * \pi d * (\ell - 10.00) = 35.19 d (\ell - 10.00)$

Substituting, ultimate load

$$q_{uf} = 95.86d + 35.19d (\ell - 10.00) \text{ (For Pile terminating at 12.00m from F.G.L.)}$$

Where, ℓ is the pile length and d is diameter of piles, substituting

Ultimate load by both bearing and friction can be as follows for various lengths of piles,

$$q_{uc} = q_{ub} + q_{uf}$$

$$q_{uc} = 17.01d^3 + 279.46d^2 + 95.86d + 35.19d (\ell - 10.00)$$

(For Pile terminating at 12.00m from F.G.L.)

By substituting various diameters of piles having various lengths, the safe load is worked out considering the safety factor of 2.50 and are given in table below,

Safe Load on Piles in Compression (in Ton)

Termination Depth of Pile in m, from FGL	Termination Depth of Pile in m, from cut-off	Diameter of Pile in, m
		0.60
12.00	11.00	81.42

3.3) Ultimate Load in Uplift

Considering skin friction for determination of uplift

Safe Load on Piles in Uplift (in Ton)

Termination Depth of Pile in m, from FGL	Termination Depth of Pile in m, from cut-off	Diameter of Pile in, m
		0.60
12.00	11.00	37.77

Note: Self weight of pile is considered in calculation of ultimate load in uplift.

Self weight of Pile (in Ton)

Termination Depth of Pile in m, from FGL	Termination Depth of Pile in m, from cut-off	Diameter of Pile in, m
		0.60
12.00	11.00	4.67

3.4) Lateral Pile Capacity

Pile would be long and elastic (i.e. $L > 4T$). For a prescribed deflection of 5mm and with M 30 grade of concrete, the lateral load and moment were worked out as follows,

Diameters in m		0.60
Subgrade reaction in MN/m^3		2.88
Stiffness factor T in m		2.28
Depth of fixity in m	Free Head	4.30
	Fixed Head	5.00
Allowable Horizontal Force in T	Free Head	3.30
	Fixed Head	8.70
Allowable Moment capacity in Tm	Free Head	4.97
	Fixed Head	17.68

4) Notes:

1) Initial and Routine pile load tests shall be carried out as per IS 2911, P-4 on the piles to confirm the capacity of pile worked out theoretically. For design and construction, specifications of IS 2911, P-I, S-2, shall strictly be followed. Termination depth of pile shall be from FGL.

KCT Consultancy Services LLP, Ahmedabad

APPENDIX - 2 (For BH-49 & 104 (Pipe Rack))

SUMMARY OF ALLOWABLE BEARING PRESSURE BASED ON SHEAR AND SETTLEMENT CRITERION**Project :** Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

Depth of Foundation from NGL (R.L. 197.50m)	Depth of foundation from FGL	RL of Foundation from FGL	Length of Foundation	Width of Foundation	Safe Bearing Capacities calculated based on Shear Criteria (See Appendix 2.1)	Safe Bearing Pressures calculated based on Settlement Criteria (See Appendix 2.2)		Allowable Bearing Pressure suggested (<u>Min. of Shear and Settlement Criterion</u>)	
						For 25 mm Settlement	For 40 mm Settlement	For 25 mm Settlement	For 40 mm Settlement
(m)	(m)	(m)	(m)	(m)	(t / m ²)	(t / m ²)	(t / m ²)	(t / m ²)	(t / m ²)
3.00	8.00	194.50	1.50	1.50	26	45	72	26	26
3.00	8.00	194.50	2.00	2.00	24	36	58	24	24
3.00	8.00	194.50	2.50	2.50	23	31	49	23	23
3.00	8.00	194.50	3.00	3.00	22	27	43	22	22
3.50	8.50	194.00	1.50	1.50	27	50	79	27	27
3.50	8.50	194.00	2.00	2.00	25	40	64	25	25
3.50	8.50	194.00	2.50	2.50	24	34	55	24	24
3.50	8.50	194.00	3.00	3.00	23	30	49	23	23
4.00	9.00	193.50	1.50	1.50	29	61	97	29	29
4.00	9.00	193.50	2.00	2.00	26	50	79	26	26
4.00	9.00	193.50	2.50	2.50	25	42	68	25	25
4.00	9.00	193.50	3.00	3.00	24	37	59	24	24

Notes :

- 1) The factor of safety of 2.5 is considered.
- 2) The depth of foundation is considered from the RL 197.50m.
- 3) Calculations are considering the effect of water table at FGL.
- 4) 4.00T/m² overburden of filling considered in calculation.

KCT Consultancy Services LLP, Ahmedabad

APPENDIX - 2.1 (For BH-49 & 104 (Pipe Rack))

Calculation of Net Safe Bearing Capacity Based on Shear Parameters C - ϕ

$$q_u = 1 / FS [2 / 3 C N_c d_c S_c i_c + \gamma d (N_q - 1) S_q d_q i_q W_q + 0.5 \gamma B N_\gamma S_\gamma d_\gamma i_\gamma W_\gamma]$$

Project : Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTTP) at village Hirma, Talabira, Odisha**For Square Isolated Foundation**

Sr. No.	Size of Foundation		Depth of Foundation from NGL m	Depth of Foundation from FGL m	RL of Foundation m	Shear Parameter		Bearing Capacity Factors			Shape Factors			Depth Factors			Inclination Factors			Unit Weight		Water Table Correction		Safe Bearing Capacity t / m ²
	Length	Width				C	ϕ	N _c	N _q - 1	N _γ	S _c	S _q	S _γ	d _c	d _q	d _γ	i _c	i _q	i _γ	γ	0.5 γ			
	m	m				Kg/cm ²	degree													gm/cc		W _q	W _γ	
1	1.50	1.50	3.00	8.00	194.50	0.95	2	5.51	0.15	0.12	1.30	1.20	0.80	1.41	1.00	1.00	1.00	1.00	1.00	1.96	0.98	0.50	0.50	26
2	2.00	2.00	3.00	8.00	194.50	0.95	2	5.51	0.15	0.12	1.30	1.20	0.80	1.31	1.00	1.00	1.00	1.00	1.00	1.96	0.98	0.50	0.50	24
3	2.50	2.50	3.00	8.00	194.50	0.95	2	5.51	0.15	0.12	1.30	1.20	0.80	1.25	1.00	1.00	1.00	1.00	1.00	1.96	0.98	0.50	0.50	23
4	3.00	3.00	3.00	8.00	194.50	0.95	2	5.51	0.15	0.12	1.30	1.20	0.80	1.20	1.00	1.00	1.00	1.00	1.00	1.96	0.98	0.50	0.50	22
5	1.50	1.50	3.50	8.50	194.00	0.95	2	5.51	0.15	0.12	1.30	1.20	0.80	1.48	1.00	1.00	1.00	1.00	1.00	1.96	0.98	0.50	0.50	27
6	2.00	2.00	3.50	8.50	194.00	0.95	2	5.51	0.15	0.12	1.30	1.20	0.80	1.36	1.00	1.00	1.00	1.00	1.00	1.96	0.98	0.50	0.50	25
7	2.50	2.50	3.50	8.50	194.00	0.95	2	5.51	0.15	0.12	1.30	1.20	0.80	1.29	1.00	1.00	1.00	1.00	1.00	1.96	0.98	0.50	0.50	24
8	3.00	3.00	3.50	8.50	194.00	0.95	2	5.51	0.15	0.12	1.30	1.20	0.80	1.24	1.00	1.00	1.00	1.00	1.00	1.96	0.98	0.50	0.50	23
9	1.50	1.50	4.00	9.00	193.50	0.95	2	5.51	0.15	0.12	1.30	1.20	0.80	1.55	1.00	1.00	1.00	1.00	1.00	1.96	0.98	0.50	0.50	29
10	2.00	2.00	4.00	9.00	193.50	0.95	2	5.51	0.15	0.12	1.30	1.20	0.80	1.41	1.00	1.00	1.00	1.00	1.00	1.96	0.98	0.50	0.50	26
11	2.50	2.50	4.00	9.00	193.50	0.95	2	5.51	0.15	0.12	1.30	1.20	0.80	1.33	1.00	1.00	1.00	1.00	1.00	1.96	0.98	0.50	0.50	25
12	3.00	3.00	4.00	9.00	193.50	0.95	2	5.51	0.15	0.12	1.30	1.20	0.80	1.27	1.00	1.00	1.00	1.00	1.00	1.96	0.98	0.50	0.50	24

Note :-

- 1) The factor of safety of 2.5 is considered.
- 2) The depth of foundation is considered from the RL 197.50m.
- 3) Calculations are considering the effect of water table at FGL.
- 4) 4.00T/m² overburden of filling considered in calculation.

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APPENDIX - 2.2 (For BH-49 & 104 (Pipe Rack))

Calculation of Safe Bearing Pressure for Settlement of 25 and 40 mm

Project :-

Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

Sr. No.	Foundation Details					Immediate Settlement				Consolidation Settlement					Safe Bearing Pressure	
	Depth D	RL of Foundation	Depth of foundation from FGL	Width B	Length L	Poissons ratio μ	Modulus of Elasticity E	Factor Cd	Rigidity Factor	Coefficient of Volume Compressibility	Depth of Compressible Stratum H	λ factor related to pore pressure parameter	Depth Factor df	Rigidity Factor	For 25 mm Settlement	For 40 mm Settlement
	m	m	m	m	m		kg/cm ²			cm ² /kg	m				T / m ³	T / m ²
1	3.00	194.50	8.00	1.50	1.50	0.40	475	1.12	0.80	0.0116	1.50	0.70	0.73	0.80	45	72
2	3.00	194.50	8.00	2.00	2.00	0.40	475	1.12	0.80	0.0116	1.50	0.70	0.73	0.80	36	58
3	3.00	194.50	8.00	2.50	2.50	0.40	475	1.12	0.80	0.0116	1.50	0.70	0.73	0.80	31	49
4	3.00	194.50	8.00	3.00	3.00	0.40	475	1.12	0.80	0.0116	1.50	0.70	0.73	0.80	27	43
5	3.50	194.00	8.50	1.50	1.50	0.40	475	1.12	0.80	0.0116	1.00	0.70	0.73	0.80	50	79
6	3.50	194.00	8.50	2.00	2.00	0.40	475	1.12	0.80	0.0116	1.00	0.70	0.73	0.80	40	64
7	3.50	194.00	8.50	2.50	2.50	0.40	475	1.12	0.80	0.0116	1.00	0.70	0.73	0.80	34	55
8	3.50	194.00	8.50	3.00	3.00	0.40	475	1.12	0.80	0.0116	1.00	0.70	0.73	0.80	30	49
9	4.00	193.50	9.00	1.50	1.50	0.40	475	1.12	0.80	0.0116	0.50	0.70	0.73	0.80	61	97
10	4.00	193.50	9.00	2.00	2.00	0.40	475	1.12	0.80	0.0116	0.50	0.70	0.73	0.80	50	79
11	4.00	193.50	9.00	2.50	2.50	0.40	475	1.12	0.80	0.0116	0.50	0.70	0.73	0.80	42	68
12	4.00	193.50	9.00	3.00	3.00	0.40	475	1.12	0.80	0.0116	0.50	0.70	0.73	0.80	37	59

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APPENDIX - 2.3 (For BH-49 & 104 (Pipe Rack))

SUMMARY OF ALLOWABLE BEARING PRESSURE BASED ON SHEAR AND SETTLEMENT CRITERION**Project :** Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

Depth of Foundation from NGL (R.L. 197.50m)	Depth of foundation from FGL	RL of Foundation from FGL	Length of Foundation	Width of Foundation	Safe Bearing Capacities calculated based on Shear Criteria (See Appendix 2.4)	Safe Bearing Pressures calculated based on Settlement Criteria (See Appendix 2.5)		Allowable Bearing Pressure suggested (<u>Min. of Shear and Settlement Criterion</u>)	
						For 25 mm Settlement	For 40 mm Settlement	For 25 mm Settlement	For 40 mm Settlement
(m)	(m)	(m)	(m)	(m)	(t / m ²)	(t / m ²)	(t / m ²)	(t / m ²)	(t / m ²)
3.00	8.00	194.50	3.50	3.50	22	24	38	22	22
3.00	8.00	194.50	4.00	4.00	21	21	34	21	21
3.00	8.00	194.50	5.00	5.00	21	18	29	18	21
3.00	8.00	194.50	6.00	6.00	21	16	25	16	21
3.50	8.50	194.00	3.50	3.50	22	27	44	22	22
3.50	8.50	194.00	4.00	4.00	22	25	39	22	22
3.50	8.50	194.00	5.00	5.00	21	21	33	21	21
3.50	8.50	194.00	6.00	6.00	21	18	28	18	21
4.00	9.00	193.50	3.50	3.50	23	33	53	23	23
4.00	9.00	193.50	4.00	4.00	22	30	47	22	22
4.00	9.00	193.50	5.00	5.00	22	25	39	22	22
4.00	9.00	193.50	6.00	6.00	21	21	34	21	21

Notes :

- 1) The factor of safety of 2.5 is considered.
- 2) The depth of foundation is considered from the RL 197.50m.
- 3) Calculations are considering the effect of water table at FGL.
- 4) 4.00T/m² overburden of filling considered in calculation.

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APPENDIX - 2.4 (For BH-49 & 104 (Pipe Rack))

Calculation of Net Safe Bearing Capacity Based on Shear Parameters C - ϕ

$$q_u = 1 / FS [2 / 3 C N_c d_c S_c i_c + \gamma d (N_q - 1) S_q d_q i_q W_q + 0.5 \gamma B N_\gamma S_\gamma d_\gamma i_\gamma W_\gamma]$$

Project : Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTTP) at village Hirma, Talabira, Odisha**For Square Isolated Foundation**

Sr. No.	Size of Foundation		Depth of Foundation from NGL m	Depth of Foundation from FGL m	RL of Foundation m	Shear Parameter		Bearing Capacity Factors			Shape Factors			Depth Factors			Inclination Factors			Unit Weight		Water Table Correction		Safe Bearing Capacity t / m ²
	Length	Width				C	ϕ																	
	m	m				Kg/cm ²	degree															W _q	W _{γ}	
1	3.50	3.50	3.00	8.00	194.50	0.95	2	5.51	0.15	0.12	1.30	1.20	0.80	1.18	1.00	1.00	1.00	1.00	1.00	1.96	0.98	0.50	0.50	22
2	4.00	4.00	3.00	8.00	194.50	0.95	2	5.51	0.15	0.12	1.30	1.20	0.80	1.15	1.00	1.00	1.00	1.00	1.00	1.96	0.98	0.50	0.50	21
3	5.00	5.00	3.00	8.00	194.50	0.95	2	5.51	0.15	0.12	1.30	1.20	0.80	1.12	1.00	1.00	1.00	1.00	1.00	1.96	0.98	0.50	0.50	21
4	6.00	6.00	3.00	8.00	194.50	0.95	2	5.51	0.15	0.12	1.30	1.20	0.80	1.10	1.00	1.00	1.00	1.00	1.00	1.96	0.98	0.50	0.50	21
5	3.50	3.50	3.50	8.50	194.00	0.95	2	5.51	0.15	0.12	1.30	1.20	0.80	1.20	1.00	1.00	1.00	1.00	1.00	1.96	0.98	0.50	0.50	22
6	4.00	4.00	3.50	8.50	194.00	0.95	2	5.51	0.15	0.12	1.30	1.20	0.80	1.18	1.00	1.00	1.00	1.00	1.00	1.96	0.98	0.50	0.50	22
7	5.00	5.00	3.50	8.50	194.00	0.95	2	5.51	0.15	0.12	1.30	1.20	0.80	1.14	1.00	1.00	1.00	1.00	1.00	1.96	0.98	0.50	0.50	21
8	6.00	6.00	3.50	8.50	194.00	0.95	2	5.51	0.15	0.12	1.30	1.20	0.80	1.12	1.00	1.00	1.00	1.00	1.00	1.96	0.98	0.50	0.50	21
9	3.50	3.50	4.00	9.00	193.50	0.95	2	5.51	0.15	0.12	1.30	1.20	0.80	1.23	1.00	1.00	1.00	1.00	1.00	1.96	0.98	0.50	0.50	23
10	4.00	4.00	4.00	9.00	193.50	0.95	2	5.51	0.15	0.12	1.30	1.20	0.80	1.20	1.00	1.00	1.00	1.00	1.00	1.96	0.98	0.50	0.50	22
11	5.00	5.00	4.00	9.00	193.50	0.95	2	5.51	0.15	0.12	1.30	1.20	0.80	1.16	1.00	1.00	1.00	1.00	1.00	1.96	0.98	0.50	0.50	22
12	6.00	6.00	4.00	9.00	193.50	0.95	2	5.51	0.15	0.12	1.30	1.20	0.80	1.14	1.00	1.00	1.00	1.00	1.00	1.96	0.98	0.50	0.50	21

Note :-

- 1) The factor of safety of 2.5 is considered.
- 2) The depth of foundation is considered from the RL 197.50m.
- 3) Calculations are considering the effect of water table at FGL.
- 4) 4.00T/m² overburden of filling considered in calculation.

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APPENDIX - 2.5 (For BH-49 & 104 (Pipe Rack))

Calculation of Safe Bearing Pressure for Settlement of 25 and 40 mm

Project :-

Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

Sr. No.	Foundation Details					Immediate Settlement				Consolidation Settlement					Safe Bearing Pressure	
	Depth D	RL of Foundation	Depth of foundation from FGL	Width B	Length L	Poissons ratio μ	Modulus of Elasticity E	Factor Cd	Rigidity Factor	Coefficient of Volume Compressibility	Depth of Compressible Stratum H	λ factor related to pore pressure parameter	Depth Factor df	Rigidity Factor	For 25 mm Settlement	For 40 mm Settlement
	m	m	m	m	m		kg/cm ²			cm ² /kg	m				T / m ³	T / m ²
1	3.00	194.50	8.00	3.50	3.50	0.40	475	1.12	0.80	0.0116	1.50	0.70	0.75	0.80	24	38
2	3.00	194.50	8.00	4.00	4.00	0.40	475	1.12	0.80	0.0116	1.50	0.70	0.77	0.80	21	34
3	3.00	194.50	8.00	5.00	5.00	0.40	475	1.12	0.80	0.0116	1.50	0.70	0.82	0.80	18	29
4	3.00	194.50	8.00	6.00	6.00	0.40	475	1.12	0.80	0.0116	1.50	0.70	0.85	0.80	16	25
5	3.50	194.00	8.50	3.50	3.50	0.40	475	1.12	0.80	0.0116	1.00	0.70	0.73	0.80	27	44
6	3.50	194.00	8.50	4.00	4.00	0.40	475	1.12	0.80	0.0116	1.00	0.70	0.75	0.80	25	39
7	3.50	194.00	8.50	5.00	5.00	0.40	475	1.12	0.80	0.0116	1.00	0.70	0.79	0.80	21	33
8	3.50	194.00	8.50	6.00	6.00	0.40	475	1.12	0.80	0.0116	1.00	0.70	0.82	0.80	18	28
9	4.00	193.50	9.00	3.50	3.50	0.40	475	1.12	0.80	0.0116	0.50	0.70	0.73	0.80	33	53
10	4.00	193.50	9.00	4.00	4.00	0.40	475	1.12	0.80	0.0116	0.50	0.70	0.73	0.80	30	47
11	4.00	193.50	9.00	5.00	5.00	0.40	475	1.12	0.80	0.0116	0.50	0.70	0.76	0.80	25	39
12	4.00	193.50	9.00	6.00	6.00	0.40	475	1.12	0.80	0.0116	0.50	0.70	0.80	0.80	21	34

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APPENDIX - 2.6 (For BH-49 & 104 (Pipe Rack))

SUMMARY OF ALLOWABLE BEARING PRESSURE BASED ON SHEAR AND SETTLEMENT CRITERION**Project :** Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

Depth of Foundation from NGL (R.L. 197.50m)	Depth of foundation from FGL	RL of Foundation from FGL	Length of Foundation	Width of Foundation	Safe Bearing Capacities calculated based on Shear Criteria (See Appendix 2.7)	Safe Bearing Pressures calculated based on Settlement Criteria (See Appendix 2.8)		Allowable Bearing Pressure suggested (Min. of Shear and Settlement Criterion)	
						For 25 mm Settlement	For 40 mm Settlement	For 25 mm Settlement	For 40 mm Settlement
(m)	(m)	(m)	(m)	(m)	(t / m ²)	(t / m ²)	(t / m ²)	(t / m ²)	(t / m ²)
3.00	8.00	194.50	7.00	7.00	20	14	22	14	20
3.00	8.00	194.50	8.00	8.00	20	13	20	13	20
3.00	8.00	194.50	9.00	9.00	20	11	18	11	18
3.00	8.00	194.50	10.00	10.00	20	11	17	11	17
3.50	8.50	194.00	7.00	7.00	21	16	25	16	21
3.50	8.50	194.00	8.00	8.00	20	14	23	14	20
3.50	8.50	194.00	9.00	9.00	20	13	21	13	20
3.50	8.50	194.00	10.00	10.00	20	12	19	12	19
4.00	9.00	193.50	7.00	7.00	21	18	29	18	21
4.00	9.00	193.50	8.00	8.00	21	16	26	16	21
4.00	9.00	193.50	9.00	9.00	21	15	24	15	21
4.00	9.00	193.50	10.00	10.00	20	13	22	13	20

Notes :

- 1) The factor of safety of 2.5 is considered.
- 2) The depth of foundation is considered from the RL 197.50m.
- 3) Calculations are considering the effect of water table at FGL.
- 4) 4.00T/m² overburden of filling considered in calculation.

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APPENDIX - 2.7 (For BH-49 & 104 (Pipe Rack))

Calculation of Net Safe Bearing Capacity Based on Shear Parameters C - ϕ

$$q_u = 1 / FS [2 / 3 C N_c d_c S_c i_c + \gamma d (N_q - 1) S_q d_q i_q W_q + 0.5 \gamma B N_\gamma S_\gamma d_\gamma i_\gamma W_\gamma]$$

Project : Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTTP) at village Hirma, Talabira, Odisha**For Square Isolated Foundation**

Sr. No.	Size of Foundation		Depth of Foundation from NGL m	Depth of Foundation from FGL m	RL of Foundation m	Shear Parameter		Bearing Capacity Factors			Shape Factors			Depth Factors			Inclination Factors			Unit Weight		Water Table Correction		Safe Bearing Capacity t / m ²
	Length	Width				C	ϕ													γ	0.5γ			
	m	m				Kg/cm ²	degree													gm/cc		W _q	W _{γ}	
1	7.00	7.00	3.00	8.00	194.50	0.95	2	5.51	0.15	0.12	1.30	1.20	0.80	1.09	1.00	1.00	1.00	1.00	1.00	1.96	0.98	0.50	0.50	20
2	8.00	8.00	3.00	8.00	194.50	0.95	2	5.51	0.15	0.12	1.30	1.20	0.80	1.08	1.00	1.00	1.00	1.00	1.00	1.96	0.98	0.50	0.50	20
3	9.00	9.00	3.00	8.00	194.50	0.95	2	5.51	0.15	0.12	1.30	1.20	0.80	1.07	1.00	1.00	1.00	1.00	1.00	1.96	0.98	0.50	0.50	20
4	10.00	10.00	3.00	8.00	194.50	0.95	2	5.51	0.15	0.12	1.30	1.20	0.80	1.06	1.00	1.00	1.00	1.00	1.00	1.96	0.98	0.50	0.50	20
5	7.00	7.00	3.50	8.50	194.00	0.95	2	5.51	0.15	0.12	1.30	1.20	0.80	1.10	1.00	1.00	1.00	1.00	1.00	1.96	0.98	0.50	0.50	21
6	8.00	8.00	3.50	8.50	194.00	0.95	2	5.51	0.15	0.12	1.30	1.20	0.80	1.09	1.00	1.00	1.00	1.00	1.00	1.96	0.98	0.50	0.50	20
7	9.00	9.00	3.50	8.50	194.00	0.95	2	5.51	0.15	0.12	1.30	1.20	0.80	1.08	1.00	1.00	1.00	1.00	1.00	1.96	0.98	0.50	0.50	20
8	10.00	10.00	3.50	8.50	194.00	0.95	2	5.51	0.15	0.12	1.30	1.20	0.80	1.07	1.00	1.00	1.00	1.00	1.00	1.96	0.98	0.50	0.50	20
9	7.00	7.00	4.00	9.00	193.50	0.95	2	5.51	0.15	0.12	1.30	1.20	0.80	1.12	1.00	1.00	1.00	1.00	1.00	1.96	0.98	0.50	0.50	21
10	8.00	8.00	4.00	9.00	193.50	0.95	2	5.51	0.15	0.12	1.30	1.20	0.80	1.10	1.00	1.00	1.00	1.00	1.00	1.96	0.98	0.50	0.50	21
11	9.00	9.00	4.00	9.00	193.50	0.95	2	5.51	0.15	0.12	1.30	1.20	0.80	1.09	1.00	1.00	1.00	1.00	1.00	1.96	0.98	0.50	0.50	21
12	10.00	10.00	4.00	9.00	193.50	0.95	2	5.51	0.15	0.12	1.30	1.20	0.80	1.08	1.00	1.00	1.00	1.00	1.00	1.96	0.98	0.50	0.50	20

Note :-

- 1) The factor of safety of 2.5 is considered.
- 2) The depth of foundation is considered from the RL 197.50m.
- 3) Calculations are considering the effect of water table at FGL.
- 4) 4.00T/m² overburden of filling considered in calculation.

KCT Consultancy Services LLP, Ahmedabad

APPENDIX - 2.8 (For BH-49 & 104 (Pipe Rack))

Calculation of Safe Bearing Pressure for Settlement of 25 and 40 mm

Project :-

Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

Sr. No.	Foundation Details					Immediate Settlement				Consolidation Settlement					Safe Bearing Pressure	
	Depth D	RL of Foundation	Depth of foundation from FGL	Width B	Length L	Poissons ratio μ	Modulus of Elasticity E	Factor Cd	Rigidity Factor	Coefficient of Volume Compressibility	Depth of Compressible Stratum H	λ factor related to pore pressure parameter	Depth Factor df	Rigidity Factor	For 25 mm Settlement	For 40 mm Settlement
	m	m	m	m	m		kg/cm ²			cm ² /kg	m				T / m ³	T / m ²
1	3.00	194.50	8.00	7.00	7.00	0.40	475	1.12	0.80	0.0116	1.50	0.70	0.87	0.80	14	22
2	3.00	194.50	8.00	8.00	8.00	0.40	475	1.12	0.80	0.0116	1.50	0.70	0.89	0.80	13	20
3	3.00	194.50	8.00	9.00	9.00	0.40	475	1.12	0.80	0.0116	1.50	0.70	0.91	0.80	11	18
4	3.00	194.50	8.00	10.00	10.00	0.40	475	1.12	0.80	0.0116	1.50	0.70	0.92	0.80	11	17
5	3.50	194.00	8.50	7.00	7.00	0.40	475	1.12	0.80	0.0116	1.00	0.70	0.85	0.80	16	25
6	3.50	194.00	8.50	8.00	8.00	0.40	475	1.12	0.80	0.0116	1.00	0.70	0.87	0.80	14	23
7	3.50	194.00	8.50	9.00	9.00	0.40	475	1.12	0.80	0.0116	1.00	0.70	0.89	0.80	13	21
8	3.50	194.00	8.50	10.00	10.00	0.40	475	1.12	0.80	0.0116	1.00	0.70	0.90	0.80	12	19
9	4.00	193.50	9.00	7.00	7.00	0.40	475	1.12	0.80	0.0116	0.50	0.70	0.83	0.80	18	29
10	4.00	193.50	9.00	8.00	8.00	0.40	475	1.12	0.80	0.0116	0.50	0.70	0.85	0.80	16	26
11	4.00	193.50	9.00	9.00	9.00	0.40	475	1.12	0.80	0.0116	0.50	0.70	0.87	0.80	15	24
12	4.00	193.50	9.00	10.00	10.00	0.40	475	1.12	0.80	0.0116	0.50	0.70	0.88	0.80	13	22

Appendix – 3A

Calculation of Safe Load carrying capacity of piles socketed inside rock (Near BH-60) (ESP cum FGD control room Unit-1)

Project Name: - Proposed structures of thermal power project of NTTTP at Hirma, Talabira

1.0 Introduction

In situations where overburden offering low bearing pressure is followed by rock at relatively shallower depths, end bearing piles is the suitable foundation option. Piles in rocks and weathered rocks of varying degree of weathering derive their capacity by end bearing and socket side resistance.

In situations, where, rock strata comprises of highly fragmented rock, as in present case, where RQD is nil or $(CR+RQD)/2$ is less than 30 % or when the crushing strength is less than 10 MPa, the appropriate approach would be of that suggested by Cole & Stroud.

In present site overburden soils overlay fractured / laminated / foliated rock. The founding stratum having highly fragmented rock with nil RQD and $(CR+RQD)/2$ to be less than 30 %, the approach suggested by Cole and Stroud as per Annex B under clause 6.3.1.1 and 6.3.2 of IS 2911 Pa/S2 has been used for safe load calculations.

An illustrative calculation of safe load on pile and summary of pile capacities is as follows,

2.0 Sub soil strata Characterization

General stratification at the location of boreholes BH 60 show primarily two characterized layers,

1. Overburden comprising of fine to medium grained, sandy clays of low plasticity followed by fine to medium grained, sandy clays of intermediate plasticity with little to some gravels followed by fine to coarse grained, clayey sand with some to much gravels followed by fine to medium grained, cemented silty clayey sand with some to much gravels followed by fine to coarse grained, cemented, silty sand with much gravels upto 5.70m (i.e. RL 190.55m).
2. Second characterized layer below the overburden soils comprises of Highly weathered, weak, yellowish brown, fine to coarse grained, fractured rock upto 8.50m (i.e. RL 187.75m).

3.0 Design Considerations

1. Length of socket considered 3D from depth of rock encountered.
2. The pile is considered to have socket length below 5.70 m below NGL (i.e. RL 190.55 m) depth.
3. For present case of pile terminating in highly weathered rock. SPT at depths between 5.70 to 8.50m (between RL 190.55 to 187.75 m) is > 100 with just 2.0 cm penetration in 50 blows. SPT can be extrapolated for 30 cm i.e. $50 * 30 / 2.00 = 750$.

Based on recommendation of fig no. 3 in B 8 in Annex B under clause 6.3.1.1 and 6.3.2 of IS 2911 P1/S2, average shear strength q_c corresponding to assumed SPT of 200 may be taken as 1300 kN/m²

4. Allowable Capacity of pile socketed into rock $Q_a = R_e + R_{sf} = C_{u1} N_c \pi B^2 / 4 (F_s = 3) + \alpha C_{u2} \pi BL / (F_s = 6)$

4.0 Safe Load on Pile in Compression

Where,

End bearing component, $R_e = C_{u1} N_c \pi B^2 / 4 F_s$,

C_{u1} = Shear strength below base of pile = 1300 kN/m²

B = diameter of the pile = d

F_s = Factor of Safety = 3

$N_c = 9$

Therefore, **$R_e = 3061.5 d^2$**

Skin friction component of socketed length of pile, $R_{sf} = \alpha C_{u2}$

$\pi BL / F_s$

$\alpha = 0.9$ (recommended value in IS 2911 P1/S2)

L = length of the socket = $3 D$

C_{u2} = Ultimate shear strength along socket length which shall be restricted to shear capacity of concrete of the pile = 1300 kN/m²

F_s = Factor of Safety = 6

Therefore, **$R_{sf} = 1836.9 d^2$**

Thus,

$$Q_a = c_{u1} N_c \cdot \frac{\pi B^2}{4 F_s} + \alpha c_{u2} \cdot \frac{\pi BL}{F_s}$$

$$= 3061.5 d^2 + 1836.9 d^2 = 4898.4 d^2$$

Substituting the values of various diameters and socket lengths equal to 3 times diameter, allowable load on single pile can be summarized as follows,

Summary of the Safe load calculation in Compression

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	13.75	14.23	14.65
Termination level RL in m	188.75	188.27	187.85
End Bearing Component in kN	1102.1	1768.3	2479.8
Friction Component in kN	661.3	1060.9	1487.9
Safe load in Compression in kN	1763.4	2829.3	3967.7
Safe load in Compression in T	176	283	397

5.0 Safe Load on Pile in uplift

At 6.50m from FGL

The overburden soils, though, will not contribute in compression capacity would offer resistance in uplift capacity. The parameters of BH 60 are considered for calculation of uplift resistance as summarized below,

Depth in m from RL 202.5 m	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Submerged density in gm/cc γ_{sub}	Reduction Factor α	Earth pressure coefficient K	Angle of wall friction $\delta = \phi$	SPT N Value
FGL to 6.50	No contribution considered - Cut off level						
6.50 to 8.95	0.52	6~0*	0.95	0.85	NA	NA	6-10
8.95 to 11.95	0.08~0.00*	25	0.97	NA	1.00	27	16->100
11.95 to 20.75	Rock strata – Resistance would be as per skin friction capacity in socket as already calculated in compression capacity						

Ultimate load in skin friction,

$$Q_{uf} = \alpha_i C_{ai} A_{si} + K_i P D_i \tan \delta_i A_{si}$$

First Layer – Cut off level

$$\text{Second Layer} - \alpha_2 C_{a2} A_{s2} = 0.85 * 5.20 * \pi d * 2.45 = 34.02 d$$

$$\text{Third Layer} - K_3 P D_3 \tan \delta_3 A_{s3} = 1.00 * 9.83 * \tan 25 * \pi d * 3.00 = 43.20 d$$

Fourth Layer – 1836.90 d² in rock socket

$$\text{Substituting, ultimate load } q_{uf} = 772.20 d + 1836.9 d^2$$

The safe load in uplift is worked out (considering the safety factor of 2.50 for overburden soils) and summarized below,

Safe Load on Piles in Uplift (in Ton)

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	13.75	14.23	14.65
Termination level RL in m	188.75	188.27	187.85
Safe load in Uplift in kN	846.61	1295.74	1765.88
Self-weight of pile in kN	28.61	49.17	72.96
Safe load in Uplift in T (Considering self-weight of pile)	87.52	134.49	183.88

6.0 Lateral Pile Capacity

Pile would be long and elastic (i.e. $L > 4T$). For a prescribed deflection of 5mm and with M 30 grade of concrete, the lateral load and moment were worked out as follows,

Diameters in m		0.60	0.76	0.90
Subgrade reaction in MN/m ³		8.64	8.64	8.64
Stiffness factor T in m		1.83	2.21	2.53
Depth of fixity in m	Free Head	3.50	4.20	4.80
	Fixed Head	4.00	4.80	5.50
Allowable Horizontal Force in T	Free Head	6.30	9.20	12.10
	Fixed Head	16.80	24.50	32.10
Allowable Moment capacity in Tm	Free Head	7.71	13.59	20.39
	Fixed Head	27.43	48.38	72.59

7.0 Notes

1. Pile shall be terminated after socketing 3D inside rock.
2. Initial and routine pile load test is required to verify the actual carrying capacity of pile in compression, uplift and lateral loads.
3. For design and construction, specification of IS: 2911, P1/S2, IS: 456, 2000 shall strictly be followed.

(Dr. K. K. Thaker)

Appendix – 4A

Calculation of Safe Load carrying capacity of piles socketed inside rock (Near BH-59) (ID Fan Unit-1)

Project Name: - Proposed structures of thermal power project of NTTTP at Hirma, Talabira

1.0 Introduction

In situations where overburden offering low bearing pressure is followed by rock at relatively shallower depths, end bearing piles is the suitable foundation option. Piles in rocks and weathered rocks of varying degree of weathering derive their capacity by end bearing and socket side resistance.

In situations, where, rock strata comprises of highly fragmented rock, as in present case, where RQD is nil or $(CR+RQD)/2$ is less than 30 % or when the crushing strength is less than 10 MPa, the appropriate approach would be of that suggested by Cole & Stroud.

In present site overburden soils overlay fractured / laminated / foliated rock. The founding stratum having highly fragmented rock with nil RQD and $(CR+RQD)/2$ to be less than 30 %, the approach suggested by Cole and Stroud as per Annex B under clause 6.3.1.1 and 6.3.2 of IS 2911 Pa/S2 has been used for safe load calculations.

An illustrative calculation of safe load on pile and summary of pile capacities is as follows,

2.0 Sub soil strata Characterization

General stratification at the location of boreholes BH 59 show primarily two characterized layers,

1. Overburden comprising of fine to very fine grained, sandy clays of low plasticity with occasional gravels followed by fine to coarse grained, sandy clays of intermediate plasticity with some gravels followed by fine to very fine grained, clayey sand with some gravels followed by fine to very fine grained, cemented silty clayey sand upto 7.30m (i.e. RL 190.30m).
2. Second characterized layer below the overburden soils comprises of Highly weathered, very weak and friable yellowish brown, fine to medium grained, fractured rock followed by Highly weathered, weak, yellowish brown, fine to medium grained, fractured rock upto 14.50m (i.e. RL 183.10m).

3.0 Design Considerations

1. Length of socket considered 3D from depth of rock encountered.
2. The pile is considered to have socket length below 7.30 m below NGL (i.e. RL 190.30 m) depth.
3. For present case of pile terminating in highly weathered rock. SPT at depths between 7.30 to 14.50m (between RL 190.30 to 183.10 m) is > 100 with just 2.0 cm penetration in 50 blows. SPT can be extrapolated for 30 cm i.e. $50 * 30 / 2.00 = 750$.

Based on recommendation of fig no. 3 in B 8 in Annex B under clause 6.3.1.1 and 6.3.2 of IS 2911 P1/S2, average shear strength q_c corresponding to assumed SPT of 200 may be taken as 1300 kN/m²

4. Allowable Capacity of pile socketed into rock $Q_a = R_e + R_{sf} = C_{u1} N_c \pi B^2 / 4 (F_s = 3) + \alpha C_{u2} \pi BL / (F_s = 6)$

4.0 Safe Load on Pile in Compression

Where,

End bearing component, $R_e = C_{u1} N_c \pi B^2 / 4 F_s$,

C_{u1} = Shear strength below base of pile = 1300 kN/m²

B = diameter of the pile = d

F_s = Factor of Safety = 3

$N_c = 9$

Therefore, **$R_e = 3061.5 d^2$**

Skin friction component of socketed length of pile, $R_{sf} = \alpha C_{u2}$

$\pi BL / F_s$

$\alpha = 0.9$ (recommended value in IS 2911 P1/S2)

L = length of the socket = $3 D$

C_{u2} = Ultimate shear strength along socket length which shall be restricted to shear capacity of concrete of the pile = 1300 kN/m²

F_s = Factor of Safety = 6

Therefore, **$R_{sf} = 1836.9 d^2$**

Thus,

$$Q_a = c_{u1} N_c \cdot \frac{\pi B^2}{4 F_s} + \alpha c_{u2} \cdot \frac{\pi B L}{F_s}$$

$$= 3061.5 d^2 + 1836.9 d^2 = 4898.4 d^2$$

Substituting the values of various diameters and socket lengths equal to 3 times diameter, allowable load on single pile can be summarized as follows,

Summary of the Safe load calculation in Compression

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	14.00	14.48	14.90
Termination level RL in m	188.50	188.02	187.60
End Bearing Component in kN	1102.1	1768.3	2479.8
Friction Component in kN	661.3	1060.9	1487.9
Safe load in Compression in kN	1763.4	2829.3	3967.7
Safe load in Compression in T	176	283	397

5.0 Safe Load on Pile in uplift

At 5.00m FGL

The overburden soils, though, will not contribute in compression capacity would offer resistance in uplift capacity. The parameters of BH 59 are considered for calculation of uplift resistance as summarized below,

Depth in m from RL 202.5 m	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Submerged density in gm/cc γ_{sub}	Reduction Factor α	Earth pressure coefficient K	Angle of wall friction $\delta = \phi$	SPT N Value
FGL to 5.00	No contribution considered - Cut off level						
5.00 to 8.50	0.36 [#]	6~0*	0.94	1.00	NA	NA	4-7
8.50 to 12.20	0.06~0.00*	28 [#]	1.03	NA	1.00	28	10->100
12.20 to 29.40	Rock strata – Resistance would be as per skin friction capacity in socket as already calculated in compression capacity						

#Average of the parameters falling in the same layer has been considered.

Ultimate load in skin friction,

$$Q_{uf} = \alpha_i C_{ai} A_{si} + K_i P D_i \tan \delta_i A_{si}$$

First Layer – Cut off level

$$\text{Second Layer} - \alpha_2 C_{a2} A_{s2} = 1.00 * 3.60 * \pi d * 3.50 = 39.58d$$

$$\text{Third Layer} - K_3 P D_3 \tan \delta_3 A_{s3} = 1.00 * 9.20 * \tan 28^\circ * \pi d * 3.70 = 56.86d$$

Fourth Layer – 1836.90 d² in rock socket

$$\text{Substituting, ultimate load } q_{uf} = 964.41 d + 1836.9 d^2$$

The safe load in uplift is worked out (considering the safety factor of 2.50 for overburden soils) and summarized below,

Safe Load on Piles in Uplift (in Ton)

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	14.00	14.48	14.90
Termination level RL in m	188.50	188.02	187.60
Safe load in Uplift in kN	892.74	1354.17	1835.08
Self-weight of pile in kN	38.15	64.48	94.42
Safe load in Uplift in T (Considering self-weight of pile)	93.09	141.87	192.95

6.0 Lateral Pile Capacity

Pile would be long and elastic (i.e. $L > 4T$). For a prescribed deflection of 5mm and with M 30 grade of concrete, the lateral load and moment were worked out as follows,

Diameters in m		0.60	0.76	0.90
Subgrade reaction in MN/m ³		5.76	5.76	5.76
Stiffness factor T in m		1.99	2.40	2.75
Depth of fixity in m	Free Head	3.80	4.60	5.20
	Fixed Head	4.30	5.20	6.00
Allowable Horizontal Force in T	Free Head	5.00	7.20	9.50
	Fixed Head	13.10	19.20	25.10
Allowable Moment capacity in Tm	Free Head	6.55	11.56	17.34
	Fixed Head	23.32	41.13	61.72

7.0 Notes

1. Pile shall be terminated after socketing 3D inside rock.
2. Initial and routine pile load test is required to verify the actual carrying capacity of pile in compression, uplift and lateral loads.
3. For design and construction, specification of IS: 2911, P1/S2, IS: 456, 2000 shall strictly be followed.

(Dr. K. K. Thaker)

Appendix – 5A

Calculation of Safe Load carrying capacity of piles socketed inside rock (Near BH-67) (Absorber & RC pump house Unit-1)

Project Name: - Proposed structures of thermal power project of NTTTP at Hirma, Talabira

1.0 Introduction

In situations where overburden offering low bearing pressure is followed by rock at relatively shallower depths, end bearing piles is the suitable foundation option. Piles in rocks and weathered rocks of varying degree of weathering derive their capacity by end bearing and socket side resistance.

In situations, where, rock strata comprises of highly fragmented rock, as in present case, where RQD is nil or $(CR+RQD)/2$ is less than 30 % or when the crushing strength is less than 10 MPa, the appropriate approach would be of that suggested by Cole & Stroud.

In present site overburden soils overlay fractured / laminated / foliated rock. The founding stratum having highly fragmented rock with nil RQD and $(CR+RQD)/2$ to be less than 30 %, the approach suggested by Cole and Stroud as per Annex B under clause 6.3.1.1 and 6.3.2 of IS 2911 Pa/S2 has been used for safe load calculations.

An illustrative calculation of safe load on pile and summary of pile capacities is as follows,

2.0 Sub soil strata Characterization

General stratification at the location of boreholes BH 67 show primarily two characterized layers,

1. Overburden comprising of fine to very fine grained, sandy clays of low plasticity with some gravels followed by fine to very fine grained, sandy clays of intermediate plasticity with some gravels followed by fine to coarse grained, clayey sand with some to much gravels followed by fine to medium grained, cemented silty clayey sand upto 7.10m (i.e. RL 189.40m).
2. Second characterized layer below the overburden soils comprises of Highly weathered, weak, light brownish yellow, fine to medium grained, fractured rock upto 9.00m (i.e. RL 187.50m).

3.0 Design Considerations

1. Length of socket considered 3D from depth of rock encountered.
2. The pile is considered to have socket length below 7.10 m below NGL (i.e. RL 189.40 m) depth.
3. For present case of pile terminating in highly weathered rock. SPT at depths between 7.10 to 9.00m (between RL 189.40 to 187.50 m) is > 100 with just 5.0 cm penetration in 50 blows. SPT can be extrapolated for 30 cm i.e. $50 * 30 / 5.00 = 300$.
Based on recommendation of fig no. 3 in B 8 in Annex B under clause 6.3.1.1 and 6.3.2 of IS 2911 P1/S2, average shear strength q_c corresponding to assumed SPT of 200 may be taken as 1300 kN/m²
4. Allowable Capacity of pile socketed into rock $Q_a = R_e + R_{sf} = C_{u1} N_c \pi B^2 / 4 (F_s = 3) + \alpha C_{u2} \pi BL / (F_s = 6)$

4.0 Safe Load on Pile in Compression

Where,

End bearing component, $R_e = C_{u1} N_c \pi B^2 / 4 F_s$,

C_{u1} = Shear strength below base of pile = 1300 kN/m²

B = diameter of the pile = d

F_s = Factor of Safety = 3

$N_c = 9$

Therefore, **$R_e = 3061.5 d^2$**

Skin friction component of socketed length of pile, $R_{sf} = \alpha C_{u2} \pi BL / F_s$

$\alpha = 0.9$ (recommended value in IS 2911 P1/S2)

L = length of the socket = $3 D$

C_{u2} = Ultimate shear strength along socket length which shall be restricted to shear capacity of concrete of the pile = 1300 kN/m²

F_s = Factor of Safety = 6

Therefore, **$R_{sf} = 1836.9 d^2$**

Thus,

$$Q_a = c_{u1} N_c \cdot \frac{\pi B^2}{4 F_s} + \alpha c_{u2} \cdot \frac{\pi B L}{F_s}$$

$$= 3061.5 d^2 + 1836.9 d^2 = 4898.4 d^2$$

Substituting the values of various diameters and socket lengths equal to 3 times diameter, allowable load on single pile can be summarized as follows,

Summary of the Safe load calculation in Compression

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	14.90	15.38	15.80
Termination level RL in m	187.60	187.12	186.70
End Bearing Component in kN	1102.1	1768.3	2479.8
Friction Component in kN	661.3	1060.9	1487.9
Safe load in Compression in kN	1763.4	2829.3	3967.7
Safe load in Compression in T	176	283	397

5.0 Safe Load on Pile in uplift

At 6.00m FGL

The overburden soils, though, will not contribute in compression capacity would offer resistance in uplift capacity. The parameters of BH 67 are considered for calculation of uplift resistance as summarized below,

Depth in m from RL 202.5 m	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Submerged density in gm/cc γ_{sub}	Reduction Factor α	Earth pressure coefficient K	Angle of wall friction $\delta = \phi$	SPT N Value
FGL to 6.00	No contribution considered - Cut off level						
6.00 to 8.60	0.31	7~0*	0.95	1.00	NA	NA	4-6
8.60 to 13.10	0.05#~0.00*	26#	1.00	NA	1.00	28	12->100
13.10 to 24.00	Rock strata – Resistance would be as per skin friction capacity in socket as already calculated in compression capacity						

#Average of the parameters falling in the same layer has been considered.

Ultimate load in skin friction,

$$Q_{uf} = \alpha_i C_{ai} A_{si} + K_i P D_i \tan \delta_i A_{si}$$

First Layer – Cut off level

$$\text{Second Layer} - \alpha_2 C_{a2} A_{s2} = 1.00 * 3.10 * \pi d * 2.60 = 25.32d$$

$$\text{Third Layer} - K_3 P D_3 \tan \delta_3 A_{s3} = 1.00 * 9.52 * \tan 26 * \pi d * 4.50 = 65.64 d$$

Fourth Layer – 1836.90 d² in rock socket

$$\text{Substituting, ultimate load } q_{uf} = 909.62 d + 1836.9 d^2$$

The safe load in uplift is worked out (considering the safety factor of 2.50 for overburden soils) and summarized below,

Safe Load on Piles in Uplift (in Ton)

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	14.90	15.38	15.80
Termination level RL in m	187.60	187.12	186.70
Safe load in Uplift in kN	879.59	1337.52	1815.35
Self-weight of pile in kN	37.73	63.80	93.47
Safe load in Uplift in T (Considering self-weight of pile)	91.73	140.13	190.88

6.0 Lateral Pile Capacity

Pile would be long and elastic (i.e. $L > 4T$). For a prescribed deflection of 5mm and with M 30 grade of concrete, the lateral load and moment were worked out as follows,

Diameters in m		0.60	0.76	0.90
Subgrade reaction in MN/m ³		5.76	5.76	5.76
Stiffness factor T in m		1.99	2.40	2.75
Depth of fixity in m	Free Head	3.80	4.60	5.20
	Fixed Head	4.30	5.20	6.00
Allowable Horizontal Force in T	Free Head	5.00	7.20	9.50
	Fixed Head	13.10	19.20	25.10
Allowable Moment capacity in Tm	Free Head	6.55	11.56	17.34
	Fixed Head	23.32	41.13	61.72

7.0 Notes

1. Pile shall be terminated after socketing 3D inside rock.
2. Initial and routine pile load test is required to verify the actual carrying capacity of pile in compression, uplift and lateral loads.
3. For design and construction, specification of IS: 2911, P1/S2, IS: 456, 2000 shall strictly be followed.

(Dr. K. K. Thaker)

Appendix – 6A

Calculation of Safe Load carrying capacity of piles socketed inside rock (Near BH-51) (ESP Unit-1)

Project Name: - Proposed structures of thermal power project of NTTTP at Hirma, Talabira

1.0 Introduction

In situations where overburden offering low bearing pressure is followed by rock at relatively shallower depths, end bearing piles is the suitable foundation option. Piles in rocks and weathered rocks of varying degree of weathering derive their capacity by end bearing and socket side resistance.

In situations, where, rock strata comprises of highly fragmented rock, as in present case, where RQD is nil or $(CR+RQD)/2$ is less than 30 % or when the crushing strength is less than 10 MPa, the appropriate approach would be of that suggested by Cole & Stroud.

In present site overburden soils overlay fractured / laminated / foliated rock. The founding stratum having highly fragmented rock with nil RQD and $(CR+RQD)/2$ to be less than 30 %, the approach suggested by Cole and Stroud as per Annex B under clause 6.3.1.1 and 6.3.2 of IS 2911 Pa/S2 has been used for safe load calculations.

An illustrative calculation of safe load on pile and summary of pile capacities is as follows,

2.0 Sub soil strata Characterization

General stratification at the location of boreholes BH 51 show primarily two characterized layers,

1. Overburden comprising of fine to medium grained, sandy clays of low plasticity followed by fine to medium grained, clayey sand with occasional gravels followed by very fine grained, silty clays of intermediate plasticity followed by very fine grained, clays of intermediate plasticity followed by very fine grained, clays of intermediate plasticity upto 7.00m (i.e. RL 189.05m).
2. Second characterized layer below the overburden soils comprises of Highly weathered, very weak, greyish brown, fine to very fine grained, fractured rock followed by Moderately weathered, weak, light brownish yellow, fine to very fine grained, rock with very close spacing of discontinuities upto 10.50m (i.e. RL 185.55m).

3.0 Design Considerations

1. Length of socket considered 3D from depth of rock encountered.
2. The pile is considered to have socket length below 7.00 m below NGL (i.e. RL 189.05 m) depth.
3. For present case of pile terminating in highly weathered rock. SPT at depths between 7.00 to 10.50m (between RL 189.05 to 185.55 m) is > 200.
Based on recommendation of fig no. 3 in B 8 in Annex B under clause 6.3.1.1 and 6.3.2 of IS 2911 P1/S2, average shear strength q_c corresponding to assumed SPT of 200 may be taken as 1300 kN/m²
4. Allowable Capacity of pile socketed into rock $Q_a = R_e + R_{sf} = C_{u1} N_c \pi B^2/4(F_s=3) + \alpha C_{u2} \pi BL/(F_s=6)$

4.0 Safe Load on Pile in Compression

Where,

End bearing component, $R_e = C_{u1} N_c \pi B^2/4F_s$,

C_{u1} = Shear strength below base of pile = 1300 kN/m²

B = diameter of the pile = d

F_s = Factor of Safety = 3

$N_c = 9$

Therefore, **$R_e = 3061.5 d^2$**

Skin friction component of socketed length of pile, $R_{sf} = \alpha C_{u2} \pi BL / F_s$

$\alpha = 0.9$ (recommended value in IS 2911 P1/S2)

L = length of the socket = $3 D$

C_{u2} = Ultimate shear strength along socket length which shall be restricted to shear capacity of concrete of the pile = 1300 kN/m²

F_s = Factor of Safety = 6

Therefore, **$R_{sf} = 1836.9 d^2$**

Thus,

$$Q_a = c_{u1} N_c \cdot \frac{\pi B^2}{4 F_s} + \alpha c_{u2} \cdot \frac{\pi B L}{F_s}$$

$$= 3061.5 d^2 + 1836.9 d^2 = 4898.4 d^2$$

Substituting the values of various diameters and socket lengths equal to 3 times diameter, allowable load on single pile can be summarized as follows,

Summary of the Safe load calculation in Compression

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	15.25	15.73	16.15
Termination level RL in m	187.25	186.77	186.35
End Bearing Component in kN	1102.1	1768.3	2479.8
Friction Component in kN	661.3	1060.9	1487.9
Safe load in Compression in kN	1763.4	2829.3	3967.7
Safe load in Compression in T	176	283	397

5.0 Safe Load on Pile in uplift

At 6.50m FGL

The overburden soils, though, will not contribute in compression capacity would offer resistance in uplift capacity. The parameters of BH 51 are considered for calculation of uplift resistance as summarized below,

Depth in m from RL 202.5 m	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Submerged density in gm/cc γ_{sub}	Reduction Factor α	Earth pressure coefficient K	Angle of wall friction $\delta = \phi$	SPT N Value
FGL to 6.50	No contribution considered - Cut off level						
6.50 to 9.15	0.03 ^{\$} ~0.00*	27 ^{\$}	0.99	NA	1.00	27	4-6
9.15 to 13.45	0.72	4~0*	0.99	0.61	NA	NA	16-47
13.45 to 24.45	Rock strata – Resistance would be as per skin friction capacity in socket as already calculated in compression capacity						

#Average of the parameters falling in the same layer has been considered.

\$Parameters of this layer is considered based on SPT N value.

Ultimate load in skin friction,

$$Q_{uf} = \alpha_i C_{ai} A_{si} + K_i P D_i \tan \delta_i A_{si}$$

First Layer – Cut off level

$$\text{Second Layer} - K_2 P D_2 \tan \delta_2 A_{s2} = 1.00 * 7.16 * \tan 27 * \pi d * 2.65 = 30.37 d$$

$$\text{Third Layer} - \alpha_3 C_{a3} A_{s3} = 0.61 * 7.20 * \pi d * 4.30 = 59.33 d$$

Fourth Layer – 1836.90 d² in rock socket

$$\text{Substituting, ultimate load } q_{uf} = 897.00 d + 1836.9 d^2$$

The safe load in uplift is worked out (considering the safety factor of 2.50 for overburden soils) and summarized below,

Safe Load on Piles in Uplift (in Ton)

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	15.25	15.73	16.15
Termination level RL in m	187.25	186.77	186.35
Safe load in Uplift in kN	876.56	1333.68	1810.81
Self-weight of pile in kN	37.11	62.81	92.09
Safe load in Uplift in T (Considering self-weight of pile)	91.37	139.65	190.29

6.0 Lateral Pile Capacity

Pile would be long and elastic (i.e. $L > 4T$). For a prescribed deflection of 5mm and with M 30 grade of concrete, the lateral load and moment were worked out as follows,

Diameters in m		0.60	0.76	0.90
Subgrade reaction in MN/m ³		5.50	5.50	5.50
Stiffness factor T in m		2.00	2.42	2.77
Depth of fixity in m	Free Head	3.80	4.60	5.30
	Fixed Head	4.40	5.30	6.00
Allowable Horizontal Force in T	Free Head	4.80	7.00	9.20
	Fixed Head	12.80	18.70	24.50
Allowable Moment capacity in Tm	Free Head	6.43	11.35	17.02
	Fixed Head	22.90	40.38	60.59

7.0 Notes

1. Pile shall be terminated after socketing 3D inside rock.
2. Initial and routine pile load test is required to verify the actual carrying capacity of pile in compression, uplift and lateral loads.
3. For design and construction, specification of IS: 2911, P1/S2, IS: 456, 2000 shall strictly be followed.

(Dr. K. K. Thaker)

Appendix – 7A

Calculation of Safe Load carrying capacity of piles socketed inside rock (Near BH-87) (ESP cum FGD control room Unit-2)

Project Name: - Proposed structures of thermal power project of NTTTP at Hirma, Talabira

1.0 Introduction

In situations where overburden offering low bearing pressure is followed by rock at relatively shallower depths, end bearing piles is the suitable foundation option. Piles in rocks and weathered rocks of varying degree of weathering derive their capacity by end bearing and socket side resistance.

In situations, where, rock strata comprises of highly fragmented rock, as in present case, where RQD is nil or $(CR+RQD)/2$ is less than 30 % or when the crushing strength is less than 10 MPa, the appropriate approach would be of that suggested by Cole & Stroud.

In present site overburden soils overlay fractured / laminated / foliated rock. The founding stratum having highly fragmented rock with nil RQD and $(CR+RQD)/2$ to be less than 30 %, the approach suggested by Cole and Stroud as per Annex B under clause 6.3.1.1 and 6.3.2 of IS 2911 Pa/S2 has been used for safe load calculations.

An illustrative calculation of safe load on pile and summary of pile capacities is as follows,

2.0 Sub soil strata Characterization

General stratification at the location of boreholes BH 87 show primarily two characterized layers,

1. Overburden comprising of fine to very fine grained, sandy clays of intermediate plasticity followed by fine to very fine grained, sandy clays of intermediate plasticity followed by fine to very fine grained, clayey sand with occasional gravels followed by fine to very fine grained, clayey sand followed by fine to very fine grained, clayey sand with some gravels upto 12.30m (i.e. RL 185.13m).
2. Second characterized layer below the overburden soils comprises of Highly weathered, very weak and friable, brownish yellow, fine to medium grained, interlocking fragments of fractured rock upto 15.00m (i.e. RL 182.43m).

3.0 Design Considerations

1. Length of socket considered 3D from depth of rock encountered.
2. The pile is considered to have socket length below 12.30 m below NGL (i.e. RL 185.13 m) depth.
3. For present case of pile terminating in highly weathered rock. SPT at depths between 12.30 to 15.00m (between RL 185.13 to 182.43 m) is > 200.
Based on recommendation of fig no. 3 in B 8 in Annex B under clause 6.3.1.1 and 6.3.2 of IS 2911 P1/S2, average shear strength q_c corresponding to assumed SPT of 200 may be taken as 1300 kN/m²
4. Allowable Capacity of pile socketed into rock $Q_a = R_e + R_{sf} = C_{u1} N_c \pi B^2 / 4 (F_s = 3) + \alpha C_{u2} \pi BL / (F_s = 6)$

4.0 Safe Load on Pile in Compression

Where,

End bearing component, $R_e = C_{u1} N_c \pi B^2 / 4 F_s$,

C_{u1} = Shear strength below base of pile = 1300 kN/m²

B = diameter of the pile = d

F_s = Factor of Safety = 3

$N_c = 9$

Therefore, **$R_e = 3061.5 d^2$**

Skin friction component of socketed length of pile, $R_{sf} = \alpha C_{u2}$

$\pi BL / F_s$

$\alpha = 0.9$ (recommended value in IS 2911 P1/S2)

L = length of the socket = $3 D$

C_{u2} = Ultimate shear strength along socket length which shall be restricted to shear capacity of concrete of the pile = 1300 kN/m²

F_s = Factor of Safety = 6

Therefore, **$R_{sf} = 1836.9 d^2$**

Thus,

$$Q_a = c_{u1} N_c \cdot \frac{\pi B^2}{4 F_s} + \alpha c_{u2} \cdot \frac{\pi B L}{F_s}$$

$$= 3061.5 d^2 + 1836.9 d^2 = 4898.4 d^2$$

Substituting the values of various diameters and socket lengths equal to 3 times diameter, allowable load on single pile can be summarized as follows,

Summary of the Safe load calculation in Compression

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	19.17	19.65	20.07
Termination level RL in m	183.33	182.85	182.43
End Bearing Component in kN	1102.1	1768.3	2479.8
Friction Component in kN	661.3	1060.9	1487.9
Safe load in Compression in kN	1763.4	2829.3	3967.7
Safe load in Compression in T	176	283	397

5.0 Safe Load on Pile in uplift

At 5.00m FGL

The overburden soils, though, will not contribute in compression capacity would offer resistance in uplift capacity. The parameters of BH 87 are considered for calculation of uplift resistance as summarized below,

Depth in m from RL 202.5 m	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Submerged density in gm/cc γ_{sub}	Reduction Factor α	Earth pressure coefficient K	Angle of wall friction $\delta = \phi$	SPT N Value
FGL to 5.00	No contribution considered - Cut off level						
5.00 to 8.97	1.02 [#]	7~0*	1.00	0.42	NA	NA	11-21
8.97 to 17.37	0.04~0.00*	28 [#]	1.00	NA	1.00	28	15->100
17.37 to 26.07	Rock strata – Resistance would be as per skin friction capacity in socket as already calculated in compression capacity						

Ultimate load in skin friction,

$$Q_{uf} = \alpha_i C_{ai} A_{si} + K_i P D_i \tan \delta_i A_{si}$$

First Layer – Cut off level

$$\text{Second Layer} - \alpha_2 C_{a2} A_{s2} = 0.42 * 10.20 * \pi d * 3.97 = 53.43d$$

$$\text{Third Layer} - K_3 P D_3 \tan \delta_3 A_{s3} = 1.00 * 10.40 * \tan 28^\circ * \pi d * 1.03 = 17.89 d$$

Fourth Layer – 1836.90 d² in rock socket

$$\text{Substituting, ultimate load } q_{uf} = 713.20 d + 1836.9 d^2$$

The safe load in uplift is worked out (considering the safety factor of 2.50 for overburden soils) and summarized below,

Safe Load on Piles in Uplift (in Ton)

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	19.17	19.65	20.07
Termination level RL in m	183.33	182.85	182.43
Safe load in Uplift in kN	832.45	1277.81	1744.64
Self-weight of pile in kN	60.07	99.64	143.73
Safe load in Uplift in T (Considering self-weight of pile)	89.25	137.75	188.84

6.0 Lateral Pile Capacity

Pile would be long and elastic (i.e. $L > 4T$). For a prescribed deflection of 5mm and with M 30 grade of concrete, the lateral load and moment were worked out as follows,

Diameters in m		0.60	0.76	0.90
Subgrade reaction in MN/m ³		15.84	15.84	15.84
Stiffness factor T in m		1.62	1.96	2.24
Depth of fixity in m	Free Head	3.10	3.70	4.30
	Fixed Head	3.50	4.30	4.90
Allowable Horizontal Force in T	Free Head	9.10	13.30	17.40
	Fixed Head	24.10	35.20	46.10
Allowable Moment capacity in Tm	Free Head	9.82	17.32	25.99
	Fixed Head	34.96	61.65	92.50

7.0 Notes

1. Pile shall be terminated after socketing 3D inside rock.
2. Initial and routine pile load test is required to verify the actual carrying capacity of pile in compression, uplift and lateral loads.
3. For design and construction, specification of IS: 2911, P1/S2, IS: 456, 2000 shall strictly be followed.

(Dr. K. K. Thaker)

Appendix – 7B

Calculation of Safe Load on Uniform Diameter Bored Cast in situ Pile. (Near BH-87) (ESP cum FGD control room Unit-2)

The safe load is calculated as follows,

1) Design Stipulations

- | | |
|---|---|
| 1. Type of pile | - Bored cast in situ uniform diameter pile. |
| 2. Pile diameter considered | - 0.60m |
| 3. Termination depth of pile considered | - 16.00m from FGL. |
| 4. Cut off Level | - At 5.00m from FGL. |
| 5. Factor of Safety | - 2.50 |
| 6. Depth of Water table | - Considered at FGL. |
| 7. Ref | - IS 2911 P-I, Sec-II, 2021. |

2) Test Data

The parameters are based on BH 87. For evaluation of safe load on piles following characterized layers are considered as described in table below,

Depth in m from RL 202.5 m	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Submerged density in gm/cc γ_{sub}	Reduction Factor α	Earth pressure coefficient K	Angle of wall friction $\delta = \phi$	SPT N Value
FGL to 5.00	No contribution considered - Cut off level						
5.00 to 8.97	1.02 [#]	7~0*	1.00	0.42	NA	NA	11-21
8.97 to 17.37	0.04~0.00*	28 [#]	1.00	NA	1.00	28	15->100
17.37 to 26.07	Rock strata – Resistance would be as per skin friction capacity in socket as already calculated in compression capacity						

Notes: - Layers are characterized based on classification and the state of soil in that stratum.

* - In cohesive soils the contribution of the angle of internal friction being insignificant is ignored.

Shear parameters are the most representative for the layer. NA means not applicable. Characterized N values are considered for each layer.

- Weighted Average of the parameters falling in the same layer has been considered

\$-Parameters are correlated based on SPT value N.

3) Ultimate Load in Compression

3.1) Ultimate load in Compression by Bearing

Ultimate load on pile in end bearing,

$$q_{ub} = A_p (0.5 \cdot D \cdot \gamma \cdot N_v + P D N_q)$$

$$A_p = \text{Cross section area of Pile stem at toe} = \pi d^2 / 4$$

$$D = \text{Diameter of pile} = d \text{ in m}$$

$$N_v = 42.90$$

$$N_q = 40.00$$

$$q_{ub} = 0.785d^2 (0.5 \cdot d \cdot 1.00 \cdot 42.90 + 9.00 \cdot 40.00) = 16.84d^3 + 282.60d^2$$

(For Pile terminating at 16.00m from F.G.L.)

Note: As the pile terminating just above rock level, we have considered parameter for end bearing component based on rock strata.

3.2) Ultimate Load in Compression by Skin Friction

Ultimate load in skin friction,

$$q_{uf} = \alpha_i C_{ai} A_i + K_i P D_i \tan \delta_i A_{si}$$

First Layer – No contribution considered due to cut off level

$$\text{Second Layer} - \alpha_2 C_{a2} A_{s2} = 0.42 \cdot 10.20 \cdot \pi \cdot d \cdot 3.97 = 53.43d$$

$$\text{Third Layer} - K_3 P D_3 \tan \delta_3 A_{s3} = 1.00 \cdot 7.49 \cdot \tan 28^\circ \cdot \pi \cdot d \cdot (\ell - 8.97) = 12.51 d (\ell - 8.97)$$

Substituting, ultimate load

$$q_{uf} = 53.43d + 12.51d (\ell - 8.97) \text{ (For Pile terminating at 16.00m from F.G.L.)}$$

Where, ℓ is the pile length and d is diameter of piles, substituting

Ultimate load by both bearing and friction can be as follows for various lengths of piles,

$$q_{uc} = q_{ub} + q_{uf}$$

$$q_{uc} = 16.84d^3 + 282.60d^2 + 53.43d + 12.51d(l - 8.97)$$

(For Pile terminating at 16.00m from F.G.L.).

By substituting various diameters of piles having various lengths, the safe load is worked out considering the safety factor of 2.50 and are given in table below,

Safe Load on Piles in Compression (in Ton)

Termination Depth of Pile in m, from FGL	Termination Depth of Pile in m, from cut-off	Diameter of Pile in, m
		0.60
16.00	11.00	75.93

3.3) Ultimate Load in Uplift

Considering skin friction for determination of uplift

Safe Load on Piles in Uplift (in Ton)

Termination Depth of Pile in m, from FGL	Termination Depth of Pile in m, from cut-off	Diameter of Pile in, m
		0.60
16.00	11.00	32.82

Note: Self weight of pile is considered in calculation of ultimate load in uplift.

Self weight of Pile (in Ton)

Termination Depth of Pile in m, from FGL	Termination Depth of Pile in m, from cut-off	Diameter of Pile in, m
		0.60
16.00	11.00	4.67

3.4) Lateral Pile Capacity

Pile would be long and elastic (i.e. $L > 4T$). For a prescribed deflection of 5mm and with M 30 grade of concrete, the lateral load and moment were worked out as follows,

Diameters in m		0.60
Subgrade reaction in MN/m ³		15.84
Stiffness factor T in m		1.62
Depth of fixity in m	Free Head	3.10
	Fixed Head	3.50
Allowable Horizontal Force in T	Free Head	9.10
	Fixed Head	24.10
Allowable Moment capacity in Tm	Free Head	9.82
	Fixed Head	34.96

4) Notes:

1) Initial and Routine pile load tests shall be carried out as per IS 2911, P-4 on the piles to confirm the capacity of pile worked out theoretically. For design and construction, specifications of IS 2911, P-I, S-2, shall strictly be followed. Termination depth of pile shall be from FGL.

Dr. K. K. Thaker

Appendix – 8A

Calculation of Safe Load carrying capacity of piles socketed inside rock (Near BH-91) (ID fan Unit-2)

Project Name: - Proposed structures of thermal power project of NTTTP at Hirma, Talabira

1.0 Introduction

In situations where overburden offering low bearing pressure is followed by rock at relatively shallower depths, end bearing piles is the suitable foundation option. Piles in rocks and weathered rocks of varying degree of weathering derive their capacity by end bearing and socket side resistance.

In situations, where, rock strata comprises of highly fragmented rock, as in present case, where RQD is nil or $(CR+RQD)/2$ is less than 30 % or when the crushing strength is less than 10 MPa, the appropriate approach would be of that suggested by Cole & Stroud.

In present site overburden soils overlay fractured / laminated / foliated rock. The founding stratum having highly fragmented rock with nil RQD and $(CR+RQD)/2$ to be less than 30 %, the approach suggested by Cole and Stroud as per Annex B under clause 6.3.1.1 and 6.3.2 of IS 2911 Pa/S2 has been used for safe load calculations.

An illustrative calculation of safe load on pile and summary of pile capacities is as follows,

2.0 Sub soil strata Characterization

General stratification at the location of boreholes BH 91 show primarily two characterized layers,

1. Overburden comprising of fine to very fine grained, clayey sand followed by fine to very fine grained, sandy clays of intermediate plasticity followed by fine to very fine grained, clayey sand followed by fine to very fine grained, sandy clays of low plasticity with little gravels followed by fine to very fine grained, clayey sand followed by fine to very fine grained, clays of high plasticity upto 15.60m (i.e. RL 182.93m).
2. Second characterized layer below the overburden soils comprises of moderately weathered, weak, dark blackish grey, fractured rock followed by Fresh, moderately weak, brownish grey, fine to medium grained, massive rock upto 19.00m (i.e. RL 179.53m).

3.0 Design Considerations

1. Length of socket considered 3D from depth of rock encountered.
2. The pile is considered to have socket length below 15.60 m below NGL (i.e. RL 182.93 m) depth.
3. For present case of pile terminating in highly weathered rock. SPT at depths between 15.60 to 19.00m (between RL 182.93 to 179.53 m) is > 100 with just 5.0 cm penetration in 50 blows. SPT can be extrapolated for 30 cm i.e. $50 * 30 / 5.00 = 300$.

Based on recommendation of fig no. 3 in B 8 in Annex B under clause 6.3.1.1 and 6.3.2 of IS 2911 P1/S2, average shear strength q_c corresponding to assumed SPT of 200 may be taken as 1300 kN/m²

4. Allowable Capacity of pile socketed into rock $Q_a = R_e + R_{sf} = C_{u1} N_c \pi B^2 / 4 (F_s = 3) + \alpha C_{u2} \pi BL / (F_s = 6)$

4.0 Safe Load on Pile in Compression

Where,

End bearing component, $R_e = C_{u1} N_c \pi B^2 / 4 F_s$,

C_{u1} = Shear strength below base of pile = 1300 kN/m²

B = diameter of the pile = d

F_s = Factor of Safety = 3

$N_c = 9$

Therefore, **$R_e = 3061.5 d^2$**

Skin friction component of socketed length of pile, $R_{sf} = \alpha C_{u2}$

$\pi BL / F_s$

$\alpha = 0.9$ (recommended value in IS 2911 P1/S2)

L = length of the socket = 3 D

C_{u2} = Ultimate shear strength along socket length which shall be restricted to shear capacity of concrete of the pile = 1300 kN/m²

F_s = Factor of Safety = 6

Therefore, **$R_{sf} = 1836.9 d^2$**

Thus,

$$Q_a = c_{u1} N_c \cdot \frac{\pi B^2}{4 F_s} + \alpha c_{u2} \cdot \frac{\pi B L}{F_s}$$

$$= 3061.5 d^2 + 1836.9 d^2 = 4898.4 d^2$$

Substituting the values of various diameters and socket lengths equal to 3 times diameter, allowable load on single pile can be summarized as follows,

Summary of the Safe load calculation in Compression

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	21.37	21.85	22.27
Termination level RL in m	181.13	180.65	18.0.23
End Bearing Component in kN	1102.1	1768.3	2479.8
Friction Component in kN	661.3	1060.9	1487.9
Safe load in Compression in kN	1763.4	2829.3	3967.7
Safe load in Compression in T	176	283	397

5.0 Safe Load on Pile in uplift

At 4.00m FGL

The overburden soils, though, will not contribute in compression capacity would offer resistance in uplift capacity. The parameters of BH 91 are considered for calculation of uplift resistance as summarized below,

Depth in m from RL 202.5 m	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Submerged density in gm/cc γ_{sub}	Reduction Factor α	Earth pressure coefficient K	Angle of wall friction $\delta = \phi$	SPT N Value
FGL to 4.00	No contribution considered - Cut off level						
4.00 to 8.67	0.62 [#]	4~0*	0.97	0.72	NA	NA	4-12
8.67 to 10.27	0.07~0.00*	27 [#]	1.02	NA	1.00	27	17-20
10.27 to 11.57	0.80	7~0*	0.99	0.58	NA	NA	14
11.57 to 17.27	0.06 [#] ~0.00*	27 [#]	1.03	NA	1.00	27	18->100
17.27 to 19.57	4.00 ^{\$}	0	1.04	0.28	NA	NA	>100
19.57 to 22.97	Rock strata – Resistance would be as per skin friction capacity in socket as already calculated in compression capacity						

Ultimate load in skin friction,

$$Q_{uf} = \alpha_i C_{ai} A_{si} + K_i P D_i \tan \delta_i A_{si}$$

First Layer – Cut off level

$$\text{Second Layer} - \alpha_2 C_{a2} A_{s2} = 0.72 * 6.20 * \pi d * 4.67 = 65.49 d$$

$$\text{Third Layer} - K_3 P D_3 \tan \delta_3 A_{s3} = 1.00 * 8.55 * \tan 27 * \pi d * 1.60 = 21.90 d$$

$$\text{Fourth Layer} - \alpha_4 C_{a4} A_{s4} = 0.58 * 8.00 * \pi d * 1.30 = 18.95 d$$

$$\text{Fifth Layer} - K_5 P D_5 \tan \delta_5 A_{s5} = 1.00 * 10.48 * \tan 27 * \pi d * 5.70 = 95.62 d$$

$$\text{Sixth Layer} - \alpha_6 C_{a6} A_{s6} = 0.28 * 40.00 * \pi d * 2.30 = 80.93 d$$

Seventh Layer – 1836.90 d² in rock socket

$$\text{Substituting, ultimate load } q_{uf} = 2828.90 d + 1836.9 d^2$$

The safe load in uplift is worked out (considering the safety factor of 2.50 for overburden soils) and summarized below,

Safe Load on Piles in Uplift (in Ton)

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	21.37	21.85	22.27
Termination level RL in m	181.13	180.65	180.23
Safe load in Uplift in kN	1340.22	1920.98	2506.29
Self-weight of pile in kN	73.63	121.40	174.25
Safe load in Uplift in T (Considering self-weight of pile)	141.39	204.24	268.05

6.0 Lateral Pile Capacity

Pile would be long and elastic (i.e. $L > 4T$). For a prescribed deflection of 5mm and with M 30 grade of concrete, the lateral load and moment were worked out as follows,

Diameters in m		0.60	0.76	0.90
Subgrade reaction in MN/m ³		5.76	5.76	5.76
Stiffness factor T in m		1.99	2.40	2.75
Depth of fixity in m	Free Head	3.80	4.60	5.20
	Fixed Head	4.30	5.20	6.00
Allowable Horizontal Force in T	Free Head	5.00	7.20	9.50
	Fixed Head	13.10	19.20	25.10
Allowable Moment capacity in Tm	Free Head	6.55	11.56	17.34
	Fixed Head	23.32	41.13	61.72

7.0 Notes

1. Pile shall be terminated after socketing 3D inside rock.
2. Initial and routine pile load test is required to verify the actual carrying capacity of pile in compression, uplift and lateral loads.
3. For design and construction, specification of IS: 2911, P1/S2, IS: 456, 2000 shall strictly be followed.

(Dr. K. K. Thaker)

Appendix – 8B

Calculation of Safe Load on Uniform Diameter Bored Cast in situ Pile. (Near BH-91) (ID fan Unit-2)

The safe load is calculated as follows,

1) Design Stipulations

- | | |
|---|---|
| 1. Type of pile | - Bored cast in situ uniform diameter pile. |
| 2. Pile diameter considered | - 0.60m |
| 3. Termination depth of pile considered | - 15.00m from FGL. |
| 4. Cut off Level | - At 4.00m from FGL. |
| 5. Factor of Safety | - 2.50 |
| 6. Depth of Water table | - Considered at FGL. |
| 7. Ref | - IS 2911 P-I, Sec-II, 2021. |

2) Test Data

The parameters are based on BH 91. For evaluation of safe load on piles following characterized layers are considered as described in table below,

Depth in m from RL 202.5 m	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Submerged density in gm/cc γ_{sub}	Reduction Factor α	Earth pressure coefficient K	Angle of wall friction $\delta = \phi$	SPT N Value
FGL to 4.00	No contribution considered - Cut off level						
4.00 to 8.67	0.62 [#]	4~0*	0.97	0.72	NA	NA	4-12
8.67 to 10.27	0.07~0.00*	27 [#]	1.02	NA	1.00	27	17-20
10.27 to 11.57	0.80	7~0*	0.99	0.58	NA	NA	14
11.57 to 17.27	0.06 [#] ~0.00*	27 [#]	1.03	NA	1.00	27	18->100
17.27 to 19.57	4.00 ^{\$}	0	1.04	0.28	NA	NA	>100
19.57 to 22.97	Rock strata – Resistance would be as per skin friction capacity in socket as already calculated in compression capacity						

Notes: - Layers are characterized based on classification and the state of soil in that stratum.

* - In cohesive soils the contribution of the angle of internal friction being insignificant is ignored.

Shear parameters are the most representative for the layer. NA means not applicable. Characterized N values are considered for each layer.

- Weighted Average of the parameters falling in the same layer has been considered

\$-Parameters are correlated based on SPT value N.

3) Ultimate Load in Compression

3.1) Ultimate load in Compression by Bearing

Ultimate load on pile in end bearing,

$$q_{ub} = A_p (0.5 \cdot D \cdot \gamma \cdot N_v + P D N_q)$$

$$A_p = \text{Cross section area of Pile stem at toe} = \pi d^2 / 4$$

$$D = \text{Diameter of pile} = d \text{ in m}$$

$$N_v = 42.90$$

$$N_q = 40.00$$

$$q_{ub} = 0.785d^2 (0.5 \cdot d \cdot 1.04 \cdot 42.90 + 8.92 \cdot 40.00) = 17.51d^3 + 280.09d^2$$

(For Pile terminating at 15.00m from F.G.L.)

Note: As the pile terminating just above rock level, we have considered parameter for end bearing component based on rock strata.

3.2) Ultimate Load in Compression by Skin Friction

Ultimate load in skin friction,

$$q_{uf} = \alpha_i C_{ai} A_i + K_i P D_i \tan \delta_i A_{si}$$

First Layer – No contribution considered due to cut off level

Second Layer – $\alpha_2 C_{a2} A_{s2} = 0.72 \cdot 6.20 \cdot \pi \cdot d \cdot 4.67 = 65.49 d$

Third Layer – $K_3 P D_3 \tan \delta_3 A_{s3} = 1.00 \cdot 5.35 \cdot \tan 27^\circ \cdot \pi \cdot d \cdot 1.60 = 13.70 d$

Fourth Layer – $\alpha_4 C_{a4} A_{s4} = 0.58 \cdot 8.00 \cdot \pi \cdot d \cdot 1.30 = 18.95 d$

Fifth Layer – K5 PD5 $\tan\delta_5 A_{s5} = 1.00 \times 8.92 \times \tan 27^\circ \times \pi d (\ell - 11.57) = 14.28d (\ell - 11.57)$

Substituting, ultimate load

$$q_{uf} = 98.14d + 14.28d (\ell - 11.57) \text{ (For Pile terminating at 15.00m from F.G.L.)}$$

Where, ℓ is the pile length and d is diameter of piles, substituting

Ultimate load by both bearing and friction can be as follows for various lengths of piles,

$$q_{uc} = q_{ub} + q_{uf}$$

$$q_{uc} = 17.51d^3 + 280.09d^2 + 98.14d + 14.28d (\ell - 11.57)$$

(For Pile terminating at 15.00m from F.G.L.)

By substituting various diameters of piles having various lengths, the safe load is worked out considering the safety factor of 2.50 and are given in table below,

Safe Load on Piles in Compression (in Ton)

Termination Depth of Pile in m, from FGL	Termination Depth of Pile in m, from cut-off	Diameter of Pile in, m
		0.60
15.00	11.00	77.23

3.3) Ultimate Load in Uplift

Considering skin friction for determination of uplift

Safe Load on Piles in Uplift (in Ton)

Termination Depth of Pile in m, from FGL	Termination Depth of Pile in m, from cut-off	Diameter of Pile in, m
		0.60
15.00	11.00	34.15

Note: Self weight of pile is considered in calculation of ultimate load in uplift.

Self-weight of Pile (in Ton)

Termination Depth of Pile in m, from FGL	Termination Depth of Pile in m, from cut-off	Diameter of Pile in, m
		0.60
15.00	11.00	4.67

3.4) Lateral Pile Capacity

Pile would be long and elastic (i.e. $L > 4T$). For a prescribed deflection of 5mm and with M 30 grade of concrete, the lateral load and moment were worked out as follows,

Diameters in m		0.60
Subgrade reaction in MN/m ³		5.76
Stiffness factor T in m		1.99
Depth of fixity in m	Free Head	3.80
	Fixed Head	4.30
Allowable Horizontal Force in T	Free Head	5.00
	Fixed Head	13.10
Allowable Moment capacity in Tm	Free Head	6.55
	Fixed Head	23.32

4) Notes:

1) Initial and Routine pile load tests shall be carried out as per IS 2911, P-4 on the piles to confirm the capacity of pile worked out theoretically. For design and construction, specifications of IS 2911, P-I, S-2, shall strictly be followed. Termination depth of pile shall be from FGL.

Dr. K. K. Thaker

Appendix – 9A

Calculation of Safe Load carrying capacity of piles socketed inside rock (Near BH-106) (ID Fan Unit-3)

Project Name: - Proposed structures of thermal power project of NTTTP at Hirma, Talabira

1.0 Introduction

In situations where overburden offering low bearing pressure is followed by rock at relatively shallower depths, end bearing piles is the suitable foundation option. Piles in rocks and weathered rocks of varying degree of weathering derive their capacity by end bearing and socket side resistance.

In situations, where, rock strata comprises of highly fragmented rock, as in present case, where RQD is nil or $(CR+RQD)/2$ is less than 30 % or when the crushing strength is less than 10 MPa, the appropriate approach would be of that suggested by Cole & Stroud.

In present site overburden soils overlay fractured / laminated / foliated rock. The founding stratum having highly fragmented rock with nil RQD and $(CR+RQD)/2$ to be less than 30 %, the approach suggested by Cole and Stroud as per Annex B under clause 6.3.1.1 and 6.3.2 of IS 2911 Pa/S2 has been used for safe load calculations.

An illustrative calculation of safe load on pile and summary of pile capacities is as follows,

2.0 Sub soil strata Characterization

General stratification at the location of boreholes BH 106 show primarily two characterized layers,

1. Overburden comprising of fine to medium grained, sandy clays of intermediate plasticity with some gravels followed by fine to coarse grained, clayey sand with much gravels followed by fine to medium grained, clayey sand with little to some gravels followed by fine to very fine grained, sandy clays of intermediate plasticity followed by fine to very fine grained, clayey sand with occasional gravels followed by fine to very fine grained, cemented sandy clays of low plasticity- mud stone followed by fine to very fine grained, cemented, sandy clays of low plasticity –mud stone upto 10.30m (i.e. RL 186.80m).
2. Second characterized layer below the overburden soils comprises of Highly weathered, weak light yellowish brown to reddish brown, fine to very fine grained, fractured rock upto 15.50m (i.e. RL 181.60m).

3.0 Design Considerations

1. Length of socket considered 3D from depth of rock encountered.
2. The pile is considered to have socket length below 10.30 m below NGL (i.e. RL 186.80 m) depth.
3. For present case of pile terminating in highly weathered rock. SPT at depths between 10.30 to 15.50m (between RL 186.80 to 181.60 m) is > 100 with just 7.0 cm penetration in 50 blows. SPT can be extrapolated for 30 cm i.e. $50 * 30 / 7.00 = 214$.

Based on recommendation of fig no. 3 in B 8 in Annex B under clause 6.3.1.1 and 6.3.2 of IS 2911 P1/S2, average shear strength q_c corresponding to assumed SPT of 200 may be taken as 1300 kN/m²

4. Allowable Capacity of pile socketed into rock $Q_a = R_e + R_{sf} = C_{u1} N_c \pi B^2 / 4 (F_s = 3) + \alpha C_{u2} \pi BL / (F_s = 6)$

4.0 Safe Load on Pile in Compression

Where,

End bearing component, $R_e = C_{u1} N_c \pi B^2 / 4 F_s$,

C_{u1} = Shear strength below base of pile = 1300 kN/m²

B = diameter of the pile = d

F_s = Factor of Safety = 3

$N_c = 9$

Therefore, **$R_e = 3061.5 d^2$**

Skin friction component of socketed length of pile, $R_{sf} = \alpha C_{u2} \pi BL / F_s$

$\alpha = 0.9$ (recommended value in IS 2911 P1/S2)

L = length of the socket = 3 D

C_{u2} = Ultimate shear strength along socket length which shall be restricted to shear capacity of concrete of the pile = 1300 kN/m²

F_s = Factor of Safety = 6

Therefore, **$R_{sf} = 1836.9 d^2$**

Thus,

$$Q_a = c_{u1} N_c \cdot \frac{\pi B^2}{4 F_s} + \alpha c_{u2} \cdot \frac{\pi BL}{F_s}$$

$$= 3061.5 d^2 + 1836.9 d^2 = 4898.4 d^2$$

Substituting the values of various diameters and socket lengths equal to 3 times diameter, allowable load on single pile can be summarized as follows,

Summary of the Safe load calculation in Compression

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	17.50	17.98	18.40
Termination level RL in m	185.00	184.52	184.10
End Bearing Component in kN	1102.1	1768.3	2479.8
Friction Component in kN	661.3	1060.9	1487.9
Safe load in Compression in kN	1763.4	2829.3	3967.7
Safe load in Compression in T	176	283	397

5.0 Safe Load on Pile in uplift

At 6.00m FGL

The overburden soils, though, will not contribute in compression capacity would offer resistance in uplift capacity. The parameters of BH 106 are considered for calculation of uplift resistance as summarized below,

Depth in m from RL 202.5 m	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Submerged density in gm/cc γ_{sub}	Reduction Factor α	Earth pressure coefficient K	Angle of wall friction $\delta = \phi$	SPT N Value
FGL to 6.00	No contribution considered - Cut off level						
6.00 to 7.80	0.28 ^{\$}	0	0.67	1.00	NA	NA	7-11
7.80 to 11.20	0.08 [#] ~0.00*	26 [#]	0.92	NA	1.00	26	10-18
11.20 to 12.30	1.65	6~0*	1.00	0.28	NA	NA	12
12.30 to 13.20	0.07~0.00*	29	1.12	NA	1.00	29	42
13.20 to 15.70	6.66 ^{\$}	0	1.12	0.28	NA	NA	>100
15.70 to 30.40	Rock strata – Resistance would be as per skin friction capacity in socket as already calculated in compression capacity						

#Average of the parameters falling in the same layer has been considered.

\$Parameters of this layer is considered based on SPT N value.

Ultimate load in skin friction,

$$Q_{uf} = \alpha_i C_{ai} A_{si} + K_i P D_i \tan \delta_i A_{si}$$

First Layer – Cut off level

$$\text{Second Layer} - \alpha_2 C_{a2} A_{s2} = 1.00 * 2.80 * \pi d * 1.80 = 15.83d$$

$$\text{Third Layer} - K_3 P D_3 \tan \delta_3 A_{s3} = 1.00 * 7.57 * \tan 26^\circ * \pi d * 3.40 = 39.44 d$$

$$\text{Fourth Layer} - \alpha_4 C_{a4} A_{s4} = 0.28 * 16.50 * \pi d * 1.10 = 15.97d$$

$$\text{Fifth Layer} - K_5 P D_5 \tan \delta_5 A_{s5} = 1.00 * 9.34 * \tan 29^\circ * \pi d * 0.90 = 14.64 d$$

$$\text{Sixth Layer} - \alpha_6 C_{a6} A_{s6} = 0.28 * 66.60 * \pi d * 2.50 = 146.46d$$

Seventh Layer – 1836.90 d² in rock socket

$$\text{Substituting, ultimate load } q_{uf} = 2323.41 d + 1836.9 d^2$$

The safe load in uplift is worked out (considering the safety factor of 2.50 for overburden soils) and summarized below,

Safe Load on Piles in Uplift (in Ton)

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	17.50	17.98	18.40
Termination level RL in m	185.00	184.52	184.10
Safe load in Uplift in kN	1218.90	1767.31	2324.32
Self-weight of pile in kN	48.75	81.48	118.27
Safe load in Uplift in T (Considering self-weight of pile)	126.77	184.88	244.26

6.0 Lateral Pile Capacity

Pile would be long and elastic (i.e. $L > 4T$). For a prescribed deflection of 5mm and with M 30 grade of concrete, the lateral load and moment were worked out as follows,

Diameters in m		0.60	0.76	0.90
Subgrade reaction in MN/m ³		10.08	10.08	10.08
Stiffness factor T in m		1.78	2.14	2.46
Depth of fixity in m	Free Head	3.40	4.10	4.70
	Fixed Head	3.90	4.70	5.40
Allowable Horizontal Force in T	Free Head	6.90	10.10	13.30
	Fixed Head	18.40	26.80	35.20
Allowable Moment capacity in Tm	Free Head	8.20	14.46	21.69
	Fixed Head	29.18	51.45	77.20

7.0 Notes

1. Pile shall be terminated after socketing 3D inside rock.
2. Initial and routine pile load test is required to verify the actual carrying capacity of pile in compression, uplift and lateral loads.
3. For design and construction, specification of IS: 2911, P1/S2, IS: 456, 2000 shall strictly be followed.

(Dr. K. K. Thaker)

Appendix – 9B

Calculation of Safe Load on Uniform Diameter Bored Cast in situ Pile. (Near BH-106) (ID Fan Unit-3)

The safe load is calculated as follows,

1) Design Stipulations

- | | |
|---|---|
| 1. Type of pile | - Bored cast in situ uniform diameter pile. |
| 2. Pile diameter considered | - 0.60m |
| 3. Termination depth of pile considered | - 15.00m from FGL. |
| 4. Cut off Level | - At 5.50m from FGL. |
| 5. Factor of Safety | - 2.50 |
| 6. Depth of Water table | - Considered at FGL. |
| 7. Ref | - IS 2911 P-I, Sec-II, 2021. |

2) Test Data

The parameters are based on BH 106. For evaluation of safe load on piles following characterized layers are considered as described in table below,

Depth in m from RL 202.5 m	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Submerged density in gm/cc γ_{sub}	Reduction Factor α	Earth pressure coefficient K	Angle of wall friction $\delta = \phi$	SPT N Value
FGL to 5.50	No contribution considered - Cut off level						
5.50 to 7.80	0.28 ^{\$}	0	0.67	1.00	NA	NA	7-11
7.80 to 11.20	0.08 [#] ~0.00*	26 [#]	0.92	NA	1.00	26	10-18
11.20 to 12.30	1.65	6~0*	1.00	0.28	NA	NA	12
12.30 to 13.20	0.07~0.00*	29	1.12	NA	1.00	29	42
13.20 to 15.70	4.00 ^{\$}	0	1.12	0.28	NA	NA	>100

Notes: - Layers are characterized based on classification and the state of soil in that stratum.

* - In cohesive soils the contribution of the angle of internal friction being insignificant is ignored.

Shear parameters are the most representative for the layer. NA means not applicable. Characterized N values are considered for each layer.

- Weighted Average of the parameters falling in the same layer has been considered

\$-Parameters are correlated based on SPT value N.

3) Ultimate Load in Compression

3.1) Ultimate load in Compression by Bearing

Ultimate load on pile in end bearing,

$$q_{ub} = A_p (0.5 \cdot D \cdot \gamma \cdot N_v + P D N_q)$$

$$A_p = \text{Cross section area of Pile stem at toe} = \pi d^2/4$$

$$D = \text{Diameter of pile} = d \text{ in m}$$

$$N_v = 42.90$$

$$N_q = 40.00$$

$$q_{ub} = 0.785d^2 (0.5 \cdot d \cdot 1.12 \cdot 42.90 + 8.23 \cdot 40.00) = 18.86d^3 + 258.42d^2$$

(For Pile terminating at 15.00m from F.G.L.)

Note: As the pile terminating just above rock level, we have considered parameter for end bearing component based on rock strata.

3.2) Ultimate Load in Compression by Skin Friction

Ultimate load in skin friction,

$$q_{uf} = \alpha_i C_{ai} A_i + K_i P D_i \tan \delta_i A_{si}$$

First Layer – No contribution considered due to cut off level

$$\text{Second Layer} - \alpha_2 C_{a2} A_{s2} = 1.00 \cdot 2.80 \cdot \pi \cdot d \cdot 2.30 = 20.23d$$

$$\text{Third Layer} - K_3 P D_3 \tan \delta_3 A_{s3} = 1.00 \cdot 3.11 \cdot \tan 26^\circ \cdot \pi \cdot d \cdot 3.40 = 16.20d$$

$$\text{Fourth Layer} - \alpha_4 C_{a4} A_{s4} = 0.28 \cdot 16.50 \cdot \pi \cdot d \cdot 1.10 = 15.97d$$

$$\text{Fifth Layer} - K_5 P D_5 \tan \delta_5 A_{s5} = 1.00 \cdot 6.27 \cdot \tan 29^\circ \cdot \pi \cdot d \cdot 0.90 = 9.31d$$

$$\text{Sixth Layer} - \alpha_6 C_{a6} A_{s6} = 0.28 \cdot 66.60 \cdot \pi \cdot d \cdot (15.70 - 13.20) = 385.8d$$

Substituting, ultimate load

$$q_{uf} = 61.71d + 58.58d (\ell - 13.20) \text{ (For Pile terminating at 15.00m from F.G.L.)}$$

Where, ℓ is the pile length and d is diameter of piles, substituting

Ultimate load by both bearing and friction can be as follows for various lengths of piles,

$$q_{uc} = q_{ub} + q_{uf}$$

$$q_{uc} = 18.86d^3 + 258.42d^2 + 61.71d + 58.58d (\ell - 13.20) \text{ (For Pile terminating at 15.00m from F.G.L.)}$$

By substituting various diameters of piles having various lengths, the safe load is worked out considering the safety factor of 2.50 and are given in table below,

Safe Load on Piles in Compression (in Ton)

Termination Depth of Pile in m, from FGL	Termination Depth of Pile in m, from cut-off	Diameter of Pile in, m
		0.60
15.00	9.50	79.07

3.3) Ultimate Load in Uplift

Considering skin friction for determination of uplift

Safe Load on Piles in Uplift (in Ton)

Termination Depth of Pile in m, from FGL	Termination Depth of Pile in m, from cut-off	Diameter of Pile in, m
		0.60
15.00	9.50	37.54

Note: Self weight of pile is considered in calculation of ultimate load in uplift.

Self weight of Pile (in Ton)

Termination Depth of Pile in m, from FGL	Termination Depth of Pile in m, from cut-off	Diameter of Pile in, m
		0.60
15.00	9.00	4.03

3.4) Lateral Pile Capacity

Pile would be long and elastic (i.e. $L > 4T$). For a prescribed deflection of 5mm and with M 30 grade of concrete, the lateral load and moment were worked out as follows,

Diameters in m		0.60
Subgrade reaction in MN/m ³		10.08
Stiffness factor T in m		1.78
Depth of fixity in m	Free Head	3.40
	Fixed Head	3.90
Allowable Horizontal Force in T	Free Head	6.90
	Fixed Head	18.40
Allowable Moment capacity in Tm	Free Head	8.20
	Fixed Head	29.18

4) Notes:

1) Initial and Routine pile load tests shall be carried out as per IS 2911, P-4 on the piles to confirm the capacity of pile worked out theoretically. For design and construction, specifications of IS 2911, P-I, S-2, shall strictly be followed. Termination depth of pile shall be from FGL.

Dr. K. K. Thaker

Appendix – 10A

Calculation of Safe Load carrying capacity of piles socketed inside rock (Near IBH 18, BH-70) (Mill & Bunker Unit-1)

Project Name: - Proposed structures of thermal power project of NTTTP at Hirma, Talabira

1.0 Introduction

In situations where overburden offering low bearing pressure is followed by rock at relatively shallower depths, end bearing piles is the suitable foundation option. Piles in rocks and weathered rocks of varying degree of weathering derive their capacity by end bearing and socket side resistance.

In situations, where, rock strata comprises of highly fragmented rock, as in present case, where RQD is nil or $(CR+RQD)/2$ is less than 30 % or when the crushing strength is less than 10 MPa, the appropriate approach would be of that suggested by Cole & Stroud.

In present site overburden soils overlay fractured / laminated / foliated rock. The founding stratum having highly fragmented rock with nil RQD and $(CR+RQD)/2$ to be less than 30 %, the approach suggested by Cole and Stroud as per Annex B under clause 6.3.1.1 and 6.3.2 of IS 2911 P1/S2 has been used for safe load calculations.

An illustrative calculation of safe load on pile and summary of pile capacities is as follows,

2.0 Sub soil strata Characterization

General stratification at the location of boreholes IBH 18 show primarily two characterized layers,

1. Overburden comprising of fine to very fine grained, sandy clays of intermediate to high plasticity with occasional gravels and fine to medium grained, clayey and silty sand with little plastic fines up to 14.20 m (i.e. RL 186.14 m).
2. Second characterized layer below the overburden soils comprises of Highly weathered, very weak, dark greenish grey, very fine grained, very weak, very thinly laminated, foliated SHALE upto 16.00m (i.e. RL 184.34 m).

3.0 Design Considerations

1. Length of socket considered 3D from depth of rock encountered.
2. The pile is considered to have socket length below 14.20 m below NGL (i.e. RL 186.14 m) depth.
3. For present case of pile terminating in highly weathered rock. SPT at depths between 14.20 to 16.00m (between RL 186.14 to 184.34 m) is > 200.
Based on recommendation of fig no. 3 in B 8 in Annex B under clause 6.3.1.1 and 6.3.2 of IS 2911 P1/S2, average shear strength q_c corresponding to assumed SPT of 200 may be taken as 1300 kN/m²
4. Allowable Capacity of pile socketed into rock $Q_a = R_e + R_{sf} = C_{u1} N_c \pi B^2 / 4 (F_s = 3) + \alpha C_{u2} \pi BL / (F_s = 6)$

4.0 Safe Load on Pile in Compression

Where,

End bearing component, $R_e = C_{u1} N_c \pi B^2 / 4 F_s$,

C_{u1} = Shear strength below base of pile = 1300 kN/m²

B = diameter of the pile = d

F_s = Factor of Safety = 3

$N_c = 9$

Therefore, **$R_e = 3061.5 d^2$**

Skin friction component of socketed length of pile, $R_{sf} = \alpha C_{u2} \pi BL / F_s$

$\alpha = 0.9$ (recommended value in IS 2911 P1/S2)

L = length of the socket = $3 D$

C_{u2} = Ultimate shear strength along socket length which shall be restricted to shear capacity of concrete of the pile = 1300 kN/m^2

F_s = Factor of Safety = 6

Therefore, $R_{sf} = 1836.9 d^2$

Thus,

$$Q_a = c_{u1} N_c \cdot \frac{\pi B^2}{4 F_s} + \alpha c_{u2} \cdot \frac{\pi B L}{F_s}$$

$$= 3061.5 d^2 + 1836.9 d^2 = 4898.4 d^2$$

Substituting the values of various diameters and socket lengths equal to 3 times diameter, allowable load on single pile can be summarized as follows,

Summary of the Safe load calculation in Compression

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	18.16	18.64	19.06
Termination level RL in m	184.34	183.86	183.44
End Bearing Component in kN	1102.1	1768.3	2479.8
Friction Component in kN	661.3	1060.9	1487.9
Safe load in Compression in kN	1763.4	2829.3	3967.7
Safe load in Compression in T	176	283	397

5.0 Safe Load on Pile in uplift

For 3.00m cutoff from FGL

The overburden soils, though, will not contribute in compression capacity would offer resistance in uplift capacity. The parameters of IBH 18 are considered for calculation of uplift resistance as summarized below,

Depth in m from RL 202.5 m	Cohesion in kg/cm^2	Angle of Internal Friction ϕ	Submerged density in gm/cc γ_{sub}	Reduction Factor α	Earth pressure coefficient K	Angle of wall friction $\delta = \phi$	SPT N Value
0.00 to 3.00	Pile cutoff level – No pile						
3.00 to 11.66	1.00	4(ignored)	0.98	0.42	NA	NA	11-24
11.66 to 16.36	0.05(ignored)	28	1.04	NA	1.00	28	18->100
16.36 to 27.16	Rock strata – Resistance would be as per skin friction capacity in socket as already calculated in compression capacity						

Ultimate load in skin friction,

$$Q_{uf} = \alpha_i C_{ai} A_{si} + K_i P D_i \tan \delta_i A_{si}$$

First Layer – No contribution considered – (Within Cutoff Level).

$$\text{Second Layer} - \alpha_2 C_{a2} A_{s2} = 0.42 * 10.00 * \pi * d * 8.66 = 114.27d$$

$$\text{Third Layer} - K_3 P D_3 \tan \delta_3 A_{s3} = 1.00 * 10.63 * \tan 28 * \pi * d * 4.70 = 83.46 d$$

Fourth Layer – $1836.90 d^2$ in rock socket

$$\text{Substituting, ultimate load } q_{uf} = 1977.26 d + 1836.9 d^2$$

The safe load in uplift is worked out (considering the safety factor of 2.50 for overburden soils) and summarized below,

Safe Load on Piles in Uplift (in Ton)

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	18.16	18.64	19.06
Termination level RL in m	184.34	183.86	183.44
Safe load in Uplift in kN	1135.83	1662.08	2199.70
Self-weight of pile in kN	64.26	106.37	153.18
Safe load in Uplift in T (Considering self-weight of pile)	120.00	176.85	235.29

6.0 Lateral Pile Capacity

Pile would be long and elastic (i.e. $L > 4T$). For a prescribed deflection of 5mm and with M 30 grade of concrete, the lateral load and moment were worked out as follows,

Diameters in m		0.60	0.76	0.90
Subgrade reaction in MN/m^3		15.84	15.84	15.84
Stiffness factor T in m		1.62	1.96	2.24
Depth of fixity in m	Free Head	3.10	3.70	4.30
	Fixed Head	3.50	4.30	4.90
Allowable Horizontal Force in T	Free Head	9.10	13.30	17.40
	Fixed Head	24.10	35.20	46.10
Allowable Moment capacity in Tm	Free Head	9.82	17.32	25.99
	Fixed Head	34.96	61.65	92.50

7.0 Notes

1. Pile shall be terminated after socketing 3D inside rock.
2. Initial and routine pile load test is required to verify the actual carrying capacity of pile in compression, uplift and lateral loads.
3. For design and construction, specification of IS: 2911, P1/S2, IS: 456, 2000 shall strictly be followed.

(Dr. K. K. Thaker)

Appendix – 10B

Calculation of Safe Load on Uniform Diameter Bored Cast in situ Pile. (Near IBH 18, BH-70) (Mill & Bunker Unit-1)

The safe load is calculated as follows,

1) Design Stipulations

- | | |
|---|---|
| 1. Type of pile | - Bored cast in situ uniform diameter pile. |
| 2. Pile diameter considered | - 0.60m |
| 3. Termination depth of pile considered | - 14.00m from FGL. |
| 4. Cut off Level | - At 3.00m from FGL. |
| 5. Factor of Safety | - 2.50 |
| 6. Depth of Water table | - Considered at FGL. |
| 7. Ref | - IS 2911 P-I, Sec-II, 2021. |

2) Test Data

The parameters are based on IBH 18. For evaluation of safe load on piles following characterized layers are considered as described in table below,

Depth in m from RL 202.5 m	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Submerged density in gm/cc γ_{sub}	Reduction Factor α	Earth pressure coefficient K	Angle of wall friction $\delta = \phi$	SPT N Value
FGL to 1.00	No contribution considered - Cut off level						
3.00 to 11.66	1.00	4~0*	0.98	0.42	NA	NA	11-24
11.66 to 16.36	0.05~0.00*	28	1.04	NA	1.00	28	18->100
16.36 to 27.16	0.00	34\$	1.05	NA	1.50	34	>100

Notes: - Layers are characterized based on classification and the state of soil in that stratum.

* - In cohesive soils the contribution of the angle of internal friction being insignificant is ignored.

Shear parameters are the most representative for the layer. NA means not applicable. Characterized N values are considered for each layer.

- Weighted Average of the parameters falling in the same layer has been considered

\$-Parameters are correlated based on SPT value N.

3) Ultimate Load in Compression

3.1) Ultimate load in Compression by Bearing

Ultimate load on pile in end bearing,

$$q_{ub} = A_p (0.5 \cdot D \cdot \gamma N_\gamma + P D N_q)$$

$$A_p = \text{Cross section area of Pile stem at toe} = \pi d^2/4$$

$$D = \text{Diameter of pile} = d \text{ in m}$$

$$N_\gamma = 42.90$$

$$N_q = 40.00$$

$$q_{ub} = 0.785d^2 (0.5 \cdot d \cdot 1.04 \cdot 42.90 + 8.82 \cdot 40.00) = 17.51d^3 + 276.95d^2$$

(For Pile terminating at 14.00m from F.G.L.)

Note: As the pile terminating just above rock level, we have considered parameter for end bearing component based on rock strata.

3.2) Ultimate Load in Compression by Skin Friction

Ultimate load in skin friction,

$$q_{uf} = \alpha_i C_{ai} A_i + K_i P D_i \tan \delta_i A_{si}$$

First Layer – No contribution considered due to cut off level

$$\text{Second Layer} - \alpha_2 C_{a2} A_{s2} = 0.42 \cdot 10.00 \cdot \pi \cdot d \cdot 8.66 = 114.27d$$

$$\text{Third Layer} - K_3 P D_3 \tan \delta_3 A_{s3} = 1.00 \cdot 8.82 \cdot \tan 28^\circ \cdot \pi \cdot d \cdot (\ell - 11.66) = 14.73d (\ell - 11.66)$$

Substituting, ultimate load

$$q_{uf} = 114.27d + 14.73d (\ell - 11.66) \text{ (For Pile terminating at 14.00m from F.G.L.)}$$

Where, ℓ is the pile length and d is diameter of piles, substituting

Ultimate load by both bearing and friction can be as follows

$$q_{uc} = q_{ub} + q_{uf}$$

$$q_{uc} = 17.51d^3 + 276.95d^2 + 114.27d + 14.73d(l - 11.66) \text{ (For Pile terminating at 14.00m from F.G.L.)}$$

By substituting various diameters of piles having various lengths, the safe load is worked out considering the safety factor of 2.50 and are given in table below,

Safe Load on Piles in Compression (in Ton)

Termination Depth of Pile in m, from FGL	Termination Depth of Pile in m, from cut-off	Diameter of Pile in, m
		0.60
14.00	11.00	77.09

3.3) Ultimate Load in Uplift

Considering skin friction for determination of uplift

Safe Load on Piles in Uplift (in Ton)

Termination Depth of Pile in m, from FGL	Termination Depth of Pile in m, from cut-off	Diameter of Pile in, m
		0.60
14.00	11.00	34.40

Note: Self weight of pile is considered in calculation of ultimate load in uplift.

Self weight of Pile (in Ton)

Termination Depth of Pile in m, from FGL	Termination Depth of Pile in m, from cut-off	Diameter of Pile in, m
		0.60
14.00	11.00	4.67

3.4) Lateral Pile Capacity

Pile would be long and elastic (i.e. $L > 4T$). For a prescribed deflection of 5mm and with M 30 grade of concrete, the lateral load and moment were worked out as follows,

Diameters in m		0.60
Subgrade reaction in MN/m ³		15.84
Stiffness factor T in m		1.62
Depth of fixity in m	Free Head	3.10
	Fixed Head	3.50
Allowable Horizontal Force in T	Free Head	9.10
	Fixed Head	24.10
Allowable Moment capacity in Tm	Free Head	9.82
	Fixed Head	34.96

4) Notes:

1) Initial and Routine pile load tests shall be carried out as per IS 2911, P-4 on the piles to confirm the capacity of pile worked out theoretically. For design and construction, specifications of IS 2911, P-I, S-2, shall strictly be followed. Termination depth of pile shall be from FGL.

Dr. K. K. Thaker

Appendix – 11A

Calculation of Safe Load carrying capacity of piles socketed inside rock (Near BH-71) (MRS Silo)

Project Name: - Proposed structures of thermal power project of NTTTP at Hirma, Talabira

1.0 Introduction

In situations where overburden offering low bearing pressure is followed by rock at relatively shallower depths, end bearing piles is the suitable foundation option. Piles in rocks and weathered rocks of varying degree of weathering derive their capacity by end bearing and socket side resistance.

In situations, where, rock strata comprises of highly fragmented rock, as in present case, where RQD is nil or $(CR+RQD)/2$ is less than 30 % or when the crushing strength is less than 10 MPa, the appropriate approach would be of that suggested by Cole & Stroud.

In present site overburden soils overlay fractured / laminated / foliated rock. The founding stratum having highly fragmented rock with nil RQD and $(CR+RQD)/2$ to be less than 30 %, the approach suggested by Cole and Stroud as per Annex B under clause 6.3.1.1 and 6.3.2 of IS 2911 Pa/S2 has been used for safe load calculations.

An illustrative calculation of safe load on pile and summary of pile capacities is as follows,

2.0 Sub soil strata Characterization

General stratification at the location of boreholes BH 71 show primarily two characterized layers,

1. Overburden comprising of fine to medium grained, clayey sand followed by fine to medium grained, sandy clays of intermediate plasticity followed by very fine grained, clays of high plasticity followed by fine to very fine grained, silty clayey sand upto 11.90m (i.e. RL 185.98m).
2. Second characterized layer below the overburden soils comprises of Moderately weathered, weak, dark brownish, fine to medium grained, rock with close spacing of discontinuities upto 14.50m (i.e. RL 183.38m).

3.0 Design Considerations

1. Length of socket considered 3D from depth of rock encountered.
2. The pile is considered to have socket length below 11.90 m below NGL (i.e. RL 185.98 m) depth.
3. For present case of pile terminating in highly weathered rock. SPT at depths between 11.90 to 14.50m (between RL 185.98 to 183.38 m) is > 200.
Based on recommendation of fig no. 3 in B 8 in Annex B under clause 6.3.1.1 and 6.3.2 of IS 2911 P1/S2, average shear strength q_c corresponding to assumed SPT of 200 may be taken as 1300 kN/m²
4. Allowable Capacity of pile socketed into rock $Q_a = R_e + R_{sf} = C_{u1} N_c \pi B^2 / 4 (F_s = 3) + \alpha C_{u2} \pi BL / (F_s = 6)$

4.0 Safe Load on Pile in Compression

Where,

End bearing component, $R_e = C_{u1} N_c \pi B^2 / 4 F_s$,

C_{u1} = Shear strength below base of pile = 1300 kN/m²

B = diameter of the pile = d

F_s = Factor of Safety = 3

$N_c = 9$

Therefore, **$R_e = 3061.5 d^2$**

Skin friction component of socketed length of pile, $R_{sf} = \alpha C_{u2} \pi BL / F_s$

$\alpha = 0.9$ (recommended value in IS 2911 P1/S2)

L = length of the socket = $3 D$

C_{u2} = Ultimate shear strength along socket length which shall be restricted to shear capacity of concrete of the pile = 1300 kN/m²

F_s = Factor of Safety = 6

Therefore, **$R_{sf} = 1836.9 d^2$**

Thus,

$$Q_a = c_{u1} N_c \cdot \frac{\pi B^2}{4 F_s} + \alpha c_{u2} \cdot \frac{\pi B L}{F_s}$$

$$= 3061.5 d^2 + 1836.9 d^2 = 4898.4 d^2$$

Substituting the values of various diameters and socket lengths equal to 3 times diameter, allowable load on single pile can be summarized as follows,

Summary of the Safe load calculation in Compression

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	18.32	18.80	19.22
Termination level RL in m	184.18	183.70	183.28
End Bearing Component in kN	1102.1	1768.3	2479.8
Friction Component in kN	661.3	1060.9	1487.9
Safe load in Compression in kN	1763.4	2829.3	3967.7
Safe load in Compression in T	176	283	397

5.0 Safe Load on Pile in uplift

At 5.00m FGL

The overburden soils, though, will not contribute in compression capacity would offer resistance in uplift capacity. The parameters of BH 71 are considered for calculation of uplift resistance as summarized below,

Depth in m from RL 202.5 m	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Submerged density in gm/cc γ_{sub}	Reduction Factor α	Earth pressure coefficient K	Angle of wall friction $\delta = \phi$	SPT N Value
FGL to 5.00	No contribution considered - Cut off level						
5.00 to 10.22	0.49 [#]	4~0(ignored)	0.94	0.89	NA	NA	7-12
10.22 to 16.52	0.04 [#] ~0.00*	28 [#]	1.03	NA	1.00	28	14-53
16.52 to 24.62	Rock strata – Resistance would be as per skin friction capacity in socket as already calculated in compression capacity						

#Average of the parameters falling in the same layer has been considered.

Ultimate load in skin friction,

$$Q_{uf} = \alpha_i C_{ai} A_{si} + K_i P D_i \tan \delta_i A_{si}$$

First Layer – Cut off level

$$\text{Second Layer} - \alpha_2 C_{a2} A_{s2} = 0.89 * 4.90 * \pi d * 5.22 = 71.52d$$

$$\text{Third Layer} - K_3 P D_3 \tan \delta_3 A_{s3} = 1.00 * 10.12 * \tan 28 * \pi d * 6.30 = 106.50d$$

Fourth Layer – 1836.90 d² in rock socket

$$\text{Substituting, ultimate load } q_{uf} = 1780.19 d + 1836.9 d^2$$

The safe load in uplift is worked out (considering the safety factor of 2.50 for overburden soils) and summarized below,

Safe Load on Piles in Uplift (in Ton)

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	18.32	18.80	19.22
Termination level RL in m	184.18	183.70	183.28
Safe load in Uplift in kN	1088.53	1602.17	2128.76
Self-weight of pile in kN	56.46	93.86	135.63
Safe load in Uplift in T (Considering self-weight of pile)	114.50	169.60	226.44

6.0 Lateral Pile Capacity

Pile would be long and elastic (i.e. $L > 4T$). For a prescribed deflection of 5mm and with M 30 grade of concrete, the lateral load and moment were worked out as follows,

Diameters in m		0.60	0.76	0.90
Subgrade reaction in MN/m ³		11.52	11.52	11.52
Stiffness factor T in m		1.73	2.09	2.39
Depth of fixity in m	Free Head	3.30	4.00	4.50
	Fixed Head	3.80	4.60	5.20
Allowable Horizontal Force in T	Free Head	7.50	11.00	14.40
	Fixed Head	19.90	29.10	38.10
Allowable Moment capacity in Tm	Free Head	8.65	15.25	22.88
	Fixed Head	30.78	54.28	81.44

7.0 Notes

1. Pile shall be terminated after socketing 3D inside rock.
2. Initial and routine pile load test is required to verify the actual carrying capacity of pile in compression, uplift and lateral loads.
3. For design and construction, specification of IS: 2911, P1/S2, IS: 456, 2000 shall strictly be followed.

(Dr. K. K. Thaker)

Appendix – 11B

Calculation of Safe Load on Uniform Diameter Bored Cast in situ Pile. (Near BH-71) (MRS Silo)

The safe load is calculated as follows,

1) Design Stipulations

- | | |
|---|---|
| 1. Type of pile | - Bored cast in situ uniform diameter pile. |
| 2. Pile diameter considered | - 0.60m |
| 3. Termination depth of pile considered | - 16.00m from FGL. |
| 4. Cut off Level | - At 5.00m from FGL. |
| 5. Factor of Safety | - 2.50 |
| 6. Depth of Water table | - Considered at FGL. |
| 7. Ref | - IS 2911 P-I, Sec-II, 2021. |

2) Test Data

The parameters are based on BH 71. For evaluation of safe load on piles following characterized layers are considered as described in table below,

Depth in m from RL 202.5 m	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Submerged density in gm/cc γ_{sub}	Reduction Factor α	Earth pressure coefficient K	Angle of wall friction $\delta = \phi$	SPT N Value
FGL to 6.00	No contribution considered - Cut off level						
5.00 to 10.22	0.49 [#]	4~0*	0.94	0.89	NA	NA	7-12
10.22 to 16.52	0.04 [#] ~0.00*	28 [#]	1.03	NA	1.0	28	14-53

Notes: - Layers are characterized based on classification and the state of soil in that stratum.

* - In cohesive soils the contribution of the angle of internal friction being insignificant is ignored.

Shear parameters are the most representative for the layer. NA means not applicable. Characterized N values are considered for each layer.

- Weighted Average of the parameters falling in the same layer has been considered

\$-Parameters are correlated based on SPT value N.

3) Ultimate Load in Compression

3.1) Ultimate load in Compression by Bearing

Ultimate load on pile in end bearing,

$$q_{ub} = A_p (0.5 \cdot D \cdot \gamma N_\gamma + PD N_q)$$

$$A_p = \text{Cross section area of Pile stem at toe} = \pi d^2 / 4$$

$$D = \text{Diameter of pile} = d \text{ in m}$$

$$N_\gamma = 42.90$$

$$N_q = 40.00$$

$$q_{ub} = 0.785d^2 (0.5 \cdot d \cdot 1.03 \cdot 42.90 + 8.80 \cdot 40.00) = 17.34d^3 + 276.32d^2$$

(For Pile terminating at 16.00m from F.G.L.)

Note: As the pile terminating just above rock level, we have considered parameter for end bearing component based on rock strata.

3.2) Ultimate Load in Compression by Skin Friction

Ultimate load in skin friction,

$$q_{uf} = \alpha_i C_{ai} A_i + K_i P D_i \tan \delta_i A_{si}$$

First Layer – No contribution considered due to cut off level

$$\text{Second Layer} - \alpha_2 C_{a2} A_{s2} = 0.89 \cdot 4.90 \cdot \pi \cdot d \cdot 5.22 = 71.52d$$

$$\text{Third Layer} - K_3 PD_3 \tan \delta_3 A_{s3} = 1.00 \cdot 7.88 \cdot \tan 28^\circ \cdot \pi \cdot d \cdot (\ell - 10.22) = 13.16d (\ell - 10.22)$$

Substituting, ultimate load

$$q_{uf} = 71.52d + 13.16d (\ell - 10.22) \text{ (For Pile terminating at 16.00m from F.G.L.)}$$

Where, ℓ is the pile length and d is diameter of piles, substituting

Ultimate load by both bearing and friction can be as follows for various lengths of piles,

$$q_{uc} = q_{ub} + q_{uf}$$

$q_{uc} = 17.34d^3 + 276.32d^2 + 71.52d + 13.16d (\ell - 10.22)$ (For Pile terminating at 16.00m from F.G.L.).

By substituting various diameters of piles having various lengths, the safe load is worked out considering the safety factor of 2.50 and are given in table below,

Safe Load on Piles in Compression (in Ton)

Termination Depth of Pile in m, from FGL	Termination Depth of Pile in m, from cut-off	Diameter of Pile in, m
		0.60
16.00	11.00	76.72

3.3) Ultimate Load in Uplift

Considering skin friction for determination of uplift

Safe Load on Piles in Uplift (in Ton)

Termination Depth of Pile in m, from FGL	Termination Depth of Pile in m, from cut-off	Diameter of Pile in, m
		0.60
16.00	11.00	34.19

Note: Self weight of pile is considered in calculation of ultimate load in uplift.

Self weight of Pile (in Ton)

Termination Depth of Pile in m, from FGL	Termination Depth of Pile in m, from cut-off	Diameter of Pile in, m
		0.60
16.00	11.00	4.67

3.4) Lateral Pile Capacity

Pile would be long and elastic (i.e. $L > 4T$). For a prescribed deflection of 5mm and with M 30 grade of concrete, the lateral load and moment were worked out as follows,

Diameters in m		0.60
Subgrade reaction in MN/m^3		11.52
Stiffness factor T in m		1.73
Depth of fixity in m	Free Head	3.30
	Fixed Head	3.80
Allowable Horizontal Force in T	Free Head	7.50
	Fixed Head	19.90
Allowable Moment capacity in Tm	Free Head	8.65
	Fixed Head	30.78

4) Notes:

1) Initial and Routine pile load tests shall be carried out as per IS 2911, P-4 on the piles to confirm the capacity of pile worked out theoretically. For design and construction, specifications of IS 2911, P-I, S-2, shall strictly be followed. Termination depth of pile shall be from FGL.

Dr. K. K. Thaker

Appendix – 12A

Calculation of Safe Load carrying capacity of piles socketed inside rock (Near BH-24,79,84,93 IBH-35) (Boiler Unit-2)

Project Name: - Proposed structures of thermal power project of NTTTP at Hirma, Talabira

1.0 Introduction

In situations where overburden offering low bearing pressure is followed by rock at relatively shallower depths, end bearing piles is the suitable foundation option. Piles in rocks and weathered rocks of varying degree of weathering derive their capacity by end bearing and socket side resistance.

In situations, where, rock strata comprises of highly fragmented rock, as in present case, where RQD is nil or $(CR+RQD)/2$ is less than 30 % or when the crushing strength is less than 10 MPa, the appropriate approach would be of that suggested by Cole & Stroud.

In present site overburden soils overlay fractured / laminated / foliated rock. The founding stratum having highly fragmented rock with nil RQD and $(CR+RQD)/2$ to be less than 30 %, the approach suggested by Cole and Stroud as per Annex B under clause 6.3.1.1 and 6.3.2 of IS 2911 Pa/S2 has been used for safe load calculations.

An illustrative calculation of safe load on pile and summary of pile capacities is as follows,

2.0 Sub soil strata Characterization

General stratification at the location of boreholes BH 79 show primarily two characterized layers,

1. Overburden comprising of fine to medium grained, clayey sand followed by fine to medium grained, sandy clays of intermediate plasticity with occasional gravels followed by fine to very fine grained, clays of intermediate plasticity followed by fine to very fine grained, sandy clays of intermediate plasticity followed by very fine grained, silts of intermediate plasticity upto 9.80m (i.e. RL 188.90m).
2. Second characterized layer below the overburden soils comprises of Highly weathered, very weak and friable, light brownish yellow, fine to very fine grained, fractured rock upto 12.50m (i.e. RL 186.20m).

3.0 Design Considerations

1. Length of socket considered 3D from depth of rock encountered.
2. The pile is considered to have socket length below 9.80 m below NGL (i.e. RL 188.90 m) depth.
3. For present case of pile terminating in highly weathered rock. SPT at depths between 9.80 to 12.50m (between RL 188.90 to 186.20 m) is > 200.
Based on recommendation of fig no. 3 in B 8 in Annex B under clause 6.3.1.1 and 6.3.2 of IS 2911 P1/S2, average shear strength q_c corresponding to assumed SPT of 200 may be taken as 1300 kN/m²
4. Allowable Capacity of pile socketed into rock $Q_a = R_e + R_{sf} = C_{u1} N_c \pi B^2 / 4 (F_s = 3) + \alpha C_{u2} \pi BL / (F_s = 6)$

4.0 Safe Load on Pile in Compression

Where,

End bearing component, $R_e = C_{u1} N_c \pi B^2 / 4 F_s$,

C_{u1} = Shear strength below base of pile = 1300 kN/m²

B = diameter of the pile = d

F_s = Factor of Safety = 3

$N_c = 9$

Therefore, **$R_e = 3061.5 d^2$**

Skin friction component of socketed length of pile, $R_{sf} = \alpha C_{u2} \pi BL / F_s$

$\pi BL / F_s$

$\alpha = 0.9$ (recommended value in IS 2911 P1/S2)

L = length of the socket = $3 D$

C_{u2} = Ultimate shear strength along socket length which shall be restricted to shear capacity of concrete of the pile = 1300 kN/m²

F_s = Factor of Safety = 6

Therefore, **$R_{sf} = 1836.9 d^2$**

Thus,

$$Q_a = c_{u1} N_c \cdot \frac{\pi B^2}{4 F_s} + \alpha c_{u2} \cdot \frac{\pi B L}{F_s}$$

$$= 3061.5 d^2 + 1836.9 d^2 = 4898.4 d^2$$

Substituting the values of various diameters and socket lengths equal to 3 times diameter, allowable load on single pile can be summarized as follows,

Summary of the Safe load calculation in Compression

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	15.40	15.88	16.30
Termination level RL in m	187.10	186.62	186.20
End Bearing Component in kN	1102.1	1768.3	2479.8
Friction Component in kN	661.3	1060.9	1487.9
Safe load in Compression in kN	1763.4	2829.3	3967.7
Safe load in Compression in T	176	283	397

5.0 Safe Load on Pile in uplift

At 4.00m FGL

The overburden soils, though, will not contribute in compression capacity would offer resistance in uplift capacity. The parameters of BH 79 are considered for calculation of uplift resistance as summarized below,

Depth in m from RL 202.5 m	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Submerged density in gm/cc γ_{sub}	Reduction Factor α	Earth pressure coefficient K	Angle of wall friction $\delta = \phi$	SPT N Value
FGL to 4.00	No contribution considered - Cut off level						
4.00 to 5.30	0.00	27 ^{\$}	0.91	NA	1.00	27	4
5.30 to 12.20	0.53 [#]	6 [#] (ignored)	0.94	0.84	NA	NA	6-30
12.20 to 13.60	2.10 ^{\$}	0	0.99	0.28	NA	NA	34-71
13.60 to 20.80	Rock strata – Resistance would be as per skin friction capacity in socket as already calculated in compression capacity						

#Average of the parameters falling in the same layer has been considered.

\$ Parameters of this layer is considered based on SPT N value.

Ultimate load in skin friction,

$$Q_{uf} = \alpha_i C_{ai} A_{si} + K_i P D_i \tan \delta_i A_{si}$$

First Layer – Cut off level

$$\text{Second Layer} - K_2 P D_2 \tan \delta_2 A_{s2} = 1.00 * 3.79 * \tan 27 * \pi d * 1.30 = 7.89 d$$

$$\text{Third Layer} - \alpha_3 C_{a3} A_{s3} = 0.84 * 5.30 * \pi d * 6.90 = 96.51 d$$

$$\text{Fourth Layer} - \alpha_4 C_{a4} A_{s4} = 0.28 * 21.00 * \pi d * 1.40 = 25.86 d$$

$$\text{Fifth layer} - 1836.90 d^2 \text{ in rock socket}$$

$$\text{Substituting, ultimate load } q_{uf} = 1302.60 d + 1836.9 d^2$$

The safe load in uplift is worked out (considering the safety factor of 2.50 for overburden soils) and summarized below,

Safe Load on Piles in Uplift (in Ton)

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	15.40	15.88	16.30
Termination level RL in m	187.10	186.62	186.20
Safe load in Uplift in kN	973.91	1456.98	1956.83
Self-weight of pile in kN	48.32	80.80	117.31
Safe load in Uplift in T (Considering self-weight of pile)	102.22	153.78	207.41

6.0 Lateral Pile Capacity

Pile would be long and elastic (i.e. $L > 4T$). For a prescribed deflection of 5mm and with M 30 grade of concrete, the lateral load and moment were worked out as follows,

Diameters in m		0.60	0.76	0.90
Subgrade reaction in MN/m ³		5.50	5.50	5.50
Stiffness factor T in m		2.00	2.42	2.77
Depth of fixity in m	Free Head	3.80	4.60	5.30
	Fixed Head	4.40	5.30	6.00
Allowable Horizontal Force in T	Free Head	4.80	7.00	9.20
	Fixed Head	12.80	18.70	24.50
Allowable Moment capacity in Tm	Free Head	6.43	11.35	17.02
	Fixed Head	22.90	40.38	60.59

7.0 Notes

1. Pile shall be terminated after socketing 3D inside rock.
2. Initial and routine pile load test is required to verify the actual carrying capacity of pile in compression, uplift and lateral loads.
3. For design and construction, specification of IS: 2911, P1/S2, IS: 456, 2000 shall strictly be followed.

(Dr. K. K. Thaker)

APPENDIX-13 (Mill & Bunker Unit-2) (For BH-86)

Bore Hole	EGL (in RL)	UCS of Rock (Kg/cm ²)	Foundation level (in RL)	Safe bearing pressure (T/m ²) as per core strength of rock	Safe bearing pressure (T/m ²) RMR of rock	Recommended Safe bearing pressure (T/m ²)
BH-86	199.00	42.9	193.00	60.3	52.6	45

Bearing capacity calculations as per IS 12070, clause 6.2 based on core strength of rock

$$q_s = q_c \cdot N_j$$

q_s = safe bearing pressure

q_c = average uniaxial compressive strength of rock cores

N_j = empirical co-efficient

q_c = 42.9 kg/cm² for TG area

N_j = 0.25 As per Table-4 of IS 12070 for spacing & discontinuities of about 100-300 cm

$$q_s = 42.9 \cdot 0.25 = 10.725 \text{ Kg/cm}^2$$

Other factors as per clause no. 9 of IS 12070

Water table correction = 0.75

Orientation of joint correction = 0.75

Hence safe bearing capacity = $q_s = 10.725 \cdot 0.75 \cdot 0.75$

6.03

Kg/cm²

60.3

T/m²

APPENDIX-13 (Mill & Bunker Unit-2) (For BH-86)

Bore Hole	EGL (in RL)	UCS of Rock (Kg/cm ²)	Foundation level (in RL)	Safe bearing pressure (T/m ²) as per core strength of rock	Safe bearing pressure (T/m ²) RMR of rock	Recommended Safe bearing pressure (T/m ²)
BH-86	199.00	42.9	193.00	60.3	52.6	45

Bearing capacity calculation as per IS 12070, CLAUSE 5.3 based on Rock mass rating (RMR)

Properties

Rating

Strength of intact rock material	Compressive strength 2-10MPa	1
RQD	RQD <25%	3
Spacing of discontinuities	Spacing <0.06 m	8
Condition of discontinuity	1-5 mm wide opening	10
Ground water condition	Wet	7
Adjustment for Joint orientation	Fair	-7
	Total RMR =	22

Net Safe bearing capacity as per Table-3 and amendment no. 1 $48 + (135 - 48) * 1 / (40 - 21)$
52.6 T/m²

Permissible settlement for foundations resting in rock is 12 mm.

It is to be noted that the net safe bearing capacity of open foundations placed within rocky strata is independent of the size of the foundation.

Spacing = Summation of length of each core pieces/Number of joints = $23/8 = 2.88\text{cm} = 0.029\text{m}$

For borehole BH-88, between 10.00 m and 11.50 m drill run:

Spacing = Summation of length of each core pieces/Number of joints = $83/12 = 6.92\text{cm} = 0.069\text{m}$

For borehole BH-88, between 11.50 m and 13.00 m drill run:

Spacing = Summation of length of each core pieces/Number of joints = $83/5 = 16.6\text{cm} = 0.17\text{m}$

For borehole BH-88, between 13.00 m and 14.50 m drill run:

Spacing = Summation of length of each core pieces/Number of joints = $96/8 = 12.00\text{cm} = 0.12\text{m}$

For borehole BH-88, between 14.50 m and 16.00 m drill run:

Spacing = Summation of length of each core pieces/Number of joints = $88/5 = 17.60\text{cm} = 0.18\text{m}$

For borehole BH-88, between 16.00 m and 18.00 m drill run:

Spacing = Summation of length of each core pieces/Number of joints = $150/3 = 50\text{cm} = 0.50\text{m}$

In majority of the depths the spacing is between 0.06-0.2m, as per IS:13365 Part 1, a rating of 8 is assigned. The close spacing further emphasizes the high fracture frequency, reducing rock mass strength and increasing blockiness.

7. The condition of discontinuities was assessed via core inspection, revealing apertures of 1–5 mm, indicating slightly open joints that influence shear strength and permeability. IS:13365 Part 1 assigns a rating of 10 for discontinuity apertures within this range.

8. Field observations indicated wet conditions (water table nearly around 2.0m from NGL), which reduce friction along joint surfaces and may contribute to rock mass instability. For wet conditions, IS:13365 Part 1 prescribes a rating of 7.

9. The orientation of joints relative to the excavation geometry was classified as fair, representing a moderate adverse effect on rock mass stability. A rating adjustment of –7 was applied.

Considering all the above parameters, the calculated RMR for the rock mass is 22, corresponding to very poor rock quality that necessitates significant engineering support measures.

Appendix – 13A

Calculation of Safe Load carrying capacity of piles socketed inside rock (For BH-86) (Mill & Bunker Unit-2)

Project Name: - Proposed structures of thermal power project of NTTTP at Hirma, Talabira

1.0 Introduction

In situations where overburden offering low bearing pressure is followed by rock at relatively shallower depths, end bearing piles is the suitable foundation option. Piles in rocks and weathered rocks of varying degree of weathering derive their capacity by end bearing and socket side resistance.

In situations, where, rock strata comprises of highly fragmented rock, as in present case, where RQD is nil or $(CR+RQD)/2$ is less than 30 % or when the crushing strength is less than 10 MPa, the appropriate approach would be of that suggested by Cole & Stroud.

In present site overburden soils overlay fractured / laminated / foliated rock. The founding stratum having highly fragmented rock with nil RQD and $(CR+RQD)/2$ to be less than 30 %, the approach suggested by Cole and Stroud as per Annex B under clause 6.3.1.1 and 6.3.2 of IS 2911 Pa/S2 has been used for safe load calculations.

An illustrative calculation of safe load on pile and summary of pile capacities is as follows,

2.0 Sub soil strata Characterization

General stratification at the location of boreholes BH 86 show primarily two characterized layers,

1. Overburden comprising of Yellowish brown, fine to medium grained, clayey sand followed by Light brownish yellow, fine to very fine grained, silty clays of intermediate plasticity followed by Brownish yellow, very fine grained, silts of intermediate plasticity upto 4.20m (i.e. RL 194.78m).
2. Second characterized layer below the overburden soils comprises of Highly weathered, very weak, greyish brown, fine to very fine grained, fractured rock upto 8.50m (i.e. RL 190.48m).

3.0 Design Considerations

1. Length of socket considered 3D from depth of rock encountered.
2. The pile is considered to have socket length below 4.20 m below NGL (i.e. RL 194.78m) depth.
3. For present case of pile terminating in highly weathered rock. SPT at depths between 4.20 to 8.50m (between RL to m) is > 100 with just 10.0 cm penetration in 75 blows. SPT can be extrapolated for 30 cm i.e. $75 * 30 / 10.00 = 225$.

Based on recommendation of fig no. 3 in B 8 in Annex B under clause 6.3.1.1 and 6.3.2 of IS 2911 P1/S2, average shear strength q_c corresponding to assumed SPT of 200 may be taken as 1300 kN/m²

4. Allowable Capacity of pile socketed into rock $Q_a = R_e + R_{sf} = C_{u1} N_c \pi B^2 / 4 (F_s = 3) + \alpha C_{u2} \pi BL / (F_s = 6)$

4.0 Safe Load on Pile in Compression

Where,

End bearing component, $R_e = C_{u1} N_c \pi B^2 / 4 F_s$,

C_{u1} = Shear strength below base of pile = 1300 kN/m²

B = diameter of the pile = d

F_s = Factor of Safety = 3

$N_c = 9$

Therefore, **$R_e = 3061.5 d^2$**

Skin friction component of socketed length of pile, $R_{sf} = \alpha C_{u2} \pi BL / F_s$

$\alpha = 0.9$ (recommended value in IS 2911 P1/S2)

L = length of the socket = $3 D$

C_{u2} = Ultimate shear strength along socket length which shall be restricted to shear capacity of concrete of the pile = 1300 kN/m²

F_s = Factor of Safety = 6

Therefore, **$R_{sf} = 1836.9 d^2$**

Thus,

$$Q_a = c_{u1} N_c \cdot \frac{\pi B^2}{4 F_s} + \alpha c_{u2} \cdot \frac{\pi BL}{F_s}$$

$$= 3061.5 d^2 + 1836.9 d^2 = 4898.4 d^2$$

Substituting the values of various diameters and socket lengths equal to 3 times diameter, allowable load on single pile can be summarized as follows,

Summary of the Safe load calculation in Compression

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	9.52	10.00	10.42
Termination level RL in m	192.98	192.50	192.08
End Bearing Component in kN	1102.1	1768.3	2479.8
Friction Component in kN	661.3	1060.9	1487.9
Safe load in Compression in kN	1763.4	2829.3	3967.7
Safe load in Compression in T	176	283	397

5.0 Safe Load on Pile in uplift

At 3.50m from FGL

The overburden soils, though, will not contribute in compression capacity would offer resistance in uplift capacity. The parameters of BH 86 are considered for calculation of uplift resistance as summarized below,

Depth in m from RL 202.5 m	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Submerged density in gm/cc γ_{sub}	Reduction Factor α	Earth pressure coefficient K	Angle of wall friction $\delta = \phi$	SPT N Value
FGL to 3.50	No contribution considered - Cut off level						
3.50 to 5.92	0.16*	0	0.80	1.00	NA	NA	4
5.92 to 7.72	1.60*	0	1.00	0.28	NA	NA	40->100
7.72 to 21.52	Rock strata – Resistance would be as per skin friction capacity in socket as already calculated in compression capacity						

* Parameters of this layer is considered by co-relations with SPT N value.

Ultimate load in skin friction,

$$Q_{uf} = \alpha_i C_{ai} A_{si} + K_i P D_i \tan \delta_i A_{si}$$

First Layer – Cut off level

$$\text{Second Layer} - \alpha_2 C_{a2} A_{s2} = 1.00 * 1.60 * \pi d * 2.42 = 12.16 d$$

$$\text{Third Layer} - \alpha_3 C_{a3} A_{s3} = 0.28 * 16.00 * \pi d * 1.80 = 25.33 d$$

Fourth Layer – 1836.90 d² in rock socket

$$\text{Substituting, ultimate load } q_{uf} = 374.94 d + 1836.9 d^2$$

The safe load in uplift is worked out (considering the safety factor of 2.50 for overburden soils) and summarized below,

Safe Load on Piles in Uplift (in Ton)

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	9.52	10.00	10.42
Termination level RL in m	192.98	192.50	192.08
Safe load in Uplift in kN	751.27	1174.98	1622.87
Self-weight of pile in kN	25.53	44.23	66.03
Safe load in Uplift in T (Considering self-weight of pile)	77.68	121.92	168.89

6.0 Lateral Pile Capacity

Pile would be long and elastic (i.e. $L > 4T$). For a prescribed deflection of 5mm and with M 30 grade of concrete, the lateral load and moment were worked out as follows,

Diameters in m		0.60	0.76	0.90
Subgrade reaction in MN/m ³		5.76	5.76	5.76
Stiffness factor T in m		1.99	2.40	2.75
Depth of fixity in m	Free Head	3.80	4.60	5.20
	Fixed Head	4.30	5.20	6.00
Allowable Horizontal Force in T	Free Head	5.00	7.20	9.50
	Fixed Head	13.10	19.20	25.10
Allowable Moment capacity in Tm	Free Head	6.55	11.56	17.34
	Fixed Head	23.32	41.13	61.72

7.0 Notes

1. Pile shall be terminated after socketing 3D inside rock.
2. Initial and routine pile load test is required to verify the actual carrying capacity of pile in compression, uplift and lateral loads.
3. For design and construction, specification of IS: 2911, P1/S2, IS: 456, 2000 shall strictly be followed.

(Dr. K. K. Thaker)

Appendix – 14A

Calculation of Safe Load carrying capacity of piles socketed inside rock (Near BH-76) (Power house Unit-1 Control Room)

Project Name: - Proposed structures of thermal power project of NTTTP at Hirma, Talabira

1.0 Introduction

In situations where overburden offering low bearing pressure is followed by rock at relatively shallower depths, end bearing piles is the suitable foundation option. Piles in rocks and weathered rocks of varying degree of weathering derive their capacity by end bearing and socket side resistance.

In situations, where, rock strata comprises of highly fragmented rock, as in present case, where RQD is nil or $(CR+RQD)/2$ is less than 30 % or when the crushing strength is less than 10 MPa, the appropriate approach would be of that suggested by Cole & Stroud.

In present site overburden soils overlay fractured / laminated / foliated rock. The founding stratum having highly fragmented rock with nil RQD and $(CR+RQD)/2$ to be less than 30 %, the approach suggested by Cole and Stroud as per Annex B under clause 6.3.1.1 and 6.3.2 of IS 2911 Pa/S2 has been used for safe load calculations.

An illustrative calculation of safe load on pile and summary of pile capacities is as follows,

2.0 Sub soil strata Characterization

General stratification at the location of boreholes BH 76 show primarily two characterized layers,

1. Overburden comprising of fine to medium grained, sandy clays of intermediate plasticity with occasional gravels followed by fine to medium grained, sandy clays of intermediate plasticity with occasional gravels followed by very fine grained, clays of intermediate plasticity upto 6.50m (i.e. RL 191.50m).
2. Second characterized layer below the overburden soils comprises of Moderately weathered, weak, dark greyish, fine to very fine grained, rock with wide spacing of discontinuities followed by Moderately weathered, weak, yellowish brown, fine to medium grained, rock with moderately wide spacing of discontinuities followed by Moderately weathered, moderately weak, light brownish grey, fine to medium grained, rock with moderately wide spacing of discontinuities upto 12.00m (i.e. RL 186.00m).

3.0 Design Considerations

1. Length of socket considered 3D from depth of rock encountered.
2. The pile is considered to have socket length below 6.50 m below NGL (i.e. RL 191.50 m) depth.
3. For present case of pile terminating in highly weathered rock. SPT at depths between 6.50 to 12.00m (between RL 191.50 to 186.00 m) is > 200.
Based on recommendation of fig no. 3 in B 8 in Annex B under clause 6.3.1.1 and 6.3.2 of IS 2911 P1/S2, average shear strength q_c corresponding to assumed SPT of 200 may be taken as 1300 kN/m²
4. Allowable Capacity of pile socketed into rock $Q_a = R_e + R_{sf} = C_{u1} N_c \pi B^2 / 4 (F_s = 3) + \alpha C_{u2} \pi BL / (F_s = 6)$

4.0 Safe Load on Pile in Compression

Where,

End bearing component, $R_e = C_{u1} N_c \pi B^2 / 4 F_s$,

C_{u1} = Shear strength below base of pile = 1300 kN/m²

B = diameter of the pile = d

F_s = Factor of Safety = 3

$N_c = 9$

Therefore, **$R_e = 3061.5 d^2$**

Skin friction component of socketed length of pile, $R_{sf} = \alpha C_{u2} \pi BL / F_s$

$\alpha = 0.9$ (recommended value in IS 2911 P1/S2)

L = length of the socket = $3 D$

C_{u2} = Ultimate shear strength along socket length which shall be restricted to shear capacity of concrete of the pile = 1300 kN/m²

F_s = Factor of Safety = 6

Therefore, **$R_{sf} = 1836.9 d^2$**

Thus,

$$Q_a = c_{u1} N_c \cdot \frac{\pi B^2}{4 F_s} + \alpha c_{u2} \cdot \frac{\pi B L}{F_s}$$

$$= 3061.5 d^2 + 1836.9 d^2 = 4898.4 d^2$$

Substituting the values of various diameters and socket lengths equal to 3 times diameter, allowable load on single pile can be summarized as follows,

Summary of the Safe load calculation in Compression

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	12.80	13.28	13.70
Termination level RL in m	189.70	189.22	188.80
End Bearing Component in kN	1102.1	1768.3	2479.8
Friction Component in kN	661.3	1060.9	1487.9
Safe load in Compression in kN	1763.4	2829.3	3967.7
Safe load in Compression in T	176	283	397

5.0 Safe Load on Pile in uplift

At 4.00m FGL

The overburden soils, though, will not contribute in compression capacity would offer resistance in uplift capacity. The parameters of BH 76 are considered for calculation of uplift resistance as summarized below,

Depth in m from RL 202.5 m	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Submerged density in gm/cc γ_{sub}	Reduction Factor α	Earth pressure coefficient K	Angle of wall friction $\delta = \phi$	SPT N Value
FGL to 4.00	No contribution considered - Cut off level						
4.00 to 11.00	1.83 [#]	4~0(ignored)	1.01	0.28	NA	NA	6-70
11.00 to 28.50	Rock strata – Resistance would be as per skin friction capacity in socket as already calculated in compression capacity						

#Average of the parameters falling in the same layer has been considered.

Ultimate load in skin friction,

$$Q_{uf} = \alpha_i c_{ai} A_{si} + K_i P D_i \tan \delta_i A_{si}$$

First Layer – Cut off level

$$\text{Second Layer} - \alpha_2 c_{a2} A_{s2} = 0.28 * 18.30 * \pi d * 7.00 = 112.68d$$

Third Layer – 1836.90 d² in rock socket

$$\text{Substituting, ultimate load } q_{uf} = 1126.83 d + 1836.9 d^2$$

The safe load in uplift is worked out (considering the safety factor of 2.50 for overburden soils) and summarized below,

Safe Load on Piles in Uplift (in Ton)

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	12.80	13.28	13.70
Termination level RL in m	189.70	189.22	188.80
Safe load in Uplift in kN	931.72	1403.55	1893.55
Self-weight of pile in kN	37.32	63.15	92.56
Safe load in Uplift in T (Considering self-weight of pile)	96.90	146.67	198.61

6.0 Lateral Pile Capacity

Pile would be long and elastic (i.e. $L > 4T$). For a prescribed deflection of 5mm and with M 30 grade of concrete, the lateral load and moment were worked out as follows,

Diameters in m		0.60	0.76	0.90
Subgrade reaction in MN/m ³		8.64	8.64	8.64
Stiffness factor T in m		1.83	2.21	2.53
Depth of fixity in m	Free Head	3.50	4.20	4.80
	Fixed Head	4.00	4.80	5.50
Allowable Horizontal Force in T	Free Head	6.30	9.20	12.10
	Fixed Head	16.80	24.50	32.10
Allowable Moment capacity in Tm	Free Head	7.71	13.59	20.39
	Fixed Head	27.43	48.38	72.59

7.0 Notes

1. Pile shall be terminated after socketing 3D inside rock.
2. Initial and routine pile load test is required to verify the actual carrying capacity of pile in compression, uplift and lateral loads.
3. For design and construction, specification of IS: 2911, P1/S2, IS: 456, 2000 shall strictly be followed.

(Dr. K. K. Thaker)

APPENDIX-15 (Structure: Power house Unit-2) (For BH-78,88,100)

Bore Hole	EGL (in RL)	UCS of Rock (Kg/cm ²)	Foundation level (in RL)	Foundation level adopted (in RL)	Area	Safe bearing pressure (T/m ²)	Safe bearing pressure (T/m ²) RMR of rock	Recommended Safe bearing pressure (T/m ²)
BH-78	199.07	83.4	194.07	193.5	Power house	117.3	52.6	45
BH-100	199.00	91.5	193.50					
BH-88	197.20	44.9	191.20	191.0	TG	63.1	52.6	45

Bearing capacity calculations as per IS 12070, clause 6.2 based on core strength of rock

$$q_s = q_c \cdot N_j$$

q_s = safe bearing pressure

q_c = average uniaxial compressive strength of rock cores

N_j = empirical co-efficient

q_c = 44.9 kg/cm² for TG area

N_j = 0.25 As per Table-4 of IS 12070 for spacing & discontinuities of about 100-300 cm

$$q_s = 44.9 \cdot 0.25 = 11.225 \text{ Kg/cm}^2$$

Other factors as per clause no. 9 of IS 12070

Water table correction = 0.75

Orientation of joint correction = 0.75

Hence safe bearing capacity = $q_s = 11.225 \cdot 0.75 \cdot 0.75$

6.31 Kg/cm²
63.1 T/m²

APPENDIX-15 (Structure: Power house Unit-2) (For BH-78,88,100)

Bore Hole	EGL (in RL)	UCS of Rock (Kg/cm ²)	Foundation level (in RL)	Foundation level adopted (in RL)	Area	Safe bearing pressure (T/m ²)	Safe bearing pressure (T/m ²) RMR of rock	Recommended Safe bearing pressure (T/m ²)
BH-78	199.07	83.4	194.07	193.5	Power house	117.3	52.6	45
BH-100	199.00	91.5	193.50					
BH-88	197.20	44.9	191.20	191.0	TG	63.1	52.6	45

Bearing capacity calculation as per IS 12070, CLAUSE 5.3 based on Rock mass rating (RMR)

Properties		Rating
	Compressive strength 2-	
Strength of intact rock material	10MPa	1
RQD	RQD <25%	3
Spacing of discontinuities	Spacing <0.06 m	8
Condition of discontinuity	1-5 mm wide opening	10
Ground water condition	Wet	7
Adjustment for Joint orientation	Fair	-7
	Total RMR =	22

Net Safe bearing capacity as per Table-3 and amendment no. 1 $48 + (135 - 48) * 1 / (40 - 21)$
52.6 T/m²

Permissible settlement for foundations resting in rock is 12 mm.

It is to be noted that the net safe bearing capacity of open foundations placed within rocky strata is independent of the size of the foundation.

The parameters selected for the Uniaxial Compressive Strength (UCS) and Rock Mass Rating (RMR) calculations were chosen based on their practical measurability from field and laboratory data.

For calculation of allowable bearing pressure by UCS:

1. For Factor N_j : 100–300 cm spacing refers to the major structural joints observed at the rock mass scale in field mapping. As per IS:12070, for spacing of discontinuity of 100 to 300cm, N_j is taken as 0.25.
2. As per clause 9.2, Allowances should be made for submerged conditions, cavities and slopes. Factor to be applied for Submerged Condition Under Water Table is 0.75 to 0.50 (for Rock with continuous joints with opening 1 to 5mm wide and filled with clay) and for slope 1.00 to 0.50 (Fair orientation of continuous joints in the slope). We have considered 0.75 for submerged condition and 0.75 for slope.
3. For the calculation of allowable bearing pressure we have taken the most conservative value which is minimum UCS to be very much on safer side. This is because the rock is quite fractured in nature and having very high degree of anisotropy.

For calculation of allowable bearing pressure by RMR:

4. The intact rock compressive strength, ranging from 2 to 10 MPa, reflects the inherent weakness of rock blocks between discontinuities, which is critical for evaluating load-bearing capacity. According to IS:13365 Part 1, a UCS within this range corresponds to a rating of 1.

5. RQD was determined from field borehole logs, based on the length of core samples and the respective drill runs. For borehole BH-88, between 5.50 m and 7.00 m drill run:

Length of core samples ≥ 10 cm: 0.0cm

RQD = 0%

For an RQD between 0–25%, IS:13365 Part 1 assigns a rating of 3. An RQD < 25% indicates a highly fractured rock mass with numerous joints, reflecting poor rock quality and small block sizes.

6. The average spacing of joints was calculated using the equation:

For borehole BH-88, between 5.50 m and 7.00 m drill run:

Spacing = Summation of length of each core pieces/Number of joints = $52/12 = 4.33\text{cm} = 0.043\text{m}$

For borehole BH-88, between 7.00 m and 8.50 m drill run:

Spacing = Summation of length of each core pieces/Number of joints = $30/8 = 3.75\text{cm} = 0.038\text{m}$

For borehole BH-88, between 8.50 m and 10.00 m drill run:

Spacing = Summation of length of each core pieces/Number of joints = $23/8 = 2.88\text{cm} = 0.029\text{m}$

For borehole BH-88, between 10.00 m and 11.50 m drill run:

Spacing = Summation of length of each core pieces/Number of joints = $83/12 = 6.92\text{cm} = 0.069\text{m}$

For borehole BH-88, between 11.50 m and 13.00 m drill run:

Spacing = Summation of length of each core pieces/Number of joints = $83/5 = 16.6\text{cm} = 0.17\text{m}$

For borehole BH-88, between 13.00 m and 14.50 m drill run:

Spacing = Summation of length of each core pieces/Number of joints = $96/8 = 12.00\text{cm} = 0.12\text{m}$

For borehole BH-88, between 14.50 m and 16.00 m drill run:

Spacing = Summation of length of each core pieces/Number of joints = $88/5 = 17.60\text{cm} = 0.18\text{m}$

For borehole BH-88, between 16.00 m and 18.00 m drill run:

Spacing = Summation of length of each core pieces/Number of joints = $150/3 = 50\text{cm} = 0.50\text{m}$

In majority of the depths the spacing is between 0.06-0.2m, as per IS:13365 Part 1, a rating of 8 is assigned. The close spacing further emphasizes the high fracture frequency, reducing rock mass strength and increasing blockiness.

7. The condition of discontinuities was assessed via core inspection, revealing apertures of 1–5 mm, indicating slightly open joints that influence shear strength and permeability. IS:13365 Part 1 assigns a rating of 10 for discontinuity apertures within this range.

8. Field observations indicated wet conditions (water table nearly around 2.0m from NGL), which reduce friction along joint surfaces and may contribute to rock mass instability. For wet conditions, IS:13365 Part 1 prescribes a rating of 7.

9. The orientation of joints relative to the excavation geometry was classified as fair, representing a moderate adverse effect on rock mass stability. A rating adjustment of –7 was applied.

Considering all the above parameters, the calculated RMR for the rock mass is 22, corresponding to very poor rock quality that necessitates significant engineering support measures.

Appendix – 15A

Calculation of Safe Load carrying capacity of piles socketed inside rock (For BH-78,88,100) (Structure: Power house Unit-2)

Project Name: - Proposed structures of thermal power project of NTTTP at Hirma, Talabira

1.0 Introduction

In situations where overburden offering low bearing pressure is followed by rock at relatively shallower depths, end bearing piles is the suitable foundation option. Piles in rocks and weathered rocks of varying degree of weathering derive their capacity by end bearing and socket side resistance.

In situations, where, rock strata comprises of highly fragmented rock, as in present case, where RQD is nil or $(CR+RQD)/2$ is less than 30 % or when the crushing strength is less than 10 MPa, the appropriate approach would be of that suggested by Cole & Stroud.

In present site overburden soils overlay fractured / laminated / foliated rock. The founding stratum having highly fragmented rock with nil RQD and $(CR+RQD)/2$ to be less than 30 %, the approach suggested by Cole and Stroud as per Annex B under clause 6.3.1.1 and 6.3.2 of IS 2911 Pa/S2 has been used for safe load calculations.

An illustrative calculation of safe load on pile and summary of pile capacities is as follows,

2.0 Sub soil strata Characterization

General stratification at the location of boreholes BH 78 show primarily two characterized layers,

1. Overburden comprising of Yellowish brown and dark brownish, fine to very fine grained, sandy clays of intermediate plasticity followed by Brownish yellow to light brownish, very fine grained, silts of intermediate plasticity upto 3.50m (i.e. RL 195.57m).
2. Second characterized layer below the overburden soils comprises of Highly weathered, weak, light brownish yellow, fine to very fine grained, rock with moderately close spacing of discontinuities upto 7.50m (i.e. RL 191.57m).

3.0 Design Considerations

1. Length of socket considered 3D from depth of rock encountered.
2. The pile is considered to have socket length below 3.50 m below NGL (i.e. RL 195.57 m) depth.
3. For present case of pile terminating in highly weathered rock. SPT at depths between 3.50 to 7.50m (between RL 195.57 to 191.57 m) is > 100 with just 3.0 cm penetration in 61 blows. SPT can be extrapolated for 30 cm i.e. $61 * 30 / 3.00 = 610$.
Based on recommendation of fig no. 3 in B 8 in Annex B under clause 6.3.1.1 and 6.3.2 of IS 2911 P1/S2, average shear strength q_c corresponding to assumed SPT of 200 may be taken as 1300 kN/m²
4. Allowable Capacity of pile socketed into rock $Q_a = R_e + R_{sf} = C_{u1} N_c \pi B^2 / 4 (F_s = 3) + \alpha C_{u2} \pi BL / (F_s = 6)$

4.0 Safe Load on Pile in Compression

Where,

End bearing component, $R_e = C_{u1} N_c \pi B^2 / 4 F_s$,

C_{u1} = Shear strength below base of pile = 1300 kN/m²

B = diameter of the pile = d

F_s = Factor of Safety = 3

$N_c = 9$

Therefore, **$R_e = 3061.5 d^2$**

Skin friction component of socketed length of pile, $R_{sf} = \alpha C_{u2}$

$\pi BL / F_s$

$\alpha = 0.9$ (recommended value in IS 2911 P1/S2)

L = length of the socket = 3 D

C_{u2} = Ultimate shear strength along socket length which shall be restricted to shear capacity of concrete of the pile = 1300 kN/m²

F_s = Factor of Safety = 6

Therefore, **$R_{sf} = 1836.9 d^2$**

Thus,

$$Q_a = c_{u1} N_c \cdot \frac{\pi B^2}{4 F_s} + \alpha c_{u2} \cdot \frac{\pi BL}{F_s}$$

$$= 3061.5 d^2 + 1836.9 d^2 = 4898.4 d^2$$

Substituting the values of various diameters and socket lengths equal to 3 times diameter, allowable load on single pile can be summarized as follows,

Summary of the Safe load calculation in Compression

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	8.73	9.21	9.63
Termination level RL in m	193.77	193.29	192.87
End Bearing Component in kN	1102.1	1768.3	2479.8
Friction Component in kN	661.3	1060.9	1487.9
Safe load in Compression in kN	1763.4	2829.3	3967.7
Safe load in Compression in T	176	283	397

5.0 Safe Load on Pile in uplift

At 3.50m from FGL

The overburden soils, though, will not contribute in compression capacity would offer resistance in uplift capacity. The parameters of BH 78 are considered for calculation of uplift resistance as summarized below,

Depth in m from RL 202.5 m	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Submerged density in gm/cc γ_{sub}	Reduction Factor α	Earth pressure coefficient K	Angle of wall friction $\delta = \phi$	SPT N Value
FGL to 3.50	No contribution considered - Cut off level						
3.50 to 4.73	0.24*	0	0.80	1.00	NA	NA	6
4.73 to 6.93	0.83	10~0(ignored)	0.99	0.56	NA	NA	22-44
6.93 to 21.43	Rock strata – Resistance would be as per skin friction capacity in socket as already calculated in compression capacity						

* Parameters of this layer is considered based on co-relation with SPT N value.

Ultimate load in skin friction,

$$Q_{uf} = \alpha_i C_{ai} A_{si} + K_i P D_i \tan \delta_i A_{si}$$

First Layer – Cut off level

$$\text{Second Layer} - \alpha_2 C_{a2} A_{s2} = 1.00 * 2.40 * \pi d * 1.23 = 9.27 d$$

$$\text{Third Layer} - \alpha_3 C_{a3} A_{s3} = 0.56 * 8.30 * \pi d * 2.20 = 32.12 d$$

Fourth Layer – 1836.90 d² in rock socket

$$\text{Substituting, ultimate load } q_{uf} = 413.94 d + 1836.9 d^2$$

The safe load in uplift is worked out (considering the safety factor of 2.50 for overburden soils) and summarized below,

Safe Load on Piles in Uplift (in Ton)

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	8.73	9.21	9.63
Termination level RL in m	193.77	193.29	192.87
Safe load in Uplift in kN	760.63	1186.83	1636.91
Self-weight of pile in kN	22.18	38.85	58.50
Safe load in Uplift in T (Considering self-weight of pile)	78.28	122.57	169.54

6.0 Lateral Pile Capacity

Pile would be long and elastic (i.e. $L > 4T$). For a prescribed deflection of 5mm and with M 30 grade of concrete, the lateral load and moment were worked out as follows,

Diameters in m		0.60	0.76	0.90
Subgrade reaction in MN/m ³		8.64	8.64	8.64
Stiffness factor T in m		1.83	2.21	2.53
Depth of fixity in m	Free Head	3.50	4.20	4.80
	Fixed Head	4.00	4.80	5.50
Allowable Horizontal Force in T	Free Head	6.30	9.20	12.10
	Fixed Head	16.80	24.50	32.10
Allowable Moment capacity in Tm	Free Head	7.71	13.59	20.39
	Fixed Head	27.43	48.38	72.59

7.0 Notes

1. Pile shall be terminated after socketing 3D inside rock.
2. Initial and routine pile load test is required to verify the actual carrying capacity of pile in compression, uplift and lateral loads.
3. For design and construction, specification of IS: 2911, P1/S2, IS: 456, 2000 shall strictly be followed.

(Dr. K. K. Thaker)

Appendix – 16A

Calculation of Safe Load carrying capacity of piles socketed inside rock (Near BH-130) (Power house Unit-3)

Project Name: - Proposed structures of thermal power project of NTTTP at Hirma, Talabira

1.0 Introduction

In situations where overburden offering low bearing pressure is followed by rock at relatively shallower depths, end bearing piles is the suitable foundation option. Piles in rocks and weathered rocks of varying degree of weathering derive their capacity by end bearing and socket side resistance.

In situations, where, rock strata comprises of highly fragmented rock, as in present case, where RQD is nil or $(CR+RQD)/2$ is less than 30 % or when the crushing strength is less than 10 MPa, the appropriate approach would be of that suggested by Cole & Stroud.

In present site overburden soils overlay fractured / laminated / foliated rock. The founding stratum having highly fragmented rock with nil RQD and $(CR+RQD)/2$ to be less than 30 %, the approach suggested by Cole and Stroud as per Annex B under clause 6.3.1.1 and 6.3.2 of IS 2911 Pa/S2 has been used for safe load calculations.

An illustrative calculation of safe load on pile and summary of pile capacities is as follows,

2.0 Sub soil strata Characterization

General stratification at the location of boreholes BH 130 show primarily two characterized layers,

1. Overburden comprising of fine to very fine grained, sandy clays of low plasticity followed by fine to medium grained, sandy clays of intermediate plasticity with occasional gravels followed by fine to coarse grained, clayey sand with much gravels followed by fine to very fine grained, sandy clays of intermediate plasticity with much gravels followed by fine to very fine grained, cemented clayey sand followed by fine to very fine grained, cemented, silty clays of low plasticity –mud stone followed by fine to very fine grained, cemented sandy clays of low plasticity –mud stone upto 9.10m (i.e. RL 191.98m).
2. Second characterized layer below the overburden soils comprises of Highly weathered, weak, yellowish brown, fine to medium grained, fractured rock upto 12.00m (i.e. RL 189.08m).

3.0 Design Considerations

1. Length of socket considered 3D from depth of rock encountered.
2. The pile is considered to have socket length below 9.10 m below NGL (i.e. RL 191.98 m) depth.
3. For present case of pile terminating in highly weathered rock. SPT at depths between 9.10 to 12.00m (between RL 191.98 to 189.08 m) is > 100 with just 5.0 cm penetration in 50 blows. SPT can be extrapolated for 30 cm i.e. $50 * 30 / 5.00 = 300$.

Based on recommendation of fig no. 3 in B 8 in Annex B under clause 6.3.1.1 and 6.3.2 of IS 2911 P1/S2, average shear strength q_c corresponding to assumed SPT of 200 may be taken as 1300 kN/m^2

4. Allowable Capacity of pile socketed into rock $Q_a = R_e + R_{sf} = C_{u1} N_c \pi B^2 / 4 (F_s = 3) + \alpha C_{u2} \pi BL / (F_s = 6)$

4.0 Safe Load on Pile in Compression

Where,

End bearing component, $R_e = C_{u1} N_c \pi B^2 / 4 F_s$,

C_{u1} = Shear strength below base of pile = 1300 kN/m^2

B = diameter of the pile = d

F_s = Factor of Safety = 3

$N_c = 9$

Therefore, **$R_e = 3061.5 d^2$**

Skin friction component of socketed length of pile, $R_{sf} = \alpha C_{u2} \pi BL / F_s$

$\alpha = 0.9$ (recommended value in IS 2911 P1/S2)

L = length of the socket = 3 D

C_{u2} = Ultimate shear strength along socket length which shall be restricted to shear capacity of concrete of the pile = 1300 kN/m^2

F_s = Factor of Safety = 6

Therefore, **$R_{sf} = 1836.9 d^2$**

Thus,

$$Q_a = c_{u1} N_c \cdot \frac{\pi B^2}{4 F_s} + \alpha c_{u2} \cdot \frac{\pi B L}{F_s}$$

$$= 3061.5 d^2 + 1836.9 d^2 = 4898.4 d^2$$

Substituting the values of various diameters and socket lengths equal to 3 times diameter, allowable load on single pile can be summarized as follows,

Summary of the Safe load calculation in Compression

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	12.32	12.80	13.22
Termination level RL in m	190.18	189.70	189.28
End Bearing Component in kN	1102.1	1768.3	2479.8
Friction Component in kN	661.3	1060.9	1487.9
Safe load in Compression in kN	1763.4	2829.3	3967.7
Safe load in Compression in T	176	283	397

5.0 Safe Load on Pile in uplift

At 1.50m FGL

The overburden soils, though, will not contribute in compression capacity would offer resistance in uplift capacity. The parameters of BH 130 are considered for calculation of uplift resistance as summarized below,

Depth in m from RL 202.5 m	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Submerged density in gm/cc γ_{sub}	Reduction Factor α	Earth pressure coefficient K	Angle of wall friction $\delta = \phi$	SPT N Value
FGL to 1.50	No contribution considered - Cut off level						
1.50 to 2.92	0.36 ^{\$}	0	1.02	1.00	NA	NA	9
2.92 to 4.52	0.08(ignored)	27	1.02	NA	1.00	27	18-21
4.52 to 6.12	1.59 [#]	9(ignored)	1.05 [#]	0.28	NA	NA	41
6.12 to 8.02	0.18 [#] (ignored)	30 [#]	1.13 [#]	NA	1.00	30	>100
8.02 to 10.52	6.66 ^{\$}	0	1.15	0.28	NA	NA	>100
10.52 to 22.42	Rock strata – Resistance would be as per skin friction capacity in socket as already calculated in compression capacity						

#Average of the parameters falling in the same layer has been considered.

\$ Parameters of this layer is considered based on SPT N value.

Ultimate load in skin friction,

$$Q_{uf} = \alpha_i C_{ai} A_{si} + K_i P D_i \tan \delta_i A_{si}$$

First Layer – Cut off level

$$\text{Second Layer} - \alpha_2 C_{a2} A_{s2} = 1.00 \times 3.60 \times \pi d \times 1.42 = 16.06d$$

$$\text{Third Layer} - K_3 P D_3 \tan \delta_3 A_{s3} = 1.00 \times 3.86 \times \tan 27^\circ \times \pi d \times 1.60 = 9.89 d$$

$$\text{Fourth Layer} - \alpha_4 C_{a4} A_{s4} = 0.28 \times 15.90 \times \pi d \times 1.60 = 22.38d$$

$$\text{Fifth layer} - K_5 P D_5 \tan \delta_5 A_{s5} = 1.00 \times 7.43 \times \tan 30^\circ \times \pi d \times 1.90 = 25.61 d$$

$$\text{Sixth Layer} - \alpha_6 C_{a6} A_{s6} = 0.28 \times 66.60 \times \pi d \times 2.50 = 146.46d$$

$$\text{Seventh Layer} - 1836.90 d^2 \text{ in rock socket}$$

$$\text{Substituting, ultimate load } q_{uf} = 2204.00 d + 1836.9 d^2$$

The safe load in uplift is worked out (considering the safety factor of 2.50 for overburden soils) and summarized below,

Safe Load on Piles in Uplift (in Ton)

Pile Diameter in, m	0.60	0.76	0.90
Socketing Length in, m (3 Times Diameter of Pile)	1.80	2.28	2.70
Termination depth of pile below the FGL (i.e. RL 202.50 m)	12.32	12.80	13.22
Termination level RL in m	190.18	189.70	189.28
Safe load in Uplift in kN	1190.24	1731.01	2281.33
Self-weight of pile in kN	45.89	76.89	111.84
Safe load in Uplift in T (Considering self-weight of pile)	123.61	180.79	239.32

6.0 Lateral Pile Capacity

Pile would be long and elastic (i.e. $L > 4T$). For a prescribed deflection of 5mm and with M 30 grade of concrete, the lateral load and moment were worked out as follows,

Diameters in m		0.60	0.76	0.90
Subgrade reaction in MN/m^3		12.96	12.96	12.96
Stiffness factor T in m		1.69	2.04	2.34
Depth of fixity in m	Free Head	3.20	3.90	4.40
	Fixed Head	3.70	4.40	5.10
Allowable Horizontal Force in T	Free Head	8.10	11.80	15.40
	Fixed Head	21.40	31.20	40.90
Allowable Moment capacity in Tm	Free Head	9.06	15.98	23.98
	Fixed Head	32.26	56.89	85.37

7.0 Notes

1. Pile shall be terminated after socketing 3D inside rock.
2. Initial and routine pile load test is required to verify the actual carrying capacity of pile in compression, uplift and lateral loads.
3. For design and construction, specification of IS: 2911, P1/S2, IS: 456, 2000 shall strictly be followed.

(Dr. K. K. Thaker)

Appendix – 16B

Calculation of Safe Load on Uniform Diameter Bored Cast in situ Pile. (Near BH-130) (Power house Unit-3)

The safe load is calculated as follows,

1) Design Stipulations

- | | |
|---|---|
| 1. Type of pile | - Bored cast in situ uniform diameter pile. |
| 2. Pile diameter considered | - 0.60m |
| 3. Termination depth of pile considered | - 9.50m from FGL. |
| 4. Cut off Level | - At 1.50m from FGL. |
| 5. Factor of Safety | - 2.50 |
| 6. Depth of Water table | - Considered at FGL. |
| 7. Ref | - IS 2911 P-I, Sec-II, 2021. |

2) Test Data

The parameters are based on BH 130. For evaluation of safe load on piles following characterized layers are considered as described in table below,

Depth in m from RL 202.5 m	Cohesion in kg/cm ²	Angle of Internal Friction ϕ	Submerged density in gm/cc γ_{sub}	Reduction Factor α	Earth pressure coefficient K	Angle of wall friction $\delta = \phi$	SPT N Value
FGL to 1.50	No contribution considered - Cut off level						
1.50 to 2.92	0.36 ^{\$}	0	1.02	1.00	NA	NA	9
2.92 to 4.52	0.08~0.00*	27	1.02	NA	1.0	27	18-21
4.52 to 6.12	1.59 [#]	9~0*	1.05 [#]	0.28	NA	NA	41
6.12 to 8.02	0.18 [#] ~0.00*	30 [#]	1.13 [#]	NA	1.0	30	>100
8.02 to 10.52	6.66 ^{\$}	0	1.15	0.28	NA	NA	>100

Notes: - Layers are characterized based on classification and the state of soil in that stratum.

* - In cohesive soils the contribution of the angle of internal friction being insignificant is ignored.

Shear parameters are the most representative for the layer. NA means not applicable. Characterized N values are considered for each layer.

- Weighted Average of the parameters falling in the same layer has been considered

\$-Parameters are correlated based on SPT value N.

3) Ultimate Load in Compression

3.1) Ultimate load in Compression by Bearing

Ultimate load on pile in end bearing,

$$q_{ub} = A_p (0.5 \cdot D \cdot \gamma \cdot N_v + P D N_q)$$

$$A_p = \text{Cross section area of Pile stem at toe} = \pi d^2 / 4$$

$$D = \text{Diameter of pile} = d \text{ in m}$$

$$N_v = 42.90$$

$$N_q = 40.00$$

$$q_{ub} = 0.785d^2 (0.5 \cdot d \cdot 1.15 \cdot 42.90 + 8.61 \cdot 40.00) = 19.36d^3 + 270.35d^2$$

(For Pile terminating at 9.50m from F.G.L.)

Note: As the pile terminating just above rock level, we have considered parameter for end bearing component based on rock strata.

3.2) Ultimate Load in Compression by Skin Friction

Ultimate load in skin friction,

$$q_{uf} = \alpha_i C_{ai} A_i + K_i P D_i \tan \delta_i A_{si}$$

First Layer – No contribution considered due to cut off level

$$\text{Second Layer} - \alpha_2 C_{a2} A_{s2} = 1.00 \cdot 3.60 \cdot \pi \cdot d \cdot 1.42 = 16.06d$$

$$\text{Third Layer} - K_3 P D_3 \tan \delta_3 A_{s3} = 1.00 \cdot 2.26 \cdot \tan 27^\circ \cdot \pi \cdot d \cdot 1.60 = 5.79d$$

$$\text{Fourth Layer} - \alpha_4 C_{a4} A_{s4} = 0.28 \cdot 15.90 \cdot \pi \cdot d \cdot 1.60 = 22.38d$$

$$\text{Fifth layer} - K_5 P D_5 \tan \delta_5 A_{s5} = 1.00 \cdot 5.83 \cdot \tan 30^\circ \cdot \pi \cdot d \cdot 1.90 = 20.09d$$

$$\text{Sixth Layer} - \alpha_6 C_{a6} A_{s6} = 0.28 \cdot 66.60 \cdot \pi \cdot d \cdot (l - 8.02) = 58.58d (l - 8.02)$$

Substituting, ultimate load

$$q_{uf} = 64.32d + 58.58d (\ell - 8.02) \text{ (For Pile terminating at 9.50m from F.G.L.)}$$

Where, ℓ is the pile length and d is diameter of piles, substituting

Ultimate load by both bearing and friction can be as follows for various lengths of piles,

$$q_{uc} = q_{ub} + q_{uf}$$

$$q_{uc} = 19.36d^3 + 272.24d^2 + 64.32d + 58.58d (\ell - 8.02) \text{ (For Pile terminating at 9.50m from F.G.L.)}$$

By substituting various diameters of piles having various lengths, the safe load is worked out considering the safety factor of 2.50 and are given in table below,

Safe Load on Piles in Compression (in Ton)

Termination Depth of Pile in m, from FGL	Termination Depth of Pile in m, from cut-off	Diameter of Pile in, m
		0.60
9.50	8.00	76.85

3.3) Ultimate Load in Uplift

Considering skin friction for determination of uplift

Safe Load on Piles in Uplift (in Ton)

Termination Depth of Pile in m, from FGL	Termination Depth of Pile in m, from cut-off	Diameter of Pile in, m
		0.60
9.50	8.00	33.60

Note: Self weight of pile is considered in calculation of ultimate load in uplift.

Self weight of Pile (in Ton)

Termination Depth of Pile in m, from FGL	Termination Depth of Pile in m, from cut-off	Diameter of Pile in, m
		0.60
9.50	8.00	3.39

3.4) Lateral Pile Capacity

Pile would be long and elastic (i.e. $L > 4T$). For a prescribed deflection of 5mm and with M 30 grade of concrete, the lateral load and moment were worked out as follows,

Diameters in m		0.60
Subgrade reaction in MN/m^3		12.96
Stiffness factor T in m		1.69
Depth of fixity in m	Free Head	3.20
	Fixed Head	3.70
Allowable Horizontal Force in T	Free Head	8.10
	Fixed Head	21.40
Allowable Moment capacity in Tm	Free Head	9.06
	Fixed Head	32.26

4) Notes:

1) Initial and Routine pile load tests shall be carried out as per IS 2911, P-4 on the piles to confirm the capacity of pile worked out theoretically. For design and construction, specifications of IS 2911, P-I, S-2, shall strictly be followed. Termination depth of pile shall be from FGL.

LIQUEFACTION ANALYSIS AS PER IS 1893-P-1-2016																					
Project Name :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha																					
Location - BH-98																					
Sr. No.	Depth, D	Type of Soil Stratum	Percentage Fines	Observed SPT, N Value	Undrained Shear Strength, ζ	Saturated Density	Submerged Density	Total Overburden Pressure, (σ_0)	Effective Overburden Pressure, (σ')	C_{RL}	C_{SS}	C_{BD}	C_{HT}	C_{HW}	C_N	$(N_1)_{60}$	$(\Delta N_1)_{60}$	Alpha, α	Beta, β	$(N_1)_{60CS}$	Stress Reduction Co-efficient
	m		(%)	$(N_{measured})$	t/m^2	t/m^3	t/m^3	t/m^2	t/m^2								(≤ 5.5)				(r_d)
1	1.00	CH	74	7	0.6	1.91	0.91	1.91	0.91	0.75	1.10	1.05	0.75	0.98	1.70	8	5.50	5.000	1.200	14.13	0.992
2	2.50	CH	64	8	0.8	1.92	0.92	4.79	2.29	0.75	1.10	1.05	0.75	0.98	1.70	9	5.50	5.000	1.200	15.44	0.981
3	4.00	CI	66	9	0.8	1.94	0.94	7.70	3.70	0.80	1.10	1.05	0.75	0.98	1.64	10	5.50	5.000	1.200	17.11	0.969
4	5.50	SC	37	11	2.6	1.96	0.96	10.64	5.14	0.85	1.10	1.05	0.75	0.98	1.39	11	5.50	5.000	1.200	18.34	0.958
5	7.00	SC	34	14	3.3	1.96	0.96	13.58	6.58	0.95	1.10	1.05	0.75	0.98	1.23	14	5.49	4.931	1.188	21.54	0.946
6	8.50	SM	18	12	3.9	1.96	0.96	16.52	8.02	0.95	1.10	1.05	0.75	0.98	1.12	11	4.09	3.234	1.066	14.81	0.935
7	10.00	SM	27	27	4.6	1.96	0.96	19.46	9.46	0.95	1.10	1.05	0.75	0.98	1.03	22	5.21	4.479	1.130	29.89	0.907
8	11.50	SC	32	100	5.4	1.96	0.96	22.40	10.90	1.00	1.10	1.05	0.75	0.98	0.96	82	5.43	4.828	1.171	100.46	0.867
9	13.00	SP-SM	8	100	6.0	1.96	0.96	25.34	12.34	1.00	1.10	1.05	0.75	0.98	0.90	77	0.37	0.299	1.013	78.02	0.827
10	14.50	SP-SM	6	100	6.7	1.96	0.96	28.28	13.78	1.00	1.10	1.05	0.75	0.98	0.85	73	0.03	0.030	1.005	73.00	0.787

Notes:

* Soil with combined effect of the criterias like % finer than 0.005mm < 15 %, Liquid Limit < 35 %, PI < 12 % and moisture content greater than 0.90*(LL) therefore liquefaction may be likely (Ref: " Liquefaction susceptibility criterias by Wang (1979) & Seed et.al (2003).).

* From screening criteria liqufaction unlikely when (N1)60CS exceeds 30. (Ref. : Idriss and Boulanger (2008))

1) Project Site is considered in Zone 3 (Ref: IS 1893:2016)

2) Maximum Intensity of Earthquake has been considered as 6.50

3) More severity considered into account as peak ground acceleration is taken as 0.16, as per IS 1893:2016,suggests.

4) Corrections for SPT N as per IS 1893 Part 1, 2016.

5) Water Table encountered at depth 2.40 ut considered at G.L.

6) After a 14.50 m depth from N.G.L. rocky strata encountered.

CSR	$C\sigma$	$K\sigma$	$(CRR)_{7.5}$	$CRR_{eq} = CRR^* \times K\sigma \times K\alpha \times KDR$	CRR	Z, m	H, m	w(z)	F	$W(Z)*F*H$	F.O.S	CHECK
	(≤ 0.3)											(F.O.S ≤ 1.00)
0.217	0.103	1.010	0.511	0.516	0.737	0.500	1.000	9.750	0.000	0.000	3.40	NOT LIQUEFIABLE
0.213	0.000	1.000	0.262	0.262	0.378	1.750	1.500	9.125	0.000	0.000	1.77	NOT LIQUEFIABLE
0.210	1.000	-0.308	0.174	-0.054	0.251	3.250	1.500	8.375	0.000	0.000	1.19	NOT LIQUEFIABLE
0.206	1.000	-0.637	0.196	-0.125	0.282	4.750	1.500	7.625	0.000	0.000	1.37	NOT LIQUEFIABLE
0.203	2.000	-2.768	0.236	-0.652	0.340	6.250	1.500	6.875	0.000	0.000	1.67	NOT LIQUEFIABLE
0.200	3.000	-5.246	0.158	-0.830	0.228	7.750	1.500	6.125	0.000	0.000	1.14	NOT LIQUEFIABLE
0.194	4.000	-7.988	0.460	-3.678	0.664	9.250	1.500	5.375	0.000	0.000	3.42	NOT LIQUEFIABLE
NOT LIQUEFIABLE-SEE SCREENING CRITERIAS												
NOT LIQUEFIABLE-SEE SCREENING CRITERIAS												
NOT LIQUEFIABLE-SEE SCREENING CRITERIAS												
LPI=SUM(W(Z)*F*H)									0.000			

Calculation of Allowable Bearing Pressure from Shear & Settlement Criteria.

Project: Proposed Structures in Phase 1 of 3 x 800 MW NLC Talabira, Thermal Power Project (NTTPP) at village- Hirma, Talabira, Odisha

Structure: Power House

➤ **For Square Isolated Foundations:**

Depth of foundation considered from FGL, $D_f = 1.00$ m (200.: 8 R.L.)

Width of foundation considered, $B_f = 1.50$ m

Length of foundation considered, $L_f = 1.50$ m

Bulk Density $\gamma_b = 1.67$ gm/cm³

Water Table at depth = Considered at F.G.L. for analysis.

Factor of Safety = 2.50

$$q_u = \left[\left(\frac{2}{3} \right) * c N_c d_c S_c i_c + \gamma d (N_q - 1) S_q d_q i_q W + 0.5 \gamma B N_\gamma S_\gamma d_\gamma i_\gamma W_\gamma \right],$$

Ref: - (IS 6403, Cl-5.1.2a)

Shear Parameters, $c = 0.47$ kg/cm², $\phi = 5^\circ$, $e = 0.81$

(Considered as average between all the boreholes)

Bearing Capacity Factors:

$N_c = 5.99$, $N_q = 1.35$, i.e. $N_q - 1 = 0.35$, $N_\gamma = 0.27$

(Following equations, Ref: Vesic)

$$N_c = (N_q - 1) \cot \Phi$$

$$N_q = e^{\pi \tan \Phi} \tan^2 \left(45 + \frac{\Phi}{2} \right)$$

$$N_\gamma = 2(N_q + 1) \tan \Phi$$

Shape Factors: (for rectangular footings)

(IS 6403, Table 2)

$S_c = 1.30$, $S_q = 1.20$, $S_\gamma = 0.80$

Depth Factors:

$d_c = 1.14$, $d_q = d_\gamma = 1.00$

(IS 6403, CL-5.1.2.2)

$$d_c = 1 + 0.2 D_f/B * \sqrt{N_\phi}$$

$d_q = d_\gamma = 1$ for $\Phi < 10^\circ$

Inclination Factors: (for vertical loading)

$i_c = i_q = i_\gamma = 1.00$

(IS 6403, CL-5.1.2.3)

$$i_c = i_q = \left(1 - \frac{\alpha}{90} \right)^2$$

$$i_\gamma = \left(1 - \frac{\alpha}{\phi} \right)^2$$

α = inclination of load to vertical in degrees = 0

Water Table Correction: (W.T at G.L.)

W_q , $W_\gamma = 0.5$ & 0.5 respectively,

(IS 6403, CL-5.1.2.4)

Substituting, the values for determination of ultimate bearing capacity from shear criteria,

$$q_u = \left[\left(\frac{2}{3} \right) * c N_c d_c S_c i_c + \gamma d (N_q - 1) S_q d_q i_q W_q + 0.5 \gamma B N_\gamma S_\gamma d_\gamma i_\gamma W_\gamma \right]$$

$$\begin{aligned} q_u &= \left[\left(\frac{2}{3} \right) * (0.47 * 10) * 5.99 * 1.14 * 1.30 * 1.00 + (3.35 + 1.67 \right. \\ &\quad * (1.00))(1.35 - 1.00) * 1.20 * 1.00 * 1.00 * 0.50 + 0.5 * 1.67 * 3.00 \\ &\quad \left. * 0.27 * 0.80 * 1.00 * 1.00 * 0.50 \right] \\ &= 29.15 \text{ T / m}^2 \end{aligned}$$

$$q_{\text{net safe}} = q_u / \text{FS (i.e. 2.5)} = 11.66 \text{ T / m}^2$$

$$q_{\text{net safe}} = 12.0 \text{ T / m}^2 = 120.00 \text{ kN/m}^2$$

Calculation of Allowable Bearing Pressure from Settlement Criteria.

Project: Proposed Structures in Phase 1 of 3 x 800 MW NLC Talabira, Thermal Power Project (NTTPP) at village- Hirma, Talabira, Odisha

Structure: Power House

$$S_i + S_c = \frac{C_d q_{net} B (1 - \mu^2)}{(E)} + m_v H \Delta P$$

Where,

S = Settlement of 50mm Considered

Q_{net} = Safe Bearing pressure

Factor C_d

E = Modulus of Elasticity

m_v = Co-efficient of Volume Compressibility

μ = Poisson's Ratio

B, L = Width & Length of Foundation respectively

R_f = Rigidity Factor

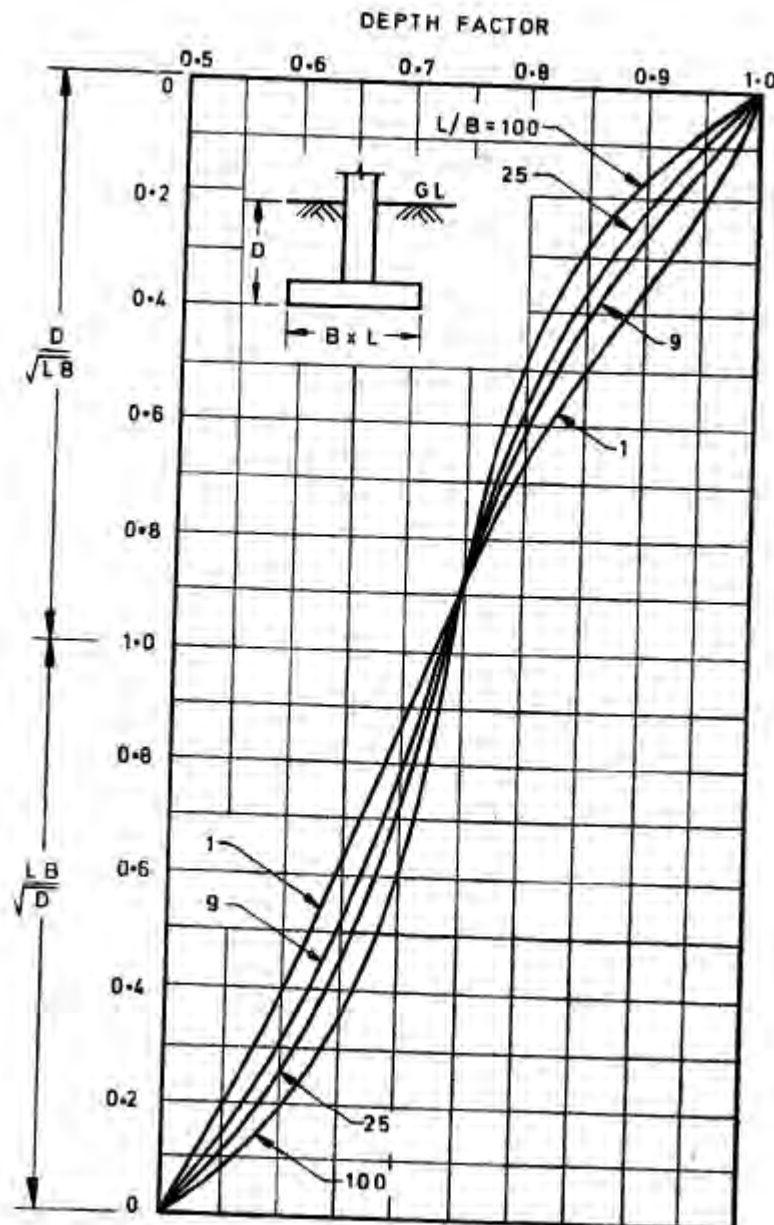
D_f = Depth factor

λ = Factor Related to Pore Pressure

Code of Reference – IS 8009 P-1

For Isolated Foundations:

- Safe Bearing Pressure for 50mm Settlement.
- Depth of foundation considered from EGL, D_f = 1.00 m (199.60 R.L.)
- Width of foundation, considered, B_f = 1.50 m
- Length of foundation, considered, L_f = 1.50 m
- Poisson's ratio, μ = 0.40 (Ref : Foundation Analysis and Design by JE Bowles)
- Co-efficient of Volume Compressibility = 0.0170 cm²/kg,
- Modulus of Elasticity, E = 183.0 kg/cm² (Modulus of Elasticity value has been considered from the results of shear test)
- Depth of Compressible Stratum, H = 3.0 m
- Rigidity Factor = 0.80
- Dispersion 1:2 – Factor = ((H/2)+B)²/ B² = ((3.00/2)+1.50)²/1.50² = 4.0, (Utilized in calculations)
- Factor Related to Pore Pressure, λ = 1.00 **Ref: - Table – 1, IS 8009, P-1**
- Depth Correction Factor = 0.80 **Ref: - From Fig-12, IS 8009, P-1**
L/B = 1.00, D/(sqrt (L*B)) = (1.00/sqrt(1.50*1.50)) = 0.67



- Factor $C_d = 1.12$ Ref: - Table-2, IS 8009, P-I,

$$\text{Net S.B.P} = 40 / (((100 * 1.12 * 1.50/2 * (1 - 0.40^2) * 0.80) / 183.0) + (100 * 0.0170 * 3.00 * 1.00 * 0.80 * 0.80 / 4.0))$$

$$= 35.52 \text{ T/m}^2$$

$$= 36 \text{ T/m}^2$$

So, Allowable Safe Bearing Pressure Considering Immediate and Consolidation Settlement is 36.00 T/m^2 .

So, Allowable Bearing Pressure = lower of both the cases, i.e. shear and settlement criteria

$$= \text{Minimum of } 12.00 \text{ T/m}^2 \text{ \& } 36.00 \text{ T/m}^2$$

$$= 12.00 \text{ T/m}^2 = 120.00 \text{ kN/m}^2.$$

Sample Calculation for Pile Lateral Capacity

Project: Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

Structure: Power House Unit -1

Cut-off of pile: 4.0 m from F.G.L. (R.L.-202.50 m)

Diameter of Pile: 0.760 m

Length of Pile: 21.80 m from F.G.L. (R.L.-202.50 m)

Here, pile would be long and elastic (i.e. $L > 4T$) therefore lateral capacity of pile calculated as per the IS 2911 (Part 1/ Sec 3): 2010 (reaffirmed 2020). Lateral pile capacity is calculated corresponding to 5 mm deflection.

Lateral Capacity for free head pile,

$$y = \frac{H (e+zf)^3}{3EI} \dots\dots\dots \text{Eq.1.}$$

Lateral Capacity for fix head pile,

$$y = \frac{H (e+zf)^3}{12EI} \dots\dots\dots \text{Eq.2.}$$

y = Deflection of Pile Head, in mm

H = lateral load, in tones

e = cantilever length above ground/bed to the point of load application, in m.

Here, e = 0m

E = Young's Modulus of pile material in kg/cm^2

M30 Grade of concrete is considered for the calculation,

$$E = 5000 * (f_{ck})^{1/2} * 10^3 = 279261.80 \text{ kg/cm}^2$$

I = moment of inertia of the pile cross-section, in cm^4

$$I = \frac{\pi}{64} * d^4$$

$$= \frac{\pi}{64} * 76^4$$

$$= 1636831.80 \text{ cm}^4$$

T = Stiffness Factor in cm,

$n_h = 2.70 \text{ MN/m}^3$ From Table 4.0 of IS 2911 (Part 1/ Sec 3): 2010 (reaffirmed 2020)

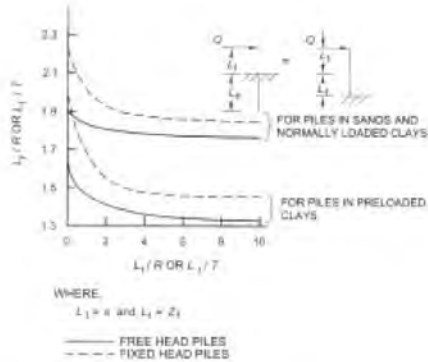
$$T = \sqrt[5]{\frac{EI}{n_h}}$$

$$T = \sqrt[5]{\frac{(279261.80 * 1636831.80)}{0.27}}$$

$$T = 279.08 \text{ cm}$$

$$T = 2.79 \text{ m}$$

Z_f = depth to point of fixity, in m



As per the Fig.3 of IS 2911 (Part 1/ Sec 3): 2010 (reaffirmed 2020) for Free Head Pile,

$$\frac{Z_f}{T} = 1.9$$

$$Z_f = 1.9 * 279.08$$

$$Z_f = 530 \text{ cm}$$

As per the Fig.3 of IS 2911 (Part 1/ Sec 3): 2010 (reaffirmed 2020) for Fix Head Pile,

$$\frac{Z_f}{T} = 2.18$$

$$Z_f = 2.18 * 279.08$$

$$Z_f = 608 \text{ cm}$$

Substituting above value in Eq. 1. For Allowable Horizontal Force in free head condition,

$$0.5 = \frac{H (0+530)^3}{3*279261.80* 1636831.80}$$

$$H = 4605.5 \text{ kg}$$

$$H = 4.61 \text{ Tones}$$

$$H = 4.60 \text{ Tones}$$

Substituting above value in Eq. 2. For Allowable Horizontal Force in free head condition,

$$0.5 = \frac{H (0+608)^3}{12*279261.80* 1636831.80}$$

$$H = 12202.70 \text{ kg}$$

$$H = 12.20 \text{ Tones}$$

NOTATIONS

C	Cohesion
ϕ	Angle of internal friction of soil
DS	Disturbed Sample
UDS	Undisturbed Sample
NMC	Natural Moisture Content
NP	Non Plastic Soils
G	Specific Gravity
G	Gravel Content
M	Silt Content
S	Sand Content
C	Clay Content
LL	Liquid Limit
PL	Plastic Limit
PI	Plasticity Index
Cc	Compression Index
K	Coefficient of Permeability
UCS	Unconfined Compression
N	SPT Value
BH	Bore Hole
Suffix	The Number of Bore Holes
Nc, Nq, N γ	Bearing Capacity Factor
Sc, Sq, S γ	Shape Factors
γ	Density of Soil
D	Depth of foundation
FS	Factor of Safety
mv	Coefficient of volume compressibility
UU	Unconsolidated undrained triaxial test
CU	Consolidated undrained triaxial test
CD	Consolidated drained triaxial test
GC	Clayey Gravels
GM	Silty Gravels
GP	Poorly Graded Gravels
GW	Well Graded Gravels
SC	Clayey Sand
SM	Silty Sand
SW	Well Graded Sand
SP	Poorly Graded Sand
CH	Clays of High Plasticity
CI	Clays of Intermediate Plasticity
CL	Clays of Low Plasticity
MH	Silts of High Plasticity
MI	Silts of Intermediate Plasticity
ML	Silts of Low Plasticity

Reference

Indian Standards

IS 2720 Pt 2, 3, 4, 5, 8, 11, 12, 13, 15, 16, 31, 27, 25,

IS 1498,

IS 6403,

IS 1904,

IS 8009,

IS 2911 Pt1/S2, Pt 4,

IS 1892

Bowles J. E., “Foundation Analysis and Design”

Murthy V.N.S., “Principals and Practice of Soil Mechanics and Foundation engineering”

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Reference - c

Soil Mechanics And Foundation Engineering by Dr.K.R.Arora
(For Mixed shear failure reference)

SOIL MECHANICS AND FOUNDATION ENGINEERING

600

and

$$N_c = 57.8, N_q = 41.4 \text{ and } N_\gamma = 42.4$$

$$N'_c = 25.2, N'_q = 12.6 \text{ and } N'_\gamma = 10.1$$

Difference $(N_c)_d = 32.6, (N_q)_d = 28.8 \text{ and } (N_\gamma)_d = 32.3$.

As the actual value of ϕ' is 35° which is 6° more than the value of ϕ' corresponding to local shear failure (viz. 29°), the proportional difference to be added to the values of N'_c, N'_q and N'_γ is $6/7$ times the total difference. Thus, the required values are

$$N_c = 25.2 + 6/7 \times 32.6 = 53.14$$

$$N_q = 12.6 + 6/7 \times 28.8 = 37.29$$

$$N_\gamma = 10.1 + 6/7 \times 32.3 = 37.79$$

(2) If the failure of the specimen of the soil occurs at a relatively small strain, say less than 5%, the failure of the footing would be by general shear failure. If the stress-strain curve does not show a peak and is a continuously rising curve even upto a strain of 10 to 20%, local shear failure would occur in the footing.

(3) If the relative density (D_r) is greater than about 70%, general shear failure would occur. If it is less than 35%, local shear failure is more likely.

(4) If the standard penetration test (SPT) value is more than 30, the general shear failure would occur. However, if it is less than 5, the local shear failure is more likely.

(5) If e is less than 0.55, the general shear failure occurs. If e is greater than 0.75, the local shear failure occurs.

23.10. EFFECT OF WATER TABLE ON BEARING CAPACITY

Eq. 23.25 for the ultimate bearing capacity has been developed based on the assumption that the water table is located at a great depth. If the water table is located close to the foundation, the bearing capacity equation needs modification, as explained below.

Case I Water table located above the base of footing [Fig. 23.11 (a)]

The effective surcharge is reduced as the effective weight below the water table is equal to the submerged unit weight. Therefore,

$$q = D_w \gamma + a \gamma'$$

where D_w = depth of water table below the ground surface,
 a = height of water table above the base of footing.

Alternatively, Eq. 23.30 can be written as, substituting $a = D_f - D_w$,

$$q = \gamma' D_f + (\gamma - \gamma') D_w$$

Moreover, the unit weight in the third term of Eq. 23.25 is equal to the submerged unit weight. Thus Eq. 23.25 becomes

$$q_u = c' N_c + [\gamma' D_f + (\gamma - \gamma') D_w] N_q + 0.5 \gamma' B N_\gamma$$

If $D_w = 0$ (i.e. $a = D_f$),

$$q_u = c' N_c + \gamma' D_f N_q + 0.5 \gamma' B N_\gamma$$

If $a = 0$ (i.e. $D_f = D_w$),

$$q_u = c' N_c + \gamma D_f N_q + 0.5 \gamma' B N_\gamma$$

(a) (b)

Fig. 23.11.

... (23.30)

... (23.31)

... (23.32)

... (23.33)

... (23.34)

Reference - d

Soil Mechanics And Foundation Engineering by V.N.S. Murthy (For Modulus of Elasticity reference)

676

Chapter 16

tests in 900 mm diameter bored holes in London clay. Marsland found that the average moduli determined from the loading tests were between 1.8 to 4.8 times those obtained from undrained triaxial tests. A suggestion to obtain the more realistic value for E_v is,

1. Undisturbed samples obtained from the field must be reconsolidated under a stress system equal to that in the field (K_0 -condition).
2. Samples must be reconsolidated isotropically to a stress equal to $1/2$ to $2/3$ of the *in-situ* vertical stress.

It may be noted here that reconsolidation of disturbed sensitive clays would lead to significant change in the water content and hence a stiffer structure which would lead to a very high E_v .

Because of the many difficulties faced in selecting a modulus value from the results of laboratory tests, it has been suggested that a correlation between the modulus of elasticity of soil and the undrained shear strength may provide a basis for settlement calculation. The modulus E_v may be expressed as

$$E_v = Ac_u \quad (18.51)$$

where the value of A for inorganic stiff clay varies from about 500 to 1500 (Bjerrum, 1972) and c_u is the undrained cohesion. It may generally be assumed that highly plastic clays give lower values for A , and low plasticity give higher values for A . For organic or soft clays the value of A may vary from 100 to 500. The undrained cohesion c_u can be obtained from any one of the field tests mentioned below and also discussed in Chapter 17.

Field methods

Field methods are increasingly used to determine the soil strength parameters. They have been found to be more reliable than the ones obtained from laboratory tests. The field tests that are normally used for this purpose are

1. Plate load tests (PLT)
2. Standard penetration test (SPT)
3. Static cone penetration test (CPT)
4. Pressuremeter test (PMT)
5. Flat dilatometer test (DMT)

TABLE 18.7

Equations for computing E_v by making use of SPT and CPT values (in kPa)

Soil	SPT	CPT
Sand (normally consolidated)	$500 (N_{60} + 15)$ $(35000 \text{ to } 50000) \log N_{60}$ (U.S.S.R. Practice)	$2 (\sigma'_v + q_c)$ $(1 + D^2) q_c$
Sand (saturated)	$250 (N_{60} + 15)$	
Sand (overconsolidated)	—	$6 \text{ to } 30 q_c$
Gravelly sand and gravel	$1200 (N_{60} + 6)$	
Clayey sand	$320 (N_{60} + 15)$	$3 \text{ to } 6 q_c$
Silty sand	$300 (N_{60} + 6)$	$1 \text{ to } 2 q_c$
Soft clay	—	$3 \text{ to } 8 q_c$

Reference - e

Soil Mechanics And Foundation Engineering by V.N.S. Murthy
(For Poisson's Ratio reference)

678

Chapter 18

corresponding value of E_s has to be determined. Table 18.8 gives typical values for μ as suggested by Bowles (1996).

I_f is a function of the L/B ratio of the foundation, and the thickness H of the compressible layer. Terzaghi has given a method of calculating I_f from curves derived by Steinbrenner (1934),

for Poisson's ratio of 0.5, $I_f = F_1$,

for Poisson's ratio of zero, $I_f = F_1 + F_2$,

where F_1 and F_2 are factors which depend upon the ratios of H/B and L/B .

For intermediate values of μ , the value of I_f can be computed by means of interpolation or by the equation

$$I_f = \left[F_1 + \frac{(1-\mu-2\mu^2)F_2}{1-\mu^2} \right] \quad (18.52b)$$

The values of F_1 and F_2 are given in Fig. 18.19a. The elastic settlement at any point N (Fig. 18.19b) is given by

$$S_e \text{ at point } N = \frac{q_n(1-\mu^2)}{E_s} [I_{f1}B_1 + I_{f2}B_2 + I_{f3}B_3 + I_{f4}B_4] \quad (18.52c)$$

To obtain the settlement at the center of the loaded area, the principle of superposition is followed. In such a case N in Fig. 18.19b will be at the center of the area when $B_1 = B_4 = L_2 = B_3$ and $B_2 = L_1$. Then the settlement at the centre is equal to four times the settlement at any one corner. The curves in Fig. 18.19a are based on the assumption that the modulus of deformation is constant with depth.

In the case of a rigid foundation, the immediate settlement at the center is approximately 0.8 times that obtained for a flexible foundation at the center. A correction factor is applied to the immediate settlement to allow for the depth of foundation by means of the depth factor d_f . Fig. 18.20

gives Fox's (1948) correction curve for depth factor. The final elastic settlement is

$$S_{ef} = C_e d_f S_e \quad (18.53)$$

where, S_{ef} = final elastic settlement

TABLE 18.8

Typical range of values for Poisson's ratio (Bowles, 1996)

Type of soil	μ
Clay, saturated	0.4-0.5
Clay, unsaturated	0.1-0.3
Sandy clay	0.2-0.3
Silt	0.3-0.35
Sand (dense)	0.2-0.4
Coarse (void ratio = 0.4 to 0.7)	0.15
Fine grained (void ratio = 0.4 to 0.7)	0.25
Rock	0.1-0.4

Reference - f

(For Modulus of Volume Compressibility, Angle of Internal friction and Cohesion reference)

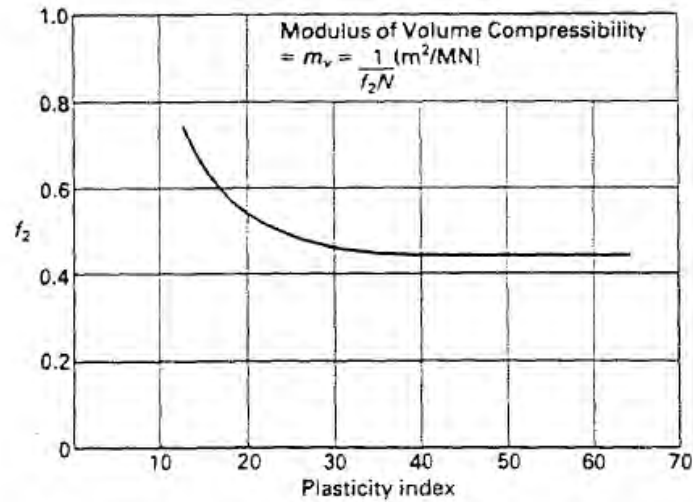


Figure 8. Relationship between Mass Shear Strength, Modulus of Volume Compressibility, Plasticity Index, and SPT-N values (after Stroud, 1975)

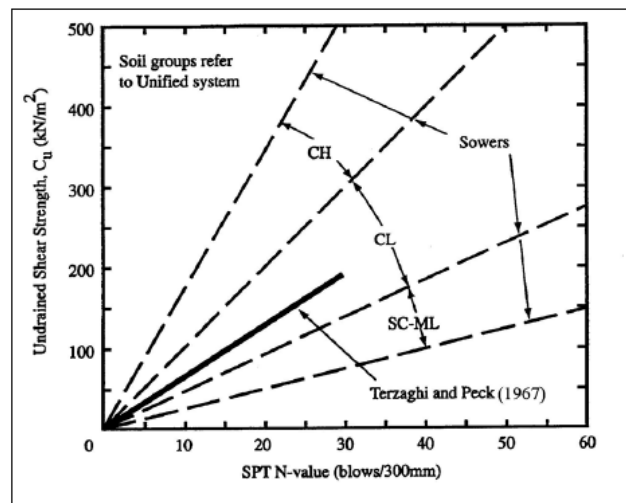


Figure 9. Approximate Correlation between Undrained Shear Strength and SPT-N values (After Sowers, 1979)

Hatanaka and Uchida (1996); $\phi' = \sqrt{20N} + 20^\circ$

$$\phi' = \sqrt{12N_{45}} + 20^\circ$$

A lower bound for the above equation is given as;

$$\phi' = \sqrt{12N_{45}} + 15^\circ$$

Reference - e

TABLE 6
PRESUMPTIVE SAFE BEARING CAPACITY OF SOIL

Sr. No	Types of Rocks/Soils	Safe bearing capacity KN/m ² /t/ m ²	Remarks
(1)	(2)	(3)	(4)
	(a) Rocks		
1.	Rocks (hard) without lamination and defects, for example , granite, trap and diorite	3,240 (330.39)	..
2.	Laminated rocks, for example, stone and lime stone in sound condition	1,620 (165.19)	..
3.	Residual deposits of shattered and broken bed rock and hard shale cemented material	880 (89.73)	..
4.	Soft Rock	440 (44.87)	..
	(b) Non-cohesive soils:		..
5.	Gravel, sand and gravel, compact and offering high resistance to penetration when excavated by tools	440 (44.87)	(See Note 2)
6.	Coarse sand, compact and dry	440 (44.87)	Dry means that the ground water level is at a depth not less than the width of foundation below the base of the foundation
7.	Medium sand, compact and dry	245 (24.98)	..
8.	Fine sand, silt (dry lumps easily pulverized by the fingers).	150 (15.30)	..
9.	Loose gravel or sand gravel mixture loose coarse to medium sand, dry	245 (24.98)	(See Note 2)
10	Fine sand, loose and dry.	100 (10.20)	
	(c) Cohesive soils:		
11.	Soft shale, hard or stiff clay in deep bed, dry	440 (44.87)	This group is susceptible to long term consolidation settlement
12.	Medium clay, readily indented with a thumb nail	245 (24.98)	..
13	Moist clay and sand clay mixture which can be indented with strong thumb pressure	150 (15.30)	..
14	Soft clay indented with moderate thumb pressure	100 (10.20)	..
15.	Very soft clay which can be penetrated several centimeters with the thumb	50 (5.10)	..
16.	Black cotton soil or other shrinkable or expansive clay in dry condition (50 percent saturation)	..	See Note 3. To be determined after investigation
	(d) Peat:		
17.	Peat	..	See Note 3 and Note 4. To be determined after investigation
	(e) Made-up Ground:		
18.	Fills or made-up ground	..	See Note 2 and Note 4. To be determined after investigation

Note: 1- Value listed in the Table are from shear consideration only

Note:2- Values are very much rough due to the following reasons:

- (a) Effect of characteristics of foundations (that is, effect of depth, width, shape, roughness, etc.) has not been considered.
- (b) Effect of range of soil properties (that is, angle of frictional resistance, cohesion, water table, density, etc) has not been considered.
- (c) Effect of eccentricity and indication of loads has not been considered.

Note:3 – For non-cohesive soils, the values listed in the Table shall be reduced by 50% if the water table is above or near the base of footing

Note 4: Compactness of non-cohesive soils may be determined by driving the cone of 65 mm dia and 60 apex angle by a hammer of 65 kg falling from 75 cm. If corrected number of blows (N) for 30 cm penetration are less than 10, the soil is called loose, if N lies between 10 and 30, it is medium, if more than 30, the soils is called as dense.

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 24

Co-Ordinate :- E - 1176, N - 3017

Reduced Level :- 195.77 m

Sr No	Depth of Sample m	Type of Sample	Field Bulk Density gm / cc	Field Dry Density gm / cc	Natural Moisture Content %	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit %	Swelling Pressure Kg/cm ²	Free Swell Index %	Soil Classification	Shear Parameter		Unconfined Compression Test Kg/cm ²	UCS by Point Load Index in rock Kg/cm ²	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation %	Void Ratio	Porosity %
							Gravel %	Sand %	Silt %	Clay %	Liquid Limit %	Plastic Limit %	Plasticity Index %					Cohesion C Kg/cm ²	Angle of Internal Friction ϕ Degree				Compression Index C _c	Coefficient of Volume Compressibility mv cm ² /kg	Pre-consolidation Pressure kg/cm ²				
1	0.00	DS	-	-	-	-	0	43	42	15	29	16	13	-	-	-	CL	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	0	22	62	16	40	26	14	-	-	-	MI	-	-	-	-	-	-	-	-	6	-	-	-
3	2.00	SPT	-	-	-	-	0	20	65	15	39	26	13	-	-	-	MI	-	-	-	-	-	-	-	-	11	-	-	-
4	2.50	SPT	-	-	-	-	0	5	80	15	40	26	14	-	-	-	MI	-	-	-	-	-	-	-	-	36	-	-	-
5	3.00	SPT	-	-	-	-	0	5	81	14	41	28	13	-	-	-	MI	-	-	-	-	-	-	-	-	77	-	-	-
6	4.50	UDS	2.31	2.07	11.51	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	143.6	UCS	-	-	-	-	-	0.31	23.8
7	6.00	UDS	2.29	2.05	11.77	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	134.2	UCS	-	-	-	-	-	0.32	24.1
8	7.50	UDS	2.39	2.19	8.96	2.73	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	172.6	-	UCS	-	-	-	-	7.33	0.24	19.7
9	9.00	UDS	2.44	2.28	6.92	2.71	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	184.1	-	UCS	-	-	-	-	28.66	0.19	15.8
10	10.50	UDS	2.50	2.37	5.62	2.73	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	199.6	-	UCS	-	-	-	-	34.00	0.15	13.3
11	12.00	UDS	2.52	2.39	5.28	2.74	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	164.2	-	UCS	-	-	-	-	8.66	0.14	12.6
12	13.50	UDS	2.45	2.29	6.85	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	130.7	-	UCS	-	-	-	-	64.66	0.19	15.7
13	15.00	UDS	2.53	2.41	5.01	2.74	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	204.9	-	UCS	-	-	-	-	78.00	0.14	12.1

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 26

Co-Ordinate :- E - 1350, N 3255

Reduced Level :- 203.10 m

Sr No	Depth of Sample	Type of Sample	Field Bulk Density	Field Dry Density	Natural Moisture Content	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit	Swelling Pressure	Free Swell Index	Soil Classification	Shear Parameter		Unconfined Compression Test	UCS by Point Load Index in rock	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation	Void Ratio	Porosity
							Gravel	Sand	Silt	Clay	Liquid Limit	Plastic Limit	Plasticity Index					Cohesion C	Angle of Internal Friction ϕ				Compression Index C _c	Coefficient of Volume Compressibility mv	Pre-consolidation Pressure				
1	0.00	DS	-	-	-	-	7	60	33	20	14	6	-	-	-	SM-SC	-	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	5	55	40	25	13	12	-	-	-	SC	-	-	-	-	-	-	-	-	2	-	-	-	-
3	2.00	SPT	-	-	-	-	13	48	39	32	15	17	-	-	-	SC	-	-	-	-	-	-	-	-	8	-	-	-	-
4	2.50	SPT	-	-	-	-	14	46	40	36	16	20	-	-	-	SC	-	-	-	-	-	-	-	-	7	-	-	-	-
5	3.00	SPT	-	-	-	-	14	60	26	32	15	17	-	-	-	SC	-	-	-	-	-	-	-	-	9	-	-	-	-
6	3.50	UDS	1.95	1.52	28.10	2.66	14	59	27	33	14	19	-	-	-	SC	0.07	25	-	-	DSU	-	-	-	-	-	-	0.75	42.8
7	4.00	SPT	-	-	-	-	2	38	40	20	33	16	17	-	-	-	CI	-	-	-	-	-	-	-	9	-	-	-	-
8	4.50	UDS	1.96	1.55	26.24	2.62	4	30	41	25	42	19	23	-	-	-	CI	0.46	6	-	-	TUU	0.14	0.0218	0.72	-	-	0.69	40.7
9	5.00	SPT	-	-	-	-	0	20	51	29	47	22	25	-	-	-	CI	-	-	-	-	-	-	-	29	-	-	-	-
10	5.50	UDS	2.00	1.61	24.24	2.64	14	32	35	19	40	23	17	-	-	-	CI	1.52	8	-	-	TUU	0.12	0.0059	0.89	-	-	0.64	39.0
11	6.00	SPT	-	-	-	-	2	21	51	26	43	20	23	-	-	-	CI	-	-	-	-	-	-	-	21	-	-	-	-
12	6.50	UDS	2.01	1.63	23.63	2.64	0	44	36	20	39	22	17	-	-	-	CI	0.99	9	-	-	TUU	0.12	0.0082	1.27	-	-	0.62	38.4
13	7.00	SPT	-	-	-	-	0	30	42	28	41	16	25	-	-	-	CI	-	-	-	-	-	-	-	27	-	-	-	-
14	7.50	SPT	-	-	-	-	0	84	16	23	16	7	-	-	-	SM-SC	-	-	-	-	-	-	-	-	21	-	-	-	-
15	8.00	SPT	-	-	-	-	0	35	47	18	36	20	16	-	-	-	CI	-	-	-	-	-	-	-	29	-	-	-	-
16	8.50	SPT	-	-	-	-	0	27	51	22	39	19	20	-	-	-	CI	-	-	-	-	-	-	-	38	-	-	-	-
17	9.00	SPT	-	-	-	-	0	26	51	23	40	20	20	-	-	-	CI	-	-	-	-	-	-	-	40	-	-	-	-
18	9.50	SPT	-	-	-	-	0	35	41	24	43	22	21	-	-	-	CI	-	-	-	-	-	-	-	24	-	-	-	-
19	10.00	SPT	-	-	-	-	1	44	35	20	36	18	18	-	-	-	CI	-	-	-	-	-	-	-	28	-	-	-	-
20	11.00	SPT	-	-	-	-	0	1	75	24	49	27	22	-	-	-	CI	-	-	-	-	-	-	-	41	-	-	-	-
21	11.50	SPT	-	-	-	-	0	2	78	20	45	28	17	-	-	-	CI	-	-	-	-	-	-	-	>100	-	-	-	-
22	12.50	SPT	-	-	-	-	5	5	68	22	44	25	19	-	-	-	CI	-	-	-	-	-	-	-	>100	-	-	-	-
23	13.50	SPT	-	-	-	-	0	4	75	21	41	23	18	-	-	-	CI	-	-	-	-	-	-	-	>100	-	-	-	-
24	14.00	SPT	-	-	-	-	0	2	77	21	44	25	19	-	-	-	CI	-	-	-	-	-	-	-	>100	-	-	-	-
25	14.50	SPT	-	-	-	-	0	10	70	20	42	24	18	-	-	-	CI	-	-	-	-	-	-	-	>100	-	-	-	-
26	15.50	SPT	-	-	-	-	0	4	71	25	47	25	22	-	-	-	CI	-	-	-	-	-	-	-	>100	-	-	-	-
27	16.00	SPT	-	-	-	-	0	6	71	23	45	24	21	-	-	-	CI	-	-	-	-	-	-	-	>100	-	-	-	-
28	17.00	SPT	-	-	-	-	0	2	67	31	48	22	26	-	-	-	CI	-	-	-	-	-	-	-	>100	-	-	-	-
29	17.50	SPT	-	-	-	-	0	8	75	17	40	24	16	-	-	-	CI	-	-	-	-	-	-	-	>100	-	-	-	-
30	19.00	UDS	2.29	2.04	12.25	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	96.9	UCS	-	-	-	-	-	0.33	25.0
31	19.00	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	>100	-	-	-	-
32	20.50	UDS	2.33	2.09	11.25	2.74	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	116.1	UCS	-	-	-	-	-	0.31	23.6
33	20.50	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	>100	-	-	-	-
34	22.00	UDS	2.29	2.04	12.01	2.71	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	108.8	UCS	-	-	-	-	-	0.33	24.6
35	23.50	UDS	2.34	2.11	10.66	2.73	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	138.4	UCS	-	-	-	-	-	0.29	22.5
36	25.00	UDS	2.25	1.97	14.31	2.74	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	107.4	-	UCS	-	-	-	-	8.00	0.39	28.2

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 49

Co-Ordinate :- E - 1081, N - 3296

Reduced Level :- 197.50 m

Sr No	Depth of Sample m	Type of Sample	Field Bulk Density gm / cc	Field Dry Density gm / cc	Natural Moisture Content %	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit %	Swelling Pressure Kg/cm ²	Free Swell Index %	Soil Classification	Shear Parameter		Unconfined Compression Test Kg/cm ²	UCS by Point Load Index in rock Kg/cm ²	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation %	Void Ratio	Porosity %
							Gravel %	Sand %	Silt %	Clay %	Liquid Limit %	Plastic Limit %	Plasticity Index %					Cohesion C Kg/cm ²	Angle of Internal Friction ϕ Degree				Compression Index C _c	Coefficient of Volume Compressibility m _v cm ² /kg	Pre-consolidation Pressure kg/cm ²				
1	0.00	DS	-	-	-	-	0	41	35	24	38	17	21	-	-	-	CI	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	3	36	35	26	40	18	22	-	-	-	CI	-	-	-	-	-	-	-	-	14	-	-	-
3	2.00	SPT	-	-	-	-	9	18	44	29	43	16	27	-	-	-	CI	-	-	-	-	-	-	-	-	18	-	-	-
4	2.50	UDS	1.96	1.55	26.24	2.62	6	10	48	36	48	17	31	-	-	-	CI	0.95	2	-	-	TUU	0.13	0.0116	0.62	-	-	0.69	40.7
5	3.00	SPT	-	-	-	-	0	14	56	30	46	19	27	-	-	-	CL	-	-	-	-	-	-	-	-	22	-	-	-
6	3.50	UDS	1.98	1.58	25.51	2.64	10	32	36	22	40	21	19	-	-	-	CI	1.16	5	-	-	TUU	0.12	0.0069	0.64	-	-	0.67	40.2
7	4.00	SPT	-	-	-	-	0	59	41		36	20	16	-	-	-	SC	-	-	-	-	-	-	-	-	33	-	-	-
8	4.50	SPT	-	-	-	-	0	14	72	14	30	18	12	-	-	-	CL	-	-	-	-	-	-	-	-	>100	-	-	-
9	5.00	SPT	-	-	-	-	0	13	71	16	32	17	15	-	-	-	CL	-	-	-	-	-	-	-	-	>100	-	-	-
10	5.50	SPT	-	-	-	-	0	19	67	14	28	15	13	-	-	-	CL	-	-	-	-	-	-	-	-	>100	-	-	-
11	6.00	SPT	-	-	-	-	56	26	18		26	16	10	-	-	-	Boulders	-	-	-	-	-	-	-	-	>100	-	-	-
12	7.50	UDS	2.29	2.06	11.28	2.68	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	40.6	UCS	-	-	-	-	-	0.30	23.2
13	7.50	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-
14	9.00	UDS	2.27	2.02	12.29	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	48.1	UCS	-	-	-	-	-	0.33	24.9
15	9.00	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-
16	10.50	UDS	2.27	2.03	12.05	2.68	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	44.6	UCS	-	-	-	-	-	0.32	24.4
17	12.00	UDS	2.30	2.07	11.15	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	45.1	UCS	-	-	-	-	-	0.30	23.1
18	13.50	UDS	2.29	2.06	11.28	2.68	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	71.3	-	UCS	-	-	-	-	10.66	0.30	23.2
19	15.00	UDS	2.34	2.11	10.66	2.73	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	86.9	-	UCS	-	-	-	-	26.66	0.29	22.5
20	16.50	UDS	2.33	2.11	10.30	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	85.0	-	UCS	-	-	-	-	6.66	0.28	21.8
21	18.00	UDS	2.34	2.11	10.89	2.74	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	99.1	-	UCS	-	-	-	-	22.66	0.30	23.0
22	19.50	UDS	2.35	2.13	10.08	2.72	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	115.4	-	UCS	-	-	-	-	32.66	0.27	21.5

KCT Consultancy Services LLP, Ahmedabad

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 50

Co-Ordinate :- E 1281, N 3254

Reduced Level :- 201.55 m

Sr No	Depth of Sample m	Type of Sample	Field Bulk Density gm / cc	Field Dry Density gm / cc	Natural Moisture Content %	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit %	Swelling Pressure Kg/cm ²	Free Swell Index %	Soil Classification	Shear Parameter		Unconfined Compression Test Kg/cm ²	UCS by Point Load Index in rock Kg/cm ²	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation %	Void Ratio	Porosity %
							Gravel %	Sand %	Silt %	Clay %	Liquid Limit %	Plastic Limit %	Plasticity Index %					Cohesion C Kg/cm ²	Angle of Internal Friction ϕ Degree				Compression Index C _c	Coefficient of Volume Compressibility mv cm ² /kg	Pre-consolidation Pressure kg/cm ²				
1	0.00	DS	-	-	-	-	0	32	43	25	45	24	21	-	-	-	CI	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	0	34	45	21	42	23	19	-	-	-	CI	-	-	-	-	-	-	-	-	7	-	-	-
3	2.00	SPT	-	-	-	-	0	23	48	29	47	21	26	16	-	43	CI	-	-	-	-	-	-	-	-	11	-	-	-
4	2.50	SPT	-	-	-	-	0	28	49	23	44	23	21	-	-	-	CI	-	-	-	-	-	-	-	-	16	-	-	-
5	3.00	SPT	-	-	-	-	0	31	47	22	40	20	20	-	-	-	CI	-	-	-	-	-	-	-	-	19	-	-	-
6	3.50	UDS	1.99	1.59	25.16	2.65	0	33	47	20	39	22	17	18	0.13	31	CI	0.96	7	-	-	TUU	0.13	0.0091	0.62	-	-	0.67	40.0
7	4.00	SPT	-	-	-	-	0	30	45	25	42	19	23	-	-	-	CI	-	-	-	-	-	-	-	-	24	-	-	-
8	4.50	UDS	2.00	1.61	24.24	2.64	0	29	41	30	45	18	27	-	-	-	CI	1.23	6	-	-	TUU	0.12	0.0083	0.73	-	-	0.64	39.0
9	5.00	SPT	-	-	-	-	0	12	34	54	67	21	46	-	-	-	CH	-	-	-	-	-	-	-	-	23	-	-	-
10	5.50	UDS	2.02	1.65	22.45	2.62	0	16	39	45	61	23	38	8	0.49	78	CH	1.25	2	-	-	TUU	0.11	0.0093	0.86	-	-	0.59	37.0
11	6.00	SPT	-	-	-	-	0	23	37	40	60	24	36	-	-	-	CH	-	-	-	-	-	-	-	-	28	-	-	-
12	6.50	UDS	2.04	1.67	21.85	2.64	0	20	31	49	64	22	42	-	-	-	CH	1.52	3	-	-	TUU	0.11	0.0081	0.98	-	-	0.58	36.6
13	7.00	SPT	-	-	-	-	0	21	36	43	63	26	37	-	-	-	CH	-	-	-	-	-	-	-	-	26	-	-	-
14	7.50	UDS	2.06	1.70	21.00	2.65	0	27	50	23	40	19	21	-	-	-	CI	1.39	3	-	-	TUU	0.10	0.0071	1.46	-	-	0.56	35.8
15	8.00	SPT	-	-	-	-	0	29	49	22	39	20	19	-	-	-	CI	-	-	-	-	-	-	-	-	30	-	-	-
16	8.50	UDS	2.09	1.75	19.66	2.66	0	36	46	18	37	21	16	-	-	-	CI	1.54	7	-	-	TUU	0.09	0.0056	2.08	-	-	0.52	34.3
17	9.00	SPT	-	-	-	-	0	29	45	26	41	19	22	-	-	-	CI	-	-	-	-	-	-	-	-	32	-	-	-
18	9.50	SPT	-	-	-	-	0	27	48	25	46	23	23	-	-	-	CI	-	-	-	-	-	-	-	-	31	-	-	-
19	10.00	SPT	-	-	-	-	0	32	46	22	39	20	19	-	-	-	CI	-	-	-	-	-	-	-	-	33	-	-	-
20	11.00	SPT	-	-	-	-	0	21	40	39	59	23	36	-	-	-	CH	-	-	-	-	-	-	-	-	36	-	-	-
21	11.50	SPT	-	-	-	-	0	16	34	50	66	20	46	-	-	-	CH	-	66	-	-	-	-	-	-	41	-	-	-
22	12.50	SPT	-	-	-	-	0	37	42	21	43	24	19	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-
23	13.00	SPT	-	-	-	-	0	29	41	30	48	22	26	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-
24	14.00	SPT	-	-	-	-	0	31	49	20	42	25	17	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-
25	15.50	SPT	-	-	-	-	0	21	35	44	62	23	39	-	-	-	CH	-	-	-	-	-	-	-	-	>100	-	-	-
26	16.00	SPT	-	-	-	-	0	16	33	51	66	19	47	-	-	-	CH	-	-	-	-	-	-	-	-	>100	-	-	-
27	17.00	SPT	-	-	-	-	0	20	39	41	61	23	38	-	-	-	CH	-	-	-	-	-	-	-	-	>100	-	-	-
28	17.50	SPT	-	-	-	-	0	21	41	38	57	25	32	-	-	-	CH	-	-	-	-	-	-	-	-	>100	-	-	-
29	18.50	SPT	-	-	-	-	0	16	39	45	62	22	40	-	-	-	CH	-	-	-	-	-	-	-	-	>100	-	-	-
30	20.50	UDS	2.23	1.95	14.65	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	49.8	-	UCS	-	-	-	-	9.23	0.40	28.5
31	21.50	UDS	2.39	2.19	9.19	2.74	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	118.4	-	UCS	-	-	-	-	13.33	0.25	20.1
32	23.00	UDS	2.36	2.13	10.66	2.76	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	92.5	-	UCS	-	-	-	-	80.00	0.29	22.7

UDS - Undisturbed Sample
DS - Disturbed Sample
SPT - Standard Penetration Tests
NP - Non Plastic

TUU - Triaxial Unconsolidated Undrained
TCU - Triaxial Consolidated Undrained
DSU - Direct Shear Test
UCS - Unconfined Compression Strength

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 51

Co-Ordinate :- E - 1007, N - 3246

Reduced Level :- 196.05 m

Sr No	Depth of Sample m	Type of Sample	Field Bulk Density gm / cc	Field Dry Density gm / cc	Natural Moisture Content %	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit %	Swelling Pressure Kg/cm ²	Free Swell Index %	Soil Classification	Shear Parameter		Unconfined Compression Test Kg/cm ²	UCS by Point Load Index in rock Kg/cm ²	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation %	Void Ratio	Porosity %
							Gravel %	Sand %	Silt %	Clay %	Liquid Limit %	Plastic Limit %	Plasticity Index %					Cohesion C Kg/cm ²	Angle of Internal Friction ϕ Degree				Compression Index C _c	Coefficient of Volume Compressibility m _v cm ² /kg	Pre-consolidation Pressure kg/cm ²				
1	0.00	DS	-	-	-	-	0	43	44	13	23	12	11	-	-	-	CL	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	0	63	37	22	12	10	-	-	-	-	SC	-	-	-	-	-	-	-	-	4	-	-	-
3	2.00	SPT	-	-	-	-	5	69	26	27	13	14	-	-	-	-	SC	-	-	-	-	-	-	-	-	6	-	-	-
4	2.50	UDS	1.99	1.59	25.44	2.66	0	46	35	19	36	19	17	-	-	-	CI	0.30	8	-	-	TUU	0.12	0.0292	0.44	-	-	0.68	40.4
5	3.00	SPT	-	-	-	-	0	3	69	28	47	23	24	-	-	-	CI	-	-	-	-	-	-	-	-	16	-	-	-
6	3.50	UDS	1.98	1.58	24.93	2.62	0	19	59	22	44	25	19	-	-	-	CI	0.88	3	-	-	TUU	0.11	0.0114	0.57	-	-	0.65	39.5
7	4.00	SPT	-	-	-	-	0	14	66	20	41	23	18	-	-	-	CI	-	-	-	-	-	-	-	-	19	-	-	-
8	4.50	UDS	2.01	1.64	22.76	2.61	0	12	63	25	43	20	23	-	-	-	CI	0.98	2	-	-	TUU	0.10	0.0101	0.73	-	-	0.59	37.3
9	6.00	SPT	-	-	-	-	0	17	62	21	40	21	19	-	-	-	CI	-	-	-	-	-	-	-	-	47	-	-	-
10	7.50	UDS	2.34	2.13	9.71	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	47.9	UCS	-	-	-	-	-	0.26	20.7
11	9.00	UDS	2.41	2.24	7.62	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	83.4	-	UCS	-	-	-	-	6.66	0.21	17.1
12	10.50	UDS	2.49	2.34	6.35	2.75	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	117.6	-	UCS	-	-	-	-	34.66	0.17	14.9
13	12.00	UDS	2.45	2.29	6.85	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	92.2	-	UCS	-	-	-	-	15.33	0.19	15.7
14	13.50	UDS	2.43	2.25	7.91	2.74	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	72.5	-	UCS	-	-	-	-	22.66	0.22	17.8
15	15.00	UDS	2.41	2.22	8.77	2.75	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	121.4	-	UCS	-	-	-	-	22.66	0.24	19.4
16	16.50	UDS	2.49	2.33	6.78	2.77	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	162.3	-	UCS	-	-	-	-	57.33	0.19	15.8
17	18.00	UDS	2.48	2.32	6.85	2.76	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	176.9	-	UCS	-	-	-	-	78.33	0.19	15.9

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RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 53

Co-Ordinate :- E 11+° N 3260

Reduced Level :- 199.480 m

Sr No	Depth of Sample m	Type of Sample	Field Bulk Density gm / cc	Field Dry Density gm / cc	Natural Moisture Content %	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit %	Swelling Pressure Kg/cm ²	Free Swell Index %	Soil Classification	Shear Parameter		Unconfined Compression Test Kg/cm ²	UCS by Point Load Index in rock Kg/cm ²	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation %	Void Ratio	Porosity %
							Gravel %	Sand %	Silt %	Clay %	Liquid Limit %	Plastic Limit %	Plasticity Index %					Cohesion C Kg/cm ²	Angle of Internal Friction ϕ Degree				Compression Index C _c	Coefficient of Volume Compressibility mv cm ² /kg	Pre-consolidation Pressure kg/cm ²				
1	0.00	DS	-	-	-	-	0	64	36		26	16	10	-	-	-	SC	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	1	19	55	25	42	20	22	-	-	-	CI	-	-	-	-	-	-	-	-	7	-	-	-
3	2.00	SPT	-	-	-	-	3	22	55	20	39	22	17	-	-	-	CI	-	-	-	-	-	-	-	-	12	-	-	-
4	2.50	UDS	1.97	1.56	26.45	2.65	0	18	58	24	42	21	21	20	0.14	36	CI	1.05	2	-	-	TUU	0.14	0.0126	0.42	-	-	0.70	41.2
5	3.00	SPT	-	-	-	-	4	12	56	28	44	20	24	-	-	-	CI	-	-	-	-	-	-	-	-	22	-	-	-
6	3.50	SPT	-	-	-	-	5	14	58	23	43	23	20	-	-	-	CI	-	-	-	-	-	-	-	-	26	-	-	-
7	4.00	SPT	-	-	-	-	2	11	58	29	46	20	26	-	-	-	CI	-	-	-	-	-	-	-	-	29	-	-	-
8	4.50	UDS	1.99	1.60	24.58	2.63	0	10	52	38	56	22	34	12	0.31	59	CH	1.11	1	-	-	TUU	0.12	0.0109	0.64	-	-	0.65	39.3
9	5.00	SPT	-	-	-	-	0	9	48	43	58	21	37	-	-	-	CH	-	-	-	-	-	-	-	-	16	-	-	-
10	5.50	DS	-	-	-	-	0	12	55	33	54	25	29	-	-	-	CH	-	-	-	-	-	-	-	-	-	-	-	-
11	6.00	SPT	-	-	-	-	0	10	57	33	55	26	29	-	-	-	CH	-	-	-	-	-	-	-	-	17	-	-	-
12	6.50	UDS	1.99	1.59	24.87	2.64	0	14	57	29	53	28	25	13	0.26	56	CH	0.93	3	-	-	TUU	0.13	0.0113	0.81	-	-	0.66	39.6
13	7.00	SPT	-	-	-	-	0	13	50	37	56	25	31	-	-	-	CH	-	-	-	-	-	-	-	-	16	-	-	-
14	7.50	UDS	1.98	1.57	25.80	2.65	0	30	57	13	28	16	12	-	-	-	CL	0.74	7	-	-	TUU	-	-	-	-	-	0.68	40.6
15	8.00	SPT	-	-	-	-	0	32	56	12	26	15	11	-	-	-	CL	-	-	-	-	-	-	-	-	14	-	-	-
16	8.50	UDS	1.99	1.60	24.58	2.63	0	29	57	14	30	18	12	-	-	-	CL	0.79	6	-	-	TUU	0.12	0.0089	1.02	-	-	0.65	39.3
17	9.00	SPT	-	-	-	-	0	66	34		26	16	10	-	-	-	SC	-	-	-	-	-	-	-	-	18	-	-	-
18	9.50	UDS	2.00	1.60	24.81	2.66	0	60	40		29	15	14	-	-	-	SC	0.06	26	-	-	DSU	-	-	-	-	-	0.66	39.8
19	10.00	SPT	-	-	-	-	8	76	16		NP	NP	NP	-	-	-	SM	-	-	-	-	-	-	-	-	19	-	-	-
20	11.00	UDS	2.02	1.63	23.87	2.67	10	77	13		NP	NP	NP	-	-	-	SM	0.00	31	-	-	DSU	-	-	-	-	-	0.64	38.9
21	11.50	SPT	-	-	-	-	6	88	6		NP	NP	NP	-	-	-	SP-SM	-	-	-	-	-	-	-	-	22	-	-	-
22	12.50	DS	-	-	-	-	9	82	9		NP	NP	NP	-	-	-	SP-SM	-	-	-	-	-	-	-	-	-	-	-	-
23	13.00	SPT	-	-	-	-	3	89	8		NP	NP	NP	-	-	-	SP-SM	-	-	-	-	-	-	-	-	31	-	-	-
24	14.00	DS	-	-	-	-	6	84	10		NP	NP	NP	-	-	-	SP-SM	-	-	-	-	-	-	-	-	-	-	-	-
25	14.50	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-
26	16.00	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-
27	17.50	DS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	-	-	-	-
28	17.50	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-
29	19.00	UDS	2.19	1.89	15.62	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	35.6	UCS	-	-	-	-	-	0.42	29.6
30	19.00	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-
31	20.50	UDS	2.31	2.08	11.03	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	138.6	UCS	-	-	-	-	-	0.30	22.9
32	22.00	UDS	2.32	2.08	11.61	2.74	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	205.6	-	UCS	-	-	-	-	19.00	0.32	24.1
33	23.50	UDS	2.30	2.05	12.12	2.73	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	165.1	UCS	-	-	-	-	-	0.33	24.9
34	25.00	UDS	2.26	2.00	13.18	2.71	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	99.7	-	UCS	-	-	-	-	32.00	0.36	26.3

UDS - Undisturbed Sample
DS - Disturbed Sample
SPT - Standard Penetration Tests
NP - Non Plastic

TUU - Triaxial Unconsolidated Undrained
TCU - Triaxial Consolidated Undrained
DSU - Direct Shear Test
UCS - Unconfined Compression Strength

KCT Consultancy Services LLP, Ahmedabad

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 56

Co-Ordinate :- E 1152, N 3231

Reduced Level :- 198.42 m

Sr No	Depth of Sample m	Type of Sample	Field Bulk Density gm / cc	Field Dry Density gm / cc	Natural Moisture Content %	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit %	Swelling Pressure Kg/cm ²	Free Swell Index %	Soil Classification	Shear Parameter		Unconfined Compression Test Kg/cm ²	UCS by Point Load Index in rock Kg/cm ²	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation %	Void Ratio	Porosity %
							Gravel %	Sand %	Silt %	Clay %	Liquid Limit %	Plastic Limit %	Plasticity Index %					Cohesion C Kg/cm ²	Angle of Internal Friction ϕ Degree				Compression Index C _c	Coefficient of Volume Compressibility mv cm ² /kg	Pre-consolidation Pressure kg/cm ²				
1	0.00	DS	-	-	-	-	0	63	37		34	17	17	-	-	-	SC	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	4	26	43	27	46	22	24	-	-	-	CI	-	-	-	-	-	-	-	-	10	-	-	-
3	2.00	SPT	-	-	-	-	6	31	42	21	39	20	19	-	-	-	CI	-	-	-	-	-	-	-	-	17	-	-	-
4	2.50	UDS	1.97	1.57	25.87	2.63	4	26	43	27	44	21	23	19	0.15	36	CI	0.93	5	-	-	TUU	0.14	0.0113	0.45	-	-	0.68	40.5
5	3.00	SPT	-	-	-	-	2	34	42	22	41	22	19	-	-	-	CI	-	-	-	-	-	-	-	-	33	-	-	-
6	3.50	DS	-	-	-	-	4	30	41	25	47	24	23	-	-	-	CI	-	-	-	-	-	-	-	-	-	-	-	-
7	4.00	SPT	-	-	-	-	0	22	45	33	58	29	29	-	-	-	CH	-	-	-	-	-	-	-	-	16	-	-	-
8	4.50	UDS	1.99	1.60	23.99	2.61	0	9	55	36	63	31	32	9	0.46	55	CH	0.89	1	-	-	TUU	0.12	0.0130	0.61	-	-	0.63	38.5
9	5.00	SPT	-	-	-	-	0	12	57	31	54	26	28	-	-	-	CH	-	-	-	-	-	-	-	-	26	-	-	-
10	5.50	UDS	2.02	1.64	23.02	2.64	0	23	47	30	53	27	26	13	0.38	49	CH	1.38	7	-	-	TUU	0.11	0.0077	0.74	-	-	0.61	37.8
11	6.00	SPT	-	-	-	-	0	15	48	37	58	26	32	-	-	-	CH	-	-	-	-	-	-	-	-	29	-	-	-
12	6.50	UDS	2.05	1.68	21.84	2.66	0	61	39		31	14	17	-	-	-	SC	0.10	27	-	-	DSU	-	-	-	-	-	0.58	36.7
13	7.00	SPT	-	-	-	-	0	67	33		29	16	13	-	-	-	SC	-	-	-	-	-	-	-	-	28	-	-	-
14	7.50	UDS	2.00	1.61	24.53	2.65	0	65	35		30	15	15	-	-	-	SC	0.08	25	-	-	DSU	-	-	-	-	-	0.65	39.4
15	8.00	SPT	-	-	-	-	0	63	37		31	17	14	-	-	-	SC	-	-	-	-	-	-	-	-	16	-	-	-
16	8.50	UDS	1.98	1.57	25.80	2.65	0	64	36		28	15	13	-	-	-	SC	0.09	25	-	-	DSU	-	-	-	-	-	0.68	40.6
17	9.00	SPT	-	-	-	-	4	76	20		24	14	10	-	-	-	SM	-	-	-	-	-	-	-	-	22	-	-	-
18	9.50	Remoulded	2.01	1.61	24.47	2.67	5	81	14		NP	NP	NP	-	-	-	SM	0.00	30	-	-	DSU	-	-	-	-	-	0.65	39.5
19	10.00	SPT	-	-	-	-	3	79	18		16	NP	NP	-	-	-	SM	-	-	-	-	-	-	-	-	20	-	-	-
20	11.00	Remoulded	2.04	1.67	22.41	2.66	3	75	22		21	17	4	-	-	-	SM	0.00	29	-	-	DSU	-	-	-	-	-	0.60	37.3
21	11.50	SPT	-	-	-	-	5	71	24		23	18	5	-	-	-	SM	-	-	-	-	-	-	-	-	30	-	-	-
22	12.50	Remoulded	2.08	1.73	20.46	2.67	3	76	21		22	18	4	-	-	-	SM	0.00	31	-	-	DSU	-	-	-	-	-	0.55	35.3
23	13.00	SPT	-	-	-	-	4	74	22		19	15	4	-	-	-	SM	-	-	-	-	-	-	-	-	>100	-	-	-
24	14.50	UDS	2.26	2.01	12.69	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	38.4	UCS	-	-	-	-	-	0.34	25.4
25	16.00	UDS	2.29	2.06	11.28	2.68	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	49.1	UCS	-	-	-	-	-	0.30	23.2
26	17.50	UDS	2.27	2.02	12.54	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	45.5	UCS	-	-	-	-	-	0.34	25.3
27	19.00	UDS	2.31	2.07	11.51	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	102.6	UCS	-	-	-	-	-	0.31	23.8
28	20.50	UDS	2.37	2.16	9.86	2.74	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	122.4	-	UCS	-	-	-	-	58.66	0.27	21.3
29	22.00	UDS	2.34	2.12	10.19	2.71	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	96.3	-	UCS	-	-	-	-	48.00	0.28	21.6
30	23.50	UDS	2.40	2.21	8.63	2.73	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	112.8	-	UCS	-	-	-	-	70.00	0.24	19.1
31	25.00	UDS	2.35	2.13	10.08	2.72	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	89.1	-	UCS	-	-	-	-	51.33	0.27	21.5
32	26.50	UDS	2.41	2.22	8.77	2.75	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	148.7	-	UCS	-	-	-	-	86.00	0.24	19.4

UDS - Undisturbed Sample
DS - Disturbed Sample
SPT - Standard Penetration Tests
NP - Non Plastic

TUU - Triaxial Unconsolidated Undrained
TCU - Triaxial Consolidated Undrained
DSU - Direct Shear Test
UCS - Unconfined Compression Strength

KCT Consultancy Services LLP, Ahmedabad

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 57

Co-Ordinate :- E 1077, N 3230

Reduced Level :- 196.65 m

Sr No	Depth of Sample	Type of Sample	Field Bulk Density	Field Dry Density	Natural Moisture Content	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit	Swelling Pressure	Free Swell Index	Soil Classification	Shear Parameter		Unconfined Compression Test	UCS by Point Load Index in rock	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation	Void Ratio	Porosity	
							Gravel	Sand	Silt	Clay	Liquid Limit	Plastic Limit	Plasticity Index					Cohesion C	Angle of Internal Friction ϕ				Compression Index C _c	Coefficient of Volume Compressibility mv	Pre-consolidation Pressure					
																														%
1	0.00	DS	-	-	-	-	0	30	45	25	39	18	21	-	-	-	CI	-	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	0	27	48	25	44	22	22	-	-	-	CI	-	-	-	-	-	-	-	-	10	-	-	-	-
3	2.00	SPT	-	-	-	-	0	26	48	26	45	21	24	-	-	-	CI	-	-	-	-	-	-	-	-	7	-	-	-	-
4	2.50	UDS	1.93	1.49	29.21	2.65	0	29	48	23	43	23	20	-	-	-	CI	0.53	7	-	-	TUU	0.18	0.0182	0.38	-	-	0.77	43.6	-
5	3.00	SPT	-	-	-	-	0	32	47	21	39	20	19	-	-	-	CI	-	-	-	-	-	-	-	-	16	-	-	-	-
6	3.50	UDS	1.96	1.55	26.54	2.63	0	28	49	23	45	25	20	-	-	-	CI	0.81	5	-	-	TUU	0.14	0.0121	0.51	-	-	0.70	41.1	-
7	4.00	SPT	-	-	-	-	0	16	52	32	53	24	29	-	-	-	CH	-	-	-	-	-	-	-	-	15	-	-	-	-
8	4.50	UDS	1.98	1.59	24.63	2.61	0	10	51	39	57	21	36	-	-	-	CH	0.82	1	-	-	TUU	0.12	0.0139	0.60	-	-	0.64	39.1	-
9	5.00	SPT	-	-	-	-	0	8	52	40	59	25	34	-	-	-	CH	-	-	-	-	-	-	-	-	19	-	-	-	-
10	5.50	UDS	1.97	1.57	25.58	2.62	0	14	49	37	58	26	32	-	-	-	CH	0.64	2	-	-	TUU	0.13	0.0177	0.67	-	-	0.67	40.1	-
11	6.00	SPT	-	-	-	-	0	68	32	30	20	10	10	-	-	-	SC	-	-	-	-	-	-	-	-	11	-	-	-	-
12	6.50	UDS	2.00	1.61	24.53	2.65	0	59	41	32	19	13	13	-	-	-	SC	0.12	25	-	-	DSU	-	-	-	-	-	0.65	39.4	-
13	7.00	SPT	-	-	-	-	0	72	28	26	16	10	10	-	-	-	SC	-	-	-	-	-	-	-	-	13	-	-	-	-
14	7.50	DS	-	-	-	-	0	83	17	16	NP	NP	NP	-	-	-	SM	-	-	-	-	-	-	-	-	-	-	-	-	-
15	8.00	SPT	-	-	-	-	0	79	21	20	16	4	4	-	-	-	SM	-	-	-	-	-	-	-	-	17	-	-	-	-
16	8.50	SPT	-	-	-	-	0	81	19	18	NP	NP	NP	-	-	-	SM	-	-	-	-	-	-	-	-	15	-	-	-	-
17	9.00	SPT	-	-	-	-	0	80	20	19	15	4	4	-	-	-	SM	-	-	-	-	-	-	-	-	17	-	-	-	-
18	9.50	SPT	-	-	-	-	0	76	24	25	20	5	5	-	-	-	SM	-	-	-	-	-	-	-	-	20	-	-	-	-
19	10.00	SPT	-	-	-	-	0	63	37	29	19	10	10	-	-	-	SC	-	-	-	-	-	-	-	-	>100	-	-	-	-
20	11.00	SPT	-	-	-	-	0	66	34	27	18	9	9	-	-	-	SC	-	-	-	-	-	-	-	-	>100	-	-	-	-
21	11.50	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-	-
22	13.00	UDS	2.40	2.22	8.17	2.71	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	154.3	-	UCS	-	-	-	-	68.00	0.22	18.1	-
23	14.50	UDS	2.39	2.19	8.96	2.73	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	124.9	-	UCS	-	-	-	-	52.66	0.24	19.7	-
24	16.00	UDS	2.31	2.08	11.03	2.70	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	86.1	-	UCS	-	-	-	-	64.33	0.30	22.9	-
25	17.50	UDS	2.22	1.95	14.07	2.68	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	52.4	-	UCS	-	-	-	-	46.00	0.38	27.4	-
26	19.00	UDS	2.25	1.99	13.09	2.69	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	60.7	-	UCS	-	-	-	-	32.00	0.35	26.0	-
27	20.50	UDS	2.20	1.91	14.93	2.68	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	74.2	-	UCS	-	-	-	-	85.33	0.40	28.6	-

UDS - Undisturbed Sample
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NP - Non Plastic

TUU - Triaxial Unconsolidated Undrained
TCU - Triaxial Consolidated Undrained
DSU - Direct Shear Test
UCS - Unconfined Compression Strength

KCT Consultancy Services LLP, Ahmedabad

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 58

Co-Ordinate :- E 1217, N 3229

Reduced Level :- 200.2 m

Sr No	Depth of Sample m	Type of Sample	Field Bulk Density gm / cc	Field Dry Density gm / cc	Natural Moisture Content %	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit %	Swelling Pressure Kg/cm ²	Free Swell Index %	Soil Classification	Shear Parameter		Unconfined Compression Test Kg/cm ²	UCS by Point Load Index in rock Kg/cm ²	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation %	Void Ratio	Porosity %
							Gravel %	Sand %	Silt %	Clay %	Liquid Limit %	Plastic Limit %	Plasticity Index %					Cohesion C Kg/cm ²	Angle of Internal Friction ϕ Degree				Compression Index C _c	Coefficient of Volume Compressibility mv cm ² /kg	Pre-consolidation Pressure kg/cm ²				
1	0.00	DS	-	-	-	-	5	33	43	19	40	23	17	-	-	-	CI	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	8	31	36	25	42	20	22	-	-	-	CI	-	-	-	-	-	-	-	-	4	-	-	-
3	2.00	SPT	-	-	-	-	2	19	48	31	46	19	27	-	-	-	CI	-	-	-	-	-	-	-	-	11	-	-	-
4	2.50	SPT	-	-	-	-	5	23	45	27	45	22	23	-	-	-	CI	-	-	-	-	-	-	-	-	5	-	-	-
5	3.00	SPT	-	-	-	-	0	10	56	34	56	27	29	-	-	-	CH	-	-	-	-	-	-	-	-	14	-	-	-
6	3.50	SPT	-	-	-	-	0	13	56	31	54	28	26	-	-	-	CH	-	-	-	-	-	-	-	-	16	-	-	-
7	4.00	SPT	-	-	-	-	0	16	53	31	53	25	28	-	-	-	CH	-	-	-	-	-	-	-	-	18	-	-	-
8	4.50	UDS	1.95	1.54	26.32	2.60	0	9	55	36	60	27	33	-	-	-	CH	0.93	1	-	-	TUU	0.14	0.0125	0.84	-	-	0.68	40.6
9	5.00	SPT	-	-	-	-	0	20	52	28	53	28	25	-	-	-	CH	-	-	-	-	-	-	-	-	17	-	-	-
10	5.50	UDS	1.99	1.60	24.58	2.63	0	18	47	35	56	26	30	-	-	-	CH	0.94	2	-	-	TUU	0.12	0.0120	0.90	-	-	0.65	39.3
11	6.00	SPT	-	-	-	-	0	16	52	32	57	28	29	-	-	-	CH	-	-	-	-	-	-	-	-	20	-	-	-
12	6.50	SPT	-	-	-	-	0	11	57	32	53	26	27	-	-	-	CH	-	-	-	-	-	-	-	-	16	-	-	-
13	7.00	SPT	-	-	-	-	0	15	48	37	57	25	32	-	-	-	CH	-	-	-	-	-	-	-	-	24	-	-	-
14	7.50	UDS	1.99	1.59	25.16	2.65	0	20	48	32	54	27	27	-	-	-	CH	0.81	2	-	-	TUU	0.13	0.0136	1.11	-	-	0.67	40.0
15	8.00	SPT	-	-	-	-	0	62	38	32	26	25	-	-	-	-	SC	-	-	-	-	-	-	-	-	14	-	-	-
16	8.50	UDS	1.98	1.57	26.09	2.66	0	70	30	30	18	12	-	-	-	-	SC	0.08	25	-	-	DSU	-	-	-	-	-	0.69	41.0
17	9.00	SPT	-	-	-	-	0	83	17	NP	NP	NP	-	-	-	-	SM	-	-	-	-	-	-	-	-	25	-	-	-
18	9.50	UDS	2.02	1.63	23.87	2.67	0	80	20	19	15	4	-	-	-	-	SM	0.00	31	-	-	DSU	-	-	-	-	-	0.64	38.9
19	10.00	SPT	-	-	-	-	0	81	19	17	NP	NP	-	-	-	-	SM	-	-	-	-	-	-	-	-	23	-	-	-
20	11.00	SPT	-	-	-	-	0	87	13	NP	NP	NP	-	-	-	-	SM	-	-	-	-	-	-	-	-	22	-	-	-
21	11.50	SPT	-	-	-	-	0	78	22	20	16	4	-	-	-	-	SM	-	-	-	-	-	-	-	-	26	-	-	-
22	12.50	SPT	-	-	-	-	0	76	24	21	16	5	-	-	-	-	SM	-	-	-	-	-	-	-	-	29	-	-	-
23	13.00	SPT	-	-	-	-	0	81	19	NP	NP	NP	-	-	-	-	SM	-	-	-	-	-	-	-	-	21	-	-	-
24	14.00	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Mud Rock	-	-	-	-	-	-	-	-	>100	-	-	-
25	15.50	UDS	2.11	1.78	18.63	2.66	-	-	-	-	-	-	-	-	-	-	Mud Rock	-	-	21.3	-	UCS	-	-	-	-	6.66	0.50	33.1
26	17.00	UDS	2.12	1.79	18.13	2.66	-	-	-	-	-	-	-	-	-	-	Mud Rock	-	-	23.5	-	UCS	-	-	-	-	16.00	0.48	32.5
27	18.50	UDS	2.22	1.95	14.07	2.68	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	49.0	UCS	-	-	-	-	-	0.38	27.4
28	20.00	UDS	2.35	2.13	10.08	2.72	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	97.4	-	UCS	-	-	-	-	28.00	0.27	21.5
29	21.50	UDS	2.31	2.07	11.74	2.73	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	101.6	-	UCS	-	-	-	-	42.66	0.32	24.3
30	23.00	UDS	2.39	2.19	8.96	2.73	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	131.4	-	UCS	-	-	-	-	80.00	0.24	19.7

UDS - Undisturbed Sample
DS - Disturbed Sample
SPT - Standard Penetration Tests
NP - Non Plastic

TUU - Triaxial Unconsolidated Undrained
TCU - Triaxial Consolidated Undrained
DSU - Direct Shear Test
UCS - Unconfined Compression Strength

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 59

Co-Ordinate :- E - 967, N - 3209

Reduced Level :- 197.6 m

Sr No	Depth of Sample m	Type of Sample	Field Bulk Density gm / cc	Field Dry Density gm / cc	Natural Moisture Content %	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit %	Swelling Pressure Kg/cm ²	Free Swell Index %	Soil Classification	Shear Parameter		Unconfined Compression Test Kg/cm ²	UCS by Point Load Index in rock Kg/cm ²	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation %	Void Ratio	Porosity %
							Gravel %	Sand %	Silt %	Clay %	Liquid Limit %	Plastic Limit %	Plasticity Index %					Cohesion C Kg/cm ²	Angle of Internal Friction ϕ Degree				Compression Index C _c	Coefficient of Volume Compressibility m _v cm ² /kg	Pre-consolidation Pressure kg/cm ²				
1	0.00	DS	-	-	-	-	2	36	48	14	27	15	12	-	-	-	CL	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	5	28	41	26	42	19	23	-	-	-	CI	-	-	-	-	-	-	-	-	4	-	-	-
3	2.00	SPT	-	-	-	-	9	32	38	21	40	21	19	-	-	-	CI	-	-	-	-	-	-	-	-	7	-	-	-
4	2.50	SPT	-	-	-	-	12	33	32	23	37	17	20	-	-	-	CI	-	-	-	-	-	-	-	-	6	-	-	-
5	3.00	SPT	-	-	-	-	11	34	38	17	36	21	15	-	-	-	CI	-	-	-	-	-	-	-	-	7	-	-	-
6	3.50	UDS	1.94	1.51	28.50	2.65	9	30	31	30	47	20	27	-	-	-	CI	0.36	6	-	-	TUU	0.16	0.0292	0.62	-	-	0.76	43.0
7	4.00	SPT	-	-	-	-	14	58		28	26	15	11	-	-	-	SC	-	-	-	-	-	-	-	-	10	-	-	-
8	4.50	UDS	1.96	1.54	27.41	2.66	10	55		35	32	17	15	-	-	-	SC	0.08	25	-	-	DSU	-	-	-	-	-	0.73	42.2
9	5.00	SPT	-	-	-	-	16	52		32	31	19	12	-	-	-	SC	-	-	-	-	-	-	-	-	34	-	-	-
10	5.50	UDS	2.09	1.74	19.93	2.67	15	63		22	26	16	10	-	-	-	SC	0.04	30	-	-	DSU	-	-	-	-	-	0.53	34.7
11	6.00	SPT	-	-	-	-	12	59		29	28	15	13	-	-	-	SC	-	-	-	-	-	-	-	-	54	-	-	-
12	6.50	SPT	-	-	-	-	0	79		21	22	16	6	-	-	-	SM-SC	-	-	-	-	-	-	-	-	>100	-	-	-
13	7.00	SPT	-	-	-	-	0	73		27	24	17	7	-	-	-	SM-SC	-	-	-	-	-	-	-	-	>100	-	-	-
14	7.50	UDS	2.19	1.89	15.62	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	51.9	UCS	-	-	-	-	-	0.42	29.6
15	7.50	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-
16	8.50	UDS	2.17	1.86	16.78	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	39.9	UCS	-	-	-	-	-	0.45	31.2
17	10.00	UDS	2.26	1.98	13.90	2.74	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	125.6	UCS	-	-	-	-	-	0.38	27.6
18	10.00	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-
19	11.50	UDS	2.30	2.06	11.88	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	139.4	UCS	-	-	-	-	-	0.32	24.4
20	13.00	UDS	2.29	2.04	12.49	2.73	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	127.2	UCS	-	-	-	-	-	0.34	25.4
21	14.50	UDS	2.32	2.08	11.61	2.74	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	155.9	UCS	-	-	-	-	-	0.32	24.1
22	16.00	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-
23	17.00	UDS	2.11	1.77	19.42	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	50.4	UCS	-	-	-	-	-	0.52	34.3
24	18.50	UDS	2.13	1.80	18.16	2.68	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	41.5	UCS	-	-	-	-	-	0.49	32.7
25	20.00	UDS	2.24	1.97	13.74	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	67.9	-	UCS	-	-	-	-	17.33	0.37	27.1
26	21.50	UDS	2.21	1.91	15.50	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	54.1	-	UCS	-	-	-	-	13.30	0.42	29.7
27	23.00	UDS	2.18	1.86	17.32	2.74	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	113.6	UCS	-	-	-	-	-	0.47	32.2
28	24.50	UDS	2.31	2.06	12.21	2.75	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	143.5	-	UCS	-	-	-	-	26.00	0.34	25.1

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 60

Co-Ordinate :- E - 909, N - 3227

Reduced Level :- 196.25 m

Sr No	Depth of Sample m	Type of Sample	Field Bulk Density gm / cc	Field Dry Density gm / cc	Natural Moisture Content %	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit %	Swelling Pressure Kg/cm ²	Free Swell Index %	Soil Classification	Shear Parameter		Unconfined Compression Test Kg/cm ²	UCS by Point Load Index in rock Kg/cm ²	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation %	Void Ratio	Porosity %	
							Gravel %	Sand %	Silt %	Clay %	Liquid Limit %	Plastic Limit %	Plasticity Index %					Cohesion C Kg/cm ²	Angle of Internal Friction ϕ Degree				Compression Index C _c	Coefficient of Volume Compressibility m _v cm ² /kg	Pre-consolidation Pressure kg/cm ²					
1	0.00	DS	-	-	-	-	0	34	50	16	29	15	14	-	-	-	CL	-	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	6	37	46	11	27	17	10	-	-	-	CI	-	-	-	-	-	-	-	-	6	-	-	-	-
3	2.00	SPT	-	-	-	-	9	30	32	29	43	16	27	-	-	-	CI	-	-	-	-	-	-	-	-	10	-	-	-	-
4	2.50	UDS	1.95	1.53	27.81	2.65	12	31	32	25	40	18	22	-	-	-	CI	0.52	6	-	-	TUU	0.15	0.0192	0.43	-	-	0.74	42.4	-
5	3.00	SPT	-	-	-	-	19	49	32		27	16	11	-	-	-	SC	-	-	-	-	-	-	-	-	16	-	-	-	-
6	3.50	UDS	1.97	1.55	26.74	2.66	15	51	34		29	15	14	-	-	-	SC	0.08	25	-	-	DSU	-	-	-	-	-	0.71	41.6	-
7	4.00	SPT	-	-	-	-	9	68	23		24	18	6	-	-	-	SM-SC	-	-	-	-	-	-	-	-	56	-	-	-	-
8	4.50	SPT	-	-	-	-	18	63	19		23	17	6	-	-	-	SM-SC	-	-	-	-	-	-	-	-	>100	-	-	-	-
9	5.00	SPT	-	-	-	-	8	60	32		25	18	7	-	-	-	SM-SC	-	-	-	-	-	-	-	-	>100	-	-	-	-
10	5.50	SPT	-	-	-	-	15	68	17		NP	NP	NP	-	-	-	SM	-	-	-	-	-	-	-	-	>100	-	-	-	-
11	7.00	UDS	2.31	2.06	11.98	2.74	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	121.8	UCS	-	-	-	-	-	0.33	24.7	-
12	8.50	UDS	2.36	2.15	9.73	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	149.7	UCS	-	-	-	-	-	0.26	20.9	-
13	10.00	UDS	2.24	1.97	13.74	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	89.4	-	UCS	-	-	-	-	16.00	0.37	27.1	-
14	11.50	UDS	2.19	1.90	15.36	2.68	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	60.3	UCS	-	-	-	-	-	0.41	29.2	-
15	13.00	UDS	2.44	2.25	8.27	2.77	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	126.7	UCS	-	-	-	-	-	0.23	18.6	-
16	14.50	UDS	2.47	2.30	7.59	2.78	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	152.5	UCS	-	-	-	-	-	0.21	17.4	-

KCT Consultancy Services LLP, Ahmedabad

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 61

Co-Ordinate :- E 1265, N 3214

Reduced Level :- 201.1 m

Sr No	Depth of Sample m	Type of Sample	Field Bulk Density gm / cc	Field Dry Density gm / cc	Natural Moisture Content %	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit %	Swelling Pressure Kg/cm ²	Free Swell Index %	Soil Classification	Shear Parameter		Unconfined Compression Test Kg/cm ²	UCS by Point Load Index in rock Kg/cm ²	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation %	Void Ratio	Porosity %	
							Gravel %	Sand %	Silt %	Clay %	Liquid Limit %	Plastic Limit %	Plasticity Index %					Cohesion C Kg/cm ²	Angle of Internal Friction ϕ Degree				Coefficient of Volume Compressibility mv cm ² /kg	Pre-consolidation Pressure kg/cm ²						
1	0.00	DS	-	-	-	-	0	61	39	49	20	29	-	-	-	SC	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	0	29	29	42	55	19	36	12	-	58	CH	-	-	-	-	-	-	-	-	7	-	-	-	-
3	2.00	SPT	-	-	-	-	3	23	49	25	48	25	23	-	-	-	CI	-	-	-	-	-	-	-	-	8	-	-	-	-
4	2.50	UDS	1.67	1.45	14.87	2.63	5	21	46	28	49	24	25	15	0.20	45	CI	0.47	5	-	-	TUU	0.19	0.0222	0.41	-	-	0.81	44.7	
5	3.00	SPT	-	-	-	-	1	29	45	25	46	25	21	-	-	-	CI	-	-	-	-	-	-	-	-	10	-	-	-	-
6	3.50	SPT	-	-	-	-	0	28	44	28	47	23	24	-	-	-	CI	-	-	-	-	-	-	-	-	18	-	-	-	-
7	4.00	SPT	-	-	-	-	0	17	42	41	61	25	36	-	-	-	CH	-	-	-	-	-	-	-	-	19	-	-	-	-
8	4.50	UDS	1.92	1.50	28.43	2.60	0	5	45	50	66	21	45	9	0.44	91	CH	0.99	1	-	-	TUU	0.16	0.0126	0.79	-	-	0.74	42.5	
9	5.00	SPT	-	-	-	-	0	14	43	43	63	25	38	-	-	-	CH	-	-	-	-	-	-	-	-	17	-	-	-	-
10	5.50	UDS	1.94	1.52	27.61	2.62	0	15	47	38	60	27	33	12	0.39	62	CH	0.97	4	-	-	TUU	0.15	0.0113	0.91	-	-	0.72	42.0	
11	6.00	SPT	-	-	-	-	0	18	45	37	59	28	31	-	-	-	CH	-	-	-	-	-	-	-	-	18	-	-	-	-
12	6.50	UDS	1.96	1.56	25.94	2.61	0	6	46	48	65	24	41	9	0.47	88	CH	1.03	1	-	-	TUU	0.13	0.0120	0.92	-	-	0.68	40.4	
13	7.00	SPT	-	-	-	-	0	8	51	41	64	26	38	-	-	-	CH	-	-	-	-	-	-	-	-	19	-	-	-	-
14	7.50	UDS	2.01	1.62	23.91	2.65	0	61	39		30	19	11	-	-	-	SC	0.09	26	-	-	DSU	-	-	-	-	-	0.63	38.8	
15	8.00	SPT	-	-	-	-	0	67	33		26	16	10	-	-	-	SC	-	-	-	-	-	-	-	-	34	-	-	-	-
16	8.50	UDS	2.06	1.70	21.00	2.65	0	65	35		27	15	12	-	-	-	SC	0.10	29	-	-	DSU	-	-	-	-	-	0.56	35.8	
17	9.00	SPT	-	-	-	-	0	64	36		29	16	13	-	-	-	SC	-	-	-	-	-	-	-	-	31	-	-	-	-
18	9.50	SPT	-	-	-	-	0	34	43	23	40	20	20	-	-	-	CI	-	-	-	-	-	-	-	-	26	-	-	-	-
19	10.00	SPT	-	-	-	-	0	17	53	30	45	19	26	-	-	-	CI	-	-	-	-	-	-	-	-	64	-	-	-	-
20	11.00	SPT	-	-	-	-	0	28	42	30	44	18	26	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-	-
21	11.50	SPT	-	-	-	-	0	33	45	22	41	21	20	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-	-
22	12.50	SPT	-	-	-	-	0	30	42	28	42	18	24	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-	-
23	13.00	SPT	-	-	-	-	0	34	44	22	40	21	19	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-	-
24	14.00	SPT	-	-	-	-	0	21	41	38	54	20	34	-	-	-	CH	-	-	-	-	-	-	-	-	>100	-	-	-	-
25	14.50	SPT	-	-	-	-	0	24	44	32	53	23	30	-	-	-	CH	-	-	-	-	-	-	-	-	>100	-	-	-	-
26	15.50	SPT	-	-	-	-	0	20	44	36	55	22	33	-	-	-	CH	-	-	-	-	-	-	-	-	>100	-	-	-	-
27	16.00	SPT	-	-	-	-	0	14	47	39	56	20	36	-	-	-	CH	-	-	-	-	-	-	-	-	>100	-	-	-	-
28	17.00	SPT	-	-	-	-	0	16	50	34	54	25	29	-	-	-	CH	-	-	-	-	-	-	-	-	>100	-	-	-	-
29	17.50	SPT	-	-	-	-	0	19	47	34	55	24	31	-	-	-	CH	-	-	-	-	-	-	-	-	>100	-	-	-	-

UDS - Undisturbed Sample
DS - Disturbed Sample
SPT - Standard Penetration Tests
NP - Non Plastic

TUU - Triaxial Unconsolidated Undrained
TCU - Triaxial Consolidated Undrained
DSU - Direct Shear Test
UCS - Unconfined Compression Strength

KCT Consultancy Services LLP, Ahmedabad

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 63

Co-Ordinate :- E 1178, N 3201

Reduced Level :- 199.12 m

Sr No	Depth of Sample m	Type of Sample	Field Bulk Density gm / cc	Field Dry Density gm / cc	Natural Moisture Content %	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit %	Swelling Pressure Kg/cm ²	Free Swell Index %	Soil Classification	Shear Parameter		Unconfined Compression Test Kg/cm ²	UCS by Point Load Index in rock Kg/cm ²	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation %	Void Ratio	Porosity %
							Gravel %	Sand %	Silt %	Clay %	Liquid Limit %	Plastic Limit %	Plasticity Index %					Cohesion C Kg/cm ²	Angle of Internal Friction ϕ Degree				Compression Index C _c	Coefficient of Volume Compressibility mv cm ² /kg	Pre-consolidation Pressure kg/cm ²				
1	0.00	SPT	-	-	-	-	0	68	32		28	16	12	-	-	-	SC	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	0	33	43	24	39	18	21	-	-	-	CI	-	-	-	-	-	-	-	-	4	-	-	-
3	2.00	SPT	-	-	-	-	0	31	41	28	42	17	25	-	-	-	CI	-	-	-	-	-	-	-	-	14	-	-	-
4	2.50	UDS	1.95	1.54	26.92	2.62	0	15	56	29	48	22	26	16	0.15	44	CI	0.78	2	-	-	TUU	0.15	0.0146	0.49	-	-	0.71	41.4
5	3.00	SPT	-	-	-	-	0	21	58	21	42	23	19	-	-	-	CI	-	-	-	-	-	-	-	-	23	-	-	-
6	3.50	UDS	1.97	1.56	26.16	2.64	0	25	51	24	41	20	21	18	0.11	34	CI	1.06	3	-	-	TUU	0.14	0.0097	0.52	-	-	0.69	40.9
7	4.00	SPT	-	-	-	-	0	26	54	20	40	23	17	-	-	-	CI	-	-	-	-	-	-	-	-	19	-	-	-
8	4.50	SPT	-	-	-	-	0	17	58	25	44	21	23	-	-	-	CI	-	-	-	-	-	-	-	-	-	-	-	-
9	5.00	SPT	-	-	-	-	0	16	57	27	45	20	25	-	-	-	CI	-	-	-	-	-	-	-	-	10	-	-	-
10	5.50	UDS	1.96	1.54	27.12	2.65	0	29	46	25	43	22	21	-	-	-	CI	0.61	5	-	-	TUU	0.15	0.0172	0.65	-	-	0.72	41.8
11	6.00	SPT	-	-	-	-	0	30	49	21	42	24	18	-	-	-	CI	-	-	-	-	-	-	-	-	11	-	-	-
12	6.50	UDS	1.97	1.56	26.45	2.65	0	34	39	27	44	21	23	-	-	-	CI	0.60	6	-	-	TUU	0.14	0.0178	0.79	-	-	0.70	41.2
13	7.00	SPT	-	-	-	-	0	29	40	31	47	20	27	-	-	-	CI	-	-	-	-	-	-	-	-	16	-	-	-
14	7.50	DS	-	-	-	-	0	28	43	29	48	23	25	-	-	-	CI	-	-	-	-	-	-	-	-	-	-	-	-
15	8.00	SPT	-	-	-	-	0	30	46	24	45	25	20	-	-	-	CI	-	-	-	-	-	-	-	-	10	-	-	-
16	8.50	DS	-	-	-	-	0	34	47	19	40	23	17	-	-	-	CI	-	-	-	-	-	-	-	-	-	-	-	-
17	9.00	SPT	-	-	-	-	0	33	55	12	29	18	11	-	-	-	CL	-	-	-	-	-	-	-	-	11	-	-	-
18	9.50	DS	-	-	-	-	0	64	36		27	17	10	-	-	-	SC	-	-	-	-	-	-	-	-	-	-	-	-
19	10.00	SPT	-	-	-	-	0	68	32		26	18	8	-	-	-	SC	-	-	-	-	-	-	-	-	12	-	-	-
20	11.00	DS	-	-	-	-	0	79	21		20	15	5	-	-	-	SM	-	-	-	-	-	-	-	-	-	-	-	-
21	11.50	SPT	-	-	-	-	0	82	18		18	14	4	-	-	-	SM	-	-	-	-	-	-	-	-	27	-	-	-
22	12.50	DS	-	-	-	-	0	65	35		29	16	13	-	-	-	SC	-	-	-	-	-	-	-	-	-	-	-	-
23	13.00	SPT	-	-	-	-	0	62	38		31	15	16	-	-	-	SC	-	-	-	-	-	-	-	-	28	-	-	-
24	14.00	DS	-	-	-	-	0	66	34		30	17	13	-	-	-	SC	-	-	-	-	-	-	-	-	-	-	-	-
25	14.50	SPT	-	-	-	-	0	78	22		23	16	7	-	-	-	SM-SC	-	-	-	-	-	-	-	-	29	-	-	-
26	15.00	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-
27	16.50	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-
28	18.00	UDS	2.22	1.95	14.07	2.68	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	39.3	UCS	-	-	-	-	-	0.38	27.4
29	19.50	UDS	2.19	1.90	15.36	2.68	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	64.1	UCS	-	-	-	-	-	0.41	29.2
30	21.00	UDS	2.33	2.11	10.30	2.70	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	83.5	-	UCS	-	-	-	-	49.33	0.28	21.8
31	22.50	UDS	2.34	2.12	10.19	2.71	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	51.3	-	UCS	-	-	-	-	30.66	0.28	21.6
32	24.00	UDS	2.32	2.08	11.38	2.73	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	109.2	-	UCS	-	-	-	-	53.33	0.31	23.7
33	25.50	UDS	2.41	2.23	8.08	2.72	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	86.9	-	UCS	-	-	-	-	74.00	0.22	18.0
34	27.00	UDS	2.37	2.17	9.16	2.71	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	73.7	-	UCS	-	-	-	-	79.33	0.25	19.9

UDS - Undisturbed Sample
DS - Disturbed Sample
SPT - Standard Penetration Tests
NP - Non Plastic

TUU - Triaxial Unconsolidated Undrained
TCU - Triaxial Consolidated Undrained
DSU - Direct Shear Test
UCS - Unconfined Compression Strength

KCT Consultancy Services LLP, Ahmedabad

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 64

Co-Ordinate :- E 1128, N 3195

Reduced Level :- 197.4 m

Sr No	Depth of Sample m	Type of Sample	Field Bulk Density gm / cc	Field Dry Density gm / cc	Natural Moisture Content %	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit %	Swelling Pressure Kg/cm ²	Free Swell Index %	Soil Classification	Shear Parameter		Unconfined Compression Test Kg/cm ²	UCS by Point Load Index in rock Kg/cm ²	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation %	Void Ratio	Porosity %
							Gravel %	Sand %	Silt %	Clay %	Liquid Limit %	Plastic Limit %	Plasticity Index %					Cohesion C Kg/cm ²	Angle of Internal Friction ϕ Degree				Compression Index C _c	Coefficient of Volume Compressibility mv cm ² /kg	Pre-consolidation Pressure kg/cm ²				
1	0.00	DS	-	-	-	-	0	21	51	28	51	25	26	-	-	-	CH	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	0	17	49	34	57	27	30	13	-	54	CH	-	-	-	-	-	-	-	-	4	-	-	-
3	2.00	SPT	-	-	-	-	0	31	37	32	53	26	27	-	-	-	CH	-	-	-	-	-	-	-	-	10	-	-	-
4	2.50	UDS	1.93	1.49	29.21	2.65	0	33	38	29	52	27	25	15	0.32	49	CH	0.53	8	-	-	TUU	0.17	0.0200	0.44	-	-	0.77	43.6
5	3.00	SPT	-	-	-	-	0	30	37	33	54	25	29	-	-	-	CH	-	-	-	-	-	-	-	-	15	-	-	-
6	3.50	UDS	1.97	1.57	25.28	2.61	0	17	48	35	55	24	31	12	0.38	58	CH	0.82	3	-	-	TUU	0.11	0.0139	0.58	-	-	0.66	39.8
7	4.00	SPT	-	-	-	-	0	23	50	27	52	27	25	-	-	-	CH	-	-	-	-	-	-	-	-	16	-	-	-
8	4.50	UDS	1.98	1.57	25.80	2.65	0	37	35	28	51	26	25	15	0.34	48	CH	0.68	6	-	-	TUU	0.12	0.0154	0.64	-	-	0.68	40.6
9	5.00	SPT	-	-	-	-	0	17	44	39	57	24	33	-	-	-	CH	-	-	-	-	-	-	-	-	13	-	-	-
10	5.50	UDS	2.00	1.60	24.81	2.66	0	63	37	30	16	14	-	-	-	-	SC	0.09	27	-	-	DSU	-	-	-	-	-	0.66	39.8
11	6.00	SPT	-	-	-	-	0	71	29	26	15	11	-	-	-	-	SC	-	-	-	-	-	-	-	-	19	-	-	-
12	6.50	UDS	2.02	1.64	23.31	2.65	0	61	39	32	17	15	-	-	-	-	SC	0.10	27	-	-	DSU	-	-	-	-	-	0.62	38.2
13	7.00	SPT	-	-	-	-	0	67	33	27	16	11	-	-	-	-	SC	-	-	-	-	-	-	-	-	19	-	-	-
14	7.50	Remoulded	2.04	1.66	22.69	2.67	3	81	16	NP	NP	NP	-	-	-	-	SM	0.00	29	-	-	DSU	-	-	-	-	-	0.61	37.7
15	8.00	SPT	-	-	-	-	5	83	12	NP	NP	NP	-	-	-	-	SM	-	-	-	-	-	-	-	-	18	-	-	-
16	8.50	DS	-	-	-	-	4	77	19	18	14	4	-	-	-	-	SM	-	-	-	-	-	-	-	-	-	-	-	-
17	9.00	SPT	-	-	-	-	6	72	22	21	16	5	-	-	-	-	SM	-	-	-	-	-	-	-	-	22	-	-	-
18	9.50	Remoulded	2.07	1.71	21.00	2.67	3	77	20	18	14	4	-	-	-	-	SM	0.00	31	-	-	DSU	-	-	-	-	-	0.56	35.9
19	10.00	SPT	-	-	-	-	5	73	22	20	16	4	-	-	-	-	SM	-	-	-	-	-	-	-	-	62	-	-	-
20	11.00	SPT	-	-	-	-	0	16	61	23	41	20	21	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-
21	12.50	UDS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	-	-	-	-
22	12.50	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-
23	14.00	UDS	2.31	2.08	11.03	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	94.8	-	UCS	-	-	-	-	10.00	0.30	22.9
24	15.50	UDS	2.29	2.04	12.49	2.73	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	90.9	UCS	-	-	-	-	-	0.34	25.4
25	17.00	UDS	2.33	2.11	10.54	2.71	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	73.0	-	UCS	-	-	-	-	64.00	0.29	22.2
26	18.50	UDS	2.40	2.21	8.40	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	95.1	-	UCS	-	-	-	-	71.00	0.23	18.6
27	20.00	UDS	2.39	2.20	8.50	2.71	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	90.8	-	UCS	-	-	-	-	73.00	0.23	18.7
28	21.50	UDS	2.44	2.27	7.60	2.74	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	144.7	-	UCS	-	-	-	-	91.00	0.21	17.2

KCT Consultancy Services LLP, Ahmedabad

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 65

Co-Ordinate :- E 1335, N 3190

Reduced Level :- 201.95

Sr No	Depth of Sample	Type of Sample	Field Bulk Density	Field Dry Density	Natural Moisture Content	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit	Swelling Pressure	Free Swell Index	Soil Classification	Shear Parameter		Unconfined Compression Test	UCS by Point Load Index in rock	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation	Void Ratio	Porosity
							Gravel	Sand	Silt	Clay	Liquid Limit	Plastic Limit	Plasticity Index					Cohesion C	Angle of Internal Friction ϕ				Compression Index C _c	Coefficient of Volume Compressibility mv	Pre-consolidation Pressure				
1	0.00	DS	-	-	-	-	0	61	39	28	16	12	-	-	-	SC	-	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	0	29	41	30	43	17	26	15	-	39	CI	-	-	-	-	-	-	-	-	8	-	-	-
3	2.00	SPT	-	-	-	-	0	22	54	24	39	18	21	-	-	-	CI	-	-	-	-	-	-	-	-	16	-	-	-
4	2.50	UDS	1.95	1.54	26.62	2.61	0	16	53	31	44	16	28	15	0.16	41	CI	0.81	3	-	-	TUU	0.13	0.0136	0.43	-	-	0.69	41.0
5	3.00	SPT	-	-	-	-	0	29	44	27	42	19	23	-	-	-	CI	-	-	-	-	-	-	-	-	15	-	-	-
6	3.50	SPT	-	-	-	-	0	20	35	45	59	20	39	-	-	-	CH	-	-	-	-	-	-	-	-	21	-	-	-
7	4.00	SPT	-	-	-	-	0	16	39	45	64	22	42	-	-	-	CH	-	-	-	-	-	-	-	-	28	-	-	-
8	4.50	UDS	2.00	1.61	24.24	2.64	0	19	43	38	60	25	35	12	0.44	64	CH	1.28	4	-	-	TUU	0.11	0.0093	0.84	-	-	0.64	39.0
9	5.00	SPT	-	-	-	-	0	24	40	36	59	26	33	-	-	-	CH	-	-	-	-	-	-	-	-	22	-	-	-
10	5.50	UDS	1.99	1.59	25.44	2.66	0	67	33	43	20	23	-	-	-	SC	0.10	26	-	-	DSU	-	-	-	-	-	0.68	40.4	
11	6.00	SPT	-	-	-	-	0	61	39	46	21	25	-	-	-	SC	-	-	-	-	-	-	-	-	-	23	-	-	-
12	6.50	UDS	2.01	1.62	24.19	2.66	0	66	34	45	24	21	-	-	-	SC	0.12	27	-	-	DSU	-	-	-	-	-	0.64	39.2	
13	7.00	SPT	-	-	-	-	0	36	32	32	52	23	29	-	-	-	CH	-	-	-	-	-	-	-	-	28	-	-	-
14	7.50	SPT	-	-	-	-	0	29	31	40	56	21	35	-	-	-	CH	-	-	-	-	-	-	-	-	36	-	-	-
15	8.00	SPT	-	-	-	-	0	34	30	36	55	23	32	-	-	-	CH	-	-	-	-	-	-	-	-	38	-	-	-
16	8.50	SPT	-	-	-	-	0	32	47	21	39	20	19	-	-	-	CI	-	-	-	-	-	-	-	-	40	-	-	-
17	9.00	SPT	-	-	-	-	0	35	37	28	43	18	25	-	-	-	CI	-	-	-	-	-	-	-	-	65	-	-	-
18	9.50	SPT	-	-	-	-	0	29	38	33	45	17	28	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-
19	10.00	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-
20	11.00	UDS	2.21	1.93	14.75	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	46.6	UCS	-	-	-	-	-	0.40	28.4
21	12.50	UDS	2.24	1.97	13.74	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	51.6	UCS	-	-	-	-	-	0.37	27.1
22	14.00	DS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	-	-	-	-
23	15.50	DS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	-	-	-	-
24	17.00	DS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	-	-	-	-
25	18.50	UDS	2.38	2.18	9.29	2.73	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	87.9	-	UCS	-	-	-	-	88.00	0.25	20.2

KCT Consultancy Services LLP, Ahmedabad

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 66

Co-Ordinate :- E 1280, N 3169

Reduced Level :- 200.86 m

Sr No	Depth of Sample	Type of Sample	Field Bulk Density	Field Dry Density	Natural Moisture Content	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit	Swelling Pressure	Free Swell Index	Soil Classification	Shear Parameter		Unconfined Compression Test	UCS by Point Load Index in rock	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation	Void Ratio	Porosity	
							Gravel	Sand	Silt	Clay	Liquid Limit	Plastic Limit	Plasticity Index					Cohesion C	Angle of Internal Friction ϕ				Compression Index C _c	Coefficient of Volume Compressibility mv	Pre-consolidation Pressure					
																														%
1	0.00	DS	-	-	-	-	0	59	41	29	16	13	-	-	-	SC	-	-	-	-	-	-	-	-	-	-	-	-	-	
2	1.00	SPT	-	-	-	-	0	19	56	25	42	19	23	-	-	-	CI	-	-	-	-	-	-	-	-	8	-	-	-	
3	2.00	SPT	-	-	-	-	0	28	51	21	40	22	18	-	-	-	CI	-	-	-	-	-	-	-	-	11	-	-	-	
4	2.50	UDS	1.93	1.49	29.21	2.65	0	30	51	19	39	23	16	20	0.14	31	CI	0.76	6	-	-	TUU	0.18	0.0119	0.42	-	-	0.77	43.6	
5	3.00	SPT	-	-	-	-	0	24	53	23	42	21	21	-	-	-	CI	-	-	-	-	-	-	-	-	18	-	-	-	
6	3.50	SPT	-	-	-	-	0	20	41	39	59	24	35	-	-	-	CH	-	-	-	-	-	-	-	-	16	-	-	-	
7	4.00	SPT	-	-	-	-	0	9	39	52	68	21	47	-	-	-	CH	-	-	-	-	-	-	-	-	20	-	-	-	
8	4.50	UDS	1.93	1.51	28.01	2.61	0	11	42	47	65	25	40	9	0.44	73	CH	0.88	2	-	-	TUU	0.16	0.0139	0.60	-	-	0.73	42.2	
9	5.00	SPT	-	-	-	-	0	18	44	38	60	26	34	-	-	-	CH	-	-	-	-	-	-	-	-	13	-	-	-	
10	5.50	UDS	1.92	1.48	29.34	2.63	0	12	44	44	63	24	39	10	0.41	69	CH	0.76	3	-	-	TUU	0.18	0.0159	0.78	-	-	0.77	43.6	
11	6.00	SPT	-	-	-	-	0	31	48	21	41	23	18	-	-	-	CI	-	-	-	-	-	-	-	-	15	-	-	-	
12	6.50	UDS	1.97	1.56	26.45	2.65	0	37	44	19	39	22	17	21	0.14	31	CI	1.54	7	-	-	TUU	0.14	0.0059	1.94	-	-	0.70	41.2	
13	7.00	SPT	-	-	-	-	0	16	58	26	44	21	23	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-	
14	7.50	SPT	-	-	-	-	0	23	54	23	42	22	20	-	-	-	CI	-	-	-	-	-	-	-	-	56	-	-	-	
15	8.00	SPT	-	-	-	-	0	18	57	25	43	21	22	-	-	-	CI	-	-	-	-	-	-	-	-	65	-	-	-	
16	8.50	SPT	-	-	-	-	0	21	61	18	41	24	17	-	-	-	CI	-	-	-	-	-	-	-	-	71	-	-	-	
17	9.00	SPT	-	-	-	-	0	14	58	28	46	20	26	-	-	-	CI	-	-	-	-	-	-	-	-	64	-	-	-	
18	9.50	SPT	-	-	-	-	0	19	61	20	40	23	17	-	-	-	CI	-	-	-	-	-	-	-	-	70	-	-	-	
19	10.00	SPT	-	-	-	-	0	17	61	22	41	22	19	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-	
20	11.00	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-	
21	12.50	UDS	2.19	1.89	15.62	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	53.1	UCS	-	-	-	-	-	-	0.42	29.6
22	14.00	UDS	2.17	1.87	16.26	2.68	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	49.7	UCS	-	-	-	-	-	-	0.44	30.4
23	15.50	UDS	2.21	1.92	15.00	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	96.8	UCS	-	-	-	-	-	-	0.40	28.8
24	17.00	UDS	2.35	2.14	9.84	2.71	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	104.8	-	UCS	-	-	-	-	-	58.66	0.27	21.1
25	18.50	UDS	2.32	2.08	11.38	2.73	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	119.9	-	UCS	-	-	-	-	-	45.33	0.31	23.7
26	20.50	UDS	2.34	2.12	10.43	2.72	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	124.8	-	UCS	-	-	-	-	-	55.33	0.28	22.1
27	21.50	UDS	2.31	2.08	11.27	2.71	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	91.8	-	UCS	-	-	-	-	-	27.33	0.31	23.4
28	23.00	UDS	2.39	2.19	9.19	2.74	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	148.9	-	UCS	-	-	-	-	-	95.33	0.25	20.1

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 67

Co-Ordinate :- E - 900, N - 3182

Reduced Level :- 196.5 m

Sr No	Depth of Sample	Type of Sample	Field Bulk Density	Field Dry Density	Natural Moisture Content	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit	Swelling Pressure	Free Swell Index	Soil Classification	Shear Parameter		Unconfined Compression Test	UCS by Point Load Index in rock	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation	Void Ratio	Porosity
							Gravel	Sand	Silt	Clay	Liquid Limit	Plastic Limit	Plasticity Index					Cohesion C	Angle of Internal Friction ϕ				Compression Index C _c	Coefficient of Volume Compressibility mv	Pre-consolidation Pressure				
1	0.00	DS	-	-	-	-	8	29	49	14	28	16	12	-	-	-	CL	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	11	32	34	23	39	18	21	-	-	-	CI	-	-	-	-	-	-	-	4	-	-	-	-
3	2.00	SPT	-	-	-	-	6	27	40	27	44	21	23	-	-	-	CI	-	-	-	-	-	-	-	6	-	-	-	-
4	2.50	UDS	1.95	1.53	27.81	2.65	9	30	37	24	43	23	20	-	-	-	CI	0.31	7	-	-	TUU	0.15	0.0303	0.43	-	-	0.74	42.4
5	3.00	SPT	-	-	-	-	18	52	30	28	16	12	-	-	-	-	SC	-	-	-	-	-	-	-	13	-	-	-	-
6	3.50	UDS	1.97	1.55	27.03	2.67	13	49	38	32	15	17	-	-	-	-	SC	0.08	26	-	-	DSU	-	-	-	-	-	0.72	41.9
7	4.00	SPT	-	-	-	-	16	59	25	24	16	8	-	-	-	-	SC	-	-	-	-	-	-	-	12	-	-	-	-
8	4.50	UDS	1.98	1.57	25.80	2.65	8	57	35	31	18	13	-	-	-	-	SC	0.05	25	-	-	DSU	-	-	-	-	-	0.68	40.6
9	5.00	SPT	-	-	-	-	14	48	38	32	17	15	-	-	-	-	SC	-	-	-	-	-	-	-	23	-	-	-	-
10	5.50	UDS	2.05	1.68	21.84	2.66	0	69	31	26	19	7	-	-	-	-	SM-SC	0.01	28	-	-	DSU	-	-	-	-	-	0.58	36.7
11	6.00	SPT	-	-	-	-	0	73	27	22	16	6	-	-	-	-	SM-SC	-	-	-	-	-	-	-	>100	-	-	-	-
12	6.50	SPT	-	-	-	-	0	71	29	25	18	7	-	-	-	-	SM-SC	-	-	-	-	-	-	-	>100	-	-	-	-
13	7.00	SPT	-	-	-	-	0	75	25	23	17	6	-	-	-	-	SM-SC	-	-	-	-	-	-	-	15	-	-	-	-
14	7.50	UDS	2.34	2.12	10.43	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	79.6	UCS	-	-	-	-	-	0.28	22.1
15	9.00	UDS	2.39	2.18	9.42	2.75	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	89.6	-	UCS	-	-	-	-	42.00	0.26	20.6
16	10.50	UDS	2.42	2.23	8.68	2.76	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	177.1	-	UCS	-	-	-	-	50.66	0.24	19.3
17	12.00	UDS	2.39	2.19	8.96	2.73	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	148.2	-	UCS	-	-	-	-	27.33	0.24	19.7
18	13.50	UDS	2.44	2.26	8.05	2.76	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	201.6	-	UCS	-	-	-	-	37.33	0.22	18.2
19	15.00	UDS	2.46	2.28	7.88	2.78	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	209.7	-	UCS	-	-	-	-	52.66	0.22	18.0
20	16.50	UDS	2.38	2.16	10.20	2.77	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	186.3	-	UCS	-	-	-	-	44.66	0.28	22.0
21	18.00	UDS	2.47	2.30	7.59	2.78	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	138.5	-	UCS	-	-	-	-	58.66	0.21	17.4

KCT Consultancy Services LLP, Ahmedabad

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 68

Co-Ordinate :- E 1050, N 3179

Reduced Level :- 197.4 m

Sr No	Depth of Sample	Type of Sample	Field Bulk Density	Field Dry Density	Natural Moisture Content	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit	Swelling Pressure	Free Swell Index	Soil Classification	Shear Parameter		Unconfined Compression Test	UCS by Point Load Index in rock	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation	Void Ratio	Porosity	
							Gravel	Sand	Silt	Clay	Liquid Limit	Plastic Limit	Plasticity Index					Cohesion C	Angle of Internal Friction ϕ				Compression Index C _c	Coefficient of Volume Compressibility mv	Pre-consolidation Pressure					
																														%
1	0.00	DS	-	-	-	-	0	27	50	23	42	22	20	-	-	-	CI	-	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	0	30	52	18	39	22	17	-	-	-	CI	-	-	-	-	-	-	-	-	7	-	-	-	-
3	2.00	SPT	-	-	-	-	0	29	46	25	43	20	23	-	-	-	CI	-	-	-	-	-	-	-	-	19	-	-	-	-
4	2.50	UDS	1.94	1.52	27.91	2.63	0	10	60	30	48	22	26	15	0.16	45	CI	0.71	2	-	-	TUU	0.16	0.0154	0.43	-	-	0.73	42.3	-
5	3.00	SPT	-	-	-	-	0	15	62	23	44	24	20	-	-	-	CI	-	-	-	-	-	-	-	-	13	-	-	-	-
6	3.50	UDS	1.95	1.54	26.32	2.60	0	9	63	28	47	23	24	16	0.16	41	CI	0.72	1	-	-	TUU	0.14	0.0151	0.52	-	-	0.68	40.6	-
7	4.00	SPT	-	-	-	-	0	12	44	44	69	30	39	-	-	-	CH	-	-	-	-	-	-	-	-	16	-	-	-	-
8	4.50	UDS	2.00	1.61	24.24	2.64	0	18	41	41	66	31	35	9	0.49	66	CH	0.86	3	-	-	TUU	0.12	0.0130	0.61	-	-	0.64	39.0	-
9	5.00	SPT	-	-	-	-	0	23	41	36	62	29	33	-	-	-	CH	-	-	-	-	-	-	-	-	19	-	-	-	-
10	5.50	SPT	-	-	-	-	0	11	51	38	64	31	33	-	-	-	CH	-	-	-	-	-	-	-	-	16	-	-	-	-
11	6.00	SPT	-	-	-	-	0	10	61	29	47	21	26	-	-	-	CI	-	-	-	-	-	-	-	-	19	-	-	-	-
12	6.50	UDS	1.96	1.56	25.94	2.61	0	13	62	25	43	22	21	-	-	-	CI	0.57	4	-	-	TUU	0.13	0.0168	0.80	-	-	0.68	40.4	-
13	7.00	SPT	-	-	-	-	0	69	31	28	16	12	-	-	-	-	SC	-	-	-	-	-	-	-	-	11	-	-	-	-
14	7.50	UDS	1.98	1.57	26.09	2.66	0	62	38	30	15	15	-	-	-	-	SC	0.08	25	-	-	DSU	-	-	-	-	-	0.69	41.0	-
15	8.00	SPT	-	-	-	-	0	68	32	26	17	9	-	-	-	-	SC	-	-	-	-	-	-	-	-	15	-	-	-	-
16	8.50	SPT	-	-	-	-	0	71	29	24	16	8	-	-	-	-	SC	-	-	-	-	-	-	-	-	17	-	-	-	-
17	9.00	SPT	-	-	-	-	4	77	19	18	14	4	-	-	-	-	SM	-	-	-	-	-	-	-	-	20	-	-	-	-
18	9.50	SPT	-	-	-	-	5	74	21	20	15	5	-	-	-	-	SM	-	-	-	-	-	-	-	-	16	-	-	-	-
19	10.00	SPT	-	-	-	-	11	69	20	22	17	5	-	-	-	-	SM	-	-	-	-	-	-	-	-	19	-	-	-	-
20	11.00	SPT	-	-	-	-	10	72	18	17	NP	NP	-	-	-	-	SM	-	-	-	-	-	-	-	-	>100	-	-	-	-
21	11.50	SPT	-	-	-	-	4	71	25	24	19	5	-	-	-	-	SM	-	-	-	-	-	-	-	-	>100	-	-	-	-
22	12.50	SPT	-	-	-	-	8	67	25	26	21	5	-	-	-	-	SM	-	-	-	-	-	-	-	-	19	-	-	-	-
23	13.00	SPT	-	-	-	-	4	73	23	22	18	4	-	-	-	-	SM	-	-	-	-	-	-	-	-	22	-	-	-	-
24	14.00	SPT	-	-	-	-	0	64	36	26	16	10	-	-	-	-	SC	-	-	-	-	-	-	-	-	>100	-	-	-	-
25	14.50	SPT	-	-	-	-	0	19	68	13	28	17	11	-	-	-	CL	-	-	-	-	-	-	-	-	>100	-	-	-	-
26	16.00	UDS	2.31	2.06	11.98	2.74	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	83.7	-	UCS	-	-	-	-	7.80	0.33	24.7	-
27	17.50	UDS	2.40	2.20	9.32	2.76	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	137.6	-	UCS	-	-	-	-	31.33	0.26	20.5	-

UDS - Undisturbed Sample
DS - Disturbed Sample
SPT - Standard Penetration Tests
NP - Non Plastic

TUU - Triaxial Unconsolidated Undrained
TCU - Triaxial Consolidated Undrained
DSU - Direct Shear Test
UCS - Unconfined Compression Strength

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 70

Co-Ordinate :- E - 1216, N - 3170

Reduced Level :- 201.82 m

Sr No	Depth of Sample m	Type of Sample	Field Bulk Density gm / cc	Field Dry Density gm / cc	Natural Moisture Content %	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit %	Swelling Pressure Kg/cm ²	Free Swell Index %	Soil Classification	Shear Parameter		Unconfined Compression Test Kg/cm ²	UCS by Point Load Index in rock Kg/cm ²	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation %	Void Ratio	Porosity %
							Gravel %	Sand %	Silt %	Clay %	Liquid Limit %	Plastic Limit %	Plasticity Index %					Cohesion C Kg/cm ²	Angle of Internal Friction ϕ Degree				Compression Index C _c	Coefficient of Volume Compressibility m _v cm ² /kg	Pre-consolidation Pressure kg/cm ²				
1	0.00	DS	-	-	-	-	3	54	43	25	13	12	-	-	-	SC	-	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	3	42	32	23	36	16	20	-	-	-	CI	-	-	-	-	-	-	-	-	5	-	-	-
3	2.00	SPT	-	-	-	-	1	31	39	29	44	18	26	-	-	-	CI	-	-	-	-	-	-	-	-	10	-	-	-
4	2.50	UDS	1.96	1.54	27.12	2.65	3	37	36	24	42	20	22	-	-	-	CI	0.53	6	-	-	TUU	0.14	0.0192	0.43	-	-	0.72	41.8
5	3.00	SPT	-	-	-	-	1	29	44	26	43	19	24	-	-	-	CI	-	-	-	-	-	-	-	-	13	-	-	-
6	3.50	SPT	-	-	-	-	2	25	50	23	38	17	21	-	-	-	CI	-	-	-	-	-	-	-	-	15	-	-	-
7	4.00	SPT	-	-	-	-	0	23	47	30	45	19	26	-	-	-	CI	-	-	-	-	-	-	-	-	10	-	-	-
8	4.50	UDS	1.97	1.57	25.87	2.63	0	21	59	20	41	23	18	-	-	-	CI	0.55	3	-	-	TUU	0.13	0.0179	0.66	-	-	0.68	40.5
9	5.00	SPT	-	-	-	-	0	38	49	13	36	25	11	-	-	-	MI	-	-	-	-	-	-	-	-	85	-	-	-
10	6.50	UDS	2.13	1.79	18.68	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	23.7	UCS	-	-	-	-	-	0.50	33.5
11	8.00	UDS	2.16	1.85	16.99	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	40.9	UCS	-	-	-	-	-	0.46	31.4
12	9.50	UDS	2.15	1.82	18.22	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	37.1	UCS	-	-	-	-	-	0.50	33.1
13	11.00	UDS	2.12	1.77	19.70	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	34.9	-	UCS	-	-	-	-	8.66	0.54	34.9
14	12.50	UDS	2.10	1.75	20.20	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	44.3	-	UCS	-	-	-	-	7.33	0.55	35.3
15	14.00	UDS	2.39	2.20	8.73	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	133.7	-	UCS	-	-	-	-	31.33	0.24	19.2
16	15.50	UDS	2.34	2.11	10.66	2.73	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	96.4	-	UCS	-	-	-	-	17.00	0.29	22.5
17	17.00	UDS	2.68	2.59	3.35	2.84	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	363.9	-	UCS	-	-	-	-	59.33	0.10	8.7
18	18.50	UDS	2.54	2.42	5.18	2.76	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	246.5	-	UCS	-	-	-	-	100.00	0.14	12.5

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 71

Co-Ordinate :- E - 1175, N - 3163

Reduced Level :- 197.88 m

Sr No	Depth of Sample	Type of Sample	Field Bulk Density	Field Dry Density	Natural Moisture Content	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit	Swelling Pressure	Free Swell Index	Soil Classification	Shear Parameter		Unconfined Compression Test	UCS by Point Load Index in rock	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation	Void Ratio	Porosity
							Gravel	Sand	Silt	Clay	Liquid Limit	Plastic Limit	Plasticity Index					Cohesion C	Angle of Internal Friction ϕ				Compression Index C _c	Coefficient of Volume Compressibility m _v	Pre-consolidation Pressure				
1	0.00	DS	-	-	-	-	0	61	39	22	13	9	-	-	-	SC	-	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	0	43	29	28	39	15	24	-	-	-	CI	-	-	-	-	-	-	-	-	8	-	-	-
3	2.00	SPT	-	-	-	-	0	37	32	31	41	13	28	-	-	-	CI	-	-	-	-	-	-	-	-	10	-	-	-
4	2.50	UDS	1.95	1.53	27.81	2.65	0	29	48	23	43	23	20	-	-	-	CI	0.53	6	-	-	TUU	0.15	0.0185	0.42	-	-	0.74	42.4
5	3.00	SPT	-	-	-	-	0	10	49	41	56	21	35	-	-	-	CH	-	-	-	-	-	-	-	-	12	-	-	-
6	3.50	SPT	-	-	-	-	0	7	61	32	54	27	27	-	-	-	CH	-	-	-	-	-	-	-	-	11	-	-	-
7	4.00	SPT	-	-	-	-	0	4	61	35	56	25	31	-	-	-	CH	-	-	-	-	-	-	-	-	7	-	-	-
8	4.50	UDS	1.90	1.46	30.23	2.61	0	5	63	32	55	26	29	-	-	-	CH	0.39	1	-	-	TUU	0.18	0.0292	0.61	-	-	0.79	44.1
9	5.00	SPT	-	-	-	-	0	11	58	31	52	25	27	-	-	-	CH	-	-	-	-	-	-	-	-	11	-	-	-
10	5.50	UDS	1.96	1.54	27.12	2.65	0	35	28	37	51	18	33	-	-	-	CH	0.54	7	-	-	TUU	0.14	0.0189	0.73	-	-	0.72	41.8
11	6.00	SPT	-	-	-	-	0	71	29		28	21	7	-	-	-	SM-SC	-	-	-	-	-	-	-	-	14	-	-	-
12	6.50	UDS	1.99	1.58	25.73	2.67	0	85	15		25	19	6	-	-	-	SM-SC	0.02	26	-	-	DSU	-	-	-	-	-	0.69	40.7
13	7.00	SPT	-	-	-	-	0	84	16		26	20	6	-	-	-	SM-SC	-	-	-	-	-	-	-	-	19	-	-	-
14	7.50	UDS	2.04	1.67	22.41	2.66	0	77	23		27	20	7	-	-	-	SM-SC	0.04	28	-	-	DSU	-	-	-	-	-	0.60	37.3
15	8.00	SPT	-	-	-	-	0	84	16		23	17	6	-	-	-	SM-SC	-	-	-	-	-	-	-	-	24	-	-	-
16	8.50	UDS	2.05	1.68	21.84	2.66	0	75	25		27	20	7	-	-	-	SM-SC	0.05	29	-	-	DSU	-	-	-	-	-	0.58	36.7
17	9.00	SPT	-	-	-	-	0	86	14		22	16	6	-	-	-	SM-SC	-	-	-	-	-	-	-	-	26	-	-	-
18	9.50	SPT	-	-	-	-	0	83	17		27	21	6	-	-	-	SM-SC	-	-	-	-	-	-	-	-	36	-	-	-
19	10.00	SPT	-	-	-	-	0	72	28		25	18	7	-	-	-	SM-SC	-	-	-	-	-	-	-	-	38	-	-	-
20	11.00	SPT	-	-	-	-	0	87	13		23	17	6	-	-	-	SM-SC	-	-	-	-	-	-	-	-	27	-	-	-
21	11.50	SPT	-	-	-	-	0	85	15		26	20	6	-	-	-	SM-SC	-	-	-	-	-	-	-	-	53	-	-	-
22	13.00	UDS	2.28	2.02	12.64	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	125.3	-	UCS	-	-	-	-	10.00	0.34	25.6
23	14.50	UDS	2.31	2.06	11.98	2.74	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	143.4	-	UCS	-	-	-	-	21.00	0.33	24.7
24	16.00	UDS	2.46	2.29	7.44	2.76	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	218.3	-	UCS	-	-	-	-	56.66	0.21	17.0
25	17.50	UDS	2.40	2.22	8.17	2.71	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	183.4	-	UCS	-	-	-	-	35.33	0.22	18.1
26	19.00	UDS	2.46	2.31	6.55	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	206.9	-	UCS	-	-	-	-	48.00	0.18	15.1
27	20.00	UDS	2.45	2.28	7.30	2.74	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	195.2	-	UCS	-	-	-	-	30.00	0.20	16.7

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 73

Co-Ordinate :- E - 886, N - 3136

Reduced Level :- % * " - m

Sr No	Depth of Sample	Type of Sample	Field Bulk Density	Field Dry Density	Natural Moisture Content	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit	Swelling Pressure	Free Swell Index	Soil Classification	Shear Parameter		Unconfined Compression Test	UCS by Point Load Index in rock	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation	Void Ratio	Porosity
							Gravel	Sand	Silt	Clay	Liquid Limit	Plastic Limit	Plasticity Index					Cohesion C	Angle of Internal Friction ϕ				Compression Index C _c	Coefficient of Volume Compressibility m _v	Pre-consolidation Pressure				
1	0.00	DS	-	-	-	-	0	39	47	14	25	13	12	-	-	-	CL	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	0	47	35	18	31	15	16	-	-	-	CL	-	-	-	-	-	-	-	-	9	-	-	-
3	2.00	SPT	-	-	-	-	0	36	40	24	37	16	21	-	-	-	CI	-	-	-	-	-	-	-	-	14	-	-	-
4	2.50	UDS	1.96	1.54	27.12	2.65	0	28	45	27	39	16	23	-	-	-	CI	0.76	5	-	-	TUU	0.14	0.0128	0.43	-	-	0.72	41.8
5	3.00	SPT	-	-	-	-	0	39	35	26	37	15	22	-	-	-	CI	-	-	-	-	-	-	-	-	19	-	-	-
6	3.50	UDS	1.99	1.58	25.73	2.67	21	50	29	36	18	18	-	-	-	-	SC	0.07	27	-	-	DSU	-	-	-	-	-	0.69	40.7
7	4.00	SPT	-	-	-	-	4	62	34	39	16	23	-	-	-	-	SC	-	-	-	-	-	-	-	-	24	-	-	-
8	4.50	UDS	2.00	1.60	24.81	2.66	7	61	32	41	21	20	-	-	-	-	SC	0.06	25	-	-	DSU	-	-	-	-	-	0.66	39.8
9	5.00	SPT	-	-	-	-	0	55	45	44	20	24	-	-	-	-	SC	-	-	-	-	-	-	-	-	16	-	-	-
10	5.50	UDS	2.04	1.67	22.13	2.65	0	52	48	28	16	12	-	-	-	-	SC	0.09	26	-	-	DSU	-	-	-	-	-	0.59	37.0
11	6.00	SPT	-	-	-	-	0	62	38	26	18	8	-	-	-	-	SC	-	-	-	-	-	-	-	-	33	-	-	-
12	6.50	SPT	-	-	-	-	0	70	30	23	17	6	-	-	-	-	SM-SC	-	-	-	-	-	-	-	-	29	-	-	-
13	7.00	SPT	-	-	-	-	0	68	32	24	17	7	-	-	-	-	SM-SC	-	-	-	-	-	-	-	-	25	-	-	-
14	7.50	SPT	-	-	-	-	0	64	36	25	14	11	-	-	-	-	SC	-	-	-	-	-	-	-	-	>100	-	-	-
15	8.00	SPT	-	-	-	-	0	69	31	29	16	13	-	-	-	-	SC	-	-	-	-	-	-	-	-	>100	-	-	-
16	8.50	SPT	-	-	-	-	0	70	30	28	18	10	-	-	-	-	SC	-	-	-	-	-	-	-	-	>100	-	-	-
17	9.00	SPT	-	-	-	-	0	68	32	30	16	14	-	-	-	-	SC	-	-	-	-	-	-	-	-	>100	-	-	-
18	9.50	SPT	-	-	-	-	0	64	36	32	15	17	-	-	-	-	SC	-	-	-	-	-	-	-	-	>100	-	-	-
19	10.00	SPT	-	-	-	-	12	52	36	31	17	14	-	-	-	-	SC	-	-	-	-	-	-	-	-	>100	-	-	-
20	11.00	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-
21	11.50	UDS	2.46	2.31	6.55	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	149.3	UCS	-	-	-	-	-	0.18	15.1
22	13.00	UDS	2.47	2.31	6.70	2.74	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	125.7	-	UCS	-	-	-	-	28.00	0.18	15.5
23	14.50	UDS	2.56	2.46	4.21	2.74	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	167.2	-	UCS	-	-	-	-	86.00	0.12	10.3

KCT Consultancy Services LLP, Ahmedabad

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 75

Co-Ordinate :- E 917, N 3123

Reduced Level :- 197.60 m

Sr No	Depth of Sample	Type of Sample	Field Bulk Density	Field Dry Density	Natural Moisture Content	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit	Swelling Pressure	Free Swell Index	Soil Classification	Shear Parameter		Unconfined Compression Test	UCS by Point Load Index in rock	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation	Void Ratio	Porosity
							Gravel	Sand	Silt	Clay	Liquid Limit	Plastic Limit	Plasticity Index					Cohesion C	Angle of Internal Friction ϕ				Compression Index C _c	Coefficient of Volume Compressibility mv	Pre-consolidation Pressure				
1	0.00	DS	-	-	-	-	0	68	32	29	15	14	-	-	-	SC	-	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	0	18	56	26	44	20	24	18	-	42	CI	-	-	-	-	-	-	-	-	4	-	-	-
3	2.00	SPT	-	-	-	-	0	14	49	37	57	25	32	13	-	59	CH	-	-	-	-	-	-	-	-	7	-	-	-
4	2.50	UDS	1.91	1.48	29.16	2.60	0	11	47	42	61	24	37	9	0.39	76	CH	0.43	1	-	-	TUU	0.16	0.0266	0.42	-	-	0.76	43.1
5	3.00	SPT	-	-	-	-	0	18	51	31	53	26	27	-	-	-	CH	-	-	-	-	-	-	-	-	10	-	-	-
6	3.50	UDS	1.95	1.53	27.22	2.63	0	22	43	35	55	25	30	13	0.36	56	CH	0.53	3	-	-	TUU	0.14	0.0204	0.50	-	-	0.72	41.7
7	4.00	SPT	-	-	-	-	0	16	47	37	57	24	33	-	-	-	CH	-	-	-	-	-	-	-	-	11	-	-	-
8	4.50	UDS	1.99	1.59	25.16	2.65	0	37	44	19	40	23	17	19	0.29	32	CI	0.84	7	-	-	TUU	0.12	0.0108	0.59	-	-	0.67	40.0
9	5.00	SPT	-	-	-	-	0	39	41	20	39	21	18	-	-	-	CI	-	-	-	-	-	-	-	-	26	-	-	-
10	5.50	UDS	2.08	1.73	20.19	2.66	0	65	35	43	20	23	-	-	-	SC	0.10	27	-	-	DSU	-	-	-	-	-	0.54	34.9	
11	6.00	SPT	-	-	-	-	0	70	30	40	22	18	-	-	-	SC	-	-	-	-	-	-	-	-	-	30	-	-	-
12	6.50	UDS	2.02	1.64	23.31	2.65	0	64	36	44	20	24	-	-	-	SC	0.11	25	-	-	DSU	-	-	-	-	-	0.62	38.2	
13	7.00	SPT	-	-	-	-	0	29	41	30	46	20	26	-	-	-	CI	-	-	-	-	-	-	-	-	15	-	-	-
14	7.50	SPT	-	-	-	-	0	32	44	24	45	23	22	-	-	-	CI	-	-	-	-	-	-	-	-	12	-	-	-
15	8.00	SPT	-	-	-	-	0	64	36	40	24	16	-	-	-	SC	-	-	-	-	-	-	-	-	-	14	-	-	-
16	8.50	SPT	-	-	-	-	0	59	41	44	22	22	-	-	-	SC	-	-	-	-	-	-	-	-	-	24	-	-	-
17	9.00	SPT	-	-	-	-	0	67	33	39	23	16	-	-	-	SC	-	-	-	-	-	-	-	-	-	>100	-	-	-
18	9.50	SPT	-	-	-	-	0	66	34	40	21	19	-	-	-	SC	-	-	-	-	-	-	-	-	-	>100	-	-	-
19	10.00	SPT	-	-	-	-	0	71	29	37	24	13	-	-	-	SC	-	-	-	-	-	-	-	-	-	>100	-	-	-
20	11.00	UDS	2.29	2.04	12.01	2.71	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	80.9	-	UCS	-	-	-	-	-	17.50	0.33	24.6
21	11.00	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	-	>100	-	-	-
22	12.50	UDS	2.38	2.19	8.59	2.70	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	124.7	-	UCS	-	-	-	-	-	24.00	0.23	18.8
23	14.00	UDS	2.42	2.24	8.00	2.73	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	128.7	-	UCS	-	-	-	-	-	62.66	0.22	17.9
24	15.50	UDS	2.40	2.21	8.40	2.72	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	129.8	-	UCS	-	-	-	-	-	96.00	0.23	18.6

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 76

Co-Ordinate :- E - 1204, N 3137

Reduced Level :- 198.89 m

Sr No	Depth of Sample	Type of Sample	Field Bulk Density	Field Dry Density	Natural Moisture Content	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit	Swelling Pressure	Free Swell Index	Soil Classification	Shear Parameter		Unconfined Compression Test	UCS by Point Load Index in rock	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation	Void Ratio	Porosity	
							Gravel	Sand	Silt	Clay	Liquid Limit	Plastic Limit	Plasticity Index					Cohesion C	Angle of Internal Friction ϕ				Compression Index C _c	Coefficient of Volume Compressibility mv	Pre-consolidation Pressure					
																														%
1	0.00	DS	-	-	-	-	0	31	40	29	44	18	26	-	-	-	CI	-	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	0	28	39	33	47	17	30	-	-	-	CI	-	-	-	-	-	-	-	6	-	-	-	-	-
3	2.00	SPT	-	-	-	-	0	35	43	22	39	19	20	-	-	-	CI	-	-	-	-	-	-	-	6	-	-	-	-	-
4	2.50	UDS	1.93	1.50	28.62	2.63	5	25	49	21	40	22	18	-	-	-	CI	0.30	7	-	-	TUU	0.16	0.0362	0.43	-	-	0.75	42.9	-
5	3.00	SPT	-	-	-	-	0	21	54	25	44	21	23	-	-	-	CI	-	-	-	-	-	-	-	36	-	-	-	-	-
6	3.50	UDS	2.02	1.64	23.31	2.65	0	28	56	16	37	23	14	-	-	-	CI	1.96	6	-	-	TUU	0.10	0.0040	0.81	-	-	0.62	38.2	-
7	4.00	SPT	-	-	-	-	0	23	57	20	38	20	18	-	-	-	CI	-	-	-	-	-	-	-	35	-	-	-	-	-
8	4.50	UDS	2.03	1.67	21.86	2.62	0	21	58	21	41	22	19	-	-	-	CI	1.89	4	-	-	TUU	0.10	0.0052	1.46	-	-	0.57	36.4	-
9	5.00	SPT	-	-	-	-	0	10	75	15	36	23	13	-	-	-	CI	-	-	-	-	-	-	-	58	-	-	-	-	-
10	5.50	UDS	2.05	1.70	20.43	2.61	0	12	71	17	37	22	15	-	-	-	CI	3.16	2	-	-	TUU	-	-	-	-	-	0.53	34.8	-
11	6.00	SPT	-	-	-	-	0	6	74	20	39	21	18	-	-	-	CI	-	-	-	-	-	-	-	70	-	-	-	-	-
12	7.50	UDS	2.23	1.95	14.65	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	129.1	-	UCS	-	-	-	-	43.00	0.40	28.5	-
13	9.00	UDS	2.18	1.86	17.07	2.73	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	100.5	-	UCS	-	-	-	-	36.00	0.47	31.8	-
14	10.50	UDS	2.24	1.97	13.74	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	153.4	-	UCS	-	-	-	-	23.00	0.37	27.1	-
15	12.00	UDS	2.46	2.29	7.22	2.75	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	186.2	-	UCS	-	-	-	-	56.00	0.20	16.6	-
16	13.50	UDS	2.49	2.34	6.57	2.76	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	173.9	-	UCS	-	-	-	-	60.00	0.18	15.3	-
17	15.00	UDS	2.48	2.34	6.19	2.73	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	198.9	-	UCS	-	-	-	-	47.00	0.17	14.5	-
18	16.50	UDS	2.51	2.37	5.78	2.75	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	206.4	-	UCS	-	-	-	-	51.00	0.16	13.7	-
19	18.00	UDS	2.43	2.27	7.23	2.71	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	194.2	-	UCS	-	-	-	-	71.33	0.20	16.4	-
20	19.50	UDS	2.45	2.29	7.07	2.73	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	195.2	-	UCS	-	-	-	-	69.33	0.19	16.2	-
21	21.00	UDS	2.59	2.47	4.92	2.81	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	394.6	-	UCS	-	-	-	-	70.66	0.14	12.2	-
22	22.50	UDS	2.58	2.44	5.59	2.83	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	426.1	-	UCS	-	-	-	-	56.00	0.16	13.7	-
23	24.00	UDS	2.59	2.45	5.54	2.84	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	405.8	-	UCS	-	-	-	-	85.33	0.16	13.6	-

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 78

Co-Ordinate :- E - 1253, N - 3105

Reduced Level :- 199.07 m

Sr No	Depth of Sample m	Type of Sample	Field Bulk Density gm / cc	Field Dry Density gm / cc	Natural Moisture Content %	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit %	Swelling Pressure Kg/cm ²	Free Swell Index %	Soil Classification	Shear Parameter		Unconfined Compression Test Kg/cm ²	UCS by Point Load Index in rock Kg/cm ²	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation %	Void Ratio	Porosity %	
							Gravel %	Sand %	Silt %	Clay %	Liquid Limit %	Plastic Limit %	Plasticity Index %					Cohesion C Kg/cm ²	Angle of Internal Friction φ Degree				Compression Index C _c	Coefficient of Volume Compressibility m _v cm ² /kg	Pre-consolidation Pressure kg/cm ²					
1	0.00	DS	-	-	-	-	0	30	53	17	36	21	15	-	-	-	CI	-	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	0	34	39	27	43	18	25	-	-	-	CI	-	-	-	-	-	-	-	-	6	-	-	-	-
3	2.00	SPT	-	-	-	-	0	10	76	14	38	25	13	-	-	-	MI	-	-	-	-	-	-	-	-	22	-	-	-	-
4	2.50	UDS	1.99	1.60	24.29	2.62	0	22	65	13	37	26	11	-	-	-	MI	0.83	10	-	-	TUU	0.11	0.0053	0.46	-	-	0.64	38.9	-
5	3.00	SPT	-	-	-	-	0	2	82	16	40	26	14	-	-	-	MI	-	-	-	-	-	-	-	-	48	-	-	-	-
6	4.50	UDS	2.34	2.11	10.66	2.73	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	116.8	-	UCS	-	-	-	-	26.00	0.29	22.5	-
7	6.00	UDS	2.23	1.95	14.15	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	83.4	-	UCS	-	-	-	-	19.33	0.38	27.6	-
8	7.50	UDS	2.39	2.20	8.73	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	134.1	-	UCS	-	-	-	-	21.33	0.24	19.2	-
9	9.00	UDS	2.30	2.06	11.64	2.71	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	-	108.3	UCS	-	-	-	-	-	0.32	24.0	-
10	10.50	UDS	2.31	2.09	10.78	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	136.2	UCS	-	-	-	-	-	0.29	22.5	-
11	12.00	UDS	2.40	2.20	8.86	2.74	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	169.4	-	UCS	-	-	-	-	22.66	0.24	19.5	-
12	13.50	UDS	2.53	2.36	7.13	2.84	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	337.4	-	UCS	-	-	-	-	22.60	0.20	16.8	-
13	15.00	UDS	2.56	2.40	6.52	2.85	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	401.2	-	UCS	-	-	-	-	40.66	0.19	15.7	-
14	16.50	UDS	2.54	2.38	6.86	2.84	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	435.1	-	UCS	-	-	-	-	51.33	0.19	16.3	-
15	18.00	UDS	2.57	2.41	6.46	2.86	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	478.6	-	UCS	-	-	-	-	75.33	0.18	15.6	-

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 79

Co-Ordinate :- E - 1172, N - 3104

Reduced Level :- 198.70 m

Sr No	Depth of Sample	Type of Sample	Field Bulk Density	Field Dry Density	Natural Moisture Content	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit	Swelling Pressure	Free Swell Index	Soil Classification	Shear Parameter		Unconfined Compression Test	UCS by Point Load Index in rock	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation	Void Ratio	Porosity
							Gravel	Sand	Silt	Clay	Liquid Limit	Plastic Limit	Plasticity Index					Cohesion C	Angle of Internal Friction ϕ				Compression Index C _c	Coefficient of Volume Compressibility mv	Pre-consolidation Pressure				
1	0.00	DS	-	-	-	-	0	52	48	31	15	16	-	-	-	SC	-	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	0	66	34	22	12	10	-	-	-	SC	-	-	-	-	-	-	-	4	-	-	-	-	
3	2.00	SPT	-	-	-	-	0	42	37	21	36	17	19	-	-	-	CI	-	-	-	-	-	-	-	6	-	-	-	-
4	2.50	UDS	1.91	1.46	30.69	2.65	5	39	29	27	38	15	23	-	-	-	CI	0.30	5	-	-	TUU	0.18	0.0327	0.40	-	-	0.81	44.8
5	3.00	SPT	-	-	-	-	0	36	39	25	37	16	21	-	-	-	CI	-	-	-	-	-	-	-	7	-	-	-	-
6	3.50	UDS	1.93	1.49	29.51	2.66	0	42	34	24	36	16	20	-	-	-	CI	0.35	7	-	-	TUU	0.17	0.0260	0.49	-	-	0.78	44.0
7	4.00	SPT	-	-	-	-	1	41	36	22	37	18	19	-	-	-	CI	-	-	-	-	-	-	-	13	-	-	-	-
8	4.50	SPT	-	-	-	-	0	20	48	32	48	21	27	-	-	-	CI	-	-	-	-	-	-	-	10	-	-	-	-
9	5.00	SPT	-	-	-	-	0	32	41	27	44	20	24	-	-	-	CI	-	-	-	-	-	-	-	13	-	-	-	-
10	5.50	UDS	1.95	1.53	27.81	2.65	0	38	35	27	40	17	23	-	-	-	CI	0.67	6	-	-	TUU	0.15	0.0151	0.70	-	-	0.74	42.4
11	6.00	SPT	-	-	-	-	0	39	38	23	39	19	20	-	-	-	CI	-	-	-	-	-	-	-	15	-	-	-	-
12	6.50	UDS	1.94	1.51	28.80	2.66	0	48	29	23	36	15	21	-	-	-	CI	0.74	8	-	-	TUU	0.17	0.0123	0.79	-	-	0.77	43.4
13	7.00	SPT	-	-	-	-	0	49	29	22	36	17	19	-	-	-	CI	-	-	-	-	-	-	-	11	-	-	-	-
14	7.50	UDS	1.99	1.59	24.87	2.64	0	28	52	20	37	20	17	-	-	-	CI	0.57	4	-	-	TUU	0.11	0.0157	0.86	-	-	0.66	39.6
15	8.00	SPT	-	-	-	-	0	16	60	24	40	19	21	-	-	-	CI	-	-	-	-	-	-	-	30	-	-	-	-
16	9.00	SPT	-	-	-	-	0	7	73	20	44	27	17	-	-	-	MI	-	-	-	-	-	-	-	34	-	-	-	-
17	9.50	SPT	-	-	-	-	0	12	72	16	42	28	14	-	-	-	MI	-	-	-	-	-	-	-	71	-	-	-	-
18	11.00	UDS	2.29	2.05	11.53	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	107.8	UCS	-	-	-	-	-	0.31	23.7
19	12.50	UDS	2.35	2.14	9.60	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	159.9	-	UCS	-	-	-	-	17.33	0.26	20.6
20	14.00	UDS	2.51	2.38	5.56	2.74	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	146.3	-	UCS	-	-	-	-	40.66	0.15	13.2
21	15.50	UDS	2.46	2.30	6.77	2.73	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	197.2	-	UCS	-	-	-	-	20.00	0.18	15.6
22	17.00	UDS	2.64	2.53	4.29	2.84	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	422.6	-	UCS	-	-	-	-	79.33	0.12	10.9

KCT Consultancy Services LLP, Ahmedabad

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 82

Co-Ordinate :- E 1011, N 3100

Reduced Level :- 199.38

Sr No	Depth of Sample m	Type of Sample	Field Bulk Density gm / cc	Field Dry Density gm / cc	Natural Moisture Content %	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit %	Swelling Pressure Kg/cm ²	Free Swell Index %	Soil Classification	Shear Parameter		Unconfined Compression Test Kg/cm ²	UCS by Point Load Index in rock Kg/cm ²	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation %	Void Ratio	Porosity %
							Gravel %	Sand %	Silt %	Clay %	Liquid Limit %	Plastic Limit %	Plasticity Index %					Cohesion C Kg/cm ²	Angle of Internal Friction ϕ Degree				Coefficient of Volume Compressibility mv cm ² /kg	Pre-consolidation Pressure kg/cm ²					
1	0.00	DS	-	-	-	-	0	61	39	30	16	14	-	-	-	SC	-	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	0	28	29	43	58	20	38	-	-	-	CH	-	-	-	-	-	-	-	7	-	-	-	-
3	2.00	SPT	-	-	-	-	0	19	31	50	65	21	44	-	-	-	CH	-	-	-	-	-	-	-	8	-	-	-	-
4	2.50	SPT	-	-	-	-	0	25	29	46	64	24	40	-	-	-	CH	-	-	-	-	-	-	-	8	-	-	-	-
5	3.00	SPT	-	-	-	-	0	30	29	41	60	25	35	-	-	-	CH	-	-	-	-	-	-	-	15	-	-	-	-
6	3.50	UDS	1.96	1.55	26.83	2.64	0	29	55	16	40	26	14	-	-	-	CI	0.81	6	-	-	TUU	0.15	0.0098	0.63	-	-	0.71	41.5
7	4.00	SPT	-	-	-	-	0	19	54	27	43	18	25	-	-	-	CI	-	-	-	-	-	-	-	16	-	-	-	-
8	4.50	UDS	1.97	1.56	26.45	2.65	0	23	51	26	42	20	22	-	-	-	CI	0.84	5	-	-	TUU	0.14	0.0118	0.70	-	-	0.70	41.2
9	5.00	SPT	-	-	-	-	0	35	43	22	39	19	20	-	-	-	CI	-	-	-	-	-	-	-	16	-	-	-	-
10	5.50	UDS	1.99	1.59	25.44	2.66	0	37	36	27	47	23	24	-	-	-	CI	0.97	8	-	-	TUU	0.13	0.0103	0.90	-	-	0.68	40.4
11	6.00	SPT	-	-	-	-	0	66	34		29	21	8	-	-	-	SC	-	-	-	-	-	-	-	22	-	-	-	-
12	6.50	UDS	2.00	1.61	24.53	2.65	0	64	36		27	16	11	-	-	-	SC	0.03	27	-	-	DSU	-	-	-	-	-	0.65	39.4
13	7.00	SPT	-	-	-	-	0	24	36	40	60	23	37	-	-	-	CH	-	-	-	-	-	-	-	22	-	-	-	-
14	7.50	UDS	1.98	1.59	24.63	2.61	0	16	40	44	62	22	40	-	-	-	CH	1.32	4	-	-	TUU	0.11	0.0091	2.14	-	-	0.64	39.1
15	8.00	SPT	-	-	-	-	0	15	36	49	64	20	44	-	-	-	CH	-	-	-	-	-	-	-	28	-	-	-	-
16	8.50	UDS	1.97	1.57	25.58	2.62	0	17	40	43	61	24	37	-	-	-	CH	1.36	5	-	-	TUU	0.12	0.0082	3.36	-	-	0.67	40.1
17	9.00	SPT	-	-	-	-	0	21	31	48	64	23	41	-	-	-	CH	-	-	-	-	-	-	-	21	-	-	-	-
18	9.50	UDS	1.99	1.59	25.44	2.66	0	63	37		29	16	13	-	-	-	SC	0.06	26	-	-	DSU	-	-	-	-	-	0.68	40.4
19	10.00	SPT	-	-	-	-	0	65	35		26	15	11	-	-	-	SC	-	-	-	-	-	-	-	18	-	-	-	-
20	11.00	UDS	2.01	1.62	23.91	2.65	0	31	39	30	44	19	25	-	-	-	CI	1.38	5	-	-	TUU	0.10	0.0077	3.74	-	-	0.63	38.8
21	11.50	SPT	-	-	-	-	0	64	36		28	16	12	-	-	-	SC	-	-	-	-	-	-	-	37	-	-	-	-
22	12.50	SPT	-	-	-	-	7	79	14		NP	NP	NP	-	-	-	SM	-	-	-	-	-	-	-	39	-	-	-	-
23	13.50	SPT	-	-	-	-	9	78	13		NP	NP	NP	-	-	-	SM	-	-	-	-	-	-	-	20	-	-	-	-
24	14.00	SPT	-	-	-	-	6	63	31		27	16	11	-	-	-	SC	-	-	-	-	-	-	-	>100	-	-	-	-
25	14.50	SPT	-	-	-	-	4	60	36		29	15	14	-	-	-	SC	-	-	-	-	-	-	-	>100	-	-	-	-
26	15.50	SPT	-	-	-	-	5	57	38		30	17	13	-	-	-	SC	-	-	-	-	-	-	-	>100	-	-	-	-
27	16.00	SPT	-	-	-	-	4	59	37		28	16	12	-	-	-	SC	-	-	-	-	-	-	-	>100	-	-	-	-
28	17.00	SPT	-	-	-	-	6	62	32		26	15	11	-	-	-	SC	-	-	-	-	-	-	-	>100	-	-	-	-
29	18.50	UDS	2.21	1.93	14.75	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	43.6	-	UCS	-	-	-	-	8.33	0.40	28.4
30	20.00	UDS	2.28	2.03	12.40	2.71	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	72.5	-	UCS	-	-	-	-	66.66	0.34	25.1

UDS - Undisturbed Sample

DS - Disturbed Sample

SPT - Standard Penetration Tests

NP - Non Plastic

TUU - Triaxial Unconsolidated Undrained

TCU - Triaxial Consolidated Undrained

DSU - Direct Shear Test

UCS - Unconfined Compression Strength

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 84

Co-Ordinate :- E -1152, N 3073

Reduced Level :- 198.70 m

Sr No	Depth of Sample	Type of Sample	Field Bulk Density	Field Dry Density	Natural Moisture Content	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit	Swelling Pressure	Free Swell Index	Soil Classification	Shear Parameter		Unconfined Compression Test	UCS by Point Load Index in rock	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation	Void Ratio	Porosity
							Gravel	Sand	Silt	Clay	Liquid Limit	Plastic Limit	Plasticity Index					Cohesion C	Angle of Internal Friction ϕ				Compression Index C _c	Coefficient of Volume Compressibility m _v	Pre-consolidation Pressure				
1	0.00	DS	-	-	-	-	1	40	38	21	36	18	18	-	-	-	CI	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	1	31	49	19	35	19	16	-	-	-	CI	-	-	-	-	-	-	-	-	5	-	-	-
3	2.00	SPT	-	-	-	-	3	37	33	27	40	17	23	-	-	-	CI	-	-	-	-	-	-	-	-	7	-	-	-
4	2.50	UDS	1.93	1.49	29.51	2.66	0	42	34	24	39	18	21	-	-	-	CI	0.36	9	-	-	TUU	0.18	0.0265	0.41	-	-	0.78	44.0
5	3.00	SPT	-	-	-	-	0	41	40	19	37	20	17	-	-	-	CI	-	-	-	-	-	-	-	-	14	-	-	-
6	3.50	UDS	1.99	1.59	24.87	2.64	0	35	43	22	40	21	19	-	-	-	CI	0.74	6	-	-	TUU	0.11	0.0128	0.52	-	-	0.66	39.6
7	4.00	SPT	-	-	-	-	0	37	37	26	38	15	23	-	-	-	CI	-	-	-	-	-	-	-	-	17	-	-	-
8	4.50	UDS	2.00	1.60	24.81	2.66	0	46	31	23	37	17	20	-	-	-	CI	0.87	7	-	-	TUU	0.11	0.0109	0.61	-	-	0.66	39.8
9	5.00	SPT	-	-	-	-	0	49	33	18	35	18	17	-	-	-	CI	-	-	-	-	-	-	-	-	12	-	-	-
10	5.50	UDS	2.02	1.64	23.31	2.65	0	45	31	24	37	17	20	-	-	-	CI	0.59	6	-	-	TUU	0.10	0.0154	0.75	-	-	0.62	38.2
11	6.00	SPT	-	-	-	-	0	26	58	16	40	26	14	-	-	-	MI	-	-	-	-	-	-	-	-	23	-	-	-
12	6.50	UDS	2.04	1.69	20.42	2.59	0	25	63	12	35	25	10	-	-	-	MI	1.06	5	-	-	TUU	-	-	-	-	-	0.53	34.6
13	7.00	SPT	-	-	-	-	0	12	75	13	37	26	11	-	-	-	MI	-	-	-	-	-	-	-	-	>100	-	-	-
14	7.50	SPT	-	-	-	-	0	13	63	24	41	20	21	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-
15	8.00	SPT	-	-	-	-	0	17	64	19	40	23	17	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-
16	8.50	SPT	-	-	-	-	0	15	58	27	42	19	23	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-
17	9.00	SPT	-	-	-	-	0	14	58	28	43	18	25	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-
18	9.50	SPT	-	-	-	-	0	16	66	18	40	24	16	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-
19	10.00	SPT	-	-	-	-	0	21	56	23	39	19	20	-	-	-	CI	-	-	-	-	-	-	-	-	38	-	-	-
20	10.50	UDS	2.26	2.01	12.69	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	91.7	UCS	-	-	-	-	-	0.34	25.4
21	12.00	UDS	2.34	2.12	10.19	2.71	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	92.6	-	UCS	-	-	-	-	18.00	0.28	21.6
22	13.50	UDS	2.32	2.09	11.14	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	85.0	UCS	-	-	-	-	-	0.30	23.3
23	15.00	UDS	2.31	2.08	11.03	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	89.2	-	UCS	-	-	-	-	30.00	0.30	22.9
24	16.50	UDS	2.60	2.48	4.67	2.81	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	347.5	-	UCS	-	-	-	-	13.00	0.13	11.6
25	18.00	UDS	2.49	2.33	6.78	2.77	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	-	146.8	UCS	-	-	-	-	-	0.19	15.8

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 86

Co-Ordinate :- E - 1217, N 3081

Reduced Level :- 198.98 m

Sr No	Depth of Sample m	Type of Sample	Field Bulk Density gm / cc	Field Dry Density gm / cc	Natural Moisture Content %	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit %	Swelling Pressure Kg/cm ²	Free Swell Index %	Soil Classification	Shear Parameter		Unconfined Compression Test Kg/cm ²	UCS by Point Load Index in rock Kg/cm ²	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation %	Void Ratio	Porosity %
							Gravel %	Sand %	Silt %	Clay %	Liquid Limit %	Plastic Limit %	Plasticity Index %					Cohesion C Kg/cm ²	Angle of Internal Friction ϕ Degree				Compression Index C _c	Coefficient of Volume Compressibility m _v cm ² /kg	Pre-consolidation Pressure kg/cm ²				
1	0.00	DS	-	-	-	-	4	58	38	24	14	10	-	-	-	-	SC	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	0	17	57	26	44	21	23	-	-	-	CI	-	-	-	-	-	-	-	-	4	-	-	-
3	2.00	SPT	-	-	-	-	0	7	72	21	41	23	18	-	-	-	CI	-	-	-	-	-	-	-	-	40	-	-	-
4	2.50	SPT	-	-	-	-	0	18	71	11	35	25	10	-	-	-	MI	-	-	-	-	-	-	-	-	53	-	-	-
5	3.00	SPT	-	-	-	-	0	16	71	13	37	26	11	-	-	-	MI	-	-	-	-	-	-	-	-	64	-	-	-
6	3.50	SPT	-	-	-	-	0	13	73	14	38	25	13	-	-	-	MI	-	-	-	-	-	-	-	-	>100	-	-	-
7	4.00	SPT	-	-	-	-	0	11	77	12	36	25	11	-	-	-	MI	-	-	-	-	-	-	-	-	>100	-	-	-
8	5.50	UDS	2.28	2.03	12.15	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	42.9	UCS	-	-	-	-	-	0.33	24.7
9	7.00	UDS	2.31	2.09	10.78	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	54.1	UCS	-	-	-	-	-	0.29	22.5
10	8.50	UDS	2.32	2.09	10.90	2.71	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	39.1	-	UCS	-	-	-	-	6.66	0.30	22.8
11	10.00	UDS	2.34	2.13	9.95	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	49.6	-	UCS	-	-	-	-	14.00	0.27	21.2
12	12.00	UDS	2.36	2.15	9.97	2.73	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	100.6	-	UCS	-	-	-	-	35.00	0.27	21.4
13	13.50	UDS	2.38	2.17	9.52	2.74	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	113.1	-	UCS	-	-	-	-	32.00	0.26	20.7
14	15.00	UDS	2.37	2.16	9.63	2.73	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	94.9	-	UCS	-	-	-	-	62.00	0.26	20.8
15	16.00	UDS	2.43	2.24	8.36	2.76	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	246.6	-	UCS	-	-	-	-	40.00	0.23	18.8
16	17.50	UDS	2.34	2.12	10.43	2.72	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	156.4	-	UCS	-	-	-	-	83.33	0.28	22.1

KCT Consultancy Services LLP, Ahmedabad

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 87

Co-Ordinate :- E - 902, N - 3074

Reduced Level :- 197.73 m

Sr No	Depth of Sample m	Type of Sample	Field Bulk Density gm / cc	Field Dry Density gm / cc	Natural Moisture Content %	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit %	Swelling Pressure Kg/cm ²	Free Swell Index %	Soil Classification	Shear Parameter		Unconfined Compression Test Kg/cm ²	UCS by Point Load Index in rock Kg/cm ²	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation %	Void Ratio	Porosity %
							Gravel %	Sand %	Silt %	Clay %	Liquid Limit %	Plastic Limit %	Plasticity Index %					Cohesion C Kg/cm ²	Angle of Internal Friction ϕ Degree				Compression Index C _c	Coefficient of Volume Compressibility mv cm ² /kg	Pre-consolidation Pressure kg/cm ²				
1	0.00	DS	-	-	-	-	0	45	32	23	38	18	20	-	-	-	CI	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	0	47	33	20	36	19	17	-	-	-	CI	-	-	-	-	-	-	-	-	11	-	-	-
3	2.00	SPT	-	-	-	-	0	27	49	24	43	21	22	-	-	-	CI	-	-	-	-	-	-	-	-	16	-	-	-
4	2.50	UDS	1.98	1.57	25.80	2.65	0	33	45	22	41	22	19	-	-	-	CI	0.88	7	-	-	TUU	0.14	0.0114	0.49	-	-	0.68	40.6
5	3.00	SPT	-	-	-	-	2	44	36	18	36	19	17	-	-	-	CI	-	-	-	-	-	-	-	-	21	-	-	-
6	3.50	UDS	2.01	1.62	24.19	2.66	5	42	28	25	38	17	21	-	-	-	CI	1.15	8	-	-	TUU	0.11	0.0088	0.55	-	-	0.64	39.2
7	4.00	SPT	-	-	-	-	0	65	35	34	19	15	-	-	-	-	SC	-	-	-	-	-	-	-	-	19	-	-	-
8	4.50	UDS	2.00	1.60	24.81	2.66	4	63	33	36	17	19	-	-	-	-	SC	0.08	27	-	-	DSU	-	-	-	-	-	0.66	39.8
9	5.00	SPT	-	-	-	-	0	59	41	42	19	23	-	-	-	-	SC	-	-	-	-	-	-	-	-	17	-	-	-
10	5.50	SPT	-	-	-	-	2	72	26	36	17	19	-	-	-	-	SC	-	-	-	-	-	-	-	-	22	-	-	-
11	6.00	SPT	-	-	-	-	13	64	23	34	19	15	-	-	-	-	SC	-	-	-	-	-	-	-	-	17	-	-	-
12	6.50	SPT	-	-	-	-	2	66	32	38	16	22	-	-	-	-	SC	-	-	-	-	-	-	-	-	18	-	-	-
13	7.00	SPT	-	-	-	-	0	69	31	31	17	14	-	-	-	-	SC	-	-	-	-	-	-	-	-	15	-	-	-
14	7.50	UDS	1.99	1.58	25.73	2.67	0	75	25	30	20	10	-	-	-	-	SC	0.05	28	-	-	DSU	-	-	-	-	-	0.69	40.7
15	8.00	SPT	-	-	-	-	0	75	25	27	18	9	-	-	-	-	SC	-	-	-	-	-	-	-	-	16	-	-	-
16	8.50	UDS	2.02	1.63	23.87	2.67	0	80	20	21	17	4	-	-	-	-	SM	0.00	29	-	-	DSU	-	-	-	-	-	0.64	38.9
17	9.00	SPT	-	-	-	-	0	82	18	20	16	4	-	-	-	-	SM	-	-	-	-	-	-	-	-	29	-	-	-
18	9.50	SPT	-	-	-	-	9	54	37	29	15	14	-	-	-	-	SC	-	-	-	-	-	-	-	-	33	-	-	-
19	10.00	SPT	-	-	-	-	16	52	32	25	16	9	-	-	-	-	SC	-	-	-	-	-	-	-	-	36	-	-	-
20	11.00	SPT	-	-	-	-	10	58	32	26	15	11	-	-	-	-	SC	-	-	-	-	-	-	-	-	56	-	-	-
21	11.50	SPT	-	-	-	-	6	59	35	29	17	12	-	-	-	-	SC	-	-	-	-	-	-	-	-	>100	-	-	-
22	12.50	UDS	2.16	1.85	16.73	2.68	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	53.6	UCS	-	-	-	-	-	0.45	31.0
23	13.50	UDS	2.17	1.86	16.78	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	48.0	UCS	-	-	-	-	-	0.45	31.2
24	15.00	UDS	2.21	1.93	14.75	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	40.1	-	UCS	-	-	-	-	6.66	0.40	28.4
25	16.50	UDS	2.24	1.97	13.49	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	47.7	-	UCS	-	-	-	-	10.66	0.36	26.6
26	18.00	UDS	2.22	1.95	14.07	2.68	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	54.9	UCS	-	-	-	-	-	0.38	27.4
27	19.50	UDS	2.40	2.20	9.09	2.75	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	122.1	-	UCS	-	-	-	-	45.33	0.25	20.0
28	21.00	UDS	2.44	2.27	7.38	2.73	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	141.9	-	UCS	-	-	-	-	67.33	0.20	16.8

KCT Consultancy Services LLP, Ahmedabad

RESULTS OF LABORATORY TEST

Project :- Proposed structure in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 88

Co-Ordinate :- E 1266, N 3062

Sr No	Depth of Sample	Type of Sample	Field Bulk Density	Field Dry Density	Natural Moisture Content	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit	Swelling Pressure	Free Swell Index	Soil Classification	Shear Parameter		Unconfined Compression Test	UCS by Point Load Index in rock	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation	Void Ratio	Porosity
							Gravel	Sand	Silt	Clay	Liquid Limit	Plastic Limit	Plasticity Index					Cohesion C	Angle of Internal Friction ϕ				Coefficient of Volume Compressibility mv	Pre-consolidation Pressure					
																									cm ² /kg				
	m		gm / cc	gm / cc	%		%	%	%	%	%	%	%	Kg/cm ²	%		Kg/cm ²	Degree	Kg/cm ²	Kg/cm ²						%		%	
1	0.00	DS	-	-	-	-	0	28	60	12	24	13	11	-	-	-	CL	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	0	39	33	28	41	15	26	-	-	-	CI	-	-	-	-	-	-	-	5	-	-	-	
3	2.00	SPT	-	-	-	-	0	8	71	21	40	21	19	-	-	-	CI	-	-	-	-	-	-	-	10	-	-	-	
4	2.50	UDS	1.92	1.48	29.34	2.63	0	23	61	16	37	23	14	-	-	-	CI	0.52	5	-	-	TUU	0.17	0.0143	0.46	-	-	0.77	43.6
5	3.00	SPT	-	-	-	-	0	13	61	26	42	20	22	-	-	-	CI	-	-	-	-	-	-	-	26	-	-	-	-
6	3.50	UDS	2.13	1.81	17.90	2.67	-	-	-	-	-	-	-	-	-	-	mud rock	-	-	24.6	-	UCS	-	-	-	-	-	0.48	32.3
7	4.00	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	mud rock	-	-	-	-	-	-	-	>100	-	-	-	-
8	5.50	UDS	2.29	2.04	12.01	2.71	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	72.6	-	UCS	-	-	-	-	12.00	0.33	24.6
9	7.00	UDS	2.32	2.08	11.38	2.73	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	60.8	UCS	-	-	-	-	-	0.31	23.7
10	8.50	UDS	2.36	2.14	10.20	2.74	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	44.9	UCS	-	-	-	-	-	0.28	21.8
11	10.00	UDS	2.34	2.13	9.95	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	56.5	UCS	-	-	-	-	-	0.27	21.2
12	11.50	UDS	2.33	2.10	10.78	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	56.8	-	UCS	-	-	-	-	18.66	0.29	22.7
13	13.00	UDS	2.57	2.47	3.95	2.74	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	69.3	-	UCS	-	-	-	-	52.66	0.11	9.8
14	14.50	UDS	2.49	2.34	6.57	2.76	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	154.3	-	UCS	-	-	-	-	52.66	0.18	15.3
15	16.00	UDS	2.46	2.28	7.67	2.77	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	133.8	-	UCS	-	-	-	-	48.00	0.21	17.5
16	17.50	UDS	2.51	2.37	6.00	2.76	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	223.6	-	UCS	-	-	-	-	100.00	0.17	14.2

KCT Consultancy Services LLP, Ahmedabad

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 9\$

Co-Ordinate :- E, , (, N 303-

Reduced Level :- 197.5% m

Sr No	Depth of Sample m	Type of Sample	Field Bulk Density gm / cc	Field Dry Density gm / cc	Natural Moisture Content %	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit %	Swelling Pressure Kg/cm ²	Free Swell Index %	Soil Classification	Shear Parameter		Unconfined Compression Test Kg/cm ²	UCS by Point Load Index in rock Kg/cm ²	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation %	Void Ratio	Porosity %
							Gravel %	Sand %	Silt %	Clay %	Liquid Limit %	Plastic Limit %	Plasticity Index %					Cohesion C Kg/cm ²	Angle of Internal Friction ϕ Degree				Compression Index C _c	Coefficient of Volume Compressibility mv cm ² /kg	Pre-consolidation Pressure kg/cm ²				
1	0.00	DS	-	-	-	-	0	28	44	28	42	18	24	-	-	-	CI	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	0	20	41	39	57	22	35	13	-	59	CH	-	-	-	-	-	-	-	-	9	-	-	-
3	2.00	SPT	-	-	-	-	0	18	34	48	64	23	41	-	-	-	CH	-	-	-	-	-	-	-	-	22	-	-	-
4	2.50	UDS	1.96	1.55	26.24	2.62	0	16	39	45	63	25	38	9	0.44	71	CH	0.88	3	-	-	TUU	0.14	0.0136	0.43	-	-	0.69	40.7
5	3.00	SPT	-	-	-	-	0	33	24	43	61	23	38	-	-	-	CH	-	-	-	-	-	-	-	-	11	-	-	-
6	3.50	UDS	1.96	1.55	26.83	2.64	0	29	33	38	60	25	35	12	0.41	64	CH	0.78	7	-	-	TUU	0.15	0.0148	0.53	-	-	0.71	41.5
7	4.00	SPT	-	-	-	-	0	30	33	37	57	24	33	-	-	-	CH	-	-	-	-	-	-	-	-	20	-	-	-
8	4.50	UDS	2.00	1.61	24.53	2.65	0	34	27	39	56	22	34	14	0.40	58	CH	1.22	9	-	-	TUU	0.12	0.0089	0.65	-	-	0.65	39.4
9	5.00	SPT	-	-	-	-	0	67	33	44	24	20	-	-	-	-	SC	-	-	-	-	-	-	-	-	27	-	-	-
10	5.50	UDS	2.05	1.68	21.84	2.66	0	63	37	46	23	23	-	-	-	-	SC	0.07	27	-	-	DSU	-	-	-	-	-	0.58	36.7
11	6.00	SPT	-	-	-	-	0	70	30	43	25	18	-	-	-	-	SC	-	-	-	-	-	-	-	-	30	-	-	-
12	6.50	SPT	-	-	-	-	0	73	27	38	23	15	-	-	-	-	SC	-	-	-	-	-	-	-	-	30	-	-	-
13	7.00	SPT	-	-	-	-	0	65	35	41	22	19	-	-	-	-	SC	-	-	-	-	-	-	-	-	21	-	-	-
14	7.50	SPT	-	-	-	-	0	64	36	43	23	20	-	-	-	-	SC	-	-	-	-	-	-	-	-	>100	-	-	-
15	8.00	SPT	-	-	-	-	0	68	32	37	23	14	-	-	-	-	SC	-	-	-	-	-	-	-	-	>100	-	-	-
16	9.50	UDS	2.20	1.91	15.18	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	49.5	UCS	-	-	-	-	-	0.41	29.0
17	9.50	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-
18	11.00	UDS	2.23	1.95	14.15	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	46.0	UCS	-	-	-	-	-	0.38	27.6
19	11.00	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-
20	12.50	UDS	2.24	1.97	13.49	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	48.1	UCS	-	-	-	-	-	0.36	26.6
21	12.50	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-
22	14.00	UDS	2.31	2.07	11.74	2.73	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	51.3	UCS	-	-	-	-	-	0.32	24.3
23	15.50	UDS	2.29	2.05	11.77	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	51.9	UCS	-	-	-	-	-	0.32	24.1
24	17.00	UDS	2.21	1.91	15.50	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	45.3	UCS	-	-	-	-	-	0.42	29.7
25	18.50	UDS	2.41	2.22	8.54	2.74	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	125.3	-	UCS	-	-	-	-	6.66	0.23	19.0
26	20.00	UDS	2.42	2.24	8.00	2.73	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	110.0	UCS	-	-	-	-	-	0.22	17.9
27	20.00	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-
28	21.50	UDS	2.45	2.29	6.85	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	157.5	UCS	-	-	-	-	-	0.19	15.7
29	23.00	UDS	2.38	2.18	9.29	2.73	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	119.5	-	UCS	-	-	-	-	29.33	0.25	20.2
30	24.50	UDS	2.36	2.15	9.97	2.73	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	72.7	-	UCS	-	-	-	-	81.33	0.27	21.4

UDS - Undisturbed Sample
DS - Disturbed Sample
SPT - Standard Penetration Tests
NP - Non Plastic

TUU - Triaxial Unconsolidated Undrained
TCU - Triaxial Consolidated Undrained
DSU - Direct Shear Test
UCS - Unconfined Compression Strength

KCT Consultancy Services LLP, Ahmedabad

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 91

Co-Ordinate :- E - 978, N 3061

Reduced Level :- 198.53 m

Sr No	Depth of Sample	Type of Sample	Field Bulk Density	Field Dry Density	Natural Moisture Content	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit	Swelling Pressure	Free Swell Index	Soil Classification	Shear Parameter		Unconfined Compression Test	UCS by Point Load Index in rock	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation	Void Ratio	Porosity	
							Gravel	Sand	Silt	Clay	Liquid Limit	Plastic Limit	Plasticity Index					Cohesion C	Angle of Internal Friction ϕ				Compression Index C _c	Coefficient of Volume Compressibility mv	Pre-consolidation Pressure					
																														%
1	0.00	DS	-	-	-	-	0	65	35	24	14	10	-	-	-	-	SC	-	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	0	36	40	24	39	17	22	-	-	-	CI	-	-	-	-	-	-	-	4	-	-	-	-	-
3	2.00	SPT	-	-	-	-	0	40	41	19	36	19	17	-	-	-	CI	-	-	-	-	-	-	-	5	-	-	-	-	-
4	2.50	UDS	1.95	1.53	27.51	2.64	0	24	52	24	38	17	21	-	-	-	CI	0.44	5	-	-	TUU	0.16	0.0236	0.41	-	-	0.73	42.1	-
5	3.00	SPT	-	-	-	-	9	23	43	25	40	18	22	-	-	-	CI	-	-	-	-	-	-	-	11	-	-	-	-	-
6	3.50	UDS	1.97	1.56	26.45	2.65	0	33	49	18	36	19	17	-	-	-	CI	0.59	6	-	-	TUU	0.15	0.0159	0.52	-	-	0.70	41.2	-
7	4.00	SPT	-	-	-	-	0	36	42	22	37	17	20	-	-	-	CI	-	-	-	-	-	-	-	12	-	-	-	-	-
8	4.50	UDS	1.99	1.60	24.29	2.62	0	20	55	25	39	18	21	-	-	-	CI	0.82	2	-	-	TUU	0.13	0.0126	0.62	-	-	0.64	38.9	-
9	5.00	SPT	-	-	-	-	0	55	45	35	16	19	-	-	-	-	SC	-	-	-	-	-	-	-	20	-	-	-	-	-
10	5.50	UDS	2.02	1.63	23.59	2.66	0	59	41	34	17	17	-	-	-	-	SC	0.07	27	-	-	DSU	-	-	-	-	-	0.63	38.6	-
11	6.00	SPT	-	-	-	-	10	65	25	32	16	16	-	-	-	-	SC	-	-	-	-	-	-	-	17	-	-	-	-	-
12	7.00	SPT	-	-	-	-	0	46	40	14	30	18	12	-	-	-	CL	-	-	-	-	-	-	-	14	-	-	-	-	-
13	7.50	UDS	1.99	1.59	25.16	2.65	0	40	46	14	31	19	12	-	-	-	CL	0.80	7	-	-	TUU	0.13	0.0074	0.95	-	-	0.67	40.0	-
14	8.00	SPT	-	-	-	-	0	64	36		28	18	10	-	-	-	SC	-	-	-	-	-	-	-	18	-	-	-	-	-
15	8.50	UDS	2.02	1.63	23.59	2.66	0	62	38		29	17	12	-	-	-	SC	0.06	26	-	-	DSU	-	-	-	-	-	0.63	38.6	-
16	9.00	SPT	-	-	-	-	0	56	44		33	19	14	-	-	-	SC	-	-	-	-	-	-	-	19	-	-	-	-	-
17	9.50	UDS	2.04	1.66	22.69	2.67	0	66	34		29	16	13	-	-	-	SC	0.05	27	-	-	DSU	-	-	-	-	-	0.61	37.7	-
18	10.00	SPT	-	-	-	-	0	63	37		31	17	14	-	-	-	SC	-	-	-	-	-	-	-	18	-	-	-	-	-
19	11.00	SPT	-	-	-	-	0	69	31		27	18	9	-	-	-	SC	-	-	-	-	-	-	-	46	-	-	-	-	-
20	11.50	SPT	-	-	-	-	0	61	39		30	16	14	-	-	-	SC	-	-	-	-	-	-	-	40	-	-	-	-	-
21	12.50	SPT	-	-	-	-	35	42	23		26	17	9	-	-	-	SC	-	-	-	-	-	-	-	>100	-	-	-	-	-
22	13.00	SPT	-	-	-	-	0	68	32		29	15	14	-	-	-	SC	-	-	-	-	-	-	-	>100	-	-	-	-	-
23	14.00	SPT	-	-	-	-	0	8	56	36	52	21	31	-	-	-	CH	-	-	-	-	-	-	-	>100	-	-	-	-	-
24	14.50	SPT	-	-	-	-	28	6	26	40	54	20	34	-	-	-	CH	-	-	-	-	-	-	-	>100	-	-	-	-	-
25	15.50	SPT	-	-	-	-	2	11	53	34	53	23	30	-	-	-	CH	-	-	-	-	-	-	-	>100	-	-	-	-	-
26	16.00	UDS	2.29	2.05	11.53	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	76.2	UCS	-	-	-	-	-	0.31	23.7	-
27	17.50	UDS	2.38	2.19	8.59	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	98.2	-	UCS	-	-	-	-	28.66	0.23	18.8	-
28	19.00	UDS	2.44	2.27	7.60	2.74	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	133.7	-	UCS	-	-	-	-	93.33	0.21	17.2	-

KCT Consultancy Services LLP, Ahmedabad

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTP) at village Hirma, Talabira, Odisha

BH No. :- 92

Co-Ordinate :- E 13(, , N 30' (

Reduced Level :- 200.7 m

Sr No	Depth of Sample	Type of Sample	Field Bulk Density	Field Dry Density	Natural Moisture Content	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit	Swelling Pressure	Free Swell Index	Soil Classification	Shear Parameter		Unconfined Compression Test	UCS by Point Load Index in rock	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation	Void Ratio	Porosity	
							Gravel	Sand	Silt	Clay	Liquid Limit	Plastic Limit	Plasticity Index					Cohesion C	Angle of Internal Friction ϕ				Compression Index C _c	Coefficient of Volume Compressibility mv	Pre-consolidation Pressure					
																														%
1	0.00	DS	-	-	-	-	0	28	46	26	41	18	23	-	-	-	CI	-	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	0	15	47	38	56	22	34	13	-	59	CH	-	-	-	-	-	-	-	10	-	-	-	-	
3	2.00	SPT	-	-	-	-	0	71	29		43	24	19	-	-	-	SC	-	-	-	-	-	-	-	23	-	-	-	-	
4	2.50	UDS	1.99	1.59	25.16	2.65	0	9	56	35	55	23	32	13	0.39	56	CH	1.18	3	-	-	TUU	0.12	0.0095	0.43	-	-	0.67	40.0	-
5	3.00	SPT	-	-	-	-	0	20	48	32	52	25	27	-	-	-	CH	-	-	-	-	-	-	-	21	-	-	-	-	
6	3.50	UDS	2.00	1.60	24.81	2.66	0	16	62	22	41	21	20	18	0.15	37	CI	1.63	5	-	-	TUU	0.11	0.0062	0.54	-	-	0.66	39.8	-
7	4.00	SPT	-	-	-	-	0	22	58	20	38	20	18	-	-	-	CI	-	-	-	-	-	-	-	>100	-	-	-	-	
8	4.50	SPT	-	-	-	-	0	14	60	26	39	16	23	-	-	-	CI	-	-	-	-	-	-	-	>100	-	-	-	-	
9	5.00	SPT	-	-	-	-	0	11	64	25	42	20	22	-	-	-	CI	-	-	-	-	-	-	-	>100	-	-	-	-	
10	5.50	SPT	-	-	-	-	0	18	56	26	41	19	22	-	-	-	CI	-	-	-	-	-	-	-	>100	-	-	-	-	
11	6.00	SPT	-	-	-	-	0	12	59	29	44	18	26	-	-	-	CI	-	-	-	-	-	-	-	>100	-	-	-	-	
12	7.00	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	>100	-	-	-	-	
13	7.50	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	>100	-	-	-	-	
14	8.00	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	>100	-	-	-	-	
15	9.50	UDS	2.10	1.75	19.94	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	38.1	UCS	-	-	-	-	-	0.54	34.9	-
16	9.50	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	>100	-	-	-	-	
17	11.00	DS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	-	-	-	-	
18	11.00	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	>100	-	-	-	-	
19	12.50	UDS	2.58	2.48	4.13	2.76	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	341.6	UCS	-	-	-	-	-	0.11	10.2	-
20	12.50	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	>100	-	-	-	-	
21	14.00	UDS	2.53	2.39	5.66	2.77	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	290.9	UCS	-	-	-	-	-	0.16	13.6	-
22	15.50	UDS	2.51	2.37	6.00	2.76	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	320.5	UCS	-	-	-	-	-	0.17	14.2	-
23	17.00	UDS	2.28	2.02	12.88	2.73	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	91.6	-	UCS	-	-	-	-	60.66	0.35	26.0	-
24	18.50	UDS	2.41	2.23	8.08	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	132.4	-	UCS	-	-	-	-	97.33	0.22	18.0	-

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 93

Co-Ordinate :- E -1172, N 3048

Reduced Level :- 198.96 m

Sr No	Depth of Sample	Type of Sample	Field Bulk Density	Field Dry Density	Natural Moisture Content	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit	Swelling Pressure	Free Swell Index	Soil Classification	Shear Parameter		Unconfined Compression Test	UCS by Point Load Index in rock	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation	Void Ratio	Porosity	
							Gravel	Sand	Silt	Clay	Liquid Limit	Plastic Limit	Plasticity Index					Cohesion C	Angle of Internal Friction ϕ				Compression Index C _c	Coefficient of Volume Compressibility m _v	Pre-consolidation Pressure					
																														%
1	0.00	DS	-	-	-	-	0	35	47	18	33	17	16	-	-	-	CL	-	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	9	60	31		40	19	21	-	-	-	SC	-	-	-	-	-	-	-	-	9	-	-	-	-
3	2.00	SPT	-	-	-	-	0	19	68	13	36	25	11	-	-	-	MI	-	-	-	-	-	-	-	-	10	-	-	-	-
4	2.50	UDS	1.94	1.53	26.70	2.59	0	9	75	16	41	27	14	-	-	-	MI	0.53	2	-	-	TUU	0.14	0.0143	0.42	-	-	0.69	40.9	-
5	3.00	SPT	-	-	-	-	0	3	83	14	38	26	12	-	-	-	MI	-	-	-	-	-	-	-	-	34	-	-	-	-
6	3.50	UDS	2.00	1.62	23.37	2.61	1	15	71	13	37	26	11	-	-	-	MI	1.67	5	-	-	TUU	0.09	0.0035	0.54	-	-	0.61	37.9	-
7	4.00	SPT	-	-	-	-	0	19	69	12	35	24	11	-	-	-	MI	-	-	-	-	-	-	-	-	60	-	-	-	-
8	4.50	SPT	-	-	-	-	6	41	43	10	35	26	9	-	-	-	MI	-	-	-	-	-	-	-	-	67	-	-	-	-
9	6.00	UDS	2.16	1.84	17.24	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	34.1	-	UCS	-	-	-	-	26.00	0.47	31.8	-
10	7.50	UDS	2.11	1.77	19.16	2.68	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	29.9	-	UCS	-	-	-	-	15.33	0.51	33.9	-
11	9.00	UDS	2.17	1.85	17.03	2.71	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	36.6	-	UCS	-	-	-	-	21.33	0.46	31.6	-
12	10.50	UDS	2.29	2.03	12.73	2.74	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	97.2	-	UCS	-	-	-	-	63.33	0.35	25.9	-
13	12.00	UDS	2.26	2.00	12.93	2.70	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	79.8	-	UCS	-	-	-	-	54.00	0.35	25.9	-
14	13.50	UDS	2.45	2.28	7.52	2.75	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	160.3	-	UCS	-	-	-	-	54.66	0.21	17.1	-
15	15.00	UDS	2.53	2.40	5.45	2.76	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	184.1	-	UCS	-	-	-	-	57.33	0.15	13.1	-
16	16.50	UDS	2.52	2.39	5.28	2.74	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	203.8	-	UCS	-	-	-	-	61.33	0.14	12.6	-
17	18.00	UDS	2.59	2.50	3.66	2.75	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	230.7	-	UCS	-	-	-	-	84.00	0.10	9.1	-

KCT Consultancy Services LLP, Ahmedabad

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 94

Co-Ordinate :- E 110- , N 3047

Reduced Level :- 199.89m

Sr No	Depth of Sample m	Type of Sample	Field Bulk Density gm / cc	Field Dry Density gm / cc	Natural Moisture Content %	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit %	Swelling Pressure Kg/cm ²	Free Swell Index %	Soil Classification	Shear Parameter		Unconfined Compression Test Kg/cm ²	UCS by Point Load Index in rock Kg/cm ²	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation %	Void Ratio	Porosity %
							Gravel %	Sand %	Silt %	Clay %	Liquid Limit %	Plastic Limit %	Plasticity Index %					Cohesion C Kg/cm ²	Angle of Internal Friction ϕ Degree				Compression Index C _c	Coefficient of Volume Compressibility mv cm ² /kg	Pre-consolidation Pressure kg/cm ²				
1	0.00	DS	-	-	-	-	0	31	55	14	29	16	13	-	-	-	CL	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	0	63	37		26	15	11	-	-	-	SC	-	-	-	-	-	-	-	-	12	-	-	-
3	2.00	SPT	-	-	-	-	0	34	45	21	38	20	18	-	-	-	CI	-	-	-	-	-	-	-	-	10	-	-	-
4	2.50	UDS	1.92	1.48	29.64	2.64	0	27	49	24	41	21	20	18	-	36	CI	0.47	7	-	-	TUU	0.19	0.0206	0.41	-	-	0.78	43.9
5	3.00	SPT	-	-	-	-	0	16	50	34	54	23	31	-	-	-	CH	-	-	-	-	-	-	-	-	9	-	-	-
6	3.50	SPT	-	-	-	-	0	22	49	29	52	25	27	-	-	-	CH	-	-	-	-	-	-	-	-	11	-	-	-
7	4.00	SPT	-	-	-	-	0	9	56	35	56	24	32	-	-	-	CH	-	-	-	-	-	-	-	-	16	-	-	-
8	4.50	UDS	1.94	1.52	27.31	2.61	0	13	56	31	54	27	27	14	-	53	CH	0.69	3	-	-	TUU	0.15	0.0157	0.59	-	-	0.71	41.6
9	5.00	SPT	-	-	-	-	0	18	53	29	51	26	25	-	-	-	CH	-	-	-	-	-	-	-	-	11	-	-	-
10	5.50	UDS	1.93	1.51	27.71	2.60	0	10	56	34	53	24	29	14	-	55	CH	0.64	2	-	-	TUU	0.16	0.0174	0.70	-	-	0.72	41.9
11	6.00	SPT	-	-	-	-	0	19	53	28	52	27	25	-	-	-	CH	-	-	-	-	-	-	-	-	14	-	-	-
12	6.50	UDS	1.97	1.57	25.87	2.63	0	18	52	30	53	27	26	-	-	-	CH	0.78	4	-	-	TUU	0.14	0.0133	0.79	-	-	0.68	40.5
13	7.00	SPT	-	-	-	-	0	11	55	34	58	28	30	-	-	-	CH	-	-	-	-	-	-	-	-	16	-	-	-
14	7.50	UDS	1.98	1.59	24.63	2.61	0	10	52	38	59	26	33	-	-	-	CH	0.83	2	-	-	TUU	0.12	0.0130	0.88	-	-	0.64	39.1
15	8.00	SPT	-	-	-	-	0	23	51	26	42	19	23	-	-	-	CI	-	-	-	-	-	-	-	-	17	-	-	-
16	8.50	SPT	-	-	-	-	0	26	50	24	41	20	21	-	-	-	CI	-	-	-	-	-	-	-	-	19	-	-	-
17	9.00	SPT	-	-	-	-	0	69	31		24	15	9	-	-	-	SC	-	-	-	-	-	-	-	-	25	-	-	-
18	9.50	UDS	1.98	1.57	25.80	2.65	0	64	36		29	16	13	-	-	-	SC	0.10	26	-	-	DSU	-	-	-	-	-	0.68	40.6
19	10.00	SPT	-	-	-	-	0	63	37		30	15	15	-	-	-	SC	-	-	-	-	-	-	-	-	11	-	-	-
20	11.00	SPT	-	-	-	-	0	70	30		25	14	11	-	-	-	SC	-	-	-	-	-	-	-	-	19	-	-	-
21	11.50	SPT	-	-	-	-	0	69	31		26	16	10	-	-	-	SC	-	-	-	-	-	-	-	-	20	-	-	-
22	12.50	SPT	-	-	-	-	0	67	33		28	14	14	-	-	-	SC	-	-	-	-	-	-	-	-	20	-	-	-
23	13.00	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-
24	14.50	UDS	2.20	1.91	15.18	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	50.3	UCS	-	-	-	-	-	0.41	29.0
25	16.00	UDS	2.24	1.98	12.99	2.67	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	43.7	-	UCS	-	-	-	-	8.00	0.35	25.7
26	17.50	UDS	2.19	1.89	15.62	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	48.0	-	UCS	-	-	-	-	12.00	0.42	29.6
27	19.00	UDS	2.34	2.12	10.19	2.71	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	93.9	-	UCS	-	-	-	-	29.33	0.28	21.6
28	20.50	UDS	2.35	2.13	10.08	2.72	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	99.6	-	UCS	-	-	-	-	42.00	0.27	21.5
29	22.00	UDS	2.31	2.08	11.03	2.70	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	80.8	-	UCS	-	-	-	-	42.66	0.30	22.9
30	23.50	UDS	2.38	2.18	9.06	2.72	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	125.7	-	UCS	-	-	-	-	49.33	0.25	19.8
31	25.00	UDS	2.37	2.16	9.63	2.73	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	155.4	-	UCS	-	-	-	-	41.33	0.26	20.8

UDS - Undisturbed Sample
DS - Disturbed Sample
SPT - Standard Penetration Tests
NP - Non Plastic

TUU - Triaxial Unconsolidated Undrained
TCU - Triaxial Consolidated Undrained
DSU - Direct Shear Test
UCS - Unconfined Compression Strength

KCT Consultancy Services LLP, Ahmedabad

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 98

Co-Ordinate :- E 912, N 3024

Reduced Level :- 197.45 m

Sr No	Depth of Sample	Type of Sample	Field Bulk Density	Field Dry Density	Natural Moisture Content	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit	Swelling Pressure	Free Swell Index	Soil Classification	Shear Parameter		Unconfined Compression Test	UCS by Point Load Index in rock	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation	Void Ratio	Porosity		
							Gravel	Sand	Silt	Clay	Liquid Limit	Plastic Limit	Plasticity Index					Cohesion C	Angle of Internal Friction ϕ				Compression Index C _c	Coefficient of Volume Compressibility mv	Pre-consolidation Pressure						
																														%	%
1	0.00	DS	-	-	-	-	0	34	42	24	39	19	20	-	-	-	CI	-	-	-	-	-	-	-	-	-	-	-	-	-	
2	1.00	SPT	-	-	-	-	0	26	42	32	56	27	29	-	-	-	CH	-	-	-	-	-	-	-	-	7	-	-	-	-	
3	2.00	SPT	-	-	-	-	0	31	37	32	52	25	27	-	-	-	CH	-	-	-	-	-	-	-	-	8	-	-	-	-	
4	2.50	UDS	1.91	1.46	30.69	2.65	0	36	29	35	54	24	30	13	0.33	57	CH	0.47	7	-	-	TUU	0.17	0.0227	0.42	-	-	0.81	44.8	-	
5	3.00	SPT	-	-	-	-	0	37	43	20	42	25	17	-	-	-	CI	-	-	-	-	-	-	-	-	10	-	-	-	-	
6	3.50	UDS	1.92	1.48	29.64	2.64	0	28	49	23	45	24	21	20	0.15	39	CI	0.48	5	-	-	TUU	0.16	0.0206	0.50	-	-	0.78	43.9	-	
7	4.00	SPT	-	-	-	-	0	34	40	26	44	21	23	-	-	-	CI	-	-	-	-	-	-	-	-	9	-	-	-	-	
8	4.50	UDS	1.94	1.51	28.80	2.66	0	66	34	41	22	19	-	-	-	-	SC	0.10	25	-	-	DSU	-	-	-	-	-	0.77	43.4	-	
9	5.00	SPT	-	-	-	-	0	65	35	43	21	22	-	-	-	-	SC	-	-	-	-	-	-	-	-	16	-	-	-	-	
10	5.50	UDS	1.96	1.54	27.12	2.65	0	63	37	45	22	23	-	-	-	-	SC	0.12	26	-	-	DSU	-	-	-	-	-	0.72	41.8	-	
11	6.00	SPT	-	-	-	-	0	67	33	40	22	18	-	-	-	-	SC	-	-	-	-	-	-	-	-	11	-	-	-	-	
12	6.50	SPT	-	-	-	-	0	68	32	39	24	15	-	-	-	-	SC	-	-	-	-	-	-	-	-	13	-	-	-	-	
13	7.00	SPT	-	-	-	-	0	66	34	43	23	20	-	-	-	-	SC	-	-	-	-	-	-	-	-	14	-	-	-	-	
14	7.50	SPT	-	-	-	-	0	65	35	47	21	26	-	-	-	-	SC	-	-	-	-	-	-	-	-	15	-	-	-	-	
15	8.00	SPT	-	-	-	-	8	69	23	22	17	5	-	-	-	-	SM	-	-	-	-	-	-	-	-	14	-	-	-	-	
16	8.50	SPT	-	-	-	-	12	70	18	NP	NP	NP	-	-	-	-	SM	-	-	-	-	-	-	-	-	12	-	-	-	-	
17	9.00	SPT	-	-	-	-	9	68	23	23	19	4	-	-	-	-	SM	-	-	-	-	-	-	-	-	14	-	-	-	-	
18	9.50	SPT	-	-	-	-	10	69	21	20	16	4	-	-	-	-	SM	-	-	-	-	-	-	-	-	24	-	-	-	-	
19	10.00	SPT	-	-	-	-	8	65	27	25	20	5	-	-	-	-	SM	-	-	-	-	-	-	-	-	27	-	-	-	-	
20	11.00	SPT	-	-	-	-	14	46	40	29	24	5	-	-	-	-	SC	-	-	-	-	-	-	-	-	75	-	-	-	-	
21	11.50	SPT	-	-	-	-	4	64	32	27	23	4	-	-	-	-	SC	-	-	-	-	-	-	-	-	>100	-	-	-	-	
22	12.50	SPT	-	-	-	-	18	76	6	NP	NP	NP	-	-	-	-	SP-SM	-	-	-	-	-	-	-	-	>100	-	-	-	-	
23	13.00	SPT	-	-	-	-	18	74	8	NP	NP	NP	-	-	-	-	SP-SM	-	-	-	-	-	-	-	-	>100	-	-	-	-	
24	14.00	SPT	-	-	-	-	16	75	9	NP	NP	NP	-	-	-	-	SP-SM	-	-	-	-	-	-	-	-	>100	-	-	-	-	
25	14.50	SPT	-	-	-	-	17	77	6	NP	NP	NP	-	-	-	-	SP-SM	-	-	-	-	-	-	-	-	>100	-	-	-	-	
26	16.00	UDS	2.20	1.91	15.18	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	44.6	-	UCS	-	-	-	-	-	7.14	0.41	29.0	-
27	17.50	UDS	2.19	1.89	15.87	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	51.4	UCS	-	-	-	-	-	-	0.43	30.0	-
28	19.00	UDS	2.17	1.86	16.52	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	49.6	UCS	-	-	-	-	-	-	0.44	30.8	-
29	20.50	UDS	2.26	2.00	13.18	2.71	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	60.7	-	UCS	-	-	-	-	-	6.66	0.36	26.3	-
30	22.00	UDS	2.34	2.11	10.89	2.74	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	99.3	-	UCS	-	-	-	-	-	33.33	0.30	23.0	-

UDS - Undisturbed Sample
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TUU - Triaxial Unconsolidated Undrained
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RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 100

Co-Ordinate :- E - 1240, N - 3017

Reduced Level :- 199.00 m

Sr No	Depth of Sample m	Type of Sample	Field Bulk Density gm / cc	Field Dry Density gm / cc	Natural Moisture Content %	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit %	Swelling Pressure Kg/cm ²	Free Swell Index %	Soil Classification	Shear Parameter		Unconfined Compression Test Kg/cm ²	UCS by Point Load Index in rock Kg/cm ²	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation %	Void Ratio	Porosity %
							Gravel %	Sand %	Silt %	Clay %	Liquid Limit %	Plastic Limit %	Plasticity Index %					Cohesion C Kg/cm ²	Angle of Internal Friction ϕ Degree				Compression Index C _c	Coefficient of Volume Compressibility mv cm ² /kg	Pre-consolidation Pressure kg/cm ²				
1	0.00	DS	-	-	-	-	0	20	71	9	23	15	8	-	-	-	CL	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	0	32	55	13	36	25	11	-	-	-	MI	-	-	-	-	-	-	-	-	11	-	-	-
3	2.00	SPT	-	-	-	-	0	8	77	15	39	26	13	-	-	-	MI	-	-	-	-	-	-	-	-	19	-	-	-
4	2.50	UDS	1.96	1.56	25.94	2.61	0	20	69	11	37	27	10	-	-	-	MI	0.99	4	-	-	TUU	0.12	0.0062	0.45	-	-	0.68	40.4
5	3.00	SPT	-	-	-	-	0	8	75	17	40	25	15	-	-	-	MI	-	-	-	-	-	-	-	-	60	-	-	-
6	3.50	UDS	2.04	1.69	20.71	2.60	1	13	74	12	41	31	10	-	-	-	MI	2.26	2	-	-	TUU	-	-	-	-	-	0.54	35.0
7	5.00	UDS	2.29	2.04	12.49	2.73	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	91.3	UCS	-	-	-	-	-	0.34	25.4
8	6.50	UDS	2.30	2.06	11.64	2.71	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	137.9	UCS	-	-	-	-	-	0.32	24.0
9	8.00	UDS	2.33	2.10	11.02	2.73	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	158.5	UCS	-	-	-	-	-	0.30	23.1
10	9.50	UDS	2.36	2.15	9.97	2.73	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	226.3	-	UCS	-	-	-	-	59.33	0.27	21.4
11	11.00	UDS	2.44	2.26	7.83	2.75	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	198.9	-	UCS	-	-	-	-	26.66	0.22	17.7
12	12.50	UDS	2.31	2.08	11.03	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	134.6	-	UCS	-	-	-	-	24.00	0.30	22.9
13	14.00	UDS	2.45	2.28	7.52	2.75	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	246.3	-	UCS	-	-	-	-	54.66	0.21	17.1

KCT Consultancy Services LLP, Ahmedabad

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 101

Co-Ordinate :- E 1047, N 3016

Reduced Level :- 199.53 m

Sr No	Depth of Sample m	Type of Sample	Field Bulk Density gm / cc	Field Dry Density gm / cc	Natural Moisture Content %	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit %	Swelling Pressure Kg/cm ²	Free Swell Index %	Soil Classification	Shear Parameter		Unconfined Compression Test Kg/cm ²	UCS by Point Load Index in rock Kg/cm ²	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation %	Void Ratio	Porosity %
							Gravel %	Sand %	Silt %	Clay %	Liquid Limit %	Plastic Limit %	Plasticity Index %					Cohesion C Kg/cm ²	Angle of Internal Friction ϕ Degree				Compression Index C _c	Coefficient of Volume Compressibility mv cm ² /kg	Pre-consolidation Pressure kg/cm ²				
1	0.00	DS	-	-	-	-	0	34	50	16	29	15	14	-	-	-	CL	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	0	15	38	47	66	26	40	-	-	-	CH	-	-	-	-	-	-	-	-	6	-	-	-
3	2.00	SPT	-	-	-	-	0	14	37	49	70	27	43	-	-	-	CH	-	-	-	-	-	-	-	-	7	-	-	-
4	2.50	UDS	1.92	1.48	29.34	2.63	0	10	46	44	62	25	37	-	-	-	CH	0.38	2	-	-	TUU	0.18	0.0311	0.42	-	-	0.77	43.6
5	3.00	SPT	-	-	-	-	0	19	46	35	58	26	32	-	-	-	CH	-	-	-	-	-	-	-	-	8	-	-	-
6	3.50	UDS	1.95	1.52	28.10	2.66	0	27	49	24	40	19	21	-	-	-	CI	0.48	5	-	-	TUU	0.16	0.0206	0.49	-	-	0.75	42.8
7	4.00	SPT	-	-	-	-	0	29	50	21	39	20	19	-	-	-	CI	-	-	-	-	-	-	-	-	12	-	-	-
8	4.50	UDS	1.97	1.56	26.45	2.65	0	32	40	28	46	22	24	-	-	-	CI	0.75	6	-	-	TUU	0.14	0.0143	0.61	-	-	0.70	41.2
9	5.00	SPT	-	-	-	-	0	34	41	25	43	21	22	-	-	-	CI	-	-	-	-	-	-	-	-	15	-	-	-
10	5.50	UDS	1.99	1.59	25.44	2.66	0	61	39		34	19	15	-	-	-	SC	0.07	25	-	-	DSU	-	-	-	-	-	0.68	40.4
11	6.00	SPT	-	-	-	-	0	67	33		31	17	14	-	-	-	SC	-	-	-	-	-	-	-	-	16	-	-	-
12	6.50	SPT	-	-	-	-	0	28	44	28	44	20	24	-	-	-	CI	-	-	-	-	-	-	-	-	40	-	-	-
13	7.00	SPT	-	-	-	-	0	64	36		28	16	12	-	-	-	SC	-	-	-	-	-	-	-	-	50	-	-	-
14	7.50	UDS	2.12	1.79	18.13	2.66	0	61	39		29	15	14	-	-	-	SC	0.10	28	-	-	DSU	-	-	-	-	-	0.48	32.5
15	8.00	SPT	-	-	-	-	0	68	32		27	15	12	-	-	-	SC	-	-	-	-	-	-	-	-	>100	-	-	-
16	8.50	SPT	-	-	-	-	0	71	29		26	14	12	-	-	-	SC	-	-	-	-	-	-	-	-	>100	-	-	-
17	9.00	SPT	-	-	-	-	0	79	21		24	17	7	-	-	-	SM-SC	-	-	-	-	-	-	-	-	>100	-	-	-
18	9.95	SPT	-	-	-	-	0	82	18		22	16	6	-	-	-	SM-SC	-	-	-	-	-	-	-	-	>100	-	-	-
19	10.00	SPT	-	-	-	-	0	80	20		23	17	6	-	-	-	SM-SC	-	-	-	-	-	-	-	-	>100	-	-	-
20	11.00	SPT	-	-	-	-	0	76	24		26	19	7	-	-	-	SM-SC	-	-	-	-	-	-	-	-	>100	-	-	-
21	11.50	UDS	2.29	2.04	12.01	2.71	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	91.3	UCS	-	-	-	-	-	0.33	24.6
22	11.50	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-
23	12.50	UDS	2.34	2.12	10.43	2.72	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	86.4	-	UCS	-	-	-	-	58.00	0.28	22.1
24	14.00	UDS	2.20	1.91	15.43	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	39.8	-	UCS	-	-	-	-	57.33	0.42	29.4
25	15.50	UDS	2.19	1.90	15.36	2.68	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	38.1	-	UCS	-	-	-	-	22.66	0.41	29.2
26	17.00	UDS	2.32	2.09	11.14	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	83.5	-	UCS	-	-	-	-	6.66	0.30	23.3
27	18.50	UDS	2.28	2.02	12.88	2.73	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	97.6	-	UCS	-	-	-	-	19.33	0.35	26.0
28	20.00	UDS	2.31	2.07	11.51	2.72	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	99.1	-	UCS	-	-	-	-	52.00	0.31	23.8
29	21.50	UDS	2.21	1.92	15.00	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	44.5	-	UCS	-	-	-	-	35.33	0.40	28.8
30	23.00	UDS	2.19	1.89	15.62	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	56.8	-	UCS	-	-	-	-	7.33	0.42	29.6
31	24.50	UDS	2.38	2.18	9.29	2.73	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	148.7	-	UCS	-	-	-	-	16.00	0.25	20.2
32	25.00	UDS	2.41	2.22	8.54	2.74	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	130.4	-	UCS	-	-	-	-	24.00	0.23	19.0

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RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 103

Co-Ordinate :- E 856, N 2994

Reduced Level :- 197.10

Sr No	Depth of Sample m	Type of Sample	Field Bulk Density gm / cc	Field Dry Density gm / cc	Natural Moisture Content %	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit %	Swelling Pressure Kg/cm ²	Free Swell Index %	Soil Classification	Shear Parameter		Unconfined Compression Test Kg/cm ²	UCS by Point Load Index in rock Kg/cm ²	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation %	Void Ratio	Porosity %
							Gravel %	Sand %	Silt %	Clay %	Liquid Limit %	Plastic Limit %	Plasticity Index %					Cohesion C Kg/cm ²	Angle of Internal Friction ϕ Degree				Compression Index C _c	Coefficient of Volume Compressibility mv cm ² /kg	Pre-consolidation Pressure kg/cm ²				
1	0.00	DS	-	-	-	-	0	26	38	36	59	28	31	13	-	59	CH	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	0	32	22	46	65	25	40	-	-	-	CH	-	-	-	-	-	-	-	-	2	-	-	-
3	2.00	SPT	-	-	-	-	0	33	22	45	64	26	38	9	-	72	CH	-	-	-	-	-	-	-	-	5	-	-	-
4	2.50	SPT	-	-	-	-	0	19	63	18	38	22	16	-	-	-	CI	-	-	-	-	-	-	-	-	5	-	-	-
5	3.00	SPT	-	-	-	-	0	17	62	21	42	24	18	-	-	-	CI	-	-	-	-	-	-	-	-	7	-	-	-
6	3.50	UDS	1.91	1.47	29.78	2.62	0	16	53	31	49	22	27	15	0.32	48	CI	0.39	2	-	-	TUU	0.17	0.0286	0.59	-	-	0.78	43.8
7	4.00	SPT	-	-	-	-	0	22	51	27	46	23	23	-	-	-	CI	-	-	-	-	-	-	-	-	7	-	-	-
8	4.50	UDS	1.95	1.52	28.10	2.66	0	62	38	45	22	23	-	-	-	-	SC	0.09	25	-	-	DSU	-	-	-	-	-	0.75	42.8
9	5.00	SPT	-	-	-	-	0	67	33	41	24	17	-	-	-	-	SC	-	-	-	-	-	-	-	-	14	-	-	-
10	5.50	UDS	1.97	1.56	26.16	2.64	0	64	36	42	21	21	-	-	-	-	SC	0.07	26	-	-	DSU	-	-	-	-	-	0.69	40.9
11	6.00	SPT	-	-	-	-	0	61	39	46	22	24	-	-	-	-	SC	-	-	-	-	-	-	-	-	18	-	-	-
12	6.50	SPT	-	-	-	-	0	68	32	39	21	18	-	-	-	-	SC	-	-	-	-	-	-	-	-	21	-	-	-
13	7.00	SPT	-	-	-	-	5	79	16	NP	NP	NP	-	-	-	-	SM	-	-	-	-	-	-	-	-	24	-	-	-
14	8.00	SPT	-	-	-	-	4	78	18	19	15	4	-	-	-	-	SM	-	-	-	-	-	-	-	-	28	-	-	-
15	8.50	SPT	-	-	-	-	0	23	54	23	41	20	21	-	-	-	CI	-	-	-	-	-	-	-	-	49	-	-	-
16	9.00	SPT	-	-	-	-	0	19	55	26	45	22	23	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-
17	9.50	SPT	-	-	-	-	0	18	55	27	46	21	25	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-
18	10.00	SPT	-	-	-	-	0	69	31	29	16	13	-	-	-	-	SC	-	-	-	-	-	-	-	-	>100	-	-	-
19	11.00	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-
20	12.00	UDS	2.18	1.88	16.07	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	53.8	UCS	-	-	-	-	-	0.43	30.2
21	12.00	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-
22	13.50	UDS	2.16	1.85	16.99	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	42.8	UCS	-	-	-	-	-	0.46	31.4
23	15.00	UDS	2.29	2.05	11.77	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	54.6	-	UCS	-	-	-	-	24.00	0.32	24.1
24	16.50	UDS	2.24	1.97	13.74	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	49.4	-	UCS	-	-	-	-	12.00	0.37	27.1
25	18.00	UDS	2.36	2.16	9.50	2.71	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	99.8	-	UCS	-	-	-	-	30.00	0.26	20.5

UDS - Undisturbed Sample
DS - Disturbed Sample
SPT - Standard Penetration Tests
NP - Non Plastic

TUU - Triaxial Unconsolidated Undrained
TCU - Triaxial Consolidated Undrained
DSU - Direct Shear Test
UCS - Unconfined Compression Strength

KCT Consultancy Services LLP, Ahmedabad

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 104

Co-Ordinate :- E 1082, N 2970

Reduced Level :- 200 m

Sr No	Depth of Sample m	Type of Sample	Field Bulk Density gm / cc	Field Dry Density gm / cc	Natural Moisture Content %	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit %	Swelling Pressure Kg/cm ²	Free Swell Index %	Soil Classification	Shear Parameter		Unconfined Compression Test Kg/cm ²	UCS by Point Load Index in rock Kg/cm ²	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation %	Void Ratio	Porosity %
							Gravel %	Sand %	Silt %	Clay %	Liquid Limit %	Plastic Limit %	Plasticity Index %					Cohesion C Kg/cm ²	Angle of Internal Friction ϕ Degree				Compression Index C _c	Coefficient of Volume Compressibility mv cm ² /kg	Pre-consolidation Pressure kg/cm ²				
1	0.00	DS	-	-	-	-	0	19	59	22	38	18	20	-	-	-	CI	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	0	9	47	44	71	31	40	8	-	82	CH	-	-	-	-	-	-	-	-	5	-	-	-
3	2.00	SPT	-	-	-	-	0	12	44	44	68	29	39	-	-	-	CH	-	-	-	-	-	-	-	-	7	-	-	-
4	2.50	SPT	-	-	-	-	0	21	46	33	60	30	30	12	-	59	CH	-	-	-	-	-	-	-	-	12	-	-	-
5	3.00	SPT	-	-	-	-	0	69	31	27	16	11	-	-	-	-	SC	-	-	-	-	-	-	-	-	39	-	-	-
6	3.50	UDS	2.07	1.72	20.18	2.64	0	63	37	29	15	14	-	-	-	-	SC	0.09	30	-	-	DSU	-	-	-	-	-	0.53	34.8
7	4.00	SPT	-	-	-	-	0	71	29	23	14	9	-	-	-	-	SC	-	-	-	-	-	-	-	-	>100	-	-	-
8	4.50	SPT	-	-	-	-	0	68	32	26	16	10	-	-	-	-	SC	-	-	-	-	-	-	-	-	>100	-	-	-
9	5.00	SPT	-	-	-	-	0	67	33	28	15	13	-	-	-	-	SC	-	-	-	-	-	-	-	-	>100	-	-	-
10	5.50	SPT	-	-	-	-	0	71	29	25	14	11	-	-	-	-	SC	-	-	-	-	-	-	-	-	>100	-	-	-
11	6.00	SPT	-	-	-	-	0	74	26	29	17	12	-	-	-	-	SC	-	-	-	-	-	-	-	-	>100	-	-	-
12	6.50	SPT	-	-	-	-	0	69	31	32	16	16	-	-	-	-	SC	-	-	-	-	-	-	-	-	>100	-	-	-
13	7.00	SPT	-	-	-	-	0	64	36	35	18	17	-	-	-	-	SC	-	-	-	-	-	-	-	-	>100	-	-	-
14	7.50	SPT	-	-	-	-	0	63	37	30	16	14	-	-	-	-	SC	-	-	-	-	-	-	-	-	>100	-	-	-
15	8.00	SPT	-	-	-	-	0	69	31	27	15	12	-	-	-	-	SC	-	-	-	-	-	-	-	-	>100	-	-	-
16	8.50	SPT	-	-	-	-	0	65	35	30	14	16	-	-	-	-	SC	-	-	-	-	-	-	-	-	>100	-	-	-
17	9.00	SPT	-	-	-	-	0	73	27	25	16	9	-	-	-	-	SC	-	-	-	-	-	-	-	-	>100	-	-	-
18	9.50	SPT	-	-	-	-	0	72	28	26	15	11	-	-	-	-	SC	-	-	-	-	-	-	-	-	>100	-	-	-
19	10.00	SPT	-	-	-	-	0	64	36	38	18	20	-	-	-	-	SC	-	-	-	-	-	-	-	-	>100	-	-	-
20	11.00	SPT	-	-	-	-	0	68	32	30	16	14	-	-	-	-	SC	-	-	-	-	-	-	-	-	>100	-	-	-
21	11.50	SPT	-	-	-	-	0	70	30	28	19	9	-	-	-	-	SC	-	-	-	-	-	-	-	-	>100	-	-	-
22	12.50	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Cemented Sand	-	-	-	-	-	-	-	-	>100	-	-	-
23	14.00	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	>100	-	-	-
24	15.50	UDS	2.12	1.78	18.92	2.69	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	0.51	33.7
25	15.50	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-	-	>100	-	-	-
26	17.00	SPT	-	-	-	-	10	59	31	24	14	10	-	-	-	-	SC	-	-	-	-	-	-	-	-	>100	-	-	-
27	18.00	SPT	-	-	-	-	14	63	23	22	13	9	-	-	-	-	SC	-	-	-	-	-	-	-	-	>100	-	-	-
28	19.50	UDS	2.27	2.01	12.78	2.71	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	41.7	UCS	-	-	-	-	-	0.35	25.7
29	19.50	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-
30	21.00	UDS	2.37	2.16	9.63	2.73	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	115.9	-	UCS	-	-	-	-	7.33	0.26	20.8
31	22.50	UDS	2.42	2.23	8.45	2.75	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	136.8	-	UCS	-	-	-	-	10.66	0.23	18.9
32	24.50	UDS	2.41	2.23	7.85	2.71	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	154.2	-	UCS	-	-	-	-	18.66	0.21	17.5
33	25.00	UDS	2.44	2.27	7.38	2.73	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	159.7	-	UCS	-	-	-	-	57.00	0.20	16.8

UDS - Undisturbed Sample
DS - Disturbed Sample
SPT - Standard Penetration Tests
NP - Non Plastic

TUU - Triaxial Unconsolidated Undrained
TCU - Triaxial Consolidated Undrained
DSU - Direct Shear Test
UCS - Unconfined Compression Strength

KCT Consultancy Services LLP, Ahmedabad

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 105

Co-Ordinate :- E 916, N 298*

Reduced Level :- 197.67

Sr No	Depth of Sample m	Type of Sample	Field Bulk Density gm / cc	Field Dry Density gm / cc	Natural Moisture Content %	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit %	Swelling Pressure Kg/cm ²	Free Swell Index %	Soil Classification	Shear Parameter		Unconfined Compression Test Kg/cm ²	UCS by Point Load Index in rock Kg/cm ²	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation %	Void Ratio	Porosity %	
							Gravel %	Sand %	Silt %	Clay %	Liquid Limit %	Plastic Limit %	Plasticity Index %					Cohesion C Kg/cm ²	Angle of Internal Friction ϕ Degree				Compression Index C _c	Coefficient of Volume Compressibility mv cm ² /kg	Pre-consolidation Pressure kg/cm ²					
1	0.00	DS	-	-	-	-	0	29	43	28	42	18	24	17	-	40	CI	-	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	0	32	46	22	40	20	20	-	-	-	CI	-	-	-	-	-	-	-	-	10	-	-	-	-
3	2.00	SPT	-	-	-	-	0	12	51	37	55	22	33	-	-	-	CH	-	-	-	-	-	-	-	-	12	-	-	-	-
4	2.50	UDS	1.95	1.54	26.62	2.61	0	18	49	33	54	24	30	13	0.36	57	CH	0.77	2	-	-	TUU	0.13	0.0110	2.75	-	-	0.69	41.0	
5	3.00	SPT	-	-	-	-	0	29	37	34	52	23	29	-	-	-	CH	-	-	-	-	-	-	-	-	24	-	-	-	-
6	3.50	SPT	-	-	-	-	0	33	38	29	51	25	26	14	-	51	CH	-	-	-	-	-	-	-	-	18	-	-	-	-
7	4.00	SPT	-	-	-	-	0	30	36	34	52	23	29	-	-	-	CH	-	-	-	-	-	-	-	-	15	-	-	-	-
8	4.50	SPT	-	-	-	-	0	29	36	35	54	24	30	-	-	-	CH	-	-	-	-	-	-	-	-	26	-	-	-	-
9	5.00	SPT	-	-	-	-	0	30	43	27	43	20	23	19	-	39	CI	-	-	-	-	-	-	-	-	22	-	-	-	-
10	5.50	SPT	-	-	-	-	0	29	41	30	44	17	27	-	-	-	CI	-	-	-	-	-	-	-	-	28	-	-	-	-
11	6.00	SPT	-	-	-	-	0	62	38	41	22	19	-	-	-	-	SC	-	-	-	-	-	-	-	-	20	-	-	-	-
12	6.50	UDS	2.00	1.61	24.53	2.65	0	69	31	43	21	22	-	-	-	-	SC	0.10	27	-	-	DSU	-	-	-	-	-	-	0.65	39.4
13	7.00	SPT	-	-	-	-	0	78	22	20	16	4	-	-	-	-	SM	-	-	-	-	-	-	-	-	41	-	-	-	-
14	7.50	UDS	2.02	1.63	23.59	2.66	0	77	23	21	16	5	-	-	-	-	SM	0.00	30	-	-	DSU	-	-	-	-	-	-	0.63	38.6
15	8.00	SPT	-	-	-	-	0	82	18	16	NP	NP	-	-	-	-	SM	-	-	-	-	-	-	-	-	28	-	-	-	-
16	8.50	UDS	2.01	1.61	24.47	2.67	0	79	21	19	15	4	-	-	-	-	SM	0.00	29	-	-	DSU	-	-	-	-	-	-	0.65	39.5
17	9.00	DS	-	-	-	-	0	78	22	20	15	5	-	-	-	-	SM	-	-	-	-	-	-	-	-	-	-	-	-	-
18	9.50	UDS	2.00	1.60	24.81	2.66	0	76	24	22	17	5	-	-	-	-	SM	0.00	29	-	-	DSU	-	-	-	-	-	-	0.66	39.8
19	10.00	SPT	-	-	-	-	0	81	19	17	NP	NP	-	-	-	-	SM	-	-	-	-	-	-	-	-	22	-	-	-	-
20	11.00	UDS	2.05	1.68	21.84	2.66	0	77	23	20	16	4	-	-	-	-	SM	0.00	30	-	-	DSU	-	-	-	-	-	-	0.58	36.7
21	11.50	SPT	-	-	-	-	0	62	38	27	16	11	-	-	-	-	SC	-	-	-	-	-	-	-	-	78	-	-	-	-
22	12.50	SPT	-	-	-	-	0	60	40	29	15	14	-	-	-	-	SC	-	-	-	-	-	-	-	-	>100	-	-	-	-
23	13.00	UDS	2.14	1.81	17.94	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	49.5	UCS	-	-	-	-	-	-	0.48	32.5
24	14.50	UDS	2.29	2.04	12.01	2.71	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	89.6	-	UCS	-	-	-	-	8.66	0.33	24.6	
25	14.50	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-	-
26	16.00	UDS	2.31	2.06	11.98	2.74	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	72.4	UCS	-	-	-	-	-	-	0.33	24.7
27	17.50	UDS	2.38	2.17	9.52	2.74	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	145.7	-	UCS	-	-	-	-	9.33	0.26	20.7	
28	19.00	UDS	2.41	2.22	8.77	2.75	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	124.8	-	UCS	-	-	-	-	56.66	0.24	19.4	
29	20.50	UDS	2.40	2.20	8.86	2.74	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	134.1	-	UCS	-	-	-	-	79.33	0.24	19.5	

UDS - Undisturbed Sample
DS - Disturbed Sample
SPT - Standard Penetration Tests
NP - Non Plastic

TUU - Triaxial Unconsolidated Undrained
TCU - Triaxial Consolidated Undrained
DSU - Direct Shear Test
UCS - Unconfined Compression Strength

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 106

Co-Ordinate :- E - 888, N - 2972

Reduced Level :- 197.10 m

Sr No	Depth of Sample m	Type of Sample	Field Bulk Density gm / cc	Field Dry Density gm / cc	Natural Moisture Content %	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit %	Swelling Pressure Kg/cm ²	Free Swell Index %	Soil Classification	Shear Parameter		Unconfined Compression Test Kg/cm ²	UCS by Point Load Index in rock Kg/cm ²	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation %	Void Ratio	Porosity %
							Gravel %	Sand %	Silt %	Clay %	Liquid Limit %	Plastic Limit %	Plasticity Index %					Cohesion C Kg/cm ²	Angle of Internal Friction ϕ Degree				Compression Index C _c	Coefficient of Volume Compressibility m _v cm ² /kg	Pre-consolidation Pressure kg/cm ²				
1	0.00	DS	-	-	-	-	9	32	36	23	39	19	20	-	-	-	CI	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	7	28	37	28	42	16	26	-	-	-	CI	-	-	-	-	-	-	-	-	7	-	-	-
3	2.00	SPT	-	-	-	-	12	31	32	25	40	18	22	-	-	-	CI	-	-	-	-	-	-	-	-	11	-	-	-
4	2.50	UDS	1.67	1.56	7.26	2.67	19	45	36		30	16	14	-	-	-	SC	0.07	25	-	-	DSU	-	-	-	-	-	0.71	41.7
5	3.00	SPT	-	-	-	-	15	49	36		27	15	12	-	-	-	SC	-	-	-	-	-	-	-	-	10	-	-	-
6	3.50	UDS	1.99	1.59	25.44	2.66	5	58	37		30	16	14	-	-	-	SC	0.08	26	-	-	DSU	-	-	-	-	-	0.68	40.4
7	4.00	SPT	-	-	-	-	4	64	32		28	17	11	-	-	-	SC	-	-	-	-	-	-	-	-	11	-	-	-
8	4.50	UDS	2.00	1.60	24.81	2.66	10	54	36		32	19	13	-	-	-	SC	0.10	26	-	-	DSU	-	-	-	-	-	0.66	39.8
9	5.00	SPT	-	-	-	-	12	59	29		26	16	10	-	-	-	SC	-	-	-	-	-	-	-	-	18	-	-	-
10	5.50	UDS	2.01	1.61	24.47	2.67	7	63	30		28	17	11	-	-	-	SC	0.06	28	-	-	DSU	-	-	-	-	-	0.65	39.5
11	6.00	SPT	-	-	-	-	0	39	40	21	40	21	19	-	-	-	CI	-	-	-	-	-	-	-	-	12	-	-	-
12	6.50	UDS	2.00	1.61	23.95	2.63	0	32	41	27	42	19	23	-	-	-	CI	1.65	6	-	-	TUU	0.11	0.0064	0.88	-	-	0.63	38.7
13	7.00	SPT	-	-	-	-	2	59	39		29	18	11	-	-	-	SC	-	-	-	-	-	-	-	-	42	-	-	-
14	7.50	UDS	2.12	1.79	18.13	2.66	3	67	30		26	16	10	-	-	-	SC	0.07	29	-	-	DSU	-	-	-	-	-	0.48	32.5
15	8.00	SPT	-	-	-	-	0	29	52	19	31	15	16	-	-	-	CL	-	-	-	-	-	-	-	-	>100	-	-	-
16	8.50	SPT	-	-	-	-	0	31	57	12	28	17	11	-	-	-	CL	-	-	-	-	-	-	-	-	>100	-	-	-
17	9.00	SPT	-	-	-	-	0	28	56	16	30	16	14	-	-	-	CL	-	-	-	-	-	-	-	-	>100	-	-	-
18	9.50	SPT	-	-	-	-	0	30	57	13	29	18	11	-	-	-	CL	-	-	-	-	-	-	-	-	>100	-	-	-
19	10.00	SPT	-	-	-	-	0	37	54	9	27	19	8	-	-	-	CL	-	-	-	-	-	-	-	-	>100	-	-	-
20	11.00	UDS	2.29	2.04	12.01	2.71	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	76.1	UCS	-	-	-	-	-	0.33	24.6
21	12.50	UDS	2.26	2.00	12.93	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	92.4	UCS	-	-	-	-	-	0.35	25.9
22	14.00	UDS	2.31	2.08	11.03	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	110.3	UCS	-	-	-	-	-	0.30	22.9
23	15.50	UDS	2.36	2.15	9.73	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	121.7	UCS	-	-	-	-	-	0.26	20.9
24	15.50	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-
25	17.00	UDS	2.52	2.39	5.50	2.75	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	192.1	UCS	-	-	-	-	-	0.15	13.1
26	18.50	UDS	2.57	2.46	4.38	2.76	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	183.0	UCS	-	-	-	-	-	0.12	10.8
27	20.00	UDS	2.82	2.80	0.77	2.86	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	527.4	UCS	-	-	-	-	-	0.02	2.2
28	21.50	UDS	2.80	2.78	0.78	2.84	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	510.6	-	UCS	-	-	-	-	26.66	0.02	2.2
29	23.00	UDS	2.51	2.39	5.11	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	137.9	-	UCS	-	-	-	-	22.00	0.14	12.2
30	24.00	UDS	2.53	2.41	4.79	2.73	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	150.2	-	UCS	-	-	-	-	30.00	0.13	11.6
31	25.00	UDS	2.50	2.38	4.94	2.70	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	167.7	-	UCS	-	-	-	-	33.00	0.13	11.8

KCT Consultancy Services LLP, Ahmedabad

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 108

Co-Ordinate :- E 1278, N 2950

Reduced Level :- 201.17 m

Sr No	Depth of Sample	Type of Sample	Field Bulk Density	Field Dry Density	Natural Moisture Content	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit	Swelling Pressure	Free Swell Index	Soil Classification	Shear Parameter		Unconfined Compression Test	UCS by Point Load Index in rock	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation	Void Ratio	Porosity
							Gravel	Sand			Liquid Limit	Plastic Limit	Plasticity Index					Cohesion C	Angle of Internal Friction ϕ				Compression Index C _c	Coefficient of Volume Compressibility mv	Pre-consolidation Pressure				
1	0.00	DS	-	-	-	-	0	26	37	37	56	23	33	-	-	-	CH	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	0	23	54	23	36	16	20	-	-	-	CI	-	-	-	-	-	-	-	7	-	-	-	-
3	2.00	SPT	-	-	-	-	0	67	33		45	22	23	-	-	-	SC	-	-	-	-	-	-	-	23	-	-	-	-
4	2.50	SPT	-	-	-	-	0	62	38		48	23	25	-	-	-	SC	-	-	-	-	-	-	-	18	-	-	-	-
5	3.00	SPT	-	-	-	-	0	23	52	25	42	20	22	-	-	-	CI	-	-	-	-	-	-	-	18	-	-	-	-
6	3.50	UDS	1.95	1.54	26.62	2.61	0	18	53	29	46	19	27	-	-	-	CI	1.32	2	-	-	TUU	0.13	0.0085	0.62	-	-	0.69	41.0
7	4.00	SPT	-	-	-	-	6	59	35		28	16	12	-	-	-	SC	-	-	-	-	-	-	-	68	-	-	-	-
8	4.50	UDS	2.10	1.77	18.87	2.65	5	62	33		26	15	11	-	-	-	SC	0.10	27	-	-	DSU	-	-	-	-	-	0.50	33.3
9	5.00	SPT	-	-	-	-	69	12	19		25	16	9	-	-	-	GC	-	-	-	-	-	-	-	>100	-	-	-	-
10	5.50	SPT	-	-	-	-	78	8	14		24	15	9	-	-	-	GC	-	-	-	-	-	-	-	>100	-	-	-	-
11	6.00	UDS	2.26	2.01	12.69	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	38.9	UCS	-	-	-	-	-	0.34	25.4
12	6.00	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	>100	-	-	-	-
13	7.50	UDS	2.30	2.06	11.40	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	51.3	UCS	-	-	-	-	-	0.31	23.5
14	7.50	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	>100	-	-	-	-
15	9.00	UDS	2.34	2.11	10.66	2.73	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	98.9	UCS	-	-	-	-	-	0.29	22.5
16	10.50	UDS	2.31	2.07	11.51	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	93.8	UCS	-	-	-	-	-	0.31	23.8
17	12.00	UDS	2.36	2.14	10.20	2.74	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	156.4	UCS	-	-	-	-	-	0.28	21.8
18	13.50	UDS	2.18	1.87	16.57	2.71	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	52.1	-	UCS	-	-	-	-	7.00	0.45	31.0
19	15.00	UDS	2.29	2.04	12.49	2.73	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	53.2	-	UCS	-	-	-	-	27.00	0.34	25.4
20	16.50	UDS	2.25	1.96	14.78	2.76	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	60.4	-	UCS	-	-	-	-	44.00	0.41	29.0
21	18.00	UDS	2.37	2.15	10.09	2.75	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	81.9	-	UCS	-	-	-	-	94.00	0.28	21.7

KCT Consultancy Services LLP, Ahmedabad

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 109

Co-Ordinate :- E 1177, N 2943

Reduced Level :- 200.77 m

Sr No	Depth of Sample m	Type of Sample	Field Bulk Density gm / cc	Field Dry Density gm / cc	Natural Moisture Content %	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit %	Swelling Pressure Kg/cm ²	Free Swell Index %	Soil Classification	Shear Parameter		Unconfined Compression Test Kg/cm ²	UCS by Point Load Index in rock Kg/cm ²	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation %	Void Ratio	Porosity %	
							Gravel %	Sand %	Silt %	Clay %	Liquid Limit %	Plastic Limit %	Plasticity Index %					Cohesion C Kg/cm ²	Angle of Internal Friction ϕ Degree				Compression Index C _c	Coefficient of Volume Compressibility mv cm ² /kg	Pre-consolidation Pressure kg/cm ²					
1	0.00	DS	-	-	-	-	0	31	54	15	28	15	13	-	-	-	CL	-	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	0	22	61	17	32	17	15	-	-	-	CL	-	-	-	-	-	-	-	-	9	-	-	-	-
3	2.00	SPT	-	-	-	-	0	13	48	39	55	20	35	13	-	57	CH	-	-	-	-	-	-	-	-	10	-	-	-	-
4	2.50	SPT	-	-	-	-	0	15	51	34	53	22	31	-	-	-	CH	-	-	-	-	-	-	-	-	11	-	-	-	-
5	3.00	SPT	-	-	-	-	0	23	38	39	61	25	36	9	-	69	CH	-	-	-	-	-	-	-	-	19	-	-	-	-
6	3.50	SPT	-	-	-	-	0	9	48	43	63	24	39	-	-	-	CH	-	-	-	-	-	-	-	-	24	-	-	-	-
7	4.00	SPT	-	-	-	-	0	19	48	33	56	26	30	-	-	-	CH	-	-	-	-	-	-	-	-	26	-	-	-	-
8	4.50	UDS	1.99	1.59	25.16	2.65	0	23	37	40	58	24	34	12	0.41	63	CH	1.42	4	-	-	TUU	0.11	0.0080	1.79	-	-	0.67	40.0	
9	5.00	SPT	-	-	-	-	0	67	33	31	16	15	-	-	-	-	SC	-	-	-	-	-	-	-	-	>100	-	-	-	-
10	5.50	SPT	-	-	-	-	0	71	29	28	15	13	-	-	-	-	SC	-	-	-	-	-	-	-	-	79	-	-	-	-
11	6.00	SPT	-	-	-	-	0	64	36	32	17	15	-	-	-	-	SC	-	-	-	-	-	-	-	-	>100	-	-	-	-
12	6.50	SPT	-	-	-	-	0	69	31	28	16	12	-	-	-	-	SC	-	-	-	-	-	-	-	-	>100	-	-	-	-
13	7.00	SPT	-	-	-	-	0	72	28	26	17	9	-	-	-	-	SC	-	-	-	-	-	-	-	-	>100	-	-	-	-
14	7.50	SPT	-	-	-	-	0	70	30	29	16	13	-	-	-	-	SC	-	-	-	-	-	-	-	-	>100	-	-	-	-
15	8.00	UDS	2.13	1.81	17.63	2.66	0	36	39	25	40	19	21	-	-	-	CI	4.26	8	-	-	TUU	-	-	-	-	-	-	0.47	31.9
16	8.00	SPT	-	-	-	-	0	29	44	27	43	18	25	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-	-
17	9.50	UDS	2.24	1.97	13.49	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	39.8	-	UCS	-	-	-	-	6.00	0.36	26.6	
18	11.00	UDS	2.23	1.95	14.40	2.71	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	51.0	-	UCS	-	-	-	-	29.00	0.39	28.1	
19	12.50	UDS	2.37	2.16	9.63	2.73	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	112.6	-	UCS	-	-	-	-	43.00	0.26	20.8	
20	14.00	UDS	2.36	2.15	9.73	2.72	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	114.8	-	UCS	-	-	-	-	44.00	0.26	20.9	

KCT Consultancy Services LLP, Ahmedabad

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 111

Co-Ordinate :- E 1' \$), N 2- ' \$

Reduced Level :- 200.98 m

Sr No	Depth of Sample m	Type of Sample	Field Bulk Density gm / cc	Field Dry Density gm / cc	Natural Moisture Content %	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit %	Swelling Pressure Kg/cm ²	Free Swell Index %	Soil Classification	Shear Parameter		Unconfined Compression Test Kg/cm ²	UCS by Point Load Index in rock Kg/cm ²	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation %	Void Ratio	Porosity %
							Gravel %	Sand %	Silt %	Clay %	Liquid Limit %	Plastic Limit %	Plasticity / Index %					Cohesion C Kg/cm ²	Angle of Internal Friction ϕ Degree				Coefficient of Volume Compressibility mv cm ² /kg	Pre-consolidation Pressure kg/cm ²					
1	0.00	DS	-	-	-	-	0	69	31	31	17	14	-	-	-	SC	-	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	9	31	31	29	40	15	25	-	-	-	CI	-	-	-	-	-	-	-	14	-	-	-	-
3	2.00	SPT	-	-	-	-	16	26	33	25	39	18	21	-	-	-	CI	-	-	-	-	-	-	-	18	-	-	-	-
4	2.50	SPT	-	-	-	-	11	30	37	22	41	21	20	-	-	-	CI	-	-	-	-	-	-	-	13	-	-	-	-
5	3.00	SPT	-	-	-	-	0	19	42	39	53	20	33	-	-	-	CH	-	-	-	-	-	-	-	23	-	-	-	-
6	3.50	UDS	1.97	1.57	25.87	2.63	0	17	47	36	54	22	32	-	-	-	CH	1.22	5	-	-	TUU	0.13	0.0091	0.76	-	-	0.68	40.5
7	4.00	SPT	-	-	-	-	0	20	61	19	42	24	18	-	-	-	CI	-	-	-	-	-	-	-	77	-	-	-	-
8	4.50	SPT	-	-	-	-	0	21	61	18	41	25	16	-	-	-	CI	-	-	-	-	-	-	-	30	-	-	-	-
9	5.00	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	>100	-	-	-	-
10	6.50	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	>100	-	-	-	-
11	8.00	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	>100	-	-	-	-
12	9.50	UDS	2.13	1.80	18.42	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	46.7	-	UCS	-	-	-	-	6.66	0.50	33.1
13	11.00	UDS	2.10	1.74	20.72	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	42.6	UCS	-	-	-	-	-	0.56	36.0
14	12.50	UDS	2.11	1.76	19.69	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	48.1	UCS	-	-	-	-	-	0.53	34.7
15	14.00	UDS	2.19	1.89	15.87	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	55.6	-	UCS	-	-	-	-	21.33	0.43	30.0
16	15.50	UDS	2.17	1.86	16.52	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	49.8	-	UCS	-	-	-	-	14.66	0.44	30.8
17	17.00	UDS	2.21	1.91	15.50	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	92.7	-	UCS	-	-	-	-	24.00	0.42	29.7

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 112

Co-Ordinate :- E - 100(, N - 2928

Reduced Level :- % - '\$) m

Sr No	Depth of Sample m	Type of Sample	Field Bulk Density gm / cc	Field Dry Density gm / cc	Natural Moisture Content %	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit %	Swelling Pressure Kg/cm ²	Free Swell Index %	Soil Classification	Shear Parameter		Unconfined Compression Test Kg/cm ²	UCS by Point Load Index in rock Kg/cm ²	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation %	Void Ratio	Porosity %
							Gravel %	Sand %	Silt %	Clay %	Liquid Limit %	Plastic Limit %	Plasticity Index %					Cohesion C Kg/cm ²	Angle of Internal Friction ϕ Degree				Compression Index C _c	Coefficient of Volume Compressibility m _v cm ² /kg	Pre-consolidation Pressure kg/cm ²				
1	0.00	DS	-	-	-	-	0	40	49	11	21	12	9	-	-	-	CL	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	5	23	44	28	41	17	24	-	-	-	CI	-	-	-	-	-	-	-	-	5	-	-	-
3	2.00	SPT	-	-	-	-	9	28	37	26	36	13	23	-	-	-	CI	-	-	-	-	-	-	-	-	8	-	-	-
4	2.50	UDS	1.75	1.52	15.25	2.64	0	22	59	19	37	21	16	-	-	-	CI	0.42	3	-	-	TUU	0.15	0.0208	0.43	-	-	0.74	42.5
5	3.00	SPT	-	-	-	-	0	30	44	26	40	17	23	-	-	-	CI	-	-	-	-	-	-	-	-	13	-	-	-
6	3.50	UDS	1.97	1.56	26.45	2.65	0	28	45	27	40	16	24	-	-	-	CI	0.71	4	-	-	TUU	0.13	0.0154	0.55	-	-	0.70	41.2
7	4.00	SPT	-	-	-	-	10	22	40	28	38	13	25	-	-	-	CI	-	-	-	-	-	-	-	-	14	-	-	-
8	4.50	SPT	-	-	-	-	3	59	38	34	16	18	-	-	-	-	SC	-	-	-	-	-	-	-	-	16	-	-	-
9	5.00	SPT	-	-	-	-	2	40	32	26	37	14	23	-	-	-	CI	-	-	-	-	-	-	-	-	8	-	-	-
10	5.50	UDS	1.92	1.47	30.24	2.66	5	52	43	32	13	19	-	-	-	-	SC	0.09	23	-	-	DSU	-	-	-	-	-	0.80	44.6
11	6.00	SPT	-	-	-	-	6	55	39	35	14	21	-	-	-	-	SC	-	-	-	-	-	-	-	-	12	-	-	-
12	6.50	UDS	1.96	1.53	27.70	2.67	19	54	27	40	16	24	-	-	-	-	SC	0.06	26	-	-	DSU	-	-	-	-	-	0.74	42.5
13	7.00	SPT	-	-	-	-	0	52	48	27	15	12	-	-	-	-	SC	-	-	-	-	-	-	-	-	16	-	-	-
14	7.50	SPT	-	-	-	-	6	69	25	24	14	10	-	-	-	-	SC	-	-	-	-	-	-	-	-	25	-	-	-
15	8.00	SPT	-	-	-	-	11	65	24	23	16	7	-	-	-	-	SM-SC	-	-	-	-	-	-	-	-	>100	-	-	-
16	8.50	SPT	-	-	-	-	32	48	20	21	15	6	-	-	-	-	SM-SC	-	-	-	-	-	-	-	-	>100	-	-	-
17	9.00	SPT	-	-	-	-	0	76	24	27	21	6	-	-	-	-	SM-SC	-	-	-	-	-	-	-	-	>100	-	-	-
18	9.50	SPT	-	-	-	-	0	80	20	25	18	7	-	-	-	-	SM-SC	-	-	-	-	-	-	-	-	>100	-	-	-
19	10.00	SPT	-	-	-	-	0	83	17	24	18	6	-	-	-	-	SM-SC	-	-	-	-	-	-	-	-	>100	-	-	-
20	11.50	UDS	2.28	2.02	12.64	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	47.3	-	UCS	-	-	-	-	30.00	0.34	25.6
21	11.50	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-
22	13.00	UDS	2.23	1.96	13.90	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	39.6	UCS	-	-	-	-	-	0.37	27.2
23	13.00	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-
24	14.50	UDS	2.24	1.97	13.74	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	44.8	UCS	-	-	-	-	-	0.37	27.1
25	14.50	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-
26	16.00	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-
27	17.50	UDS	2.30	2.06	11.40	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	74.6	UCS	-	-	-	-	-	0.31	23.5
28	17.50	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-
29	19.00	UDS	2.58	2.46	4.76	2.79	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	309.6	-	UCS	-	-	-	-	14.66	0.13	11.7
30	20.00	UDS	2.33	2.11	10.54	2.71	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	77.6	UCS	-	-	-	-	-	0.29	22.2

KCT Consultancy Services LLP, Ahmedabad

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 113

Co-Ordinate :- E 908, N 2941

Reduced Level :- 197.55

Sr No	Depth of Sample m	Type of Sample	Field Bulk Density gm / cc	Field Dry Density gm / cc	Natural Moisture Content %	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit %	Swelling Pressure Kg/cm ²	Free Swell Index %	Soil Classification	Shear Parameter		Unconfined Compression Test Kg/cm ²	UCS by Point Load Index in rock Kg/cm ²	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation %	Void Ratio	Porosity %	
							Gravel %	Sand %	Silt %	Clay %	Liquid Limit %	Plastic Limit %	Plasticity Index %					Cohesion C Kg/cm ²	Angle of Internal Friction ϕ Degree				Coefficient of Volume Compressibility mv cm ² /kg	Pre-consolidation Pressure kg/cm ²						
1	0.00	DS	-	-	-	-	0	28	45	27	43	19	24	18	-	38	CI	-	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	0	33	45	22	40	21	19	-	-	-	CI	-	-	-	-	-	-	-	-	7	-	-	-	-
3	2.00	SPT	-	-	-	-	0	17	47	36	56	25	31	-	-	-	CH	-	-	-	-	-	-	-	-	15	-	-	-	-
4	2.50	UDS	1.93	1.51	27.71	2.60	0	11	44	45	62	23	39	9	0.42	69	CH	0.82	2	-	-	TUU	0.15	0.0139	0.41	-	-	0.72	41.9	-
5	3.00	SPT	-	-	-	-	0	16	41	43	60	24	36	-	-	-	CH	-	-	-	-	-	-	-	-	26	-	-	-	-
6	3.50	UDS	1.98	1.58	25.51	2.64	3	34	39	24	41	20	21	18	0.15	39	CI	1.41	6	-	-	TUU	0.12	0.0073	0.51	-	-	0.67	40.2	-
7	4.00	SPT	-	-	-	-	5	31	36	28	47	22	25	-	-	-	CI	-	-	-	-	-	-	-	-	20	-	-	-	-
8	4.50	UDS	2.00	1.60	24.81	2.66	0	66	34		43	20	23	-	-	-	SC	0.14	26	-	-	DSU	-	-	-	-	-	0.66	39.8	-
9	5.00	SPT	-	-	-	-	0	63	37		45	23	22	-	-	-	SC	-	-	-	-	-	-	-	-	29	-	-	-	-
10	5.50	SPT	-	-	-	-	0	29	49	22	44	24	20	19	-	41	CI	-	-	-	-	-	-	-	-	27	-	-	-	-
11	6.00	SPT	-	-	-	-	0	33	46	21	40	21	19	-	-	-	CI	-	-	-	-	-	-	-	-	70	-	-	-	-
12	6.50	SPT	-	-	-	-	0	65	35		29	16	13	-	-	-	SC	-	-	-	-	-	-	-	-	>100	-	-	-	-
13	7.00	SPT	-	-	-	-	0	61	39		32	15	17	-	-	-	SC	-	-	-	-	-	-	-	-	>100	-	-	-	-
14	7.50	SPT	-	-	-	-	0	64	36		31	17	14	-	-	-	SC	-	-	-	-	-	-	-	-	>100	-	-	-	-
15	8.00	SPT	-	-	-	-	0	27	55	18	30	15	15	-	-	-	CL	-	-	-	-	-	-	-	-	>100	-	-	-	-
16	8.50	SPT	-	-	-	-	0	29	58	13	29	17	12	-	-	-	CL	-	-	-	-	-	-	-	-	>100	-	-	-	-
17	9.00	SPT	-	-	-	-	0	33	56	11	26	16	10	-	-	-	CL	-	-	-	-	-	-	-	-	>100	-	-	-	-
18	9.50	SPT	-	-	-	-	0	31	54	15	28	15	13	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-	-
19	10.00	SPT	-	-	-	-	0	30	53	17	29	14	15	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-	-
20	11.00	UDS	2.26	2.00	12.93	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	79.1	UCS	-	-	-	-	-	0.35	25.9	-
21	12.50	UDS	2.19	1.89	15.62	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	69.8	-	UCS	-	-	-	-	28.00	0.42	29.6	-
22	14.00	UDS	2.18	1.88	15.81	2.68	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	84.1	-	UCS	-	-	-	-	14.66	0.42	29.8	-
23	15.50	UDS	2.24	1.97	13.74	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	98.6	-	UCS	-	-	-	-	20.00	0.37	27.1	-
24	17.00	UDS	2.29	2.05	11.53	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	76.2	UCS	-	-	-	-	-	0.31	23.7	-
25	18.50	UDS	2.28	2.03	12.40	2.71	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	89.1	-	UCS	-	-	-	-	39.33	0.34	25.1	-
26	20.00	UDS	2.36	2.14	10.20	2.74	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	121.4	-	UCS	-	-	-	-	30.00	0.28	21.8	-
27	21.50	UDS	2.51	2.37	6.00	2.76	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	329.8	-	UCS	-	-	-	-	30.00	0.17	14.2	-
28	23.00	UDS	2.54	2.42	5.18	2.76	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	387.1	-	UCS	-	-	-	-	56.00	0.14	12.5	-
29	24.50	UDS	2.50	2.35	6.50	2.77	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	355.6	-	UCS	-	-	-	-	46.00	0.18	15.3	-

UDS - Undisturbed Sample
DS - Disturbed Sample
SPT - Standard Penetration Tests
NP - Non Plastic

TUU - Triaxial Unconsolidated Undrained
TCU - Triaxial Consolidated Undrained
DSU - Direct Shear Test
UCS - Unconfined Compression Strength

KCT Consultancy Services LLP, Ahmedabad

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 115

Co-Ordinate :- E 1217, N 2- 18

Reduced Level :- 200.71 m

Sr No	Depth of Sample m	Type of Sample	Field Bulk Density gm / cc	Field Dry Density gm / cc	Natural Moisture Content %	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit	Swelling Pressure Kg/cm ²	Free Swell Index %	Soil Classification	Shear Parameter		Unconfined Compression Test Kg/cm ²	UCS by Point Load Index in rock Kg/cm ²	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation %	Void Ratio	Porosity %	
							Gravel %	Sand %	Silt %	Clay %	Liquid Limit %	Plastic Limit %	Plasticity Index %					Cohesion C Kg/cm ²	Angle of Internal Friction ϕ Degree				Coefficient of Volume Compressibility mv cm ² /kg	Pre-consolidation Pressure kg/cm ²						
1	0.00	DS	-	-	-	-	0	19	41	40	57	21	36	-	-	-	CH	-	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	0	14	39	47	63	22	41	9	-	74	CH	-	-	-	-	-	-	-	-	7	-	-	-	-
3	2.00	SPT	-	-	-	-	11	29	35	25	41	19	22	-	-	-	CI	-	-	-	-	-	-	-	-	22	-	-	-	-
4	2.50	SPT	-	-	-	-	0	15	35	50	69	23	46	8	-	93	CH	-	-	-	-	-	-	-	-	20	-	-	-	-
5	3.00	SPT	-	-	-	-	0	18	32	50	65	22	43	-	-	-	CH	-	-	-	-	-	-	-	-	17	-	-	-	-
6	3.50	UDS	1.89	1.58	19.46	2.65	0	30	47	23	45	24	21	20	-	41	CI	1.27	7	-	-	TUU	0.13	0.0079	0.67	-	-	0.67	40.3	-
7	4.00	SPT	-	-	-	-	0	33	45	22	40	20	20	-	-	-	CI	-	-	-	-	-	-	-	-	23	-	-	-	-
8	4.50	UDS	2.02	1.64	23.02	2.64	0	29	46	25	42	21	21	-	-	-	CI	1.23	6	-	-	TUU	0.11	0.0084	0.86	-	-	0.61	37.8	-
9	5.00	SPT	-	-	-	-	0	25	49	26	44	22	22	-	-	-	CI	-	-	-	-	-	-	-	-	65	-	-	-	-
10	5.50	SPT	-	-	-	-	0	30	44	26	46	23	23	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-	-
11	7.00	UDS	2.40	2.21	8.63	2.73	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	126.4	UCS	-	-	-	-	-	0.24	19.1	-
12	8.50	UDS	2.19	1.89	15.62	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	41.3	-	UCS	-	-	-	-	18.66	0.42	29.6	-
13	10.00	UDS	2.30	2.06	11.88	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	87.9	-	UCS	-	-	-	-	24.00	0.32	24.4	-
14	11.50	UDS	2.33	2.11	10.54	2.71	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	99.5	-	UCS	-	-	-	-	62.00	0.29	22.2	-
15	13.00	UDS	2.29	2.04	12.25	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	74.2	-	UCS	-	-	-	-	36.66	0.33	25.0	-
16	14.50	UDS	2.36	2.16	9.26	2.70	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	162.8	-	UCS	-	-	-	-	6.66	0.25	20.0	-

KCT Consultancy Services LLP, Ahmedabad

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 116

Co-Ordinate :- E 1154, N 2913

Reduced Level :- 200.6- m

Sr No	Depth of Sample m	Type of Sample	Field Bulk Density gm / cc	Field Dry Density gm / cc	Natural Moisture Content %	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit %	Swelling Pressure Kg/cm ²	Free Swell Index %	Soil Classification	Shear Parameter		Unconfined Compression Test Kg/cm ²	UCS by Point Load Index in rock Kg/cm ²	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation %	Void Ratio	Porosity %
							Gravel %	Sand %	Silt %	Clay %	Liquid Limit %	Plastic Limit %	Plasticity Index %					Cohesion C Kg/cm ²	Angle of Internal Friction ϕ Degree				Compression Index C _c	Coefficient of Volume Compressibility mv cm ² /kg	Pre-consolidation Pressure kg/cm ²				
1	0.00	DS	-	-	-	-	0	27	51	22	39	19	20	-	-	-	CI	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	0	12	48	40	65	30	35	9	-	66	CH	-	-	-	-	-	-	-	-	8	-	-	-
3	2.00	SPT	-	-	-	-	0	8	59	33	59	31	28	-	-	-	CH	-	-	-	-	-	-	-	-	21	-	-	-
4	2.50	UDS	1.84	1.55	18.43	2.61	0	7	49	44	66	26	40	9	0.47	79	CH	1.01	2	-	-	TUU	0.11	0.0109	0.45	-	-	0.68	40.5
5	3.00	SPT	-	-	-	-	0	21	39	40	65	28	37	-	-	-	CH	-	-	-	-	-	-	-	-	19	-	-	-
6	3.50	UDS	2.00	1.61	24.24	2.64	0	27	44	29	48	23	25	14	0.17	48	CI	1.18	6	-	-	TUU	0.10	0.0091	0.64	-	-	0.64	39.0
7	4.00	SPT	-	-	-	-	0	34	44	22	40	21	19	-	-	-	CI	-	-	-	-	-	-	-	-	27	-	-	-
8	4.50	UDS	2.03	1.65	22.71	2.65	0	28	53	19	39	22	17	-	-	-	CI	1.45	5	-	-	TUU	0.08	0.0064	0.69	-	-	0.60	37.6
9	5.00	SPT	-	-	-	-	0	32	47	21	37	19	18	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-
10	5.50	SPT	-	-	-	-	0	29	46	25	42	20	22	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-
11	6.00	SPT	-	-	-	-	0	30	40	30	49	23	26	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-
12	6.50	SPT	-	-	-	-	0	31	49	20	40	22	18	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-
13	7.00	SPT	-	-	-	-	0	28	46	26	43	21	22	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-
14	7.50	SPT	-	-	-	-	0	17	54	29	48	23	25	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-
15	8.00	SPT	-	-	-	-	0	18	55	27	45	22	23	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-
16	8.50	SPT	-	-	-	-	0	10	62	28	46	20	26	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-
17	9.00	SPT	-	-	-	-	0	8	62	30	48	23	25	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-
18	9.50	SPT	-	-	-	-	9	26	51	14	28	16	12	-	-	-	CL	-	-	-	-	-	-	-	-	>100	-	-	-
19	10.00	SPT	-	-	-	-	10	28	47	15	29	15	14	-	-	-	CL	-	-	-	-	-	-	-	-	>100	-	-	-
20	11.00	SPT	-	-	-	-	7	29	48	16	28	14	14	-	-	-	CL	-	-	-	-	-	-	-	-	>100	-	-	-
21	11.50	SPT	-	-	-	-	9	27	53	11	26	16	10	-	-	-	CL	-	-	-	-	-	-	-	-	>100	-	-	-
22	12.50	SPT	-	-	-	-	10	28	47	15	29	15	14	-	-	-	CL	-	-	-	-	-	-	-	-	>100	-	-	-
23	13.00	SPT	-	-	-	-	0	30	49	21	42	23	19	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-
24	14.00	SPT	-	-	-	-	0	32	41	27	44	20	24	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-
25	15.50	UDS	2.31	2.08	11.03	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	108.8	-	UCS	-	-	-	-	20.00	0.30	22.9
26	17.00	UDS	2.34	2.12	10.43	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	96.4	-	UCS	-	-	-	-	52.00	0.28	22.1
27	18.50	UDS	2.32	2.08	11.38	2.73	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	97.7	-	UCS	-	-	-	-	46.00	0.31	23.7
28	20.00	UDS	2.39	2.20	8.73	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	116.6	-	UCS	-	-	-	-	45.00	0.24	19.2
29	21.50	UDS	2.38	2.17	9.52	2.74	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	130.8	-	UCS	-	-	-	-	46.00	0.26	20.7

UDS - Undisturbed Sample
DS - Disturbed Sample
SPT - Standard Penetration Tests
NP - Non Plastic

TUU - Triaxial Unconsolidated Undrained
TCU - Triaxial Consolidated Undrained
DSU - Direct Shear Test
UCS - Unconfined Compression Strength

KCT Consultancy Services LLP, Ahmedabad

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 120

Co-Ordinate :- E 884, N 2920

Reduced Level :- 197.30

Sr No	Depth of Sample m	Type of Sample	Field Bulk Density gm / cc	Field Dry Density gm / cc	Natural Moisture Content %	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit %	Swelling Pressure Kg/cm ²	Free Swell Index %	Soil Classification	Shear Parameter		Unconfined Compression Test Kg/cm ²	UCS by Point Load Index in rock Kg/cm ²	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation %	Void Ratio	Porosity %	
							Gravel %	Sand %	Silt %	Clay %	Liquid Limit %	Plastic Limit %	Plasticity Index %					Cohesion C Kg/cm ²	Angle of Internal Friction ϕ Degree				Coefficient of Volume Compressibility mv cm ² /kg	Pre-consolidation Pressure kg/cm ²						
1	0.00	DS	-	-	-	-	0	31	43	26	41	19	22	-	-	-	CI	-	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	0	19	43	38	53	20	33	-	-	-	CH	-	-	-	-	-	-	-	5	-	-	-	-	-
3	2.00	SPT	-	-	-	-	0	21	49	30	51	25	26	-	-	-	CH	-	-	-	-	-	-	-	14	-	-	-	-	-
4	2.50	UDS	1.94	1.52	27.91	2.63	0	16	50	34	54	24	30	13	-	58	CH	0.86	3	-	-	TUU	0.15	0.0128	0.43	-	-	0.73	42.3	-
5	3.00	SPT	-	-	-	-	0	18	53	29	52	26	26	-	-	-	CH	-	-	-	-	-	-	-	18	-	-	-	-	-
6	3.50	UDS	1.97	1.56	26.16	2.64	0	21	45	34	51	22	29	14	-	51	CH	1.12	4	-	-	TUU	0.13	0.0097	0.59	-	-	0.69	40.9	-
7	4.00	SPT	-	-	-	-	0	64	36		48	24	24	-	-	-	SC	-	-	-	-	-	-	-	26	-	-	-	-	-
8	4.50	SPT	-	-	-	-	0	59	41		49	22	27	-	-	-	SC	-	-	-	-	-	-	-	36	-	-	-	-	-
9	5.00	SPT	-	-	-	-	0	66	34		31	20	11	-	-	-	SC	-	-	-	-	-	-	-	36	-	-	-	-	-
10	5.50	SPT	-	-	-	-	0	68	32		26	17	9	-	-	-	SC	-	-	-	-	-	-	-	34	-	-	-	-	-
11	6.00	SPT	-	-	-	-	0	66	34		29	16	13	-	-	-	SC	-	-	-	-	-	-	-	>100	-	-	-	-	-
12	6.50	SPT	-	-	-	-	0	61	39		36	19	17	-	-	-	SC	-	-	-	-	-	-	-	>100	-	-	-	-	-
13	7.00	SPT	-	-	-	-	0	63	37		34	20	14	-	-	-	SC	-	-	-	-	-	-	-	>100	-	-	-	-	-
14	7.50	SPT	-	-	-	-	0	67	33		32	22	10	-	-	-	SC	-	-	-	-	-	-	-	>100	-	-	-	-	-
15	8.00	SPT	-	-	-	-	0	20	48	35	46	19	26	-	-	-	CI	-	-	-	-	-	-	-	>100	-	-	-	-	-
16	8.50	SPT	-	-	-	-	2	61	37		35	20	15	-	-	-	SC	-	-	-	-	-	-	-	>100	-	-	-	-	-
17	9.00	SPT	-	-	-	-	6	66	28		29	16	13	-	-	-	SC	-	-	-	-	-	-	-	>100	-	-	-	-	-
18	9.50	SPT	-	-	-	-	5	65	30		33	15	18	-	-	-	SC	-	-	-	-	-	-	-	>100	-	-	-	-	-
19	11.00	UDS	2.29	2.04	12.25	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	79.8	-	UCS	-	-	-	-	8.46	0.33	25.0	-
20	12.50	UDS	2.30	2.06	11.64	2.71	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	89.5	-	UCS	-	-	-	-	17.33	0.32	24.0	-
21	14.00	UDS	2.28	2.02	12.64	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	81.6	-	UCS	-	-	-	-	56.00	0.34	25.6	-
22	15.50	UDS	2.20	1.91	15.18	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	60.8	-	UCS	-	-	-	-	29.33	0.41	29.0	-
23	17.00	UDS	2.38	2.18	9.29	2.73	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	97.4	-	UCS	-	-	-	-	98.00	0.25	20.2	-

UDS - Undisturbed Sample
DS - Disturbed Sample
SPT - Standard Penetration Tests
NP - Non Plastic

TUU - Triaxial Unconsolidated Undrained
TCU - Triaxial Consolidated Undrained
DSU - Direct Shear Test
UCS - Unconfined Compression Strength

KCT Consultancy Services LLP, Ahmedabad

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTP) at village Hirma, Talabira, Odisha

BH No. :- 121

Co-Ordinate :- E 967, N 2897

Reduced Level :- 198.42 m

Sr No	Depth of Sample	Type of Sample	Field Bulk Density	Field Dry Density	Natural Moisture Content	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit	Swelling Pressure	Free Swell Index	Soil Classification	Shear Parameter		Unconfined Compression Test	UCS by Point Load Index in rock	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation	Void Ratio	Porosity
							Gravel	Sand	Silt	Clay	Liquid Limit	Plastic Limit	Plasticity Index					Cohesion C	Angle of Internal Friction ϕ				Compression Index C _c	Coefficient of Volume Compressibility mv	Pre-consolidation Pressure				
1	0.00	DS	-	-	-	-	0	29	47	24	39	17	22	-	-	-	CI	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	0	15	44	41	55	20	35	-	-	-	CH	-	-	-	-	-	-	-	17	-	-	-	-
3	2.00	SPT	-	-	-	-	0	19	46	35	53	23	30	-	-	-	CH	-	-	-	-	-	-	-	17	-	-	-	-
4	2.50	UDS	1.95	1.55	26.01	2.59	0	9	47	44	59	20	39	9	0.39	71	CH	0.92	2	-	-	TUU	0.13	0.0128	0.42	-	-	0.67	40.3
5	3.00	SPT	-	-	-	-	0	11	52	37	57	23	34	-	-	-	CH	-	-	-	-	-	-	-	22	-	-	-	-
6	3.50	UDS	1.98	1.58	24.93	2.62	0	18	50	32	54	25	29	13	0.33	59	CH	1.19	4	-	-	TUU	-	-	-	-	-	0.65	39.5
7	4.00	SPT	-	-	-	-	0	21	48	31	53	26	27	-	-	-	CH	-	-	-	-	-	-	-	23	-	-	-	-
8	4.50	UDS	2.00	1.61	23.95	2.63	0	25	65	10	28	19	9	-	-	-	CL	1.25	5	-	-	TUU	0.12	0.0051	1.09	-	-	0.63	38.7
9	5.00	SPT	-	-	-	-	0	10	46	44	59	21	38	-	-	-	CH	-	-	-	-	-	-	-	54	-	-	-	-
10	5.50	UDS	2.05	1.70	20.72	2.62	0	16	53	31	53	25	28	-	-	-	CH	2.96	5	-	-	TUU	-	-	-	-	-	0.54	35.2
11	6.00	SPT	-	-	-	-	0	26	53	21	37	19	18	-	-	-	CI	-	-	-	-	-	-	-	67	-	-	-	-
12	6.50	UDS	2.09	1.76	18.84	2.63	0	18	58	24	42	20	22	-	-	-	CI	3.52	8	-	-	TUU	0.08	0.0028	3.64	-	-	0.50	33.1
13	7.00	SPT	-	-	-	-	0	30	50	20	36	19	17	-	-	-	CI	-	-	-	-	-	-	-	>100	-	-	-	-
14	8.50	UDS	2.16	1.84	17.24	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	34.7	UCS	-	-	-	-	-	0.47	31.8
15	10.00	UDS	2.34	2.11	10.66	2.73	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	126.9	-	UCS	-	-	-	-	10.00	0.29	22.5
16	11.50	UDS	2.41	2.23	8.08	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	117.4	-	UCS	-	-	-	-	16.00	0.22	18.0
17	13.00	UDS	2.39	2.19	9.19	2.74	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	122.1	UCS	-	-	-	-	-	0.25	20.1
18	14.50	UDS	2.42	2.24	8.22	2.74	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	139.1	-	UCS	-	-	-	-	18.00	0.23	18.4
19	16.00	UDS	2.43	2.26	7.68	2.73	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	156.6	-	UCS	-	-	-	-	30.66	0.21	17.3
20	17.50	UDS	2.38	2.16	9.98	2.76	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	133.9	-	UCS	-	-	-	-	54.66	0.28	21.6
21	19.00	UDS	2.43	2.25	8.14	2.75	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	147.2	-	UCS	-	-	-	-	75.33	0.22	18.3

KCT Consultancy Services LLP, Ahmedabad

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 123

Co-Ordinate :- E 1265, N 2898

Reduced Level :- 85%85 m

Sr No	Depth of Sample	Type of Sample	Field Bulk Density	Field Dry Density	Natural Moisture Content	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit	Swelling Pressure	Free Swell Index	Soil Classification	Shear Parameter		Unconfined Compression Test	UCS by Point Load Index in rock	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation	Void Ratio	Porosity
							Gravel	Sand	Silt	ClayG	Liquid Limit	Plastic Limit	Plasticity Index					Cohesion C	Angle of Internal Friction ϕ				Compression Index C _c	Coefficient of Volume Compressibility mv	Pre-consolidation Pressure				
1	0.00	DS	-	-	-	-	8	19	48	25	43	20	23	-	-	-	CI	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	10	16	52	22	41	22	19	-	-	-	CI	-	-	-	-	-	-	-	-	24	-	-	-
3	2.00	SPT	-	-	-	-	9	21	50	20	40	23	17	-	-	-	CI	-	-	-	-	-	-	-	-	28	-	-	-
4	2.50	UDS	1.97	1.57	25.58	2.62	7	18	51	24	43	21	22	-	-	-	CI	0.95	8	-	-	TUU	0.11	0.0111	0.43	-	-	0.67	40.1
5	3.00	SPT	-	-	-	-	14	46	40	46	20	26	-	-	-	-	SC	-	-	-	-	-	-	-	-	17	-	-	-
6	3.50	UDS	1.98	1.57	26.37	2.67	16	53	31	44	22	22	-	-	-	-	SC	0.03	25	-	-	DSU	-	-	-	-	-	0.70	41.3
7	4.00	SPT	-	-	-	-	0	9	53	38	64	29	35	-	-	-	CH	-	-	-	-	-	-	-	-	23	-	-	-
8	4.50	SPT	-	-	-	-	0	12	53	35	60	30	30	-	-	-	CH	-	-	-	-	-	-	-	-	43	-	-	-
9	5.00	SPT	-	-	-	-	0	11	52	37	61	29	32	-	-	-	CH	-	-	-	-	-	-	-	-	69	-	-	-
10	5.50	SPT	-	-	-	-	0	18	56	26	47	25	22	-	-	-	CI	-	-	-	-	-	-	-	-	74	-	-	-
11	6.00	SPT	-	-	-	-	0	21	57	22	43	23	20	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-
12	6.50	SPT	-	-	-	-	0	19	55	26	45	22	23	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-
13	7.00	SPT	-	-	-	-	0	12	45	43	66	29	37	-	-	-	CH	-	-	-	-	-	-	-	-	>100	-	-	-
14	8.50	UDS	2.27	2.02	12.54	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	81.4	UCS	-	-	-	-	-	0.34	25.3
15	10.00	UDS	2.28	2.01	13.35	2.75	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	99.6	-	UCS	-	-	-	-	7.33	0.37	26.9
16	11.50	UDS	2.35	2.12	11.00	2.76	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	108.4	-	UCS	-	-	-	-	8.00	0.30	23.3
17	13.00	UDS	2.31	2.08	11.27	2.71	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	100.1	UCS	-	-	-	-	-	0.31	23.4
18	14.50	UDS	2.29	2.04	12.25	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	92.3	UCS	-	-	-	-	-	0.33	25.0
19	16.00	UDS	2.34	2.11	10.66	2.73	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	87.8	-	UCS	-	-	-	-	25.33	0.29	22.5
20	17.50	UDS	2.29	2.03	12.73	2.74	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	101.2	-	UCS	-	-	-	-	10.00	0.35	25.9
21	19.00	UDS	2.36	2.15	9.73	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	109.9	-	UCS	-	-	-	-	24.00	0.26	20.9
22	20.50	UDS	2.35	2.14	9.84	2.71	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	100.2	-	UCS	-	-	-	-	66.66	0.27	21.1
23	22.00	UDS	2.31	2.07	11.74	2.73	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	96.5	-	UCS	-	-	-	-	96.00	0.32	24.3

KCT Consultancy Services LLP, Ahmedabad

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 124

Co-Ordinate :- E 860, N 2885

Reduced Level :- 197.52

Sr No	Depth of Sample m	Type of Sample	Field Bulk Density gm / cc	Field Dry Density gm / cc	Natural Moisture Content %	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit	Swelling Pressure Kg/cm ²	Free Swell Index %	Soil Classification	Shear Parameter		Unconfined Compression Test Kg/cm ²	UCS by Point Load Index in rock Kg/cm ²	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation %	Void Ratio	Porosity %	
							Gravel %	Sand %	Silt %	Clay %	Liquid Limit %	Plastic Limit %	Plasticity Index %					Cohesion C Kg/cm ²	Angle of Internal Friction ϕ Degree				Coefficient of Volume Compressibility mv cm ² /kg	Pre-consolidation Pressure kg/cm ²						
1	0.00	DS	-	-	-	-	0	27	49	24	41	19	22	-	-	-	CI	-	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	0	14	43	43	61	23	38	-	-	-	CH	-	-	-	-	-	-	-	-	3	-	-	-	-
3	2.00	SPT	-	-	-	-	0	16	42	42	60	24	36	-	-	-	CH	-	-	-	-	-	-	-	-	6	-	-	-	-
4	2.50	UDS	1.91	1.47	29.78	2.62	0	19	37	44	58	21	37	12	-	61	CH	0.48	4	-	-	TUU	0.18	0.0278	0.40	-	-	0.78	43.8	-
5	3.00	SPT	-	-	-	-	0	18	39	43	61	22	39	-	-	-	CH	-	-	-	-	-	-	-	-	12	-	-	-	-
6	3.50	UDS	1.90	1.45	30.84	2.63	0	22	44	34	57	26	31	13	-	58	CH	0.41	8	-	-	TUU	0.20	0.0260	0.49	-	-	0.81	44.8	-
7	4.00	SPT	-	-	-	-	0	16	44	40	62	25	37	-	-	-	CH	-	-	-	-	-	-	-	-	5	-	-	-	-
8	4.50	SPT	-	-	-	-	0	37	40	23	43	23	20	-	-	-	CI	-	-	-	-	-	-	-	-	10	-	-	-	-
9	5.00	SPT	-	-	-	-	0	33	45	22	37	18	19	-	-	-	CI	-	-	-	-	-	-	-	-	18	-	-	-	-
10	5.50	UDS	1.94	1.51	28.21	2.64	0	28	48	24	40	19	21	18	-	37	CI	0.78	5	-	-	TUU	0.17	0.0126	0.68	-	-	0.74	42.7	-
11	6.00	SPT	-	-	-	-	0	34	38	28	46	22	24	-	-	-	CI	-	-	-	-	-	-	-	-	12	-	-	-	-
12	6.50	UDS	1.97	1.56	26.16	2.64	0	29	37	34	48	18	30	16	-	48	CI	1.28	6	-	-	TUU	0.14	0.0087	0.83	-	-	0.69	40.9	-
13	7.00	SPT	-	-	-	-	0	34	41	25	46	24	22	-	-	-	CI	-	-	-	-	-	-	-	-	37	-	-	-	-
14	7.50	SPT	-	-	-	-	0	68		32	31	22	9	-	-	-	SC	-	-	-	-	-	-	-	-	>100	-	-	-	-
15	8.00	SPT	-	-	-	-	0	64		36	34	21	13	-	-	-	SC	-	-	-	-	-	-	-	-	>100	-	-	-	-
16	8.50	UDS	2.19	1.89	15.62	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	50.1	UCS	-	-	-	-	-	0.42	29.6	-
17	10.00	UDS	2.36	2.15	9.73	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	79.9	-	UCS	-	-	-	-	34.00	0.26	20.9	-
18	11.50	UDS	2.40	2.21	8.63	2.73	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	121.1	-	UCS	-	-	-	-	48.00	0.24	19.1	-
19	13.00	UDS	2.42	2.25	7.77	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	123.4	-	UCS	-	-	-	-	38.00	0.21	17.4	-
20	14.50	UDS	2.41	2.22	8.54	2.74	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	159.6	-	UCS	-	-	-	-	63.00	0.23	19.0	-

UDS - Undisturbed Sample
DS - Disturbed Sample
SPT - Standard Penetration Tests
NP - Non Plastic

TUU - Triaxial Unconsolidated Undrained
TCU - Triaxial Consolidated Undrained
DSU - Direct Shear Test
UCS - Unconfined Compression Strength

KCT Consultancy Services LLP, Ahmedabad

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 126

Co-Ordinate :- E 1180, N 2881

Reduced Level :- 200.68 m

Sr No	Depth of Sample	Type of Sample	Field Bulk Density	Field Dry Density	Natural Moisture Content	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit	Swelling Pressure	Free Swell Index	Soil Classification	Shear Parameter		Unconfined Compression Test	UCS by Point Load Index in rock	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation	Void Ratio	Porosity		
							Gravel	Sand	Silt	Clay	Liquid Limit	Plastic Limit	Plasticity Index					Cohesion C	Angle of Internal Friction ϕ				Compression Index C _c	Coefficient of Volume Compressibility mv	Pre-consolidation Pressure						
																														%	%
1	0.00	DS	-	-	-	-	0	69	31	27	17	10	-	-	-	SC	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
2	1.00	SPT	-	-	-	-	0	21	36	43	59	22	37	12	-	63	CH	-	-	-	-	-	-	-	-	9	-	-	-	-	
3	2.00	SPT	-	-	-	-	0	19	36	45	65	24	41	-	-	-	CH	-	-	-	-	-	-	-	-	9	-	-	-	-	
4	2.50	SPT	-	-	-	-	0	16	38	46	67	25	42	8	-	79	CH	-	-	-	-	-	-	-	-	13	-	-	-	-	
5	3.00	SPT	-	-	-	-	0	19	42	39	62	28	34	-	-	-	CH	-	-	-	-	-	-	-	-	9	-	-	-	-	
6	3.50	UDS	1.91	1.47	29.78	2.62	0	15	38	47	68	25	43	8	0.44	85	CH	0.54	2	-	-	TUU	0.17	0.0213	0.61	-	-	0.78	43.8	-	
7	4.00	SPT	-	-	-	-	0	20	35	45	63	24	39	-	-	-	CH	-	-	-	-	-	-	-	-	10	-	-	-	-	
8	4.50	UDS	1.99	1.59	25.16	2.65	0	66	34	29	16	13	-	-	-	SC	0.10	28	-	-	DSU	-	-	-	-	-	-	0.67	40.0	-	
9	5.00	SPT	-	-	-	-	0	68	32	25	15	10	-	-	-	SC	-	-	-	-	-	-	-	-	-	82	-	-	-	-	
10	5.50	UDS	2.08	1.73	19.92	2.65	0	64	36	31	18	13	-	-	-	SC	0.11	30	-	-	DSU	-	-	-	-	-	-	0.53	34.5	-	
11	6.00	SPT	-	-	-	-	0	27	49	24	42	20	22	-	-	-	CI	-	-	-	-	-	-	-	-	99	-	-	-	-	
12	6.50	UDS	2.10	1.77	18.32	2.63	0	29	44	27	44	19	25	18	0.38	41	CI	4.67	7	-	-	TUU	-	-	-	-	-	-	0.48	32.5	-
13	7.00	SPT	-	-	-	-	0	26	52	22	39	20	19	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-	-	
14	7.50	SPT	-	-	-	-	8	29	51	12	29	19	10	-	-	-	CL	-	-	-	-	-	-	-	-	>100	-	-	-	-	
15	8.00	SPT	-	-	-	-	5	37	48	10	27	18	9	-	-	-	CL	-	-	-	-	-	-	-	-	>100	-	-	-	-	
16	8.50	SPT	-	-	-	-	12	30	46	12	25	14	11	-	-	-	CL	-	-	-	-	-	-	-	-	>100	-	-	-	-	
17	9.50	UDS	2.23	1.95	14.15	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	41.6	UCS	-	-	-	-	-	-	0.38	27.6	-
18	9.50	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-	-	
19	11.00	UDS	2.24	1.97	13.74	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	53.6	UCS	-	-	-	-	-	-	0.37	27.1	-
20	11.00	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-	-	
21	12.50	UDS	2.23	1.96	13.90	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	50.7	UCS	-	-	-	-	-	-	0.37	27.2	-
22	12.50	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-	-	
23	14.00	UDS	2.18	1.88	15.81	2.68	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	41.7	-	UCS	-	-	-	-	-	8.66	0.42	29.8	-
24	15.50	UDS	2.21	1.93	14.75	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	58.6	-	UCS	-	-	-	-	-	14.66	0.40	28.4	-
25	17.00	UDS	2.23	1.95	14.15	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	53.7	-	UCS	-	-	-	-	-	9.33	0.38	27.6	-
26	18.50	UDS	2.25	1.99	12.84	2.68	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	51.8	-	UCS	-	-	-	-	-	14.00	0.34	25.6	-
27	20.00	UDS	2.30	2.06	11.88	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	76.9	-	UCS	-	-	-	-	-	32.00	0.32	24.4	-
28	21.50	UDS	2.35	2.13	10.31	2.73	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	93.1	-	UCS	-	-	-	-	-	17.33	0.28	22.0	-
29	23.00	UDS	2.30	2.05	12.12	2.73	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	96.2	-	UCS	-	-	-	-	-	15.33	0.33	24.9	-
30	24.50	UDS	2.31	2.07	11.51	2.72	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	85.8	-	UCS	-	-	-	-	-	30.66	0.31	23.8	-
31	26.00	UDS	2.29	2.04	12.49	2.73	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	98.7	-	UCS	-	-	-	-	-	87.33	0.34	25.4	-

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 127

Co-Ordinate :- E - 1319, N - 2868

Reduced Level :- 202.28 m

Sr No	Depth of Sample m	Type of Sample	Field Bulk Density gm / cc	Field Dry Density gm / cc	Natural Moisture Content %	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit %	Swelling Pressure Kg/cm ²	Free Swell Index %	Soil Classification	Shear Parameter		Unconfined Compression Test Kg/cm ²	UCS by Point Load Index in rock Kg/cm ²	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation %	Void Ratio	Porosity %
							Gravel %	Sand %	Silt %	Clay %	Liquid Limit %	Plastic Limit %	Plasticity Index %					Cohesion C Kg/cm ²	Angle of Internal Friction ϕ Degree				Compression Index C _c	Coefficient of Volume Compressibility m _v cm ² /kg	Pre-consolidation Pressure kg/cm ²				
1	0.00	DS	-	-	-	-	10	28	37	25	41	20	21	-	-	-	CI	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	8	30	39	23	40	21	19	-	-	-	CI	-	-	-	-	-	-	-	-	4	-	-	-
3	2.00	SPT	-	-	-	-	12	56	32	28	16	12	-	-	-	-	SC	-	-	-	-	-	-	-	-	8	-	-	-
4	2.50	UDS	1.73	1.54	12.43	2.67	9	62	29	25	17	8	-	-	-	-	SC	0.06	24	-	-	DSU	-	-	-	-	-	0.74	42.4
5	3.00	SPT	-	-	-	-	14	52	34	28	18	10	-	-	-	-	SC	-	-	-	-	-	-	-	-	20	-	-	-
6	3.50	UDS	1.99	1.59	25.44	2.66	10	55	35	29	16	13	-	-	-	-	SC	0.08	27	-	-	DSU	-	-	-	-	-	0.68	40.4
7	4.00	SPT	-	-	-	-	0	21	55	24	41	20	21	-	-	-	CI	-	-	-	-	-	-	-	-	31	-	-	-
8	4.50	UDS	2.07	1.73	19.90	2.63	0	19	55	26	44	22	22	-	-	-	CI	1.69	5	-	-	TUU	0.09	0.0062	3.16	-	-	0.52	34.4
9	5.00	SPT	-	-	-	-	0	24	58	18	39	23	16	-	-	-	CI	-	-	-	-	-	-	-	-	36	-	-	-
10	5.50	UDS	2.09	1.76	18.56	2.62	0	17	54	29	45	19	26	-	-	-	CI	1.96	5	-	-	TUU	0.08	0.0057	2.34	-	-	0.49	32.7
11	6.00	SPT	-	-	-	-	0	19	58	23	42	22	20	-	-	-	CI	-	-	-	-	-	-	-	-	46	-	-	-
12	6.50	SPT	-	-	-	-	0	21	60	19	40	23	17	-	-	-	CI	-	-	-	-	-	-	-	-	77	-	-	-
13	7.00	SPT	-	-	-	-	0	18	58	24	41	20	21	-	-	-	CI	-	-	-	-	-	-	-	-	52	-	-	-
14	7.50	SPT	-	-	-	-	0	23	55	22	39	19	20	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-
15	8.00	SPT	-	-	-	-	0	21	54	25	41	20	21	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-
16	8.50	SPT	-	-	-	-	0	26	54	20	38	21	17	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-
17	9.00	SPT	-	-	-	-	0	17	54	29	47	20	27	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-
18	9.50	SPT	-	-	-	-	0	21	58	21	41	22	19	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-
19	10.00	SPT	-	-	-	-	0	15	58	27	48	23	25	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-
20	11.00	SPT	-	-	-	-	0	22	49	29	46	21	25	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-
21	11.50	SPT	-	-	-	-	0	20	58	22	42	23	19	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-
22	12.50	UDS	2.30	2.06	11.40	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	133.5	UCS	-	-	-	-	-	0.31	23.5
23	12.50	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-
24	14.00	UDS	2.33	2.10	10.78	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	159.1	UCS	-	-	-	-	-	0.29	22.7
25	14.00	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-
26	15.50	UDS	2.29	2.05	11.77	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	132.4	-	UCS	-	-	-	-	11.33	0.32	24.1
27	17.00	UDS	2.32	2.09	10.90	2.71	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	100.9	UCS	-	-	-	-	-	0.30	22.8
28	18.50	UDS	2.34	2.11	10.89	2.74	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	136.9	-	UCS	-	-	-	-	26.66	0.30	23.0
29	20.00	UDS	2.36	2.13	10.66	2.76	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	142.2	-	UCS	-	-	-	-	42.66	0.29	22.7
30	21.50	UDS	2.46	2.28	7.67	2.77	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	186.5	-	UCS	-	-	-	-	53.33	0.21	17.5
31	23.00	UDS	2.43	2.26	7.68	2.73	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	148.4	-	UCS	-	-	-	-	15.33	0.21	17.3
32	24.50	UDS	2.39	2.18	9.64	2.76	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	206.6	-	UCS	-	-	-	-	77.33	0.27	21.0

KCT Consultancy Services LLP, Ahmedabad

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 129

Co-Ordinate :- E 1128, N 2880

Reduced Level :- 200.() m

Sr No	Depth of Sample	Type of Sample	Field Bulk Density	Field Dry Density	Natural Moisture Content	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit	Swelling Pressure	Free Swell Index	Soil Classification	Shear Parameter		Unconfined Compression Test	UCS by Point Load Index in rock	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation	Void Ratio	Porosity	
							Gravel	Sand	Silt	Clay	Liquid Limit	Plastic Limit	Plasticity Index					Cohesion C	Angle of Internal Friction ϕ				Compression Index C _c	Coefficient of Volume Compressibility mv	Pre-consolidation Pressure					
																														%
1	0.00	DS	-	-	-	-	0	29	45	26	43	20	23	-	-	-	CI	-	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	0	34	46	20	39	21	18	-	-	-	CI	-	-	-	-	-	-	-	-	19	-	-	-	-
3	2.00	SPT	-	-	-	-	0	22	43	35	57	26	31	-	-	-	CH	-	-	-	-	-	-	-	-	30	-	-	-	-
4	2.50	UDS	2.08	1.75	19.08	2.62	0	29	41	30	54	27	27	-	-	-	CH	1.57	6	-	-	UCS	-	-	-	-	-	0.50	33.3	-
5	3.00	SPT	-	-	-	-	15	49	36		48	25	23	-	-	-	SC	-	-	-	-	-	-	-	-	61	-	-	-	-
6	3.50	UDS	2.01	1.63	23.34	2.63	0	31	34	35	57	27	30	-	-	-	CH	1.47	7	-	-	UCS	0.10	0.0077	0.58	-	-	0.61	38.0	-
7	4.00	SPT	-	-	-	-	0	29	32	39	63	29	34	-	-	-	CH	-	-	-	-	-	-	-	-	18	-	-	-	-
8	4.50	UDS	1.98	1.59	24.63	2.61	0	21	35	44	69	30	39	-	-	-	CH	1.19	5	-	-	TUU	0.11	0.0099	0.72	-	-	0.64	39.1	-
9	5.00	SPT	-	-	-	-	0	22	37	41	65	28	37	-	-	-	CH	-	-	-	-	-	-	-	-	25	-	-	-	-
10	5.50	UDS	2.04	1.67	21.85	2.64	0	31	34	35	58	26	32	-	-	-	CH	1.34	6	-	-	TUU	0.10	0.0083	0.94	-	-	0.58	36.6	-
11	6.00	SPT	-	-	-	-	0	63	37		31	16	15	-	-	-	SC	-	-	-	-	-	-	-	-	25	-	-	-	-
12	6.50	SPT	-	-	-	-	0	71	29		26	15	11	-	-	-	SC	-	-	-	-	-	-	-	-	26	-	-	-	-
13	7.00	SPT	-	-	-	-	0	68	32		28	16	12	-	-	-	SC	-	-	-	-	-	-	-	-	21	-	-	-	-
14	7.50	SPT	-	-	-	-	0	65	35		30	14	16	-	-	-	SC	-	-	-	-	-	-	-	-	33	-	-	-	-
15	8.00	SPT	-	-	-	-	0	33	46	21	39	20	19	-	-	-	CI	-	-	-	-	-	-	-	-	26	-	-	-	-
16	8.50	SPT	-	-	-	-	0	27	49	24	43	22	21	-	-	-	CI	-	-	-	-	-	-	-	-	40	-	-	-	-
17	9.00	SPT	-	-	-	-	0	28	51	21	42	23	19	-	-	-	CI	-	-	-	-	-	-	-	-	31	-	-	-	-
18	9.50	SPT	-	-	-	-	0	32	45	23	40	21	19	-	-	-	CI	-	-	-	-	-	-	-	-	44	-	-	-	-
19	10.00	SPT	-	-	-	-	0	69	31		29	16	13	-	-	-	SC	-	-	-	-	-	-	-	-	45	-	-	-	-
20	11.00	SPT	-	-	-	-	0	24	52	24	43	21	22	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-	-
21	11.50	SPT	-	-	-	-	0	29	49	22	41	22	19	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-	-
22	13.00	UDS	2.14	1.82	17.67	2.68	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	59.3	UCS	-	-	-	-	-	0.47	32.1	-
23	14.50	UDS	2.16	1.85	16.99	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	51.8	UCS	-	-	-	-	-	0.46	31.4	-
24	16.00	UDS	2.12	1.79	18.66	2.68	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	64.1	UCS	-	-	-	-	-	0.50	33.3	-
25	17.50	UDS	2.28	2.02	12.64	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	87.7	-	UCS	-	-	-	-	14.00	0.34	25.6	-
26	19.00	UDS	2.31	2.06	11.98	2.74	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	99.5	-	UCS	-	-	-	-	88.00	0.33	24.7	-

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 130

Co-Ordinate :- E - 1248, N - 2855

Reduced Level :- 201.08 m

Sr No	Depth of Sample m	Type of Sample	Field Bulk Density gm / cc	Field Dry Density gm / cc	Natural Moisture Content %	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit %	Swelling Pressure Kg/cm ²	Free Swell Index %	Soil Classification	Shear Parameter		Unconfined Compression Test Kg/cm ²	UCS by Point Load Index in rock Kg/cm ²	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation %	Void Ratio	Porosity %
							Gravel %	Sand %	Silt %	Clay %	Liquid Limit %	Plastic Limit %	Plasticity Index %					Cohesion C Kg/cm ²	Angle of Internal Friction ϕ Degree				Compression Index C _c	Coefficient of Volume Compressibility m _v cm ² /kg	Pre-consolidation Pressure kg/cm ²				
1	0.00	DS	-	-	-	-	0	36	51	13	28	16	12	-	-	-	CL	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	5	31	38	26	40	18	22	-	-	-	CI	-	-	-	-	-	-	-	-	9	-	-	-
3	2.00	SPT	-	-	-	-	21	52		27	24	14	10	-	-	-	SC	-	-	-	-	-	-	-	-	21	-	-	-
4	2.50	UDS	2.02	1.63	23.87	2.67	17	44	39		29	16	13	-	-	-	SC	0.08	27	-	-	DSU	-	-	-	-	-	0.64	38.9
5	3.00	SPT	-	-	-	-	16	49	35		28	17	11	-	-	-	SC	-	-	-	-	-	-	-	-	18	-	-	-
6	3.50	UDS	2.00	1.61	24.53	2.65	12	29	33	26	43	20	23	-	-	-	CI	0.96	8	-	-	TUU	0.11	0.0105	0.63	-	-	0.65	39.4
7	4.00	SPT	-	-	-	-	20	24	39	17	36	21	15	-	-	-	CI	-	-	-	-	-	-	-	-	41	-	-	-
8	4.50	UDS	2.09	1.74	19.93	2.67	15	30	34	21	40	22	18	-	-	-	CI	2.22	9	-	-	TUU	-	-	-	-	-	0.53	34.7
9	5.00	SPT	-	-	-	-	0	68	32		29	16	13	-	-	-	SC	-	-	-	-	-	-	-	-	>100	-	-	-
10	5.50	UDS	2.10	1.76	19.14	2.66	0	59	41		32	18	14	-	-	-	SC	0.19	29	-	-	DSU	-	-	-	-	-	0.51	33.7
11	6.00	SPT	-	-	-	-	0	71	29		27	16	11	-	-	-	SC	-	-	-	-	-	-	-	-	>100	-	-	-
12	6.50	UDS	2.15	1.84	16.67	2.66	0	66	34		30	14	16	-	-	-	SC	0.16	30	-	-	DSU	-	-	-	-	-	0.44	30.7
13	7.00	SPT	-	-	-	-	0	17	63	20	32	15	17	-	-	-	CL	-	-	-	-	-	-	-	-	>100	-	-	-
14	7.50	SPT	-	-	-	-	0	23	62	15	30	17	13	-	-	-	CL	-	-	-	-	-	-	-	-	>100	-	-	-
15	8.00	SPT	-	-	-	-	0	36	51	13	29	18	11	-	-	-	CL	-	-	-	-	-	-	-	-	>100	-	-	-
16	8.50	SPT	-	-	-	-	0	37	52	11	27	17	10	-	-	-	CL	-	-	-	-	-	-	-	-	>100	-	-	-
17	9.00	SPT	-	-	-	-	0	28	56	16	29	15	14	-	-	-	CL	-	-	-	-	-	-	-	-	>100	-	-	-
18	10.50	UDS	2.31	2.08	11.27	2.71	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	126.3	UCS	-	-	-	-	-	0.31	23.4
19	10.50	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-
20	12.00	UDS	2.29	2.04	12.49	2.73	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	111.7	-	UCS	-	-	-	-	6.66	0.34	25.4
21	13.50	UDS	2.45	2.28	7.52	2.75	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	157.2	-	UCS	-	-	-	-	32.00	0.21	17.1
22	15.00	UDS	2.39	2.19	9.19	2.74	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	126.9	-	UCS	-	-	-	-	8.66	0.25	20.1
23	16.50	UDS	2.43	2.26	7.46	2.72	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	189.9	-	UCS	-	-	-	-	16.00	0.20	16.9
24	18.00	UDS	2.46	2.31	6.32	2.71	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	164.6	-	UCS	-	-	-	-	39.33	0.17	14.6
25	20.00	UDS	2.44	2.28	7.15	2.72	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	243.9	-	UCS	-	-	-	-	67.33	0.19	16.3
26	21.00	UDS	2.42	2.25	7.77	2.72	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	209.7	-	UCS	-	-	-	-	84.66	0.21	17.4

KCT Consultancy Services LLP, Ahmedabad

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 131

Co-Ordinate :- E 912, N 2848

Reduced Level :- 197.8 m

Sr No	Depth of Sample	Type of Sample	Field Bulk Density	Field Dry Density	Natural Moisture Content	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit	Swelling Pressure	Free Swell Index	Soil Classification	Shear Parameter		Unconfined Compression Test	UCS by Point Load Index in rock	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation	Void Ratio	Porosity		
							Gravel	Sand	Silt	Clay	Liquid Limit	Plastic Limit	Plasticity Index					Cohesion C	Angle of Internal Friction ϕ				Compression Index C _c	Coefficient of Volume Compressibility mv	Pre-consolidation Pressure						
																														%	%
1	0.00	DS	-	-	-	-	0	17	60	23	41	20	21	-	-	-	CI	-	-	-	-	-	-	-	-	-	-	-	-		
2	1.00	SPT	-	-	-	-	0	9	48	43	69	30	39	-	-	-	CH	-	-	-	-	-	-	-	5	-	-	-	-		
3	2.00	SPT	-	-	-	-	0	9	40	51	72	28	44	-	-	-	CH	-	-	-	-	-	-	-	7	-	-	-	-		
4	2.50	UDS	1.90	1.46	30.23	2.61	0	21	43	36	61	29	32	9	0.37	67	CH	0.37	3	-	-	TUU	0.18	0.0304	0.41	-	-	0.79	44.1		
5	3.00	SPT	-	-	-	-	0	14	46	40	63	28	35	-	-	-	CH	-	-	-	-	-	-	-	7	-	-	-	-		
6	3.50	UDS	1.91	1.48	29.16	2.60	0	20	43	37	58	27	31	12	0.36	58	CH	0.55	2	-	-	TUU	0.16	0.0208	0.63	-	-	0.76	43.1		
7	4.00	SPT	-	-	-	-	0	16	48	36	59	29	30	-	-	-	CH	-	-	-	-	-	-	-	-	12	-	-	-	-	
8	4.50	SPT	-	-	-	-	0	70	30	48	23	25	-	-	-	-	SC	-	-	-	-	-	-	-	-	45	-	-	-	-	
9	5.00	SPT	-	-	-	-	0	67	33	44	22	22	-	-	-	-	SC	-	-	-	-	-	-	-	-	90	-	-	-	-	
10	5.50	SPT	-	-	-	-	0	65	35	43	24	19	-	-	-	-	SC	-	-	-	-	-	-	-	-	>100	-	-	-	-	
11	6.00	SPT	-	-	-	-	0	68	32	40	20	20	-	-	-	-	SC	-	-	-	-	-	-	-	-	-	>100	-	-	-	-
12	6.50	SPT	-	-	-	-	0	72	28	39	23	16	-	-	-	-	SC	-	-	-	-	-	-	-	-	-	>100	-	-	-	-
13	7.00	SPT	-	-	-	-	0	26	42	32	56	27	29	-	-	-	CH	-	-	-	-	-	-	-	-	-	>100	-	-	-	-
14	8.50	UDS	2.23	1.96	13.90	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	60.4	-	UCS	-	-	-	-	-	8.67	0.37	27.2	
15	10.00	UDS	2.31	2.07	11.51	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	91.6	UCS	-	-	-	-	-	-	0.31	23.8	
16	11.50	UDS	2.30	2.06	11.64	2.71	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	106.6	UCS	-	-	-	-	-	-	0.32	24.0	
17	13.00	UDS	2.26	1.98	13.90	2.74	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	99.4	UCS	-	-	-	-	-	-	0.38	27.6	
18	14.50	UDS	2.69	2.64	1.92	2.78	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	349.8	UCS	-	-	-	-	-	-	0.05	5.1	
19	16.00	UDS	2.46	2.31	6.32	2.71	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	151.2	UCS	-	-	-	-	-	-	0.17	14.6	
20	17.50	UDS	2.64	2.56	3.28	2.79	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	352.4	UCS	-	-	-	-	-	-	0.09	8.4	
21	19.00	UDS	2.70	2.66	1.69	2.78	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	384.0	-	UCS	-	-	-	-	-	54.00	0.05	4.5	

KCT Consultancy Services LLP, Ahmedabad

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 134

Co-Ordinate :- E 1209, N 2839

Reduced Level :- 200.95 m

Sr No	Depth of Sample	Type of Sample	Field Bulk Density	Field Dry Density	Natural Moisture Content	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit	Swelling Pressure	Free Swell Index	Soil Classification	Shear Parameter		Unconfined Compression Test	UCS by Point Load Index in rock	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation	Void Ratio	Porosity		
							Gravel	Sand	Silt	Clay	Liquid Limit	Plastic Limit	Plasticity Index					Cohesion C	Angle of Internal Friction ϕ				Compression Index C _c	Coefficient of Volume Compressibility mv	Pre-consolidation Pressure						
																														%	%
1	0.00	DS	-	-	-	-	0	29	45	26	44	21	23	-	-	-	CI	-	-	-	-	-	-	-	-	-	-	-	-	-	
2	1.00	SPT	-	-	-	-	0	9	49	42	64	28	36	-	-	-	CH	-	-	-	-	-	-	-	-	16	-	-	-	-	
3	2.00	SPT	-	-	-	-	0	12	52	36	62	29	33	-	-	-	CH	-	-	-	-	-	-	-	-	12	-	-	-	-	
4	2.50	UDS	1.97	1.57	25.87	2.63	0	28	53	19	40	23	17	-	-	-	CI	0.67	5	-	-	TUU	0.11	0.0133	0.42	-	-	0.68	40.5		
5	3.00	SPT	-	-	-	-	0	10	53	37	61	29	32	-	-	-	CH	-	-	-	-	-	-	-	-	14	-	-	-	-	
6	3.50	SPT	-	-	-	-	0	18	55	27	44	20	24	-	-	-	CI	-	-	-	-	-	-	-	-	26	-	-	-	-	
7	4.00	SPT	-	-	-	-	0	27	47	26	43	21	22	-	-	-	CI	-	-	-	-	-	-	-	-	17	-	-	-	-	
8	4.50	SPT	-	-	-	-	0	32	49	19	39	23	16	-	-	-	CI	-	-	-	-	-	-	-	-	30	-	-	-	-	
9	5.00	SPT	-	-	-	-	0	30	46	24	40	20	20	-	-	-	CI	-	-	-	-	-	-	-	-	42	-	-	-	-	
10	5.50	SPT	-	-	-	-	0	29	47	24	43	21	22	-	-	-	CI	-	-	-	-	-	-	-	-	48	-	-	-	-	
11	6.00	SPT	-	-	-	-	0	31	49	20	40	23	17	-	-	-	CI	-	-	-	-	-	-	-	-	51	-	-	-	-	
12	6.50	SPT	-	-	-	-	0	34	45	21	38	20	18	-	-	-	CI	-	-	-	-	-	-	-	-	84	-	-	-	-	
13	7.00	SPT	-	-	-	-	0	30	57	13	28	16	12	-	-	-	CL	-	-	-	-	-	-	-	-	82	-	-	-	-	
14	7.50	SPT	-	-	-	-	0	29	54	17	29	14	15	-	-	-	CL	-	-	-	-	-	-	-	-	85	-	-	-	-	
15	8.00	SPT	-	-	-	-	0	36	52	12	26	16	10	-	-	-	CL	-	-	-	-	-	-	-	-	>100	-	-	-	-	
16	8.50	SPT	-	-	-	-	0	33	50	17	31	15	16	-	-	-	CL	-	-	-	-	-	-	-	-	>100	-	-	-	-	
17	10.00	UDS	2.35	2.15	9.12	2.68	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	93.9	-	UCS	-	-	-	-	-	30.00	0.24	19.6	
18	11.50	UDS	2.29	2.05	11.77	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	86.1	UCS	-	-	-	-	-	-	0.32	24.1	
19	13.00	UDS	2.30	2.06	11.64	2.71	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	83.6	-	UCS	-	-	-	-	-	14.00	0.32	24.0	
20	14.50	UDS	2.32	2.08	11.38	2.73	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	91.5	-	UCS	-	-	-	-	-	10.00	0.31	23.7	
21	16.00	UDS	2.27	2.02	12.54	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	89.6	UCS	-	-	-	-	-	-	0.34	25.3	
22	17.50	UDS	2.51	2.38	5.56	2.74	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	149.8	UCS	-	-	-	-	-	-	0.15	13.2	
23	19.00	UDS	2.54	2.42	4.96	2.75	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	136.5	UCS	-	-	-	-	-	-	0.14	12.0	
24	20.50	UDS	2.27	2.00	13.27	2.73	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	81.3	-	UCS	-	-	-	-	-	9.00	0.36	26.6	
25	22.00	UDS	2.54	2.43	4.74	2.74	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	116.2	-	UCS	-	-	-	-	-	7.00	0.13	11.5	
26	23.50	UDS	2.57	2.47	4.17	2.75	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	129.0	-	UCS	-	-	-	-	-	62.00	0.11	10.3	
27	25.00	UDS	2.34	2.12	10.43	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	84.7	-	UCS	-	-	-	-	-	26.00	0.28	22.1	
28	26.50	UDS	2.31	2.06	11.98	2.74	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	90.5	-	UCS	-	-	-	-	-	92.00	0.33	24.7	

KCT Consultancy Services LLP, Ahmedabad

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 135

Co-Ordinate :- E 1150, N 2851

Reduced Level :- 200.55 m

Sr No	Depth of Sample	Type of Sample	Field Bulk Density	Field Dry Density	Natural Moisture Content	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit	Swelling Pressure	Free Swell Index	Soil Classification	Shear Parameter		Unconfined Compression Test	UCS by Point Load Index in rock	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation	Void Ratio	Porosity		
							Gravel	Sand	Silt	Clay	Liquid Limit	Plastic Limit	Plasticity Index					Cohesion C	Angle of Internal Friction ϕ				Compression Index C _c	Coefficient of Volume Compressibility mv	Pre-consolidation Pressure						
																														%	%
1	0.00	DS	-	-	-	-	0	26	51	23	38	18	20	-	-	-	CI	-	-	-	-	-	-	-	-	-	-	-	-	-	
2	1.00	SPT	-	-	-	-	0	23	51	26	42	19	23	-	-	-	CI	-	-	-	-	-	-	-	-	11	-	-	-	-	
3	2.00	SPT	-	-	-	-	0	27	52	21	39	21	18	20	-	36	CI	-	-	-	-	-	-	-	-	10	-	-	-	-	
4	2.50	UDS	1.93	1.51	28.01	2.61	0	19	33	48	69	26	43	8	0.48	87	CH	0.75	3	-	-	TUU	0.15	0.0149	0.42	-	-	0.73	42.2		
5	3.00	SPT	-	-	-	-	0	21	31	48	68	27	41	-	-	-	CH	-	-	-	-	-	-	-	-	18	-	-	-	-	
6	3.50	UDS	1.97	1.56	26.45	2.65	0	34	46	20	37	20	17	19	0.13	32	CI	0.96	7	-	-	TUU	0.13	0.0096	0.52	-	-	0.70	41.2		
7	4.00	SPT	-	-	-	-	0	29	49	22	39	19	20	-	-	-	CI	-	-	-	-	-	-	-	-	19	-	-	-	-	
8	4.50	UDS	1.98	1.58	25.22	2.63	0	27	51	22	41	22	19	-	-	-	CI	1.24	4	-	-	TUU	0.12	0.0095	0.61	-	-	0.66	39.9		
9	5.00	SPT	-	-	-	-	0	31	36	33	52	23	29	-	-	-	CI	-	-	-	-	-	-	-	-	29	-	-	-	-	
10	5.50	UDS	2.04	1.68	21.29	2.62	0	20	42	38	54	21	33	-	-	-	CH	1.92	2	-	-	TUU	0.09	0.0058	2.09	-	-	0.56	35.8		
11	6.00	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-	-	
12	6.50	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-	-	
13	7.00	UDS	2.21	1.92	15.00	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	43.6	UCS	-	-	-	-	-	0.40	28.8		
14	8.50	UDS	2.19	1.89	16.12	2.71	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	36.9	UCS	-	-	-	-	-	0.44	30.4		
15	8.50	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-	-	
16	10.00	UDS	2.16	1.85	16.99	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	51.7	UCS	-	-	-	-	-	0.46	31.4		
17	10.00	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-	-	
18	11.50	UDS	2.24	1.97	13.74	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	54.4	UCS	-	-	-	-	-	0.37	27.1		
19	11.50	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-	-	
20	13.00	UDS	2.29	2.05	11.77	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	61.9	-	UCS	-	-	-	-	-	8.66	0.32	24.1	
21	13.00	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-	-	
22	14.50	UDS	2.24	1.96	14.23	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	58.9	UCS	-	-	-	-	-	0.39	27.9		
23	16.00	UDS	2.26	2.00	13.18	2.71	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	61.3	UCS	-	-	-	-	-	0.36	26.3		
24	17.50	UDS	2.31	2.07	11.74	2.73	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	95.1	-	UCS	-	-	-	-	13.33	0.32	24.3		
25	19.00	UDS	2.38	2.17	9.52	2.74	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	152.2	-	UCS	-	-	-	-	6.66	0.26	20.7		
26	20.50	UDS	2.39	2.18	9.64	2.76	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	157.1	-	UCS	-	-	-	-	90.00	0.27	21.0		

UDS - Undisturbed Sample
DS - Disturbed Sample
SPT - Standard Penetration Tests
NP - Non Plastic

TUU - Triaxial Unconsolidated Undrained
TCU - Triaxial Consolidated Undrained
DSU - Direct Shear Test
UCS - Unconfined Compression Strength

KCT Consultancy Services LLP, Ahmedabad

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 137

Co-Ordinate :- E 952, N 2825

Reduced Level :- 198.35

Sr No	Depth of Sample m	Type of Sample	Field Bulk Density gm / cc	Field Dry Density gm / cc	Natural Moisture Content %	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit %	Swelling Pressure Kg/cm ²	Free Swell Index %	Soil Classification	Shear Parameter		Unconfined Compression Test Kg/cm ²	UCS by Point Load Index in rock Kg/cm ²	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation %	Void Ratio	Porosity %
							Gravel %	Sand %	Silt %	Clay %	Liquid Limit %	Plastic Limit %	Plasticity Index %					Cohesion C Kg/cm ²	Angle of Internal Friction ϕ Degree				Compression Index C _c	Coefficient of Volume Compressibility mv cm ² /kg	Pre-consolidation Pressure kg/cm ²				
1	0.00	DS	-	-	-	-	0	31	57	12	27	16	11	-	-	-	CL	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	0	15	45	40	56	21	35	12	-	58	CH	-	-	-	-	-	-	-	-	7	-	-	-
3	2.00	SPT	-	-	-	-	0	16	48	36	54	23	31	-	-	-	CH	-	-	-	-	-	-	-	-	7	-	-	-
4	2.50	UDS	1.89	1.43	31.92	2.64	0	64	36		43	24	19	-	-	-	SC	0.10	24	-	-	DSU	-	-	-	-	-	0.84	45.7
5	3.00	SPT	-	-	-	-	0	20	41	39	54	20	34	-	-	-	CH	-	-	-	-	-	-	-	-	11	-	-	-
6	3.50	UDS	1.93	1.50	28.32	2.62	0	24	44	32	52	24	28	14	0.34	53	CH	0.51	6	-	-	TUU	0.17	0.0208	0.50	-	-	0.74	42.6
7	4.00	SPT	-	-	-	-	0	16	46	38	57	23	34	-	-	-	CH	-	-	-	-	-	-	-	-	10	-	-	-
8	4.50	UDS	1.94	1.52	27.31	2.61	0	17	47	36	56	25	31	12	0.37	59	CH	0.53	4	-	-	TUU	0.15	0.0208	0.59	-	-	0.71	41.6
9	5.00	SPT	-	-	-	-	0	11	47	42	58	23	35	-	-	-	CH	-	-	-	-	-	-	-	-	11	-	-	-
10	5.50	UDS	1.97	1.56	26.16	2.64	0	29	50	21	42	24	18	19	0.15	34	CI	0.64	8	-	-	TUU	0.14	0.0140	0.67	-	-	0.69	40.9
11	6.00	SPT	-	-	-	-	0	33	49	18	41	25	16	-	-	-	CI	-	-	-	-	-	-	-	-	16	-	-	-
12	6.50	SPT	-	-	-	-	0	25	40	35	59	27	32	-	-	-	CH	-	-	-	-	-	-	-	-	12	-	-	-
13	7.00	SPT	-	-	-	-	0	20	31	49	64	21	43	-	-	-	CH	-	-	-	-	-	-	-	-	16	-	-	-
14	7.50	UDS	1.99	1.60	24.58	2.63	0	18	26	56	67	19	48	9	0.51	102	CH	0.74	2	-	-	TUU	0.12	0.0155	1.01	-	-	0.65	39.3
15	8.00	SPT	-	-	-	-	0	21	37	42	63	25	38	-	-	-	CH	-	-	-	-	-	-	-	-	13	-	-	-
16	8.50	SPT	-	-	-	-	0	24	34	42	59	22	37	-	-	-	CH	-	-	-	-	-	-	-	-	15	-	-	-
17	9.00	SPT	-	-	-	-	0	17	60	23	44	24	20	-	-	-	CI	-	-	-	-	-	-	-	-	30	-	-	-
18	9.50	SPT	-	-	-	-	0	20	55	25	41	20	21	-	-	-	CI	-	-	-	-	-	-	-	-	19	-	-	-
19	10.00	SPT	-	-	-	-	0	15	52	33	53	24	29	-	-	-	CH	-	-	-	-	-	-	-	-	20	-	-	-
20	11.00	SPT	-	-	-	-	0	22	45	33	51	23	28	-	-	-	CH	-	-	-	-	-	-	-	-	>100	-	-	-
21	11.50	SPT	-	-	-	-	0	33	52	15	29	16	13	-	-	-	CL	-	-	-	-	-	-	-	-	>100	-	-	-
22	12.50	UDS	2.21	1.93	14.75	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	48.3	UCS	-	-	-	-	-	0.40	28.4
23	12.50	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-
24	14.00	UDS	2.29	2.04	12.25	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	85.9	UCS	-	-	-	-	-	0.33	25.0
25	14.00	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-
26	15.50	UDS	2.30	2.06	11.64	2.71	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	101.5	UCS	-	-	-	-	-	0.32	24.0
27	15.50	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-
28	17.00	UDS	2.24	1.96	14.47	2.73	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	89.8	-	UCS	-	-	-	-	38.00	0.40	28.3
29	18.50	UDS	2.36	2.15	9.73	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	55.7	-	UCS	-	-	-	-	26.00	0.26	20.9
30	20.00	UDS	2.37	2.16	9.63	2.73	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	91.6	-	UCS	-	-	-	-	90.00	0.26	20.8

UDS - Undisturbed Sample

DS - Disturbed Sample

SPT - Standard Penetration Tests

NP - Non Plastic

TUU - Triaxial Unconsolidated Undrained

TCU - Triaxial Consolidated Undrained

DSU - Direct Shear Test

UCS - Unconfined Compression Strength

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- 139

Co-Ordinate :- E - 1337, N - 2828

Reduced Level :- 202.56 m

Sr No	Depth of Sample	Type of Sample	Field Bulk Density	Field Dry Density	Natural Moisture Content	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit	Swelling Pressure	Free Swell Index	Soil Classification	Shear Parameter		Unconfined Compression Test	UCS by Point Load Index in rock	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation	Void Ratio	Porosity	
							Gravel	Sand	Silt	Clay	Liquid Limit	Plastic Limit	Plasticity Index					Cohesion C	Angle of Internal Friction ϕ				Compression Index C _c	Coefficient of Volume Compressibility m _v	Pre-consolidation Pressure					
																														%
1	0.00	DS	-	-	-	-	18	61	21	23	15	8	-	-	-	SC	-	-	-	-	-	-	-	-	-	-	-	-	-	
2	1.00	SPT	-	-	-	-	14	58	28	28	16	12	-	-	-	SC	-	-	-	-	-	-	-	-	7	-	-	-	-	
3	2.00	SPT	-	-	-	-	17	53	30	30	15	15	-	-	-	SC	-	-	-	-	-	-	-	-	10	-	-	-	-	
4	2.50	UDS	1.96	1.54	27.12	2.65	11	51	38	32	18	14	-	-	-	SC	0.07	24	-	-	DSU	-	-	-	-	-	0.72	41.8	-	
5	3.00	SPT	-	-	-	-	18	58	24	26	16	10	-	-	-	SC	-	-	-	-	-	-	-	-	28	-	-	-	-	
6	3.50	UDS	2.01	1.63	23.05	2.62	1	24	55	20	41	23	18	-	-	-	CI	1.53	5	-	-	TUU	0.10	0.0060	1.10	-	-	0.60	37.7	-
7	4.00	SPT	-	-	-	-	3	12	57	28	46	21	25	-	-	-	CI	-	-	-	-	-	-	-	-	50	-	-	-	-
8	4.50	UDS	2.09	1.77	18.28	2.61	1	15	59	25	45	22	23	-	-	-	CI	2.76	4	-	-	TUU	-	-	-	-	-	0.48	32.3	-
9	5.00	SPT	-	-	-	-	0	17	61	22	43	23	20	-	-	-	CI	-	-	-	-	-	-	-	-	55	-	-	-	-
10	5.50	UDS	2.11	1.80	16.98	2.60	0	14	59	27	44	20	24	-	-	-	CI	2.94	4	-	-	TUU	-	-	-	-	-	0.44	30.6	-
11	6.00	SPT	-	-	-	-	0	34	42	24	41	19	22	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-	-
12	6.50	SPT	-	-	-	-	0	31	44	25	43	20	23	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-	-
13	7.00	UDS	2.29	2.06	11.28	2.68	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	88.9	UCS	-	-	-	-	-	-	0.30	23.2	-
14	8.50	UDS	2.30	2.08	10.66	2.67	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	76.4	UCS	-	-	-	-	-	-	0.28	22.2	-
15	10.00	UDS	2.39	2.20	8.73	2.72	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	84.2	UCS	-	-	-	-	-	-	0.24	19.2	-
16	11.50	UDS	2.41	2.23	8.31	2.73	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	81.9	UCS	-	-	-	-	-	-	0.23	18.5	-
17	11.50	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	-	>100	-	-	-	-
18	13.00	UDS	2.40	2.20	9.09	2.75	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	99.3	-	UCS	-	-	-	-	-	6.70	0.25	20.0	-
19	13.00	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	-	>100	-	-	-	-
20	14.50	UDS	2.32	2.10	10.66	2.70	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	77.3	UCS	-	-	-	-	-	-	0.29	22.4	-
21	16.00	UDS	2.31	2.07	11.51	2.72	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	88.2	UCS	-	-	-	-	-	-	0.31	23.8	-
22	17.50	UDS	2.36	2.13	10.66	2.76	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	89.4	UCS	-	-	-	-	-	-	0.29	22.7	-
23	19.00	UDS	2.40	2.20	8.86	2.74	-	-	-	-	-	-	-	-	-	ROCK	-	-	105.4	-	UCS	-	-	-	-	-	23.30	0.24	19.5	-
24	20.00	UDS	2.45	2.23	9.68	2.85	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	386.2	-	UCS	-	-	-	-	-	23.00	0.28	21.6	-

KCT Consultancy Services LLP, Ahmedabad

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- IBH 18

Co-Ordinate :- E 1218, N 3266

Reduced Level :- 200.34 m

Sr No	Depth of Sample	Type of Sample	Field Bulk Density	Field Dry Density	Natural Moisture Content	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit	Swelling Pressure	Free Swell Index	Soil Classification	Shear Parameter		Unconfined Compression Test	UCS by Point Load Index in rock	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation	Void Ratio	Porosity	
							Gravel	Sand	Silt	Clay	Liquid Limit	Plastic Limit	Plasticity Index					Cohesion C	Angle of Internal Friction ϕ				Compression Index C _c	Coefficient of Volume Compressibility mv	Pre-consolidation Pressure					
																														%
1	0.00	DS	-	-	-	-	3	66	31	29	16	13	-	-	-	SC	-	-	-	-	-	-	-	-	-	-	-	-	-	
2	1.00	SPT	-	-	-	-	1	28	47	24	42	20	22	-	-	-	CI	-	-	-	-	-	-	-	-	11	-	-	-	
3	2.00	SPT	-	-	-	-	6	23	44	27	44	21	23	-	-	-	CI	-	-	-	-	-	-	-	-	11	-	-	-	
4	2.50	UDS	1.95	1.54	26.92	2.62	2	19	51	28	45	20	25	-	-	-	CI	0.75	3	-	-	TUU	0.15	0.0143	0.43	-	-	0.71	41.4	
5	3.00	SPT	-	-	-	-	4	26	51	19	40	23	17	-	-	-	CI	-	-	-	-	-	-	-	-	17	-	-	-	
6	3.50	UDS	1.98	1.58	25.51	2.64	0	30	54	16	37	22	15	-	-	-	CI	1.07	6	-	-	TUU	-	-	-	-	-	0.67	40.2	
7	4.00	SPT	-	-	-	-	10	14	41	35	53	21	32	-	-	-	CH	-	-	-	-	-	-	-	-	22	-	-	-	
8	4.50	SPT	-	-	-	-	4	9	46	41	57	19	38	-	-	-	CH	-	-	-	-	-	-	-	-	22	-	-	-	
9	5.00	SPT	-	-	-	-	6	16	44	34	52	21	31	-	-	-	CH	-	-	-	-	-	-	-	-	24	-	-	-	
10	5.50	UDS	2.00	1.61	23.95	2.63	2	18	49	31	51	24	27	-	-	-	CH	1.18	3	-	-	TUU	0.13	0.0093	1.93	-	-	0.63	38.7	
11	6.00	SPT	-	-	-	-	5	10	47	38	56	23	33	-	-	-	CH	-	-	-	-	-	-	-	-	20	-	-	-	
12	6.50	SPT	-	-	-	-	8	19	41	32	53	25	28	-	-	-	CH	-	-	-	-	-	-	-	-	21	-	-	-	
13	7.00	SPT	-	-	-	-	2	21	46	31	52	26	26	-	-	-	CH	-	-	-	-	-	-	-	-	19	-	-	-	
14	7.50	UDS	1.99	1.60	24.29	2.62	1	16	44	39	56	22	34	-	-	-	CH	1.06	2	-	-	TUU	-	-	-	-	-	0.64	38.9	
15	8.00	SPT	-	-	-	-	6	24	33	37	54	21	33	-	-	-	CH	-	-	-	-	-	-	-	-	20	-	-	-	
16	8.50	UDS	2.00	1.61	24.53	2.65	0	30	55	15	29	16	13	-	-	-	CL	0.96	8	-	-	TUU	0.12	0.0063	2.03	-	-	0.65	39.4	
17	9.00	SPT	-	-	-	-	0	31	55	14	28	15	13	-	-	-	CL	-	-	-	-	-	-	-	-	21	-	-	-	
18	9.50	UDS	2.02	1.63	23.59	2.66	0	64	36	27	17	10	10	-	-	-	SC	0.09	27	-	-	DSU	-	-	-	-	-	0.63	38.6	
19	10.00	SPT	-	-	-	-	2	69	29	25	16	9	9	-	-	-	SC	-	-	-	-	-	-	-	-	22	-	-	-	
20	11.00	Remoulded	2.05	1.68	21.84	2.66	0	77	23	18	14	4	4	-	-	-	SM	0.00	29	-	-	DSU	-	-	-	-	-	0.58	36.7	
21	11.50	SPT	-	-	-	-	0	76	24	19	15	4	4	-	-	-	SM	-	-	-	-	-	-	-	-	18	-	-	-	
22	13.00	SPT	-	-	-	-	0	82	18	NP	NP	NP	NP	-	-	-	SM	-	-	-	-	-	-	-	-	20	-	-	-	
23	14.50	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-	
24	16.00	UDS	2.18	1.88	16.07	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	30.4	-	UCS	-	-	-	-	-	12.00	0.43	30.2
25	17.50	UDS	2.16	1.85	16.99	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	-	-	0.46	31.4	
26	19.00	UDS	2.21	1.93	14.49	2.68	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	29.6	-	UCS	-	-	-	-	-	8.00	0.39	28.0
27	20.50	UDS	2.30	2.06	11.40	2.70	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	41.7	-	UCS	-	-	-	-	-	30.00	0.31	23.5
28	22.00	UDS	2.28	2.04	11.91	2.69	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	43.6	-	UCS	-	-	-	-	-	20.00	0.32	24.3
29	23.50	UDS	2.29	2.04	12.01	2.71	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	46.5	-	UCS	-	-	-	-	-	80.00	0.33	24.6
30	25.00	UDS	2.28	2.03	12.15	2.70	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	39.4	-	UCS	-	-	-	-	-	56.00	0.33	24.7

UDS - Undisturbed Sample
DS - Disturbed Sample
SPT - Standard Penetration Tests
NP - Non Plastic

TUU - Triaxial Unconsolidated Undrained
TCU - Triaxial Consolidated Undrained
DSU - Direct Shear Test
UCS - Unconfined Compression Strength

KCT Consultancy Services LLP, Ahmedabad

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- IBH 19

Co-Ordinate :- E 1218, N 2964

Reduced Level :- 200.35 m

Sr No	Depth of Sample m	Type of Sample	Field Bulk Density gm / cc	Field Dry Density gm / cc	Natural Moisture Content %	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit %	Swelling Pressure Kg/cm ²	Free Swell Index %	Soil Classification	Shear Parameter		Unconfined Compression Test Kg/cm ²	UCS by Point Load Index in rock Kg/cm ²	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation %	Void Ratio	Porosity %	
							Gravel %	Sand %	Silt %	Clay %	Liquid Limit %	Plastic Limit %	Plasticity Index %					Cohesion C Kg/cm ²	Angle of Internal Friction ϕ Degree				Coefficient of Volume Compressibility mv cm ² /kg	Pre-consolidation Pressure kg/cm ²						
1	0.00	DS	-	-	-	-	0	29	45	26	44	20	24	-	-	-	CI	-	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	0	20	41	39	61	28	33	-	-	-	CH	-	-	-	-	-	-	-	-	25	-	-	-	-
3	2.00	SPT	-	-	-	-	0	11	45	44	64	25	39	-	-	-	CH	-	-	-	-	-	-	-	-	21	-	-	-	-
4	2.50	UDS	1.98	1.58	24.93	2.62	0	19	49	32	56	29	27	14	0.36	53	CH	0.65	3	-	-	TUU	0.10	0.0157	0.51	-	-	0.65	39.5	-
5	3.00	SPT	-	-	-	-	0	23	27	50	68	25	43	-	-	-	CH	-	-	-	-	-	-	-	-	50	-	-	-	-
6	3.50	UDS	2.01	1.64	22.47	2.60	0	9	43	48	73	29	44	8	0.59	91	CH	2.69	1	-	-	TUU	0.08	0.0045	2.16	-	-	0.58	36.9	-
7	4.00	SPT	-	-	-	-	0	34	45	21	38	20	18	-	-	-	CI	-	-	-	-	-	-	-	-	31	-	-	-	-
8	4.50	SPT	-	-	-	-	0	26	50	24	40	19	21	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-	-
9	5.00	SPT	-	-	-	-	0	35	46	19	37	21	16	-	-	-	CI	-	-	-	-	-	-	-	-	>100	-	-	-	-
10	5.50	SPT	-	-	-	-	0	34	59	7	26	20	6	-	-	-	CL	-	-	-	-	-	-	-	-	>100	-	-	-	-
11	6.00	SPT	-	-	-	-	0	29	61	10	28	19	9	-	-	-	CL	-	-	-	-	-	-	-	-	>100	-	-	-	-
12	7.50	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-	-
13	9.00	UDS	2.29	2.04	12.01	2.71	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	82.7	-	UCS	-	-	-	-	18.50	0.33	24.6	-
14	10.50	UDS	2.23	1.96	13.90	2.69	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	51.6	-	UCS	-	-	-	-	42.60	0.37	27.2	-
15	12.00	UDS	2.21	1.93	14.49	2.68	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	52.2	UCS	-	-	-	-	-	0.39	28.0	-
16	13.50	UDS	2.33	2.11	10.30	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	86.6	-	UCS	-	-	-	-	36.00	0.28	21.8	-
17	15.00	UDS	2.37	2.16	9.63	2.73	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	104.9	-	UCS	-	-	-	-	86.00	0.26	20.8	-
18	16.50	UDS	2.36	2.14	10.43	2.75	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	96.8	-	UCS	-	-	-	-	68.66	0.29	22.3	-
19	18.00	UDS	2.37	2.16	9.63	2.73	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	100.9	-	UCS	-	-	-	-	98.60	0.26	20.8	-

KCT Consultancy Services LLP, Ahmedabad

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- IBH 34

Co-Ordinate :- E 1131, N 3266

Reduced Level :- 198.51 m

Sr No	Depth of Sample m	Type of Sample	Field Bulk Density gm / cc	Field Dry Density gm / cc	Natural Moisture Content %	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit %	Swelling Pressure Kg/cm ²	Free Swell Index %	Soil Classification	Shear Parameter		Unconfined Compression Test Kg/cm ²	UCS by Point Load Index in rock Kg/cm ²	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation %	Void Ratio	Porosity %
							Gravel %	Sand %	Silt %	Clay %	Liquid Limit %	Plastic Limit %	Plasticity Index %					Cohesion C Kg/cm ²	Angle of Internal Friction ϕ Degree				Compression Index C _c	Coefficient of Volume Compressibility mv cm ² /kg	Pre-consolidation Pressure kg/cm ²				
1	0.00	DS	-	-	-	-	0	31	55	14	28	15	13	-	-	-	CL	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	0	29	47	24	40	19	21	18	-	36	CI	-	-	-	-	-	-	-	-	9	-	-	-
3	2.00	SPT	-	-	-	-	0	28	47	25	42	20	22	-	-	-	CI	-	-	-	-	-	-	-	-	12	-	-	-
4	2.50	UDS	1.98	1.57	25.80	2.65	0	31	49	20	40	23	17	20	0.14	33	CI	0.66	7	-	-	TUU	0.14	0.0144	0.42	-	-	0.68	40.6
5	3.00	SPT	-	-	-	-	0	28	50	22	41	22	19	-	-	-	CI	-	-	-	-	-	-	-	-	27	-	-	-
6	3.50	DS	-	-	-	-	0	32	51	17	39	24	15	-	-	-	CI	-	-	-	-	-	-	-	-	-	-	-	-
7	4.00	SPT	-	-	-	-	0	19	53	28	52	27	25	-	-	-	CH	-	-	-	-	-	-	-	-	17	-	-	-
8	4.50	UDS	1.99	1.60	24.29	2.62	0	15	52	33	54	25	29	13	0.38	57	CH	0.93	1	-	-	TUU	0.12	0.0120	0.62	-	-	0.64	38.9
9	5.00	SPT	-	-	-	-	0	16	52	32	53	26	27	-	-	-	CH	-	-	-	-	-	-	-	-	30	-	-	-
10	5.50	UDS	2.07	1.73	19.90	2.63	0	20	53	27	51	27	24	-	-	-	CH	1.62	5	-	-	TUU	0.10	0.0067	1.64	-	-	0.52	34.4
11	6.00	SPT	-	-	-	-	0	18	51	31	54	26	28	-	-	-	CH	-	-	-	-	-	-	-	-	31	-	-	-
12	6.50	UDS	2.08	1.75	19.08	2.62	0	17	48	35	55	25	30	12	0.48	59	CH	1.61	4	-	-	TUU	0.09	0.0069	2.15	-	-	0.50	33.3
13	7.00	SPT	-	-	-	-	0	20	52	28	52	27	25	-	-	-	CH	-	-	-	-	-	-	-	-	30	-	-	-
14	7.50	UDS	2.05	1.68	21.84	2.66	0	71	29	28	16	12	-	-	-	-	SC	0.07	25	-	-	DSU	-	-	-	-	-	0.58	36.7
15	8.00	SPT	-	-	-	-	0	64	36	31	15	16	-	-	-	-	SC	-	-	-	-	-	-	-	-	13	-	-	-
16	8.50	UDS	2.03	1.65	22.71	2.65	0	66	34	30	16	14	-	-	-	-	SC	0.10	26	-	-	DSU	-	-	-	-	-	0.60	37.6
17	9.00	SPT	-	-	-	-	0	76	24	24	17	7	-	-	-	-	SM-SC	-	-	-	-	-	-	-	-	26	-	-	-
18	9.50	UDS	2.05	1.68	21.84	2.66	0	71	29	26	20	6	-	-	-	-	SM-SC	0.02	28	-	-	DSU	-	-	-	-	-	0.58	36.7
19	10.00	SPT	-	-	-	-	0	79	21	21	15	6	-	-	-	-	SM-SC	-	-	-	-	-	-	-	-	23	-	-	-
20	11.00	UDS	2.11	1.78	18.36	2.65	0	66	34	25	14	11	-	-	-	-	SC	0.08	26	-	-	DSU	-	-	-	-	-	0.49	32.7
21	11.50	SPT	-	-	-	-	0	65	35	26	13	13	-	-	-	-	SC	-	-	-	-	-	-	-	-	34	-	-	-
22	12.50	DS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	-	-	-	-
23	13.00	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-
24	14.50	DS	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	-	-	-	-
25	14.50	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-
26	16.00	UDS	2.19	1.90	15.36	2.68	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	56.3	UCS	-	-	-	-	-	0.41	29.2
27	17.50	UDS	2.24	1.97	13.49	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	51.7	UCS	-	-	-	-	-	0.36	26.6
28	19.00	UDS	2.25	1.99	13.33	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	38.9	-	UCS	-	-	-	-	17.33	0.36	26.5
29	20.50	UDS	2.20	1.91	15.18	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	34.1	-	UCS	-	-	-	-	13.33	0.41	29.0
30	22.00	UDS	2.18	1.87	16.57	2.71	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	62.9	-	UCS	-	-	-	-	62.00	0.45	31.0
31	23.50	UDS	2.39	2.20	8.73	2.72	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	116.8	-	UCS	-	-	-	-	48.00	0.24	19.2
32	25.00	UDS	2.23	1.94	14.89	2.73	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	61.3	-	UCS	-	-	-	-	24.00	0.41	28.9

UDS - Undisturbed Sample

DS - Disturbed Sample

SPT - Standard Penetration Tests

NP - Non Plastic

TUU - Triaxial Unconsolidated Undrained

TCU - Triaxial Consolidated Undrained

DSU - Direct Shear Test

UCS - Unconfined Compression Strength

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- IBH 35

Co-Ordinate :- E - 1132, N - 3102

Reduced Level :- 198.78 m

Sr No	Depth of Sample m	Type of Sample	Field Bulk Density gm / cc	Field Dry Density gm / cc	Natural Moisture Content %	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit %	Swelling Pressure Kg/cm ²	Free Swell Index %	Soil Classification	Shear Parameter		Unconfined Compression Test Kg/cm ²	UCS by Point Load Index in rock Kg/cm ²	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation %	Void Ratio	Porosity %
							Gravel %	Sand %	Silt %	Clay %	Liquid Limit %	Plastic Limit %	Plasticity Index %					Cohesion C Kg/cm ²	Angle of Internal Friction ϕ Degree				Compression Index C _c	Coefficient of Volume Compressibility m _v cm ² /kg	Pre-consolidation Pressure kg/cm ²				
1	0.00	DS	-	-	-	-	0	56	44		34	18	16	-	-	-	SC	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	0	38	35	27	43	19	24	-	-	-	CI	-	-	-	-	-	-	-	-	5	-	-	-
3	2.00	SPT	-	-	-	-	0	37	32	31	45	17	28	-	-	-	CI	-	-	-	-	-	-	-	-	7	-	-	-
4	2.50	UDS	1.96	1.54	27.12	2.65	0	35	28	37	49	16	33	-	-	-	CI	0.36	6	-	-	TUU	0.15	0.0298	0.43	-	-	0.72	41.8
5	3.00	SPT	-	-	-	-	6	42	27	25	40	18	22	-	-	-	CI	-	-	-	-	-	-	-	-	9	-	-	-
6	3.50	UDS	1.98	1.57	26.09	2.66	2	40	32	26	48	24	24	-	-	-	CI	0.44	8	-	-	TUU	0.14	0.0214	0.56	-	-	0.69	41.0
7	4.00	SPT	-	-	-	-	4	43	31	22	46	26	20	-	-	-	CI	-	-	-	-	-	-	-	-	14	-	-	-
8	4.50	SPT	-	-	-	-	0	41	29	30	46	20	26	-	-	-	CI	-	-	-	-	-	-	-	-	17	-	-	-
9	5.00	SPT	-	-	-	-	0	18	45	37	48	16	32	-	-	-	CI	-	-	-	-	-	-	-	-	30	-	-	-
10	6.00	SPT	-	-	-	-	0	20	53	27	41	18	23	-	-	-	CI	-	-	-	-	-	-	-	-	23	-	-	-
11	6.50	UDS	1.99	1.59	25.16	2.65	0	31	44	25	47	25	22	-	-	-	CI	1.23	6	-	-	TUU	0.13	0.0081	1.38	-	-	0.67	40.0
12	7.50	SPT	-	-	-	-	0	68	32		33	21	12	-	-	-	SC	-	-	-	-	-	-	-	-	17	-	-	-
13	8.00	SPT	-	-	-	-	0	69	31		32	22	10	-	-	-	SC	-	-	-	-	-	-	-	-	13	-	-	-
14	8.50	SPT	-	-	-	-	0	84	16		21	15	6	-	-	-	SM-SC	-	-	-	-	-	-	-	-	14	-	-	-
15	9.00	SPT	-	-	-	-	0	81	19		26	19	7	-	-	-	SM-SC	-	-	-	-	-	-	-	-	17	-	-	-
16	9.50	SPT	-	-	-	-	0	82	18		25	19	6	-	-	-	SM-SC	-	-	-	-	-	-	-	-	16	-	-	-
17	10.00	SPT	-	-	-	-	0	79	21		27	20	7	-	-	-	SM-SC	-	-	-	-	-	-	-	-	20	-	-	-
18	11.00	SPT	-	-	-	-	0	80	20		25	19	6	-	-	-	SM-SC	-	-	-	-	-	-	-	-	23	-	-	-
19	11.50	SPT	-	-	-	-	0	84	16		23	17	6	-	-	-	SM-SC	-	-	-	-	-	-	-	-	20	-	-	-
20	12.50	SPT	-	-	-	-	0	22	55	23	39	18	21	-	-	-	CI	-	-	-	-	-	-	-	-	91	-	-	-
21	13.00	UDS	2.29	2.06	11.28	2.68	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	43.1	UCS	-	-	-	-	-	0.30	23.2
22	14.50	UDS	2.30	2.07	11.15	2.69	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	46.0	UCS	-	-	-	-	-	0.30	23.1
23	16.00	UDS	2.32	2.10	10.66	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	110.6	-	UCS	-	-	-	-	13.23	0.29	22.4
24	17.50	UDS	2.34	2.13	9.95	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	139.7	-	UCS	-	-	-	-	47.00	0.27	21.2
25	19.00	UDS	2.64	2.54	3.89	2.82	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	526.3	-	UCS	-	-	-	-	22.00	0.11	9.9
26	20.50	UDS	2.68	2.59	3.35	2.84	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	436.1	-	UCS	-	-	-	-	51.33	0.10	8.7
27	22.00	UDS	2.31	2.08	11.03	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	146.2	-	UCS	-	-	-	-	36.00	0.30	22.9
28	23.50	UDS	2.71	2.64	2.48	2.83	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	552.8	-	UCS	-	-	-	-	94.66	0.07	6.6

KCT Consultancy Services LLP, Ahmedabad

RESULTS OF LABORATORY TEST

Project :- Proposed structures in Phase 1 of 3 x 800 MW NLC Talabira Thermal Power Project (NTTPP) at village Hirma, Talabira, Odisha

BH No. :- IBH 36

Co-Ordinate :- E 1132, N 2951

Reduced Level :- 200.53 m

Sr No	Depth of Sample	Type of Sample	Field Bulk Density	Field Dry Density	Natural Moisture Content	Specific Gravity	Grain Size Analysis				Consistency limits			Shrinkage Limit	Swelling Pressure	Free Swell Index	Soil Classification	Shear Parameter		Unconfined Compression Test	UCS by Point Load Index in rock	Type of Shear Test	Consolidation Parameters			SPT N Value	Rock Quality Designation	Void Ratio	Porosity	
							Gravel	Sand	Silt	Clay	Liquid Limit	Plastic Limit	Plasticity Index					Cohesion C	Angle of Internal Friction ϕ				Compression Index C _c	Coefficient of Volume Compressibility mv	Pre-consolidation Pressure					
																														%
1	0.00	DS	-	-	-	-	0	30	38	32	53	24	29	-	-	-	CH	-	-	-	-	-	-	-	-	-	-	-	-	-
2	1.00	SPT	-	-	-	-	0	32	40	28	51	25	26	-	-	-	CH	-	-	-	-	-	-	-	-	7	-	-	-	-
3	2.00	SPT	-	-	-	-	0	19	47	34	58	27	31	-	-	-	CH	-	-	-	-	-	-	-	-	15	-	-	-	-
4	2.50	SPT	-	-	-	-	0	12	45	43	66	29	37	-	-	-	CH	-	-	-	-	-	-	-	-	10	-	-	-	-
5	3.00	SPT	-	-	-	-	0	10	43	47	68	28	40	-	-	-	CH	-	-	-	-	-	-	-	-	16	-	-	-	-
6	3.50	UDS	1.96	1.56	25.94	2.61	0	13	44	43	65	29	36	-	-	-	CH	0.93	2	-	-	TUU	0.10	0.0128	0.67	-	-	0.68	40.4	
7	4.00	SPT	-	-	-	-	0	21	46	33	54	26	28	-	-	-	CH	-	-	-	-	-	-	-	-	18	-	-	-	-
8	4.50	SPT	-	-	-	-	0	19	46	35	59	28	31	-	-	-	CH	-	-	-	-	-	-	-	-	25	-	-	-	-
9	5.00	SPT	-	-	-	-	0	33	38	29	51	26	25	-	-	-	CH	-	-	-	-	-	-	-	-	22	-	-	-	-
10	5.50	SPT	-	-	-	-	0	34	34	32	53	25	28	-	-	-	CH	-	-	-	-	-	-	-	-	21	-	-	-	-
11	6.00	SPT	-	-	-	-	0	29	49	22	43	23	20	-	-	-	CI	-	-	-	-	-	-	-	-	22	-	-	-	-
12	6.50	SPT	-	-	-	-	0	26	43	31	47	21	26	-	-	-	CI	-	-	-	-	-	-	-	-	25	-	-	-	-
13	7.00	SPT	-	-	-	-	0	61	39		46	22	24	-	-	-	SC	-	-	-	-	-	-	-	-	26	-	-	-	-
14	7.50	UDS	2.01	1.62	24.19	2.66	0	66	34		48	23	25	-	-	-	SC	0.11	26	-	-	DSU	-	-	-	-	-	-	0.64	39.2
15	8.00	SPT	-	-	-	-	0	70	30		47	24	23	-	-	-	SC	-	-	-	-	-	-	-	-	22	-	-	-	-
16	8.50	SPT	-	-	-	-	0	73	27		49	26	23	-	-	-	SC	-	-	-	-	-	-	-	-	21	-	-	-	-
17	9.00	SPT	-	-	-	-	0	64	36		43	23	20	-	-	-	SC	-	-	-	-	-	-	-	-	18	-	-	-	-
18	9.50	SPT	-	-	-	-	0	66	34		45	21	24	-	-	-	SC	-	-	-	-	-	-	-	-	17	-	-	-	-
19	10.00	SPT	-	-	-	-	0	69	31		48	22	26	-	-	-	SC	-	-	-	-	-	-	-	-	25	-	-	-	-
20	11.00	SPT	-	-	-	-	0	72	28		49	20	29	-	-	-	SC	-	-	-	-	-	-	-	-	35	-	-	-	-
21	12.50	SPT	-	-	-	-	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	-	-	-	-	-	>100	-	-	-	-
22	13.00	UDS	2.31	2.08	11.03	2.70	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	-	103.6	UCS	-	-	-	-	-	-	0.30	22.9
23	14.50	UDS	2.29	2.04	12.01	2.71	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	94.0	-	UCS	-	-	-	-	30.00	0.33	24.6	
24	16.00	UDS	2.43	2.26	7.68	2.73	-	-	-	-	-	-	-	-	-	-	W.ROCK	-	-	135.8	-	UCS	-	-	-	-	24.66	0.21	17.3	
25	17.50	UDS	2.48	2.35	5.73	2.71	-	-	-	-	-	-	-	-	-	-	ROCK	-	-	97.6	-	UCS	-	-	-	-	77.33	0.16	13.5	

Project : BHEL

Bore Hole No. : 24

Location : Hirma, Talabira

Depth of Termination : 15

Co-ordinates: E 1176, N 3017

Depth of Water Table : Encountered at 0.50 m depth during investigation

Date of Start: 31-03-2025


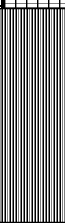

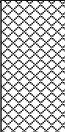
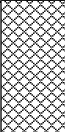
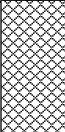
Date of Completion: 01-04-2025

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced level: %) "++'a

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recov- ery (%)	RQD (%)	Remarks	
						From m	To m		N ₁	N ₂	N ₃	N				
Rotary drilling method	0.00	Not used		Brownish, fine to medium grained, sandy clays of low plasticity (CL) 0.00 to 0.30m	0.00	0.00	1.00	DS	-	-	-	-	-	-		
	0.50			Brownish yellow to yellowish brown, fine to very fine grained, silts of intermediate plasticity (MI) 0.30 to 3.50m	1.00	1.00	2.00	SPT	2	3	3	6	-	-		
	1.00				2.00	2.00	2.50	SPT	3	5	6	11	-	-		
	1.50				2.50	2.50	3.00	SPT	7	15	21	36	-	-		
	2.00				3.00	3.00	3.50	SPT	16	36	41	77	-	-		
	2.50															
	3.00															
	3.50			Highly weathered, weak, brownish yellow, fine to medium grained, fractured roc 3.50 too 7.50m	4.50	3.50	4.50	Core	-	-	-	-	33.00			
	4.00															
	4.50															
	5.00															
	5.50															
	6.00															
	6.50															
	7.00															
	7.50															
	8.00															
	8.50			Highly weathered, weak, brownish yellow, fine to medium grained, rock with close spacing of discontinuities 7.50 to 9.00m	9.00	7.50	9.00	Core	-	-	-	-	50.00	28.66		
	9.50															
	10.00															
	10.50															
	11.00															
	11.50															
	12.00			Moderately weathered, weak, dark greyish, fine to very fine grained, rock with close spacing of discontinuities 12.00 to 13.50m	12.00	10.50	12.00	Core	-	-	-	-	66.00	8.66		
	12.50															
	13.00															
	13.50			Slightly weathered, weak, greyish black, fine to medium grained, massive rock	13.50	12.00	13.50	Core	-	-	-	-	64.66	64.66		
14.00																
14.50																
15.00																
13.50 to 15.00m																

Project : BHEL

Bore Hole No. : 26

Location : Talabira

Depth of Termination : 25.0 M

Co-ordinates: E 4° 42' 41" N, 81° 42' 41" E

Depth of Water Table : Encountered at 2.60m depth during investigation

Date of Start: 05-09-2024

Date of Completion: 11-09-2024

Diameter of Bore: 150mm and Nx size

Bit Used: Surface Bit and NX Size

Reduced Level: 85' 7" a

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks		
						From m	To m		N ₁	N ₂	N ₃	N					
Rotary drilling method	0.00	Not Used		Brownish, fine to medium grained, silty clayey sand with little gravels (SM-SC) 0.00 to 0.30m	0.00	0.00	1.00	DS	-	-	-	-	-	-			
	0.50																
	1.00																
	1.50																
	2.00					Reddish yellow to light brownish, fine to medium grained, clayey sand with occasional to some gravels (SC) 0.30 to 3.60m	2.00	2.00	2.50	SPT	2	3	5	8	-	-	
	2.50						2.50	2.50	3.00	SPT	2.00	3	4.00	7	-	-	
	3.00						3.00	3.00	3.50	SPT	5	5	4	9	-	-	
	3.50						3.50	3.50	4.00	UDS	-	-	-	-	-	-	
	4.00						4.00	4.00	4.50	SPT	3	4	5	9	-	-	
	4.50						4.50	4.50	5.00	UDS	-	-	-	-	-	-	
	5.00					Reddish yellow, fine to very fine grained, sandy clays of intermediate plasticity with occasional gravels (CI) 3.60 to 7.30m	5.00	5.00	5.50	SPT	5	13	16	29	-	-	
	5.50						5.50	5.50	6.00	UDS	-	-	-	-	-	-	
	6.00						6.00	6.00	6.50	SPT	7	9	12	21	-	-	
	6.50						6.50	6.50	7.00	UDS	-	-	-	-	-	-	
	7.00						7.00	7.00	7.50	SPT	11	11	16	27	-	-	
	7.50					Reddish yellow, fine to medium grained, silty clayey sand (SM-SC) 7.30 to 7.90m	7.50	7.50	8.00	SPT	11	11	10	21	-	-	
	8.00						8.00	8.00	8.50	SPT	12	14	15	29	-	-	
	8.50					Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI) 7.90 to 10.60m	8.50	8.50	9.00	SPT	13	18	20	38	-	-	
	9.00						9.00	9.00	9.50	SPT	15	18	22.00	40	-	-	
	9.50						9.50	9.50	10.00	SPT	7	10	14.00	24	-	-	
	10.00						10.00	10.00	11.00	SPT	7	12	16.00	28	-	-	
	10.50																
	11.00						11.00	11.00	11.50	SPT	10	17	24.00	41	-	-	
	11.50						11.50	11.50	12.50	SPT	12	35	65/14cm	>100	-	-	
	12.00																
	12.50						12.50	12.50	13.50	SPT	24.00	40	60/13cm	>100	-	-	
	+ 13.00																
	13.50					Yellowish brown, very fine grained, indurated, silty clays of intermediate plasticity (CI) (Silt stone) 10.60 to 18.60m	13.50	13.50	14.00	SPT	41.00	59/14cm	-	>100	-	-	
	14.00						14.00	14.00	14.50	SPT	50/13cm	-	-	>100	-	-	
	14.50						14.50	14.50	15.50	SPT	50/10cm	-	-	>100	-	-	
	15.00																
	15.50						15.50	15.50	16.00	SPT	50/9cm	-	-	>100	-	-	
16.00				16.00	16.00	17.00	SPT	50/8cm	-	-	>100	-	-				
16.50																	
17.00				17.00	17.00	17.50	SPT	50/8cm	-	-	>100	-	-				
17.50				17.50	17.50	17.58	SPT	50/8cm	-	-	>100	-	-				
18.00																	
18.50																	
19.00				19.00	17.58	19.00	Core	-	-	-	-	12.00	-				
19.50				19.00	19.00	19.03	SPT	50/3cm	-	-	>100						
20.00																	
20.50				20.50	19.03	20.50	Core	-	-	-	-	10.00	-				
21.00				20.50	20.50	20.53	SPT	50/3cm	-	-	>100						
21.50			Highly weathered, weak, brownish, black, very fine grained, fractured laminated to very thinly bedded rock														
22.00				22.00	20.53	22.00	Core		-	-	-	66.00	-				
22.50																	
23.00																	
23.50				23.50	22.00	23.50	Core		-	-	-	24.00	-				
24.00																	
24.50																	
25.00				25.00	23.50	25.00	Core	-	-	-	-	30.66	8.00				
18.60 to 25.00m																	

Project : BHEL

Bore Hole No. : 49

Location : Hirma, Talabira

Depth of Termination : 19.5

Co-ordinates: E 1081, N 3296

Depth of Water Table : Encountered at 1.30 m depth during investigation

Date of Start: 29-11-2024



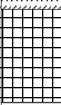


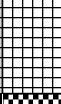
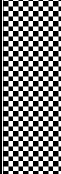

Date of Completion: 04-12-2024

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced level: % +) \$ a

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks	
						From m	To m		N ₁	N ₂	N ₃	N				
Rotary drilling method	0.00	Not used		Yellowish brown, fine to medium grained, sandy clays of intermediate plasticity (CI) 0.00 to 0.80m	0.00	0.00	1.00	DS	-	-	-	-	-	-		
	0.50															
	1.00				Dark brownish and yellowish brown, fine to very fine grained, sandy and silty clays of intermediate plasticity with little to occasional gravels (CI) 0.80 to 2.90m	1.00	1.00	2.00	SPT	4	6	8	14	-	-	
	1.50															
	2.00															
	2.50															
	3.00			Yellowish brown, fine to very fine grained, silty clays of low plasticity (CL) 2.90 to 3.50m		3.00	3.00	3.50	SPT	6	10	12	22	-	-	
	3.50				Yellowish brown, fine to coarse grained, sandy clays of intermediate plasticity with some gravels (CI) 3.50 to 4.00m	3.50	3.50	4.00	UDS	-	-	-	-	-	-	
	4.00					Yellowish brown, fine to very fine grained, clayey sand (SC) 4.00 to 4.50m	4.00	4.00	4.50	SPT	10	15	18	33		
	4.50					Yellowish brown, fine to very fine grained, indurated silty clays of low plasticity (CL) (silty stone) 4.50 to 5.60m	4.50	4.50	5.00	SPT	22	50/7 cm	-	>100		
	5.00															
	5.50															
	6.00		Boulderous formation of highly weathered, completely fractured, gravels, pebbles, cobbles size fragments with lightly yellowish brown, fine to very fine grained, indurated silty clays of low plasticity 5.60 to 7.00m		6.00	6.00	6.04	SPT	60/4 cm	-	-	>100				
	6.50															
	7.00															
	7.50															
	8.00															
	8.50															
	9.00															
	9.50															
	10.00															
	10.50															
	11.00	used		Highly weathered, very weak, light yellowish brown and dark brownish, fine to very fine grained, very thinly laminated rock	10.50	9.00	10.50	Core	-	-	-	-	20.00			
	11.50															
	12.00															
	12.50															
	13.00															
	13.50															
	14.00															
	14.50															
15.00																
15.50																
16.00																
16.50																
17.00																
17.50																
18.00																
18.50																
19.00																
19.50																
16.80 to 19.50m																

K.C.T. Consultancy Services®

Project : BHEL

Bore Hole No. : 50

Location : Hirma, Talabira

Depth of Termination : 23

Co-ordinates: E 1281, N 3254

Depth of Water Table : Encountered at 3.70m depth during investigation

Date of Start: 18-07-2024

Date of Completion: 21-07-2024

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced level: 201.55 m

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks
						From m	To m		N ₁	N ₂	N ₃	N			
Rotary drilling method with Hydraulic feed	0.00			Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI) 0.00 to 0.50m	0.00	0.00	1.50	DS	-	-	-	-	-	-	
	0.50														
	1.00			Dark yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI) 0.50 to 2.40m	1.00	1.00	2.00	SPT	2	3	4	7	-	-	
	1.50														
	2.00				2.00	2.00	2.50	SPT	3	5	6	11			
	2.50				2.50	2.50	2.00	SPT	5	7	9	16			
	3.00			Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI) 2.40 to 4.90m	3.00	3.00	3.40	SPT	6	8	11	19	-	-	
	3.50				3.50	3.50	4.00	UDS	-	-	-	-			
	4.00				4.00	4.00	4.50	SPT	7	10	14	24			
	4.50				4.50	4.50	5.00	UDS	-	-	-	-			
	5.00				5.00	5.00	5.50	SPT	7	10	13	23			
	5.50				5.50	5.50	6.00	UDS	-	-	-	-			
	6.00			Yellowish brown, fine to very fine grained, clays of high plasticity (CH) 4.90 to 7.45m	6.00	6.00	6.50	SPT	8	12	16	28	-	-	
	6.50				6.50	6.50	7.00	UDS	-	-	-	-			
	7.00				7.00	7.00	7.50	SPT	7	11	15	26			
	7.50				7.50	7.50	8.00	UDS	-	-	-	-			
	8.00				8.00	8.00	8.50	SPT	9	13	17	30			
	8.50			Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI) 7.45 to 10.80m	8.50	8.50	9.00	UDS	-	-	-	-			
	9.00				9.00	9.00	9.50	SPT	9	14	18	32	-	-	
	9.50				9.50	9.50	10.00	SPT	10	14	17	31		-	
	10.00				10.00	10.00	11.50	SPT	10	15	18	33			
	10.50														
	11.00			Yellowish brown, fine to very fine grained, clays of high plasticity (CH) 10.80 to 12.20m	11.00	11.00	11.50	SPT	11	16	20	36		-	
	11.50				11.50	11.50	12.50	SPT	13	18	23	41			
	12.00														
	12.50			Brownish, fine to very fine grained, sandy clays of intermediate plasticity (CI) 12.20 to 14.40m	12.50	12.50	13.00	SPT	40	55/10 cm	-	>100	-		
	13.00				13.00	13.00	14.00	SPT	37	61	10/1 cm	>100			
	13.50														
	14.00				14.00	14.00	14.50	SPT	60/10 cm	-	-	>100	-	-	
	14.50														
	15.00														
	15.50				15.50	15.50	16.00	SPT	60/12 cm	-	-	>100	-		
	16.00				16.00	16.00	17.00	SPT	60/9 cm	-	-	>100			
	16.50			Dark brownish, fine to very fine grained, clays of high plasticity (CH) 14.40 to 18.57m											
	17.00				17.00	17.00	17.50	SPT	60/8 cm	-	-	>100	-	-	
	17.50				17.50	17.50	17.59	SPT	60/9 cm	-	-	>100			
	18.00														
	18.50				18.50	18.50	18.57	SPT	60/7 cm	-	-	>100	-	-	
	19.00			Highly weathered, very weak, brownish, fine to very fine grained, thinly bedded rock 18.57 to 20.50m											
	19.50														
	20.00														
	20.50			Moderately weathered, moderately weak, dark greyish black, fine to very fine grained, thinly bedded rock 20.50 to 22.00m	20.50	18.57	20.50	Core	-	-	-	-	34.61	9.23	
	21.00														
	21.50				21.50	20.50	21.50	Core	-	-	-	-	45.33	13.33	
	22.00														
	22.50			Slightly weathered, weak, dark greyish brown, fine to very fine grained, massive rock											
	23.00				23.00	21.50	23.00	Core	-	-	-	-	97.33	80.00	
22.00 to 23.00m															

Project : BHEL

Bore Hole No. : 51

Location : Talabira

Depth of Termination : 18

Co-ordinates: 9°1'45.28"N & 78°1'10.00"E

Depth of Water Table : Encountered at 1.40m depth during investigation

Date of Start: 06-04-2025

Date of Completion: 08-04-2025

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced Level: 99.50 m

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks
						From m	To m		N ₁	N ₂	N ₃	N			
Rotary drilling method	0.00	Used		Yellowish brown, fine to medium grained, sandy clays of low plasticity (CL) 0.00 to 0.75m	0.00	0.00	1.00	DS	-	-	-	-	-	-	
	0.50														
	1.00			Yellowish brown, fine to medium grained, clayey sand with occasional gravels (SC) 0.75 to 2.70m	1.00	1.00	2.00	SPT	2	2	2	4	-	-	
	1.50														
	2.00				2.00	2.00	2.50	SPT	2	3	3	6	-	-	
	2.50				2.50	2.50	3.00	UDS	-	-	-	-	-	-	
	3.00			Yellowish brown, very fine grained, silty clays of intermediate plasticity (CI) 2.70 to 3.70m	3.00	3.00	3.50	SPT	3	7	9	16	-	-	
	3.50				3.50	3.50	4.00	UDS	-	-	-	-	-	-	
	4.00			Yellowish brown, very fine grained, clays of intermediate plasticity (CI) 3.70 to 4.90m	4.00	4.00	4.50	SPT	5	7	12	19	-	-	
	4.50				4.50	4.50	4.90	UDS	-	-	-	-	-	-	
	5.00														
	5.50														
	6.00			Brownish, very fine grained, clays of intermediate plasticity (CI) 4.90 to 7.00m	6.00	4.90	6.00	SPT	11	22	25	47	-	-	
	6.50														
	7.00														
	7.50			Highly weathered, very weak, greyish brown, fine to very fine grained, fractured rock 7.00 to 9.00m	7.50	6.00	7.50	Core	-	-	-	-	10.66	-	
	8.00														
	8.50														
	9.00			Moderately weathered, weak, light brownish yellow, fine to very fine grained, rock with very close spacing of discontinuities 9.00 to 10.50m	9.00	7.50	9.00	Core	-	-	-	-	42.00	6.66	
	9.50														
	10.00														
	10.50			Moderately weathered, weak, dark brownish yellow, fine to medium grained, rock with wide spacing of discontinuities 10.50 to 12.00m	10.50	9.00	10.50	Core	-	-	-	-	60.66	34.66	
	11.00														
	11.50														
	12.00														
	12.50			Moderately weathered, weak, dark greyish, fine to medium grained, rock with very close spacing of discontinuities 12.00 to 15.00m	12.00	10.50	12.00	Core	-	-	-	-	53.33	15.33	
	13.00														
	13.50														
14.00															
14.50															
15.00		Slightly weathered, weak, greyish black, fine to medium grained, rock with moderately close spacing of discontinuities 15.00 to 16.50m	15.00	13.50	15.00	Core	-	-	-	-	60.66	22.66			
15.50															
16.00															
16.50															
17.00															
17.50				Slightly weathered, weak, greyish black, fine to medium grained, massive rock											
18.00					18.00	16.50	18.00	Core	-	-	-	-	93.33	78.33	
16.50 to 18.00m															

Project : BHEL

Bore Hole No. : BH 53

Location : Hirma, Talabira

Depth of Termination : 25.0 M

Co-ordinates: E 11° F, N 3260

Depth of Water Table : Encountered at 2.80 m depth during investigation

Date of Start: 21-06-2024


Date of Completion: 23-06-2024

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced level: 199.480 m

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks
						From m	To m		N ₁	N ₂	N ₃	N			
Rotary drilling method	0.00	Used		Yellowish brown, fine to medium grained, clayey sand (SC) 0.00 to 0.80m	0.00	0.00	1.50	DS	-	-	-	-	-	-	
	0.50														
	1.00				1.00	1.00	2.00	SPT	3	3	4	7			
	1.50														
	2.00			Reddish yellow, fine to very fine grained, silty and sandy clays of intermediate plasticity with occasional gravels (CI) 0.80 to 4.40m	2.00	2.00	2.50	SPT	3	5	7	12	-	-	
	2.50				2.50	2.50	2.00	UDS	-	-	-	-			
	3.00				3.00	3.00	3.40	SPT	6	10	12	22	-	-	
	3.50				3.50	3.50	4.00	SPT	7	12	14	26			
	4.00				4.00	4.00	4.50	SPT	8	13	16	29			
	4.50				4.50	4.50	5.00	UDS	-	-	-	-	-	-	
	5.00			Yellowish brown, fine to medium grained, clays of very fine grained, clays of high plasticity (CH) 4.40 to 7.50m	5.00	5.00	5.50	SPT	5	7	9	16			
	5.50				5.50	5.50	6.00	DS	UDS attempted but not recovered						
	6.00				6.00	6.00	6.50	SPT	4	8	9	17	-	-	
	6.50				6.50	6.50	7.00	UDS	-	-	-	-	-	-	
	7.00				7.00	7.00	7.50	SPT	5	7	9	16			
	7.50				7.50	7.50	8.00	UDS	-	-	-	-			
	8.00			Brownish yellow, very fine grained, sandy clays of low plasticity (CL) 7.50 to 8.80m	8.00	8.00	8.50	SPT	5	6	8	14			
	8.50				8.50	8.50	9.00	UDS	-	-	-	-			
	9.00				9.00	9.00	9.50	SPT	7	8	10	18	-	-	
	9.50			Reddish yellow, fine to medium grained, clayey sand (SC) 8.80 to 10.00m	9.50	9.50	10.00	UDS	-	-	-	-			
	10.00				10.00	10.00	11.00	SPT	5	9	10	19			
	10.50														
	11.00			Brownish yellow, fine to medium grained, silty sand with little plastic fines (SM) 10.00 to 11.50m	11.00	11.00	11.50	UDS	-	-	-	-	-	-	
	11.50				11.50	11.50	12.00	SPT	7	10	12	22	-	-	
	12.00														
	12.50			Brownish yellow, fine to coarse grained, poorly graded sand and silty sand with little gravels (SP-SM) 11.50 to 14.50m	12.50	12.50	13.00	DS	-	-	-	-			
	13.00				13.00	13.00	14.00	SPT	9	12	19	31	-	-	
	13.50														
	14.00				14.00	14.00	14.50	DS	-	-	-	-	-	-	
	14.50			Highly weathered, very weak, very thinly laminated/foliated, dark greenish grey, very fine grained, Shale mixed with greenish grey, fine to very fine grained, clays of intermediate plasticity 14.50 to 16.00m	14.50	14.50	15.50	SPT	30	50/10 cm	-	>100	-	-	
	15.00														
	15.50														
	16.00			Highly weathered, dark greyish black, fine grained, very thinly laminated foliated Shale 16.00 to 21.10m	16.00	16.00	16.10	SPT	50/10 cm	-	-	>100			
	16.50														
	17.00														
	17.50				17.50	16.10	17.50	DS						-	
18.00	17.50	17.50	17.08		SPT	50/08 cm	-	-	>100						
18.50															
19.00	19.00	17.08	19.00		Core	-	-	-	-	9.00	-				
19.50	19.00	19.00	19.00		SPT	50/05 cm	-	-	>100						
20.00															
20.50	20.50	19.00	20.50		Core	-	-	-	-	25.00	-				
21.00	Moderately weathered, moderately weak, dark greyish black, fine grained, thinly laminated Shale 21.10 to 24.0m	21.00													
21.50															
22.00		22.00	20.50	22.00	Core	-	-	-	-	43.00	19.00				
22.50															
23.00															
23.50		23.50	22.00	23.50	Core	-	-	-	-	42.00	-				
24.00	Slightly weathered, weak, dark greyish black, very fine grained, thinly bedded foliated Shale	24.00													
24.50															
25.00		25.00	23.50	25.00	Core	-	-	-	-	91.00	32.00				
25.00		25.00	23.50	25.00	Core	-	-	-	-	91.00	32.00				
24.00 to 25.00m															

K.C.T. Consultancy Services®

Project : BHEL

Bore Hole No. : 56

Location : Talabira

Depth of Termination : 26.5 M

Co-ordinates: E 1152, N 3231

Depth of Water Table : Encountered at 2.10m depth during investigation

Date of Start: 21-06-2024

Date of Completion: 25-06-2024

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced Level: 198.42

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks			
						From m	To m		N ₁	N ₂	N ₃	N						
Rotary drilling method	0.00	Used		Brownish, fine to medium grained, clayey sand (SC) 0.00 to 0.60m	0.00	0.00	1.00	DS	-	-	-	-	-	-				
	0.50																	
	1.00																	
	1.50				Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity with occasional gravels (CI) 0.60 to 4.00m	1.00	1.00	2.00	SPT	3	4	6	10	-	-			
	2.00				2.00	2.50	SPT	6	8	9	17	-	-					
	2.50				2.50	3.00	UDS	-	-	-	-	-	-					
	3.00				3.00	3.50	SPT	9	16	17	33	-	-					
	3.50				3.50	4.00	DS	-	UDS attempted but not recovered									
	4.00				Yellowish brown, fine to very fine grained, clays of high plasticity (CH) 4.00 to 6.30m	4.00	4.00	4.50	SPT	7	8	8	16	-	-			
	4.50				4.50	5.00	UDS	-	-	-	-	-	-					
	5.00				5.00	5.50	SPT	11	12	14	26	-	-					
	5.50				5.50	6.00	UDS	-	-	-	-	-	-					
	6.00				6.00	6.50	SPT	10	13	16	29	-	-					
	6.50				Yellowish brown, fine to very fine grained, clayey sand (SC) 6.30 to 8.70m	6.50	6.50	7.00	UDS	-	-	-	-	-	-			
	7.00				7.00	7.50	SPT	9	14	14	28	-	-					
	7.50				7.50	8.00	SPT	-	-	-	-	-	-					
	8.00				8.00	8.50	SPT	5	7	9	16	-	-					
	8.50				8.50	9.00	UDS	-	-	-	-	-	-					
	9.00				Yellowish brown, fine to medium grained, silty sand with little to occasional gravels (SM) 8.70 to 13.60m	9.00	9.00	9.50	SPT	7	10	12	22	-	-			
	9.50					9.50	10.00	UDS	-	-	-	-	-	-				
	10.00					10.00	11.00	SPT	8	10	10	20	-	-				
	10.50																	
	11.00					11.00	11.50	UDS	-	-	-	-	-	-				
	11.50					11.50	12.50	SPT	8	14	16	30	-	-				
	12.00																	
	12.50					12.50	13.00	UDS	-	-	-	-	-	-				
	13.00						Highly weathered, completely fractured and disintegrated, dark brownish black, very fine grained, rock 13.60 to 14.50m	13.00	13.00	13.06	SPT	50/6cm	-	-	>100	-	-	
	13.50																	
	14.00																	
	14.50				Highly weathered, very weak, dark greyish, very fine grained, very thinly laminated rock 14.50 to 18.90m		14.50	13.06	14.50	Core	-	-	-	-	8.66	-		
	15.00																	
	15.50																	
	16.00					14.50	16.00	Core	-	-	-	-	21.33	-				
	16.50																	
	17.00				Moderately weathered, weak, dark greyish black, very fine grained, thickly bedded rock 18.90 to 22.00m	17.50	16.00	17.50	Core	-	-	-	-	38.00	-			
	17.50																	
18.00																		
18.50																		
19.00	17.50	19.00	Core			-	-	-	-	53.33	-							
19.50		Slightly weathered, weak, dark greyish black, very fine grained, massive rock 22.00 to 26.50m	19.50															
20.00																		
20.50			20.50	19.00	20.50	Core	-	-	-	-	76.00	58.66						
21.00																		
21.50																		
22.00			22.00	20.50	22.00	Core	-	-	-	-	74.00	48.00						
22.50																		
23.00																		
23.50			23.50	22.00	23.50	Core	-	-	-	-	79.00	70.00						
24.00																		
24.50																		
25.00																		
25.50																		
26.00																		
26.50																		

Page 289 of 356

K.C.T. Consultancy Services®

Project : BHEL

Bore Hole No. : 57

Location : Hirma, Talabira

Depth of Termination : 23

Co-ordinates: E 1077, N 3230

Depth of Water Table : Encountered at 1.40m depth during investigation

Date of Start: 23-06-2024

Date of Completion: 16-07-2024

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced level: 196.65 m

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.				Core Recovery (%)	RQD (%)	Remarks	
						From m	To m		N ₁	N ₂	N ₃	N				
Rotary drilling method with Hydraulic feed	0.00	Used		Brownish, fine to medium grained, sandy clays of intermediate plasticity (CI) 0.00 to 0.60m	0.00	0.00	1.50	DS	-	-	-	-	-	-		
	0.50															
	1.00				1.00	2.00	SPT	3	4	6	10					
	1.50															
	2.00				Yellowish brow, fine to very fine grained, sandy clays of intermediate plasticity (CI) 0.60 to 3.70m	2.00	2.00	2.50	SPT	3	3	4	7	-	-	
	2.50				2.50	2.50	2.00	UDS	-	-	-	-				
	3.00				3.00	3.00	3.40	SPT	4	6	10	16	-	-		
	3.50				3.50	3.50	4.00	UDS	-	-	-	-				
	4.00				Yellowish brown, fine to very fine grained, clays of high plasticity (CH) 3.70 to 5.60m	4.00	4.00	4.50	SPT	4	6	9	15			
	4.50				4.50	4.50	5.00	UDS	-	-	-	-				
	5.00				5.00	5.00	5.50	SPT	4	8	11	19				
	5.50				5.50	5.50	6.00	UDS	-	-	-	-				
	6.00				Yellowish brown, fine to very fine grained, clayey sand (SC) 5.60 to 7.10m	6.00	6.00	6.50	SPT	4	5	6	11	-	-	
	6.50				6.50	6.50	7.00	UDS	-	-	-	-				
	7.00				7.00	7.00	7.50	SPT	4	6	7	13				
	7.50				7.50	7.50	8.00	DS	-	UDS attempted but not recovered						
	8.00				Yellowish brown, fine to medium grained, silty sand (SM) 7.10 to 9.60m	8.00	8.00	8.50	SPT	4	7	10	17			
	8.50				8.50	8.50	9.00	SPT	5	7	8	15				
	9.00				9.00	9.00	9.50	SPT	5	8	9	17	-	-		
	9.50				9.50	9.50	10.00	SPT	6	8	12	20		-		
	10.00				Yellowish brown, fine to very fine grained, clayey sand (SC) 9.60 to 11.30m	10.00	10.00	11.50	SPT	50/12 cm	-	-	>100			
	10.50															
	11.00				11.00	11.00	11.50	SPT	50/10 cm	-	-	>100		-		
	11.50				11.50	11.50	11.57	SPT	50/7 cm	-	-	>100				
	12.00				Highly weathered, very weak, dark reddish yellow, very fine grained, very thinly laminated rock 11.30 to 13.00m											
	12.50															
	13.00				Slightly weathered, moderately weak, dark yellowish brown, fine to medium grained, massive rock 13.00 to 14.50m	13.00	11.57	13.00	Core	-	-	-	-	94.00	68.00	
	13.50															
	14.00					14.50	13.00	14.50	Core	-	-	-	-	74.00	52.66	
	14.50															
	15.00					16.00	14.50	16.00	Core	-	-	-	-	85.33	64.33	
	15.50															
16.00																
16.50																
17.00																
17.50		Slightly weathered, very weak, dark grey, very fine grained, massive rock	17.50	16.00	17.50	Core	-	-	-	-	96.00	46.00				
18.00																
18.50																
19.00			19.00	17.50	19.00	Core	-	-	-	-	80.66	32.00				
19.50																
20.00																
20.50			20.50	19.00	20.50	Core	-	-	-	-	96.66	85.33				
14.50 to 20.50m																

K.C.T. Consultancy Services®

Project : BHEL

Bore Hole No. : 58

Location : Hirma, Talabira

Depth of Termination : 23

Co-ordinates: E 1217, N 3229

Depth of Water Table : Encountered at 2.80m depth during investigation

Date of Start: 17-07-2024





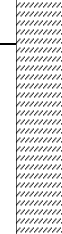

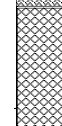

Date of Completion: 19-07-2024

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced level: 200.20 m

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks		
						From m	To m		N ₁	N ₂	N ₃	N					
Rotary drilling method with Hydraulic feed	0.00	Not used		Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity with little to some gravels (CI) 0.00 to 2.60m	0.00	0.00	1.50	DS	-	-	-	-	-	-			
	0.50																
	1.00																
	1.50						1.00	1.00	2.00	SPT	2	2	2	4		-	-
	2.00						2.00	2.00	2.50	SPT	4	5	6	11			
	2.50					2.50	2.50	2.00	SPT	1	2	3	5				
	3.00					3.00	3.40	SPT	4	6	8	14	-	-			
	3.50					3.50	4.00	SPT	6	6	10	16					
	4.00					4.00	4.50	SPT	7	8	10	18					
	4.50					4.50	5.00	UDS	-	-	-	-					
	5.00					5.00	5.50	SPT	5	7	10	17					
	5.50					5.50	6.00	UDS	-	-	-	-					
	6.00					6.00	6.50	SPT	6	9	11	20	-	-			
	6.50					6.50	7.00	SPT	5	7	9	16		-			
	7.00					7.00	7.50	SPT	9	11	13	24					
	7.50					7.50	7.50	8.00	UDS	-	-	-	-				
	8.00					8.00	8.50	SPT	5	6	8	14					
	8.50	8.50	9.00			UDS	-	-	-	-							
	9.00			Yellowish brown, fine to very fine grained, silty sand (SM) 8.60 to 13.10m	9.00	9.00	9.50	SPT	10	11	14	25	-	-			
	9.50				9.50	10.00	UDS	-	-	-	-		-				
	10.00				10.00	11.50	SPT	7	10	13	23						
	10.50																
	11.00																
	11.50																
	12.00																
	12.50																
	13.00						12.50	12.50	13.00	SPT	11	13	16	29		-	
	13.00						13.00	14.00	SPT	6	10	11	21				
	13.50																
	14.00					14.00	14.00	14.45	SPT	42	59/8 cm	-	>100	-		-	
	14.50																
	15.00																
	15.50					15.50	14.45	15.50	Core	-	-	-	-	16.00		6.66	
	16.00																
16.50						17.00	17.00	17.50	Core	-	-	-	-	37.33	16.00		
17.50																	
18.00																	
18.50			18.50	18.50	18.50	Core	-	-	-	-	34.66	-					
19.00																	
19.50			Slightly weathered, very weak, dark blackish brown grey, very fine grained, moderately thinly bedded rock 20.00 to 21.60m	20.00	18.00	20.00	Core	-	-	-	-	99.33	28.00				
20.50																	
21.00																	
21.50			21.50	20.00	21.50	Core	-	-	-	-	58.66	42.66					
22.00			Slightly weathered, moderately weak, dark blackish grey, very fine grained, massive rock		22.00												
22.50																	
23.00	23.00	21.50			23.00	Core	-	-	-	-	83.33	80.00					
21.60 to 23.00m																	

Bore Hole No. : 59

Date of Start: 06-12-2024

Date of Completion: 09-12-2024

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced Level: 197.60 m

[illegible]

K.C.T. Consultancy Services®

Project : BHEL

Bore Hole No. : 60

Location : Hirma, Talabira

Depth of Termination : 14.50 m

Co-ordinates: E 909, N 3227

Depth of Water Table : Encountered at 1.60m depth during investigation

Date of Start: 10-12-2024

Date of Completion: 11-12-2024

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced level: 196.25 M

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks
						From m	To m		N ₁	N ₂	N ₃	N			
Rotary drilling method with Hydraulic feed	0.00	Not Used		Yellowish brown, fine to medium grained, sandy clays of low plasticity (CL) 0.00 to 0.10m	0.00	0.00	1.50	DS	-	-	-	-	-	-	
	0.50			Brownish yellow, fine to medium grained, sandy clays of intermediate plasticity with little to some gravels (CI) 0.10 to 2.70m	1.00	1.00	2.00	SPT	2	3	3	6	-	-	
	1.00				2.00	2.00	2.50	SPT	4	4	6	10	-	-	
	1.50				2.50	2.50	2.00	UDS	-	-	-	-	-	-	
	2.00			Brownish yellow, fine to coarse grained, clayey sand with some to much gravels (SC) 2.70 to 3.60m	3.00	3.00	3.40	SPT	14	6	10	16	-	-	
	2.50				3.50	3.50	4.00	UDS	-	-	-	-	-	-	
	3.00			Yellowish brown, fine to medium grained, cemented silty clayey sand with some to much gravels (SM-SC) 3.60 to 5.20m	4.00	4.00	4.50	SPT	17	22	34	56	-	-	
	3.50				4.50	4.50	5.00	SPT	50/5 cm	-	-	>100	-	-	
	4.00				5.00	5.00	5.50	SPT	50/7 cm	-	-	>100	-	-	
	4.50			Yellowish brown, fine to coarse grained, cemented, silty sand with much gravels (SM) 5.20 to 5.70m	5.50	5.50	6.00	SPT	50/2 cm	-	-	>100	-	-	
	5.00				6.00	6.00	7.00	Core	-	-	-	-	21.33	-	
	5.50				7.00	7.00	8.50	Core	-	-	-	-	53.33	-	
	6.00			Highly weathered, very weak, yellowish brown, fine to medium grained, fractured rock 8.50 to 10.00m	8.50	7.00	8.50	Core	-	-	-	-	62.00	16.00	
	6.50				10.00	8.50	10.00	Core	-	-	-	-	58.66	-	
	7.00			Highly weathered, very weak, yellowish brown, fine to medium grained, rock with close spacing of discontinuities 10.00 to 11.50m	11.50	10.00	11.50	Core	-	-	-	-	68.66	-	
	7.50				13.00	11.50	13.00	Core	-	-	-	-	88.00	-	
	8.00				14.50	13.00	14.50	Core	-	-	-	-	-	-	
	8.50														
	9.00														
	9.50			Moderately weathered, moderately weak, light brownish grey, fine to medium grained, fractured rock 11.50 to 14.50m											
	10.00														
	10.50														
	11.00														
	11.50														

K.C.T. Consultancy Services®

Project : BHEL

Bore Hole No. : 61

Location : Hirma, Talabira

Depth of Termination : 23

Co-ordinates: E 1265, N 3214

Depth of Water Table : Encountered at 3.50m depth during investigation

Date of Start: 19-07-2024

Date of Completion: 22-07-2024

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced level: 201.10 m

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks	
						From m	To m		N ₁	N ₂	N ₃	N				
Rotary drilling method with Hydraulic feed	0.00	Used		Yellowish brown, fine to very fine grained, clayey sand with high plasticity(SC) 0.00 to 0.60m	0.00	0.00	1.50	DS	-	-	-	-	-	-		
	0.50			Reddish yellow brown, fine to very fine grained, sandy clays of high plasticity (CH) 0.60 to 2.00m	1.00	1.00	2.00	SPT	2	3	4	7	-	-		
	1.00				2.00	2.00	2.50	SPT	3	4	4	8	-	-		
	1.50				2.50	2.50	2.00	UDS	-	-	-	-	-	-		
	2.00			Reddish yellow brown, fine to very fine grained, sandy clays of intermediate plasticity with little gravels 2.00 to 3.95m	3.00	3.00	3.40	SPT	3	4	6	10	-	-		
	2.50				3.50	3.50	4.00	SPT	5	8	10	18	-	-		
	3.00				4.00	4.00	4.50	SPT	6	8	11	19	-	-		
	3.50			Yellowish brown, fine to veryfine grained, sandy clays of high plasticity (CH) 3.95 to 7.45m	4.50	4.50	5.00	UDS	-	-	-	-	-	-		
	4.00				5.00	5.00	5.50	SPT	5	7	10	17	-	-		
	4.50				5.50	5.50	6.00	UDS	-	-	-	-	-	-		
	5.00				6.00	6.00	6.50	SPT	6	8	10	18	-	-		
	5.50				6.50	6.50	7.00	UDS	-	-	-	-	-	-		
	6.00				7.00	7.00	7.50	SPT	6	8	11	19	-	-		
	6.50				7.50	7.50	8.00	UDS	-	-	-	-	-	-		
	7.00				8.00	8.00	8.50	SPT	10	15	19	34	-	-		
	7.50				8.50	8.50	9.00	UDS	-	-	-	-	-	-		
	8.00				9.00	9.00	9.50	SPT	9	13	18	31	-	-		
	8.50				9.50	9.50	10.00	SPT	8	11	15	26	-	-		
	9.00			Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI) 9.95 to 13.40m	10.00	10.00	11.50	SPT	15	25	39	64	-	-		
	9.50				11.00	11.00	11.50	SPT	21	38	63	>100	-	-		
	10.00				11.50	11.50	12.50	SPT	25	42	50/7 cm	>100	-	-		
	10.50				12.50	12.50	13.00	SPT	35	50/9 cm	-	>100	-	-		
	11.00				13.00	13.00	14.00	SPT	40	50/7 cm	-	>100	-	-		
	11.50				14.00	14.00	14.50	SPT	60/13 cm	-	-	>100	-	-		
	12.00			Dark brownish, fine to very fine grained, clays of high plasticity (CH) 13.40 to 17.60m	14.50	14.50	15.50	SPT	39	50/8 cm	-	>100	-	-		
	12.50				15.50	15.50	16.00	SPT	59	50/5 cm	-	>100	-	-		
	13.00				16.00	16.00	16.00	SPT	60/10 cm	-	-	>100	-	-		
	13.50				17.00	17.00	17.50	SPT	60/6 cm	-	-	>100	-	-		
	14.00				17.50	17.50	18.50	SPT	60/5 cm	-	-	>100	-	-		
	14.50				18.50	18.50	18.50	Core	-	-	-	-	63.33	35.55		
	15.00				Moderately weathered, weak, dark greyish, fine to very fine grained, moderately thickly bedded rock 17.60 to 20.00m	20.00	18.00	20.00	Core	-	-	-	-	74.66	46.66	
	15.50					21.50	20.00	21.50	Core	-	-	-	-	87.33	55.33	
16.00	23.00	21.50	23.00			Core	-	-	-	-	98.00	94.00				
16.50	Moderately weathered, moderately weak, dark greyish black, fine to very fine grained, moderately thickly bedded rock 20.00 to 22.00m	23.00	21.50		23.00	Core	-	-	-	-	98.00	94.00				
17.00		23.00	21.50	23.00	Core	-	-	-	-	98.00	94.00					
17.50		23.00	21.50	23.00	Core	-	-	-	-	98.00	94.00					
18.00		23.00	21.50	23.00	Core	-	-	-	-	98.00	94.00					
18.50		23.00	21.50	23.00	Core	-	-	-	-	98.00	94.00					
19.00		23.00	21.50	23.00	Core	-	-	-	-	98.00	94.00					
19.50		23.00	21.50	23.00	Core	-	-	-	-	98.00	94.00					
20.00	Slightly weathered, weak, dark greyish, fine to very fine grained, massive rock 22.00 to 23.00m	23.00	21.50	23.00	Core	-	-	-	-	98.00	94.00					
20.50		23.00	21.50	23.00	Core	-	-	-	-	98.00	94.00					
21.00		23.00	21.50	23.00	Core	-	-	-	-	98.00	94.00					
21.50		23.00	21.50	23.00	Core	-	-	-	-	98.00	94.00					
22.00		23.00	21.50	23.00	Core	-	-	-	-	98.00	94.00					
22.50		23.00	21.50	23.00	Core	-	-	-	-	98.00	94.00					
23.00		23.00	21.50	23.00	Core	-	-	-	-	98.00	94.00					
22.00 to 23.00m																

Project : BHEL

Bore Hole No. : 63

Location : Talabira

Depth of Termination : 27.0 M

Co-ordinates: E 1178, N 3201

Depth of Water Table : Encountered at 1.10m depth during investigation

Date of Start: 24-06-2024

Date of Completion: 26-06-2024

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced Level: 199.12 m

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks							
						From m	To m		N ₁	N ₂	N ₃	N										
Rotary drilling method	0.00	Used		Brownish, fine to very fine grained, clayey sand (SC) 0.00 to 0.60m	0.00	0.00	1.00	DS	-	-	-	-	-	-								
	0.50				Yellowish brown, fine to very fine grained, sandy clays of interemdiat e plasticity (CI) 0.60 to 8.60m	1.00	1.00	2.00	SPT	2	2	2	4	-	-							
	1.00					2.00	2.00	2.50	SPT	3	6	8	14	-	-							
	1.50					2.50	2.50	3.00	UDS	-	-	-	-	-	-							
	2.00					3.00	3.00	3.50	SPT	9	11	12	23	-	-							
	2.50					3.50	3.50	4.00	UDS	-	-	-	-	-	-							
	3.00					4.00	4.00	4.50	SPT	7	9	10	19	-	-							
	3.50					4.50	4.50	5.00	DS	-	UDS attempted but not recovered				-	-						
	4.00					5.00	5.00	5.50	SPT	4	5	5	10	-	-							
	4.50					5.50	5.50	6.00	UDS	-	-	-	-	-	-							
	5.00					6.00	6.00	6.50	SPT	5	5	6	11	-	-							
	5.50					6.50	6.50	7.00	UDS	-	-	-	-	-	-							
	6.00					7.00	7.00	7.50	SPT	5	7	9	16	-	-							
	6.50					7.50	7.50	8.00	DS	-	UDS attempted but not recovered				-	-						
	7.00					8.00	8.00	8.50	SPT	4	5	5	10	-	-							
	7.50						Yellowish brown, fine to very fine grained, sandy clays of low plasticity (CL) 8.60 to 9.30m	8.50	8.50	9.00	DS	-	UDS attempted but not recovered				-	-				
	9.00							9.00	9.50	SPT	5	5	6	11	-	-						
	9.50						Yellowish brown, fine to very fine grained, clayey sand (SC) 9.30 to 10.50m	9.50	9.50	10.00	DS	-	UDS attempted but not recovered				-	-				
	10.00							10.00	11.00	SPT	4	6	6	12	-	-						
	10.50				Yellowish brown, fine to medium grained, silty sand (SM) 10.50 to 11.70m	11.00	11.00	11.50	DS	-	UDS attempted but not recovered				-	-						
	11.00					11.50	12.50	SPT	9	12	15	27	-	-								
	11.50				Yellowish brown, fine to medium grained, clayey sand (SC) 11.70 to 14.10m	12.50	12.50	13.00	DS	-	UDS attempted but not recovered				-	-						
	12.00					13.00	14.00	SPT	9	11	17	28	-	-								
	12.50				Light yellowish brown, fine to medium grained, silty clayey sand (SM-SC) 14.10 to 14.80m	13.50	13.50	14.00	DS	-	UDS attempted but not recovered				-	-						
	14.00					14.00	14.50	DS	-	UDS attempted but not recovered				-	-							
	14.50				Highly weathered, very weak, dark brownish grey, fine grained, very thinly laminated rock	14.50	14.50	15.00	SPT	9	12	17	29	-	-							
	15.00					15.00	16.50	SPT	50/12cm	-	-	>100	-	-								
	15.50					16.50	16.50	16.57	SPT	50/7cm	-	-	-	>100	-	-						
	16.00																					
	16.50																					
	17.00																					
	17.50					18.00	16.57	18.00	Core	-	-	-	-	32.66								
	18.00																					
	18.50					19.50	18.00	19.50	Core	-	-	-	-	56.00								
	19.00																					
	19.50				Slightly weathered, very weak, dark greyish black, very fine grained, thickly bedded rock	20.50	14.80 to 21.00m				21.00	19.50	21.00	Core	-	-	-	-	82.00	49.33		
21.00																						
21.50																						
22.00																						
22.50	22.50	21.00	22.50			Core	-	-	-	-											47.33	30.66
23.00																						
23.50																						
24.00	24.00	22.50	24.00			Core	-	-	-	-											62.66	53.33
24.50																						
25.00	25.50	24.00	25.50			Core	-	-	-	-											79.33	74.00
25.50	27.00	25.50	27.00	Core	-	-	-	-	83.33	79.33												
26.00	21.00 to 27.00m																					

Project : BHEL

Bore Hole No. : 64

Location : Talabira

Depth of Termination : 21.5 M

Co-ordinates: E 1128, N 3195

Depth of Water Table : Encountered at 1.40m depth during investigation

Date of Start: 24-06-2024

Date of Completion: 26-06-2024

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced Level: 197.40 m

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N S.S.S	Value/Penetration of				Core Recovery (%)	RQD (%)	Remarks
						From m	To m			N ₁	N ₂	N ₃	N			
Rotary drilling method	0.00	Used		Yellowish brown, fine to very fine grained, sandy clays of high plasticity (CH) 0.00 to 5.50m	0.00	0.00	1.00	DS	-	-	-	-	-	-	-	
	0.50															
	1.00				1.00	1.00	2.00	SPT	3	2	2	4	-	-	-	
	1.50															
	2.00				2.00	2.00	2.50	SPT	3	4	6	10	-	-	-	
	2.50				2.50	2.50	3.00	UDS	-	-	-	-	-	-	-	
	3.00				3.00	3.00	3.50	SPT	4	6	9	15	-	-	-	
	3.50				3.50	3.50	4.00	UDS	-	-	-	-	-	-	-	
	4.00				4.00	4.00	4.50	SPT	5	7	9	16	-	-	-	
	4.50				4.50	4.50	5.00	UDS	-	-	-	-	-	-	-	
	5.00				5.00	5.00	5.50	SPT	4	5	8	13	-	-	-	
	5.50	Used		Yellowish brown, fine to very fine grained, clayey sand (SC) 5.50 to 7.20m	5.50	5.50	6.00	UDS	-	-	-	-	-	-	-	
	6.00				6.00	6.00	6.50	SPT	5	7	12	19	-	-	-	
	6.50				6.50	6.50	7.00	UDS	-	-	-	-	-	-	-	
	7.00				7.00	7.00	7.50	SPT	6	8	11	19	-	-	-	
	7.50				7.50	7.50	8.00	SPT	-	-	-	-	-	-	-	
	8.00			Yellowish brown, fine to very fine grained, silty sand with occasional gravels (SM) 7.20 to 10.10m	8.00	8.00	8.50	SPT	6	8	10	18	-	-	-	
	8.50				8.50	8.50	9.00	DS	-	UDS attempted but not recovered				-	-	
	9.00				9.00	9.00	9.50	SPT	7	10	12	22	-	-	-	
	9.50				9.50	9.50	10.00	UDS	-	-	-	-	-	-	-	
	10.00															
	10.50				10.00	10.00	11.00	SPT	31	27	35	62	-	-	-	
	11.00															
	11.50				11.00	11.00	11.14	SPT	50/14cm	-	-	>100	-	-	-	
	12.00	Not used		Highly weathered, moderately weak, dark brownish grey, very fine grained, fractured and disintegrated rock 11.20 to 14.00m	12.50	11.14	12.50	Core	-	-	-	-	4.00	-	-	
	12.50				12.50	12.50	12.53	SPT	50/3cm	-	-	>100	-	-	-	
	13.00															
	13.50				14.00	12.53	14.00	Core	-	-	-	-	30.00	10.00	-	
	14.00															
	14.50				15.50	14.00	15.50	Core	-	-	-	-	26.00	-	-	
	15.00															
	15.50				17.00	15.50	17.00	Core	-	-	-	-	64.00	64.00	-	
	16.00															
	16.50															
	17.00			Moderately weathered, weak, dark greyish, fine to very fine grained, massive rock 17.00 to 21.50m	18.50	17.00	18.50	Core	-	-	-	-	71.00	71.00	-	
	17.50															
	18.00															
	18.50															
	19.00															
	19.50															
	20.00				20.00	18.50	20.00	Core	-	-	-	-	73.00	73.00	-	
	20.50															
	21.00															
	21.50				21.50	20.00	21.50	Core	-	-	-	-	92.00	91.00	-	

17.00 to 21.50m

K.C.T. Consultancy Services®

Project : BHEL

Bore Hole No. : 65

Location : Hirma, Talabira

Depth of Termination : 18.5

Co-ordinates: E 1335, N 3190

Depth of Water Table : Encountered at 4.10m depth during investigation

Date of Start: 19-07-2024

Date of Completion: 22-07-2024

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced level: 201.95 m

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth Sample m	Drill Run		Type Sample	SPT N Value/Penetration of S.S.S				Core Recov- ery (%)	RQD (%)	Remarks		
						From m	To m		N ₁	N ₂	N ₃	N					
Rotary drilling method with Hydraulic feed	0.00	Not used		Yellowish brown, fine to very fine grained, clayey sand (SC) 0.00 to 0.20m	0.00	0.00	1.50	DS	-	-	-	-	-	-			
	0.50			Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI) 0.20 to 3.50m	1.00	1.00	2.00	SPT	3	3	5	8	-	-			
	1.00					Yellowish brown, very fine grained, clays of high plasticity (CH) 3.50 to 5.50m	2.00	2.00	2.50	SPT	5	7	9	16	-	-	
	1.50						2.50	2.50	2.00	UDS	-	-	-	-			
	2.00						3.00	3.00	3.40	SPT	6	8	7	15	-	-	
	2.50						3.50	3.50	4.00	SPT	5	8	13	21			
	3.00					Light yellowish brown, fine to very fine grained, clayey sand (SC) 5.50 to 7.00m	4.00	4.00	4.50	SPT	8	12	16	28			
	3.50			Yellowish brown, fine to very fine grained, sandy clays of high plasticity (CH) 7.00 to 8.30m			4.50	4.50	5.00	UDS	-	-	-	-			
	4.00						5.00	5.00	5.50	SPT	7	9	13	22			
	4.50						5.50	5.50	6.00	UDS	-	-	-	-			
	5.00						6.00	6.00	6.50	SPT	6	10	13	23	-	-	
	5.50			Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI) 8.30 to 10.00m			6.50	6.50	7.00	UDS	-	-	-	-		-	
	6.00					Highly weathered, very weak, yellowish brown and brownish grey, very fine grained, very thinly laminated rock 10.00 to 17.00m	7.00	7.00	7.50	SPT	10	13	15	28			
	6.50						7.50	7.50	8.00	SPT	11	15	21	36			
	7.00						8.00	8.00	8.50	SPT	10	13	25	38			
	7.50						8.50	8.50	9.00	SPT	11	13	27	40			
	8.00					Fresh , weak, dark greyish black, fine to very fine grained, massive rock 17.00 to 18.50m	8.50	9.00	9.50	SPT	18	25	40	65	-	-	
	9.00		9.50	10.00			SPT	35	66/11 cm	-	>100		-				
	9.50		10.00	10.45			SPT	45	56/10 cm	-	>100		-				
	10.00		11.00	11.00			Core	-	-	-	-	12.66	-				
	10.50																
	11.00																
	11.50																
	12.00																
	12.50																
	13.00																
	13.50																
	14.00																
	14.50																
	15.00																
	15.50																
	16.00																
	16.50																
	17.00																
	17.50																
	18.00																
	18.50																
	17.00 to 18.50m																

K.C.T. Consultancy Services®

Project : BHEL

Bore Hole No. : 66

Location : Hirma, Talabira

Depth of Termination : 23

Co-ordinates: E 1280, N 3169

Depth of Water Table : Encountered at 1.80m depth during investigation

Date of Start: 20-07-2024

Date of Completion: 22-07-2024

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced level: 200.86 m

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks
						From m	To m		N ₁	N ₂	N ₃	N			
Rotary drilling method with Hydraulic feed	0.00	Used		Yellowish brown, fine to very fine grained, clayey sand (SC) 0.00 to 0.20m	0.00	0.00	1.50	DS	-	-	-	-	-	-	
	0.50														
	1.00			Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI) 0.20 to 3.20m	1.00	1.00	2.00	SPT	2	3	5	8	-	-	
	1.50														
	2.00			2.00	2.00	2.50	SPT	4	4	7	11				
	2.50			2.50	2.50	2.00	UDS	-	-	-	-				
	3.00				3.00	3.00	3.40	SPT	6	8	10	18	-	-	
	3.50			3.50	3.50	4.00	SPT	5	7	9	16				
	4.00			4.00	4.00	4.50	SPT	7	9	11	20				
	4.50			4.50	4.50	5.00	UDS	-	-	-	-				
	5.00			5.00	5.00	5.50	SPT	4	6	7	13				
	5.50			5.50	5.50	6.00	UDS	-	-	-	-				
	6.00			6.00	6.00	6.50	SPT	9	7	8	15	-	-		
	6.50			6.50	6.50	7.00	UDS	-	-	-	-				
	7.00			Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI) 5.70 to 7.30m	7.00	7.00	7.50	SPT	35	66/13 cm	-	>100			
	7.50			7.50	7.50	8.00	SPT	18	24	32	56				
	8.00			8.00	8.00	8.50	SPT	16	28	37	65				
	8.50			8.50	8.50	9.00	SPT	16	31	40	71				
	9.00			Yellowish brown, fine to very fine grained, clays of intermediate plasticity (CI) 7.30 to 10.10m	9.00	9.00	9.50	SPT	13	28	36	64	-	-	
	9.50			9.50	9.50	10.00	SPT	16	30	40	70	-	-		
	10.00	10.00		10.00	11.50	SPT	42	59/8 cm	-	>100					
	10.50														
	11.00	11.00		11.00	11.04	SPT	51/4 cm	-	-	>100		-			
	11.50														
	12.00														
	12.50			Highly weathered, very weak, light greyish, very fine grained, very thinly laminated mud rock 10.10 to 15.50m	12.50	11.04	12.50	Core	-	-	-	-	14.66		
	13.00														
	13.50														
	14.00		14.00	12.50	14.00	Core	-	-	-	-	21.33	-			
	14.50														
	15.00														
	15.50			Highly weathered, weak, dark greyish black, fine to very fine grained, very thinly laminated rock 15.50 to 17.00m	15.50	14.00	15.50	Core	-	-	-	-	29.00		
	16.00														
	16.50														
	17.00				17.00	15.50	17.00	Core	-	-	-	-	85.33	58.66	
	17.50														
18.00															
18.50	18.50		17.00	18.50	Core	-	-	-	-	82.00	45.33				
19.00															
19.50															
20.00															
20.50	20.50		18.50	20.50	Core	-	-	-	-	76.66	55.33				
21.00															
21.50		Moderately weathered, weak, dark greyish black, fine to very fine grained, very thinly bedded rock 21.50 to 22.00m	21.50	20.50	21.50	Core	-	-	-	-	42.66	27.33			
22.00															
22.50															
23.00			Slightly weathered, moderately weak, dark blackish grey, fine to very fine grained, massive rock	23.00	21.50	23.00	Core	-	-	-	-	95.33	95.33		
22.00 to 23.00m															

K.C.T. Consultancy Services®

Project : BHEL

Bore Hole No. : 67

Location : Talabira

Depth of Termination : 18.0 M

Co-ordinates: E 900, N 3182

Depth of Water Table : Encountered at 2.00m depth during investigation

Date of Start: 02-12-2024


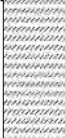


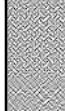


Date of Completion: 05-12-2024

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced Level: 196.50 m

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks
						From m	To m		N ₁	N ₂	N ₃	N			
Rotary drilling method	0.00	Not Used		Yellowish brown, fine to very fine grained, sandy clays of low plasticity with some gravels (CL) 0.00 to 0.10m	0.00	0.00	1.00	DS	-	-	-	-	-	-	
	0.50			Reddish yellow, fine to very fine grained, sandy clays of intermediate plasticity with some gravels (CI) 0.10 to 2.60m	1.00	1.00	2.00	SPT	2	2	2	4	-	-	
	1.00				2.00	2.00	2.50	SPT	2	3	3	6	-	-	
	1.50				2.50	2.50	3.00	UDS	-	-	-	-	-	-	
	2.00				3.00	3.00	3.50	SPT	4	5	8	13	-	-	
	2.50				3.50	3.50	4.00	UDS	-	-	-	-	-	-	
	3.00			Brownish yellow, fine to coarse grained, clayey sand with some to much gravels (SC) 2.60 to 5.40m	4.00	4.00	4.50	SPT	4	6	6	12	-	-	
	3.50				4.50	4.50	5.00	UDS	-	-	-	-	-	-	
	4.00				5.00	5.00	5.50	SPT	5	10	13	23	-	-	
	4.50				5.50	5.50	6.00	UDS	-	-	-	-	-	-	
	5.00				6.00	6.00	6.50	SPT	54/14 cm	-	-	>100	-	-	
	5.50			Yellowish brown, fine to medium grained, cemented silty clayey sand (SM-SC) 5.4 to 7.10m	6.00	6.00	6.50	SPT	50/7 cm	-	-	>100	-	-	
	6.50				6.50	7.00	SPT	50/5 cm	-	-	15	-	-		
	7.00				7.00	7.10	SPT	-	-	-	-	-	-		
	7.50			Highly weathered, weak, light brownish yellow, fine to medium grained, fractured rock 7.10 to 9.00m	7.50	7.10	7.50	Core	-	-	-	-	92.50	-	
	8.00														
	8.50														
	9.00			Slightly weathered, moderately weak, yellowish brown, fine to medium grained, rock with wide spacing of discontinuities 9.00 to 13.50m	9.00	7.50	9.00	Core	-	-	-	-	74.66	42.00	
	9.50														
	10.00														
	10.50														
	11.00														
	11.50														
	12.00														
	12.50														
	13.00														
	13.50														
	14.00														
	14.50														
	15.00														
	15.50														
	16.00					Slightly weathered, moderately weak, light brownish grey, fine to medium grained, massive rock	16.50	15.00	16.50	Core	-	-	-	-	66.00
	16.50														
	17.00														
	17.50														
	18.00														
	13.50 to 18.00m														

Project : BHEL

Bore Hole No. : 68

Location : Hirma, Talabira

Depth of Termination : 17.5 m

Co-ordinates: E 1050, N 3179

Depth of Water Table : Encountered at 2.70 m depth during investigation

Date of Start: 01-08-2024

Date of Completion: 02-08-2024

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced level: 197.40m

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks
						From m	To m		N ₁	N ₂	N ₃	N			
Rotary drilling method	0.00				0.00	0.00	1.00	DS	-	-	-	-	-	-	
	0.50														
	1.00			Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI)	1.00	1.00	2.00	SPT	2	3	4	7			
	1.50			0.00 to 2.30m									-	-	
	2.00				2.00	2.00	2.50	SPT	6	8	11	19			
	2.50			Yellowish brown, fine to very fine grained, clays of intermediate plasticity (CI)	2.50	2.50	3.00	UDS	-	-	-	-			
	3.00			2.30 to 3.60m	3.00	3.00	3.50	SPT	4	5	8	13	-	-	
	3.50				3.50	3.50	4.00	UDS	-	-	-	-			
	4.00			Yellowish brown, very fine grained, clays of high plasticity (CH)	4.00	4.00	4.50	SPT	5	7	9	16			
	4.50			3.60 to 5.90m	4.50	4.50	5.00	UDS	-	-	-	-	-	-	
	5.00				5.00	5.00	5.50	SPT	5	9	10	19			
	5.50				5.50	5.50	6.00	SPT	6	7	9	16	-		
	6.00			Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI)	6.00	6.00	6.50	SPT	6	9	10	19	-	-	
	6.50			5.90 to 6.80m	6.50	6.50	7.00	UDS	-	-	-	-	-		
	7.00				7.00	7.00	7.50	SPT	4	5	6	11			
	7.50			Yellowish brown, fine to very fine grained, clayey sand (SC)	7.50	7.50	8.00	UDS	-	-	-	-	-		
	8.00			6.80 to 8.70m	8.00	8.00	8.50	SPT	4	6	9	15			
	8.50				8.50	8.50	9.00	SPT	4	7	10	17			
	9.00				9.00	9.00	9.50	SPT	5	8	12	20			
	9.50				9.50	9.50	10.00	SPT	7	8	9	16			
	10.00				10.00	10.00	11.00	SPT	6	8	11	19			
	10.50														
	11.00			Yellowish brown, fine to medium grained, silty sand with little to some gravels (SM)	11.00	11.00	11.50	SPT	50/12cm	-	-	>100			
	11.50			8.70 to 13.50m	11.50	11.50	12.50	SPT	50/9cm	-	-	>100			
	12.00														
	12.50				12.50	12.50	13.00	SPT	6	8	11	19			
	13.00				13.00	13.00	14.00	SPT	8	10	12	22			
	13.50			Yellowish brown, fine to medium grained, clayey sand (SC)											
	14.00			13.50 to 14.20m											
	14.50			Brownish, fine to very fine grained, sandy clays of low plasticity (CL)	14.00	14.00	14.50	SPT	50/13cm	-	-	>100			
	15.00			14.20 to 14.60m	14.50	14.50	14.56	SPT	50/6cm	-	-	>100			
	15.50			Moderately weathered, weak, brownish grey, fine to medium grained, thinly bedded rock											
	16.00			14.60 to 16.50m	16.00	14.56	16.00	Core	-	-	-	-	61.42	7.80	
	16.50														
	17.00			Slightly weathered, moderately weak, dark greyish, fine to medium grained, moderately thickly bedded rock											
	17.50				17.50	16.00	17.50	Core	-	-	-	-	92.00	31.33	
16.50 to 17.50m															

Project : BHEL

Bore Hole No. : 70

Location : Talabira

Depth of Termination : 18.5

Co-ordinates: E 1216, N 3170

Depth of Water Table : Encountered at 1.70m depth during investigation

Date of Start: 04-04-2025

Date of Completion: 06-04-2025

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced Level: 85%, &

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks		
						From m	To m		N ₁	N ₂	N ₃	N					
Rotary drilling method	0.00	Used		Yellowish brown, fine to medium grained, clayey sand with occasional gravels (SC) 0.00 to 0.40m	0.00	0.00	1.00	DS	-	-	-	-	-	-			
	0.50																
	1.00				Yellowish brown, fine to medium grained, sandy clays of intermediate plasticity with occasional gravels (CI) 0.40 to 2.70m	1.00	1.00	2.00	SPT	2	2	3	5	-	-		
	1.50																
	2.00					2.00	2.00	2.50	SPT	4	5	5	10	-	-		
	2.50					2.50	2.50	3.00	UDS	-	-	-	-				
	3.00					3.00	3.00	3.50	SPT	4	5	8	13	-	-		
	3.50				Brownish yellow, fine to very fine grained, clays of intermediate plasticity (CI) 2.70 to 4.70m	3.50	3.50	4.00	SPT	5	6	9	15	-	-		
	4.00					4.00	4.00	4.50	SPT	4	4	6	10	-	-		
	4.50					4.50	4.50	5.00	UDS	-	-	-	-				
	5.00				Yellowish brown, fine to very fine grained, silts of intermedite plasticity (MI) 4.70 to 5.50m	5.00	5.00	5.50	SPT	13	30	55	85	-	-		
	5.50																
	6.00																
	6.50					6.50	5.50	6.50	Core	-	-	-	-	11.00			
	7.00																
	7.50					Highly weathered, very weak and friable, yellowish brown, fine to very fine grained, fractured rock 5.50 to 9.50m											
	8.00					8.00	6.50	8.00	Core	-	-	-	-	22.66			
	8.50																
	9.00																
	9.50						9.50	9.00	9.50	Core	-	-	-	-	51.33		
	10.00																
	10.50					Highly weathered, very weak, dark grey, fine to very fine grained, rock with close spacing of discontinuities 9.50 to 12.50m											
	11.00					11.00	9.00	11.00	Core	-	-	-	-	17.33	8.66		
	11.50																
	12.00																
	12.50					Moderately weathered, weak, dark greyish, fine to very fine grained, rock with moderately wide spacing of discontinuities 12.50 to 14.00m	12.50	11.00	12.50	Core	-	-	-	-	43.33	7.33	
	13.00																
	13.50																
	14.00					Moderately weathered, weak, dark greyish, fine to very fine grained, rock with moderately close spacing of discontinuities 14.00 to 15.50m	14.00	12.50	14.00	Core	-	-	-	-	53.33	31.33	
	14.50																
	15.00																
	15.50						15.50	14.00	15.50	Core	-	-	-	-	37.33	17	
	16.00					Slightly weathered, moderately strong, greyish black, fine to medium grained, massive rock 15.50 to 17.50m											
	16.50																
	17.00						17.00	15.50	17.00	Core	-	-	-	-	63.33	59.33	
	17.50																
	18.00					Slightly weathered, moderately weak, greyish black, fine to medium grained, massive rock											
	18.50						18.50	17.00	18.50	Core	-	-	-	-	100.00	100	
17.50 to 18.50m																	

Project : BHEL

Bore Hole No. : 71

Location : Talabira

Depth of Termination : 20

Co-ordinates: E 1175, N 3163

Depth of Water Table : Encountered at 1.50m depth during investigation

Date of Start: 04-04-2025

Date of Completion: 06-04-2025

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced Level: '% +', 'a

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks		
						From m	To m		N ₁	N ₂	N ₃	N					
Rotary drilling method	0.00	Used		Brownish, fine to medium grained, clayey sand (SC) 0.00 to 0.80m	0.00	0.00	1.00	DS	-	-	-	-	-	-			
	0.50																
	1.00			Yellowish brown, fine to medium grained, sandy clays of intermediate plasticity (CI) 0.80 to 2.60m	1.00	1.00	2.00	SPT	3	4	4	8	-	-			
	1.50																
	2.00					2.00	2.00	2.50	SPT	4	5	5	10	-	-		
	2.50					2.50	2.50	3.00	UDS	-	-	-	-	-	-		
	3.00			Yellowish brown, very fine grained, clays of high plasticity (CH) 2.60 to 5.60m	3.00	3.00	3.50	SPT	4	5	7	12	-	-			
	3.50				3.50	3.50	4.00	SPT	4	5	6	11	-	-			
	4.00				4.00	4.00	4.50	SPT	2	3	4	7	-	-			
	4.50				4.50	4.50	5.00	UDS	-	-	-	-	-	-			
	5.00				5.00	5.00	5.50	SPT	4	4	7	11	-	-			
	5.50				5.50	5.50	6.00	UDS	-	-	-	-	-	-			
	6.00				6.00	6.00	6.50	SPT	4	6	8	14	-	-			
	6.50				6.50	6.50	7.00	UDS	-	-	-	-	-	-			
	7.00			Brownish yellow, fine to very fine grained, silty clayey sand (SM-SC) 5.60 to 11.90m	7.00	7.00	7.50	SPT	5	7	12	19	-	-			
	7.50				7.50	7.50	8.00	UDS	-	-	-	-	-	-			
	8.00				8.00	8.00	8.50	SPT	6	8	16	24	-	-			
	8.50				8.50	8.50	9.00	UDS	-	-	-	-	-	-			
	9.00				9.00	9.00	9.50	SPT	8	11	15	26	-	-			
	9.50				9.50	9.50	10.00	SPT	11	15	21	36	-	-			
	10.00				10.00	10.00	11.00	SPT	9	16	22	38	-	-			
	10.50																
	11.00				11.00	11.00	11.50	SPT	8	11	16	27	-	-			
	11.50				11.50	11.50	11.90	SPT	13	22	31	53	-	-			
	12.00			Moderately weatherd, weak, dark brownish, fine to medium grained, rock with close spacing of discontinuities 11.90 to 14.50m													
	12.50																
	13.00				13.00	11.90	13.00	Core	-	-	-	-	63.63	10			
	13.50																
	14.00			Highly weathered, moderately weak, brownish grey, fine to medium grained, rock with moderately close spacing of discontinuities 14.50 to 16.00m													
	14.50				14.50	13.00	14.50	Core	-	-	-	-	27.33	21			
	15.00																
	15.50																
	16.00			Not used		Moderately weathered, moderately weak, greyish black, fine to medium grained, massive rock	16.00	14.50	16.00	Core	-	-	-	-	56.66	56.66	
	16.50																
	17.00																
	17.50						17.50	16.00	17.50	Core	-	-	-	-	46.66	35.33	
18.00																	
18.50																	
19.00																	
19.50		19.00	17.50				19.00	Core	-	-	-	-	55.33	48.00			
20.00		20.00	19.00				20.00	Core	-	-	-	-	50.00	30.00			
16.00 to 20.00m							Page 302 of 356										

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Project : BHEL

Bore Hole No. : 73

Location : Talabira

Depth of Termination : 14.50 M

Co-ordinates: E 886, N 3136

Depth of Water Table : Encountered at 2.30m depth during investigation

Date of Start: 05-08-2024

Date of Completion: 06-08-2024

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced Level: % * " - ' a

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks		
						From m	To m		N ₁	N ₂	N ₃	N					
Rotary drilling method	0.00	Used		Yellowish brown, fine to very fine grained, sandy clays of low plasticity (CL) 0.00 to 1.90m	0.00	0.00	1.00	DS	-	-	-	-	-	-			
	0.50			1.00	1.00	2.00	SPT	2	4	5	9	-	-				
	1.00																
	1.50																
	2.00			Yellowish brown, fine to medium grained, sandy clays of intermediate plasticity (CI) 1.90 to 3.50m	2.00	2.00	2.50	SPT	4	6	8	14	-	-			
	2.50				2.50	3.00	UDS	-	-	-	-	-	-				
	3.00				3.00	3.50	SPT	7	8	11	19	-	-				
	3.50				3.50	4.00	UDS	-	-	-	-	-	-				
	4.00				Brownish yellow, fine to medium grained, clayey sand with occational gravels (SC)	4.00	4.00	4.50	SPT	5	9	15	24	-		-	
	4.50					4.50	5.00	UDS	-	-	-	-	-	-			
	5.00			3.50 to 6.40m		5.00	5.00	5.50	SPT	4	7	9	16	-		-	
	5.50				5.50	6.00	UDS	-	-	-	-	-	-				
	6.00				Brownish, fine to very fine grained, silty and clayey sand (SM-SC) 6.40 to 7.50m	6.00	6.00	6.50	SPT	7	10	13	33	-		-	
	6.50			6.50		7.00	SPT	9	12	17	29	-	-				
	7.00			7.00		7.50	SPT	7	11	14	25	-	-				
	7.50			Light brownish and reddish yellow, fine to very fine grained, clayey sand (SC)		7.50	7.50	8.00	SPT	31	56/7cm	-	>100	-		-	
	8.00					8.00	8.50	SPT	52/8cm	-	-	>100	-	-			
	8.50					8.50	9.00	SPT	50/9cm	-	-	>100	-	-			
	9.00				9.00	9.50	SPT	50/10cm	-	-	>100	-	-				
	9.50				7.50 to 11.05m	9.50	9.50	10.00	SPT	50/9cm	-	-	>100	-		-	
	10.00					10.00	11.00	SPT	56/10cm	-	-	>100	-	-			
	10.50																
	11.00			Not used		Moderately weathered, moderately weak, dark brownish grey, fine to medium grained, fractured rock with moderately closely spaced discontinuities 11.05 to 13.20m	11.00	11.00	11.03	SPT	50/3cm	-	-	>100		-	-
	11.50						11.50	11.50	Core	-	-	-	-	66.66		-	
	12.00						13.00	11.50	13.00	Core	-	-	-	-		62.00	28.00
	12.50																
	13.00																
	13.50					Fresh, moderately weak, dark brownish grey, fine to meidum grained, massive rock	14.50	13.00	14.50	Core	-	-	-	-		98.00	86.00
	14.00																
14.50																	
13.20 to 14.50m																	

Project : BHEL

Bore Hole No. : 75

Location : Hirma, Talabira

Depth of Termination : 15.5 m

Co-ordinates: E 917, N 3123

Depth of Water Table : Encountered at 2.60 m depth during investigation

Date of Start: 05-08-2024






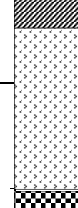
Date of Completion: 05-08-2024

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced level: 197.60 M

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks		
						From m	To m		N ₁	N ₂	N ₃	N					
Rotary drilling method	0.00	Not used		Yellowish brown, fine to very fine grained, clayey sand (SC) 0.00 to 0.70m	0.00	0.00	1.00	DS	-	-	-	-	-	-			
	0.50																
	1.00				Yellowish brown, fine to very fine grained, clays of intermediate plasticity (CI) 0.70 to 1.70m	1.00	1.00	2.00	SPT	1	2	2	4				
	1.50																
	2.00				Yellowish brown, very fine grained, clays of high plasticity (CH)	2.00	2.00	2.50	SPT	2	3	4	7	-	-		
	2.50					2.50	3.00	UDS	-	-	-	-	-	-			
	3.00					3.00	3.50	SPT	3	4	6	10	-	-			
	3.50					3.50	4.00	UDS	-	-	-	-	-	-			
	4.00					1.70 to 4.50m	4.00	4.00	4.50	SPT	4	5	6	11			
	4.50																
	5.00				Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI) 4.50 to 5.20m	4.50	4.50	5.00	UDS	-	-	-	-	-	-		
	5.50					5.50	6.00	UDS	-	-	-	-	-	-			
	6.00					Yellowish brown, fine to medium grained, clayey sand (SC) 5.20 to 6.90m	6.00	6.00	6.50	SPT	10	13	17	30	-	-	
	6.50						6.50	7.00	UDS	-	-	-	-	-	-		
	7.00						Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI) 6.90 to 8.00m	7.00	7.00	7.50	SPT	5	7	8	15		
	7.50							7.50	8.00	SPT	4	5	7	12	-		
	8.00				Yellowish brown, fine to medium grained, clayey sand (SC) 8.00 to 10.20m	8.00	8.00	8.50	SPT	4	6	8	14				
	8.50					8.50	9.00	SPT	5	10	14	24	-				
	9.00					9.00	9.50	SPT	39	50/12cm	-	>100					
	9.50					9.50	10.00	SPT	50/10cm	-	-	>100	-	-			
	10.00					10.00	10.06	SPT	50/6 cm	-	-	>100					
	10.50																
	11.00	USED		Highly weathered, weak, yellowish brown, fine to medium grained, thinly bedded rock	11.00	10.06	11.00	Core	-	-	-	-	18.75	17.50			
	11.50				11.00	11.00	11.03	SPT	50/3 cm	-	-	>100					
	12.00			Moderately weathered, moderately weak, dark brownish grey, fine to medium grained, massive rock	10.20 to 12.50m												
	12.50				12.50	11.03	12.50	Core	-	-	-	-	51.33	24.00			
	13.00																
	13.50																
14.00				14.00	12.50	14.00	Core	-	-	-	-	67.33	62.66				
14.50																	
15.00																	
15.50				15.50	14.00	15.50	Core	-	-	-	-	96.00	96.00				
12.50 to 15.50m																	

Project : BHEL

Bore Hole No. : 76

Location : Talabira

Depth of Termination : 24

Co-ordinates: 9°1'45.5" N 82°5'10" E

Depth of Water Table : Encountered at 1.60m depth during investigation

Date of Start: 22-03-2025

Date of Completion: 24-03-2025

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced Level: 9.85, 9.85, 9.85

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks
						From m	To m		N ₁	N ₂	N ₃	N			
Rotary drilling method	0.00			Yellowish brown, fine to medium grained, sandy clays of intermediate plasticity with occasional gravels (CI) 0.00 to 0.40m	0.00	0.00	1.00	DS	-	-	-	-	-	-	
	0.50														
	1.00			Brownish yellow, fine to medium grained, sandy clays of intermediate plasticity with occasional gravels (CI) 0.40 to 3.00m	1.00	1.00	2.00	SPT	3	3	3	6	-	-	
	1.50														
	2.00														
	2.50														
	3.00														
	3.50														
	4.00			Brownish yellow, very fine grained, clays of intermediate plasticity (CI) 3.00 to 6.50m	4.00	4.00	4.50	SPT	11	13	22	35	-	-	
	4.50														
	5.00														
	5.50														
	6.00														
	6.50														
	7.00			Moderately weathered, weak, dark greyish, fine to very fine grained, rock with wide spacing of discontinuities 8.50 to 9.00m	7.50	6.45	7.50	Core	-	-	-	-	43.00	43.00	
	7.50														
	8.00														
	8.50														
	9.00			Moderately weathered, weak, yellowish brown, fine to medium grained, rock with moderately wide spacing of discontinuities 9.00 to 10.50m	9.00	7.50	9.00	Core	-	-	-	-	47.33	36	
	9.50														
	10.00														
	10.50			Moderately weathered, moderately weak, light brownish grey, fine to medium grained, rock with moderately wide spacing of discontinuities 10.50 to 12.00m	10.50	9.00	10.50	Core	-	-	-	-	52.00	23	
	11.00														
	11.50														
	12.00														
	12.50														
	13.00														
	13.50			Moderately weathered, moderately weak, light brownish grey, fine to medium grained, rock with very wide spacing of discontinuities 12.00 to 16.50m	13.50	12.00	13.50	Core	-	-	-	-	62.00	60	
	14.00														
	14.50														
	15.00														
	15.50														
	16.00														
	16.50			Slightly weathered, moderately weak, greyish black, fine to medium grained, rock with very wide spacing of discontinuities 16.50 to 18.00m	16.50	15.00	16.50	Core	-	-	-	-	63.33	51	
	17.00														
	17.50														
	18.00														
	18.50			Slightly weathered, moderately weak, greyish black, fine to medium grained, massive rock 18.00 to 20.00m	18.00	16.50	18.00	Core	-	-	-	-	71.33	71.33	
	19.00														
	19.50														
	20.00														
	20.50														
	21.00														
	21.50														
	22.00			Slightly weathered, moderately strong, greyish black, fine to medium grained, massive rock	22.50	21.00	22.50	Core	-	-	-	-	56.00	56.00	
	22.50														
	23.00														
	23.50														
	24.00														
20.00 to 24.00m					24.00	22.50	24.00	Core	-	-	-	-	93.33	85.33	

Project : BHEL

Bore Hole No. : 78

Location : Talabira

Depth of Termination : 18

Co-ordinates: E 1253, N 3105

Depth of Water Table : Encountered at 0.80m depth during investigation

Date of Start: 02-04-2025


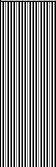

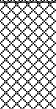




Date of Completion: 04-04-2025

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced Level: % - '\$+`a

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recov-ery (%)	RQD (%)	Remarks		
						From m	To m		N ₁	N ₂	N ₃	N					
Rotary drilling method	0.00	Not used		Yellowish brown and dark brownish, fine to veru fome grained, sandy clays of intermediate plasticity (CI) 0.00 to 1.30m	0.00	0.00	1.00	DS	-	-	-	-	-	-			
	0.50																
	1.00						1.00	1.00	2.00	SPT	2	3	3	6	-	-	
	1.50			Brownish yellow to light brownish, very fine grained, silts of intermediate plasticity (MI) 1.30 to 3.50m	2.00	2.00	2.50	SPT	4	7	15	22	-	-			
	2.50				2.50	3.00	UDS	-	-	-	-	-	-	-			
	3.00				3.00	3.50	SPT	16	23	25	48	-	-	-			
	3.50			Highly weathered, weak, light brownish yellow, fine to very fine grained, rock with moderately close spacing of discontinuities 3.50 to 7.50m	4.50	3.50	4.50	Core	-	-	-	-	41.00	26.00			
	5.00																
	5.50																
	6.00				6.00	4.50	6.00	Core	-	-	-	-	34.00	19.33			
	6.50																
	7.00																
	7.50			Slightly weathered, weak, dark brownish, fine to medium grained, rock with moderately close spacing of discontinuities 7.50 to 9.00m	7.50	6.00	7.50	Core	-	-	-	-	53.33	21.33			
	8.00																
	8.50																
	9.00			Highly weathered, weak, dark brownish, fine to medium grained, fractured rock 9.00 to 10.50m	9.00	7.50	9.00	Core	-	-	-	-	45.33	-			
	9.50																
	10.00																
	10.50			Highly weathered, moderately weak, greyish brown, fine to very fine grained, fractured rock 10.50 to 12.00m	10.50	9.00	10.50	Core	-	-	-	-	27.33				
	11.00																
	11.50																
	12.00			Moderately weathered, moderately strong, greyish brown, fine to medium grained, rock with moderately close spacing of discontinuities 12.00 to 15.00m	12.00	10.50	12.00	Core	-	-	-	-	64.00	22.66			
	12.50																
	13.00																
	13.50				13.50	12.00	13.50	Core	-	-	-	-	58.00	22.60			
	14.00																
	14.50																
	15.00				15.00	13.50	15.00	Core	-	-	-	-	53.33	40.66			
	15.50			Moderately weathered, moderately strong, dark greyish black, fine to medium grained, rock with wide spacing of discontinuities													
	16.00																
	16.50						16.50	15.00	16.50	Core	-	-	-	-	51.33	51.33	
	17.00																
	17.50																
	18.00						18.00	16.50	18.00	Core	-	-	-	-	75.33	75.33	
	15.00 to 18.00m																

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Project : BHEL

Bore Hole No. : 79

Location : Hirma, Talabira

Depth of Termination : 17.0 m

Co-ordinates: E 1172, N 3104

Depth of Water Table : Encountered at 2.60m depth during investigation

Date of Start: 10-04-2025

Date of Completion: 12-04-2025

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced level: % , "+\$ 'a

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks
						From m	To m		N ₁	N ₂	N ₃	N			
Rotary drilling method with Hydraulic feed	0.00	Used		Yellowish brown, fine to medium grained, clayey sand (SC) 0.00 to 1.50m	0.00	0.00	1.50	DS	-	-	-	-	-	-	
	0.50				1.00	1.00	2.00	SPT	2	2	2	4	-	-	
	1.00			Yellowish brown, fine to medium grained, sandy clays of intermediate plasticity with occasional gravels (CI) 1.50 to 4.30m	2.00	2.00	2.50	SPT	2	3	3	6	-	-	
	1.50				2.50	2.50	2.00	UDS	-	-	-	-	-	-	
	2.00				3.00	3.00	3.50	SPT	1	3	4	7	-	-	
	2.50				3.50	3.50	4.00	UDS	-	-	-	-	-	-	
	3.00				4.00	4.00	4.50	SPT	4	6	7	13	-	-	
	3.50				4.50	4.50	5.00	SPT	4	4	6	10	-	-	
	4.00			Brownish yellow, fine to very fine grained, clays of intermediate plasticity (CI) 4.30 to 5.50m	5.00	5.00	5.50	SPT	4	5	8	13	-	-	
	4.50				5.50	5.50	6.00	UDS	-	-	-	-	-	-	
	5.00				6.00	6.00	6.50	SPT	4	6	9	15	-	-	
	5.50				6.50	6.50	7.00	UDS	-	-	-	-	-	-	
	6.00			Brownish yellow, fine to very fine grained, sandy clays of intermediate plasticity (CI) 5.50 to 8.40m	7.00	7.00	7.50	SPT	3	3	8	11	-	-	
	6.50				7.50	7.50	8.00	UDS	-	-	-	-	-	-	
	7.00				8.00	8.00	8.50	SPT	9	14	16	30	-	-	
	7.50				8.50	8.50	9.00	SPT	9	12	22	34	-	-	
	8.00			Brownish yellow, very fine grained, silts of intermediate plasticity (MI) 8.40 to 9.80m	9.00	9.00	9.50	SPT	15	25	46	71	-	-	
	8.50				9.50	9.50	9.80	SPT	-	-	-	-	-	-	
	9.00	Not used		Highly weathered, very weak and friable, light brownish yellow, fine to very fine grained, fractured rock 9.80 to 12.50m	11.00	9.80	11.00	Core	-	-	-	-	11.66	-	
	9.50				12.50	11.00	12.50	Core	-	-	-	-	47.33	17.33	
	10.00			Highly weathered, moderate weak, yellowish brown, fine to very fine grained, rock with close spacing of discontinuities 12.50 to 14.00m	14.00	12.50	14.00	Core	-	-	-	-	58.66	40.66	
	10.50				15.50	14.00	15.50	Core	-	-	-	-	65.33	20.00	
	11.00			Moderately weathered, moderately strong, light brownish, fine to very fine grained, rock with close spacing of discontinuities 15.50 to 16.00m	16.00	15.50	17.00	Core	-	-	-	-	92.66	79.33	
	11.50				17.00	15.50	17.00	Core	-	-	-	-	92.66	79.33	
	12.00			Slightly weathered, weak, greyish black, fine to very fine grained, very wide spacing of discontinuities	17.00	15.50	17.00	Core	-	-	-	-	92.66	79.33	
	12.50				17.00	15.50	17.00	Core	-	-	-	-	92.66	79.33	
	13.00			Slightly weathered, weak, greyish black, fine to very fine grained, very wide spacing of discontinuities	17.00	15.50	17.00	Core	-	-	-	-	92.66	79.33	
	13.50				17.00	15.50	17.00	Core	-	-	-	-	92.66	79.33	
	14.00			Slightly weathered, weak, greyish black, fine to very fine grained, very wide spacing of discontinuities	17.00	15.50	17.00	Core	-	-	-	-	92.66	79.33	
	14.50				17.00	15.50	17.00	Core	-	-	-	-	92.66	79.33	
	15.00			Slightly weathered, weak, greyish black, fine to very fine grained, very wide spacing of discontinuities	17.00	15.50	17.00	Core	-	-	-	-	92.66	79.33	
	15.50				17.00	15.50	17.00	Core	-	-	-	-	92.66	79.33	
	16.00			Slightly weathered, weak, greyish black, fine to very fine grained, very wide spacing of discontinuities	17.00	15.50	17.00	Core	-	-	-	-	92.66	79.33	
	16.50				17.00	15.50	17.00	Core	-	-	-	-	92.66	79.33	
	17.00			Slightly weathered, weak, greyish black, fine to very fine grained, very wide spacing of discontinuities	17.00	15.50	17.00	Core	-	-	-	-	92.66	79.33	
	17.00				17.00	15.50	17.00	Core	-	-	-	-	92.66	79.33	

16.00 to 17.00m

Project : BHEL

Bore Hole No. : 82

Location : Hirma, Talabira

Depth of Termination : 20.0 m

Co-ordinates: E 1011, N 3100

Depth of Water Table : Encountered at 3.10 m depth during investigation

Date of Start: 30-07-2024

Date of Completion: 31-07-2024

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced level: 199.38

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks	
						From m	To m		N ₁	N ₂	N ₃	N				
Rotary drilling method	0.00	Not used		Yellowish brown, fine to very fine grained, clayey sand (SC) 0.00 to 0.50m	0.00	0.00	1.00	DS	-	-	-	-	-	-		
	0.50				Yellowish brown, fine to very fine grained, sandy clays of high plasticity (CH)	1.00	1.00	2.00	SPT	2	3	4	7	-	-	
	1.00					2.00	2.00	2.50	SPT	2	3	5	8			
	1.50					2.50	2.50	3.00	SPT	2	3	5	8			
	2.00					3.00	3.00	3.50	SPT	4	6	9	15	-	-	
	2.50					3.50	3.50	4.00	UDS	-	-	-	-			
	3.00				Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI)	3.50	3.50	4.00	UDS	-	-	-	-	-	-	
	4.00					4.00	4.50	SPT	4	6	10	16				
	4.50					4.50	5.00	UDS	-	-	-	-	-	-	-	
	5.00					5.00	5.50	SPT	5	7	9	16				
	5.50					5.50	6.00	UDS	-	-	-	-	-	-	-	
	6.00				Yellowish brown, fine to medium grained, clayey sand (SC) 5.80 to 7.00m	6.00	6.00	6.50	SPT	11	10	12	22	-	-	
	6.50					6.50	7.00	UDS	-	-	-	-	-	-	-	
	7.00					7.00	7.50	SPT	8	9	13	22				
	7.50					7.50	8.00	UDS	-	-	-	-	-	-	-	
	8.00					8.00	8.50	SPT	8	11	17	28				
	8.50				Yellowish brown, fine to very fine grained, clays of high plasticity (CH)	8.50	8.50	9.00	UDS	-	-	-	-	-	-	
	9.00					9.00	9.50	SPT	5	8	13	21				
	9.50					9.50	10.00	UDS	-	-	-	-	-	-	-	
	10.00					10.00	11.00	SPT	5	7	11	18				
	10.50						Yellowish brown, fine to very fine grained, clayey sand (SC) 9.20 to 10.50m	11.00	11.00	11.50	UDS	-	-	-	-	-
	11.50			11.50	12.50			SPT	8	16	21	37				
	12.00			12.50	13.50			SPT	11	16	23	39		-		
	12.50			13.50	14.00			SPT	8	9	11	20				
	13.00			14.00	14.50			SPT	50/14cm	-	-	>100				
	13.50				Yellowish brown, fine to medium grained, silty sand with some gravels (SM) 10.50 to 13.90m	14.50	14.50	15.50	SPT	50/9cm	-	-	>100			
	14.00					15.50	16.00	SPT	50/8cm	-	-	>100				
	14.50					16.00	17.00	SPT	50/7cm	-	-	>100				
	15.00					17.00	17.07	SPT	50/7cm	-	-	>100				
	15.50					17.00	17.00	17.07	SPT	50/7cm	-	-	>100			
	16.00					17.00	17.00	17.07	SPT	50/7cm	-	-	>100			
	16.50					17.00	17.00	17.07	SPT	50/7cm	-	-	>100			
	17.00					17.00	17.07	SPT	50/7cm	-	-	>100				
17.50		Yellowish brown, fine to very fine grained, clayey sand with little gravels (SC)	17.50	17.50	18.50	Core	-	-	-	-	28.00	8.33				
18.00			18.50	18.50	Core	-	-	-	-	86.00	66.66					
18.50			18.50	18.50	Core	-	-	-	-	86.00	66.66					
19.00			18.50	18.50	Core	-	-	-	-	86.00	66.66					
19.50			18.50	18.50	Core	-	-	-	-	86.00	66.66					
20.00		Highly weathered, very weak, yellowish brown, fine to medium grained, very thinly bedded rock	20.00	20.00	20.00	Core	-	-	-	-	86.00	66.66				
20.00			20.00	20.00	Core	-	-	-	-	86.00	66.66					
19.60 to 20.00m																

Project : BHEL

Bore Hole No. : 84

Location : Talabira

Depth of Termination : 18

Co-ordinates: 9°14'48"N 82°51'45"E

Depth of Water Table : Encountered at 1.60m depth during investigation

Date of Start: 27-03-2025


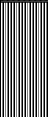




Date of Completion: 03-03-2025

Diameter of Bore: 150mm and Nx size

6 it Used: Soil Surface Bit and NX Size

Reduced Level: 9.10m, 9.15m

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks	
						From m	To m		N ₁	N ₂	N ₃	N				
Rotary drilling method	0.00	Used		Yellowish brown to brownish yellow, fine to medium grained, sandy clays of intermediate plasticity with occasional gravels (CI) 0.00 to 5.70m	0.00	0.00	1.00	DS	-	-	-	-	-	-		
	0.50															
	1.00				1.00	1.00	2.00	SPT	2	2	3	5	-	-		
	1.50															
	2.00				2.00	2.00	2.50	SPT	2	3	4	7	-	-		
	2.50				2.50	2.50	3.00	UDS	-	-	-	-	-	-		
	3.00				3.00	3.00	3.50	SPT	6	7	7	14	-	-		
	3.50				3.50	3.50	4.00	UDS	-	-	-	-	-	-		
	4.00				4.00	4.00	4.50	SPT	6	8	9	17	-	-		
	4.50				4.50	4.50	5.00	UDS	-	-	-	-	-	-		
	5.00				5.00	5.00	5.50	SPT	4	4	8	12	-	-		
	5.50				5.50	5.50	6.00	UDS	-	-	-	-	-	-		
	6.00				Light brownish, fine to very fine grained, sandy silts of intermediate plasticity (MI) 5.70 to 7.30m	6.00	6.00	6.50	SPT	6	11	12	23	-		-
	6.50					6.50	7.00	UDS	-	-	-	-	-	-		
	7.00					7.00	7.50	SPT	75/10 cm	-	-	>100	-	-		
	7.50					7.50	8.00	SPT	85/8 cm	-	-	>100	-	-		
	8.00				Dark brownish grey, fine to very fine grained, cemented clays of intermediate plasticity -mud stone 7.30 to 10.20m	8.00	8.00	8.50	SPT	77/8 cm	-	-	>100	-		-
	8.50					8.50	9.00	SPT	75/7 cm	-	-	>100	-	-		
	9.00					9.00	9.50	SPT	76/6 cm	-	-	>100	-	-		
	9.50					9.50	10.00	SPT	77/8 cm	-	-	>100	-	-		
	10.00					10.00	10.20	SPT	9	16	22	38	-	-		
	10.50				Highly weathered, weak, light yellowish brown, very fine grained, fractured and friable rock 10.20 to 15.20m	10.50	10.20	10.50	Core	-	-	-	-	80.00		-
	11.00															
	11.50															
	12.00					12.00	10.50	12.00	Core	-	-	-	-	66.66		18
	12.50															
	13.00															
	13.50					13.50	12.00	13.50	Core	-	-	-	-	21.33		-
	14.00															
	14.50															
	15.00					15.00	13.50	15.00	Core	-	-	-	-	33.33		30
	15.50															
	16.00						Highly weathered, moderately strong, greyish brown, fine to very fine grained, rock with moderately wide spacing of discontinuities 15.20 to 16.50m	16.50	15.00	16.50	Core	-	-	-		-
	16.50															
	17.00															
	17.50				Slightly weathered, moderately weak, brownish black, fine to very fine grained, fractured rock	18.00	16.50	18.00	Core	-	-	-	-	91.33		-
	18.00															
	17.00 to 18.00m															

Project : BHEL

Bore Hole No. : 86

Location : Talabira

Depth of Termination : 17.5

Co-ordinates: 9° 22' 42" N, 76° 10' 00" E

Depth of Water Table : Encountered at 0.40m depth during investigation

Date of Start: 10-04-2025

Date of Completion: 12-04-2025

Diameter of Bore: 150mm and Nx size

6 it Used: Soil Surface Bit and NX Size

Reduced Level: %, ", 'a

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks		
						From m	To m		N ₁	N ₂	N ₃	N					
Rotary drilling method	0.00	Not Used		Yellowish brown, fine to medium grained, clayey sand (SC) 0.00 to 0.60m	0.00	0.00	1.00	DS	-	-	-	-	-	-			
	0.50																
	1.00				Light brownish yellow, fine to very fine grained, silty clays of intermediate plasticity (CI) 0.60 to 2.40m	1.00	1.00	2.00	SPT	1	2	2	4	-	-		
	1.50																
	2.00					2.00	2.00	2.50	SPT	10	17	23	40	-	-		
	2.50					2.50	2.50	3.00	SPT	11	22	31	53	-	-		
	3.00				Brownish yellow, very fine grained, silts of intermediate plasticity (MI) 2.40 to 4.20m	3.00	3.00	3.50	SPT	16	28	36	64	-	-		
	3.50					3.50	3.50	4.00	SPT	61/11 cm	-	-	>100	-	-		
	4.00					4.00	4.00	4.10	SPT	75/10 cm	-	-	>100	-	-		
	4.50																
	5.00																
	5.50						5.50	4.10	5.50	Core	-	-	-	-	36.00	-	
	6.00					Highly weathered, very weak, greyish brown, fine to very fine grained, fractured rock 4.20 to 8.50m											
	6.50																
	7.00						7.00	5.50	7.00	Core	-	-	-	-	10.66	-	
	7.50																
	8.00																
	8.50						8.50	7.00	8.50	Core	-	-	-	-	21.33	6.66	
	9.00																
	9.50																
	10.00					Highly weathered, very weak, dark grey, fine to very fine grained, rock with close spacing of discontinuities 8.50 to 11.50m	10.00	8.50	10.00	Core	-	-	-	-	40.66	14	
	10.50																
	11.00																
	11.50																
	12.00						12.00	10.00	12.00	Core	-	-	-	-	60.00	35	
	12.50																
	13.00																
	13.50					Moderately weathered, weak, yellowish brown to greyish, fine to medium grained, rock with moderately wide spacing of discontinuities 11.50 to 14.50m	13.50	12.00	13.50	Core	-	-	-	-	57.33	32	
	14.00																
	14.50																
	15.00					Moderately weathered, weak, light greyish brown, fine to medium grained, fractured rock 14.50 to 16.00m	15.00	13.50	15.00	Core	-	-	-	-	62.00	62	
	15.50																
	16.00					Moderately weathered, moderately weak, light greyish, fine to medium grained, rock with wide spacing of discontinuities 16.00 to 17.00m	16.00	15.00	16.00	Core					43.00	40.00	
	16.50																
	17.00																
	17.50					Slightly weathered, weak, greyish black, fine to very fine grained, massive rock	17.50	16.00	17.50	Core					88.66	83.33	
17.00 to 18.00m																	

K.C.T. Consultancy Services®

Project : BHEL

Bore Hole No. : 87

Location : Talabira

Depth of Termination : 21.0 M

Co-ordinates: E 902, N 3074

Depth of Water Table : Encountered at 2.45m depth during investigation

Date of Start: 04-08-2024

Date of Completion: 09-08-2024

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced Level: % + "a" 'a

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks
						From m	To m		N ₁	N ₂	N ₃	N			
Rotary drilling method	0.00	Used		Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI) 0.00 to 0.80m	0.00	0.00	1.00	DS	-	-	-	-	-	-	
	0.50														
	1.00			Dark Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI) 0.80 to 3.90m	1.00	1.00	2.00	SPT	4	5	6	11	-	-	
	1.50														
	2.00														
	2.50														
	3.00														
	3.50														
	4.00			Dark Yellowish brown, fine to very fine grained, clayey sand with occasional gravels (SC) 3.90 to 7.30m	4.00	4.00	4.50	SPT	7	7	12	19	-	-	
	4.50														
	5.00														
	5.50														
	6.00														
	6.50														
	7.00			Light yellowish brown, fine to very fine grained, clayey sand (SC) 7.30 to 8.40m	7.00	7.00	7.50	SPT	6	6	9	15	-	-	
	7.50														
	8.00														
	8.50														
	9.00														
	9.50														
	10.00			Yellowish brown, fine to very fine grained, clayey sand with some gravels (SC) 9.40 to 12.30m	10.00	9.50	10.00	SPT	10	14	19	33	-	-	
	10.50														
	11.00														
	11.50														
	12.00														
	12.50														
	+ 13.00	Not Used		Highly weathered, very weak and friable, brownish yellow, fine to medium grained, interlocking fragments of fractured rock 12.30 to 15.00m	12.50	11.70	12.50	Core	-	-	-	-	20.00	-	
	13.50														
	14.00														
	14.50														
	15.00			Highly weathered, completely fractured and disintegrated, brownish yellow, fine to medium grained, very weak and friable rock with very close spacing of discontinuities 15.00 to 18.00m	15.00	13.50	15.00	Core	-	-	-	-	28.00	6.66	
	15.50														
	16.00														
16.50															
17.00															
17.50															
18.00	Moderately weathered, very weak, fine to medium grained, fractured rock 18.00 to 19.50m			18.00	16.50	18.00	Core	-	-	-	-	64.66	-		
18.50															
19.00															
19.50															
20.00	Moderately weathered, moderately weak, brownish yellow, fine to very fine grained, rock with wide spacing discontinuities 19.50 to 20.00m			19.50	18.00	19.50	Core	-	-	-	-	60.00	45.33		
20.50															
21.00															
20.00 to 21.00m															

K.C.T. Consultancy Services®

Project : BHEL

Bore Hole No. : 88

Location : Talabira

Depth of Termination : 17.50 m

Co-ordinates: E 1266, N 3062

Depth of Water Table : Encountered at 0.60m depth during investigation

Date of Start: 13-04-2025





































Date of Completion: 16-04-2025

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced Level: 197.20 M

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks	
						From m	To m		N ₁	N ₂	N ₃	N				
Rotary drilling method	0.00	Not Used		Yellowish brown, fine to very fine grained, sandy clays of low plasticity with some gravels (CL) 0.00 to 0.60m	0.00	0.00	1.00	DS	-	-	-	-	-	-		
	0.50															
	1.00					1.00	1.00	2.00	SPT	2	2	3	5	-	-	
	1.50															
	2.00															
	2.50															
	3.00															
	3.50															
	4.00															
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	5.00															
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	10.00															
	10.50															
	11.00															
	11.50															
	12.00															
	12.50															
	+ 13.00															
	13.50															
14.00																
14.50																
15.00																
15.50																
16.00																
16.50																
17.00																
17.50																
16.00 to 17.50m																

Project : BHEL

Bore Hole No. : 90

Location : Hirma, Talabira

Depth of Termination : 24.5 m

Co-ordinates: E 884, N 3039

Depth of Water Table : Encountered at 2.50 m depth during investigation

Date of Start: 31-07-2024

Date of Completion: 03-08-2024

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced level: 197.10 m

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks	
						From m	To m		N ₁	N ₂	N ₃	N				
Rotary drilling method	0.00	used		Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI)	0.00	0.00	1.00	DS	-	-	-	-	-	-		
	0.50		0.00 to 0.90m													
	1.00					1.00	1.00	2.00	SPT	3	4	5	9			
	1.50															
	2.00			Yellowish brown, fine to very fine grained, clays of high plasticity (CH)	2.00	2.00	2.50	SPT	7	11	11	22	-	-		
	2.50			0.90 to 2.80m	2.50	2.50	3.00	UDS	-	-	-	-				
	3.00				3.00	3.00	3.50	SPT	3	5	6	11	-	-		
	3.50			Yellowish brown, fine to very fine grained, sandy clays of high plasticity (CH)	3.50	3.50	4.00	UDS	-	-	-	-				
	4.00				2.80 to 4.90m	4.00	4.00	4.50	SPT	7	8	12	20			
	4.50				4.50	4.50	5.00	UDS	-	-	-	-	-	-		
	5.00				5.00	5.00	5.50	SPT	7	12	15	27				
	5.50		Yellowish brown, fine to medium grained, clayey sand (SC)	5.50	5.50	6.00	UDS	-	-	-	-	-	-			
	6.00			6.00	6.00	6.50	SPT	9	14	16	30	-	-			
	6.50			6.50	6.50	7.00	SPT	10	13	17	30	-	-			
	7.00			7.00	7.00	7.50	SPT	7	10	11	21					
	7.50			7.50	7.50	8.00	SPT	50/10cm	-	-	>100	-				
	8.00			8.00	8.00	8.11	SPT	50/11cm	-	-	>100					
	8.50															
	9.00			Not Used												
	9.50				9.50	8.11	9.50	Core	-	-	-	-	10.37	-		
	10.00				9.50	9.50	9.53	SPT	50/3cm	-	-	>100	-	-		
	10.50															
	11.00				11.00	9.53	11.00	Core	-	-	-	-	6.00	-		
	11.50				11.00	11.00	11.04	SPT	50/4cm	-	-	>100	-	-		
	12.00															
	12.50	Highly weathered, very weak, brownish yellow, fine to medium grained, very thinly laminated rock	12.50		11.04	12.50	Core	-	-	-	-	19.33	-			
	13.00		12.50		12.50	12.52	SPT	50/2cm	-	-	>100	-	-			
	13.50		8.25 to 18.00m													
	14.00				14.00	12.52	14.00	Core	-	-	-	-	21.33	-		
	14.50															
	15.00															
	15.50				15.50	14.00	15.50	Core	-	-	-	-	26.66	-		
	16.00															
16.50																
17.00		17.00	15.50	17.00	Core	-	-	-	-	28.66	-					
17.50																
18.00	Highly weathered, moderately weak, dark greyish, fine to very fine grained, very thinly bedded rock	18.00														
18.50			18.50	17.00	18.50	Core	-	-	-	-	28.00	6.66				
19.00																
19.50																
20.00			20.00	18.50	20.00	Core	-	-	-	-	7.33	-				
20.50		18.00 to 23.00m	20.00	20.00	20.03	SPT	50/3cm	-	-	>100	-	-				
21.00																
21.50			21.50	20.03	21.50	Core	-	-	-	-	21.33	-				
22.00																
22.50																
23.00	Highly weathered, moderately weak, dark greyish, fine to very fine grained, moderately thinly bedded rock	23.00	21.50	23.00	Core	-	-	-	-	66.00	29.33					
23.50		23.00 to 24.00m														
24.00		Slightly weathered, weak, dark greyish black, fine to very fine grained, massive rock	24.00													
24.50			24.50	23.00	24.50	Core	-	-	-	-	87.33	81.33				
				24.00 to 25.00m	Page 212 of 256											

Project : BHEL

Bore Hole No. : 91

Location : Hirma, Talabira

Depth of Termination : 19.0 m

Co-ordinates: 9° - +, 78° 5' - %

Depth of Water Table : Encountered at 2.90 m depth during investigation

Date of Start: 10-08-2024

Date of Completion: 11-08-2024

Diameter of Bore: 150mm and Nx size

6 bit Used: Soil Surface Bit and NX Size

Reduced level: % , " ' a

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks
						From m	To m		N ₁	N ₂	N ₃	N			
Rotary drilling method	0.00			Yellowish brown, fine to very fine grained, clayey sand (SC) 0.00 to 0.50m	0.00	0.00	1.00	DS	-	-	-	-	-	-	
	0.50														
	1.00				1.00	1.00	2.00	SPT	1	2	2	4			
	1.50												-	-	
	2.00				2.00	2.00	2.50	SPT	2	3	2	5			
	2.50			Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI) 0.50 to 4.70m	2.50	2.50	3.00	UDS	-	-	-	-			
	3.00				3.00	3.00	3.50	SPT	4	4	7	11	-	-	
	3.50				3.50	3.50	4.00	UDS	-	-	-	-			
	4.00				4.00	4.00	4.50	SPT	3	5	7	12			
	4.50				4.50	4.50	5.00	UDS	-	-	-	-	-	-	
	5.00				5.00	5.00	5.50	SPT	6	9	11	20			
	5.50			Yellowish brown, fine to very fine grained, clayey sand (SC) 4.70 to 6.30m	5.50	5.50	6.00	UDS	-	-	-	-	-	-	
	6.00				6.00	6.00	7.00	SPT	5	7	10	17	-	-	
	6.50			Yellowish brown, fine to very fine grained, sandy clays of low plasticity with little gravels (CL) 6.30 to 7.60m											
	7.00				7.00	7.00	7.50	SPT	5	6	8	14			
	7.50				7.50	7.50	8.00	UDS	-	-	-	-	-	-	
	8.00				8.00	8.00	8.50	SPT	5	7	11	18			
	8.50				8.50	8.50	9.00	UDS	-	-	-	-			
	9.00				9.00	9.00	9.50	SPT	5	8	11	19			
	9.50				9.50	9.50	10.00	UDS	-	-	-	-			
	10.00			Yellowish brown, fine to very fine grained, clayey sand (SC) 7.60 to 13.30m	10.00	10.00	11.00	SPT	5	8	10	18			
	10.50														
	11.00				11.00	11.00	11.50	SPT	18	22	24	46			
	11.50				11.50	11.50	12.50	SPT	16	18	22	40			
	12.00														
	12.50				12.50	12.50	13.00	SPT	50/14cm	-	-	>100			
	13.00				13.00	13.00	14.00	SPT	36	50/12cm	-	>100			
	13.50														
	14.00			Dark brownish, fine to very fine grained, clays of high plasticity (CH) 13.30 to 15.60m	14.00	14.00	14.50	SPT	50/12cm	-	-	>100			
	14.50				14.50	14.50	15.50	SPT	50/9cm	-	-	>100			
	15.00														
	15.50				15.50	15.50	15.55	SPT	50/5 cm	-	-	>100			
	16.00			Moderately weathered, weak, dark blackish grey, fractured rock 15.60 to 17.50m	16.00	15.55	16.00	Core	-	-	-	-	60.00	-	
	16.50														
	17.00														
	17.50				17.50	16.00	17.50	Core	-	-	-	-	76.00	28.66	
	18.00			Fresh, moderately weak, brownish grey, fine to medium grained, massive rock											
	18.50														
	19.00				19.00	17.50	19.00	Core	-	-	-	-	93.33	93.33	
17.50 to 19.00m															

Project : BHEL

Bore Hole No. : 92

Location : Hirma, Talabira

Date of Start: 23-07-2024

Date of Completion: 31-07-2024

Depth of Termination : 18.5 m

Diameter of Bore: 150mm and Nx size

Co-ordinates: E 131 1, N 303I

Bit Used: Soil Surface Bit and NX Size

Depth of Water Table : Encountered at 2.40 m depth during investigation

Reduced level: 200.70

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks
						From m	To m		N ₁	N ₂	N ₃	N			
Rotary drilling method	0.00	Not used		Light yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI) 0.00 to 0.40m	0.00	0.00	1.00	DS	-	-	-	-	-	-	
	0.50			Yellowish brown, fine to very fine grained, clays of high plasticity (CH) 0.40 to 1.80m	1.00	1.00	2.00	SPT	3	4	6	10	-	-	
	1.00			Yellowish brown, fine to medium grained, clayey sand (SC) 1.80 to 2.50m	2.00	2.00	2.50	SPT	8	13	10	23	-	-	
	1.50			Yellowish brown, fine to very fine grained, clays of high plasticity (CH) 2.50 to 3.50m	2.50	2.50	3.00	UDS	-	-	-	-	-	-	
	2.00				3.00	3.00	3.50	SPT	9	10	11	21	-	-	
	2.50				3.50	3.50	4.00	UDS	-	-	-	-	-	-	
	3.00				4.00	4.00	4.50	SPT	36	38	66	>100	-	-	
	3.50				4.50	4.50	5.00	SPT	15	50/9cm	-	>100	-	-	
	4.00				5.00	5.00	5.50	SPT	18	52	50/7cm	>100	-	-	
	4.50				5.50	5.50	6.00	SPT	50/14cm	-	-	>100	-	-	
	5.00				6.00	6.00	7.00	SPT	50/12cm	-	-	>100	-	-	
	5.50				7.00	7.00	7.50	SPT	50/6 cm	-	-	>100	-	-	
	6.00				7.50	7.50	8.00	SPT	50/8 cm	-	-	>100	-	-	
	6.50				8.00	8.00	8.10	SPT	50/10cm	-	-	>100	-	-	
	7.00				8.50	8.50	9.50	Core	-	-	-	-	12.72	-	
	7.50				9.50	9.50	9.53	SPT	50/3 cm	-	-	>100	-	-	
	8.00				10.00	10.00	11.00	DS	-	-	-	-	4.66	-	
	8.50				11.00	11.00	11.05	SPT	50/5 cm	-	-	>100	-	-	
	9.00				12.50	12.50	12.50	Core	-	-	-	-	8.00	-	
	9.50				12.50	12.50	12.52	SPT	50/2 cm	-	-	>100	-	-	
	10.00	USED			14.00	12.52	14.00	Core	-	-	-	-	29.33	-	
	10.50				15.50	14.00	15.50	Core	-	-	-	-	46.00	-	
	11.00				17.00	15.50	17.00	Core	-	-	-	-	66.66	60.66	
	11.50				18.50	17.00	18.50	Core	-	-	-	-	97.33	97.33	
	12.00														
	12.50														
	13.00														
	13.50														
	14.00														
	14.50														
	15.00														
	15.50														
	16.00														
	16.50														
	17.00														
	17.50														
	18.00														
	18.50														

Project : BHEL

Bore Hole No. : 93

Location : Talabira

Depth of Termination : 18

Co-ordinates: 9°19'48.22"N 82°51'54.12"E

Depth of Water Table : Encountered at 1.50m depth during investigation

Date of Start: 28-03-2025

Date of Completion: 31-03-2025

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced Level: 51.20 m

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks
						From m	To m		N ₁	N ₂	N ₃	N			
Rotary drilling method	0.00			Brownish, fine to medium grained, sandy clays of low plasticity (CL) 0.00 to 0.30m	0.00	0.00	1.00	DS	-	-	-	-	-	-	
	0.50			Brownish yellow, fine to coarse grained, clayey sand (SC) 0.30 to 1.50m	1.00	1.00	2.00	SPT	3	3	6	9	-	-	
	1.00				2.00	2.00	2.50	SPT	4	4	6	10	-	-	
	1.50				2.50	2.50	3.00	UDS	-	-	-	-	-	-	
	2.00				3.00	3.00	3.50	SPT	6	12	22	34	-	-	
	2.50				3.50	3.50	4.00	UDS	-	-	-	-	-	-	
	3.00				4.00	4.00	4.50	SPT	15	29	31	60	-	-	
	3.50				4.50	4.50	5.10	SPT	18	28	39	67	-	-	
	4.00														
	4.50														
	5.00														
	5.50														
	6.00			Highly weathered, very weak and friable, yellowish brown, fine to very fine grained, rock with moderately close spacing of discontinuities 5.10 to 7.50m	6.00	5.10	6.00	Core	-	-	-	-	87.77	26	
	6.50														
	7.00														
	7.50			Highly weathered, very weak, light brownish, fine to very fine grained, rock with close spacing of discontinuities 7.50 to 9.00m	7.50	6.00	7.50	Core	-	-	-	-	34.66	15.33	
	8.00														
	8.50														
	9.00			Moderately weathered, weak, dark brownish, fine to very fine grained, rock with moderately close spacing of discontinuities 9.00 to 10.50m	9.00	7.50	9.00	Core	-	-	-	-	46.00	21.33	
	9.50														
	10.00														
	10.50			Slightly weathered, weak, greyish black, fine to medium grained, rock with wide spacing of discontinuities 10.50 to 12.00m	10.50	9.00	10.50	Core	-	-	-	-	70.66	63.33	
	11.00														
	11.50														
	12.00			Slightly weathered, moderately weak, brownish grey fine to medium grained, rock with very wide spacing of discontinuities 12.00 to 13.50m	12.00	10.50	12.00	Core	-	-	-	-	54.00	54.00	
	12.50														
	13.00														
	13.50														
	14.00														
	14.50														
	15.00														
	15.50			Slightly weathered, moderately weak, greyish black, fine to medium grained, massive rock	15.00	13.50	15.00	Core	-	-	-	-	62.66	57.33	
	16.00														
	16.50														
	17.00														
	17.50														
	18.00				18.00	16.50	18.00	Core	-	-	-	-	92.66	84.00	
13.50 to 18.00m															

K.C.T. Consultancy Services®

Project : BHEL

Bore Hole No. : 94

Location : Hirma, Talabira

Depth of Termination : 25.0 m

Co-ordinates : E 110J, N 3047

Depth of Water Table : Encountered at 3.40m depth during investigation

Date of Start: 17-07-2024

Date of Completion: 20-07-2024

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced level: 199.89 m

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks
						From m	To m		N ₁	N ₂	N ₃	N			
Rotary drilling method with Hydraulic feed	0.00			Yellowish brown, fine to very fine grained, sandy clays of low plasticity (CL) 0.00 to 0.70m	0.00	0.00	1.50	DS	-	-	-	-	-	-	
	0.50														
	1.00			Yellowish brown, fine to medium grained, clayey sand (SC) 0.70 to 1.70m	1.00	1.00	2.00	SPT	5	6	6	12	-	-	
	1.50														
	2.00			Yellowish brown, fine to medium grained, sandy clays of intermediate plasticity (CI) 1.70 to 2.60m	2.00	2.00	2.50	SPT	4	4	6	10	-	-	
	2.50														
	3.00														
	3.50														
	4.00														
	4.50														
	5.00			Yellowish brown, fine to very fine grained, clays of high plasticity (CH) 2.60 to 7.80m	4.50	4.50	5.00	UDS	-	-	-	-	-	-	
	5.50														
	6.00														
	6.50														
	7.00														
	7.50			Yellowish brown, fine to medium grained, sandy clays of intermediate plasticity (CI) 7.80 to 8.60m	5.00	5.00	5.50	SPT	4	5	6	11	-	-	
	8.00														
	8.50														
	9.00														
	9.50														
	10.00														
	10.50			Yellowish brown, fine to medium grained, clayey sand (SC) 8.60 to 12.95m	5.50	5.50	6.00	UDS	-	-	-	-	-	-	
	11.00														
	11.50														
	12.00														
	12.50														
	13.00														
	13.50														
	14.00			Highly weathered, very weak, greyish brown, very fine grained, thinly laminated rock	6.00	6.00	6.50	SPT	4	6	8	14	-	-	
	14.50														
	15.00														
	15.50			12.95 to 16.00m	6.50	6.50	7.00	UDS	-	-	-	-	-	-	
	16.00														
	16.50														
	17.00			Moderately weathered, very weak, greyish brown, very fine grained, thinly bedded rock	7.00	7.00	7.50	SPT	7	8	8	16	-	-	
	17.50														
	18.00														
	18.50			16.00 to 19.00m	7.50	7.50	8.00	UDS	-	-	-	-	-	-	
	19.00														
	19.50														
	20.00														
	20.50			slightly weathered, weak, dark greyish black, fine grained, moderately thickly bedded rock	8.00	8.00	8.50	SPT	8	8	9	17	-	-	
	21.00														
	21.50														
	22.00														
	22.50			19.00 to 23.00m	8.50	8.50	9.00	SPT	7	9	12	19	-	-	
	23.00														
	23.50														
	24.00			Slightly weathered, moderately weak to moderately strong, dark greyish, fine to medium grained, thickly bedded rock	9.00	9.00	9.50	SPT	8	10	15	25	-	-	
	24.50														
	25.00														
23.00 to 25.00m															

Project : BHEL

Bore Hole No. : 98

Location : Hirma, Talabira

Depth of Termination : 22.0 m

Co-ordinates : E 912, N 3024

Depth of Water Table : Encountered at 2.40 m depth during investigation

Date of Start: 02-08-2024

Date of Completion: 07-08-2024

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced level: 197.45 m

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks
						From m	To m		N ₁	N ₂	N ₃	N			
Rotary drilling method	0.00	Not used		Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI)	0.00	0.00	1.00	DS	-	-	-	-	-	-	
	0.50			0.00 to 0.70m											
	1.00				1.00	1.00	2.00	SPT	2	3	4	7			
	1.50				Yellowish brown, fine to very fine grained, sandy clays fo high palsticity (CH)										
	2.00					2.00	2.00	2.50	SPT	3	3	5	8	-	-
	2.50				0.70 to 3.00m	2.50	2.50	3.00	UDS	-	-	-	-		
	3.00				Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI)	3.00	3.00	3.50	SPT	3	4	6	10	-	-
	3.50				3.00 to 4.50m	3.50	3.50	4.00	UDS	-	-	-	-		
	4.00					4.00	4.00	4.50	SPT	3	4	5	9		
	4.50					4.50	4.50	5.00	UDS	-	-	-	-	-	-
	5.00					5.00	5.00	5.50	SPT	4	6	10	16		
	5.50				Yellowish brown, fine to very fine grained, clayey sand (SC)	5.50	5.50	6.00	UDS	-	-	-	-	-	
	6.00					6.00	6.00	6.50	SPT	4	5	6	11	-	-
	6.50					6.50	6.50	7.00	SPT	4	5	8	13	-	-
	7.00				4.50 to 7.90m	7.00	7.00	7.50	SPT	4	4	10	14	-	-
	7.50					7.50	7.50	8.00	SPT	5	6	9	15	-	-
	8.00					8.00	8.00	8.50	SPT	4	6	8	14	-	-
	8.50				Yellowish brown, fine to medium grained, silty sand with some gravels (SM)	8.50	8.50	9.00	SPT	4	5	7	12	-	-
	9.00					9.00	9.00	9.50	SPT	5	7	7	14	-	-
	9.50				7.90 to 10.40m	9.50	9.50	10.00	SPT	5	8	16	24	-	-
	10.00					10.00	10.00	11.00	SPT	6	10	17	27	-	-
	10.50														
	11.00				Yellowish brown, fine to medium grained, clayey sand with much to little gravels (SC)	11.00	11.00	11.50	SPT	16	38	37	75	-	-
	11.50				10.40 to 12.20m	11.50	11.50	12.50	SPT	50/9cm	-	-	>100	-	-
	12.00														
	12.50					12.50	12.50	13.00	SPT	50/8cm	-	-	>100	-	-
	13.00				Light yellowish brown, medium to coarse grained, poorly graded and silty sand with much gravels (SP-SM)	13.00	13.00	14.00	SPT	50/4cm	-	-	>100	-	-
	13.50														
	14.00				12.20 to 14.60m	14.00	14.00	14.50	SPT	50/4cm	-	-	>100	-	-
	14.50					14.50	14.50	14.53	SPT	50/3cm	-	-	>100	-	-
	15.00														
	15.50				Highly weathered, very weak, medium grained, brownish, fine to medium grained, thinly bedded rock										
	16.00					16.00	14.53	16.00	Core	-	-	-	-	36.92	7.14
16.50			14.60 to 17.00m												
17.00															
17.50			Highly weathered, very weak and fraible , yellowish brown, fine to medium grained, very thinly laminated rock	17.50	16.00	17.50	Core	-	-	-	-	58.66	-		
18.00															
18.50															
19.00			17.00 to 19.50m	19.00	17.50	19.00	Core	-	-	-	-	50.00	-		
19.50															
20.00			Moderately weathered, very weak, brownish grey, fine to medium grained, very thinly bedded rock												
20.50			19.50 to 21.50m	20.50	19.00	20.50	Core	-	-	-	-	64.66	6.66		
21.00															
21.50			Slightly weathered, weak, yellowish brown, fine to medium grained, moderately thickly bedded rock												
22.00				22.00	20.50	22.00	Core	-	-	-	-	92.00	33.33		
21.50 to 22.00m															

Project : BHEL

Bore Hole No. : 100

Location : Talabira

Depth of Termination : 14.0 m

Co-ordinates: E 1240, N 3017

Depth of Water Table : Encountered at 0.80m depth during investigation

Date of Start: 02-04-2025

Date of Completion: 03-04-2025

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced Level: % - '\$\$

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recov- ery (%)	RQD (%)	Remarks		
						From m	To m		N ₁	N ₂	N ₃	N					
Rotary drilling method	0.00	Not used		Brownish yellow, fine to very fine grained, silty clays of low plasticity (CL) 0.00 to 0.30m	0.00	0.00	1.00	DS	-	-	-	-	-	-			
	0.50																
	1.00				Yellowish brown, fine to very fine grained, silts of intermediate plasticity (MI) 0.30 to 3.60m	1.00	1.00	2.00	SPT	3	4	7	11	-	-		
	1.50																
	2.00					2.00	2.00	2.50	SPT	5	9	10	19	-	-		
	2.50					2.50	2.50	3.00	UDS	-	-	-	-	-	-		
	3.00					3.00	3.00	3.50	SPT	15	25	35	60	-	-		
	3.50				3.50	3.50	3.60	UDS	-	-	-	-	-	-			
	4.00																
	4.50																
	5.00					5.00	3.60	5.00	Core	-	-	-	-	7.33	-		
	5.50																
	6.00					Highly weathered, weak, yellowish brown, fine to very fine grained, fractured rock 3.60 to 9.50m											
	6.50				6.50		5.00	6.50	Core	-	-	-	-	28.00	-		
	7.00																
	7.50																
	8.00				8.00		6.50	8.00	Core	-	-	-	-	48.33	-		
	8.50																
	9.00																
	9.50				Moderately weathered, moderately weak, brownish yellow, fine to medium grained, massive rock 9.50 to 10.50m	9.50	8.00	9.50	Core	-	-	-	-	68.66	59.33		
	10.00																
	10.50					Moderately weathered, weak, dark blackish, fine to very fine grained, rock with moderately close spacing of discontinuities 10.50 to 13.00m	11.00	9.50	11.00	Core	-	-	-	-	47.33	26.66	
	11.00																
	11.50																
	12.00																
	12.50				12.50		11.00	12.50	Core	-	-	-	-	64.66	24.00		
	13.00				Slightly weathered, moderately weak, greyish black, fine to medium grained, massive rock												
	13.50																
	14.00																
			14.00	12.50		14.00	Core	-	-	-	-	86.66	54.66				
13.00 to 14.00m																	

K.C.T. Consultancy Services®

Project : BHEL

Bore Hole No. : 101

Location : Talabira

Depth of Termination : 25.0 M

Co-ordinates: E 1047, N 3016

Depth of Water Table : Encountered at 2.70m depth during investigation

Date of Start: 18-07-2024

Date of Completion: 22-07-2024

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced Level: 199.53

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks	
						From m	To m		N ₁	N ₂	N ₃	N				
Rotary drilling method	0.00	Used		Yellowish brown, fine to very fine grained, sandy clays of low plasticity (CL) 0.00 to 0.80m	0.00	0.00	1.00	DS	-	-	-	-	-	-		
	0.50															
	1.00															
	1.50															
	2.00				Yellowish brown, very fine grained, clays of high plasticity (CH)	1.00	1.00	2.00	SPT	3	3	3	6	-	-	
	2.50			0.80 to 3.20m	2.00	2.00	2.50	SPT	3	3	4	7	-	-		
	2.50		2.50		3.00	UDS	-	-	-	-	-	-	-			
	3.00		3.00		3.50	SPT	3	4	4	8	-	-	-			
	3.50		3.50		4.00	UDS	-	-	-	-	-	-	-			
	4.00			Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI) 3.20 to 5.30m	4.00	4.00	4.50	SPT	5	5	7	12	-	-		
	4.50			5.30 to 6.30m	4.50	4.50	5.00	UDS	-	-	-	-	-	-		
	5.00		5.00		5.50	SPT	5	6	9	15	-	-	-			
	5.50				5.50	6.00	UDS	-	-	-	-	-	-	-		
	6.00				6.00	6.50	SPT	7	7	9	16	-	-	-		
	6.50			Yellowish brown, fine to very fine graiend, sandy clays of intermediate plasticity (CI) 6.30 to 7.00m	6.50	6.50	7.00	SPT	15	17	23	40	-	-		
	7.00				7.00	7.00	7.50	SPT	13	19	31	50	-	-		
	7.50			7.00 to 9.00m	7.50	7.50	8.00	UDS	-	-	-	-	-	-		
	8.00		8.00		8.50	SPT	37	50/10cm	-	>100	-	-	-			
	8.50		8.50		9.00	SPT	50/10cm	-	-	>100	-	-	-			
	9.00		9.00		9.50	SPT	50/11cm	-	-	>100	-	-	-			
	9.50			9.00 to 11.30m	9.50	9.50	10.00	SPT	50/9cm	-	-	>100	-	-		
	10.00		10.00		11.00	SPT	50/13cm	-	-	>100	-	-	-			
	10.50				11.00	11.00	11.10	SPT	56/10cm	-	-	>100	-	-		
	11.00				11.50	11.10	11.50	Core	-	-	-	-	30.00	-		
	12.00			Highly weathered, weak, yellowish brown, fine to medium grained, very thinly laminated rock 11.30 to 12.50m	11.50	11.50	11.53	SPT	50/3cm	-	-	>100	-	-		
	12.50			Slightly weathered, weak, yellowish brown, fine to medium grained, thickly bedded rock 12.50 to 14.00m	12.50	11.53	12.50	Core	-	-	-	-	85.00	58.00		
	13.00				14.00	12.50	14.00	Core	-	-	-	-	73.33	57.33		
	13.50				15.50	14.00	15.50	Core	-	-	-	-	75.33	22.66		
	14.00			Moderately weathered, very weak, brownish yellow, fine to medium grained, thickly bedded rock 14.00 to 16.00m	17.00	15.50	17.00	Core	-	-	-	-	54.66	6.66		
	14.50				18.50	17.00	18.50	Core	-	-	-	-	84.00	19.33		
	15.00			Moderately weathered, weak, yellowish brown, fine to medium grained, very thinly bedded rock 16.00 to 17.50m	20.00	18.50	20.00	Core	-	-	-	-	90.66	52.00		
	15.50				21.50	20.00	21.50	Core	-	-	-	-	60.66	35.33		
	16.00				23.00	21.50	23.00	Core	-	-	-	-	73.33	7.33		
	16.50				24.50	23.00	24.50	Core	-	-	-	-	72.66	16.00		
	17.00				25.00	24.50	25.00	Core	-	-	-	-	72.00	24.00		
	17.50															
18.00																
18.50																
19.00																
19.50																
20.00																
20.50																
21.00																
21.50																
22.00																
22.50																
23.00																
23.50																
24.00																
24.50																
25.00																
21.60 to 25.00m																

K.C.T. Consultancy Services®

Project : BHEL

Bore Hole No. : 103

Location : Talabira

Depth of Termination : 18.0 M

Co-ordinates: E 856, N 2994

Depth of Water Table : Encountered at 2.70m depth during investigation

Date of Start: 31-07-2024

Date of Completion: 02-08-2024

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced Level: 197.10

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks
						From m	To m		N ₁	N ₂	N ₃	N			
Rotary drilling method	0.00	used		Light yellowish brown, fine to very fine grained, sandy clays of high plasticity (CH) 0.00 to 2.10m	0.00	0.00	1.00	DS	-	-	-	-	-	-	
	0.50														
	1.00				1.00	1.00	2.00	SPT	1	1	1	2	-	-	
	1.50														
	2.00			Yellowish brown, fine to very fine grained, clays of intermediate plasticity (CI) 2.10 to 4.30m	2.00	2.00	2.50	SPT	2	2	3	5	-	-	
	2.50				2.50	3.00	SPT	1	2	3	5	-	-		
	3.00				3.00	3.50	SPT	2	3	4	7	-	-		
	3.50				3.50	4.00	UDS	-	-	-	-	-	-		
	4.00			Yellowish brown, fine to medium grained, clayey sand (SC) 4.30 to 6.70m	4.00	4.00	4.50	SPT	3	3	4	7	-	-	
	4.50				4.50	5.00	UDS	-	-	-	-	-	-		
	5.00				5.00	5.50	SPT	4	7	7	14	-	-		
	5.50				5.50	6.00	UDS	-	-	-	-	-	-		
	6.00			Yellowish brown, fine to medium grained, silty sand with occasional gravels (SM) 6.70 to 8.10m	6.00	6.00	6.50	SPT	5	8	10	18	-	-	
	6.50				6.50	7.00	SPT	5	8	13	21	-	-		
	7.00				7.00	8.00	SPT	7	9	15	24	-	-		
	7.50														
	8.00		Yellowish brown, fine to very fine grained, clays of intermediate plasticity (CI) 8.10 to 9.70m	8.00	8.00	8.50	SPT	6	12	16	28	-	-		
	8.50			8.50	9.00	SPT	10	15	34	49	-	-			
	9.00			9.00	9.50	SPT	50/14cm	-	-	>100	-	-			
	9.50			9.50	10.00	SPT	50/13cm	-	-	>100	-	-			
	10.00		Yellowish brown, fine to very fine grained, clayeys and (SC) 9.70 to 10.20m	9.50	9.50	10.00	SPT	50/13cm	-	-	>100	-	-		
	10.50			10.00	10.00	11.00	SPT	50/7cm	-	-	>100	-	-		
	11.00	Not used		Mixture of Highly weathered,completely fractured and disintegrated, dark brownish red, fine to medium grained, gravel, pebble size fractured rock with yellowish brown, fine to medium grained, clayey sand 10.20 to 11.20m	11.00	11.00	11.05	SPT	50/5cm	-	-	>100	-	-	
	11.50														
	12.00			Highly weathered, very weak, yellowish brown to light greyish, fine to medium grained, very thinly laminated rock 11.20 to 15.00m	12.00	11.05	12.00	Core	-	-	-	-	8.00	-	
	12.50				12.00	12.02	SPT	50/2cm	-	-	>100	-	-		
	13.00				13.50	12.02	13.50	Core	-	-	-	-	41.00	-	
	13.50														
	14.00			Moderately weathered, very weak, light greyish, fine to medium grained, thinly bedded rock 15.00 to 17.00m	15.00	13.50	15.00	Core	-	-	-	-	58.00	24.00	
	15.50														
	16.00				16.50	15.00	16.50	Core	-	-	-	-	55.00	12.00	
	16.50														
	17.00			Slightly weathered, weak, light greyish, fine to medium grained, moderately thinly bedded rock	17.00										
	17.50														
	18.00				18.00	16.50	18.00	Core	-	-	-	-	78.00	30.00	
					17.00 to 18.00m										

K.C.T. Consultancy Services®

Project : BHEL

Bore Hole No. : 104

Location : Talabira

Depth of Termination : 25.0 M

Co-ordinates: E 1082, N 2970

Depth of Water Table : Encountered at 3.45m depth during investigation

Date of Start: 21-07-2024

Date of Completion: 24-07-2024

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced Level: 200.00

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks	
						From m	To m		N ₁	N ₂	N ₃	N				
Rotary drilling method	0.00			Yellowish brown, fine to very fine grained, clays of intermediate plasticity (CI) 0.00 to 0.50m	0.00	0.00	1.00	DS	-	-	-	-	-	-		
	0.50			Yellowish brown, very fine grained, clays of high plasticity (CH) 0.50 to 2.90m	1.00	1.00	2.00	SPT	2	2	3	5	-	-		
	1.00															
	1.50															
	2.00			Yellowish brown, fine to very fine grained, clayey sand (SC) 2.90 to 11.70m	2.00	2.00	2.50	SPT	3	3	4	7	-	-		
	2.50															
	3.00															
	3.50															
	4.00															
	4.50															
	5.00															
	5.50															
	6.00															
	6.50															
	7.00															
	7.50															
	8.00															
	8.50															
	9.00															
	9.50															
	10.00															
	10.50															
	11.00															
	11.50															
	12.00				Yellowish brown, fine to very fine grained, cemented sand/ Sand rock with gravels 11.70 to 16.60m	12.50	12.50	14.00	SPT	50/8cm	-	-	>100	-	-	
	13.00															
	13.50															
	14.00															
	14.50															
	15.00															
	15.50															
	16.00															
	16.50															
17.00						Yellowish brown, fine to very fine grained, clayey sand with some gravels (SC) 16.60 to 18.50m	17.00	15.54	17.00	SPT	50/7 cm	-	-	>100	-	-
17.50																
18.00																
18.50				Highly weathered, very weak, dark greyish, fine to coarse grained, very thinly laminated rock 18.50 to 21.00m	18.00	17.00	18.00	SPT	50/5 cm	-	-	>100	-	-		
19.00																
19.50																
20.00																
20.50																
21.00				Moderately weathered, moderately weak, dark greyish black, fine to very fine grained, moderately thinly bedded rock 21.00 to 24.00m	21.00	19.53	21.00	Core	-	-	-	-	22.50	7.33		
21.50																
22.00																
22.50																
23.00																
23.50																
24.00				Slightly weathered, moderately weak, dark greyish, fine to medium grained, very thickly bedded rock 24.00 to 25.00m	24.00	22.50	24.50	Core	-	-	-	-	66.66	18.66		
24.50																
25.00																

Project : BHEL

Bore Hole No. : 105

Location : Talabira

Depth of Termination : 20.5 M

Co-ordinates: E 916, N 2986

Depth of Water Table : Encountered at 2.60m depth during investigation

Date of Start: 28-07-2024



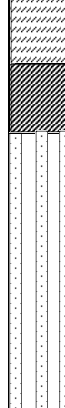

Date of Completion: 30-07-2024

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced Level: 197.67

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks
						From m	To m		N ₁	N ₂	N ₃	N			
Rotary drilling method	0.00	Used		Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI) 0.00 to 1.80m	0.00	0.00	1.00	DS	-	-	-	-	-	-	
	0.50				1.00	2.00	SPT	3	4	6	10	-	-		
	1.00														
	1.50														
	2.00			Yellowish brown, fine to very fine grained, clays of high plasticity (CH) 1.80 to 2.60m	2.00	2.00	2.50	SPT	4	5	7	12	-	-	
	2.50				2.50	3.00	UDS	-	-	-	-	-	-		
	3.00				3.00	3.50	SPT	8	11	13	24	-	-		
	3.50														
	4.00														
	4.50														
	4.00				3.50	4.00	SPT	7	7	11	18	-	-		
	4.50														
	5.00														
	5.50														
	5.00				5.00	5.50	SPT	8	8	14	22	-	-		
	5.50														
	6.00														
	6.50														
	6.00		6.00	6.50	SPT	9	10	10	20	-	-				
	6.50														
	7.00														
	7.50														
	7.00			Yellowish brown, fine to medium grained, sandy clays of intermediate plasticity (CI) 4.70 to 5.70m	7.00	7.00	7.50	SPT	15	18	23	41	-	-	
	7.50				7.50	8.00	UDS	-	-	-	-	-	-		
	8.00				8.00	8.50	SPT	8	12	16	28	-	-		
	8.50				8.50	9.00	UDS	-	-	-	-	-	-		
	9.00				9.00	9.50	DS					-	-		
	9.50														
	10.00														
	10.50														
	10.00				10.00	11.00	SPT	7	10	12	22	-	-		
	10.50														
11.00															
11.50															
11.00	11.00	11.50	UDS	-	-	-	-	-	-						
11.50															
12.00															
12.50															
12.00	11.50	12.50	SPT	20	22	56	78	-	-						
12.50															
13.00															
13.50															
13.00		Highly weathered, very weak and friable, dark brownish yellow, fine to medium grained, very thinly laminated rock 12.60 to 14.50m	12.50	12.50	12.60	SPT	50/10cm	-	-	>100	-	-			
13.50			13.00	13.00	Core	-	-	-	-	32.50	-				
14.00			14.50	14.50	Core	-	-	-	-	8.66	8.66				
14.50															
15.00															
15.50															
15.00			14.50	14.53	SPT	50/3cm	-	-	>100	-	-				
15.50															
16.00															
16.50															
16.00			16.00	16.00	Core	-	-	-	-	22.66	-				
16.50															
17.00															
17.50															
17.00	17.50	17.50	Core	-	-	-	-	32.00	9.33						
17.50															
18.00															
18.50															
18.00	17.50	19.00	Core	-	-	-	-	61.33	56.66						
18.50															
19.00															
19.50															
19.00	19.00	20.00	Core	-	-	-	-	61.33	56.66						
19.50															
20.00															
20.50															
20.00	19.00	20.50	Core	-	-	-	-	94.66	79.33						
20.50															
20.00 to 20.50m															

K.C.T. Consultancy Services®

Project : BHEL
 Bore Hole No. : 106
 Location : Talabira
 Depth of Termination : 25.0 m
 Co-ordinates : E 888, N 2972
 Depth of Water Table : Encountered at 2.60m depth during investigation

Date of Start: 20-12-2024
 Date of Completion: 24-12-2024
 Diameter of Bore: 150mm and Nx size
 Bit Used: Soil Surface Bit and NX Size
 Reduced Level: 197.30 m

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks																						
						From m	To m		N ₁	N ₂	N ₃	N																									
Rotary drilling method	0.00	Not Used		Yellowish brown, fine to medium grained, sandy clays of intermediate plasticity with some gravels (CI) 0.00 to 2.40m	0.00	0.00	1.00	DS	-	-	-	-	-	-																							
	0.50																																				
	1.00																																				
	1.50																																				
	2.00						Yellowish brown, fine to coarse grained, clayey sand with much gravels (SC) 2.40 to 3.30m	2.00	2.00	2.50	SPT	3	5	6		11	-	-																			
	2.50																																				
	3.00																																				
	3.50																																				
	4.00									Reddish yellow, fine to medium grained, clayey sand with little to some gravels (SC) 3.30 to 5.80m	4.00	4.00	4.50	SPT		4	5	6	11	-	-																
	4.50																																				
	5.00																																				
	5.50																																				
	6.00												Light yellowish brown and greyish, fine to very fine grained, sandy clays of intermediate plasticity (CI) 5.80 to 6.90m	6.00		6.00	6.50	SPT	3	4	8	12	-	-													
	6.50																																				
	7.00																Reddish yellow, fine to very fine grained, clayey sand with occasional gravels (SC) 6.90 to 7.80m	7.00	7.00	7.50	SPT	8	14	28	42	-	-										
	7.50																																				
	8.00																			Brownish, fine to very fine grained, cemented sandy clays of low plasticity- mud stone 7.80 to 9.30m	8.00	8.00	8.50	SPT	50/14 cm	-	-	>100	-	-							
	8.50																																				
	9.00																						Yellowish brown, fine to very fine grained, cemented, sandy clays of low plasticity -mud stone 9.30 to 10.30m	9.00	9.00	9.50	SPT	50/10 cm	-	-	>100	-	-				
	9.50																																				
	10.00																																				
	10.50																																				
	11.00																																				
	11.50																																				
	12.00																									Highly weathered, weak light yellowish brown to reddish brown, fine to very fine grained, fractured rock 10.30 to 15.50m	12.50	12.50	13.00	Core	-	-	-	-	32.50	-	
	12.50																																				
	13.00																																				
	13.50																																				
	14.00																																				
	14.50																																				
	15.00																																				
	15.50																												Highly weathered, moderately weak light yellowish brown to reddish brown, fine to medium grained, fractured rock 15.50 to 18.50m	15.50	14.00	15.50	Core	-	-	-	-
15.50																																					
16.00																																					
16.50																																					
17.00																																					
17.50																																					
18.00																																					
18.50			Highly weathered, strong, light greyish, fine to very fine grained, fractured rock 18.50 to 21.50m	18.50	17.00	18.50	Core								-															-	-	-	22.00	-			
19.00																																					
19.50																																					
20.00																																					
20.50																																					
21.00																																					
21.50						Highly weathered, weak, dark reddish brown, fine to coarse grained, rock with moderately close spacing of discontinuities 21.50 to 24.00	21.50	20.00	21.50	Core	-	-	-		-															41.33	-						
22.00																																					
22.50																																					
23.00																																					
23.50																																					
24.00									Slightly weathered, weak, Light greyish, fine to medium grained, rock with moderately close spacing of discontinuities	24.00	23.00	24.00	Core	-	-	-	-	44.33	-																		
24.50																																					
25.00																																					

K.C.T. Consultancy Services®

Project : BHEL

Bore Hole No. : 108

Location : Talabira

Depth of Termination : 18.0 M

Co-ordinates: E 1278, N 2950

Depth of Water Table : Encountered at 2.45m depth during investigation

Date of Start: 01-08-2024

Date of Completion: 03-08-2024

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced Level: 201.17

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks	
						From m	To m		N ₁	N ₂	N ₃	N				
Rotary drilling method	0.00	Used		Yellowish brown, fine to very fine grained, sandy clays of high plasticity (CH) 0.00 to 0.50m	0.00	0.00	1.00	DS	-	-	-	-	-	-		
	0.50			Brownish, fine to very fine grained, sandy clays of intermediate plasticity (CI) 0.50 to 1.50m	1.00	1.00	2.00	SPT	3	3	4	7	-	-		
	1.00			Yellowish brown, fine to medium grained, clayey sand (SC) 1.50 to 2.80m	2.00	2.00	2.50	SPT	6	10	13	23	-	-		
	1.50				2.50	2.50	3.00	SPT	6	9	9	18	-	-		
	2.00			Yellowish brown, very fine grained, clays of intermediate plasticity (CI) 2.80 to 3.70m	3.00	3.00	3.50	SPT	5	8	10	18	-	-		
	2.50				3.50	3.50	4.00	UDS	-	-	-	-	-	-		
	3.00			Yellowish brown, fine to very fine grained, clayey sand with little gravels (SC) 3.70 to 5.00m	4.00	4.00	4.50	SPT	16	30	38	68	-	-		
	3.50				4.50	4.50	5.00	UDS	-	-	-	-	-	-		
	4.00			Mixture of Highly weathered, completely fractured and disintegrated, dark brownish red, fine to medium grained, gravel, pebble size fragments of fractured rock with yellowish brown, fine to very fine grained, clayey sand 5.00 to 6.00	5.00	5.00	5.50	SPT	50/10cm	-	-	>100	-	-		
	4.50				5.50	5.50	5.55	SPT	50/5cm	-	-	>100	-	-		
	5.00	Not Used		Highly weathered, very weak, brownish yellow, fine to very fine grained, very thinly laminated rock 6.00 to 9.00m	6.00	5.55	6.00	Core	-	-	-	-	28.00	-		
	5.50				6.00	6.00	6.04	SPT	50/4cm	-	-	>100	-	-		
	6.00			Highly weathered, very weak, brownish yellow, fine to very fine grained, very thinly laminated rock 6.00 to 9.00m	7.50	6.04	7.50	Core	-	-	-	-	11.00	-		
	6.50				7.50	7.50	7.53	SPT	50/3cm	-	-	>100	-	-		
	7.00				9.00	7.53	9.00	Core	-	-	-	-	25.00	-		
	7.50				10.50	9.00	10.50	Core	-	-	-	-	28.00	-		
	8.00				Highly weathered, weak, greyish brown, fine to very fine grained, very thinly laminated rock 9.00 to 12.00m	12.00	10.50	12.00	Core	-	-	-	-	45.00	-	
	8.50					13.50	12.00	13.50	Core	-	-	-	-	61.00	7.00	
	9.00				Moderately weathered, moderately weak, dark greyish brown, fine to very fine grained, thinly laminated rock 12.00 to 13.50m	15.00	13.50	15.00	Core	-	-	-	-	65.00	27.00	
	9.50					16.50	15.00	16.50	Core	-	-	-	-	59.00	44.00	
	10.00		Moderately weathered, very weak, dark greyish, fine to veryfine grained, thinly bedded rock 13.50 to 17.00m	17.00	16.50	18.00	Core	-	-	-	-	98.00	94.00			
	10.50															
	11.00		Slightly weathered, weak, greyish black, fine to very fine grained, massive rock 17.00 to 20.00m													
	11.50															
	12.00															
	12.50															
	13.00															
	13.50															
	14.00															
	14.50															
	15.00															
	15.50															
	16.00															
	16.50															
	17.00															
	17.50															
	18.00															
17.00 to 20.00m																

Project : BHEL

Bore Hole No. : 109

Location : Hirma, Talabira

Depth of Termination : 14.0 m

Co-ordinates: E 1177, N 2943

Depth of Water Table : Encountered at 3.20 m depth during investigation

Date of Start: 21-07-2024

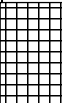




Date of Completion: 22-07-2024

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced level: 200.77

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks		
						From	To		N ₁	N ₂	N ₃	N					
						m	m										
Rotary drilling method	0.00	Not used		Yellowish brown, fine to very fine grained, sandy clays of low plasticity (CL) 0.00 to 1.40m	0.00	0.00	1.00	DS	-	-	-	-	-	-			
	0.50																
	1.00					Yellowish brown, fine to very fine grained, clays of high plasticity (CH) 1.40 to 3.50m	1.00	1.00	2.00	SPT	3	4	5	9		-	-
	1.50																
	2.00																
	2.50																
	3.00																
	3.50																
	4.00																
	4.50																
	5.00			Yellowish brown, fine to very fine grained, clayey sand (SC) 5.00 to 7.60m			5.00	5.00	5.50	SPT	13	50/13cm	-	>100		-	-
	5.50																
	6.00																
	6.50																
	7.00																
	7.50																
	8.00					Highly weathered, very weak, yellowish brown, fine to very fine grained, very thinly laminated rock 8.20 to 11.50m	8.00	7.55	8.00	Core	-	-	-	-		17.00	-
	8.50																
	9.00																
	9.50																
	10.00																
	10.50																
	11.00																
	11.50																
	12.00			Slightly weathered, weak, dark brownish grey, fine to medium grained, thickly bedded rock			12.50	11.00	12.50	Core	-	-	-	-		92.00	43.00
	13.00																
	13.50																
	14.00																
	11.50 to 14.00m																

K.C.T. Consultancy Services®

Project : BHEL

Bore Hole No. : 111

Location : Talabira

Depth of Termination : 17.0 M

Co-ordinates: E 1305 N 2930

Depth of Water Table : Encountered at 3.60m depth during investigation

Date of Start: 23-07-2024

Date of Completion: 25-07-2024

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced Level: 200.98

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks
						From m	To m		N ₁	N ₂	N ₃	N			
Rotary drilling method	0.00	Used		Yellowish brown, fine to medium grained, clayey sand (SC) 0.00 to 0.50m	0.00	0.00	1.00	DS	-	-	-	-	-	-	
	0.50		Yellowish brown, fine to medium grained, sandy clays of intermediate plasticity with much to some gravels (CI) 0.50 to 2.60m	1.00	1.00	2.00	SPT	3	5	9	14	-	-		
	1.00			2.00	2.00	2.50	SPT	6	8	10	18	-	-		
	1.50			2.50	2.50	3.00	SPT	3	4	9	13	-	-		
	2.00			3.00	3.00	3.50	SPT	8	10	13	23	-	-		
	2.50		Yellowish brown, fine to very fine grained, clays of high plasticity (CH) 2.60 to 3.60m	2.50	2.50	3.00	SPT	3	4	9	13	-	-		
	3.00			3.00	3.50	SPT	8	10	13	23	-	-			
	3.50			Yellowish brown, fine to very fine grained, clays of intermediate plasticity (CI) 3.60 to 4.60m	3.50	3.50	4.00	UDS	-	-	-	-	-	-	
	4.00				4.00	4.50	SPT	22	35	42	77	-	-		
	4.50		4.50		5.00	SPT	41	60/4cm	21	30	-	-			
	5.00		5.00		6.50	SPT	51/3cm	-	-	>100	-	-			
	5.50		Highly weathered, dark greyish and dark brownish,very fine grained, very thinly laminated rock 4.60 to 7.50m	6.50	6.50	8.00	SPT	51/3cm	-	-	>100	-	-		
	6.00			Highly weathered, completely fractured and disintegrated, dark greyish black, fine to very fine grained, rock 7.50 to 9.00m	8.00	8.00	8.03	SPT	50/3cm	-	-	>100	-	-	
	6.50	Highly weathered, very weak, light yellowish brown, very fine grained, very thinly laminated mud rock 9.00 to 10.50m			9.50	8.03	9.50	Core	-	-	-	-	23.33	6.66	
	7.00				Highly weathered, very weak, yellowish brown and brownish grey, very fine grained, thinly laminated rock 10.50 to 13.00m	11.00	9.50	11.00	Core	-	-	-	-	14.66	-
	7.50		12.50			11.00	12.50	Core	-	-	-	-	13.33	-	
	8.00		Not Used	Moderately weathered, very weak, dark blackish grey and yellowish brown, very fine grained, moderately thinly bedded rock 13.00 to 17.00m		14.00	12.50	14.00	Core	-	-	-	-	54.00	21.33
	8.50	15.50				14.00	15.50	Core	-	-	-	-	60.66	14.66	
	9.00	17.00			15.50	17.00	Core	-	-	-	-	82.00	24.00		
	9.50														
	10.00														
	10.50														
	11.00														
	11.50														
	12.00														
	12.50														
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16.00															
16.50															
17.00															
13.00 to 17.00m															

Project : BHEL

Bore Hole No. : 112

Location : Hirma, Talabira

Depth of Termination : 20.0 m

Co-ordinates: E 100(N 2928

Depth of Water Table : Encountered at 2.60 m depth during investigation

Date of Start: 10-08-2024











Date of Completion: 13-08-2024

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced level: % - '\$) 'a

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks		
						From m	To m		N ₁	N ₂	N ₃	N					
Rotary drilling method	0.00	Not used		Yellowish brown, fine to very fine grained, sandy clays of low plasticity (CL) 0.00 to 0.60m	0.00	0.00	1.00	DS	-	-	-	-	-	-			
	0.50																
	1.00			Yellowish brown, fine to medium grained, sandy clays of intermedaite plasticity with little to occational gravelsl (CI)	1.00	1.00	2.00	SPT	1	2	3	5	-	-			
	1.50																
	2.00				2.00	2.00	2.50	SPT	3	3	5	8					
	2.50				2.50	2.50	3.00	UDS	-	-	-	-					
	3.00				3.00	3.00	3.50	SPT	3	6	7	13	-	-			
	3.50				3.50	3.50	4.00	UDS	-	-	-	-					
	4.00				4.00	4.00	4.50	SPT	4	6	8	14					
	4.50				4.50	4.50	5.00	SPT	3	7	9	16	-	-			
	5.00			Brownish yellow, fine to medium grained, sandy clays of intermediate plasticity with little gravels (CI) 5.00 to 5.50m	5.00	5.00	5.50	SPT	3	4	4	8					
	5.50				5.50	5.50	6.00	UDS	-	-	-	-	-				
	6.00					Yellowish brown, fine to medium grained, clayey sand with occational to some gravels (SC)	6.00	6.00	6.50	SPT	4	5	7	12	-	-	
	6.50						6.50	7.00	UDS	-	-	-	-	-	-		
	7.00						7.00	7.50	SPT	5	7	9	16	-	-		
	7.50						7.50	8.00	SPT	7	11	14	25	-	-		
	8.00					Reddish yellow, fine to medium grained, silty and clayey sand (SM-SC)	8.00	8.00	8.50	SPT	50/14cm	-	-	>100	-	-	
	8.50						8.50	9.00	SPT	50/8cm	-	-	>100	-	-		
	9.00		9.00	9.50			SPT	50/10cm	-	-	>100	-	-				
	9.50		9.50	10.00			SPT	50/13cm	-	-	>100	-	-				
	10.00	used		8.00 to 10.40m	10.00	10.00	10.07	SPT	50/7cm	-	-	>100	-	-			
	10.50																
	11.00					Highly weathered, very weak, brownish yellow and yellowish brown, fine to medium grained, weak and friable rock with moderately closely spaced discontinuities	11.50	10.07	11.50	Core	-	-	-	-	35.00	30.00	
	12.00						11.50	11.50	11.53	SPT	50/3cm	-	-	>100	-	-	
	12.50																
	13.00		13.00	11.53			13.00	Core	-	-	-	-	12.00	-			
	13.50		13.00	13.00			13.03	SPT	50/3cm	-	-	>100	-	-			
	14.00																
	14.50		14.50	13.03			14.50	Core	-	-	-	-	12.66	-			
	15.00			Highly weathered, completely fractured and disintegrated, yellowish brown, fine to medium grained, very weka dn friable fractured rock 15.00 to 16.40m			14.50	14.50	14.54	SPT	50/4cm	-	-	>100	-	-	
	15.50																
	16.00				16.00	14.54	16.00	SPT	50/6cm	-	-	>100	-	-			
	16.50																
17.00			Highly weathered, weak, dark brownish, fine to medium grained, rock with closely spaced discontinuities 16.40 to 17.60m	17.50	16.00	17.50	Core	-	-	-	-	16.36	-				
17.50																	
18.00				17.50	17.50	17.52	SPT	50/2cm	-	-	>100	-	-				
18.50																	
19.00				Moderately weathered, dark greyish black, fine to medium grained, fractured rock	19.00	17.52	19.00	Core	-	-	-	-	58.66	14.66			
19.50																	
19.50																	
20.00		20.00			19.00	20.00	Core	-	-	-	-	51.00	-				
19.00 to 20.00m																	

K.C.T. Consultancy Services®

Project : BHEL

Bore Hole No. : 113

Location : Talabira

Depth of Termination : 24.5 M

Co-ordinates: E 908, N 2941

Depth of Water Table : Encountered at 2.70m depth during investigation

Date of Start: 30-07-2024

Date of Completion: 01-08-2024

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced Level: 197.55

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks
						From m	To m		N ₁	N ₂	N ₃	N			
Rotary drilling method	0.00	Used		Light yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI) 0.00 to 1.20m	0.00	0.00	1.00	DS	-	-	-	-	-	-	
	0.50														
	1.00				1.00	1.00	2.00	SPT	2	3	4	7	-	-	
	1.50			Yellowish brown, very fine grained, clays of high plasticity (CH)											
	2.00				2.00	2.00	2.50	SPT	5	7	8	15	-	-	
	2.50			1.20 to 3.20m	2.50	2.50	3.00	UDS	-	-	-	-	-	-	
	3.00				3.00	3.00	3.50	SPT	4	9	17	26	-	-	
	3.50			Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity with occasional gravels (CI) 3.20 to 4.40m	3.50	3.50	4.00	UDS	-	-	-	-	-	-	
	4.00				4.00	4.00	4.50	SPT	7	7	13	20	-	-	
	4.50				4.50	4.50	5.00	UDS	-	-	-	-	-	-	
	5.00			Light yellowish brown, fine to very fine grained, clayey sand (SC) 4.40 to 5.30m	5.00	5.00	5.50	SPT	9	13	16	29	-	-	
	5.50				5.50	5.50	6.00	SPT	7	13	14	27	-	-	
	6.00			Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI) 5.30 to 6.50m	6.00	6.00	6.50	SPT	8	22	48	70	-	-	
	6.50				6.50	6.50	7.00	SPT	18	52/5cm	-	>100	-	-	
	7.00			Yellowish brown, fine to very fine grained, clayey sand (SC) 6.50 to 7.80m	7.00	7.00	7.50	SPT	50/6cm	-	-	>100	-	-	
	7.50				7.50	7.50	8.00	SPT	52/3cm	-	-	>100	-	-	
	8.00				8.00	8.00	8.50	SPT	50/10cm	-	-	>100	-	-	
	8.50			Brownish, fine to very fine grained, sandy clays of low plasticity (CL) 7.80 to 9.40m	8.50	8.50	9.00	SPT	52/12cm	-	-	>100	-	-	
	9.00				9.00	9.00	9.50	SPT	50/8cm	-	-	>100	-	-	
	9.50				9.50	9.50	10.00	SPT	51/11cm	-	-	>100	-	-	
	10.00			Brownish, fine to very fine grained, sandy clays of intermediate plasticity (CI) 9.40 to 10.40m	10.00	10.00	10.06	SPT	50/6cm	-	-	>100	-	-	
	10.50														
	11.00			Moderately weathered, weak, yellowish brown, fine to medium grained, very thinly laminated rock 10.40 to 12.00m	11.00	10.06	11.00	Core	-	-	-	-	61.66	-	
	11.50														
	12.00														
	12.50			Moderately weathered, weak, yellowish brown, fine to medium grained, moderately thinly bedded rock	12.50	11.00	12.50	Core	-	-	-	-	54.00	28.00	
	13.00														
	13.50														
	14.00			12.00 to 14.50m	14.00	12.50	14.00	Core	-	-	-	-	33.33	14.66	
	14.50														
	15.00				15.50	14.00	15.50	Core	-	-	-	-	34.00	20.00	
	15.50														
	16.00														
	16.50			Highly weathered, weak, dark brownish grey, fine to medium grained, moderately thinly bedded rock	17.00	15.50	17.00	Core	-	-	-	-	24.00	-	
	17.00														
	17.50				18.50	17.00	18.50	Core	-	-	-	-	53.33	39.33	
	18.00														
	18.50														
	19.00														
	19.50			14.50 to 20.00m											
	20.00				20.00	18.50	20.00	Core	-	-	-	-	50.00	30.00	
	20.50														
	21.00				21.50	20.00	21.50	Core	-	-	-	-	50.00	30.00	
	21.50														
	22.00			Moderately weathered, moderately strong, brownish grey, fine to medium grained, moderately thick to thickly bedded rock	23.00	21.50	23.00	Core	-	-	-	-	67.33	56.00	
	22.50														
	23.00														
	23.50														
	24.00														
	24.50				24.50	23.00	24.50	Core	-	-	-	-	92.66	46.00	

K.C.T. Consultancy Services®

Project : BHEL

Bore Hole No. : 115

Location : Talabira

Depth of Termination : 14.5

Co-ordinates: E 1217, N 2J18

Depth of Water Table : Encountered at 3.00 m depth during investigation

Date of Start: 20-07-2024








Date of Completion: 22-07-2024

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced Level: 200.71

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks		
						From m	To m		N ₁	N ₂	N ₃	N					
Rotary drilling method	0.00	Not used		Yellowish brown, very fine grained, clays of high plasticity (CH) 0.00 to 1.60m	0.00	0.00	1.00	DS	-	-	-	-	-	-			
	0.50																
	1.00						1.00	1.00	2.00	SPT	3	3	4	7	-	-	
	1.50				Yellowish brown, fine to medium grained, sandy clays of intermediate plasticity with some gravels (CI) 1.60 to 2.50m												
	2.00					2.00	2.00	2.50	SPT	10	11	11	22	-	-		
	2.50					2.50	2.50	3.00	SPT	7	9	11	20	-	-		
	3.00				Yellowish brown, very fine grained, clays of high plasticity (CH) 2.50 to 3.50m	3.00	3.00	3.50	SPT	5	8	9	17	-	-		
	3.50					3.50	3.50	4.00	UDS	-	-	-	-	-	-		
	4.00					4.00	4.00	4.50	SPT	10	11	12	23	-	-		
	4.50				Yellowish brown and brownish, fine to very fine grained, sandy clays of intermediate plasticity (CI) 3.50 to 6.50m	4.50	4.50	5.00	UDS	-	-	-	-	-	-		
	5.00					5.00	5.00	5.50	SPT	17	28	37	65	-	-		
	5.50					5.50	5.50	5.56	SPT	50/6 cm	-	-	>100	-	-		
	6.00																
	6.50					Moderately weathered, moderately weak, dark brownish, fine to medium grained, thinly laminated rock 6.50 to 8.50m											
	7.00						7.00	5.56	7.00	Core	-	-	-	-	54.00	-	
	7.50																
	8.00																
	8.50					Highly weathered, very weak, yellowish brown, fine to medium grained, thinly bedded rock 8.50 to 10.00m	8.50	8.50	9.00	Core	-	-	-	-	44.66	18.66	
	9.00																
	9.50																
	10.00					Moderately weathered, weak, brownish yellow, fine to medium grained, moderately thinly bedded rock 10.00 to 11.50m	10.00	10.00	11.00	Core	-	-	-	-	58.66	24.00	
	10.50																
	11.00																
	11.50					Slightly weathered, weak, yellowish brown, fine to very fine grained, massive rock 11.50 to 13.00m	11.50	11.50	12.50	Core	-	-	-	-	94.66	62.00	
	12.00																
	12.50																
	13.00					Moderately weathered, weak, yellowish brown, fine to very fine grained, moderately thickly bedded 13.00 to 14.00m	13.00	13.00	14.00	Core	-	-	-	-	54.00	36.66	
	13.50																
	14.00																
	14.50					Slightly weathered, moderately weak, yellowish brown, fine to medium grained, thinly bedded rock 14.00 to 14.50m	14.50	14.50	15.50	Core	-	-	-	-	26.00	6.66	

Project : BHEL

Bore Hole No. : 116

Location : Hirma, Talabira

Depth of Termination : 21.5 m

Co-ordinates : E 1154, N 2913

Depth of Water Table : Encountered at 3.00 m depth during investigation

Date of Start: 20-07-2024

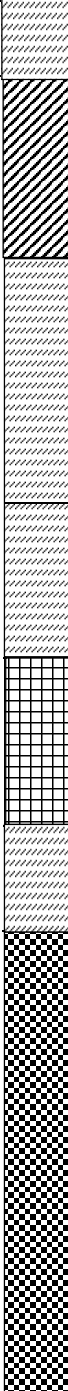
Date of Completion: 22-07-2024

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced level: 200.69

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recov- ery (%)	RQD (%)	Remarks	
						From m	To m		N ₁	N ₂	N ₃	N				
Rotary drilling method	0.00	Not used		Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI) 0.00 to 0.20m	0.00	0.00	1.00	DS	-	-	-	-	-	-		
	0.50			Yellowish brown, fine to very fine grained, clays of high plasticity (CH) 0.20 to 3.30m	1.00	1.00	2.00	SPT	2	3	5	8	-	-		
	1.00				2.00	2.00	2.50	SPT	9	10	11	21	-	-		
	1.50				2.50	2.50	3.00	UDS	-	-	-	-	-	-		
	2.00				3.00	3.00	3.50	SPT	7	9	10	19	-	-		
	2.50				3.50	3.50	4.00	UDS	-	-	-	-	-	-		
	3.00			Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI) 3.30 to 7.30m	4.00	4.00	4.50	SPT	9	13	14	27	-	-		
	3.50				4.50	4.50	5.00	UDS	-	-	-	-	-	-		
	4.00				5.00	5.00	5.50	SPT	29	55/13cm	-	>100	-	-		
	4.50				5.50	5.50	6.00	SPT	55/13cm	-	-	>100	-	-		
	5.00				6.00	6.00	6.50	SPT	48	58/9cm	-	>100	-	-		
	5.50			Brownish, very fine grained, clays of intermediate plasticity (CI) 7.30 to 9.70m	6.50	6.50	7.00	SPT	34	50/6cm	-	>100	-	-		
	6.00				7.00	7.00	7.50	SPT	29	50/8cm	-	>100	-	-		
	6.50				7.50	7.50	8.00	SPT	42	50/3cm	-	>100	-	-		
	7.00				8.00	8.00	8.50	SPT	50/13cm	-	-	>100	-	-		
	7.50				8.50	8.50	9.00	SPT	44	50/4cm	-	>100	-	-		
	8.00			Brownish, fine to very fine grained, sandy clays of low plasticity with some gravels (CL) 9.70 to 12.60m	9.00	9.00	9.50	SPT	37	50/7cm	-	>100	-	-		
	8.50				9.50	9.50	10.00	SPT	50/13cm	-	-	>100	-	-		
	9.00				10.00	10.00	11.00	SPT	50/4cm	-	-	>100	-	-		
	9.50				11.00	11.00	11.50	SPT	50/13cm	-	-	>100	-	-		
	10.00				11.50	11.50	12.50	SPT	50/9cm	-	-	>100	-	-		
	10.50			Brownish, fine to very fine grained, sandy clays of intermediate plasticity (CI) 12.60 to 14.20m	12.00	12.50	13.00	SPT	50/5cm	-	-	>100	-	-		
	11.00				13.00	13.00	14.00	SPT	50/5cm	-	-	>100	-	-		
	11.50				14.00	14.00	14.03	SPT	50/3cm	-	-	>100	-	-		
	12.00				Moderately weathered, weak, dark brownish black grey, fine to medium grained, thinly bedded rock 14.20 to 17.00m	14.50	15.00	15.50	Core	-	-	-	-	66.00	20.00	
	12.50					15.50	15.50	17.00	Core	-	-	-	-	58.00	52.00	
	13.00			17.00		17.00	18.50	Core	-	-	-	-	62.00	46.00		
	13.50			18.50		18.50	20.00	Core	-	-	-	-	65.00	45.00		
	14.00			20.00		20.00	21.50	Core	-	-	-	-	79.00	46.00		
	14.50			Moderately weathered, weak, dark greyish , fine to medium grained, very thickly and thinly bedded rock	21.00	21.50	21.50	Core	-	-	-	-	-	-		
	15.00				21.50	21.50	21.50	Core	-	-	-	-	-	-		
	15.50				21.50	21.50	21.50	Core	-	-	-	-	-	-		
	16.00				21.50	21.50	21.50	Core	-	-	-	-	-	-		
16.50	21.50	21.50	21.50		Core	-	-	-	-	-	-					
17.00	21.50	21.50	21.50		Core	-	-	-	-	-	-					
17.50	21.50	21.50	21.50		Core	-	-	-	-	-	-					
18.00	21.50	21.50	21.50		Core	-	-	-	-	-	-					
17.00 to 21.50m																

K.C.T. Consultancy Services®

Project : BHEL

Bore Hole No. : 120

Location : Talabira

Depth of Termination : 17.0 M

Co-ordinates : E 884, N 2920

Depth of Water Table : Encountered at 2.40m depth during investigation

Date of Start: 25-07-2024











Date of Completion: 26-07-2024

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced Level: 197.30

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks			
						From m	To m		N ₁	N ₂	N ₃	N						
Rotary drilling method	0.00	Used		Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity(CI) 0.00 to 0.50m	0.00	0.00	1.00	DS	-	-	-	-	-	-				
	0.50			Yellowish brown, very fine grained, clays of high plasticity (CH)	1.00	1.00	2.00	SPT	2	2	3	5	-	-				
	1.00				2.00	2.00	2.50	SPT	3	6	8	14	-	-				
	1.50				2.50	2.50	3.00	UDS	-	-	-	-	-	-				
	2.00				0.50 to 3.55m	3.00	3.00	3.50	SPT	4	7	11	18	-	-			
	2.50						3.50	3.50	4.00	UDS	-	-	-	-	-	-		
	3.00						Yellowish brown, fine to medium grained, clayey sand (SC) 3.55 to 4.50m	4.00	4.00	4.50	SPT	10	13	13	26	-	-	
	3.50			4.50	4.50	5.00		SPT	10	16	20	36	-	-				
	4.00			Yellowish brown, fine to medium grained, clayey sand (SC)	5.00	5.00	5.50	SPT	8	13	23	36	-	-				
	4.50				5.50	5.50	6.00	SPT	12	16	18	34	-	-				
	5.00				4.50 to 7.60m	6.00	6.00	6.50	SPT	55/7cm	-	-	>100	-	-			
	5.50					6.50	6.50	7.00	SPT	52/6cm	-	-	>100	-	-			
	6.00					7.00	7.00	7.50	SPT	50/9cm	-	-	>100	-	-			
	6.50					Brownish, fine to very fine grained, clays of intermediate plasticity (CI) 7.60 to 8.50m	7.50	7.50	8.00	SPT	52/11cm	-	-	>100	-	-		
	7.00				8.00		8.00	8.50	SPT	50/8cm	-	-	>100	-	-			
	7.50			8.50	8.50	9.00	SPT	52/5cm	-	-	>100	-	-					
	8.00			Yellowish brown, fine to very fine grained, clayey sand with little gravels (SC) 8.50 to 9.70m	9.00	9.00	9.50	SPT	50/9cm	-	-	>100	-	-				
	8.50				9.50	9.50	9.54	SPT	50/4cm	-	-	>100	-	-				
	9.00				Highly weathered, weak, dark brownish, fine to medium grained, thinly bedded rock	11.00	9.54	11.00	Core	-	-	-	-	33.84	8.46			
	9.50		9.70 to 13.00m	12.50		11.00	12.50	Core	-	-	-	-	47.33	17.33				
	10.00					14.00	12.50	14.00	Core	-	-	-	-	58.00	56.00			
	10.50					Moderately weathered, weak, dark brownish and grey, fine to very fine grained, very thickly bedded rock 13.00 to 14.50m	15.50	14.00	15.50	Core	-	-	-	-	63.33	29.33		
	11.00						Moderately weathered, very weak, dark greyish black, fine to very fine grained, moderately thinly bedded rock 14.50 to 16.00m	16.00	15.50	17.00	Core	-	-	-	-	98.00	98.00	
	11.50							Fresh, weak, dark greyish black, fine to very fine grained, massive rock	17.00	15.50	17.00	Core	-	-	-	-	98.00	98.00
	12.00		16.00 to 17.00m															
	12.50																	
	+ 13.00	Not Used																
	13.50																	
14.00																		
14.50																		
15.00																		
15.50																		
16.00																		
16.50																		
17.00																		

Project : BHEL

Bore Hole No. : 121

Location : Hirma, Talabira

Depth of Termination : 19.0 m

Co-ordinates : E 967, N 2897

Depth of Water Table : Encountered at 2.90 m depth during investigation

Date of Start: 25-07-2024

Date of Completion: 26-07-2024

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced level: 198.42m

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks		
						From m	To m		N ₁	N ₂	N ₃	N					
Rotary drilling method	0.00	Not used		Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI) 0.00 to 0.50m	0.00	0.00	1.00	DS	-	-	-	-	-	-			
	0.50																
	1.00					1.00	1.00	2.00	SPT	6	8	9	17				
	1.50																
	2.00				Yellowish brown, fine to very fine grained, clays of high plasticity (CH) 0.50 to 4.50m	2.00	2.00	2.50	SPT	5	8	9	17		-	-	
	2.50						2.50	2.50	3.00	UDS	-	-	-	-			
	3.00						3.00	3.00	3.50	SPT	6	9	13	22		-	-
	3.50						3.50	3.50	4.00	UDS	-	-	-	-			
	4.00						4.00	4.00	4.50	SPT	8	9	14	23			
	4.50																
	5.00				Yellowish brown, fine to very fine grained, sandy clays of low plasticity (CI) 4.50 to 5.00m	4.50	4.50	5.00	UDS	-	-	-	-	-	-		
	5.50				Yellowish brown, fine to very fine grained, clays of high plasticity (CH) 5.00 to 5.60m	5.00	5.00	5.50	SPT	16	24	30	54				
	6.00					5.50	5.50	6.00	UDS	-	-	-	-	-			
	6.50				Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI) 5.60 to 7.40m	6.00	6.00	6.50	SPT	23	25	42	67		-	-	
	7.00						6.50	6.50	7.00	UDS	-	-	-	-	-	-	
	7.50						7.00	7.00	7.33	SPT	24	38	62/13cm	>100	-	-	
	8.00				Highly weathered, very weak and friable, brownish yellow, fine to very fine grained, very thinly bedded rock 7.40 to 8.70m												
	8.50						8.50	7.33	8.50	Core	-	-	-	-	30.90	-	
	9.00																
	9.50				Highly weathered, moderately weak, light brownish, fine to medium grained, thinly bedded rock 8.70 to 11.60m												
	10.00					10.00	8.50	10.00	Core	-	-	-	-	22.00	10.00		
	10.50																
	11.00																
	11.50					11.50	10.00	11.50	Core	-	-	-	-	20.66	16.00		
	12.00																
	12.50																
	13.00																
	13.50				Highly weathered, moderately weak, brownish grey, fine to medium grained, thinly bedded rock 11.60 to 16.10m	13.00	11.50	13.00	Core	-	-	-	-	19.33	-		
	14.00																
	14.50						14.50	13.00	14.50	Core	-	-	-	-	36.66	18.00	
15.00		used															
15.50																	
16.00						16.00	14.50	16.00	Core	-	-	-	-	66.00	30.66		
16.50					Moderately weathered, moderately weak, brownish yellow, fine to medium grained, rock with thickly bedded rock 16.10 to 18.00m												
17.00																	
17.50						17.50	16.00	17.50	Core	-	-	-	-	60.00	54.66		
18.00				Slightly weathered, moderately weak, greyish black, fine to very fine grained, massive rock													
18.50																	
19.00					19.00	17.50	19.00	Core	-	-	-	-	92.00	75.33			
18.00 to 19.00m																	

Project : BHEL

Bore Hole No. : 123

Location : Hirma, Talabira

Depth of Termination : 22.0 m

Co-ordinates: E 1265, N 2898

Depth of Water Table : Encountered at 3.30 m depth during investigation

Date of Start: 23-07-2024

Date of Completion: 25-07-2024

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced level: 201.20

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks
						From m	To m		N ₁	N ₂	N ₃	N			
Rotary drilling method	0.00	used		Yellowish brown, fine to very fine grained, clays of intermediate plasticity with some gravels (CI)	0.00	0.00	1.00	DS	-	-	-	-	-	-	
	0.50				1.00	1.00	2.00	SPT	3	10	14	24	-	-	
	1.00														
	1.50														
	2.00			0.00 to 2.80m	2.00	2.00	2.50	SPT	8	10	18	28	-	-	
	2.50				2.50	2.50	3.00	UDS	-	-	-	-	-	-	
	3.00			2.80 to 4.00m	3.00	3.00	3.50	SPT	11	9	8	17	-	-	
	3.50				3.50	4.00	UDS	-	-	-	-	-	-		
	4.00				4.00	4.50	SPT	5	8	15	23	-	-		
	4.50			4.00 to 5.30m	4.50	4.50	5.00	SPT	11	16	27	43	-	-	
	5.00				5.00	5.50	SPT	24	29	40	69	-	-		
	5.50				5.50	6.00	SPT	23	32	42	74	-	-		
	6.00				5.30 to 6.80m	6.00	6.00	6.50	SPT	24	58/8cm	-	>100	-	
	6.50			6.50		7.00	SPT	50/8cm	-	-	>100	-	-		
	7.00			7.00		7.09	SPT	50/9cm	-	-	>100	-	-		
	7.50			Not Used		Highly weathered, weak, dark greyish black, fine to very fine grained, thinly laminated rock	8.50	7.09	8.50	Core	-	-	-	-	
	8.00														
	8.50														
	9.00														
	9.50														
	10.00														
	10.50														
	11.00														
	11.50														
	12.00														
	12.50														
	13.00														
	13.50														
	14.00														
	14.50														
	15.00														
	15.50														
16.00															
16.50															
17.00															
17.50															
18.00															
18.50															
19.00	7.20 to 19.50m				19.00	17.50	19.00	Core	-	-	-	-	59.33	24.00	
19.50		Moderately weathered, weak, dark greyish brown, fine to medium grained, massive rock	20.50	19.00	20.50	Core	-	-	-	-	68.00	66.66			
20.00															
20.50															
21.00															
21.50															
22.00			22.00	20.50	22.00	Core	-	-	-	-	96.00	96.00			
19.50 to 22.00m															

Project : BHEL

Bore Hole No. : 124

Location : Hirma, Talabira

Depth of Termination : 14.5 m

Co-ordinates : E 860, N 2885

Depth of Water Table : Encountered at 2.70 m depth during investigation

Date of Start: 30-07-2024

Date of Completion: 30-07-2024

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced level: 197.52

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recov- ery (%)	RQD (%)	Remarks		
						From	To		N ₁	N ₂	N ₃	N					
						m	m										
Rotary drilling method	0.00	used		Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI) 0.00 to 0.50m	0.00	0.00	1.00	DS	-	-	-	-	-	-			
	0.50			Yellowish brown, fine to very fine grained, clays of high plasticity (CH) 0.50 to 4.10m	1.00	1.00	2.00	SPT	1	1	2	3	-	-			
	1.00																
	1.50																
	2.00																
	2.50																
	3.00																
	3.50																
	4.00																
	4.50																
	5.00																
	5.50																
	6.00																
	6.50																
	7.00																
	7.50																
	8.00																
	8.50				Not used		Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI) 4.10 to 7.30m	5.00	5.00	5.50	SPT	6	8	10	18	-	-
	5.50																
	6.00																
	6.50																
	7.00																
	7.50																
	8.00																
	8.50																
	9.00			Yellowish brown, fine to very fine grained, clayey sand (SC) 7.30 to 8.30m	7.50	7.50	8.00	SPT	50/13cm	-	-	>100	-	-			
9.50				8.00	8.00	8.12	SPT	50/12cm	-	-	>100	-	-				
10.00			Highly weathered, very weak, dark brownish yellow, fine to medium grained, very thinly laminated rock 8.30 to 10.00m	8.50	8.12	8.50	Core	-	-	-	-	52.00	-				
10.50																	
11.00																	
11.50																	
12.00																	
12.50																	
13.00																	
13.50																	
14.00																	
14.50																	
11.50 to 14.50m																	

Project : BHEL

Bore Hole No. : 126

Location : Hirma, Talabira

Depth of Termination : 26.0 m

Co-ordinates: E 1180, N 2881

Depth of Water Table : Encountered at 2.90 m depth during investigation

Date of Start: 20-07-2024

Date of Completion: 22-07-2024

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced level: 200.68

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recov- ery (%)	RQD (%)	Remarks			
						From	To		N ₁	N ₂	N ₃	N						
						m	m											
Rotary drilling method	0.00	Not used		Yellowish brown, fine to very fine grained, clayey sand (SC) 0.00 to 0.50m	0.00	0.00	1.00	DS	-	-	-	-	-	-				
	0.50																	
	1.00				1.00	1.00	2.00	SPT	2	4	5	9						
	1.50																	
	2.00				Yellowish brown, very fine grained, clays of high plasticity (CH)	2.00	2.00	2.50	SPT	3	4	5	9					
	2.50					2.50	3.00	SPT	5	6	7	13			-	-		
	3.00					3.00	3.50	SPT	3	4	5	9			-	-		
	3.50					3.50	4.00	UDS	-	-	-	-						
	4.00					4.00	4.50	SPT	3	4	6	10						
	4.50					4.50	5.00	UDS	-	-	-	-			-	-		
	5.00					Yellowish brown, fine to very fine grained, clayey sand (SC) 4.50 to 6.00m	5.00	5.00	5.50	SPT	28	37	45	82				
	5.50						5.50	6.00	UDS	-	-	-	-			-	-	
	6.00			Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI) 6.00 to 7.50m	6.00		6.00	6.50	SPT	31	42	57	99			-	-	
	6.50				6.50		7.00	UDS	-	-	-	-			-	-		
	7.00				7.00	7.50	SPT	50/13cm	-	-	>100							
	7.50				7.50	8.00	SPT	50/12cm	-	-	>100			-				
	8.00			Brownish, fine to very fine grained, sandy clays of low plasticity with some gravels (CL) 7.50 to 9.20m	8.00	8.00	8.50	SPT	50/13cm	-	-	>100						
	8.50				8.50	8.54	SPT	50/4cm	-	-	>100							
	9.00				USED		9.50	8.54	9.50	Core	-	-	-	-	11.11	-		
	9.50						9.50	9.53	SPT	50/3cm	-	-	>100					
	11.00			9.53			11.00	Core	-	-	-	-	18.66	-				
	11.50			11.00			11.02	SPT	50/2cm	-	-	>100			-	-		
	12.50			11.02			12.50	Core	-	-	-	-	16.66	-				
	12.50			12.50			12.52	SPT	50/2cm	-	-	>100						
	14.00			12.52			14.00	Core	-	-	-	-	38.00	8.66				
	15.50			14.00			15.50	Core	-	-	-	-	38.66	14.66				
	17.00			15.50			17.00	Core	-	-	-	-	42.00	9.33				
	18.50			17.00			18.50	Core	-	-	-	-	44.00	14.00				
	20.00			18.50			20.00	Core	-	-	-	-	70.66	32.00				
	21.50			20.00			21.50	Core	-	-	-	-	46.66	17.33				
	23.00			21.50	23.00	Core	-	-	-	-	82.66	15.33						
	24.50			23.00	24.50	Core	-	-	-	-	83.33	30.66						
	26.00			24.50	26.00	Core	-	-	-	-	98.66	87.33						
	24.40 to 26.00m																	

K.C.T. Consultancy Services®

Project : BHEL

Bore Hole No. : 127

Location : Talabira

Depth of Termination : 24.50 m

Co-ordinates: E 1349, N 2868

Depth of Water Table : Encountered at 2.90m depth during investigation

Date of Start: 14-12-2024

Date of Completion: 17-12-2024

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced Level: 202.28 m

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks			
						From m	To m		N ₁	N ₂	N ₃	N						
Rotary drilling method	0.00	Not used		Yellowish brown to reddish yellow, fine to medium grained, sandy clays of intermediate plasticity with some gravels (CI) 0.00 to 1.60m	0.00	0.00	1.00	DS	-	-	-	-	-	-				
	0.50																	
	1.00																	
	1.50																	
	2.00					Yellowish brown, fine to coarse grained, clayey sand with some gravels (SC) 1.60 to 3.60m	2.00	2.00	2.50	SPT	2	3	5	8	-	-		
	2.50						2.50	2.50	3.00	UDS	-	-	-	-	-	-		
	3.00						3.00	3.00	3.50	SPT	8	9	11	20	-	-		
	3.50						3.50	3.50	4.00	UDS	-	-	-	-	-	-		
	4.00					Light brownish grey, very fine grained, clays of intermediate plasticity (CI) 3.60 to 5.70m	4.00	4.00	4.50	SPT	13	14	17	31	-	-		
	4.50						4.50	4.50	5.00	UDS	-	-	-	-	-	-		
	5.00						5.00	5.00	5.50	SPT	13	15	21	36	-	-		
	5.50						5.50	5.50	6.00	UDS	-	-	-	-	-	-		
	6.00						6.00	6.00	6.50	SPT	16	20	26	46	-	-		
	6.50						6.50	6.50	7.00	SPT	28	35	42	77	-	-		
	7.00						7.00	7.00	7.50	SPT	15	19	33	52	-	-		
	7.50						7.50	7.50	8.00	SPT	37	50/4 cm	-	>100	-	-		
	8.00						8.00	8.00	8.50	SPT	50/15 cm	-	-	>100	-	-		
	8.50						Brownish grey, fine to very fine grained, indurated, silty clays of intermediate plasticity (CI) 5.70 to 11.80m	8.50	8.50	9.00	SPT	42	50/6 cm	-	>100	-	-	
	9.00							9.00	9.00	9.50	SPT	37	50/6 cm	-	>100	-	-	
	9.50							9.50	9.50	9.60	SPT	50/10 cm	-	-	>100	-	-	
	10.00							10.00	10.00	11.00	SPT	50/10 cm	-	-	>100	-	-	
	10.50																	
	11.00							11.00	11.00	11.10	SPT	50/10 cm	-	-	>100	-	-	
	11.50							11.50	11.50	11.80	SPT	50/11 cm	-	-	>100	-	-	
	12.00																	
	12.50						Highly weathered, weak, dark blackish, fine to very fine grained, thinly laminated rock 11.80 to 14.00m	12.50	11.80	12.50	Core	-	-	-	-	15.71	-	
	+ 13.00							12.50	12.50	12.52	SPT	50/2 cm	-	-	>100	-	-	
	13.50																	
	14.00						Highly weathered, weak, dark blackish, fine to very fine grained, moderately thinly laminated rock 14.00 to 15.50m	14.00	12.52	14.00	Core	-	-	-	-	16.00	-	
	14.50							14.00	14.00	14.02	SPT	50/2 cm	-	-	>100	-	-	
	15.00																	
	15.50							15.50	14.00	15.50	Core	-	-	-	-	27.66	11.33	
	16.00																	
	16.50						Highly weathered, weak, dark blackish, fine to very fine grained, thinly laminated rock 15.50 to 18.50m	17.00	15.50	17.00	Core	-	-	-	-	30.66	-	
	17.00																	
	17.50																	
18.00																		
18.50				Slightly weathered, weak, dark greyish black, fine to very fine grained, moderately thinly bedded rock 18.50 to 20.00m	18.50	17.00	18.50	Core	-	-	-	-	67.33	26.66				
19.00																		
19.50																		
20.00					20.00	18.50	20.00	Core	-	-	-	-	68.00	42.66				
20.50																		
21.00				Slightly weathered, weak, dark greyish black, fine to very fine grained, thickly bedded rock 20.00 to 23.00m	21.50	20.00	21.50	Core	-	-	-	-	72.00	53.33				
21.50																		
22.00																		
22.50																		
23.00				Slightly weathered, weak, dark greyish black, fine to very fine grained, thinly bedded rock 23.00 to 24.00m	23.00	21.50	23.00	Core	-	-	-	-	68.66	15.33				
23.50																		
24.00				Slightly weathered, weak, dark greyish black, fine to very fine grained, massive rock	24.50	23.00	24.50	Core	-	-	-	-	89.33	77.33				
24.50																		
24.00 to 24.50																		

24.00 to 24.50

Project : BHEL

Bore Hole No. : 129

Location : Hirma, Talabira

Depth of Termination : 19.0 m

Co-ordinates : E 1128, N 2880

Depth of Water Table : Encountered at 2.70 m depth during investigation

Date of Start: 22-07-2024

Date of Completion: 24-07-2024

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced level: 200.45

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks	
						From m	To m		N ₁	N ₂	N ₃	N				
Rotary drilling method	0.00	used		Light yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI) 0.00 to 1.30m	0.00	0.00	1.00	DS	-	-	-	-	-	-		
	0.50															
	1.00						1.00	1.00	2.00	SPT	4	9	12	19		
	1.50			Yellowish brown, fine to very fine grained, sandy clas of high plasticity (CH) 1.30 to 2.80m										-		-
	2.00		2.00		2.00	2.50	SPT	11	13	17	30					
	2.50		2.50		3.00	UDS	-	-	-	-						
	3.00			Yellowish brown, fine to medium grained, clayey sand with much gravels (SC) 2.80 to 3.40m										-		-
	3.50		3.00		3.00	3.50	SPT	5	20	41	61					
	4.00		3.50		3.50	4.00	UDS	-	-	-	-					
	4.50		4.00	4.00	4.50	SPT	4	7	11	18						
	5.00		4.50	4.50	5.00	UDS	-	-	-	-	-	-				
	5.50		5.00	5.00	5.50	SPT	10	12	13	25						
	6.00		5.50	5.50	6.00	UDS	-	-	-	-	-	-				
	6.50		6.00	6.00	6.50	SPT	12	12	13	25	-	-				
	7.00		6.50	6.50	7.00	SPT	7	10	16	26	-	-				
	7.50		7.00	7.00	7.50	SPT	6	9	12	21	-	-				
	8.00		7.50	7.50	8.00	SPT	11	15	18	33	-	-				
	8.50		8.00	8.00	8.50	SPT	8	11	15	26	-	-				
	9.00		8.50	Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI) 7.70 to 9.90m	8.50	8.50	9.00	SPT	18	19	21	40	-	-		
	9.50		9.00		9.00	9.50	SPT	10	13	18	31	-	-			
	10.00		9.50		9.50	10.00	SPT	14	19	25	44	-	-			
	10.50		10.00		10.00	11.00	SPT	11	19	26	45	-	-			
	11.00			Not used	Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI) 10.30 to 11.70m	11.00	11.00	11.50	SPT	31	70/14cm	-	>100	-		-
	11.50		11.50			11.50	11.65	SPT	80/15cm	-	-	>100	-	-		
	12.00				Highly weathered, very weak, light brownish yellow and greyish brown, fine to very fine grained, thinly laminated rock 11.70 to 17.00m											
	12.50															
	13.00					13.00	11.65	13.00	Core	-	-	-	-	44.60		-
	13.50															
	14.00															
	14.50		14.50			13.00	14.50	Core	-	-	-	-	48.00	-		
	15.00															
	15.50															
	16.00		16.00	14.50	16.00	Core	-	-	-	-	49.00	-				
	16.50															
	17.00			Moderately weathered, weak, dark greyish black, fine to very fine grained, thinly bedded rock 17.00 to 18.00m												
	17.50		17.50		16.00	17.50	Core	-	-	-	-	66.66	14.00			
	18.00			Slightly weathered, weak, dark greyish black, fine to medium grained, massive rock												
	18.50															
19.00			19.00		17.50	19.00	Core	-	-	-	-	96.66	88.00			
18.00 to 19.00m																

K.C.T. Consultancy Services®

Project : BHEL

Bore Hole No. : 130

Location : Talabira

Depth of Termination : 21.0 m

Co-ordinates : E 1248, N 2855

Depth of Water Table : Encountered at 1.70m depth during investigation

Date of Start: 12-12-2024

Date of Completion: 14-12-2024

Diameter of Bore: 150mm and Nx size







Bit Used: Soil Surface Bit and NX Size

Reduced Level: 201.08 M

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks
						From m	To m		N ₁	N ₂	N ₃	N			
Rotary drilling method	0.00	Not Used		Brownish yellow, fine to very fine grained, sandy clays of low plasticity (CL) 0.00 to 0.80m	0.00	0.00	1.00	DS	-	-	-	-	-	-	
	0.50														
	1.00			Yellowish brown, fine to medium grained, sandy clays of intermediate plasticity with occasional gravels (CI) 0.80 to 1.50m	1.00	1.00	2.00	SPT	3	4	5	9	-	-	
	1.50			Brownish to yellowish brown, fine to coarse grained, clayey sand with much gravels (SC) 1.50 to 3.10m	2.00	2.00	2.50	SPT	6	9	12	21	-	-	
	2.50				2.50	3.00	UDS	-	-	-	-	-	-	-	
	3.00				3.00	3.50	SPT	6	8	10	18	-	-		
	3.50			Brownish yellow, fine to very fine grained, sandy clays of intermediate plasticity with much gravels (CI) 3.10 to 4.70m	3.50	3.50	4.00	UDS	-	-	-	-	-	-	
	4.00				4.00	4.50	SPT	15	17	14	41	-	-		
	4.50				4.50	5.00	UDS	-	-	-	-	-	-	-	
	5.00			Yellowish brown, fine to very fine grained, cemented clayey sand (SC) 4.70 to 6.60m	5.00	5.00	5.50	SPT	50/14 cm	-	-	>100	-	-	
	5.50				5.50	6.00	UDS	-	-	-	-	-	-	-	
	6.00				6.00	6.50	SPT	46	50/6 cm	-	>100	-	-		
	6.50			Yellowish brown, fine to very fine grained, cemented, silty clays of low plasticity -mud stone 6.60 to 7.80m	6.50	6.50	7.00	UDS	-	-	-	-	-	-	
	7.00				7.00	7.50	SPT	36	50/2 cm	-	>100	-	-		
	7.50				7.50	8.00	SPT	40	50/9 cm	-	>100	-	-		
	8.00			Greyish brown, fine to very fine grained, cemented sandy clays of low plasticity -mud stone 7.80 to 9.10m	8.00	8.00	8.50	SPT	45	50/8 cm	-	>100	-	-	
	8.50				8.50	9.00	SPT	50/14 cm	-	-	>100	-	-		
	9.00				9.00	9.07	SPT	50/7 cm	-	-	>100	-	-		
	9.50			Highly weathered, weak, yellowish brown, fine to medium grained, fractured rock 9.10 to 12.00m	10.00										
	10.50				10.50	10.52	Core	-	-	-	-	15.71			
	11.00				10.50	10.52	SPT	50/2 cm	-	-	>101				
	11.50			Highly weathered, moderately weak, yellowish brown, fine to medium grained, rock with close spacing of discontinuities 12.00 to 13.50m	12.00	12.00	12.00	Core	-	-	-	-	36.66	6.66	
	12.50														
	13.00														
	13.50			Moderately weathered, moderately weak, yellowish brown, fine to medium grained, rock with moderately wide spacing of discontinuities 13.50 to 15.00m	13.50	13.50	13.50	Core	-	-	-	-	56.66	32.00	
	14.00														
	14.50														
	15.00			Slightly weathered, moderately weak, yellowish brown and blackish brown, fine to very fine grained, rock with close spacing of discontinuities 15.00 to 16.50m	15.00	15.00	15.00	Core	-	-	-	-	70.00	8.66	
	15.50														
	16.00														
	16.50			Slightly weathered, weak, light greyish, fine to medium grained, rock with moderately close spacing of discontinuities 16.50 to 18.00m	16.50	16.50	16.50	Core	-	-	-	-	64.00	16.00	
	17.00														
	17.50														
	18.00			Slightly weathered, weak, dark brownish black, fine to medium grained, massive rock 18.00 to 21.00m	18.00	18.00	18.00	Core	-	-	-	-	74.66	39.33	
	18.50														
19.00															
19.50		Slightly weathered, weak, dark brownish black, fine to medium grained, massive rock 18.00 to 21.00m	19.50	19.50	19.50	Core	-	-	-	-	69.33	67.33			
20.00															
20.50															
21.00				21.00	21.00	21.00	Core	-	-	-	-	90.00	84.66		

Page 339 of 356

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks						
						From m	To m		N ₁	N ₂	N ₃	N									
Rotary drilling method	0.00	used		Yellowish browish, fine to very fine grained,sandy clays intermediate (CI) 0.00 to 0.50m	0.00	0.00	1.00	DS	-	-	-	-	-	-							
	0.50				Yellowish brown, very fine grained,clays of high plasticity (CH)	1.00	1.00	2.00	SPT	1	2	3	5	-	-						
	1.00					2.00	2.00	2.50	SPT	2	3	4	7	-	-						
	1.50					2.50	2.50	3.00	UDS	-	-	-	-	-	-						
	2.00					3.00	3.00	3.50	SPT	2	3	4	7	-	-						
	2.50					3.50	3.50	4.00	UDS	-	-	-	-	-	-						
	3.00					4.00	4.00	4.50	SPT	4	6	6	12	-	-						
	3.50					4.50	4.50	5.00	SPT	7	15	30	45	-	-						
	4.00					5.00	5.00	5.50	SPT	10	40	50	90	-	-						
	4.50					5.50	5.50	6.00	SPT	50/12cm	-	-	>100	-	-						
	5.00					6.00	6.00	6.50	SPT	50/9cm	-	-	>100	-	-						
	5.50					6.50	6.50	7.00	SPT	50/10cm	-	-	>100	-	-						
	6.00					7.00	7.00	7.11	SPT	50/11cm	-	-	>100	-	-						
	6.50					Not Used		Highly weathered, very weak, brownish yellow, fine to very fine grained, thinly bedded rock 7.80 to 8.60m	7.00	7.00	7.11	SPT	50/11cm	-	-	>100	-	-			
	7.50									Highly weathered, weak, dark blackish grey, fine to very fine grained, very thinly laminated rock	8.50	7.11	8.50	Core	-	-	-	-	37.00	8.67	
	8.00										10.00	8.50	10.00	Core	-	-	-	-	20.66	-	
	8.50	11.50	10.00	11.50	Core						-	-	-	-	17.33	-					
	9.00	13.00	11.50	13.00	Core						-	-	-	-	12.00	-					
	9.50	14.50	13.00	14.50	Core						-	-	-	-	22.66	-					
	10.00	16.00	14.50	16.00	Core						-	-	-	-	25.33	-					
	10.50	17.50	16.00	17.50	Core						-	-	-	-	19.33	-					
	11.00	19.00	17.50	19.00	Core						-	-	-	-	91.33	54.00					
	11.50		Slightly weathered, moderately strong, dark brownish black, fine to very fine grained, very thickly bedded rock	12.00	17.50						19.00	Core	-	-	-	-	91.33	54.00			
	12.50				18.00 to 19.00m						13.00	17.50	19.00	Core	-	-	-	-	91.33	54.00	
	13.50										17.50	19.00	Core	-	-	-	-	91.33	54.00		
	14.00										17.50	19.00	Core	-	-	-	-	91.33	54.00		
	14.50					17.50	19.00	Core	-	-	-	-	91.33	54.00							

Page 340 of 356

K.C.T. Consultancy Services®

Project : BHEL

Bore Hole No. : 134

Location : Talabira

Depth of Termination : 26.5 M

Co-ordinates: E 1209, N 2839

Depth of Water Table : Encountered at 5.60m depth during investigation

Date of Start: 22-07-2024

Date of Completion: 24-07-2024

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced Level: 200.95

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks
						From m	To m		N ₁	N ₂	N ₃	N			
Rotary drilling method	0.00	Used		Yellowish brown, fine to medium grained, sandy clays of intermediate plasticity (CI) 0.00 to 0.90m	0.00	0.00	1.00	DS	-	-	-	-	-	-	
	0.50			Yellowish brown, very fine grained, clays of high plasticity (CH) 0.90 to 2.40m	1.00	1.00	2.00	SPT	1	6	10	16	-	-	
	1.00				2.00	2.00	2.50	SPT	5	5	7	12	-	-	
	1.50				2.50	2.50	3.00	UDS	-	-	-	-	-	-	
	2.00			Yellowish brown, fine to medium grained, sandy clays of intermediate plasticity (CI) 2.40 to 3.00m	2.50	2.50	3.00	UDS	-	-	-	-	-	-	
	2.50				3.00	3.00	3.50	SPT	4	6	8	14	-	-	
	3.00			Yellowish brown, very fine grained, clays of high plasticity (CH) 3.00 to 3.50m	3.50	3.50	4.00	SPT	4	11	15	26	-	-	
	3.50				4.00	4.00	4.50	SPT	5	8	9	17	-	-	
	4.00				4.50	4.50	5.00	SPT	6	9	21	30	-	-	
	4.50				5.00	5.00	5.50	SPT	11	20	22	42	-	-	
	5.00			Yellowish brown, fine to medium grained, sandy clays of intermediate plasticity (CI) 3.50 to 7.00m	5.50	5.50	6.00	SPT	13	23	25	48	-	-	
	5.50				6.00	6.00	6.50	SPT	9	16	35	51	-	-	
	6.00				6.50	6.50	7.00	SPT	16	38	46	84	-	-	
	6.50				7.00	7.00	7.50	SPT	30	32	50	82	-	-	
	7.00				7.50	7.50	8.00	SPT	32	30	55	85	-	-	
	7.50				8.00	8.00	8.50	SPT	50/10cm	-	-	>100	-	-	
	8.00				8.50	8.50	8.58	SPT	50/8cm	-	-	>100	-	-	
	8.50														
	9.00			Yellowish brown, fine to very fine grained, sandy clays of low plasticity (CL) 8.80 to 10.00m	10.00	8.58	10.00	Core	-	-	-	-	58.00	30.00	
	9.50				11.50	10.00	11.50	Core	-	-	-	-	35.00	-	
	10.00	Not Used		Moderately weathered, weak, yellowish grey, fine to medium grained, moderately thickly bedded rock 10.00 to 12.20m	12.00										
	10.50				13.00	11.50	13.00	Core	-	-	-	-	32.00	14.00	
	11.00				14.50	13.00	14.50	Core	-	-	-	-	29.00	10.00	
	11.50				16.00	14.50	16.00	Core	-	-	-	-	34.00	-	
	12.00			Highly weathered, weak, dark greyish black, very fine grained, thinly bedded rock 12.20 to 16.50m	17.50	16.00	17.50	Core	-	-	-	-	31.00	-	
	12.50				19.00	17.50	19.00	Core	-	-	-	-	34.00	-	
	13.00				20.50	19.00	20.50	Core	-	-	-	-	29.00	9.00	
	13.50				22.00	20.50	22.00	Core	-	-	-	-	35.00	7.00	
	14.00			Moderately weathered, moderately weak, dark greyish, fine to very fine grained, thinly bedded rock 16.50 to 20.00m	23.50	22.00	23.50	Core	-	-	-	-	74.00	62.00	
	14.50				25.00	23.50	25.00	Core	-	-	-	-	43.00	26.00	
	15.00				26.50	25.00	26.50	Core	-	-	-	-	92.00	92.00	
	15.50														
	16.00			Highly weathered, weak, dark greyish, fine to medium grained, thinly bedded rock 24.00 to 25.50m	27.00	25.50	27.00	Core	-	-	-	-			
	16.50														
	17.00														
	17.50														
	18.00			Slightly weathered, weak, dark greyish blackish, fine to very fine grained, massive rock 25.50 to 26.50m											
	18.50														
	19.00														
	19.50														
	20.00														
	20.50														
	21.00														
	21.50														
	22.00														
	22.50														
	23.00														
	23.50														
	24.00														
	24.50														
	25.00														
	25.50														
	26.00														
	26.50														

25.50 to 26.50m

Project : BHEL

Bore Hole No. : 135

Location : Hirma, Talabira

Depth of Termination : 20.5 m

Co-ordinates: E 1150, N 2851

Depth of Water Table : Encountered at 2.80 m depth during investigation

Date of Start: 23-07-2024

Date of Completion: 24-07-2024

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced level: 200.55

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recov-ery (%)	RQD (%)	Remarks
						From m	To m		N ₁	N ₂	N ₃	N			
Rotary drilling method	0.00			Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI)	0.00	0.00	1.00	DS	-	-	-	-	-	-	
	0.50														
	1.00				1.00	1.00	2.00	SPT	10	5	6	11			
	1.50														
	2.00			0.00 to 2.20m									-	-	
	2.50			Yellowish brown, very fine grained, clays of high plasticity (CH) 2.20 to 3.40m	2.00	2.00	2.50	SPT	3	4	6	10			
	3.00				2.50	2.50	3.00	UDS	-	-	-	-			
	3.50			Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI) 3.40 to 5.20m	3.00	3.00	3.50	SPT	6	8	10	18	-	-	
	4.00				3.50	3.50	4.00	UDS	-	-	-	-			
	4.50				4.00	4.00	4.50	SPT	7	9	10	19			
	5.00				4.50	4.50	5.00	UDS	-	-	-	-	-	-	
	5.50			Yellowish brown, very fine grained, clays of high plasticity (CH) 5.20 to 5.90m	5.00	5.00	5.50	SPT	10	11	18	29			
	6.00				5.50	5.50	6.00	UDS	-	-	-	-	-	-	
	6.50			Highly weathered, very weak, yellowish brown and greyish brown, fine to very fine grained, very thinly laminated rock	6.00	6.00	6.50	SPT	22	50/10cm	-	>100	-	-	
	7.00				6.50	6.50	6.61	SPT	50/11cm	-	-	>100	-	-	
	7.50				7.00	6.61	7.00	Core	-	-	-	-	20.00	-	
	8.00														
	8.50				8.50	7.00	8.50	Core	-	-	-	-	13.33	-	
	9.00				8.50	8.50	8.52	SPT	50/2cm	-	-	>100			
	9.50														
	10.00				10.00	8.52	10.00	Core	-	-	-	-	14.00	-	
	10.50				10.00	10.00	10.02	SPT	50/2cm	-	-	>100			
	11.00														
	11.50				11.50	10.02	11.50	Core	-	-	-	-	19.66	-	
	12.00				11.50	11.50	11.52	SPT	50/2cm	-	-	>100			
	12.50														
	13.00			Highly weathred,very weak, brownish and blackish grey, fine to very fine grained, very thinly laminated rock	13.00	11.52	13.00	Core	-	-	-	-	16.66	8.66	
	13.50				13.00	13.00	13.02	SPT	50/2cm	-	-	>100			
	14.00			14.40 to 16.90m											
	14.50				14.50	13.02	14.50	Core	-	-	-	-	25.33	-	
	15.00			Moderately weathered, weak, greyish brown, fine to very fine grained, very thinly bedded rock											
	15.50														
	16.00			16.90 to 19.00m	16.00	14.50	16.00	Core	-	-	-	-	30.00	-	
	16.50														
	17.00			Fresh, Moderately weak, dark greyish black, very fine grained, massive rock	17.50	16.00	17.50	Core	-	-	-	-	56.00	13.33	
	17.50														
	18.00			19.00 to 20.50m											
	18.50														
	19.00				19.00	17.50	19.00	Core	-	-	-	-	56.00	6.66	
	19.50														
	20.00														
	20.50				20.50	19.00	20.50	Core	-	-	-	-	90.00	90.00	
19.00 to 20.50m															

Project : BHEL

Bore Hole No. : 137

Location : Hirma, Talabira

Depth of Termination : 20.0 m

Co-ordinates: E 952, N 2825

Depth of Water Table : Encountered at 3.00 m depth during investigation

Date of Start: 25-07-2024

Date of Completion: 26-07-2024

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced level: 198.35

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks		
						From m	To m		N ₁	N ₂	N ₃	N					
Rotary drilling method	0.00	Used		Yellowish brown, fine to very fine grained, sandy clays of low plasticity (CL) 0.00 to 0.60m	0.00	0.00	1.00	DS	-	-	-	-	-	-			
	0.50																
	1.00			Light yellowish brown, fine to very fine grained, clays of high plasticity (CH) 0.60 to 2.50m	1.00	1.00	2.00	SPT	9	3	4	7	-	-			
	1.50																
	2.00																
	2.50					Dark brownish, fine to medium grained, clayey sand (SC) 2.50 to 3.00m	2.50	2.50	3.00	UDS	-	-	-	-	-	-	
	3.00																
	3.50			Light yellowish brown, very fine grained, clays of high plasticity (CH)			3.50	3.50	3.50	SPT	4	5	6	11	-	-	
	4.00																
	4.50																
	5.00					3.00 to 5.50m	4.50	4.50	5.00	UDS	-	-	-	-	-	-	
	5.50																
	6.00																
	6.50			Light yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI) 5.50 to 6.50m			5.50	5.50	6.00	UDS	-	-	-	-	-	-	
	7.00																
	7.50																
	8.00					Yellowish brown, very fine grained, clays of high plasticity (CH)	6.50	6.50	7.00	SPT	4	6	10	16	-	-	
	8.50																
	9.00																
	9.50			Yellowish brown, very fine grained, clays of intermediate plasticity (CI) 6.50 to 9.00m			7.00	7.00	7.50	SPT	4	7	9	16	-	-	
	10.00																
	10.50																
	11.00																
	11.50			Yellowish brown, very fine grained, clays of high plasticity (CH) 10.00 to 11.50m	8.50	8.50	9.00	SPT	4	6	7	13	-	-			
	12.00																
	12.50																
	13.00					Yellowish brown, very fine grained, clays of intermediate plasticity (CI) 9.00 to 10.00m	9.00	9.00	9.50	SPT	5	12	18	30	-	-	
	13.50																
	14.00																
	14.50			Yellowish brown, very fine grained, clays of high plasticity (CH) 10.00 to 11.50m			9.50	9.50	10.00	SPT	6	8	11	19	-	-	
	15.00																
	15.50																
	16.00					Yellowish brown, very fine grained, clays of high plasticity (CH) 10.00 to 11.50m	10.00	10.00	11.00	SPT	6	7	13	20	-	-	
	16.50																
	17.00																
	17.50			Yellowish brown, fine to very fine grained, sandy clays of low plasticity (CL) 11.50 to 12.10m			11.00	11.00	11.50	SPT	50/14cm	-	-	>100	-	-	
18.00																	
18.50																	
19.00																	
19.50		Highly weathered, very weak, reddish yellow, fine to medium grained, thinly laminated rock 12.10 to 13.90m	11.50	11.50	11.58	SPT	50/8cm	-	-	>100	-	-					
20.00																	
20.50																	
21.00				Highly weathered, weak, brownish, fine to medium grained, thinly lamianted rock	12.00	12.00	12.50	Core	-	-	-	-	22.50	-			
21.50																	
22.00																	
22.50		Highly weathered, weak, brownish, fine to medium grained, thinly lamianted rock			12.50	12.50	12.53	SPT	50/3 cm	-	-	>100	-	-			
23.00																	
23.50																	
24.00				Highly weathered, weak, brownish, fine to medium grained, thinly lamianted rock	13.00	13.00	13.50	Core	-	-	-	-	16.00	-			
24.50																	
25.00																	
25.50		Highly weathered, weak, brownish, fine to medium grained, thinly lamianted rock			13.50	13.50	14.00	SPT	50/2 cm	-	-	>100	-	-			
26.00																	
26.50																	
27.00				Highly weathered, weak, brownish, fine to medium grained, thinly lamianted rock	14.00	14.00	14.02	SPT	50/2 cm	-	-	>100	-	-			
27.50																	
28.00																	
28.50		Highly weathered, weak, brownish, fine to medium grained, thinly lamianted rock			14.50	14.50	15.00	Core	-	-	-	-	18.66	-			
29.00																	
29.50																	
30.00				Highly weathered, weak, brownish, fine to medium grained, thinly lamianted rock	15.00	15.00	15.50	Core	-	-	-	-	18.66	-			
30.50																	
31.00																	
31.50		Highly weathered, weak, brownish, fine to medium grained, thinly lamianted rock			15.50	15.50	15.52	SPT	50/2 cm	-	-	>100	-	-			
32.00																	
32.50																	
33.00				Highly weathered, weak, brownish, fine to medium grained, thinly lamianted rock	16.00	16.00	16.50	Core	-	-	-	-	18.66	-			
33.50																	
34.00																	
34.50		Highly weathered, weak, brownish, fine to medium grained, thinly lamianted rock			16.50	16.50	17.00	SPT	50/2 cm	-	-	>100	-	-			
35.00																	
35.50																	
36.00				Highly weathered, weak, brownish, fine to medium grained, thinly lamianted rock	17.00	17.00	17.50	Core	-	-	-	-	43.00	38.00			
36.50																	
37.00																	
37.50		Highly weathered, weak, brownish, fine to medium grained, thinly lamianted rock			17.50	17.50	18.00	Core	-	-	-	-	43.00	38.00			
38.00																	
38.50																	
39.00				Highly weathered, weak, brownish, fine to medium grained, thinly lamianted rock	18.00	18.00	18.50	Core	-	-	-	-	62.00	26.00			
39.50																	
40.00																	
40.50		Highly weathered, weak, brownish, fine to medium grained, thinly lamianted rock			18.50	18.50	19.00	Core	-	-	-	-	62.00	26.00			
41.00																	
41.50																	
42.00				Highly weathered, weak, brownish, fine to medium grained, thinly lamianted rock	19.00	19.00	19.50	Core	-	-	-	-	62.00	26.00			
42.50																	
43.00																	
43.50		Highly weathered, weak, brownish, fine to medium grained, thinly lamianted rock			19.50	19.50	20.00	Core	-	-	-	-	90.00	90.00			
44.00																	
44.50																	
45.00				Highly weathered, weak, brownish, fine to medium grained, thinly lamianted rock	20.00	20.00	20.50	Core	-	-	-	-	90.00	90.00			
45.50																	
46.00																	
46.50		Highly weathered, weak, brownish, fine to medium grained, thinly lamianted rock			20.50	20.50	21.00	Core	-	-	-	-	90.00	90.00			
47.00																	
47.50																	
48.00				Highly weathered, weak, brownish, fine to medium grained, thinly lamianted rock	21.00	21.00	21.50	Core	-	-	-	-	90.00	90.00			
48.50																	
49.00																	
49.50		Highly weathered, weak, brownish, fine to medium grained, thinly lamianted rock			21.50	21.50	22.00	Core	-	-	-	-	90.00	90.00			
50.00																	
50.50																	
51.00				Highly weathered, weak, brownish, fine to medium grained, thinly lamianted rock	22.00	22.00	22.50	Core	-	-	-	-	90.00	90.00			
51.50																	
52.00																	
52.50		Highly weathered, weak, brownish, fine to medium grained, thinly lamianted rock			22.50	22.50	23.00	Core	-	-	-	-	90.00	90.00			
53.00																	
53.50																	
54.00				Highly weathered, weak, brownish, fine to medium grained, thinly lamianted rock	23.00	23.00	23.50	Core	-	-	-	-	90.00	90.00			
54.50																	
55.00																	
55.50		Highly weathered, weak, brownish, fine to medium grained, thinly lamianted rock			23.50	23.50	24.00	Core	-	-	-	-	90.00	90.00			
56.00																	
56.50																	
57.00				Highly weathered, weak, brownish, fine to medium grained, thinly lamianted rock	24.00	24.00	24.50	Core	-	-	-	-	90.00	90.00			
57.50																	
58.00																	
58.50		Highly weathered, weak, brownish, fine to medium grained, thinly lamianted rock			24.50	24.50	25.00	Core	-	-	-	-	90.00	90.00			
59.00																	
59.50																	
60.00				Highly weathered, weak, brownish, fine to medium grained, thinly lamianted rock	25.00	25.00	25.50	Core	-	-	-	-	90.00	90.00			
60.50																	
61.00																	
61.50		Highly weathered, weak, brownish, fine to medium grained, thinly lamianted rock			25.50	25.50	26.00	Core	-	-	-	-	90.00	90.00			
62.00																	
62.50																	
63.00				Highly weathered, weak, brownish, fine to medium grained, thinly lamianted rock	26.00	26.00	26.50	Core	-	-	-	-	90.00	90.00			
63.50																	
64.00																	
64.50		Highly weathered, weak, brownish, fine to medium grained, thinly lamianted rock			26.50	26.50	27.00	Core	-	-	-	-	90.00	90.00			
65.00																	
65.50																	
66.00				Highly weathered, weak, brownish, fine to medium grained, thinly lamianted rock	27.00	27.00	27.50	Core	-	-	-	-	90.00	90.00			
66.50																	
67.00																	
67.50		Highly weathered, weak, brownish, fine to medium grained, thinly lamianted rock			27.50	27.50	28.00	Core	-	-	-	-	90.00	90.00			
68.00																	
68.50																	
69.00				Highly weathered, weak, brownish, fine to medium grained, thinly lamianted rock	28.00	28.00	28.50	Core	-	-	-	-	90.00	90.00			
69.50																	
70.00																	
70.50		Highly weathered, weak, brownish, fine to medium grained, thinly lamianted rock			28.50	28.50	29.00	Core	-	-	-	-	90.00	90.00			
71.00																	
71.50																	
72.00				Highly weathered, weak, brownish, fine to medium grained, thinly lamianted rock	29.00	29.00	29.50	Core	-	-	-	-	90.00	90.00			
72.50																	
73.00																	
73.50		Highly weathered, weak, brownish, fine to medium grained, thinly lamianted rock			29.50	29.50											

K.C.T. Consultancy Services®

Project : BHEL

Bore Hole No. : 139

Location : Talabira

Depth of Termination : 20.0 m

Co-ordinates: E 1337, N 2828

Depth of Water Table : Encountered at 2.70m depth during investigation

Date of Start: 13-12-2024

Date of Completion: 16-12-2024

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced Level: 202.56 m

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks	
						From m	To m		N ₁	N ₂	N ₃	N				
Rotary drilling method	0.00	Not Used		Yellowish brown and reddish yellow, fine to medium grained, clayey sand with some to much gravels (SC)	0.00	0.00	1.00	DS	-	-	-	-	-	-		
	0.50				1.00	2.00	SPT	2	3	4	7	-	-			
	1.00															
	1.50															
	2.00			0.00 to 2.50m	2.00	2.00	2.50	SPT	5	3	7	10	-	-		
	2.50				Reddish yellow, fine to coarse grained, clayey sand with much to some gravels (SC) 2.50 to 3.40m	2.50	2.50	3.00	UDS	-	-	-	-	-		-
	3.00					3.00	3.50	SPT	10	12	16	28	-	-		
	3.50															
	4.00															
	4.50			Brownish and yellowish brown, dark brownish, fine to very fine grained, silty clays of intermediate plasticity with occational gravels (CI) 3.40 to 5.50m	4.50	4.50	5.00	UDS	-	-	-	-	-	-		
	5.00				5.00	5.50	SPT	20	23	27	50	-	-			
	5.50															
	6.00															
	6.50			Brownish and dark greyish brown, very fine grained, silty clays of intermediate plasticity (CI)(Indurated) 5.50 to 6.70m	6.50	6.50	6.70	SPT	34	50/4 cm	-	>100	-	-		
	7.00				7.00	6.70	7.00	Core	-	-	-	-	23.33	-		
	7.50															
	8.00															
	8.50			Highly weathered, weak, yellowish brown and light greyish brown, fine to very fine grained, very thinly laminated rock 6.70 to 13.00m	8.50	7.00	8.50	Core	-	-	-	-	30.66	-		
	9.00				10.00	8.50	10.00	Core	-	-	-	-	40.66			
	9.50															
	10.00															
	10.50				11.50	10.00	11.50	Core	-	-	-	-	18.00			
	11.00															
	11.50															
	12.00			6.70 to 13.00m	11.50	11.50	11.52	SPT	50/2 cm	-	-	>100				
	12.50				13.00	11.52	13.00	Core	-	-	-	-	19.33	6.66		
	+ 13.00															
	13.50															
	14.00			Highly weathered, weak, light greyish brown, moderately thickly laminated rock 13.00 to 14.50m	13.00	13.00	13.52	SPT	50/2 cm	-	-	>100	-	-		
	14.50				14.50	13.52	14.50	Core	-	-	-	-	54.66	-		
15.00																
15.50																
16.00	Moderately weathered, very fine grained, light greyish brownand blackish brown, thinly lamianted rock 14.50 to 18.00m	16.00	14.50	16.00	Core	-	-	-	-	58.66						
16.50		17.50	16.00	17.50	Core	-	-	-	-	28.00						
17.00																
17.50																
18.00	Slightly weathered, weak, dark brownish black, fine to medium grained, rock with moderately close spaced discontinuities 18.00 to 19.00m	19.00	17.50	19.00	Core	-	-	-	-	64.00	23.33					
18.50																
19.00																
19.50	Moderately weathered, moderately strong, dark greyish black, fine to medium grained, rock with moderately close spaced discontinuities 19.00 to 20.00m	20.00	19.00	20.00	Core	-	-	-	-	59.00	23.00					
20.00																

K.C.T. Consultancy Services®

Project : BHEL

Bore Hole No. : IBH 18

Location : Hirma, Talabira

Depth of Termination : 25.0 M

Co-ordinates: E 1218, N 3266

Depth of Water Table : Encountered at 2.80 m depth during investigation

Date of Start: 20-06-2024

Date of Completion: 22-06-2024

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced level: 200.340 m

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks	
						From m	To m		N ₁	N ₂	N ₃	N				
Rotary drilling method with Hydraulic feed	0.00	Used		Brownish, fine to very fine grained, clayey sand with occasional gravels(SC) 0.00 to 0.50m	0.00	0.00	1.50	DS	-	-	-	-	-	-		
	0.50			Pinkish yellow, fine to very fine grained, sandy clays of intermediate plasticity with occasional gravels(CI)	1.00	1.00	2.00	SPT	6	5	6	11	-	-		
	1.00															
	1.50															
	2.00			0.50 to 3.70m	2.00	2.00	2.50	SPT	5	5	6	11	-	-		
	2.50				2.50	2.00	UDS	-	-	-	-	-	-	-		
	3.00				3.00	3.40	SPT	4	7	10	17	-	-			
	3.50			3.70 to 8.50m	3.50	3.50	4.00	UDS	-	-	-	-	-	-		
	4.00				4.00	4.50	SPT	7	9	13	22	-	-			
	4.50				4.50	5.00	UDS	8	10	12	22	-	-			
	5.00				5.00	5.50	SPT	11	12	12	24	-	-			
	5.50				5.50	6.00	UDS	-	-	-	-	-	-	-		
	6.00				6.00	6.50	SPT	6	8	12	20	-	-			
	6.50				6.50	7.00	SPT	6	7	14	21	-	-			
	7.00				7.00	7.50	SPT	6	8	11	19	-	-			
	7.50				7.50	8.00	UDS	-	-	-	-	-	-	-		
	8.00			8.50 to 9.50m	8.00	8.00	8.50	SPT	5	7	13	20	-	-		
	9.00				9.00	9.50	SPT	8	9	12	21	-	-			
	9.50				9.50	10.00	UDS	-	-	-	-	-	-	-		
	10.00			9.50 to 10.50m	10.00	10.00	11.00	SPT	6	9	13	22	-	-		
	10.50															
	11.00				11.00	11.50	UDS	-	-	-	-	-	-	-		
	11.50			10.50 to 14.20m	11.50	11.50	12.50	SPT	4	6	12	18	-	-		
	12.00															
	12.50															
	+ 13.00			14.20 to 16.00m	13.00	13.00	14.00	SPT	4	7	13	20	16.00	-		
	13.50															
	14.00															
	14.50			16.00 to 19.00m	14.50	14.50	14.60	SPT	50/14 cm	-	-	>100	-	-		
	15.00															
	15.50															
	16.00			19.00 to 20.50m	16.00	14.50	16.00	Core	-	-	-	-	26.00	12.00		
	16.50															
	17.00															
	17.50			20.50 to 25.00m	17.50	16.00	17.50	Core	-	-	-	-	30.00	-		
	18.00															
18.50																
19.00		20.50 to 25.00m	19.00	17.50	19.00	Core	-	-	-	-	44.00	8.00				
19.50																
20.00																
20.50		20.50 to 25.00m	20.50	19.00	20.50	Core	-	-	-	-	58.00	30.00				
21.00																
21.50																
22.00		20.50 to 25.00m	22.00	20.50	22.00	Core	-	-	-	-	74.00	20.00				
22.50																
23.00																
23.50		20.50 to 25.00m	23.50	22.00	23.50	Core	-	-	-	-	78.00	80.00				
24.00																
24.50																
25.00		20.50 to 25.00m	25.00	23.50	25.00	Core	-	-	-	-	86.00	56.00				

K.C.T. Consultancy Services®

Project : BHEL

Bore Hole No. : IBH 19

Location : Hirma, Talabira

Depth of Termination : 18.00 M

Co-ordinates: E 1218, N 2964

Depth of Water Table : Encountered at 3.20m depth during investigation

Date of Start: 21-07-2024
















Date of Completion: 22-07-2024

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced Level: 200.35m

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks	
						From m	To m		N ₁	N ₂	N ₃	N				
Rotary drilling method	0.00	Not Used		Yellowish brown, very fine grained, sandy clays of interemdtate plasticity (CI) 0.00 to 0.70m	0.00	0.00	1.00	DS	-	-	-	-	-	-		
	0.50															
	1.00				Yellowish brown, fine to very fine grained, clays of high plasticity (CH) 0.70 to 2.80m	1.00	1.00	2.00	SPT	10	12	14	26	-	-	
	1.50															
	2.00				Yellowish brown, fine to very fine grained, sandy clays of high plasticity (CH) 2.80 to 3.70m	2.00	2.00	2.50	SPT	6	9	12	21	-	-	
	2.50															
	3.00				Yellowish brown, fine to very fine grained, sandy clays of high plasticity (CH) 3.70 to 5.70m	3.00	3.00	3.50	SPT	14	19	31	50	-	-	
	3.50															
	4.00				Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI) 5.50 to 6.65m	4.00	4.00	4.50	SPT	7	13	18	31	-	-	
	4.50															
	5.00				Highly weathered, completely fractured and disintegrated, yellowish brown, fine to medium grained, gravel, pebble size fragments of fractured rock with dark brownish red, fine to medium grained, clayey sand 6.65 to 8.30m	5.00	5.00	5.50	SPT	50/9 cm	-	-	>100	-	-	
	5.50															
	6.00				Moderately weathered, weak, brownish yellow, fine to medium grained, thinly bedded rock 8.30 to 10.50m	6.00	6.00	7.50	SPT	50/3 cm	-	-	>100	-	-	
	6.50															
	7.00				Slightly weathered, very weak, brownish yellow, fine to very fine grained, thickly bedded rock 10.50 to 12.00m	7.50	7.50	8.30	SPT	50/8 cm	-	-	>100	-	-	
	7.50															
	8.00				Moderately weathered, very weak, fine to very fine grained, thinly laminated rock 12.00 to 13.50m	8.50	8.30	9.00	Core	70/10 cm	-	-	>100	60.00	19	
	9.00															
	9.50				Moderately weathered, weak, brownish grey, fine to very fine grained, moderately thickly bedded rock 13.50 to 16.50m	10.00	9.08	10.50	Core	-	-	-	-	81.33	42.60	
	10.50															
	11.00				Slightly weathered, weak, dark blackish grey, fine to medium grained, massive rock	11.50	10.50	12.00	Core	-	-	-	-	46.00	-	
	12.00															
	12.50					13.00	12.00	13.50	Core	-	-	-	-	70.00	36.00	
	13.50															
	14.00					14.50	13.50	15.00	Core	-	-	-	-	59.00	86.00	
	15.00															
	15.50					16.00	15.00	16.50	Core	-	-	-	-	92.60	68.66	
	16.50															
17.00			17.50	16.50	18.00	Core					98.60	98.60				
18.00																
16.50 to 18.00m																

Project : BHEL

Bore Hole No. : IBH 34

Location : Hirma, Talabira

Depth of Termination : 25.0 M

Co-ordinates: E 1131, N 3266

Depth of Water Table : Encountered at 2.30m depth during investigation

Date of Start: 21-06-2024

Date of Completion: 24-06-2024

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced Level: 198.11 M

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks		
						From m	To m		N ₁	N ₂	N ₃	N					
Rotary drilling method	0.00	Used		Yellowish brown, fine to very fine grained, sandy clays of low plasticity (CL) 0.00 to 0.60m	0.00	0.00	1.00	DS	-	-	-	-	-	-			
	0.50			Yellowish brown, fine to very fine grained, sandy clays of intermediate plasticity (CI) 0.60 to 3.60m	1.00	1.00	2.00	SPT	4	4	5	9	-	-			
	1.00				2.00	2.00	2.50	SPT	3	5	7	12	-	-			
	1.50				2.50	2.50	3.00	UDS	-	-	-	-	-	-			
	2.00				3.00	3.00	3.50	SPT	8	12	15	27	-	-			
	2.50				3.50	3.50	4.00	DS	-	UDS attempted but not recovered				-	-		
	3.00				4.00	4.00	4.50	SPT	7	8	9	17	-	-			
	3.50				4.50	4.50	5.00	UDS	-	-	-	-	-	-			
	4.00				5.00	5.00	5.50	SPT	11	14	16	30	-	-			
	4.50				5.50	5.50	6.00	UDS	-	-	-	-	-	-			
	5.00				6.00	6.00	6.50	SPT	12	14	17	31	-	-			
	5.50		6.50	6.50	7.00	UDS	-	-	-	-	-	-					
	6.00		7.00	7.00	7.50	SPT	10	13	17	30	-	-					
	6.50		7.50	7.50	8.00	UDS	-	-	-	-	-	-					
	7.00		8.00	8.00	8.50	SPT	4	6	7	13	-	-					
	7.50		8.50	8.50	9.00	UDS	-	-	-	-	-	-					
	8.00		9.00	9.00	9.50	SPT	9	12	14	26	-	-					
	8.50		9.50	9.50	10.00	UDS	-	-	-	-	-	-					
	9.00		10.00	10.00	11.00	SPT	9	11	12	23	-	-					
	9.50		11.00	11.00	11.50	UDS	-	-	-	-	-	-					
	10.00		11.50	11.50	12.50	SPT	14	16	18	34	-	-					
	10.50		12.50	12.50	13.00	DS	-	UDS attempted but not recovered				-	-				
	11.00		13.00	13.00	13.10	SPT	50	-	-	>100	-	-					
	11.50		14.00	Not used		Highly weathered, fractured, dark brownish grey, very fine grained, very thinly bedded rock	14.50	13.10	14.60	Core	-	-	-	-	7.14	-	
	12.00		14.50				14.50	14.52	SPT	50	-	-	>100	-	-		
	12.50		16.00				14.52	16.00	Core	-	-	-	-	23.33	-		
	13.00		17.50				16.00	17.50	Core	-	-	-	-	21.33	-		
	13.50		19.00				17.50	19.00	Core	-	-	-	-	49.33	17.33		
	14.00		20.50				19.00	20.50	Core	-	-	-	-	41.33	13.33		
	14.50		22.00				20.50	22.00	Core	-	-	-	-	79.33	62.00		
	15.00		23.50				22.00	23.50	Core	-	-	-	-	59.33	48.00		
	15.50		24.00				23.00	25.00	Core	-	-	-	-	31.33	24.00		
16.00	25.00	23.00	25.00				Core	-	-	-	-	31.33	24.00				

K.C.T. Consultancy Services®

Project : BHEL

Bore Hole No. : IBH 35

Location : Hirma, Talabira

Depth of Termination : 23.50 m

Co-ordinates: E 1132, N 3102

Depth of Water Table : Encountered at 1.00 m depth during investigation

Date of Start: 15-01-2025



Date of Completion: 17-01-2025

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced Level: 198.78 m

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type of Sample	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks		
						From m	To m		N ₁	N ₂	N ₃	N					
Rotary drilling method	0.00	Used		Yellowish brown, fine to medium grained, clayey sand (SC) 0.00 to 0.80m	0.00	0.00	1.00	DS	-	-	-	-	-	-			
	0.50																
	1.00						1.00	1.00	2.00	SPT	2	2	3	5	-	-	
	1.50																
	2.00					Yellowish brown to brownish yellow, fine to medium grained, sandy clays of intermediate plasticity with occasional gravels (CI) 0.80 to 4.60m	2.00	2.00	2.50	SPT	2	3	4	7	-	-	
	2.50						2.50	2.50	3.00	UDS	-	-	-	-	-	-	
	3.00						3.00	3.00	3.50	SPT	3	4	5	9	-	-	
	3.50						3.50	3.50	4.00	UDS	-	-	-	-	-	-	
	4.00						4.00	4.00	4.50	SPT	5	6	8	14	-	-	
	4.50						4.50	4.50	4.60	SPT	5	8	9	17	-	-	
	5.00					Brownish yellow, fine to very fine grained, clays of intermediate plasticity (CI) 4.60 to 6.70m	5.00	5.00	5.50	SPT	8	14	16	30	-	-	
	5.50																
	6.00						6.00	6.00	6.50	SPT	6	10	13	23	-	-	
	6.50						6.50	6.50	7.00	UDS	-	-	-	-	-	-	
	7.00					Brownish yellow, fine to very fine grained, clayey sand (SC) 6.70 to 8.45m											
	7.50						7.50	7.50	8.00	SPT	6	7	10	17			
	8.00						8.00	8.00	8.50	SPT	4	5	8	13			
	8.50			8.50	8.50		9.00	SPT	5	6	8	14					
	9.00			9.00	9.00		9.50	SPT	4	8	9	17					
	9.50			9.50	9.50		10.00	SPT	5	7	9	16					
	10.00			10.00	10.00		11.00	SPT	5	8	12	20					
	10.50																
	11.00				11.00		11.00	11.50	SPT	5	8	15	23				
	11.50				11.50		11.50	12.50	SPT	6	9	11	20				
	12.00			Not Used	Dark brownish grey, fine to very fine grained, indurated clays of intermediate plasticity mud stone 12.20 to 12.80m												
	12.50					12.50	12.50	12.80	SPT	20	31	60	91	-	-		
	13.00				Highly weathered, very weak, thinly laminated fraible dark brownish, fine to very fine grained, mud stone 12.80 to 14.50m												
	13.50					13.00	12.80	13.00	Core					70.00			
	14.00					14.50	13.00	14.50	Core					25.33			
	14.50				Highly weathered, weak, dark brownish grey, fine to very fine grained, fractured rock 14.50 to 16.00m												
	15.00					16.00	14.50	16.00	Core					52.00	13.33		
	15.50																
16.00			Moderately weathered, weak, dark brownish, fine to very fine grained, rock with close spacing of discontinuities 16.00 to 18.00m														
16.50					17.50	16.00	17.50	Core					69.33	47			
17.00																	
17.50			Slightly weathered, moderately strong, greyish black, fine to medium grained, rock with wide spacing of discontinuities 18.00 to 20.50m														
18.00					19.00	17.50	19.00	Core					47.33	22.00			
18.50																	
19.00																	
19.50			Moderately weathered, weak, dark brownish, fine to very fine grained, rock with moderately close spacing of discontinuities 20.50 to 22.00m														
20.00				20.50	19.00	20.50	Core					55.33	51.33				
20.50																	
21.00																	
21.50				22.00	20.50	22.00	Core					60.00	36.00				
22.00																	
22.50																	
23.00																	
23.50																	
					23.50	22.00	23.50	Core					97.33	94.66			
22.00 to 23.50m																	

Project : BHEL

Bore Hole No. : IBH 36

Location : Hirma, Talabira

Depth of Termination : 17.5 M

Co-ordinates: E 1132, N 2951

Depth of Water Table : Encountered at 3.15m depth during investigation

Date of Start: 22-07-2024

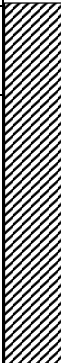





Date of Completion: 25-07-2024

Diameter of Bore: 150mm and Nx size

Bit Used: Soil Surface Bit and NX Size

Reduced Level: 200.53

BORE LOG DATA SHEET

Method of Boring	Depth m	Casing	Notation	Soil Description	Depth of Sample m	Drill Run		Type Sample of	SPT N Value/Penetration of S.S.S				Core Recovery (%)	RQD (%)	Remarks		
						From m	To m										
									N ₁	N ₂	N ₃	N					
Rotary drilling method	0.00	Not Used		Yellowish brown, fine to very fine grained, sandy clays of high plasticity (CH) 0.00 to 1.30m	0.00	0.00	1.00	DS	-	-	-	-	-	-			
	0.50																
	1.00																
	1.50						1.00	1.00	2.00	SPT	2	3	4	7	-	-	
	2.00						2.00	2.00	2.50	SPT	5	7	8	15	-	-	
	2.50			Yellowish brown, very fine grained, clays of high plasticity (CH) 1.30 to 4.95m	2.50	2.50	3.00	SPT	3	4	6	10	-	-			
	3.00				3.00	3.50	SPT	7	8	8	16	-	-				
	3.50				3.50	4.00	UDS	-	-	-	-	-	-				
	4.00				4.00	4.50	SPT	5	9	9	18	-	-				
	4.50				4.50	5.00	SPT	7	11	14	25	-	-				
	5.00			Yellowish brown, fine to medium grained, sandy clays of high plasticity (CH) 4.95 to 5.70m	5.00	5.00	5.50	SPT	7	10	12	22	-	-			
	5.50				5.50	6.00	SPT	8	9	12	21	-	-				
	6.00				6.00	6.50	SPT	9	10	12	22	-	-				
	6.50			Yellowish brown, fine to medium grained, sandy clays of intermediate plasticity (CI) 5.70 to 7.90m	6.50	6.50	7.00	SPT	10	12	13	25	-	-			
	7.00				7.00	7.50	SPT	9	13	13	26	-	-				
	7.50				7.50	8.00	UDS	-	-	-	-	-	-				
	8.00			Yellowish brown, fine to very fine grained, clayey sand (SC) 7.90 to 11.30m	8.00	8.00	8.50	SPT	8	10	12	22	-	-			
	8.50				8.50	9.00	SPT	7	10	11	21	-	-				
	9.00				9.00	9.50	SPT	7	9	9	18	-	-				
	9.50				9.50	10.00	SPT	7	7	10	17	-	-				
	10.00				10.00	11.00	SPT	9	11	14	25	-	-				
	10.50																
	11.00				11.00	12.50	SPT	9	16	19	35	-	-				
	11.50																
	12.00				Mixture of Highly weathered, weak, completely fractured and disintegrated, dark brownish grey, fine to very fine grained, thinly bedded rock 11.0 to 13.00m	12.50	12.50	12.61	SPT	50/11cm	-	-	>100	-	-		
	12.50																
	+ 13.00				Moderately weathered, weak, yellowish brown, fine to medium grained, moderately thickly laminated rock 13.00 to 14.50m	13.00	12.61	13.00	Core	-	-	-	-	50.00	-		
	13.50																
	14.00																
	14.50				Moderately weathered, weak, blackish grey, fine to medium grained, moderately thickly laminated rock 14.50 to 16.00m	14.50	13.00	14.50	Core	-	-	-	-	60.66	30.00		
15.00																	
15.50																	
16.00		Moderately weathered, moderately weak, blackish grey, fine to medium grained, moderately thinly bedded rock 16.00 to 17.00m	16.00	14.50	16.00	Core	-	-	-	-	67.33	24.66					
16.50																	
17.00		Slightly weathered, strong, dark blackish grey, fine to medium grained, massive rock	17.50	16.00	17.50	Core	-	-	-	-	92.00	77.33					
17.50																	
17.00 to 17.50m																	

17.00 to 17.50m

Sample Photographs for core boxes:







Sample Photographs for Drilling







