1.1 **Section A: Infrastructure works:**

NLCIL Clarification No.	REFERENCE	EXISTING	TO BE READ AS
1	Volume: I-A Section-2, General Project Information, Cl.2.0.0, Brief Scope of WorkCl.2.1.0-Section –A: INFRASTRUCTURE WORKS, **DOCUMENT 1 From Page 3 of 574 to page 8 of 574**	Cl.2.0.0, **Brief Scope of Work** Cl.2.1.0-Section –A: INFRASTRUCTURE WOPRKS EPC contract shall include Architectural Planning, Concept Design, Soil investigation and Survey, Design of Structure and MEP services including allied ---------- ---------- ---------- ---------- C. EXTERNAL ELECTRICAL WORKS Design, Manufacture / Procurement, Testing at Firms work, Supply,Installation, Testing at Site and Commissioning of 2 x. 6.3 MVA, 33/11 kVSubstation at NTTPP site / Talabira for providing I. Construction Power supply for Thermal Project Site	*(Existing clause modified as below)* **Cl.2.0.0, Brief Scope of Work** **Cl.2.1.0-Section –A: INFRASTRUCTURE WORKS** EPC contract shall include Architectural Planning, Concept Design, Soil investigation and Survey, Design of Structure and MEP services including allied works, getting approval for drawings from NLCIL, obtaining all statutory approvals from Local Authorities,State and Central Govt. departments / Body including services, preparing submission and execution drawing, Construction and Commissioning of the infrastructure works. The Contractor's quoted rates are deemed to include everything from the award of work up to & including handing over of completed project, defect liability period. The EPC Contractor is required to connect all the external services like Water Supply, Sewerage, Drainage, Electric Supply, LAN/WAN, etc. to the main lines of the authorities/service providers which shall be

Sl. No	Volume	Sec./Clause/Page	As existing	To be read as
1	Vol. II-E	Section-XI-Header/Page 1 to 16	NLC India Limited Thermal Power Station-II 2nd Expansion (2x660 MW) Project, Neyveli, Tamil Nadu	NLC India Limited NLC Talabira Thermal Power Project - 3x800 MW Jharsuguda, Odisha

Table C: Civil

Sl. No	Volume	Sec./Clause/Page	As existing	To be read as
1.	Vol. II-G1/Section-I	3.00.00 SCOPE OF CIVIL WORKS	Blasting shall not be permitted for excavation of foundation irrespective of the soil strata encountered.	Controlled blasting shall be permitted **as applicable with necessary statutory approval to be obtained by EPC contractor as required.**
2.	Vol. II-G1/Section-I	3.00.00 SCOPE OF CIVIL WORKS	All area grading works & Micro grading, levelling & dressing are in Bidders scope. (finished grade levels shall be as mentioned elsewhere)	All area grading works (refer Section A) & Micro grading, levelling & dressing are in Bidders scope (finished grade levels shall be as mentioned elsewhere) The bidder may visit the site and do survey to access the variation if any in contour details furnished and to access the actual site condition before quoting
3.	II-G1	4.23.10 Ash Dyke	LDPE	**HDPE**
4.	VOLUME : II-L TENDER DRAWINGS [Contd.]	CIVIL, STRUCTURAL & ARCHITECTURAL	18A03-DWG-A-0001 Architectural Standard Details (3 Sheets) 18A03-DWG-A-0002 Architectural Standard Details (3 Sheets) 18A03-DWG-A-0003 Architectural Standard Details (3 Sheets) 18A03-DWG-A-0004 Architectural Standard Details (4 Sheets) 18A03-DWG-A-0005 ESP Control Building 18A03-DWG-A-0006 Fuel Oil Unloading Cum Pressurizing Pump House 18A03-DWG-A-0007 Boiler Maintenance Building 18A03-DWG-A-0011 CPU Regeneration Building (2 sheets) 18A03-DWG-A-0012 ACW Pump House 18A03-DWG-A-0013 DM Plant 18A03-DWG-A-0020	**Deleted.**

			Chemical Lab	
~~5.~~	~~VOLUME : II-L TENDER DRAWINGS [Contd.]~~	~~CIVIL, STRUCTURAL & ARCHITECTURAL~~	~~18A03-DWG-A-0010 Service Building (8 sheets)~~	~~18A03-DWG-A-0010 Service Building (5 sheets)~~
6.	VOLUME : II-L TENDER DRAWINGS [Contd.]	CIVIL, STRUCTURAL & ARCHITECTURAL	18A03-DWG-C-0006 **Area Grading,** Plant Road & Drains	18A03-DWG-C-0006 Plant Road & Drains
7.	18A03-DWG-C-0006	Plant Road & Drains	In table : Shoulder width 1.2 m for 4.0 M wide road	In table : Shoulder width **1.5 m** for 4.0 M wide road
8.	18A03-DWG-C-0006	Plant Road & Drains	FOR 7.5 M / 10.0M WIDE RCC ROAD RAISED WALK WAY / VERM SHALL BE PROVIDED	FOR 7.5 M / 10.0M WIDE RCC ROAD RAISED WALK WAY / **BERM** SHALL BE PROVIDED
9.	18A03-DWG-C-0006	Plant Road & Drains	Roads and drain layout and roads and drain cross section	**Details of Roads and drain layout shown in this drawing need not be referred. Roads and drain cross section shall alone be referred.**
~~10.~~	~~Vol. II-G1/Section-V~~	~~1.00.00 GENERAL 1.01.00 SCOPE OF WORK~~	~~Wind tunnel study has to be done in any one of the following approved labs - SERC-Chennai, **IISc – Bangalore** and IIT – Kanpur and the study report shall be got approved by the owner / Consultant~~	~~Wind tunnel study has to be done in any one of the following approved labs - SERC-Chennai, and IIT – Kanpur and the study report shall get approved by the owner / Consultant~~
11.	Vol. II-G1/Section-I	4.23.10 **Ash Dyke**	The scope of work for Ash Dyke generally involves, design, preparation of general arrangement drawings, construction drawings, supply of labour & materials and construction of all civil and structural works as site clearance, site levelling & grading, excavation, filling, dewatering, construction of earthen embankment, providing sand filters, sand chimney, sand blanket in embankment, cut-off trench, mechanical compaction, upstream and downstream slope protection, instrumentations, forming drains, brick masonry bedding / capping, providing impervious liner on bed of pond, WBM road on dyke top, 4.00m wide bituminous inspection road all around the periphery of dyke at ground level along with cross drainage structures, rock toe, toe drain	The scope of work for Ash Dyke generally involves, design, preparation of general arrangement drawings, construction drawings, supply of labour & materials and construction of all civil and structural works as site clearance, site levelling & grading **(including grading for approach road from the main road (i.e., covered under the scope of "Section-A") to Äsh dyke" and for inspection road up to drain for the ash dyke)** excavation, filling, dewatering, construction of earthen embankment, providing sand filters, sand chimney, sand blanket in embankment, cut-off trench, mechanical compaction, upstream and downstream slope protection, instrumentations, forming drains, brick masonry bedding / capping, providing impervious liner on bed of pond, WBM

			, & spillways (box culvert), overtaking zones & approach ramps. The scope of work also includes the bund protection work for nearby Nallah.	road on dyke top, 4.00m wide bituminous **approach road,** inspection road all around the periphery of dyke at ground level along with cross drainage structures, rock toe, toe drain , & spillways (box culvert), overtaking zones & approach ramps. The scope of work also includes the bund protection work for nearby Nallah.
~~12.~~	~~Vol. II-G1~~	~~Sec-II/3.00.00 c) (i)~~	~~Loadings (both static and dynamic) of major and minor equipment, including boiler, Turbine-Generator, BFP, FD, ID,seal air fans, Beater Mill, Feed water heater, De-aerator etc. obtained from the manufacturer's certified drawings of the specified equipment to be furnished.~~	~~Loadings (both static and dynamic) of major and minor equipment, including boiler, Turbine-Generator, BFP,~~**~~PA~~**~~, FD, ID, seal air fans,~~ **~~Coal Mill,~~** ~~Feed water heater, De-aerator etc. obtained from the manufacturer's certified drawings of the specified equipment to be furnished.~~
13.	Vol.II-G1	Section-I / 4.23.10	Ash Dyke Slope Protection Works: ….Turfing with sods / clods ….	Ash Dyke **Slope Protection Works: …. Minimum 30 cm thick stone pitching with Riprap arrangement hand placed as per IS: 8237…**
~~14.~~	~~Vol-II-A~~	~~Section –II /3.02.11(b)~~	~~…. High-rise buildings ….~~	~~…. High-rise buildings~~ **~~(three storied and more) …~~**
~~15.~~	~~Vol-II-A~~	~~Section-IV/Clause 3.03.03/Page 810/6472~~	~~The main Contractor ….. shall not be subsidiary/JV Company of the main~~ **~~SE~~** ~~contractor and shall meet the following criteria~~	~~The main Contractor …….. shall not be subsidiary/JV Company of the main contractor and shall meet the following criteria~~
~~16.~~	~~Vol. II-G1 & Vol – II-A~~	~~Section-I/Clause - 3.00.00 SCOPE OF CIVIL Where ever applicable~~	~~TG,~~ **~~Crushers for both Coal and Limestone, MILL~~**~~, ID & FD fans, TDBFP and MDBFP foundations shall be provided with VIS.~~	~~TG, ID & FD fans, TDBFP and MDBFP foundations shall~~ **~~be as per manufacturers proven practise. Crushers for both Coal and Limestone shall be on VIS~~**
~~17.~~	~~Vol. II-G1~~	~~Section-II/Clause - 5.00.00 FOUNATION DESIGN~~	~~ID & FD fans and Mill foundations are to be provided with VIS.~~	~~ID & FD fans are to be provided~~ **~~as per manufacturer's proven practise.~~**
~~18.~~	~~Vol. II-G1~~	~~Section-I/Clause - 3.00.00 SCOPE OF CIVIL WORKS Ash Handling System and its related Auxiliaries~~	~~Road transport along with approach road~~	~~**Approach road from plant to Mine void along Ash pipe line and Approach road from the main road (i.e., covered under the scope of "Section-A") to Äsh dyke" and Inspection roads for the ash dyke. Area grading for Both approach roads up to drain is in the scope of bidder**~~
19.	Vol. II-G1/Sect	3.00.00 SCOPE OF	Trapezoidal section shall be provided for pond with minimum holding	Trapezoidal section shall be provided for pond with minimum holding capacity of

	ion-I	CIVIL WORKS	capacity of 40,000 m3	40,000 m3 **below the lowest invert level of the incoming drain.**
20.	Vol. II-G2/Part-A/Section-III Area Grading and Vol – II -A	3.06.03 Excavation in Hard Rock & 3.04.00	Blasting is not allowed / Prohibited	**Controlled blasting shall be permitted as applicable with necessary statutory approval to be obtained by EPC contractor as required.**
21.	Vol. II-G1/Section-I	3.00.00 SCOPE OF CIVIL WORKS	Geo-Technical investigation	Geo-Technical investigation **for all the areas under the scope of the EPC Bidder**
22.	Vol. II-G1/Section-I	3.00.00 SCOPE OF CIVIL WORKS	All the plant main road within plant area shall be connected to owner's plant main road by providing RCC box culvert at the intersection point	**Deleted**
23.	~~Vol. II-G1/Section-I~~	~~4.25.02 Raw Water Reservoir~~	~~If the excavated earth is not suitable for bund formation, it shall be disposed of and suitable earth shall be brought from nearby borrow pits shown by the Owner~~	~~If the excavated earth is not suitable for bund formation, it shall be disposed of and suitable earth shall be brought from nearby borrow pits **with in a lead of 20 km shown by the Owner without any extra cost .**~~
~~24.~~	~~Vol. II-G1~~	~~Section-I/Clause - 4.09.00 POWER HOUSE BUILDING~~	~~Turbine Building~~ ~~The A-B bay of the building is 31.0 m & B-C bay is 12.0 m. The turbine – generator bay have Four floors- ground floor at EL. 0.00m level, Mezzanine floor at EL. 8.50 m & EL.12.3 m level, operating floor at EL. 17.00m level and deaerator floor at EL. 24.0 m level shall be provided.~~	~~**Turbine Building**~~ ~~**For sizes and levels refer relevant sections** of Mechanical volume~~
25.	Vol. II-G1	Section-I/Clause - 3.00.00 SCOPE OF CIVIL WORKS Ash Handling System and its related Auxiliaries	Construction of Ash Dyke for HCSD Slurry Disposal including nearby Nallah bund strengthening	Construction of Ash Dyke for HCSD Slurry Disposal including nearby Nallah bund strengthening **of 1000 M**
~~26.~~	~~Vol II-G1~~	~~Sec- I/ Cl.3.00.00 Bridge across Bhedan River:~~	~~There shall be 2 Nos. Bridges across Bhedan River.~~	~~There shall be **1 no of bridge(4 lane) across Bhedan river having total 40 m (minimum) wide or 2 nos x 20 m (minimum) width~~
~~27.~~	~~Vol II-G1 & Vol II-A~~	~~II-A & G1~~ ~~Where ever applicable~~	~~The bridge-1(west side)~~ ~~The bridge- 2(eastside)~~	~~**The same shall be read as 1 no of bridge(4 lane) across Bhedan river having total 40 m (minimum) wide or 2 nos x 20 m (minimum) width~~**
~~28.~~	~~Vol II-G1~~	~~4.25.02 Raw Water~~	~~The reservoir shall be formed with optimum cutting and filling of the~~	~~The reservoir shall be formed with optimum cutting and filling of the earth~~

		Reservoir & 18A03-DWG-C-007	earth (without compromising the safety of power plant)	(without compromising the safety of power plant) **with top of the bund shall not exceed 204.0m including free board of 1.5 m and bottom level shall be kept above the ground water table.**
29.	Vol II-G1 & Vol II-A	4.24.00 4.24.03 Patrol Road 3.0 Scope of work	Patrol road Asphalt Carpeted WBM 3.5 M wide inspection road shall be provided along the complete pipeline route providing access by vehicles to the entire stretch of pipeline Inspection BT Road including culverts etc..Along pipe corridor from intake pump house near Hirakud to plant except water body crossings.	**Patrol road / inspection road along the raw water pipe line outside the plant boundary stands Deleted from scope**
30.	Vol. II-G1/Section-I	4.23.10 Ash Dyke	Ash dyke shall be constructed by optimized cutting/filling required to build up storage capacity as indicated in Mechanical Volume.	Ash dyke shall be constructed by optimized cutting/filling required to build up storage capacity as indicated in Mechanical Volume. **With top of the bund shall not exceed 204.0m including free board of 1.5 m and bottom level shall be kept above the ground water table.**
31.	Vol. II-G1/Section-I	4.23.10 Ash Dyke	The design of stability analysis and seepage analysis shall be safe for starter dyke plus 2 raisings at future date of 3.0m height each or as per design	The design of stability analysis and seepage analysis shall be safe for starter dyke plus 2 raisings **(External raising)** at future date of 3.0m height each or as per design

Table D: Water systems

<table>
<tr><th>Sl. No</th><th>Volume</th><th>Sec./Clause/Page</th><th>As existing</th><th>To be read as</th></tr>
<tr><td>1.</td><td>II-IB/1</td><td>Sec-I/ cl.no.4.09.00/pg 9 of 14</td><td>All Compressed Air System piping, as required, shall be sized for a velocity guided by the recommended velocity chart in Annexure-I of this section.</td><td>This clause stands deleted</td></tr>
<tr><td>2.</td><td>II-IB/1</td><td>Sec-I/Annexure-I/pg 14 of 14</td><td>RECOMMENDED VELOCITY CHART FOR PIPE SIZING
<table>
<tr><th>Sl. No.</th><th>Description of Pipe</th><th>Velocity (M/Sec.) Pipe Size Below 50 mm</th><th>Velocity (M/Sec.) Pipe Size 50 – 150 mm</th><th>Velocity (M/Sec.) Pipe Size Above 150 mm</th></tr>
<tr><td>1.</td><td>Pipelines at pump</td><td>-</td><td>1.2 - 1.5</td><td>1.2 - 1.8</td></tr>
</table></td><td>
<table>
<tr><th>Sl. No.</th><th>Description of Pipe</th><th>Velocity (M/Sec.) Pipe Size Below 50 mm</th><th>Velocity (M/Sec.) Pipe Size 50 – 150 mm</th><th>Velocity (M/Sec.) Pipe Size Above 150 mm</th></tr>
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</table></td></tr>
</table>

3 X 800 MW NLC TALABIRA THERMAL POWER PROJECT

VOLUME – II B

SPECIFICATION NO PE-TS-N80-682-C001

TECHNICAL SPECIFICATION FOR ASH DYKE (STARTER DYKE) AND ASSOCIATED WORKS

Bharat Heavy Electricals Limited
Project Engineering Management
PPEI Building, Power Sector,
Plot No. 25, Sector 16A,
Noida (U.P.)-201301

PREAMBLE

This volume is sub-divided into following sections:

Section A : This section outlines the Scope of work, Exclusions and Terminal points

Section B : This section outlines the Project information

Section C : This section outlines the specific technical requirements

3 X 800 MW NLC TALABIRA THERMAL POWER PROJECT

VOLUME – II B

SPECIFICATION NO PE-TS-N80-682-C001

SECTION – A

SCOPE OF WORK, EXCLUSIONS & TERMINAL POINTS

Bharat Heavy Electricals Limited
Project Engineering Management
PPEI Building, Power Sector,
Plot No. 25, Sector 16A,
Noida (U.P.)-201301

SECTION – A

SCOPE OF WORK, EXCLUSIONS & TERMINAL POINTS

1.0 Scope of Work:

The scope of work includes Civil, Structural & Architectural works for Ash dyke (Starter dyke) and associated works on Engineering, Procurement and Construction (EPC) basis for 3 X 800 MW NLC TALABIRA THERMAL POWER PROJECT. The scope of work described herein are in general and shall include those specified in Section-C of this specification as well.

The scope of civil work comprises of the following:

a) Ash dyke (starter dyke) including site clearance, site levelling & grading, topographical survey, geotechnical investigation, road on top of ash dyke, instrumentations etc.

b) Peripheral road and drain around the toe of embankment including connection of peripheral drain with nearest natural drain or nallah.

c) Bund protection works for nearby existing nallah (Approximate length for strengthening of existing nallah bund = 1000 m).

d) Obtaining statutory approval (including payment of necessary fee, levy and all other related misc. expenditure from the State/Central Govt. authority for obtaining statutory approval) for the ash dyke.

Any other work not specified herein but specified in Section-C and those required for successful completion of ash dyke.

1.1 Construction facilities

The following facilities shall be taken care by the bidder at their own end.

1. All civil and structural works associated with drinking and service water facilities for bidder's labour and other personnel at the work site/staff colony.

2. Development of temporary staff colony and labour colony as required along with fencing etc.

3. Making all arrangements for distribution of construction power at various locations as per requirements.

4. Making all arrangements for the supply of construction water.

5. Construction of bidder's site office, stores (open/covered as applicable), workshops, material/field testing laboratory and any other temporary facilities as required.

6. Providing all necessary firefighting devices/equipment/fire tender etc. as required during construction stage.
7. Providing all materials, tools and plants (T & P) required for completion of the work.
8. Providing skilled/semiskilled/unskilled labours and supervisory staff for quality control and execution.
9. Meeting occupational health and safety requirements.
10. Temporary illumination and lighting as required for execution of work.
11. Development of temporary approach roads, temporary drains as required for the execution.

Any other civil, mechanical, electrical works as required by the bidder enabling smooth execution of work.

1.2 Additional requirements

1. All works including materials shall be as per technical specification and approved drawings. The approval shall be obtained from BHEL & NLC/customer's consultant.
2. Bidder has to obtain approval of BHEL & NLC/customer's consultant for all works including design, drawing, construction methodology, construction materials, schedule etc.
3. All necessary statutory clearances shall be obtained by the bidder.
4. All the quality standards, tolerances, bolting and welding standards and other technical requirements shall be strictly adhered to.
5. Works shall be carried out as per approved design/drawings, specifications and field quality plans (FQP). The FQP shall be prepared by bidder and approved by BHEL & NLC/ customer's consultant.
6. The bidder should visit the site and fully apprise himself of the prevailing conditions at the site.
7. It is also to be noted that in case any other works are in progress or under execution nearby the Ash dyke area, the

work shall be planned and executed in such a way that the same shall not affect others work. No claim will be entertained by BHEL & NLC/ customer's consultant on ground of lack of knowledge on this account.

8. Necessary precaution and arrangements including sprinkling of water as required during work as acceptable to BHEL & NLC/ customer's consultant for safety, security and dust suppression etc. have to be made by the bidder.
9. Any other measures as required for safety of the adjacent existing structures/buildings/facilities during execution shall also be taken care by the bidder.
10. Bidder shall note that the analysis, design and drawings will be reviewed by BHEL; after incorporating BHEL comments/observations the same shall be further submitted to NLC/ customer's consultant for their review and approval. It is the responsibility of the bidder to get things approved by BHEL & NLC/ customer's consultant.

11. Bidder shall submit "as built drawings" after completion of construction of respective structure/building/facility in soft as well as in hard copies.

12. Foundation system and Geotechnical investigation:

a) Owner (NLC) had carried out preliminary geotechnical investigation in the vicinity of the proposed ash dyke area. The geotechnical data is attached in Section-C of this document is solely for the purpose of guidance to the bidder. BHEL/Owner does not take any responsibility about the accuracy and applicability of the geo-technical data furnished herewith. The onus of correct assessment/interpretation and understanding of the existing sub-strata conditions is on the bidder. Any variation in the data between the one furnished and to that found during execution of the work at site shall not constitute a valid reason in affecting the terms & conditions of this bid and the bidder shall note that nothing extra will be payable on this account. The bidder shall fully satisfy himself about the nature of sub-strata expected to be encountered including the type of foundation, ground water table and construction methodology to be adopted etc. prior to the submission of the bid.

b) Preliminary Geotechnical data attached is for reference only. However, bidder has to carry out detailed Geotechnical Investigation for ash dyke area. Bidder is advised to verify the content of Preliminary Geotechnical data and if necessary make his own tests at site as per requirement before submission of bid. Alternatively, Bidder may make his own assessment for the type of foundations envisaged based on this preliminary report at his own risk. In any case, Bidder has to carry out detailed Geotechnical Investigation after the award of contract, through some approved / reputed agency and submit Geotechnical Investigation report with recommendation for BHEL's review & approval. The recommendation given in approved final report becomes binding on the Bidder. The Bidder shall not be eligible for increase his price or demand any extension of time because the final report is in variance from preliminary report furnished by Owner.

2.0 Exclusions

Ash slurry pipe pedestals from peripheral drain to top of ash dyke.

3.0 Terminal points

At the outer edge of peripheral drain all around the ash dyke.

3 X 800 MW NLC TALABIRA THERMAL POWER PROJECT

VOLUME – II B

SPECIFICATION NO PE-TS-N80-682-C001

SECTION – B

PROJECT INFORMATION

Bharat Heavy Electricals Limited
Project Engineering Management
PPEI Building, Power Sector,
Plot No. 25, Sector 16A,
Noida (U.P.)-201301

1.0 Introduction

NLC India Ltd. (NLCIL) formerly Neyveli Lignite Corporation Limited is a 'Navratna', Government of India Enterprise engaged in mining of lignite and generation of power through lignite based thermal power plants. NLCIL was established by Government of India in 1956, following the discovery of lignite deposits in Neyveli, Tamil Nadu. NLCIL currently operates four open cast lignite mines in Neyveli (Tamil Nadu) and Barsingsar (Rajasthan) of total capacity of 30.6 Million Tonnes per Annum (MTPA). The company operates five pithead thermal power stations at the above locations with a total installed capacity of 3640 MW. NLCIL, through its subsidiary NTPL, has also recently commissioned a 1000 MW coal based power plant at Tuticorin (Tamil Nadu), 1001.56 MW solar plants and 51 MW wind power plant at Kazhuneerkulam (Tamil Nadu), thus bringing the total installed capacity of the company to 5581.56 MW.

In addition, another 3X660 MW coal based thermal power project at Ghatampur, U.P. in joint venture with U.P. is under execution.

NLCIL have now taken up implementation of Coal based pit head type NLC Talabira Thermal Power Project, consisting of three (3) supercritical units of 800 MW capacity each, near Kumbhari & Tareikela villages in Jharsuguda District, Odisha. Development Consultants Private Limited (DCPL) has been appointed as the Consultant for the project.

2.0 Location

The plant and township of the project proposed to be located near Kumbhari and Tareikela villages on south west of Brijraj Nagar town on Sambalpur Rourkela highway in Jharsuguda district and ash disposal area is located near Thelkolai village in Sambalpur district. The main plant area is defined by the following coordinates:

Description	Latitude	Longitude
North Extreme	21° 46’ 56.11’’ N	83° 59’ 30.59’’ E
East Extreme	21° 46’ 52.95’’ N	84° 00’ 20.72’’ E
South Extreme	21° 45’ 16.80’’ N	83° 59’ 9.36’’ E
West Extreme	21° 46’ 34.18’’ N	83° 58’ 50.54’’ E

3.0 Access

The project site is approachable from Sambalpur – Jharsuguda highway after crossing Bedhan River via state PWD road. Two separate 4 lane roads from Sambalpur – Jharsuguda highway have been envisaged for main approach to the project site. The nearest airports are at Bhubaneswar at a distance of 350 km and Raipur airport is at a distance of approx. 290 km. Nearest railway station at Jharsuguda on Howrah-Nagpur main (trunk) section is at a distance of 11 kms.

4.0 Water

The consumptive water is proposed to be drawn from Hirakud reservoir at a location downstream of Rambella bridge, at a distance of about 22 km and shall be pumped to the in-plant raw water reservoir. In-principle approval of State Government is available. The intake pump house location is proposed at Khata No. 01 (5.34 Acres) of Jogipalli Village. However, water drawl point location, pipe routing and other details need to be finalized in consultation with WRD,GOO.

Total consumptive water requirement for the Project (3x800 MW units) is estimated as 6700 cu-m/hr. with ETP recovery and COC 5.

5.0 Fuel

The primary fuel for this plant is Coal.

Coal requirement of the project shall be met from Talabira -II & III captive mines of NLC India Limited located nearby. Coal requirement is estimated to be 11.37 MTPA considering a GCV of 3700 Kcal/kg, and PLF of 85%. The coal shall be transported from the linked mines through Belt Conveyor system from coal stock at mine end up to transfer point and thereafter by Pipe conveyor for crossing Bedhan River up to crusher house located in plant area..

6.0 Power Evacuation

The power generated from the project will be evacuated through adequate no.of 765 kV& 400kV Transmission Lines Two (2) nos. of (765/√3) / (400/√3) /33 kV Interconnecting Transformer shall be provided between 765kV& 400kV GIS. Unit start-up power requirement shall be met by back charging 765 kV GIS and 400 kV GIS through ICTs. Unit start-up power requirement will be drawn from 400 kV bus through 400/11.5/11.5 kV Station Transformer

7.0 Implementation Schedule

The Project is planned to be executed through single EPC Contract. The scheduled key milestones of the Project (late finish), counted from the date of issue of LOA to the EPC Bidder for single EPC Package are as follows

a) Completion of Trial operation of Unit no. I : 52th Month from LOA
b) Completion of Trial operation of Unit no. II : 58th Month from LOA
c) Completion of Trial operation of Unit no. III : 64th Month from LOA

8.0 Meteorological Data

The meteorological station nearest from the site is Jharsuguda. Salient meteorological data of site is given below:

a) Mean Ambient temperature : 33.1 ºC maximum
20.7 ºC minimum
27.5 ºC average
b) Extreme Ambient temperature : 48.0 ºC maximum
6.0 ºC minimum
c) Mean wet bulb temp : 26.3 ºC
d) Mean relative humidity :
(i) At 8.30 hrs. 66%
(ii) At 17.30 hrs. 50%
e) Annual Rainfall : 1445 mm
f) Wind load : In accordance with IS-875 for a basic wind speed of 50 m/sec, up to a height of 10 meters above mean ground level.
g) Seismic Zone : Zone III as per IS:1893 latest edition.
h) Altitude : 203 M above MSL

3 X 800 MW NLC TALABIRA THERMAL POWER PROJECT

VOLUME – II B

SPECIFICATION NO PE-TS-N80-682-C001

SECTION-C

SPECIAL TECHNICAL REQUIREMENT

Bharat Heavy Electricals Limited
Project Engineering Management
PPEI Building, Power Sector,
Plot No. 25, Sector 16A,
Noida (U.P.)-201301

SECTION – C

SPECIFIC TECHNICAL REQUIREMENTS

NLC INDIA LIMITED
NLC TALABIRA THERMAL
POWER PROJECT- 3x800 MW
JHARSUGUDA, ODISHA

BIDDING DOCUMENT
FOR
ENGINEERING, PROCUREMENT & CONSTRUCTION

SPECIFICATION NO : 18A03-SPC-G-001

SECTION-B

VOLUME: II-A

LEAD SPECIFICATION

DEVELOPMENT CONSULTANTS PRIVATE LIMITED
CONSULTING ENGINEERS
BLOCK DG-4, SECTOR-II, SALT LAKE CITY
KOLKATA- 700 091, INDIA

November 2020

NLC INDIA LIMITED
NLC TALABIRA THERMAL
POWER PROJECT- 3x800 MW
JHARSUGUDA, ODISHA

SPECIFICATION NO : 18A03-SPC-G-001

SINGLE PACKAGES ENGINEERING, PROCUREMENT AND CONSTRUCTION

VOLUME: II-A

LEAD SPECIFICATION

DEVELOPMENT CONSULTANTS PRIVATE LIMITED
CONSULTING ENGINEERS
BLOCK DG-4, SECTOR-II, SALT LAKE CITY
KOLKATA- 700 091, INDIA

JOB NO. : 18A03
DATED : NOVEMBER, 2020

NLC INDIA LIMITED
NLC TALABIRA THERMAL
POWER PROJECT- 3x800 MW
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TENDER SPECIFICATION

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SPECIFICATION NUMBER	:	18A03-SPC-G-001
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NLC INDIA LIMITED
NLC TALABIRA THERMAL
POWER PROJECT- 3x800 MW
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ENGINEERING, PROCUREMENT & CONSTRUCTION

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~~INTENT~~ OF SPECIFICATION

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SECTION-I

INTENT OF SPECIFICATION

1.00.00 This specification is intended to cover design, engineering, manufacture, inspection and testing at manufacturer's works, packing and shipment and delivery at site, unloading, storage and handling at site of all equipment and materials, all necessary civil/structural/ architectural works, ~~erection of all mechanical / electrical / control& instrumentation equipment and materials, site testing, commissioning, trial run~~, performance and guarantee tests and other services including supply co-ordination, engineering and project management related to the equipment/systems comprising 3x800 MW Units, along with some other common facilities and provisions for future extension units as specified hereinafter and in accordance with the requirements, conditions, annexures, drawings etc. ~~stated in Volume-I and Volumes II-B to II-L which shall be considered as a part of this volume as completely as if bound herewith.~~

~~The specification consists of Volumes I, II & III detailed index of which has been furnished elsewhere.~~ This specification shall be read and construed in conjunction with the drawings and annexures to determine the scope of work. The quantities shown on drawings and annexures are indicative. Any variation arising during detailed engineering stage will be taken into account by the Bidder without any extra cost and time to the Owner.

The Bidder shall be responsible for providing all material, equipment and services, specified or otherwise which are required to meet the intent of this specification, ensuring high degree of reliability and ease of operation and maintenance. The equipment and system/sub-systems shall conform to all aspects of high standards of engineering, design and workmanship and shall be capable of performing in continuous commercial operation, in a manner acceptable to the Owner and shall also be in line with the current practice for reliable and efficient functioning of the plant.

Owner shall interpret the meaning of the specification, drawings, requirement of operation, maintenance, redundancy etc., and shall have a right to reject or accept any work or material which in his assessments is not technically complete to meet the requirements of this specification and/or applicable National and International standards mentioned elsewhere in this specification.

Bidder is required to carefully examine and understand the specifications and seek clarifications, if required, to ensure that he has understood the specifications as intended by the Owner. In the absence of any specific clarifications made by the Bidder during bidding stage, the interpretation of Owner shall be final and binding upon the successful Bidder upon award of LOA. The Bidder's offer should not carry any sections like clarifications, interpretations and/or assumptions. All such points are required to be clarified during bidding stage.

In the event of conflict between requirements of any two clauses of this specification/documents or requirements of different codes/standards, specified, the more stringent requirement as per the interpretation of the Owner shall apply.

In case all the above requirements are not complied with, the offer may be considered as incomplete and liable to be treated as non-responsive.

2.00.00 Whenever a material or article is specified or described by the name of a particular brand, manufacturer or vendor, the specific items mentioned shall be understood as establishing type, function and quality desired.

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SECTION-III

PROJECT SYNOPSIS AND GENERAL INFORMATION

1.00.00 INTRODUCTION

NLC India Ltd. (NLCIL) formerly Neyveli Lignite Corporation Limited is a 'Navratna', Government of India Enterprise engaged in mining of lignite and generation of power through lignite based thermal power plants. NLCIL was established by Government of India in 1956, following the discovery of lignite deposits in Neyveli, Tamil Nadu. NLCIL currently operates four open cast lignite mines in Neyveli (Tamil Nadu) and Barsingsar (Rajasthan) of total capacity of 30.6 Million Tonnes per Annum (MTPA). The company operates five pithead thermal power stations at the above locations with a total installed capacity of 3640 MW. NLCIL, through its subsidiary NTPL, has also recently commissioned a 1000 MW coal based power plant at Tuticorin (Tamil Nadu), 1001.56 MW solar plants and 51 MW wind power plant at Kazhuneerkulam (Tamil Nadu), thus bringing the total installed capacity of the company to 5581.56 MW.

In addition, another 3X660 MW coal based thermal power project at Ghatampur, U.P. in joint venture with U.P. is under execution

NLCIL have now taken up implementation of Coal based pit head type NLC Talabira Thermal Power Project, consisting of three (3) supercritical units of 800 MW capacity each, near Kumbhari & Tareikela villages in Jharsuguda District, Odisha. Development Consultants Private Limited (DCPL) has been appointed as the Consultant for the project.

2.00.00 LOCATION

The plant and township of the project proposed to be located near Kumbhari and Tareikela villages on south west of Brijraj Nagar town on Sambalpur Rourkela highway in Jharsuguda district and ash disposal area is located near Thelkolai village in Sambalpur district. The main plant area is defined by the following coordinates:

Description	Latitude	Longitude
North Extreme	21° 46’ 56.11’’ N	83° 59’ 30.59’’ E
East Extreme	21° 46’ 52.95’’ N	84° 00’ 20.72’’ E
South Extreme	21° 45’ 16.80’’ N	83° 59’ 9.36’’ E
West Extreme	21° 46’ 34.18’’ N	83° 58’ 50.54’’ E

3.00.00 ACCESS

The project site is approachable from Sambalpur – Jharsuguda highway after crossing Bedhan River via state PWD road. Two separate 4 lane roads from Sambalpur – Jharsuguda highway have been envisaged for main approach to the project site. The nearest airports are at Bhubaneswar at a distance of 350 km and Raipur airport is at a distance of approx. 290 km. Nearest railway station at Jharsuguda on Howrah- Nagpur main (trunk) section is at a distance of 11 kms.

4.00.00 WATER

The consumptive water is proposed to be drawn from Hirakud reservoir at a location downstream of Rambella bridge, at a distance of about 22 km and shall be pumped to the in-plant raw water reservoir. In-principle approval of State Government is available. The intake pump house location is proposed at Khata No. 01 (5.34 Acres) of Jogipalli Village. However, water drawl point location, pipe routing and other details need to be finalized in consultation with WRD,GOO.

Total consumptive water requirement for the Project (3x800 MW units) is estimated as 6700 cu-m/hr. with ETP recovery and COC 5.

The chemical analysis of raw water to be used in the Plant is attached in Section-XV of this Volume II-A**.**

5.00.00 FUEL

The primary fuel for this plant is Coal.

Coal requirement of the project shall be met from Talabira -II & III captive mines of NLC India Limited located nearby. Coal requirement is estimated to be 11.37 MTPA considering a GCV of 3700 Kcal/kg, and PLF of 85%. The coal shall be transported from the linked mines through Belt Conveyor system from coal stock at mine end up to transfer point and thereafter by Pipe conveyor for crossing Bedhan River up to crusher house located in plant area..

The characteristics of Coal to be used in the Plant are attached in Section-XV of this Volume II-A.

LDO/HSD shall be used as start-up fuel and flame stabilizing fuel.

Fuel oil (LDO/HSD) will be transported by road tankers from the nearest oil depot.

The properties of Fuel oil (LDO/HSD) to be used in the Plant are attached in Section-XV of this Volume II-A.

6.00.00 POWER EVACUATION

The power generated from the project will be evacuated through adequate no.of 765 kV& 400kV Transmission Lines Two (2) nos. of (765/√3) / (400/√3) / 33 kV Interconnecting Transformer shall be provided between 765kV& 400kV GIS. Unit start-up power requirement shall be met by back charging 765 kV GIS and 400 kV GIS through ICTs. Unit start-up power requirement will be drawn from 400 kV bus through 400/11.5/11.5 kV Station Transformer

7.00.00 IMPLEMENTATION SCHEDULE

The Project is planned to be executed through single EPC Contract. The scheduled key milestones of the Project (late finish), counted from the date of issue of LOA to the EPC Bidder for single EPC Package are as follows

a) Completion of Trial operation of Unit no. I : 52th Month from LOA

b) Completion of Trial operation of Unit no. II : 58th Month from LOA

c) Completion of Trial operation of Unit no. III : 64th Month from LOA

8.00.00 METEOROLOGICAL DATA

The meteorological station nearest from the site is Jharsuguda. Salient meteorological data of site is given below:

a)	Mean Ambient temperature	:	33.1 ºC maximum 20.7 ºC minimum 27.5 ºC average
b)	Extreme Ambient temperature	:	48.0 ºC maximum 6.0 ºC minimum
c)	Mean wet bulb temp	:	26.3 ºC
d)	Mean relative humidity	:	
	(I) At 8.30 hrs.		66%
	(ii) At 17.30 hrs.		50%
e)	Annual Rainfall	:	1445 mm
f)	Wind load	:	In accordance with IS-875 for a basic wind speed of 50 m/sec, up to a height of 10 meters above mean ground level.
g)	Seismic Zone	:	Zone III as per IS:1893 latest edition.
h)	Altitude	:	203 M above MSL

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TECHNICAL SPECIFICATIONS
FOR
CIVIL, STRUCTURAL & ARCHITECTURAL WORKS

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SECTION-I

GENERAL

1.00.00 INTRODUCTION

This specification covers site survey, soil investigation, site development works, design and construction of Civil, Structural & Architectural works for the Coal based Thermal Power Plant to be constructed as Phase-I (3 x 800 MW) near Kumbhari & Tareikela villages, Jharsuguda District, Odisha. The scope of works covers complete Civil, Structural and architectural Works including supply of all materials, labour, tools and plants as required for successful execution of the single EPC package comprising of Steam Generator (SG) & Auxiliaries package , Steam Turbine Generator (STG) & Auxiliaries package and Other Plant Structures including FGD .

This Section-I of Volume: II-G/1 lists Codes and Standards to be adopted and the principal structures of the plant, and briefly describes the basic concept, requirements and features pertinent to each. Documents to be submitted have also been brought out in this section along with the procedure to be followed for the same.

In case of any contradiction between any parts of the Bid Document with the other, requirement of most stringent one shall be applicable and in the event of conflict between requirement of any two clauses of this specification, or different codes / standards, the more stringent requirement as per the interpretation of Owner / Consultant is to be followed by bidder.

2.00.00 CODES AND STANDARDS

Following is a general listing of Codes and Standards to be used in the design of the Plant. Specific applicable codes and standards shall be identified in System Design Descriptions / Technical Specifications as appropriate. Unless otherwise stated, the latest editions/ revision of following codes and standards as on the original scheduled date of tender opening along with addendums/ amendments, if any, shall be followed:

2.01.00 General

a) Internationally accepted design Codes and Standards where Indian Codes are not available and which are equivalent to Indian Standards.(Latest Version)

b) National Building Code of India.

c) "Accepted Standards" and "Good Practice" listed in the appendix to National Building Code of India.

d) IS-1256 : Code of Practice for Building Byelaws.

2.01.01 **Earthwork**

a)	IS-1498	:	Classification and identification of soils for General Engineering purposes.
b)	IS-3764	:	Safety Code for excavation work.
c)	IS-7293	:	Safety Code for working with construction machinery.
d)	IS-4081	:	Safety Code for blasting and related drilling operation
e)	Indian Explosives Rule 2008		
f)	IS-9759	:	Guidelines for Dewatering during construction.

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2.01.02 **Concrete**

a)	IS-269	:	Specification for 33grade Ordinary portland cement.
b)	IS-383	:	Coarse and fine aggregate from natural sources for concrete.
c)	IS-432	:	Mild Steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement.
d)	IS-455	:	Portland Slag Cement.
e)	IS-456	:	Code of Practice for Plain and reinforced concrete.
f)	IS-460	:	Test Sieves (all parts).
g)	IS-516	:	Methods of test for strength of concrete.
h)	IS-1199	:	Methods of sampling and analysis of concrete.
i)	IS-1566	:	Hard drawn steel wire fabric for concrete Reinforcement.
j)	IS-1786	:	High strength deformed steel bars and wires for concrete reinforcement.
k)	IS 1489	:	Part 1: Specification for Portland pozzolana cement Part 1 Fly ash based

l)	IS-1834	:	Hot applied sealing compounds for joints in concrete.
m)	IS-2386	:	Methods of test for aggregates for concrete (all parts).
n)	IS-2502	:	Code of practice for bending and fixing of bars for concrete reinforcement.
o)	IS-3370	:	Code of practice for concrete structures for storage of liquids (all parts).
p)	IS-3414	:	Code of practice for design and installation of joints in buildings.
q)	IS-4948	:	Welded steel wire fabrics for general use.
r)	IS-7320	:	Concrete slump test apparatus.
s)	IS-7861	:	Code of practice for extreme weather concreting (all parts).
t)	IS-8041	:	Rapid Hardening Portland Cement.
u)	IS-8112	:	Specification for 43 Grade ordinary Portland Cement.
v)	IS-12269	:	Specification for 53 Grade ordinary Portland Cement.
w)	IS-10262	:	Recommended guidelines for concrete mix design.
x)	IS-13920	:	Ductile Design and Detailing of RC Structures Subjected to Seismic Forces.

2.01.03 **Foundations**

a)	IS-1904	:	Code of practice for design and construction of foundations in soils: General requirements.
b)	IS-2950	:	Code of practice for design and construction of raft foundations.
c)	IS-2974	:	Code of practice for design and construction of Machine foundations (all parts).
d)	IS 2911	:	Code of practice for Design and Construction of

Pile Foundations (All Parts).

2.01.04 **Loading**

a)	IS-875	:	Code of practice for design loads (other than earthquake) for buildings and structures.
b)	IRS	:	Bridge Rules of Government of India, Ministry of Railways (Railway Board).

2.01.05 **Masonry**

a)	IS-712	:	Building limes.
b)	IS-1077	:	Common Burnt Clay Building Bricks.
c)	IS-1127	:	Recommendations for dimensions and workmanship of natural building stones for masonry work.
d)	IS-1528	:	Methods of sampling and physical tests for refractory materials.
e)	IS-1597	:	Code of practice for construction of stone masonry (all parts).
f)	IS-2212	:	Code of practice for brickwork.
g)	IS-2116	:	Sand for masonry mortars
h)	IS-2185	:	Concrete masonry units. (all parts - Hollow and Solid concrete blocks).
i)	IS-2250	:	Code of practice for preparation and use of masonry mortars.
j)	IS-2572	:	Code of practice for construction of hollow and solid concrete block masonry.
k)	IS-2691	:	Burnt clay facing bricks.
l)	IS-3414	:	Code of practice for design and installation of joints in buildings.
m)	IS-3495	:	Methods of tests of burnt clay building bricks.
n)	IS-4441	:	Code of practice for use of Silicate type chemical resistant mortars.
o)	IS-4860	:	Acid Resistant Bricks.
p)	IS 13757	:	Specification for burnt clay fly ash building

bricks

2.01.06 **Doors, Windows & Ventilators**

a)	IS-399	:	Classification of commercial timbers and their zonal distribution.
b)	IS-883	:	Code of practice for design of structural timber in building.
c)	IS-1003	:	Timber paneled and glazed shutters (all parts).
d)	IS-1038	:	Steel doors, windows and ventilators.
e)	IS-1081	:	Code of practice for fixing and glazing of metal (steel and aluminium) doors, windows and ventilators.
f)	IS-1361	:	Steel windows for industrial buildings.
g)	IS-2835	:	Flat Transparent sheet glass
h)	IS-1948	:	Aluminium doors windows and ventilators.
i)	IS-1949	:	Aluminium windows for industrial building.
j)	IS-2191	:	Wooden flush door shutters (Cellular and hollow core type).
k)	IS-2202	:	Wooden flush door shutters (solid core type).
l)	IS-3103	:	Code of practice for Industrial ventilation.
m)	IS-3548	:	Code of practice for glazing in buildings.
n)	IS-3614	:	Specification for metallic and non-metallic Fire check doors (all parts).
o)	IS-4021	:	Timber door, windows and ventilator frames.
p)	IS-4351	:	Steel door frames.
q)	IS-6248	:	Metal rolling shutters and rolling grills.

2.01.07 **Roof & Flooring**

a)	IS-2204	:	Code of practice for construction of reinforced concrete shell roof.
b)	IS-3201	:	Criteria for the design and construction of

precast concrete trusses and purlins.

c)	IS-2210	:	Criteria for Design of R.C. shell structures and folded plates.
d)	IS-809	:	Rubber flooring materials for general purposes.
e)	IS-1195	:	Bitumen mastic for flooring.
f)	IS-1196	:	Code of practice for laying bitumen mastic flooring.
g)	IS-1198	:	Code of practice for laying, fixing and maintenance of linoleum floors.
h)	IS-1237	:	Cement concrete flooring tiles.
i)	IS-1443	:	Code of practice for laying and finishing of cement concrete flooring tiles.
j)	IS-2114	:	Code of practice for laying in situ terrazzo floor finish.
k)	IS-2571	:	Code of practice for laying in situ cement concrete flooring.
l)	IS-5491	:	Code of practice for laying in situ granolithic concrete floor topping.
m)	IS-5766	:	Code of practice for laying burnt clay brick flooring.
n)	IS-1197	:	Code of practice for laying of rubber floors.
o)	IS-2441	:	Code of practice for fixing ceiling coverings.

2.01.08 **Waterproofing**

a)	IS-1322	:	Bitumen felts for waterproofing and damp proofing.
b)	IS-1346	:	Code of practice for waterproofing of roofs with bitumen felts.
c)	IS-1609	:	Code of practice for laying damp proofing treatment using bituminous felts.
d)	IS-3036	:	Code of practice for laying lime concrete for a waterproofed roof finish.
e)	IS-3037	:	Bitumen mastic for use in waterproofing of

roofs.

f)	IS-3067	:	Code of practice for general design, details and preparatory work for damp proofing and water proofing of buildings.
g)	IS-3384	:	Bitumen primer for use in water proofing and damp proofing.
h)	IS-4365	:	Code of practice for application of bitumen mastic for waterproofing of roofs.

2.01.09 **Membrane Waterproofing**

a)	ASTMD-1076	:	Solid Content
b)	ASTMD-1475	:	Specific Gravity
c)	ASTMD-412	:	Elongation
d)	ASTMD-2240	:	Hardness
e)	ASTMD-822	:	Water vapour transmission resistance

2.01.10 **Soil Engineering**

a)	IS-1498	:	Classification and identification of soils for general Engineering purposes.
b)	IS-1892	:	Code of practice for sub-surface investigation for foundations.
c)	IS-2131	:	Method for standard penetration test for soils.
d)	IS-2720	:	Methods of test for soils (all parts).
e)	IS-10379	:	Code of Practice for Field Control of Moisture and compaction of soils for embankment and subgrade.

2.01.11 **Water Supply, Drainage & Sewerage**

a)	IS-404	:	Lead pipes
b)	IS-458	:	Pre-cast Concrete pipes (with and without reinforcements)-specification
c)	IS-651	:	Salt glazed stoneware pipes and fittings.
d)	IS-771	:	Glazed fire-clay sanitary appliances (all parts).

e)	IS-774	:	Flushing cisterns for water closets and urinals (other than plastic cisterns)-Specification.
f)	IS-783	:	Code of practice for laying of concrete pipes.
g)	IS-1172	:	Code of basic requirements for water supply, drainage and sanitation.
h)	IS-1626	:	Asbestos cement building pipes and pipe fittings, gutters and gutter fittings and roofing fittings (all parts).
i)	IS-1742	:	Code of practice for building drainage.
j)	IS-2064	:	Code of practice for selection, installation and maintenance of sanitary appliances.
k)	IS-2065	:	Code of practice for water supply in buildings.
l)	IS-2470	:	Code of practice for installation of septic tanks (all parts).
m)	IS-3114	:	Code of practice for laying of Cast Iron pipes.
n)	IS-4127	:	Code of practice for laying of glazed stoneware pipes.
o)	IS-12251	:	Code of practice for Drainage of Building Basement.
p)	IS-1536	:	Centrifugally cast (spun) iron pressure pipes for water, gas and sewage.
q)	IS-1537	:	Vertically cast iron pressure pipe for water, gas and sewage.
r)	IS-3486	:	Cast iron spigot and socket drain pipes .
s)	IS-5329	:	Code of practice for sanitary pipe work above ground for buildings.
t)	IS-3076	:	Low density polyethylene pipes for potable water supplies.
u)	IS-1538	:	Cast iron fittings for pressure pipes for water, gas and sewage.
v)	IS- 1729	:	Cast Iron/Ductile Iron Drainage Pipes and Pipe Fittings for Over Ground Non-Pressure pipeline

Socket and Spigot series.

w) IS-784 : Prestressed concrete pipes (Including Fittings)-Specification.

x) IS-1726 : Cast iron manhole covers and frames.

y) IS-5961 : Cast iron grating for drainage purposes.

z) IS-5219 : Specification for cast copper alloys traps: Part1 "P" and "S" traps.

aa) IS-772 : General requirements for enamelled cast iron sanitary appliances.

bb) IS-775 : Cast iron brackets and supports for wash basins and sinks.

cc) IS-777 : Glazed earthenware wall tiles.

dd) IS-2548 : Plastic water closet seats and covers (all parts).

ee) IS-2527 : Code of practice for fixing rainwater gutters and down pipes for roof drainage.

2.01.12 **Paving & Road Works**

a) IS-73 : Paving bitumen

b) IS-702 : Industrial Bitumen

c) IS-1201 : Method of testing tar and bituminous materials. thru' 1220

d) Practice followed by Indian Road Congress (all parts).

2.01.13 **Earthquake Resistant Design**

a) IS-1893 (all parts) : Criteria for earthquake resistant design of structures.

b) IS-4326 : Code of practice for earthquake resistant design and construction of buildings.

2.01.14 **Structural Steelwork**

a) IS-800 : Code of practice for general construction in steel.

b) IS-802 : Code of practice for use of structural steel in

			Overhead Transmission Line towers (all parts).
c)	IS-806	:	Code of practice for use of steel tubes in general building construction.
d)	IS-808	:	Dimensions for Hot Rolled steel beams, Columns, channels and angle sections.
e)	IS-813	:	Scheme of symbols for welding.
f)	IS-814	:	Covered electrodes for manual metal arc welding of carbon and carbon manganese steel.
g)	IS-816	:	Code of practice for use of metal arc welding for general construction in mild steel.
h)	IS-817	:	Code of practice for training and testing of metal arc welders.
i)	IS-818	:	Code of practice for safety and health requirements in electric and gas welding and cutting operation.
j)	IS-819	:	Code of practice for Resistance spot welding for light assemblies in Mild Steel.
k)	IS-919	:	Recommendations for limits and fits for Engineering.
l)	IS-1024	:	Code of practice for use of welding in Bridges and Structures subjected to Dynamic loading.
m)	IS-1161	:	Steel tubes for structural purposes.
n)	IS-1182	:	Recommended practice for Radiographic Examination of Fusion Welded Butt joints in steel plates.
o)	IS-1239	:	Mild steel tubes, tubulars and other wrought steel fittings (all parts).
p)	IS-1363	:	Black hexagonal bolts, nuts and locknuts (dia. 6 to 39 mm) and black hexagon screws (dia.6 to 24 mm). [all parts]
q)	IS-1364	:	Precision and semi-precision hexagon bolts, screws, nuts and locknuts (dia. range 6 to 39 mm). [all parts]
r)	IS-1365	:	Slotted countersunk flat head screws (Common Head Style) - Product Grade A

s)	IS-1367	:	Technical supply conditions for threaded steel fasteners.
t)	IS-1443	:	Code of practice for laying and finishing of cement concrete flooring tiles.
u)	IS-1608	:	Method for tensile testing of steel products.
v)	IS-1730	:	Dimensions for steel plates, sheets, strips and Flats for structural and general Engineering purpose.
w)	IS-1731	:	Dimensions for steel flats for structural and general Engineering purposes.
x)	IS-1852	:	Rolling and cutting tolerances for hot rolled steel products.
y)	IS-2016	:	Plain Washers
z)	IS-2062	:	Hot rolled medium and high tensile structural Steel
aa)	IS-2074	:	Ready mixed paint, air drying, red oxide zinc-chrome, priming.
bb)	IS-2633	:	Methods of testing uniformity of coating of zinc coated articles.
cc)	IS-3613	:	Acceptance tests for wire-flux combinations for submerged-arc welding of structural steels.
dd)	IS-3664	:	Code of practice for Ultrasonic Pulse echo testing by contact and immersions methods.
ee)	IS-3757	:	High strength structural bolts.
ff)	IS-4000	:	High strength bolts in steel structures.
gg)	IS-4759	:	Hot dip zinc coatings on structural steel and other allied products.
hh)	IS-5334	:	Code of practice for Magnetic Particle Flaw detection of welds.
ii)	IS-7215	:	Tolerances for fabrication of steel structures.
jj)	IS-7280	:	Bare-wire electrodes for sub-merged arc welding of structural steels.

	kk)	IS-7318 [Part-I]	:	Approval test for welders when welding procedure approval is not required.
	ll)	IS-8500	:	Structural steel – micro-alloyed (medium and high strength qualities).
	mm)	IS-9595	:	Recommendation for metal arc welding of carbon and carbon manganese steels.
	nn)	AWS D.1.1	:	Structural Welding Code.

2.01.15 **Painting**

	a)	IS-348	:	Specification for French Polish.
	b)	IS-427	:	Specification for Distemper, dry colour as required.
	c)	IS-428	:	Specification for Distemper, oil emulsion, colour as required.
	d)	IS-1477 [I & II]	:	Code of practice for painting of ferrous metal in buildings.
	e)	IS-2338 [I & II]	:	Code of practice for finishing of wood and wood based materials.
	f)	IS-2339	:	Specification for Aluminum Paints for general purposes in dual containers.
	g)	IS-2395	:	Code of practice for painting concrete, masonry and plaster surface.
	h)	IS-2932	:	Specification for enamel, synthetic, exterior - a) undercoating, b) finishing.
	i)	IS-2933	:	Specification for enamel, exterior - a) undercoating, b) finishing.
	j)	IS-5410	:	Specification for cement paint.

2.01.16 a) Indian Road Congress (IRC) Bridge Codes

b) Indian Railway Standard Bridge Rules

2.01.17 **Environmental Protection**

Charter on Corporate Responsibility for Environmental Protection (CREP) published in Gazette of India dated 27.08.2003.

dry fly ash pipe supports and RCC thrust block including any other supports required to complete the system requirement The Pipe Lines and Cable Racks shall be supported on steel structures as per Mechanical requirement. The steel Trestles supporting ash pipes shall be so proportioned that the transverse deflection of trestles due to wind / seismic load shall not exceed trestle height/325 (For detailed specification of Trestles and gantries CHP section may be referred.). The Steel structures shall be supported on RCC Pedestals. The height of the RCC pedestals shall be minimum 1000 mm from FGL. The foundations for pedestals and bridge across Bheden river shall be placed at minimum depth of 1.0m below natural ground level or on weathered / hard rock / Piles. Pipes shall be suitably anchored with RCC pedestals to resist lateral and vertical movements.

4.23.06 **Seal Water Sump**

Seal water Sump shall be located in the Ash water pump house to cater seal water requirement for Ash Handling System. Sump shall be RCC and designed as un-cracked section in accordance with IS: 3370 (Latest Revision) by working stress method.

4.23.07 **Intermediate Surge Hopper for Fly Ash**

Intermediate Surge hopper is a transit buffer arrangement to transfer ash from Vacuum Conveying to Pressure Conveying. The Intermediate Surge Hopper and its supporting structure shall be of structural steel. RCC foundation shall be provided to support the entire structure considering all possible loads.

4.23.08 **Different Equipment Foundations for Ash Handling System**

Foundations shall be designed, detailed and provided for the equipment for Ash handling system and auxiliaries as described in Mechanical specification. Foundations for any other equipment / components as required for completeness of the system are also in the Bidder's scope.

4.23.09 **Pedestals for High Concentration Slurry Disposal from Silo**

Foundation with Pedestals shall be provided for the high concentration slurry disposal pipes. However, the number of pedestals shall depend on Length of disposal and Garlanding around Dyke. The pedestal heights shall be minimum 1000mm above FGL. However the height may be increased to maintain the gradient of the Pipes conveying slurry to the Dyke.

4.23.10 **Ash Dyke**

General

Ash dyke shall be planned in the plot of land shown in the General Layout Plan for dumping of un-utilized fly ash and bottom ash.

Technical specifications related to the design and construction of ash dyke elements are given under this section. The specification for reinforced concrete works for spillways and water escape wells etc. shall be as given elsewhere in the specification. Ash dyke shall be constructed by optimized cutting/filling required to build up storage capacity as indicated in Mechanical volume.

Scope

The scope of work for Ash Dyke generally involves, design, preparation of general arrangement drawings, construction drawings, supply of labour & materials and construction of all civil and structural works as site clearance, site leveling & grading, excavation, filling, dewatering, construction of earthen embankment, providing sand filters, sand chimney, sand blanket in embankment, cut-off trench, mechanical compaction, upstream and downstream slope protection, instrumentations, forming drains, brick masonry bedding / capping, providing impervious liner on bed of pond, WBM road on dyke top, 4.00m wide bituminous inspection road all around the periphery of dyke at ground level along with cross drainage structures, rock toe, toe drain , & spillways (box culvert), overtaking zones & approach ramps. The scope of work also includes the bund protection work for nearby Nallah.

Geotechnical Investigation

Detailed geo-technical investigations shall be conducted by the Bidder to find out the properties including permeability of soil as specified elsewhere in the specification. The dyke shall be founded on a firm stratum suitable ground improvement if required shall also be carried out based on detailed geo-technical investigation.

Design Criteria

Ash dyke shall be designed to cater ash disposal upto ultimate height. Ultimate height of dyke shall be fixed to have ash storage volume referred in Mechanical Volume.

The design of stability analysis and seepage analysis shall be safe for starter dyke plus 2 raisings at future date of 3.0m height each or as per design. 1000 microns LDPE liner shall be provided at the bottom of the ash pond and on the inside slopes of the ash dyke.

The starter dyke construction is in the Bidder's scope. The Bidder is expected to visit actual site conditions, which will have bearing on the design and construction of the ash dyke as per specified requirements.

i) The starter dyke shall be constructed using selected earth. Provision for subsequent raising of ash dyke, in future in no. of stages (as per approved scheme) of 3 m each by upstream method using pond-ash as base material shall be considered in design and construction. The

slope of dyke shall be considered not steeper than 2.5 horizontal (H) to 1 vertical (V) in case of earth and 3H:1V in case of ash. The starter dyke construction shall be carried out by the Bidder considering loads from future dyke also. For defining the profile of the phreatic line across the dyke section, a comprehensive seepage analysis shall be done for the ultimate height of the dyke, with full water inside and tail water (if any due to H.F.L.) on outside of the dyke, before doing the stability analysis. The slope stability analysis of the dyke for ultimate stage shall be done for steady seepage condition both for static and dynamic (earthquake) cases as per IS: 7894.

ii) In order to arrest the ground water contamination from ash water provision of lining to make the ash dyke bed impervious by achieving permeability less than 1x10-6 cm/sec shall be done by providing impervious clay lining or by blending the soil with bentonite with specified thickness.

iii) Besides the toe drain, a peripheral discharge drain along the ash dyke to divert the surface run off around the ash dyke area shall be designed and the same shall be suitably connected with nearest natural drain or nallah.

Design of Embankment

i) The design of embankment shall be done by a process of successive trials and refinements. The following steps may be followed. Select a trial embankment section incorporating the available materials, with the following parameters.

ii) Top width of embankment shall be minimum 6 m having a 150mm consolidated thick WBM road (75mm consolidated thick in two layers)of 4.00 m wide over 230mm mm stone boulder sub base. Higher top width as per approved drawings shall be provided if pipelines are to be run over the dyke top.

iii) Free board shall be minimum 1.5 m..

iv) The founding level of embankment shall be at least 300 mm below natural ground level. The top soil shall be stripped to a depth of 300 mm. However, the stripping depth, if required, shall be increased to the required level as per actual conditions to totally remove all vegetations, organic matters, roots, soft spots etc.

v) Side slopes shall be minimum 2.5 Horizontal to 1 Vertical. 3m wide berms shall be provided for all slopes at about 6 m height intervals. Berm is not envisaged in the first 8 m lift.

vi) 1000 microns LDPE liner shall be provided at the bottom of the ash pond and on the inside slopes of the ash dyke. Internal drainage arrangement should be provided as follows:

a) Sand chimney of minimum 0.5 m thickness, up to 1.5 m below dyke top.

b) Sand blanket of minimum 0.5m depth.

c) Rock toe at the downstream toe of embankment. Height of rock toe should be minimum 1.0 m. With the above drainage arrangements, the phreatic line is expected to follow the drainage path.

d) The exit gradient of seepage flow near the downstream toe shall be checked by drawing flow nets. The exit gradient shall not exceed about 0.14. If the gradient is more than this value, the dyke slope shall have to be flattened to reduce the gradient.

e) Bidder shall arrange necessary borrowed earth required for the ash dyke from approved source.

Slope Protection Works

i) Downstream slopes shall be protected by . The outer slope of the embankment shall be protected from rain cuts by turfing with sods / clods. Any excavated material not required or not suitable for embankment construction shall be disposed-off in the place shown to fill the low lying areas inside/outside the plant area spread in .layers not exceeding 30 cm thickness and each layer shall be compacted to 90% standard proctor density for cohesive soil and to 75% of relative density for non-cohesive soils with a lead 5-6km.Slope protection shall be provided for the entire slope on the downstream side of the dyke.

ii) On the top of dyke, water bound macadam surfacing shall be made for movement of vehicles, which will also give protection to the earth surface against rain and wind erosion.

ii) 4.0m wide BT inspection road shall be provided along the outer periphery of dyke.

iii) PCC (M15) chute 900 mm width with plaster finish at 30 M intervals shall be provided all around the periphery of the embankment of the reservoir to drain out the storm water from embankment top. All the chutes shall be connected to the outer peripheral RCC toe drain. PCC (M15) kerb stones of size 600mm x 450mm x 100mm thick shall be provided on both sides with 300mm projection above road level of the bund top and shall be flushed with chutes.

iv) At the inner face all-round GI chain link fencing of 2.4 m height shall be provided.

v) Suitable PCC (M-15) steps (min. 1.0m width) with plaster finish shall be provided at the inside as well as outer edge of dyke along the periphery to access at the top at all turning points and at longer stretches, such steps shall be provided every 300M. Approach ramp wherever required (at least in 2 locations) shall be provided. The Ramp shall be of RCC over the embankment with M30 grade concrete minimum 200mm thick with 2 layers of 10mm reinforcements running both ways shall be provided. External protection works shall be with grass turfing. Rock toe shall be provided as per IS and design requirement.

vii) RCC box culvert for overflow arrangement weir along with the top of the bund shall be provided. RCC apron all along the overflow arrangement along the outer face of the embankment is to be provided. The apron shall be in RCC stepped slab having foundations at regular spacing based on the design requirement and founded inside the bund. Apron shall have RCC kerb in the form of wall along the apron edge on both sides having the height equal to the top level of culvert. The grade of concrete shall be M30. The over flow shall be connected to Nallah/ Bhedhan river through RCC Drain.

Cut-off Trench

Cut-off trench shall be provided in the portion upstream of sand chimney, to increase the drainage path of any seepage occurring at the junction between the embankment and its foundation. A minimum bottom width of 3m shall be provided for the cut-off trench. A depth of 1.5m (min) may be adopted with 1:1 side slope in earth. It shall be filled up in layers not exceeding 300 mm in compacted thickness using impervious soils CL or CI type having permeability less than 1x10-6 cm/sec to be obtained by the Bidder.

Sand Blanket, Chimney and Filter

Sand blanket shall be laid subsequent to foundation preparation. The prepared foundation shall be approved before laying the blanket material. The material for blanket, chimney and sand filters shall consist of clean sound and well graded coarse sand. The materials shall be free from debris, wood, vegetable matter and other deleterious matter. The gradation of sand material shall meet the requirements as specified in IS:9429-1999. The filter material shall be suitably compacted to a firm condition to achieve a relative density of 70%.

Placing

i) Sand blanket shall be laid subsequent to site clearance, stripping and excavation, if any. The foundation area shall be cleared before laying the bottom layer of blanket material. Filter material shall be laid in layers not exceeding 15 cm. Care shall be taken to ensure that materials of different layers do not get mixed,

both at the time of placing and during compaction. After the layers of filter blanket material have been laid and compacted as directed by the Engineer earth fill material shall be laid.

ii) Sand chimney of specified thickness shall be laid at the specified location by excavating and removing the already compacted bund material, exposing sand chimney in the lower layers earlier laid, and refilling the trench with sand in layers. The layer of sand shall be well rammed. The depth of each layer of chimney to be laid shall not be more than 15 cm or as directed by the Engineer. While excavating the earth for filling sand for chimney drain, the top layer of sand, which has been mixed with earth/ash, shall also be removed.

iii) Alternatively, the sand chimney can also be laid in layers simultaneously with the laying of each layer of fill. In such case, the top level of sand layer shall always be kept at about 100 mm above earth/ash level on both sides. Each layer of sand shall be compacted. Care shall be taken to avoid mixing of earth/ash and sand.

iv) The sand filter around the rock-toe and below riprap shall closely follow the levels of the embankment in the area. Sand filter shall be laid subsequent to stripping of foundation and / or trimming of slope of compacted bund. The surface to receive the sand filter shall be properly cleaned before laying of filter material. The sand filter shall be laid in layers. The thickness of the layers shall not be more than 15 cm or as directed by the Engineer. The sand layer shall be well compacted. Care shall be taken that materials of different layers do not get mixed, both at the time of placing and during compaction.

Graded Coarse Aggregate Filters

i) Graded coarse aggregate shall be used in filters below rock-toe as per IS:8237. The coarse aggregate material shall consist of durable well graded broken rock of hard stone. The materials shall range in the size from 10 mm to 75 mm and shall satisfy the filter criteria.

ii) The rock material used in the aggregate filters shall satisfy the following condition:

a) Specific gravity shall not be less than 2.50 (as per IS:1122).Sulphate soundness less than 10% loss of weight after 5 (five) cycle as per IS:1126.

b) Aggregate impact value shall not exceed 30% (as per IS:2386).

c) Water absorption shall not exceed 2.5% (as per IS:2386).

d) In slake durability test as per IS: 10050-1981, slake durability Id (second cycle) should be more than 85% (Refer Table-1 in

page-6 of IS-10050-1981).

Stripping of Foundation

The entire area of embankment shall be stripped to minimum 300 mm depth in soil to remove all unsuitable materials and to provide for benching. The unsuitable material shall include all debris, vegetable matter including roots, weathered and disintegrated rocks, organic silts, swamps material that are unsuitable for use in permanent construction or that might interfere with the proper binding of the embankment with the foundation, or the proper compaction of the materials in the embankment or that may be otherwise objectionable. Unsuitable materials from stripping operations shall be disposed-off to a disposal site to be arranged by the Bidder.

Preparation of Foundation Surface

i) Foundation preparation shall be performed as per approved drawings and as described herein subsequent to stripping of foundation and excavation. No material shall be placed in any section of the fill portion of the embankment until the foundation of the section of the fill portion of the embankment has been dewatered, suitably prepared and has been approved by the Engineer-in-Charge. All excavations made for test pits or other sub-surface investigations and all other existing cavities, found within the area which extends below the established lines of excavation for embankment foundation, shall be filled with earth of the corresponding zone and properly compacted.

ii) Filling the cut off trench / trenches for water escape pipes / formation of impervious core of dyke.

iii) The cut-off trench shall be filled up in layers not exceeding 150 mm in compacted thickness using impervious soils CL or CI type having permeability less than 1x10 6 cm/sec, to be obtained by the Bidder from approved borrow area. The suitability or otherwise of the material shall be determined by laboratory tests. In case clayey soil of the specified quality is not available, alternatively manufactured impervious soil by blending required quantity bentonite to available soil to achieve the specified permeability also can be used. Each layer of earth deposited shall then be compacted to have a dry density not less than 98% of the maximum dry density (standard proctor).

iv) The spreading of the next layer shall be carried out only after the underlying layer has been approved by the Engineer-in-Charge.

v) The impervious core of the dyke shall be made with approved clayey soil brought from elsewhere and / or with manufactured soil by blending the available soil with bentonite to achieve the permeability not more than 1x10-6 cm/sec. The procedure for laying and compaction shall be the same as specified for the shells of dyke.

Impervious Liner

i) 1000 microns LDPE liner shall be provided on bottom of ash pond and inside slopes of the ash dyke

ii) Inside and bottom surface shall be lined with impermeable LDPE lining of thickness minimum 1000 micron with overlap distance of 0.5M and jointing of LDPE lining with robotic 2 stitch welding, to prevent loss of water due to seepage. The liner shall be placed over minimum 50 mm thick fine sand. Arrangement for holding the liner in position by providing necessary RCC beam at top level of embankment shall be kept. The liner shall be protected by precast concrete tiles placed over it. Dimensions of precast concrete tiles M30 Grade laid over LDPE sheet shall be 300 x 300 x 50 mm – laid over 25 mm thick 1:4 cement mortar. The jointing and pointing between tiles shall be done with 1:3 cement mortar.

Rock Toe

i) The rock material used for the rock toe shall satisfy the quality requirements. Rock toe shall be formed with rock material consisting of sound, durable and well-graded broken rock obtained from approved quarries and shall be of approved quality. The materials shall range in size from 10 to 45 cm. All bush roots or other perishable materials shall be removed from rock-fill during spreading and disposed-off.

ii) The rock available from the excavation of water escape structure/ stripping / drain channel etc. which satisfy the quality requirements specified and found suitable for construction of rock toe by Engineer may be used. These shall be washed, cleaned, and broken into required size and stacked separately.

iii) Similarly rock materials for rock toe satisfying the quality requirements specified can also be obtained from rock if available within the land acquired for construction of earthen dyke and if found suitable. The rock shall be broken to required size and shape and shall be cleaned before utilization

iv) The stone pieces shall be hand placed to obtain a stable, well-graded and free draining fill. The rock toe shall be constructed in layers so that the smaller rock fragments shall be placed adjacent to the filter of embankment and the large rock fragments near the outer edge of the rock toe. The rock fill shall be hand placed, spread and roughly leveled in layers not greater than 30 cm in thickness in order to maintain a reasonably uniform surface and ensure that the completed fill shall be stable and do not contain any voids having

least dimension larger than 50 mm.

v) Contamination of the rock with finer materials from any other zones shall be avoided. Accumulations of soil caused by contamination shall be removed. Rock materials shall not be dumped directly but shall be hand placed in layers.

Earthen Dyke

i) Earthen dyke shall be constructed to the lines and grades shown on the drawings. Placement of fill shall be performed in an orderly way and in an efficient and workman like manner, so as to produce fills having such quantities of density, strength and permeability as shall ensure the highest practicable degree of stability and performance of the embankment. No bushes, roots, sods or other perishable or unsuitable materials shall be placed in the embankment. The suitability of each part of the foundation for placing embankment materials thereon and of all materials for use in embankment construction shall be subject to the approval of the Engineer.

ii) The dyke may be constructed in separate portions or reaches, provided that:

a) The slopes of the bonding surfaces between the previously completed portions of the embankment and materials to be placed in each zone shall not be steeper than 2.5 horizontal to 1 vertical in case of earth.

b) The embankment is constructed right across the whole section in each portion or reach.

Fill Materials

The materials for shell / embankment shall be obtained from the approved borrow areas and available excavated material to the extent possible. In general all materials from the particular borrow area shall be a mixture of materials obtained for the full depth of the cut. Some earth material available from the excavation of cut-off trench etc. if found suitable can also be used for the embankment construction. Earth used as fill material shall be got approved by Customer.

Placing the Fill Material

i) The distribution and gradation of materials throughout the fill shall be as shown in the approved drawings or as directed. The fills shall be free from lenses, pockets, streaks, or layers of material differing substantially in texture or gradation from the surrounding material. The combined excavation and placing operations shall be such that the materials when compacted in the fill shall be blended sufficiently

to produce the specified degree of compaction and stability.

ii) No stones, cobbles or rock fragments, having maximum dimensions of more than 10 cm shall be placed in the fill. Such stones and cobbles shall be removed either at the borrow pit or after being transported to the fill but before the materials in the fill are rolled and compacted. The materials shall be placed in the fill in continuous horizontal layers, stretching right across the whole section, not more than 20 cm in compacted thickness and rolled.

iii) During construction a small transverse slope from centre towards the edges should be given to avoid pools of water forming due to rains. The surface of materials to be placed thereon, shall be moistened and/or worked with harrow, scarifier or other suitable equipment, in an approved manner to a sufficient depth to provide a satisfactory bonding surface before the next layer of fill material is placed. If the rolled surface of any fill is found to be too wet for proper compaction, it shall be raked up, allowed to dry, or shall be worked with a harrow or any other approved equipment to reduce the moisture content to the required amount and then it shall be re-compacted before the next layer is placed.

iv) When compacting the fill material against steep rock abutment or walls or masonry or concrete structure the construction surface of embankment shall be sloped away from rock or masonry or concrete structures for a distance of 3 m to 4 m at an inclination not steeper than 6 horizontal to 1 vertical. If the foundation surface is too irregular to allow the use of a large roller directly against a structure/rock out crop, the roller shall be used to compact the fill material as close to the structure or the out crop as possible and the portion of the embankment directly abutting against the rock or the structure shall be compacted with pneumatic hand compactors/tampers in thin layers. The moisture content of the fill material placed against the rock or the structure shall be high enough to allow it to be compacted into all irregularities of the rock or the structure. Care shall be taken in placing the first layer of the fill so that no damage is caused by the hauling machinery to the base grade as this may get concealed by the spread layer or fill. Sheep foot roller shall not be employed for compacting till the thickness of the layers already compacted by other means is greater by 30 cm than the depth of the feet on the roller drum.

v) The material for the first layer shall be at moisture content sufficient to enable bonding of the fill with the rock surface.

Weather Conditions

Embankment materials shall be placed only when the weather conditions are satisfactory to permit accurate control of the moisture content in the embankment materials.

Moisture Control

Prior to and during compacting operations, the materials in each layer of fill shall have moisture content about 2% less than the optimum moisture content, in the case of cohesive soil. In the case of cohesion less material including ash, the placement moisture content may have only little effect on the compaction behaviour of the fill and hence appropriate moisture content required from other site considerations such as dust suppression etc, may be adopted. As far as practicable the materials shall be brought to the proper moisture content in the borrow area before excavation. If additional moisture content is required, it shall be added on the embankment by sprinkling water before rolling the layer. Bidder shall make his own arrangements for supply of water. If the moisture content is greater than required, the material shall be spread and allowed to dry before starting rolling. The moisture content shall be uniform throughout the layer of materials and ploughing, discing, harrowing or other methods of mixing may be required to obtain uniform distribution. If the moisture content is more or less than the range of the required practicable moisture content, or if it is not uniformly distributed throughout the layer, rolling shall be stopped and shall be started again only when the above conditions are satisfied.

Compaction Equipment

While the specifications provide that equipment of a particular type and size is to be furnished and used, it is to be understood that the use of improved equipment is to be encouraged. Tamping (sheep foot) rollers or pneumatic rollers shall be used for compacting cohesive materials and pneumatic rollers and vibratory rollers shall be used for compacting cohesion less materials including ash. Any other suitable type of compaction equipment also can be employed after necessary field trials about their effectiveness and with approval of the Engineer.

Rolling and Tamping

i) When each layer of material has been conditioned so as to have the proper moisture content uniformly distributed throughout the material, it shall be compacted by passing the roller. The exact number of passes shall be decided based on compaction trials to be conducted in field before start of work. The layers shall be compacted in strips overlapping not less than 0.6 m. Density tests shall be made after rolling and the dry density attained shall be not less than 95% of maximum dry density (Standard Proctor) obtained in the Laboratory for the type of material used.

ii) Rollers shall not be permitted to operate within 1.0 M of concrete and masonry structures. In locations where compaction of the fill material by means of the roller is impracticable or undesirable the material shall be specially compacted as specified here in at following locations:

a) Portions of the dyke embankment adjacent to masonry structures.

b) Earth/ash in dyke embankment adjacent to steep abutments.

c) Earth / ash fill at locations specially designated by the Engineer.

iii) Fill shall be spread in layers not more than 15 cm. in compacted thickness and shall be moistened to have the required moisture content. When each layer of material has been conditioned to have the required moisture content it shall be compacted to achieve the dry density of not less than 95% of Maximum Dry Density (Standard Proctor) by special rollers, mechanical tampers, hand held vibratory tampers or by other approved methods, and all equipment and methods used shall be subject to approval based on evidence of actual performance. The moisture control and compaction shall be equivalent to that obtained in the fill material actually placed in the dyke embankment.

Inspection Test

i) Control tests shall be carried out in laboratory from time to time to determine whether the fill produced by methods employed satisfies the requirements of the specifications. Routine field tests shall also be carried out by the Engineer and the work shall be inspected regularly. Field density test should be particularly and specially made in the following areas:

ii) Where, the degree of compaction is doubtful.

a) Where embankment operations are concentrated i.e. where 2 or more layers are placed one over the other on the same day.

b) To represent every 2000 cum in case of earth and 1000 cum in case of ash placed in the embankment.

c) At least one test for every full or part shift of compaction operations and

d) At least one test for every 250m length of dyke in each layer. The Engineer shall determine whether the desired results are being obtained.

e) Bidder shall provide all facilities such as labour, conveyance, equipment etc. required for collection of samples and to conduct tests in situ or at laboratory.

Dressing and Trimming of the Slopes

The slopes of the embankments shall be neatly dressed to line as the placing of the fill progresses. Compaction shall extend over the full width of the embankment and the material in the slopes shall be compacted as for the rest of structure. To ensure proper compaction at the outer edge, the fill shall be constructed for a minimum of 0.5m extra width on either edges or the outer edge trimmed to specified width and slope, as per construction drawings, after completion of the dyke section up to top, in different stretches of the alignment. No slope shall be left without trimming to design slope. The trimmed slope surface shall be checked for adequate compaction as specified in the Quality Assurance checklist and under compaction, if any, shall be corrected.

Provision for Settlement

While forming the embankment, due allowance of 1% of the vertical height or as appropriate shall be made to allow for settlement so as to maintain the top of dyke at designed elevation.

Dealing with Water

The whole of the works shall be carried out in the dry condition. Water from any source shall be diverted or pumped as required, clear of the works. Bidder shall make all necessary arrangement whatsoever required for keeping the work area dried by diverting and pumping of water, and also provision and operation of all temporary works including pumps, motors, fuel, piping and for the formation of any sumps, drainage channels, flumes, coffer dams and other protective works.

Rainfall Run-off

As part of the work may have to be carried out in wet season, Bidders programme and methods must be capable of dealing with run-off from rainfall on the adjacent catchment area. The associated flow in the nallahs etc. shall be diverted clear of the works by an approved system of bunds and channels. Bidder shall supply, install and operate his own temporary pumping installation.

Prevention of Pollution

Arrangement shall be made by the Bidder to prevent pollution of the water in any streams, springs, nallahs and lakes. Arrangements for sprinkling of water in the construction and borrow area to prevent any dust blowing also shall be done by the Bidder. Bidder shall be solely responsible and liable for all damage caused by any pollution that may take place during the execution of the works, and he shall make arrangements, as the Engineer may approve, for preventing pollution but, notwithstanding such approval, the entire responsibility for any pollution shall rest with the Bidder.

Obtaining statutory approval (including payment of necessary fee, levy and all

other related misc. expenditure from the State/Central Govt. authority for obtaining statutory approval) for the ash dyke is in the scope of the Bidder. Owner shall support by way of giving letters etc. for obtaining approvals for the above.

Bund protection for Nallah near Ash Dyke

Bund protection for Nallah near Ash Dyke is under the scope of Bidder. RCC /Stone masonry retaining wall from 1m below bottom of bund upto a height 1M above MFL of Bhedan River/nallah. Bidder shall make arrangements to get the MFL of the nallah/River obtained from Odisha state govt authorities. Bidder shall inspect the site before quoting the rates.

Reference

i)	IS:1498	:	Classification and identification of Soils for General Engineering Purposes.
ii)	IS:7894	:	Code of Practice for Stability Analysis of Earth Dams
iii)	IS:8237	:	Code of Practice for Protection of Slopes for Reservoir Embankment
iv)	IS:8826	:	Guidelines for design of large Earth and Rock filled Dams
v)	IS:9429	:	Code of Practice for drainage system for Earth and Rock fill Dams.
vi)	Singh and Sharma	:	Earth and Rock fill Dams
vii)	USBR	:	Design of Small Dams
viii)	USBR	:	Earth Manual

4.24.00 **Raw Water Intake System**

Raw Water Intake System (In line with Mechanical requirement) shall comprise of Inlet Water Channel, Forebay, Intake Water Pump House, Patrol Road, Raw Water Pipe Lines etc. The Raw Water Intake structure shall be located in the reservoir Area (Hirakud reservoir) based on water level Requirement as per system requirement in volume II IB/1. The location shall be such that sufficient depth of water shall be available even at “Low water Level” in the Reservoir. All civil and structural works related to raw water intake system shall be in scope of bidder as per system/process requirements.

ANNEXURE-I

LIST OF CIVIL FIELD QUALITY ASSURANCE LABORATORY APPARATUS (MINM REQMNNT)

SL NO.	DESCRIPTION	QTY
1	Cube moulds - 150 mm (ISI marked)	144
2	Cube moulds - 70.6 mm	18
3	Cube moulds - 50 mm	9
4	Cylindrical moulds – 300mm long 150mm dia	18
5	Beam mould – 700mmX150mmX150mm	18
6	Cube testing machine with two dial gauge and brick plate attachment	1
7	Digital thermometer - 200°C	6
8	Electrical oven	1
9	IS sieve set – 75 µ, 150 µ, 300 µ, 600 µ, 1.18 mm, 2.36 mm, 4.75 mm, 6.3 mm, 10 mm, 12.5 mm, 16 mm, 20 mm, 22.4 mm, 25 mm, 31.5 mm, 40 mm, 50 mm, 53 mm, 63 mm, 80 mm, 90 mm, 120 mm, 125 mm, pan (24 nos. per set)	1 Set
10	Measuring cylinder (glass) 50 ml, 200 ml, 500 ml	2 each
11	Physical balance Digital 10 kg capacity L.C. – 1 gm	1
12	Platform balance – Digital: 200 kg capacity	1
13	Pycnometer	2
14	Slump cone with tamping rod	8
15	Specific gravity bottle – 50 ml	2
16	Air entrainment meter capacity – 0.005 cum	2
17	Casagrande apparatus	1
18	Core cutter with collar and rammer	16
19	English type trowel	12
20	Hygrometer with thermometer	1
21	Impact testing machine	1
22	Le-Chatelier apparatus with water bath	1
23	Measuring cylinder (plastic) 50 ml, 100 ml, 200 ml, 500 ml	1

SL NO.	DESCRIPTION	QTY
24	Modified Proctor test apparatus	1
25	Length gauge	1
26	Penetrometer for mortar test	1
27	Moisture meter	1
28	pH meter	1
29	Sand replacement method apparatus	2
30	Screw gauge	2
31	Spatula	8
32	Standard Proctor test apparatus	1
33	Standard sand grade 1, 2, 3	500 kg each
34	Stop watch - Digital	1
35	Thermometer ordinary 50°C	10
36	Thickness gauge apparatus	1
37	Vernier calipers - Digital	1
38	Vicat apparatus	2
39	Weigh Boxes	4
40	Cylindrical measures: - capacity 0.01 cum, Dia (I) – 250 mm, Height – 280 mm, (I) with tamping rod as per IS 1199.	1

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SECTION - III

SPECIFIC DESIGN REQUIREMENT [STRUCTURAL]

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SECTION-III

SPECIFIC DESIGN REQUIREMENT [STRUCTURAL]

1.00.00 STRUCTURAL STEEL DESIGN

a) Structural steel design shall be carried out as per the National Building Code with specific consultation to IS: 800 (Latest Revision) unless noted otherwise.

b) Lateral forces along the length of the building shall be resisted by bracings in horizontal and vertical frames. The transverse lateral load shall be resisted by stiff jointed frame action or by bracing. Additional bracing or moment connection shall be used to assure stability of the structures.

c) Structural steel will conform to Grade E350 / E250 of quality (A/BR/B0), semi killed / killed as per IS: 2062 (latest) for rolled steel members or plates. All structural steel plates and sections shall be procured from any make approved by Owner.

For Crane Girder Steel will confirm to Grade E350 / E250 of quality C (Killed).

d) Shop connections shall be all welded and field connections shall generally be bolted (mainly for boiler and Main Power House) unless specified otherwise. Field bolts, wherever provided, shall be high tensile of 20 mm dia. or of higher diameter and of property class 8.8 as per IS: 1367 (Latest Revision) for all major connections. The bolted joints shall be designed for friction type connection and the H.T. bolts shall be tightened to develop the required pretension during their installation. However, the nominal connections in the field like purlins, stairs, wall beams etc. shall be done by 16 mm dia. M.S. black bolts (minimum 4.6 grade) conforming to IS: 1363 (Latest Revision) unless specified otherwise.

e) Welding shall be in accordance with the recommendations of IS: 816 - Code of Practice (Latest Revision) for use of metal arc welding for general construction in mild steel and IS: 9595 (Latest Revision) - Recommendation for Metal Arc Welding of Carbon and Carbon Manganese Steels. Built-up members shall be fabricated using submerged arc welding procedure unless manual arc welding is specifically required. All butt welds in plate girders and columns shall be full penetration.

All butt welds shall be radiographically or ultrasonically tested as per relevant IS codes and standard practice. The bare wire electrodes for submerged arc welding shall be conforming to AWS/IS classification.

f) Galvanizing of steel structures (wherever specified for switch yard structures, transformer yard structures, handrails, gratings, etc.) shall be done after all fabrication work is completed. Zinc coating over galvanized surface of structural members and threaded fasteners shall not be less than 610 gm/sqm and 375 gm/sq.m of surface area respectively. However, fasteners may be tapped or re-run after galvanizing. Threads of bolts and nuts shall be capable of developing the full strength of the bolt. The spring washers shall be electro-galvanized as per IS: 573 (Latest Revision). All galvanizing shall be uniform and of standard quality and shall withstand tests in accordance with IS: 2633 (Latest Revision). All galvanizing work shall be done at shop.

g) For painting of structural steel members :shall be applied with primer paint shall be single coat of zinc ethyl silicate primer of 75micron thick and conform to IS-2074 (Latest Revision). The surface preparation shall be done in accordance with IS : 1477 (Part I & II) (Latest Revision) – Code of Practice for Finishing of Ferrous Metals in Buildings. Two coats of synthetic enamel paint conforming to IS:2932 (Latest Revision) of approved shade and quality and not less than 50 microns each coat shall also be applied. Total Dry film thickness of the finished paint shall not be less than 175 microns.. For structures fabricated in shop, one additional coat of primer shall be given at the shop of 75 micron thick.

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h) All welding electrodes shall be of Low Hydrogen type conforming to IS: 814 (Latest Revision). All electrodes, flux, wire etc. shall be of ADOR Welding Ltd., ESAB India Ltd., D & H Secheron Electrodes Pvt. Ltd. Or any other equivalent manufacturer accepted by Owner at site.

Alternatively, flux coated arc welding (FCAW) conforming to AWS-classification which is a modified procedure of MIG/CO2 (solid wire) can be used.

If submerged arc welding is used, the bare wire electrodes shall conform to AWS/IS classification.

i) Minimum preheat & inter pass temperatures for welding over 40mm to 63mm (thickness of the thicker part at the point of welding) shall be 66°C and for over 63mm, it shall be 110°C. However, higher preheat & inter pass temperatures may be required due to joint restraint etc. and shall be followed as per approved welding procedure.

j) Minimum tests to be carried out during fabrication and erection of structural steel shall be as follows:

Steel

Ultrasonic Test: Plates above 25mm thick shall be subjected to ultrasonic test as per ASTM-A435 or equivalent to check the presence of lamination.

Fillet weld

Dye Penetration Test: 5% of the total length, Dye penetration shall be carried out to the root run.
Butt weld:

Dye Penetration Test: 10% of the total length, Dye penetration shall be carried out to the root run after back gouging

Radiographic Test: Generally splicing should not be provided in tension flange of Bunker Girders and crane girders. Spot radiography shall be carried out on 100% joints in tension zone and 10% joints in compression zone. Minimum 300mm length shall be spot radiographed. When radiograph is not possible ultrasonic test shall be carried out after grinding the surface.

Ultrasonic Test: 10% of all other Butt welds except crane girder and bunker girder shall be subject to spot radiographic test and the entire balance butt weld for ultrasonic test.

k) Connections

Connection of vertical bracings with connecting members and diagonal truss members shall be designed for full tensile capacity of the bracings.

Size of fillet weld for flange to web connection for built up column section shall be as follows:

- Full shear capacity for box section.
- 80% of full shear capacity or actual shear (if indicated in Sellers drawings) or 0.5 times of the web thickness whichever is more for I section. Weld will be double fillet.
- All welds will be continuous. The minimum size of fillet weld shall be as per relevant IS code.

Shear connections shall be designed for 75% of section strength for rolled sections and 80% of section strength for built up section or rolled section with cover plates. Design shear force should be more than actual shear.

Moment connections between beam and column shall be designed for 100% of moment capacity of the beam section.

All butt welds shall be full penetration butt welds.

Connection of base plate & gusset members with the columns shall be done considering that total load gets transferred through weld.

All splicing work shall be of full strength. Shop splicing for all sections other than rolled sections shall be carried out by full penetration butt welds. Shop splicing of all rolled sections shall be carried out using web and flange cover plate.

Following connections shall be provided during erection:

Welded Connection

Connection of secondary beam to main beam
Connection of bracing to column
Connection of bracing to longitudinal tie beam
Connection of longitudinal tie beam to column
Connection of spandrel beam to column
Connection of other secondary structures

HSFG Connection (Grade 8.8 bolts)

Splicing of column/transverse frame beam/ longitudinal tie beam
Connection of frame beam to column
Connection of Crane Girder to column
Connection between crane girders
Other major connections

Bearing Type Connection (HT bolts Grade 8.8)

All removable type connections

M.S. bolts (Grade 4.6)

Purlins, stairs, wall beams etc.

2.00.00 LOADS

Loads as defined under Clause 3.00.00 Section-II shall be applicable.

3.00.00 LOAD COMBINATIONS

While designing consideration shall be given to the following load combinations:

i) DL + LL

ii) DL + LL + PL + Equip $\pm$ TL

iii) DL + LL + PL + Equip + Cb + CtLA± CS ± TL

iv) DL + LL + PL + Equip + Cb + CtLB± CS ± TL

v) 0.9DL ± EL (for DL only) ± TL

vi) 0.9DL ± WL1 ± TL

vii) 0.9DL ± WL2 ± TL

viii) (DL + *LL + PL + Equip + Cb + Ct ± EL ± TL)
(* Appropriate portion of LL which is considered for working out EL shall only be taken)

ix) [DL+LL+ PL + Equip + Cb + CtL1 ± (CS1+WL1) ± TL]

x) [DL+LL+ PL + Equip + Cb + CtL1 ± (CS1+WL2) ± TL]

Where the above loads are:

DL = Dead load of structures, floors, walls etc.

LL = General live load on floors

PL = Pipe load

Equip = Equipment loads

Cb = Crane Bridge

Ct = Crane trolley positioned at middle of bridge

CtLA = Crane trolley + Load near one row

CtLB = Crane trolley + Load near other row

CtL1 = Crane trolley + Half load lifted at centre of bridge

CS = Crane surge for full load

CS1 = Crane surge for half load lifted

WL1 = Wind load with internal suction

WL2 = Wind load with internal pressure

EL = Earthquake load

TL = Temperature load

Limit state method to be followed for design of steel structures as per latest version of IS: 800. Applicable load factors to be used for Design of Steel Structures by Limit State Method of strength & serviceability as per IS: 800 (Latest).

Appropriate impact factor shall be considered as per IS: 875 (Part 2) (Latest Revision) while calculating crane loads.
In calculating wind loads, appropriate internal thrust / suction shall be considered along with external pressures as per IS: 875 (Part 3) (Latest Revision). All possible load conditions considering external and internal pressures shall be considered in analysis and design for each combination number (vi), (vii), (ix) & (x) above to assess worst effect on whole structure as well as its components.

4.00.00 PIPE AND CABLE RACK STRUCTURES

The pipe and cable rack structures shall accommodate the pipes/cables with proper access and adequate working space for erection and maintenance. These shall be designed to carry safely all the loads acting on them (DL, LL, WL, EQL, vertical and drag, drag forces from pipe lines as per mechanical input etc.). The structures shall be adequately rigid to carry the forces from the pipelines at anchor points without undue deflection so that the pipelines are really anchored at the anchor points. Bridges shall be provided to support pipelines of smaller diameters for which maximum permissible span are less than the distance between supporting trestles.

It is envisaged that pipe/cable rack under this Package shall have to accommodate some additional pipes and cables, which are not in the scope of the Bidder. The Bidder shall keep reasonable margin for accommodating such additional pipes/cables in the rack structure, details of which shall be furnished to him during the detailed engineering stage.

5.00.00 OTHER SPECIFIC REQUIREMENTS

All steel framed structures shall be either “rigid frame” or “simple space frames” or a combination of two.

Lateral forces shall be resisted by stiff jointed moment connections in rigid frame design. The column bases shall generally be fixed to concrete foundation pedestal by providing moment resistant base detail.

Simple space frame design utilizes single-span beam systems, vertical diagonal bracing at main column lines and horizontal bracing at the roof and major floor levels. The most of plant steel buildings shall be designed as simple space frame structures.

The turbine building design shall be a combination of rigid frame in transverse direction and simple frame in longitudinal direction.

Concrete floors shall be considered to provide continuous lateral support to the top (compression) flange of the support beams. However wherever large

cut outs (area more than 1.0 sq.m) are provided in the floor slabs horizontal floor bracing shall be provided. Grating/chequered plate floor shall neither be considered to provide lateral support to the top flange of supporting beams nor to provide a shear diaphragm. Adequate lateral support in the form of shear connector and horizontal bracing shall be provided as required.

Floors for vibrating machines of all kind together with supporting framework shall be adequately braced in both horizontal and vertical planes. Floors or structure supporting mechanical equipment shall be designed to minimize vibration, avoid resonance and maintain alignment and level. However heavy vibrating/rotating equipments shall rest on VIS if provided in intermediate floors. Resonance in structures: Structures supporting vibratory/reciprocating equipments shall be designed so as to obviate occurrence of resonance. The ratio of applied frequency to natural frequency shall not lie within the range as per codal stipulation.

Chequered plates shall conform to IS: 3502 (Latest Revision).

All indoor gratings shall be electro-forged type and outdoor gratings shall be welded type. Minimum thickness of grating shall be 40mm x 6mm for indoor installation and outdoor installation. The opening size shall not be more than 30mm x 100mm. All gratings shall be hot dip galvanized @ 610 gm/sq.m.

Where a steel beam or member is to be connected on RCC structure, it shall be connected using an insert plate and preferably through shear connection.

Only box sections shall be used for structural wall beams (provided at every 2.5 m height of brick wall) wherever brick cladding is envisaged.

Crane Girders

For crane girders, welding between web and flange plates shall be carried out by submerged arc welding process. Full penetration of weld between web plate and top flange shall be ensured. Intermediate stiffeners shall be connected with top flange plate by full penetration butt weld. Welding across tension flange shall not be permitted. Bearing edges of crane girders shall be machined. Crane stoppers shall be designed in accordance with IS: 875(part-5).

The working point of the bracing connection shall be the center of column and girder to which it connects, where practical. The connections of gusset plates to column and girders shall be made to include provisions for eccentricity in connection. The double angle back-to-back with gusset plate in between shall not be used in dust-laden areas. Where double angles are not adequate, beam sections with web in the plane of bracing are used.

Crane girders shall generally be of simply supported design, unless continuous crane girders are specifically required.

Each flange of crane girder shall have uniform thickness throughout its length. However width of flanges can be varied as per design requirement.

All intermediate stiffeners shall be fitted against top flange and welded to it by fillet welds/partial penetration butt welds. These stiffeners shall terminate short of bottom flange with at least 50 mm clear gap. The stiffeners shall be fillet welded to web plate and corners shall be cut suitably to clear thermally affected area of web to top flange connection.
End bearing stiffener plates of crane girder shall be capable of transmitting the maximum reactions to the columns. The bearing surface of the bearing plate shall be planed/ machined to ensure full contact. Thickness of End Bearing stiffeners shall not be less than top flange thickness and their width shall not be less than width of bottom flange.

Tension flange of crane girders shall be stabilized by horizontal latticed bracings, where required in order to limit the slenderness ratio of the flange to 150.

Generally for girders having span 12m and above, vertical auxiliary girder and horizontal girder at crane girder bottom flange level shall be provided.

At crane girder level, walkway shall be provided on both sides. Walkway at column location s shall have minimum clear width of 750mm.

All crane girders and their supporting structures shall be designed for loading from loaded crane in worst position of crab and crane to create most unfavourable loading condition of the girders. For increase of load due to impact and crane load combination including lateral surge & longitudinal surge shall be taken as per provision of IS: 875 (Part – 2).

Suitable approach to be provided for tightening of bolts of Crane Rail. Approach for Crane Rail fixing shall be properly planned for all types of sections of Crane Girders.

Surge Girder walkways and auxiliary beams

Continuous maintenance walkways with safety hand-railing shall be provided along each column row adjacent to each crane gantry girder. These walkways shall be of non-slip plate construction connected to crane girder top flange by continuous fillet welds. Access at every 60m shall be provided from floor for access to these walkways so that access is available within 60m from any location.

Connections between surge girder and the main columns shall be designed to resist load due to lateral braking of crane trolley.

On the periphery of the building, full length handrails shall be provided along the edge of the maintenance walkway at crane girder level.

Handrail and its clearance from crane end carriage shall conform to provisions of relevant safety regulations.

Crane stops shall be provided at the ends of each crane girder system, or as required to limit the movement of crane as per technological requirements.

Permissible Deflections

The permissible deflections of various steel members under normal loading conditions shall be as specified below. For calculation of deflections in structures and individual members dynamic effects shall not be considered, unless specified otherwise. Also, no increase in deflection limits shall be allowed when wind or seismic load are acting concurrent with normal loading conditions.

Vertical Deflection

a)	For beams supporting dynamic equipment	:	Span / 500
b)	For beams supporting floors / masonry	:	Span / 325
c)	For beams supporting pipes (pipe racks)	:	Span / 400
d)	For roofing and cladding components	:	Span / 250
e)	For gratings and chequered plates	:	Span / 200 subject to a maximum of 6 mm

For crane gantries or any member subjected to working loads, the maximum deflection under dead load and live load excluding impact shall not exceed the following values:

a)	For manually operated cranes & monorails	:	Span / 500

b) For electric overhead cranes

i)	Up to 50 t capacity	:	Span / 750
ii)	Over 50 t capacity	:	Span / 1000

Horizontal deflections

The permissible horizontal deflections shall be as per following unless specified otherwise:

a)	Single storey building (without crane load)	:	Height / 300
b)	Multistoried building including JTs (without crane load)	:	Height / 500
c)	Pipe rack columns	:	Height / 325
d)	Open Structures	:	Height / 200

e)	Crane gantry girder due to surge	:	Span / 2000 limited to maximum of 15 mm
f)	Building main columns at crane rail level due to action of crane surge load only	:	Height / 2500 limited to maximum of 10 mm
g)	Open gantry columns at crane rail level due to action of crane surge load only	:	Height / 4000 limited to maximum of 10 mm
h)	Conveyors, JNTs Conveyor support level, Conveyor support	:	Height / 1000 in across direction & Height / 500 in along direction

Provisions of IS: 800 (Latest Revision) and relevant IS Code shall be followed for limiting deflections of structural elements not listed above.

Minimum Thickness of steel elements

The minimum thickness of various components of a structure and hot rolled sections shall be as follows. The minimum thickness of rolled shapes shall mean flange thickness regardless of web thickness. Structural steel members exposed to significantly corrosive environment (exposed to open air i.e. to rain, contact with soil, coal, ash, contact with drained liquid or contaminated water, alkali/acid etc.) shall be increased suitably in thickness or suitably protected otherwise as per good practice and sound engineering judgment in each instance. For plate girders minimum thickness of web and flange shall be 8.0 mm.

a)	Trusses, purlins, girts and bracing	:	6 mm
b)	Columns and beams	:	8 mm
c)	Gussets	:	8 mm
d)	Stiffeners	:	8 mm
e)	Base plates	:	10 mm & above
f)	Chequered plates	:	8mm o/p & above
g)	Grating flats	:	6 mm

h) Minimum thickness of structural members other than gratings directly exposed to weather and inaccessible for painting and maintenance shall be 8 mm.

i) Upto 400 mm depth, Built-up sections shall not be used.

j) Minimum thickness of base plate for columns at ground level shall be 20 mm (at other levels 16 mm) and minimum thickness of washer plate at any level shall be 0.8 times of Base Plate thickness.

Tubular sections not permitted except for parking sheds

Minimum Sizes of steel elements

The flange width of purlins supporting light weight concrete slab shall not be less than 65 mm and for those supporting roof sheeting and wall cladding it shall not be less than 50 mm. Width of steel rolled section connected to other member shall be at least 50 mm. The depth of beams for floors of all structures shall not be less than 125 mm.

Slenderness and Depth Ratio

The slenderness ratio of main members in tension, compression or bending shall be in accordance with IS: 800 (Latest Revision).

The following limiting ratios of depth to span shall be considered as a general guide.

a)	Truss	1 / 10
b)	Rolled beams and girders for Ordinary floors and rafters	1 / 24
c)	Supporting floor beams for vibrating Machinery / equipment	1 / 15
d)	Roof purlins and girts	1 / 45
e)	Gable columns	1 / 30

Expansion joints

Longitudinal and transverse expansion joints shall be provided in buildings and structures in accordance with IS: 800 (Latest).

Expansion joints shall be formed by providing double rows of columns, with overhanging gantry girders, secondary roof and wall framing being detailed to allow the maximum calculated movement for the specified temperature variation.

Miscellaneous Criteria

Natural ventilation shall be provided ensuring that it does not permit rain water entry into the building. Scope of natural lighting shall be used to the maximum possible extent. For this purpose, minimum 15% of side sheeting area and 10% of roof sheeting area, unless otherwise specified, shall be provided with window/

polycarbonate sheets of 4mm thickness (wherever specified). Protective grating shall be provided below such sheets to prevent accidents due to damaged sheets.

DI gutters and DI down-pipes with gutter outlets having grating cover shall be provided to carry rain water from roofs of buildings to the drainage system at ground level. All gutters shall be designed as walkable.

Adequate facilities in the form of monorails, hoists, platforms etc. shall be provided to facilitate repair and maintenance of overhead cranes, equipment, etc. Access to these platforms shall be provided by stairs / ladders from the nearest accessible floor or platform. Wherever the monorail projecting from the building, sliding steel flush doors shall be provided (side hung doors may also be provided depending upon the location).

Edges of floors, gangways, stairs and landings shall be provided with safety hand railings. All hand railings shall be of tubular hand railings with vertical post, top rail and mid rail made up with tubes.

At gable ends of buildings, platforms shall be provided connecting the walkways at crane gantry level.

Connection by permanent bolts to structural elements subject to vibration shall be provided with lock nuts.

Monorails shall be designed for local bending both in transverse and longitudinal direction. The projection of the monorail outside the building shall be as per mechanical requirement.

Chequered plates, Purlins, Side runners, sheeting etc shall not be considered as structural members for transferring horizontal loads. Except where purlins form part of bracing system, designed for axial loads also.

Necessary number of prints of drawings and documents; as per contract shall be submitted for approval.

The slopes of bracings, lacings for columns, diagonal members of trusses, bridges, girders etc shall be kept preferably in the range of 35 to 50 degrees.

Purlins and side runners shall be considered as part of cladding unit and shall be subjected to local wind coefficients as specified in IS: 875.

Structural schematic general arrangement with plans at various levels, elevations along each row and axes, sections, considered loads and load diagrams with location etc. and Structural design drawings with BOQ and Table of members containing design forces along with design calculations shall be submitted for Purchaser's/Consultant's approval. STAAD Pro. file along with editable excel sheets with active formulae to be submitted. However the approval shall be limited to checking of overall dimensions, general stability of system, effective load transfer and deflection limits etc. The

approval shall not relieve the successful bidder of his responsibility of correctness in design, adequacy of connections, accuracy etc.

Shear force at the column base shall be resisted either by shear keys shop-welded to the underside of column base plates or by welding base plate to inserts provided in foundation.

The level of underside of column base shall be so chosen such that the complete anchor table lies below the finished floor level (wherever specified), thus keeping the shop floor free from projections of anchor tables.

Minimum thickness of base plate for columns at ground level shall be 20 mm (at other levels 16 mm) and minimum thickness of washer plate at any level shall be 0.8 times of Base Plate thickness.

All Built-up columns shall be provided with nominal stiffeners to maintain orthogonal & torsional rigidity, at a spacing not exceeding 1500 mm centre to centre

Roof Structures

a) The main supporting element for roof shall preferably be roof rafters, made of rolled sections or built-up sections, provided at uniform spacing to suit shop layout. Roof shall be provided with adequately sized roof monitor for natural ventilation, wherever required.

b) For all main technological units / buildings, rafters / roof girders shall be made of I sections either rolled upto 400mm depth or built up above 400mm depth.

c) Roof shall have suitable slope (1:5, i.e. 1 Vertical: 5 Horizontal, unless otherwise specified) to meet technological as well as rainwater drainage requirements. Hand railings at eaves level and gable ends of the roof of the building shall be provided.

d) System of bracings shall be provided in the roof top chord and bottom chord levels along with longitudinal ties to ensure stability and rigidity of the roof structures.

e) Galvanized wind tie (40x6 mm flat) shall be provided at the free edge and ridge portion of roof sheeting. Suitable arrangement of anchors shall be provided at the ridge of roof sheeting for holding lanyards of safety belts.

f) For design of roof and side wall frame work, purlins / side runners shall be treated as part of cladding unit and shall be subjected to local wind coefficients as given in codes.

g) Roof drainage system shall be designed for maximum precipitation for 5 minutes based on local meteorological data. In the absence of meteorological data, precipitation of 2mm per minute may be considered for designing drainage system. A factor of safety of 1.3 shall be kept in the design.

h) All valley and eaves gutters shall be of pressed plate construction with a minimum sole width of 600 mm so as to function as walkways.

i) Eaves gutter shall be provided for eaves height ranging between 10 m to 25 m above apron/ground level.

j) The gutters shall be laid to slope towards down-pipes with welded outlets and having grills fitted flush with gutter sole. Slope of gutters and collector pipes shall not be flatter than the following limits:

i. Longitudinal slope of gutter 1 : 500

ii. Longitudinal slope of collector pipe 1 : 300

Velocity of discharge may be considered as 1 to 2.5m/s. Corrosion factor may be taken as 1.5 mm for designing the gutter plate.

k) Poking holes with cover shall be provided in the down-pipes at suitable intervals as well as at accessible levels, to clean the down-pipes.

l) Eaves gutter shall be provided with safety handrails.

m) When rain water falls from higher to lower roof, double layer of sheets shall be provided for the portion of roof sheeting on which rain water falls, provided the drop of roof is in the range of 3 m to 6 m. In case the drop is more than 6 m, independent gutter shall be provided.

Wall Structures

a) Wall runners with necessary sag rod arrangements shall be provided to support wall and gable sheeting, including internal partition wall, wherever required.

b) Walls shall be provided with louvers and polycarbonate sheeting at appropriate levels, to provide natural ventilation and lighting.

c) Adequate framing arrangement shall be provided both in roof and side wall framing, for fixing of ventilator fans / exhaust fans as per requirement.

REPORT ON GEOTECHNICAL INVESTIGATION

FOR

PROPOSED THERMAL POWER PLANT PROJECT (3 X 800 MW)

AT

SAMBALPUR, ORISSA

FOR

M/s. NLC INDIA LIMITED
OFFICE OF THE GENERAL MANAGER/CIVIL
CTO BUILDING/BLOCK – 1/ NEYVELI – 607 801/TAMIL NADU
INDIA

JOB NO. : 30796
REPORT NO. : 0704
DATE : 13.11.2018

SKM Geosurvey
ISO 9001: 2015 CERTIFIED ORGANIZATION
BK-130, SALT LAKE, SECTOR-II, KOLKATA- 700091

PREFACE

Geotechnical investigation of sub soil was carried out for the proposed Thermal Power Plant Project (3 x 800 MW) at Sambalpur area in Odisha State. Objective of the investigation was to determine sub-soil parameters for assessing load carrying capacity of foundation for design and construction of the proposed structure.

Soil Investigation work was started at this site by M/s SKM Geosurvey on issue of letter of award having Ref No: Tender/T.No.13/2017-18/LOA/GMC/2017 by M/s NLC India Limited dated 16th October 2017. Field work was started on 18th December 2017 and completed on 24th February 2018.

The report has been prepared after in-depth study of data collected from field and laboratory tests and deals with geotechnical aspects of the sub-soil. Section-I of this report covers the field work. Results of laboratory tests and a discussion thereon are presented in Section-II. Section-III deals with an engineering appraisal and a recommendation for a suitable foundation for the proposed structures.

SECTION - I

1.0 INTRODUCTION

On instruction from M/s NLC India Limited, geotechnical investigation was carried out for the proposed Thermal Power Plant Project (3 x 800 MW) at Sambalpur area in Odisha State. Objective of the investigation was to determine sub-soil conditions at site and to determine a suitable foundation system as required for the proposed structure.

2.0 LOCATION

The site is at the Sambalpur, Odisha. The nearest railway station to the site is Jharsuguda situated about 15 km from the site. The site is located within Village Kumbhari and Tareikela. Total site is surrounded by river expect the ash pond area. The site is undulating and covered by grass and a few trees.

3.0 INVESTIGATION SCHEME AND LOCATION OF TESTS

The scheme of Soil Investigation framed by the client comprised a total of thirty (30) boreholes with the explored depth of 8.20m to 19.50m below the E.G.L, ten(10) Electrical Resistivity Test, twenty(20) Dynamic Cone Penetration Test, five(05) nos Plate Load Test, two(02) nos Cyclic Plate Load Test, fifteen(15) nos Trail Pit, tewnty(20) field permeability test, one (01) percolation test in trial pit, one(01) Block Vibration Test and one(01) Cross Hole Seismic Test. The scope of work also included collection of undisturbed soil samples from cohesive deposits, disturbed samples, conducting Standard Penetration Tests in boreholes, carrying out routine laboratory tests on soil samples. On completion of field and laboratory tests, a report on the investigation was to be submitted based on the findings, together with recommendations on foundations. The work was carried out accordingly.

4.0 FIELD WORK

4.1 Boring

The boreholes were sunk by a combination of Mechanical Cable Tools (Shell & Auger) method & Rotary wash boring at lower depths. Flush jointed steel casing tubes were used to prevent side collapse of boreholes in shell and auger method of boring. No casing was provided in the Rotary wash borings since stabilization of hole was made by circulation of bentonite mud. The depth of casings at various stages of sampling, borehole depths, depth of collection of undisturbed soil samples (UDS), description of soil, 'N' values during SPT at various depths and the depth at which ground water was encountered at different locations are shown in the respective bore logs in Appendix-I of this report.

4.2 Sampling

Both disturbed and undisturbed representative soil samples were collected during boring and subsequently sent to laboratory for visual examination and laboratory tests. For undisturbed sampling, 100 mm dia 450 mm long 'open drive' sample tube fitted with cutting shoe was driven into soil through boreholes. Such samplers were fitted with a spring loaded valve system at the top of the sampler to create vacuum during withdrawal after being pushed into soil for holding the sample in tube.

Disturbed samples were collected from the cutting shoe and split spoon sampler.

A Table depicting details of boreholes and samples collected for testing in the laboratory and other tests executed is presented below.

Number of Field Tests and Samples Collected

Test No.	Facility	R.L, (m)	Co-ordinate		Soil Boring (m)	Rock Drilling (m)	Total Depth (m)	S.W.L. (m)	Samples Collected				Field Permeability
			North	East					SPT	UDS	DS	WS	
BH-01	**Crusher House**	197.210	2411250	808575	12.00	5.00	17.00	4.20	13	3	5	-	2
BH-02	**Chimney - 1**	197.50	2411030	808685	13.50	5.00	18.50	4.30	15	2	5	-	2
BH-03	**Chimney - 2**	198.50	2410803	808685	14.50	5.00	19.50	4.50	13	4	4	1	-
BH-04	**Boiler – 1/1**	194.729	2411130	808970	6.00	5.00	11.00	0.80	5	1	5	-	1
BH-05	**Boiler – 1/2**	195.568	2411080	809045	6.50	5.00	11.50	0.10	6	-	7	1	-
BH-06	**Boiler – 2/1**	197.394	2410979	808975	7.00	5.00	12.00	2.35	5	1	5	-	1
BH-07	**Boiler – 2/2**	197.499	2410929	808950	7.00	5.00	12.00	2.40	5	1	4	1	1
BH-08	**Boiler – 3/1**	199.264	2410803	809045	12.00	5.00	17.00	3.80	8	2	5	1	1
BH-09	**Boiler – 3/2**	198.215	2410790	808950	14.50	5.00	19.50	2.85	8	2	7	1	1
BH-10	**C-Row-1**	195.668	2411175	809057	5.50	5.00	10.50	1.10	5	1	5	-	1
BH-11	**C-Row-2**	196.621	2410722	809057	11.50	5.00	16.50	3.00	12	2	6	-	2
BH-12	**A – Row -1**	199.764	2410728	809098	8.00	5.00	13.00	1.60	8	2	3	-	1
BH-13	**A – Row -2**	196.660	2411175	809098	5.60	5.00	10.60	1.65	6	-	5	1	1
BH-14	**TG Deck-1**	196.621	2411115	809083	5.32	5.00	10.32	1.50	5	1	5	-	1
BH-15	**TG Deck-2**	195.857	2411055	809083	3.20	5.00	8.20	0.15	5	-	3	-	1
BH-16	**TG Deck-3**	199.466	2410803	809083	12.00	5.00	17.00	3.00	11	1	5	-	1
BH-17	**Cooling Tower -1**	204.919	2410250	809375	12.00	5.00	17.00	4.78	8	3	5	1	1
BH-18	**Cooling Tower -2**	198.576	2409980	808900	9.00	5.00	14.00	2.30	5	2	5	-	1
BH-19	**Cooling Tower -3**	199.313	2410380	809083	10.00	5.00	15.00	2.50	7	2	5	-	1
BH-20	**Reservoir -1**	198.614	2409650	808700	8.00	5.00	13.00	4.20	4	2	5	1	-

***Note**: BH = Borehole, ERT=Electrical Resistivity Test, CHST=Crosshole Seismic Test, BVT= Block Vibration Test, TP= Trial Pit, DCPT= Dynamic Cone Penetration Test, UDS = Undisturbed Soil Samples, SPT = Standard Penetration Test, DS = Disturbed Soil Samples other than SPT samples, WS = Water Samples, SWL = Standing water level.*

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Number of Field Tests and Samples Collected

Test No.	Facility	R.L, (m)	Co-ordinate		Soil Boring (m)	Rock Drilling (m)	Total Depth (m)	S.W.L. (m)	Samples Collected				Field Permeability
			North	East					SPT	UDS	DS	WS	
BH-21	**Reservoir -2**	201.101	2409550	809200	8.50	5.00	13.50	4.50	5	2	4	1	-
BH-22	**Reservoir -3**	201.405	2409125	808900	8.20	5.00	13.20	4.30	5	2	4	-	-
BH-23	**CHP-1**	200.850	2411450	809100	8.50	5.00	13.50	3.50	6	2	4	1	-
BH-24	**CHP-2**	197.790	2411560	808950	7.00	5.00	12.00	1.90	5	2	5	-	-
BH-25	**Ash Silo**	197.000	2411560	808490	12.00	5.00	17.00	3.80	13	3	5	-	-
BH-26	**Township**	197.230	2411400	810400	6.30	5.00	11.30	1.10	4	2	4	-	-
BH-27	**Ash Dyke-1**	202.405	2409500	810500	8.50	5.00	13.50	4.70	5	2	4	-	-
BH-28	**Ash Dyke-2**	201.102	2409050	810850	8.00	5.00	13.00	4.20	5	2	4	-	-
BH-29	**Ash Dyke-3**	202.925	2408750	810200	8.50	5.00	13.50	4.70	5	2	4	-	-
BH-30	**Ash Dyke-4**	201.427	2408400	810650	8.20	5.00	13.20	4.15	5	2	4	-	-
ERT-1	**Chimney - 1**	197.500	2411023	808690	-	-	-	-	-	-	-	-	-
ERT-2	**Boiler – 1/1**	194.729	2411135	808965	-	-	-	-	-	-	-	-	-
ERT-3	**Boiler – 3/1**	199.264	2410805	809050	-	-	-	-	-	-	-	-	-
ERT-4	**Boiler – 2/1**	197.394	2410982	808982	-	-	-	-	-	-	-	-	-
ERT-5	**C-Row-2**	196.621	2410727	809065	-	-	-	-	-	-	-	-	-
ERT-6	**A – Row -1**	199.764	2410732	809099	-	-	-	-	-	-	-	-	-
ERT-7	**TG Deck-2**	195.857	2411060	809080	-	-	-	-	-	-	-	-	-
ERT-8	**Cooling Tower -2**	198.576	2409983	808900	-	-	-	-	-	-	-	-	-
ERT-9	**CHP-1**	200.850	2411455	809100	-	-	-	-	-	-	-	-	-
ERT-10	**Township**	197.230	2411405	810400	-	-	-	-	-	-	-	-	-

Note: BH = Borehole, ERT=Electrical Resistivity Test, CHST=Crosshole Seismic Test, BVT= Block Vibration Test, TP= Trial Pit, DCPT= Dynamic Cone Penetration Test, UDS = Undisturbed Soil Samples, SPT = Standard Penetration Test, DS = Disturbed Soil Samples other than SPT samples, WS = Water Samples, SWL = Standing water level.

SKM Geosurvey

Number of Field Tests and Samples Collected

Test No.	Facility	R.L, (m)	Co-ordinate		Soil Boring (m)	Rock Drilling (m)	Total Depth (m)	S.W.L. (m)	Samples Collected				Percolation Test
			North	East					SPT	UDS	DS	WS	
CHST-01	**TG Deck-3**	199.466	2410806	809090	-	-	25.00	-	-	-	-	-	-
BVT-01	**TG Deck-2**	195.857	2411055	809083	-	-	2.20	-	-	-	-	-	-
							Total Volume (m^3) (LxBxD)						
TP-01	**Crusher House**	197.210	2411240	808580	-	-	2x2x4	-	-	02	02	-	-
TP-02	**Chimney - 1**	197.50	2411020	808690	-	-	2x2x4	-	-	02	02	-	01
TP-03	**Chimney - 2**	198.50	2410815	808692	-	-	2x2x4	-	-	02	02	-	-
TP-04	**Boiler – 1/1**	194.729	2411140	808965	-	-	2x2x4	-	-	02	02	-	-
TP-05	**Ash Dyke-1**	202.405	2409510	810500	-	-	2x2x4	-	-	02	02	-	-
TP-06	**Ash Dyke-3**	202.925	2408758	810205	-	-	2x2x4	-	-	02	02	-	-
TP-07	**CHP-1**	200.850	2411457	809105	-	-	2x2x4	-	-	01	03	-	-
TP-08	**Boiler – 3/1**	199.264	2410810	809050	-	-	2x2x4	-	-	02	02	-	-
TP-09	**Reservoir -1**	198.614	2409655	808710	-	-	2x2x4	-	-	02	02	-	-
TP-10	**C-Row-1**	195.668	2411180	809065	-	-	2x2x4	-	-	01	03	-	-
TP-11	**Reservoir -2**	201.101	2409560	809200	-	-	2x2x4	-	-	02	02	-	-
TP-12	**Cooling Tower -2**	198.576	2409970	808900	-	-	2x2x4	-	-	02	02	-	-
TP-13	**A – Row -2**	196.660	2411180	809105	-	-	2x2x4	-	-	-	04	-	-
TP-14	**TG Deck-1**	196.621	2411125	809070	-	-	2x2x4	-	-	01	03	-	-
TP-15	**TG Deck-3**	199.466	2410812	809090	-	-	2x2x4	-	-	02	02	-	-

Note: BH = Borehole, ERT=Electrical Resistivity Test, CHST=Crosshole Seismic Test, BVT= Block Vibration Test, TP= Trial Pit, DCPT= Dynamic Cone Penetration Test, UDS = Undisturbed Soil Samples, SPT = Standard Penetration Test, DS = Disturbed Soil Samples other than SPT samples, WS = Water Samples, SWL = Standing water level.

SKM Geosurvey

Number of Field Tests and Samples Collected

Test No.	Facility	R.L, (m)	Co-ordinate		Soil Boring (m)	Rock Drilling (m)	Total Depth (m)	S.W.L. (m)	Samples Collected				Field Permeability
			North	East					SPT	UDS	DS	WS	
DCPT-1	**Chimney - 2**	198.50	2410807	808688	-	-	12.60	-	-	-	-	-	-
DCPT-2	**Boiler – 1/1**	194.729	2411135	808965	-	-	5.40	-	-	-	-	-	-
DCPT-3	**Boiler – 1/2**	195.568	2411085	809048	-	-	6.00	-	-	-	-	-	-
DCPT-4	**Boiler – 2/1**	197.394	2410982	808979	-	-	6.90	-	-	-	-	-	-
DCPT-5	**Boiler – 2/2**	197.499	2410933	808954	-	-	6.90	-	-	-	-	-	-
DCPT-6	**Boiler – 3/1**	199.264	2410807	809049	-	-	10.50	-	-	-	-	-	-
DCPT-7	**Boiler – 3/2**	198.215	2410795	808950	-	-	10.50	-	-	-	-	-	-
DCPT-8	**C-Row-1**	195.668	2411180	809059	-	-	5.40	-	-	-	-	-	-
DCPT-9	**C-Row-2**	196.621	2410725	809060	-	-	11.40	-	-	-	-	-	-
DCPT-10	**A – Row -1**	199.764	2410730	809099	-	-	5.70	-	-	-	-	-	-
DCPT-11	**A – Row -2**	196.660	2411180	809098	-	-	5.40	-	-	-	-	-	-
DCPT-12	**TG Deck-1**	196.621	2411120	809086	-	-	4.80	-	-	-	-	-	-
DCPT-13	**TG Deck-2**	195.857	2411050	809080	-	-	3.30	-	-	-	-	-	-
DCPT-14	**TG Deck-3**	199.466	2410806	809080	-	-	11.10	-	-	-	-	-	-
DCPT-15	**Cooling Tower -1**	204.919	2410255	809372	-	-	12.00	-	-	-	-	-	-
DCPT-16	**Cooling Tower -2**	198.576	2409980	808905	-	-	10.20	-	-	-	-	-	-
DCPT-17	**Cooling Tower -3**	199.313	2410376	809083	-	-	10.20	-	-	-	-	-	-
DCPT-18	**Chimney - 1**	197.50	2411025	808688	-	-	11.70	-	-	-	-	-	-
DCPT-19	**Crusher House**	197.210	2411255	808577	-	-	11.10	-	-	-	-	-	-
DCPT-20	**Reservoir -1**	198.614	2409655	808703	-	-	8.10	-	-	-	-	-	-

Note: BH = Borehole, ERT=Electrical Resistivity Test, CHST=Crosshole Seismic Test, BVT= Block Vibration Test, TP= Trial Pit, DCPT= Dynamic Cone Penetration Test, UDS = Undisturbed Soil Samples, SPT = Standard Penetration Test, DS = Disturbed Soil Samples other than SPT samples, WS = Water Samples, SWL = Standing water level.

SKM Geosurvey

Number of Field Tests and Samples Collected

Test No.	Facility	R.L, (m)	Co-ordinate		Soil Boring (m)	Rock Drilling (m)	Total Depth (m)	S.W.L. (m)	Samples Collected				Field Permeability
			North	East					SPT	UDS	DS	WS	
CPLT-01	**Chimney - 2**	198.50	2410807	808685	-	-	2.50	-	-	02	-	-	-
CPLT-02	***TG Deck-1***	196.621	2411120	809085	-	-	2.25	-	-	02	-	-	-
PLT-01	**Chimney - 1**	197.50	2411027	808695	-	-	2.50	-	-	02	-	-	-
PLT-02	**TG Deck-3**	199.466	2410807	809083	-	-	2.00	-	-	02	-	-	-
PLT-03	**Boiler – 2/1**	197.394	2410983	808983	-	-	2.50	-	-	02	-	-	-
PLT-04	**Boiler – 3/2**	198.215	2410785	808942	-	-	2.25	-	-	02	-	-	-
PLT-05	**CHP-1**	200.850	2411452	809100	-	-	2.50	-	-	02	-	-	-

Note: BH = Borehole, ERT=Electrical Resistivity Test, CHST=Crosshole Seismic Test, BVT= Block Vibration Test, TP= Trial Pit, DCPT= Dynamic Cone Penetration Test, UDS = Undisturbed Soil Samples, SPT = Standard Penetration Test, DS = Disturbed Soil Samples other than SPT samples, WS = Water Samples, SWL = Standing water level.

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4.3 Standard Penetration Tests

Standard penetration tests were carried out in soil encountered during boring to determine in-situ consistency and strength characteristics. This was carried out in accordance with IS: 2131. Number of blows (N-value) required driving the 50 mm outer diameter standard split spoon for a penetration of 0.30 m by a 63.5 kg hammer falling freely from a height of 750 mm is given in bore-logs in this report. Graphical view of 'N' value vs. depth is also given in this report.

4.4 Electrical Resistivity Test (ERT)

Electrical Resistivity Tests (ERT) was carried out at ten (10) pre-selected locations following IS: 3043 using Resistivity Meter (Model DDR2, IGIS).

The tests were carried out with four electrode arrangements commonly known as Wenner arrangement in Geophysical Resistivity Survey or Soil Resistivity Survey. In this method all four electrodes are placed in one line, the outer pair of electrodes are used as current electrodes (thorough which current is passed into ground) while the inner pair of electrodes are used for measuring potential difference. Equal spacing between the electrodes 'a' is kept constant and is governed by the depth to which resistivity measurement is desired. Soil conditions, geology of the sub-surface formations and conductivity of sub-surface layers also determine proper electrode spacing. At each location, readings were taken in eight directions North-South, East-West, North East – South West, North West – South East directions. Two sets of observations were taken at each electrode spacing and mean value is taken as representative.

Resistivity is estimated by the following formula:

$$\rho = 2.\pi.a.R$$

Where

ρ = Apparent resistivity (Ohm-m)

a = Distance between two electrodes (m). Resistivity corresponds to a point at the centre of electrode spreads.

R = Observed resistance (Ohm).

In the present study spacing 'a' was kept at 0.50m, 1.0 m, 2.0 m, 3.0m, 4.0m, 5.0 m, 6.0m, 8.0m and 10.0 m respectively.

Tabulated results of resistivity measurements and apparent resistivity are presented in Appendix-II of this report.

4.5 Field Permeability Test

Field permeability tests were carried out by the Falling Head method in cased boreholes. In this test, the casing was filled with water that was then allowed to seep into the soil. The rate of drop of the water level in the casing was observed by measuring the depth of the water surface below the top of the casing. These observations are made until the drop becomes negligible or until sufficient readings have been obtained.

4.6 Dynamic Cone Penetration Test (DCPT)

This test provides an easy but quick means for assessing compactness of soil. Dynamic cone penetration tests (DCPT) were conducted following IS: 4968 (Part-1)-1976 to evaluate penetration resistance of soil. In this test a standard solid steel cone of 63.5 mm diameter and apex angle of 60° attached to drill rods is driven by a 65.0 Kg steel monkey falling freely for a height of 750 mm. Number of blows (N_{cd} or N_{cbr}) required to drive the standard cone per 100 mm penetration is recorded. The results are presented in tabular and graphical form in Appendix-I.

4.7 Block Vibration Test

In order to ascertain dynamic properties of soil (Residual soil), one (01) Block Vibration Test was carried out as per IS: 5249 (Revised).

Basically co-efficient of elastic uniform compression, 'C_u' values are determined along with damping co-efficient of soil by dynamically exciting a concrete block of specific dimensions with a rotating mass type Lazan oscillator, producing varying sinusoidal free force upto 1200 kg following IS: 5249. The eccentric angle between the masses can be varied from 0^0 to 140^0 and the eccentricity can be adjusted with an adjuster circle.

The frequency range can be adjusted commensurate with the size of block to be tested and the type of soil or rock. The oscillator is driven by a 3 HP single-phase D.C. motor with variable speed control. The vibration characteristics are measured with acceleration, velocity and

displacement pick-ups. Nature of vibration due to excitation of concrete block is visually observed through an oscilloscope. Detailed processed data for block vibration test conducted at various depths below existing ground level are presented in the Appendix.

Total weight of the machine including mechanical oscillator, D.C. Motor and base plate was 118 Kg (approx.)

4.8 Plate Load Test

Five (05) routine plate load test (RPLT) was conducted at specified location and depth in accordance with IS: 1888. Size of test plate was 60 cm x 60 cm. Load on test plate was applied by hydraulic jack through ball & socket joint reacting against a gravity type kentledge made of R.S. joists, drum sheets and earth filled bags. At first a seating load was applied. Subsequent load increments were applied in stages up to required intensity. Settlement of plate with elapsed time was recorded through multiple dial gauges for every stage of loading and unloading. After reaching final settlement, load was released in stages and settlements were recorded with time. Net settlement of plate sufficiently after completion of unloading was recorded.

The test pit log, load – settlement have been drawn and enclosed in Appendix-I of this report.

4.9 Cyclic Plate Load Test

Altogether two (2) Cyclic Plate Load Tests (CPLT) were conducted on weathered rock at the specified locations at a depth ranging from 2.00m to 2.50m below GL in accordance with IS :1888. Load on test plate was applied by hydraulic jack through ball & socket joint reacting against a gravity type kentledge made of R.S. joists, drum sheets and sand bags. At first a seating load was applied. Subsequent load increments were applied to required intensity and thereafter unloaded in stages. Each cycle of test involved increment of loading to required intensity and subsequently unloaded completely before starting the next load cycle. This procedure was applied for each cycle of loading until application of full test load. Settlement of the test plate vs. time was recorded through multiple dial gauges for every loading and unloading stages. Size of test plate used was (60cm x 60 cm).

Pit log, load – settlement curves for each cycle have been drawn and are presented in Appendix-I of this report.

Pit logs for plate load tests are enclosed in Appendix-I.

4.10 Cross-Hole Seismic Velocity Tests (Chst)

Seismic Cross-Hole tests were carried out at one (1) location. The purpose of the Cross Hole Test was to determine the Compression wave (P-Wave) and Shear wave (S-Wave) and to assess dynamic soil parameters based on the seismic wave velocities.

Seismic Cross Hole Tests use two or more boreholes to measure wave propagation velocities along horizontal paths. In the present investigation, the cross-hole test configuration consists of three holes arrangement in which one contains an impulse energy source called the Source Borehole (s) and other two boreholes are Receiver holes (R-1 and R-2). The three boreholes are at a distance of 2.0m from centre to centre. By fixing both the source and the receivers at the same depth in each borehole, the wave propagation velocity of the materials between the boreholes and the source at that depth has been measured. In the present investigation, the tests were conducted at a starting depth of 2.00m below EGL and thereafter at an interval of 1.0m u to a total depth of 25.0m below EGL.

TEST PROCEDURE

Initially three boreholes of 100mm dia. were done up to the required depth of 25.0m below ground level with a spacing of 2.0m centre to centre. After boring, all the boreholes were cased with 60mm internal diameter and 70mm outer diameter PVC casing and the space between the holes and the casing were properly grouted. The cross-hole seismic system consists of four basic components viz. a Personal Computer (PC) with high-speed data acquisition card, Win Geo acquisition and analysis software and P-SV Electromechanical source and two triaxial Geophone receivers. The present system used is designed and manufactured in accordance with ASTM D4428 – D4428M – 00 Standard methods for Cross Hole Seismic Testing. The complete set up has been manufactured by OLSON ENGINEERING, Inc. USA.

In the source borehole, an electromechanical source P-SV which creates, both downward an upward polarised shear vertical waves (SV) at a given depth was installed and in the receiver holes, triaxial geophones were installed at the same depth of source borehole. The source and the receiver Geophone are separately lowered into the boreholes at the designed depth of test with a dummy inclinometer probe keeping proper orientation of the Receiver Geophone in relation to the source borehole. After the desired depth is reached, the bladder attached to the electromagnetic source piston and the receiver Geophones are inflated with air pressure so that it properly fits on the

side of casing. All the communication cables in the source and receivers are connected to the Amplifier module of the Data PC together with trigger cable. There are seven channels in the Module, three for each receiver (total six) and one for trigger.

For data acquisition, the computer is made on and after file and parameter set up, the Impact button of the trigger channel is pushed for up direction and data were recorded by the computer for all the six channels of the two receivers.

After obtaining data, the step is repeated for down direction and thus the data for both direction of Triggering will be obtained for a particular depth. After the data acquisition is completed, for a particular depth, the entire process is repeated for the next depth and the data acquisition was made for the entire 25.0m depth.

The observed values of compression and shear wave velocity at different depth including dynamic soil parameters have been enclosed in the following pages.

4.11 Ground water

Ground water observations were made during the progress of boring. The depths at which ground water was encountered and the standing water levels as observed were recorded in the borehole logs. Whenever ground water was struck, boring was stopped for half an hour to allow water level to stabilise. The depth at which water was struck was measured. After completion of borehole readings of the depth of water level was taken after suitable intervals and then the borehole was backfilled.

SECTION - II

LABORATORY TEST RESULTS AND GROUND CONDITION

5.0 LABORATORY TESTS

Soil samples collected at field were brought to laboratory for necessary testing and rechecking/reviewing the field bore logs. Laboratory tests included liquid limit & plastic limit (IS: 2720 (P-V) – 1973), natural moisture content (IS: 2720 (P-II) – 1973), bulk & dry densities. Grain size analysis (IS: 2720 (P-IV) – 1985) was performed also on cohesive and non-cohesive soils. Triaxial compression tests (IS: 2720 (P-XI) – 1971) as well as unconfined compression (UC) tests (IS: 2720 (P-X) – 1971) were performed to determine the shear strength characteristics. Oedometer tests were carried out to determine consolidation properties.

Chemical tests on ground water and soil sample were conducted to determine pH {(IS: 3025 (P-11)}, chloride {(IS: 3025 (P-32)} and sulphate {(IS: 3025 (P-24)} content.

After completion of tests, the data have been compiled and the field bore-logs have been reviewed and finalised. Final bore-logs have been presented in this report.

Results of all tests have been presented both in tabular and graphical form as applicable and presented borehole-wise. Results of all boreholes are presented in Appendix – II.

6.0 GROUND CONDITION

Four (04) different soil layers were identified and their successions are given below. Cross sections along with 'N' values have been drawn to visualise disposition and sequence of different layers together with their consistencies.

The sub-surface stratum has been marked in individual bore log and summary of laboratory test results has been prepared in tabular form along with their description for better understanding of each sub-soil stratum.

7.0 PLATE LOAD TEST RESULTS

Bearing Capacity From Plate Load Tests:

Safe Bearing Capacity (SBC) and settlement of foundation given in the above table have been determined using the following formula for cohesive soil:

$$S_f = Sp \times B/b_p$$

Where, B = size of footing in metre
b_p = size of test plate in metre
S_f = Settlement of footing in mm
Sp = settlement of test plate in mm

PLT No.	Soil Type	Depth of Test below EGL (m)	Max Load (Kpa)	Settlement (mm)	
				Gross	Net
PLT-01	Silty Clay	2.50	801.35	40.16	25.92
PLT-02	Silty Clay	2.00	801.35	31.91	24.96
PLT-03	Silty Clay	2.50	801.35	37.12	22.11
PLT-04	Silty Clay	2.50	801.35	27.18	22.32
PLT-05	Silty Clay	2.50	801.35	27.97	20.00

PLT NO.	Yield Load Intensity (Kpa)	Safe Bearing Capacity (SBC) (Kpa)	Settlement of plate(60cmx60cm) in mm under imposed load equal to the SBC	Settlement of prototype footing in mm of size 3m square under an imposed load equal to SBC
PLT-01	550	275	2.97	14.85
PLT-02	435	218	1.90	9.50
PLT-03	530	265	7.50	37.50
PLT-04	485	240	2.55	12.78
PLT-05	370	185	1.60	8.00

8.0 RESULTS AND DYNAMIC PROPERTIES BASED ON CPLT:

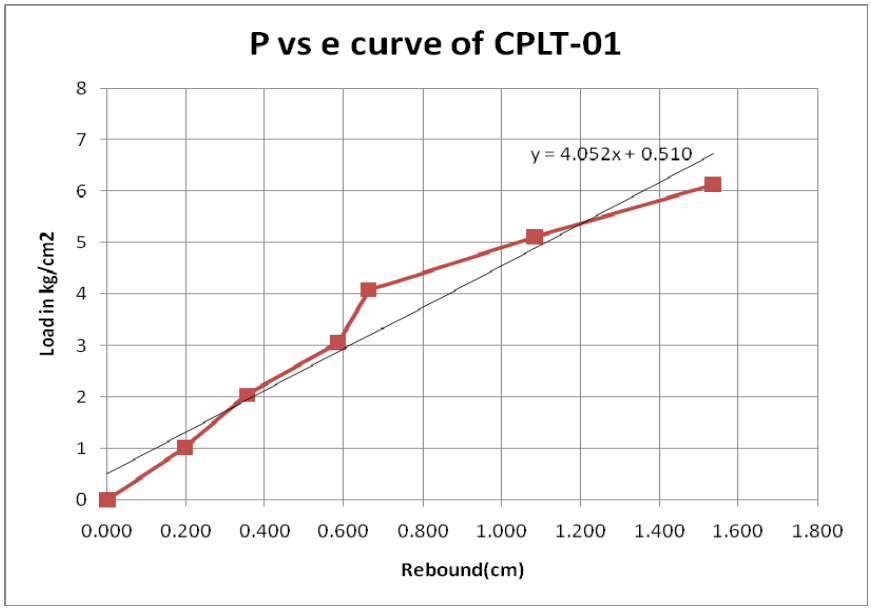
Soil parameters determined from cyclic plate load test are furnished in following table.

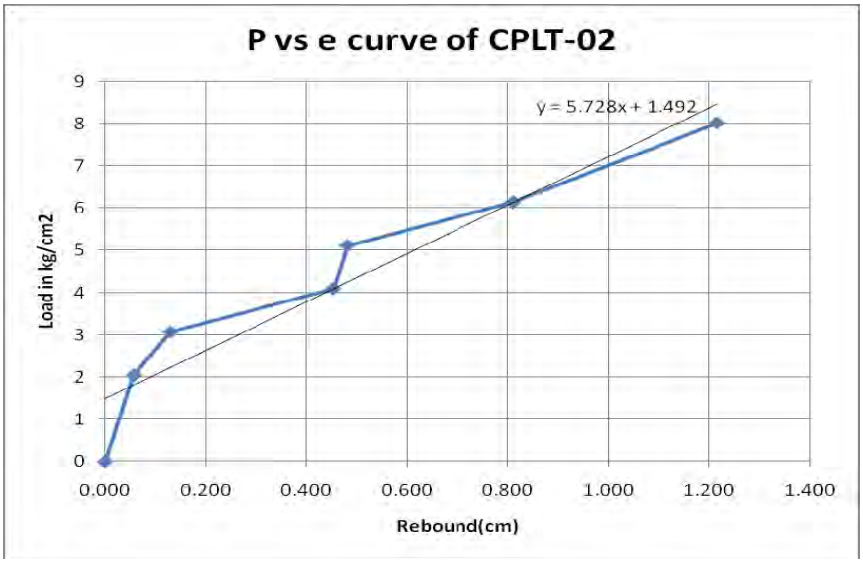
PLT No.	Soil Type	Depth of Test (m)	Max Load (kPa)	Settlement (mm)	
				Gross	Net
CPLT-1	Silty Clay/Clayey Silt	2.50	613.80	40.53	25.17
CPLT-2	Sandy Silty Clay	2.25	801.35	43.36	31.20

PLT NO.	Yield Load Intensity (Kpa)	Safe Bearing Capacity (SBC) (Kpa)	Settlement of plate in mm under imposed load equal to the SBC	Settlement of prototype footing in mm of size 3m square under an imposed load equal to SBC
CPLT-01	360	180	4.85	24.25
CPLT-02	385	190	2.18	10.90

DYNAMIC PROPERTIES OF SOIL FROM CYCLIC PLATE LOAD TEST
(For foundation with base area of 10 m^2)

Cyclic Plate Load Test No. (Unit)	Coefficient of Elastic Uniform Compression C_u Kg/Cm^3	Coefficient of Elastic Uniform Shear C_τ Kg/Cm^3	Coefficient of Elastic Non-`Uniform Compression C_ϕ Kg/Cm^3	Coefficient of Elastic Non-Uniform Shear C_ψ Kg/Cm^3	Young Modulus E Kg/Cm^2	Shear Modulus G Kg/Cm^2
CPLT-01	0.77	0.44	1.52	0.66	171.58	59.17
CPLT-02	1.09	0.62	2.15	0.93	242.21	83.52


P vs e curve of CPLT-01
y = 4.052x + 0.510
Load in kg/cm2
Rebound(cm)
0
1
2
3
4
5
6
7
8
0.000
0.200
0.400
0.600
0.800
1.000
1.200
1.400
1.600
1.800


P vs e curve of CPLT-02
y = 5.728x + 1.492
Load in kg/cm2
Rebound(cm)
0
1
2
3
4
5
6
7
8
9
0.000
0.200
0.400
0.600
0.800
1.000
1.200
1.400

Calculation of Dynamic soil properties from CPLT-01:

Load vs. elastic rebound curve has been prepared graphically from CPLT test data. The co-efficient of elastic uniform compression (C_u) may now be determined as $C_u = P/S_e$

Where, P = Load on plate in kg/cm^2

S_e = Elastic rebound corresponding to load in cm

From load-elastic rebound graph the slope of the load vs rebound is 4.052 kg/cm^3 which is Cu.

The above result should be represented for foundation base area of $10m^2$ following the general practice of presenting dynamic properties of soils and necessary correction for base area has to be been done following IS: 5249-1992.

$C_{u1} = C_u (A/A_1)^{0.5}$

The relation is valid for small variations in base area of the foundations and may be used for area up to $10m^2$. For actual foundation areas larger than $10m^2$, the value of C_u obtained for $10m^2$ may be used.

For the test plate of size 60cm square,

$A = 0.60 \times 0.60 = 0.36m^2$, $A_1 = 10m^2$, $C_u = 4.052$ Kg/cm^3

Therefore, the co-efficient of elastic uniform compression (C_{u1}) for $10m^2$ area is evaluated as: $C_{u1} = 4.052 \times (0.36/10)^{0.5} = 0.77$ kg/cm^3

All the other dynamic properties presented in the above table is calculated based on above result of C_{u1} and following standard relationships presented in IS 5249: 1992.

Coefficient of Elastic Uniform Shear C_τ (kg/cm^3) = C_u/1.5 to 2.0 (Say 1.75) = 0.44 kg/cm^3

Coefficient of Elastic Non-Uniform Compression $C_\varnothing$ (kg/cm^3) = 3.46 C_τ = 1.52 kg/cm3

Coefficient of Elastic Non-Uniform Shear C_ψ (kg/cm^3) = 1.5 C_τ = 0.66 kg/cm^3

Poisson's ratio is considered as = 0.45 (for clayey silt/sandy clayey siltty soil)

Young Modulus E (kg/cm^2) = $\{C_{u1} (1-\mu^2) x A^{0.5}\}/1.13$
= $0.77 \times (1-0.45^2) \times (10 \times 10^4)^{0.5}/1.13$
= 171.58 kg/cm^2

Shear Modulus G (kg/cm^2) = $E/\{2(1+\mu)\}$
= $171.58/2(1+0.45)$
= 59.17 kg/cm^2

9.0 BLOCK VIBRATION TEST RESULTS

One block vibration tests (BVT-1) was carried out following IS: 5429 on a 1.50 m (L) X 0.75 m (B) x 1.00 m (H) high plain cement concrete block of M15 grade. The test was carried out at 2.20 m depth below EGL.

Measured values of amplitudes for vertical vibration at different operating frequency for each set of eccentric angles have been presented in tabular form and plotted. The resonant frequency of vibration (f_n) and resonant amplitude (X_m) in microns have been evaluated and presented in tabular form.

Resonant Frequency and Amplitude:

Sl. No.	Eccentric Angle (Degrees)	Resonant Frequency (RPM)	Resonant Amplitude (Micron)
1	32	2500	171
2	40	2500	180
3	48	2500	200
4	56	2500	220

9.1 Conclusion and Recommendation

Based on the results of block vibration test following dynamic parameters for sub-soil are suggested for foundation contact area of 10 m^2. Estimated dynamic properties are presented in tabular form here under. *Poisson's ratio for the sub-soil at the test beds may be considered as 0.35*.

Sl. No.	Eccentric Angle (Degree)	For 10 m^2 foundation contact area		
		C_u (Kg/Cm^3)	E (Kg/Cm^2)	G (Kg/Cm^2)
1	32	5.87	439	152
2	40	5.87	439	152
3	48	5.87	439	152
4	56	5.87	439	152

Sample Calculation for Dynamic Properties of Soil from Block Vibration Test (BVT-1).

Coefficient of Elastic Uniform Compression (C_u)

According to IS: 5249-1979; Cl. 5.1.1.3

$$C_u = \frac{4.\pi^2.f_{nz}^2.M}{A}$$

Where, C_u = Coefficient of Elastic Uniform Compression
f_{nz} = Resonant frequency (CPS)
M = Mass of block, oscillator and motor (Kg Sec^2/Cm)
A = Contact area of the block with soil (Cm^2)

Size of block = 1.5 m x 0.75 m x 1.00 m
Wt. of block = 2.4 x 1.5 x 0.75 x 1.00 = 2.70 T
Wt. of oscillator & motor = 118 Kg = 0.118 T
Total weight = 2.7 + 0.118 = 2.818 T

Total mass: $M = \frac{2.818 \times 10^3}{981} = 2.873$ Kg Sec^2/Cm

Contact Area = 150 x 75 = 11250 Cm^2

$$\therefore \quad C_u = \frac{4.\pi^2.2.873.f_{nz}^2}{11250} = 10.08 \times 10^{-3}.f_{nz}^2 \quad Kg/Cm^3$$

From the test block, for eccentricity of 48^0 and

Resonant frequency (f_{nz}) = 2500 RPM = 41.7 CPS; C_u = 17.50 Kg/cm^3

Modulus of Elasticity and Shear Modulus (E & G)

According to IS 5249 – 1979, Annex – I

$$E = \frac{C_u(1-\mu^2)\sqrt{A}}{1.13}$$

Considering Poisson's ratio μ = 0.25

$$E = \frac{C_u(1-0.35^2)\sqrt{(150 \times 75)}}{} = 82.365\ C_u\ Kg/Cm^2$$

1.13

For C_u = 17.50 kg/Cm^3; Elastic modulus E = 1441.39 Kg/ Cm^2.

For C_U = 17.50 kg/Cm^3; $G = \frac{E}{2(1+\mu)} = \frac{1441.39}{2 \times 1.35}$ = 534 Kg/ Cm ^{2}

Similarly, C_U, E and G - value for the other eccentric angles have been made and presented in the table above.

Correction for Area

According to Cl. 5.1.1.4 of IS: 5249–1979, the value of '$(C_u)_{test}$' obtained from test block of contact area 'A' should be corrected to actual foundation area A_f as below :-

$(C_u)_{Af} = (C_u)_A \times (A / Af)^{0.5}$

This correction is to be done for contact area upto 10.0 M ^{2} and beyond that same correction factor is to be used.

Correction Factor for 10.0 M ^{2} area:

$$\frac{(C_u)_{10.0\ M^2}}{(C_u)_{test}} = \frac{(E)_{10.0\ M^2}}{(E)_{test}} = \frac{(G)_{10.0\ M^2}}{(G)_{test}}$$

$(C_u)_{10.0\ M^2} = (C_u)_{test} \times \{(1.50 \times 0.75)/ 10.0\}^{0.5} = 0.3354 \times (C_u)_{test}$

Hence, for $(C_u)_{test}$ = 17.50 Kg/Cm^3

$\therefore (C_u)_{10.0\ M^2}$ = 5.87 Kg / Cm^3

for $(E)_{test}$ = 1129.35 Kg/Cm^2

$\therefore (E)_{10.0\ M^2}$ = 483 Kg / Cm^2

for $(G)_{test}$ = 451.74 Kg/Cm^2

$\therefore (G)_{10.0\ M^2}$ = 179 Kg / Cm^2

10.0 RESULTS OBTAINED FROM CROSS HOLE SEISMIC TEST

The following table shows the results as obtained from cross hole seismic test for various stratums.

	Depth (m)	Bulk density (KN/m3)	Mass density	Vp (m/s)	Vs (m/s)	Poisson's Ratio	Youngs Modulus (T/m2)	Rigidity Modulus (T/m2)	Bulk Modulus (T/m2)
CHST-01	2.00	18.5	1.89	518	257	0.34	333000	124557	339937
	3.00	18.5	1.89	558	276	0.34	384436	143655	395640
	4.00	18.5	1.89	560	280	0.33	394264	147849	394264
	5.00	19	1.94	565	267	0.36	374517	138072	434178
	6.00	19	1.94	570.6	250	0.38	334392	121050	469192
	7.00	19	1.94	630	260	0.40	365906	130928	594145
	8.00	19.5	1.99	617	146.8	0.47	125940	42837	699605
	9.00	19.5	1.99	1080	558	0.32	1631376	618919	1493306
	10.00	19.5	1.99	1233	645	0.31	2169330	826961	1919367
	11.00	19.5	1.99	1365	630	0.36	2153286	788945	2651732
	12.00	21	2.14	1420	656	0.36	2513680	921209	3088175
	13.00	21	2.14	1511	666	0.38	2619579	949508	3621404
	14.00	23	2.34	1834	980	0.30	5855234	2251702	4883743
	15.00	23	2.34	2018	1074	0.30	7044413	2704378	5941915
	16.00	23	2.34	2239	1197	0.30	8733505	3359287	7274445
	17.00	23	2.34	2311	1373	0.23	10848199	4419772	6628538
	18.00	23	2.34	2365	1292	0.29	10076116	3913667	7895353
	19.00	23	2.34	2345	1324	0.27	10406544	4109934	7412808
	20.00	23	2.34	2466	1364	0.28	11163249	4362019	8441527
	21.00	23	2.34	2536	1417	0.27	11985881	4707589	8801687
	22.00	23	2.34	2469	1369	0.28	11231542	4394057	8433520
	23.00	23	2.34	2480	1310	0.31	10513319	4023476	9055263
	24.00	23	2.34	2536	1417	0.27	11985881	4707589	8801687
	25.00	23	2.34	2675	1503	0.27	13445631	5296351	9714893

Stratum		Description of Soil	N value	NMC (%)	LL (%)	PL (%)	γ_b Kn/m^3	Shear Parameters		(m_v) m^2/kN×10^{-4} Range(kPa)		
								C (kPa)	Φ^0	25-50	50-100	100-200
IA	12.50, 2.60	Stiff to very stiff brownish grey sandy silty clay. (CH-CI)	17	21.1	47	18	18.6	57	-	1.5	1.57	1.46
IB							19.0	91	-	1.09	1.20	1.14
II 5.00, 1.00		Medium dense brownish yellow silty sand.	30	-	NP	NP	19.0*	-	33*	E=30 MPa* μ = 0.35		
III 6.10, 0.50		Very dense brownish yellow silty sand with mica flakes.	50	-	NP	NP	19.5*	-	35*	E=45 MPa* μ = 0.35		
IVA 5.10, 0.30		Completely weathered decomposed product of rock.	>100	-	-	-	21*	-	37*	E=70 MPa* μ = 0.30		

Stratum	Description of rock	N Value	Core Recovery (%)	RQD (%)	γ_b Kn/m^3	Rock Strength (MPa)	Modulus of Elasticity (MPa)
IVB 7.50, 1.25	Highly weathered rock	37 to >100	24 to 50	0	23*	3.5	E=140 MPa* μ = 0.30
IVC >5.25	Moderately weathered rock.	>100	50 to 96	28 to 96	24*	6.0	E=360 MPa* μ = 0.30

Average Standing Water Level= BGL-1.54m, RL-197.17, * Suggested Value

Generalized Soil & Rock Profile With Design Parameters

JOB NO.30796

SKM Geosurvey

SECTION – III

11.0 ENGINEERING APPRAISAL AND RECOMMENDATION

The proposed structure for this site will be Thermal Power Project. It is expected to have various types of loading. As known from clients the Finished Ground Level of the site will be 203.00m.

Rocky strata are encountered at an average RL of about 190m. For highly loaded structures requiring high bearing capacity within tight settlement open foundations needs to placed within it. But in this situation the depth of foundations rises to about 13.00m below FGL. A water bearing sandy layer (Stratum-II and III) is also encountered at lower depth hence a suitable and constant dewatering technique should also be applicable during excavation for foundations. Considering the above situations we recommend for bored cast in situ piles for moderately to highly loaded structures and open foundations for lightly loaded structures. Safe carrying capacities of various diameters of bored cast in situ piles and aspect of open foundations are discussed below.

Susceptibility of sub soil strata to liquefaction:

Liquefaction is a phenomenon in which a saturated cohesion less soil looses strength during an earthquake and acquires a degree of mobility sufficient to permit significant movements. When sand is not saturated the earthquake may cause significant compaction and subsidence. In general, fine uniform sands are found to be most susceptible for liquefaction in terms of grain size.

In this connection, liquefaction potential of the subsoil has been studied following Simplified Procedure proposed by Idriss & Boulanger (2004) for sandy soil and from "Evaluating the Potential for Liquefaction or Cyclic Failure of silt and clays" by Boulanger and Idriss (2004) for clayey soil. Sambalpur is considered as to fall under Zone-III as per IS 1893 (Part-1): 2016 "Criteria for Earthquake Resistant Design of Structures". Peak horizontal ground acceleration (a_{max}) has been considered as 0.16g for design basis earthquake. Earthquake magnitude is considered as 7.5 for the analysis.

Under the above condition it was observed that the subsoil is not liquefiable under dynamic earthquake loading.

11.1 OPEN FOUNDATIONS

The safe carrying capacity of open foundations placed at various depths considering the soil parameters provided in the generalised subsoil profile at the end of Section-II of this report and using the thickness of individual boreholes.

However if open foundation is thought of then the Safe Bearing Capacities of open foundations placed within rocky strata is given below in the following table.

AREA	Borehole Considered	Width of square footing(m)	At 3.00m below NGL	At 4.50m below NGL	At 6.00m below NGL	At 8.00m below NGL	At 9.00m below NGL
			Net Allowable Bearing Capacity(kPa) considering shear and allowable settlement of 25mm settlement				
Crusher House	BH-01	<=3	152	165	283	300	300
		>3 to <= 6	85	113	174	256	300
Chimney 1	BH-02	<=3	152	165	283	300	300
		>3 to <= 6	84	111	174	256	300
Chimney 2	BH-03	<=3	152	165	177	194	203
		>3 to <= 6	71	80	90	108	118
Boiler 1	BH-04 & BH-05	<=3	243	300	350	450*	450*
		>3 to <= 6	222	300	350	450*	450*
Boiler 2	BH-06 & BH-07	<=3	243	263	283	600*	600*
		>3 to <= 6	156	211	243	600*	600*
Boiler 3	BH-08 & BH-09	<=3	152	165	283	300	300
		>3 to <= 6	96	146	226	300	300
C-Row 1	BH-10	<=3	243	263	450*	450*	450*
		>3 to <= 6	198	233	450*	450*	450*
C-Row 2	BH-11	<=3	243	263	283	350	350
		>3 to <= 6	144	184	243	350	350
A-Raw 1	BH-12	<=3	243	263	350	350*	350*
		>3 to <= 6	181	233	350	350*	350*
A-Raw 2	BH-13	<=3	350	350	450*	450*	450*
		>3 to <= 6	350	350	450*	450*	450*
TG Deck 1	BH-14	<=3	350	350	450*	450*	450*
		>3 to <= 6	350	350	450*	450*	450*
TG Deck 2	BH-15	<=3	350*	450*	450*	450*	450*
		>3 to <= 6	350*	450*	450*	450*	450*
TG Deck 3	BH-16	<=3	152	263	283	350	350
		>3 to <= 6	112	174	237	350	350
Cooling Tower 1	BH-17	<=3	243	263	283	350	350
		>3 to <= 6	136	176	243	350	350
Cooling Tower 2	BH-18	<=3	243	263	350	350	350*
		>3 to <= 6	163	233	350	350	350*
Cooling Tower 3	BH-19	<=3	243	350	350	350	350
		>3 to <= 6	208	350	350	350	350
Reservoir 1	BH-20	<=3	152	263	283	350	450*
		>3 to <= 6	116	188	243	350	450*
Reservoir 2	BH-21	<=3	152	165	283	300	450*
		>3 to <= 6	118	146	243	300	450*
Reservoir 3	BH-22	<=3	152	263	283	300	450*
		>3 to <= 6	120	207	243	300	450*
CHP 1	BH-23	<=3	152	350	350	350	450*
		>3 to <= 6	134	350	350	350	450*
CHP 2	BH-24	<=3	152	263	350	450*	450*
		>3 to <= 6	139	233	350	450*	450*

Ash Silo	BH-25	<=3	152	165	177	194	300
		>3 to <= 6	82	89	101	153	221
Township	BH-26	<=3	152	165	177	450*	450*
		>3 to <= 6	93	128	152	450*	450*
Ash Dyke 1	BH-27	<=3	152	165	283	300	450*
		>3 to <= 6	96	146	218	256	450*
Ash Dyke 2	BH-28	<=3	152	165	350	450*	450*
		>3 to <= 6	103	146	350	450*	450*
Ash Dyke 3	BH-29	<=3	243	263	350	350	450*
		>3 to <= 6	171	233	350	350	450*
Ash Dyke 4	BH-30	<=3	243	263	350	350	450*
		>3 to <= 6	171	233	350	350	450*

* represents that high bearing capacity is due to high depth of foundation and presence of rock at immediate vicinity designing at such bearing capacity may lead to differential settlement hence a lower value is recommended.

SBC FOR FOUNDATIONS WITH IN ROCKY STRATA

Stratum	Depth of Embedment within this stratum	Net Safe bearing capacity(kPa) for settlement within 12mm
IVA	0.50	350
IVB	0.50	450
IVC	0.50	600

The above SBC mentioned for foundations placed over rocky strata is not dependent on the size of the footings.

11.2 PILE FOUNDATIONS

Safe carrying capacities of various diameter bored cast in situ piles considering individual borehole is given below in the following table. However the same must be verified by carrying out load test at site following IS Code of practices.

The common precautions to be maintained at site:

1) Weight of chisel and capacity of operating winch shall be commensurate with diameter of pile, ultimate crushing strength (UCS) of rock, depth of socketing required in rock etc.

2) The bottom of the pile should be properly cleaned to remove rock debris, pile bore soil etc.

AREA	Borehole Considered	Diameter of pile(mm)	PILE TIP RESTING WITHIN ROCK						PILE TIP RESTING WITHIN SOIL				Free Head		Fixed Head	
			Safe Vertical Capacity(KN)		Rock Socketting within Rocky Stratum	Length of Rock Socketting (m) D = Diameter	Bored Length(m)	Shaft Length(m)	Safe Vertical Capacity(KN)		Bored Length(m)	Shaft Length(m)	Depth of fixity (m)	Lateral Capacity (KN)	Depth of fixity (m)	Lateral Capacity (KN)
			Compression	Tension					Compression	Tension						
Crusher House	BH-01	500	1150	500	IVA	6.50	18.50	17.00	450	250	12.00	10.50	3.95	19	4.57	48
		600	1750	750		6.50	18.50	17.00	650	300	12.00	10.50	4.74	22	5.49	58
		750	3000	1100		6.50	18.50	17.00	1000	400	12.00	10.50	5.92	28	6.86	72
Chimney 1	BH-02	500	1200	550	IVA	6.50	20.00	18.50	450	250	12.00	10.50	3.95	19	4.57	48
		600	1800	800		6.50	20.00	18.50	650	300	12.00	10.50	4.74	22	5.49	58
		750	3100	1200		6.50	20.00	18.50	1000	400	12.00	10.50	5.92	28	6.86	72
Chimney 2	BH-03	500	1200	550	IVA	6.50	21.00	19.50	300	200	12.00	10.50	3.95	19	4.57	48
		600	1800	800		6.50	21.00	19.50	375	250	12.00	10.50	4.74	22	5.49	58
		750	3100	1200		6.50	21.00	19.50	500	350	12.00	10.50	5.92	28	6.86	72
Boiler 1	BH-04 & BH-05	500	1050	450	IVB	3 x D	8.50	7.00	Rocky strata is encountered at shallow depth.				3.95	19	4.57	48
		600	1450	700		3 x D	9.00	7.50					4.74	22	5.49	58
		750	2200	1050		3 x D	9.50	8.00					5.92	28	6.86	72
Boiler 2	BH-06 & BH-07	500	1050	500	IVC	2 x D	8.00	6.50					3.95	19	4.57	48
		600	1500	650		2 x D	8.50	7.00					4.74	22	5.49	58
		750	2300	1000		2 x D	9.00	7.50					5.92	28	6.86	72
Boiler 3	BH-08 & BH-09	500	1350	700	IVB	3 x D	18.50	17.00	500	300	12.00	10.50	3.95	19	4.57	48
		600	1900	1000		3 x D	19.00	17.50	700	350	12.00	10.50	4.74	22	5.49	58
		750	2900	1500		3 x D	19.50	18.00	1100	450	12.00	10.50	5.92	28	6.86	72
C-Row 1	BH-10	500	1050	450	IVB	3 x D	7.00	5.50	Rocky strata is encountered at shallow depth.				3.95	19	4.57	48
		600	1450	650		3 x D	7.50	6.00					4.74	22	5.49	58
		750	2300	1000		3 x D	8.00	6.50					5.92	28	6.86	72
C–Row 2	BH-11	500	1100	500	IVB	3 x D	17.00	15.50	500	200	10.50	9.00	3.54	26	4.1	67
		600	1700	700		3 x D	17.50	16.00	750	250	10.50	9.00	4.1	35	4.75	89
		750	2950	1000		3 x D	18.00	16.50	1100	325	10.50	9.00	4.9	49	5.67	127
A-Raw 1	BH-12	500	1100	550	IVB	3 x D	11.50	10.00	350	150	8.00	6.50	3.95	19	4.57	48
		600	1550	700		3 x D	12.00	10.50	500	175	8.00	6.50	4.74	22	5.49	58
		750	2400	1100		3 x D	12.50	11.00	700	200	8.00	6.50	5.92	28	6.86	72
A-Raw 2	BH-13	500	1050	450	IVB	3 x D	7.00	5.50	Rocky strata is encountered at shallow depth.				3.54	26	4.1	67
		600	1450	650		3 x D	7.50	6.00					4.1	35	4.75	89
		750	2300	1000		3 x D	8.00	6.50					4.9	49	5.67	127
TG Deck 1	BH-14	500	1050	450	IVB	3 x D	7.00	5.50					3.54	26	4.1	67
		600	1450	650		3 x D	7.50	6.00					4.1	35	4.75	89
		750	2300	1000		3 x D	8.00	6.50					4.9	49	5.67	127
TG Deck 2	BH-15	500	950	400	IVB	3 x D	5.00	3.50					2.75	55	3.19	142
		600	1350	550		3 x D	5.50	4.00					3.19	74	3.69	190
		750	2150	900		3 x D	6.00	4.50					3.81	105	4.41	272
TG Deck 3	BH-16	500	1250	650	IVB	3 x D	15.50	14.00	450	200	10.00	8.50	3.95	19	4.57	48
		600	1750	900		3 x D	16.00	14.50	650	250	10.00	8.50	4.74	22	5.49	58
		750	2700	1350		3 x D	16.50	15.00	1000	300	10.00	8.50	5.92	28	6.86	72
Cooling Tower 1	BH-17	500	1300	700	IVB	3 x D	16.00	14.50	450	200	10.00	8.50	3.95	19	4.57	48
		600	1800	900		3 x D	16.50	15.00	650	250	10.00	8.50	4.74	22	5.49	58
		750	2700	1350		3 x D	17.00	15.50	1050	350	10.00	8.50	5.92	28	6.86	72
Cooling Tower 2	BH-18	500	1150	550	IVB	3 x D	11.00	9.50	400	150	9.00	7.50	3.95	19	4.57	48
		600	1600	750		3 x D	11.50	10.00	500	200	9.00	7.50	4.74	22	5.49	58
		750	2500	1150		3 x D	12.00	10.50	800	250	9.00	7.50	5.92	28	6.86	72

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AREA	Borehole Considered	Diameter of pile(mm)	PILE TIP RESTING WITHIN ROCK						PILE TIP RESTING WITHIN SOIL				Free Head		Fixed Head	
			Safe Vertical Capacity(KN)		Rock Socketting within Rocky Stratum	Length of Rock Socketting (m) D = Diameter	Bored Length(m)	Shaft Length(m)	Safe Vertical Capacity(KN)		Bored Length(m)	Shaft Length(m)	Depth of fixity (m)	Lateral Capacity (KN)	Depth of fixity (m)	Lateral Capacity (KN)
			Compression	Tension					Compression	Tension						
Cooling Tower 3	BH-19	500	1200	600	IVB	3 x D	12.00	10.50	450	200	10.00	8.50	3.95	19	4.57	48
		600	1650	800		3 x D	12.50	11.00	650	250	10.00	8.50	4.74	22	5.49	58
		750	2550	1200		3 x D	13.00	11.50	950	300	10.00	8.50	5.92	28	6.86	72
Reservoir 1	BH-20	500	1100	550	IVB	3 x D	10.00	8.50	250	150	8.00	6.50	3.95	19	4.57	48
		600	1550	700		3 x D	10.50	9.00	300	175	8.00	6.50	4.74	22	5.49	58
		750	2400	1100		3 x D	11.00	9.50	400	225	8.00	6.50	5.92	28	6.86	72
Reservoir 2	BH-21	500	1100	550	IVB	3 x D	10.50	9.00	250	150	8.50	7.00	3.95	19	4.57	48
		600	1550	700		3 x D	10.50	9.00	300	175	8.50	7.00	4.74	22	5.49	58
		750	2400	1100		3 x D	11.00	9.50	400	225	8.50	7.00	5.92	28	6.86	72
Reservoir 3	BH-22	500	1100	550	IVB	3 x D	10.00	8.50	250	150	8.50	7.00	3.95	19	4.57	48
		600	1550	700		3 x D	10.50	9.00	300	175	8.50	7.00	4.74	22	5.49	58
		750	2400	1100		3 x D	11.00	9.50	400	225	8.50	7.00	5.92	28	6.86	72
CHP 1	BH-23	500	1150	550	IVB	3 x D	10.50	9.00	400	150	8.50	7.00	3.95	19	4.57	48
		600	1550	750		3 x D	11.00	9.50	500	200	8.50	7.00	4.74	22	5.49	58
		750	2450	1150		3 x D	11.50	10.00	750	250	8.50	7.00	5.92	28	6.86	72
CHP 2	BH-24	500	1100	500	IVB	3 x D	9.00	7.50	200	100	7.00	5.50	3.95	19	4.57	48
		600	1500	700		3 x D	9.50	8.00	250	150	7.00	5.50	4.74	22	5.49	58
		750	2350	1050		3 x D	10.00	8.50	350	175	7.00	5.50	5.92	28	6.86	72
Ash Silo	BH-25	500	1150	550	IVA	6.50	18.50	17.00	500	250	12.00	10.50	3.95	19	4.57	48
		600	1750	750		6.50	18.50	17.00	700	300	12.00	10.50	4.74	22	5.49	58
		750	3000	1100		6.50	18.50	17.00	1100	400	12.00	10.50	5.92	28	6.86	72
Township	BH-26	500	1050	500	IVB	3 x D	9.00	7.50	180	120	7.00	5.50	3.95	19	4.57	48
		600	1500	650		3 x D	9.50	8.00	230	140	7.00	5.50	4.74	22	5.49	58
		750	2350	1050		3 x D	10.00	8.50	300	180	7.00	5.50	5.92	28	6.86	72
Ash Dyke 1	BH-27	500	1100	550	IVB	3 x D	10.50	9.00	220	150	8.50	7.00	3.95	19	4.57	48
		600	1550	700		3 x D	11.00	9.50	280	180	8.50	7.00	4.74	22	5.49	58
		750	2400	1100		3 x D	11.50	10.00	370	225	8.50	7.00	5.92	28	6.86	72
Ash Dyke 2	BH-28	500	1100	550	IVB	3 x D	10.00	8.50	225	150	8.00	6.50	3.95	19	4.57	48
		600	1550	700		3 x D	10.50	9.00	300	175	8.00	6.50	4.74	22	5.49	58
		750	2400	1100		3 x D	11.00	9.50	400	225	8.00	6.50	5.92	28	6.86	72
Ash Dyke 3	BH-29	500	1100	550	IVB	3 x D	10.50	9.00	375	150	8.50	7.00	3.95	19	4.57	48
		600	1550	700		3 x D	11.00	9.50	500	175	8.50	7.00	4.74	22	5.49	58
		750	2400	1100		3 x D	11.50	10.00	700	225	8.50	7.00	5.92	28	6.86	72
Ash Dyke 4	BH-30	500	1100	500	IVB	3 x D	10.00	8.50	375	150	8.00	6.50	3.95	19	4.57	48
		600	1550	700		3 x D	10.50	9.00	500	175	8.00	6.50	4.74	22	5.49	58
		750	2400	1100		3 x D	11.00	9.50	700	225	8.00	6.50	5.92	28	6.86	72

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12.0 CHEMICAL ACTION

Results of chemical tests on water and soil samples of the site did not indicate aggressiveness to concrete. Therefore, no special treatment is called for. However, concrete used in construction of foundation should be in line with the provisions of IS: 456 – 2000 with proper control on water – cement ratio. The concrete should be dense.

13.0 Excavations and Dewatering:

Temporary excavation in this terrain would not be problematic and may be carried out providing normal slope between 1V: 1H to 1V: 1.5H, depending on the depths and sizes of the cuts. However, stability of the unsupported slope will depend on the duration of exposure of the cut to the environment. With time, desiccation/shrinkage cracks may appear at the unsupported slope and block failure may occur. Therefore, it is suggested that deep cuts having reasonable long period of exposure to the atmosphere may be adequately supported by properly designed shoring system.

Ground water table at the site was encountered at a level close to the Existing Ground Level. Therefore, inflow of ground water into deep cuts is anticipated. However, pumping from sumps may be adequate for dewatering purpose.

14.0 Suitability of subsoil for construction of Roads & Embankments and for Area Filling:

In the context of this chapter, it would be appropriate to consult relevant guidelines of Indian Roads Congress (IRC) and Specifications of the Ministry of Road Transport and Highways, Government of India for various necessary details for design, construction and testing criteria for construction of embankment.

Special consideration should be made as per IRC guidelines for high embankments.

14.1 COEFFICIENT OF EARTH PRESSURE:

Rankine active (K_a) and passive (K_p) earth pressure coefficients may be obtained from the following equations.

$K_a = (1 - \sin\phi)/(1 + \sin\phi)$ and

$K_p = (1 + \sin\phi)/(1 - \sin\phi)$

The at rest earth pressure coefficient (K_0) may be determined from the Jacky's formula which in simplified form may be represented as

$K_0 = 1 - \sin\phi$

In case of clayey deposits in undrained condition, the Rankine active and passive pressure coefficients may be considered as

$K_a = K_p = 1.0$

The earth pressure at rest for clayey deposits may be considered within 0.5 to 1.0. For normally consolidated clay it may be considered as 0.75 while for over consolidated clay it may be considered as 1.00 (Foundation Design and Construction by M. J. Tomlinson).

Strata wise earth pressure coefficients are presented below.

Strata	Coefficient of earth pressure		
	Active (K_a)	Passive (K_p)	At – rest (K_0)
I	0.75	1.00	1.00
II	0.45	0.29	3.39
III	0.43	0.27	3.70
IVA	0.40	0.25	4.02

Earth pressure for Stratum-IVB & IVC is not included above due to the fact that earth pressure of rocks do not follow either the Rankine or the Coulomb failure wedge. These can only be evaluated based on actual fieldtests.

15.0 GENERAL RECOMMENDATIONS

a. Any soft / loose patch / pockets in foundation bed should be excavated and replaced with lean concrete.

b. The surface of the excavated area should not be left exposed and immediate mud mat must be carried out.

c. The ingress of water will not be problematic however if dewatering is required, it may be carried out by using normal pump and sump.

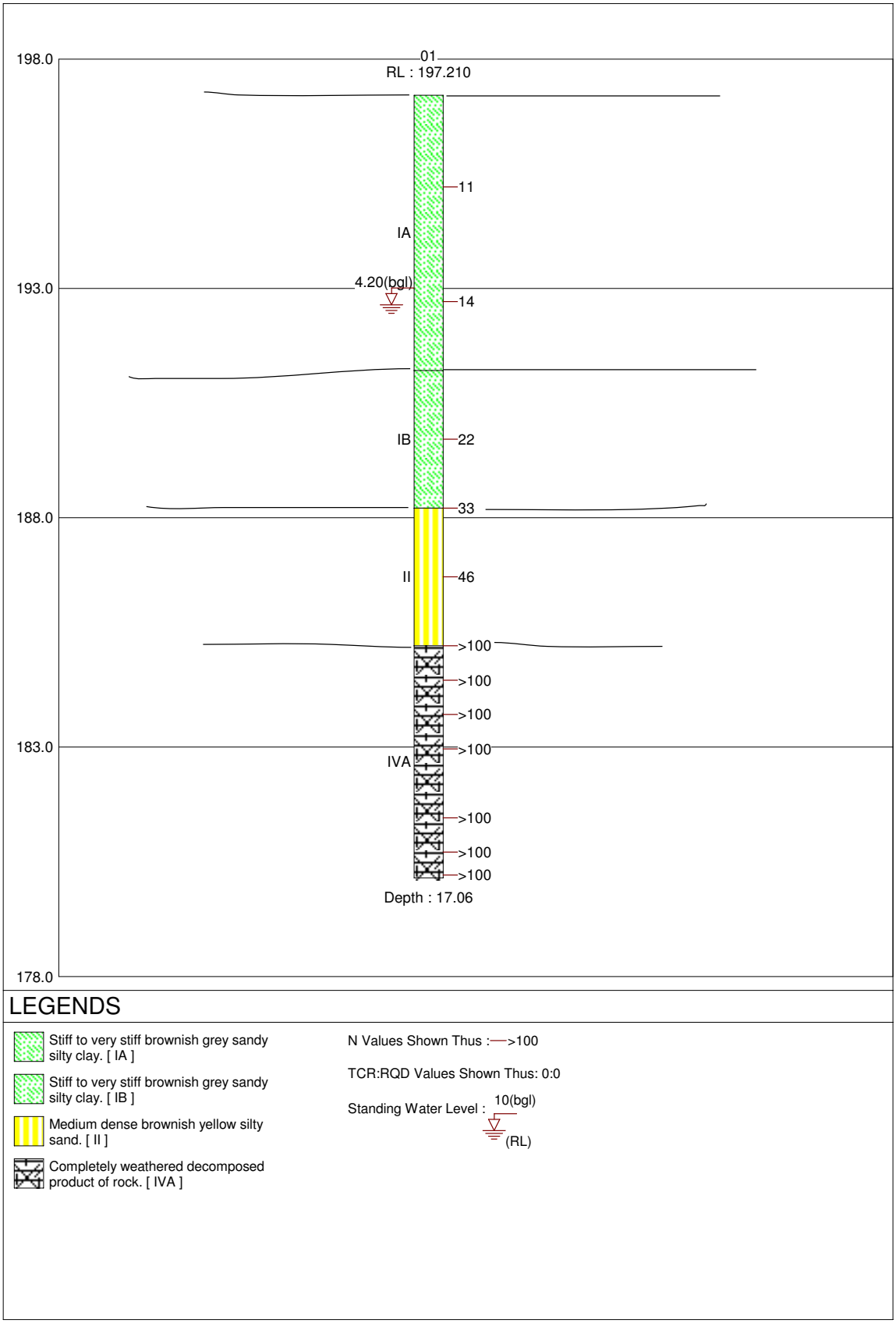
d. It is suggested to carry out the excavation and sub-structures work in the dry season, if possible. Special care needs to be taken during excavation for foundations so that the founding stratum does not get disturbed by excavation process and especially by ground/seepage water.

e. All foundation design should be carried out as per latest BIS code of practices.

f. The foundation bed should be properly shaped, levelled and properly compacted before laying the mud mat and the mud mat should also be compacted.

g. Initial and routine load test of piles should be carried out to as per IS code of practices.

J.Pal
B.Tech, M.E (Geo-tech)



LEGENDS

- Stiff to very stiff brownish grey sandy silty clay. [IA]
- Stiff to very stiff brownish grey sandy silty clay. [IB]
- Medium dense brownish yellow silty sand. [II]
- Completely weathered decomposed product of rock. [IVA]

N Values Shown Thus : —>100

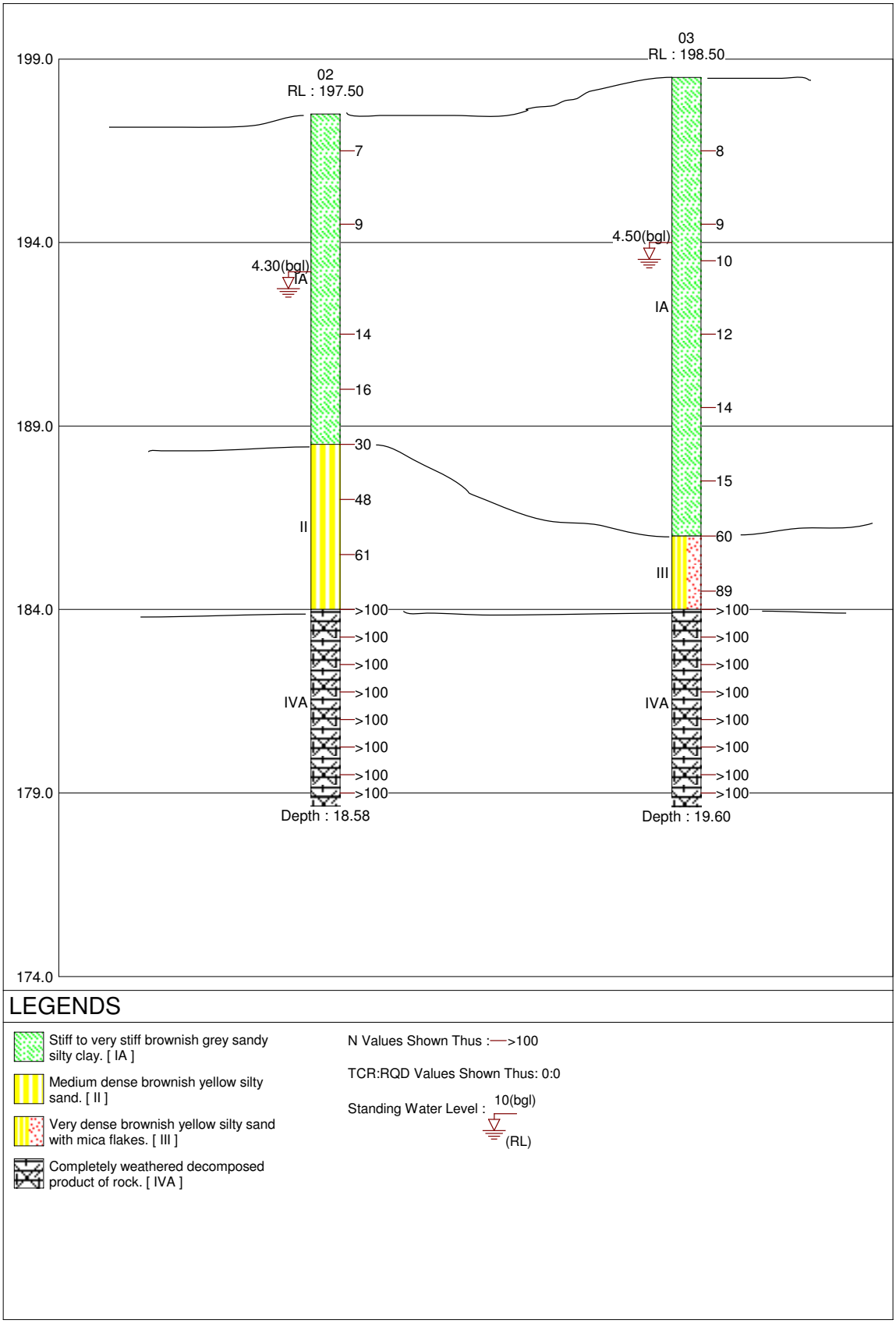
TCR:RQD Values Shown Thus: 0:0

Standing Water Level : 10(bgl) (RL)

CROSS SECTION OF SOIL PROFILE

Job No.: 30796

Sheet



LEGENDS

- Stiff to very stiff brownish grey sandy silty clay. [IA]
- Medium dense brownish yellow silty sand. [II]
- Very dense brownish yellow silty sand with mica flakes. [III]
- Completely weathered decomposed product of rock. [IVA]

N Values Shown Thus : —>100

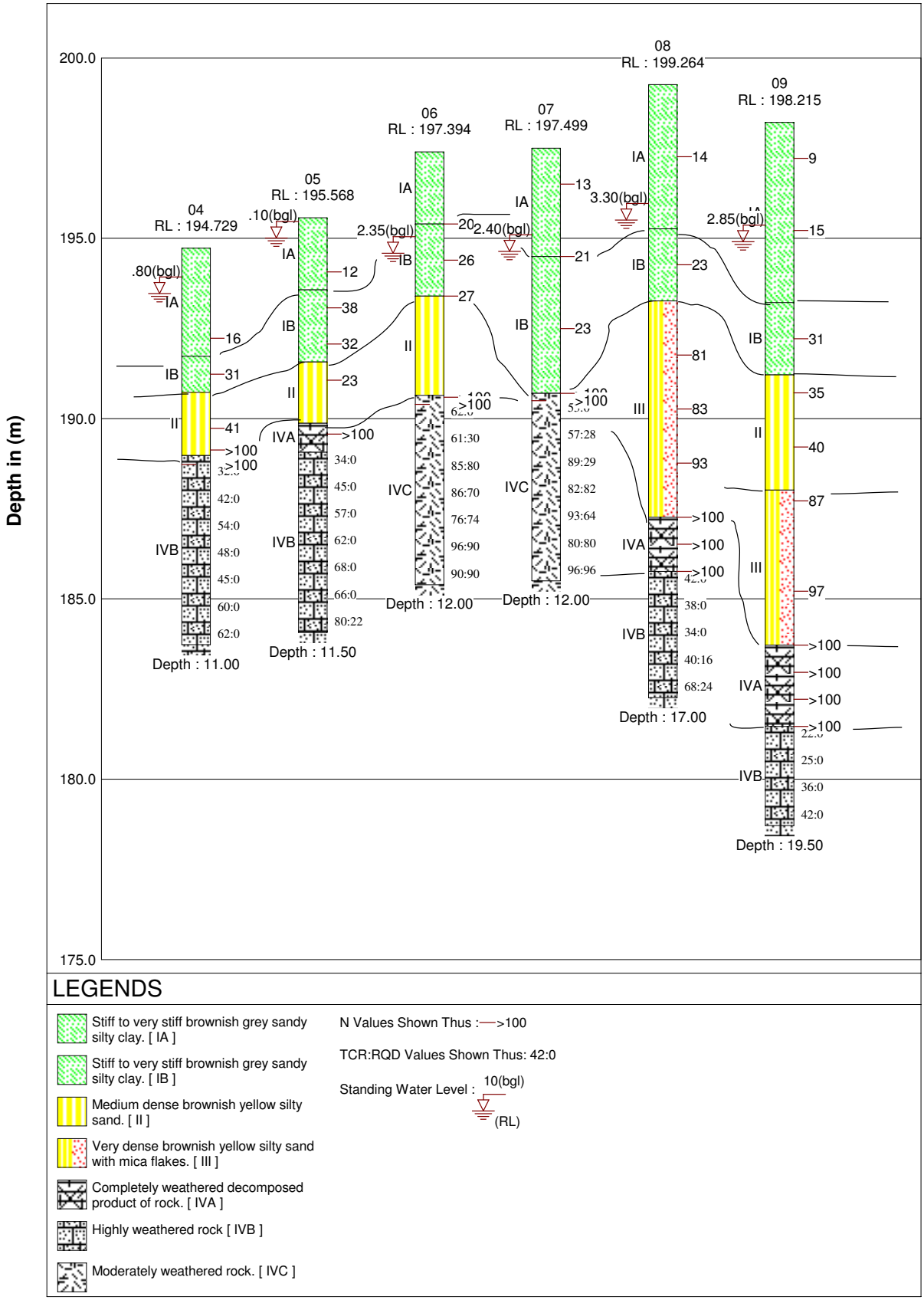
TCR:RQD Values Shown Thus: 0:0

Standing Water Level : 10(bgl) (RL)

CROSS SECTION OF SOIL PROFILE

Job No.: 30796

Sheet



LEGENDS

- Stiff to very stiff brownish grey sandy silty clay. [IA]
- Stiff to very stiff brownish grey sandy silty clay. [IB]
- Medium dense brownish yellow silty sand. [II]
- Very dense brownish yellow silty sand with mica flakes. [III]
- Completely weathered decomposed product of rock. [IVA]
- Highly weathered rock [IVB]
- Moderately weathered rock. [IVC]

N Values Shown Thus : —>100

TCR:RQD Values Shown Thus: 42:0

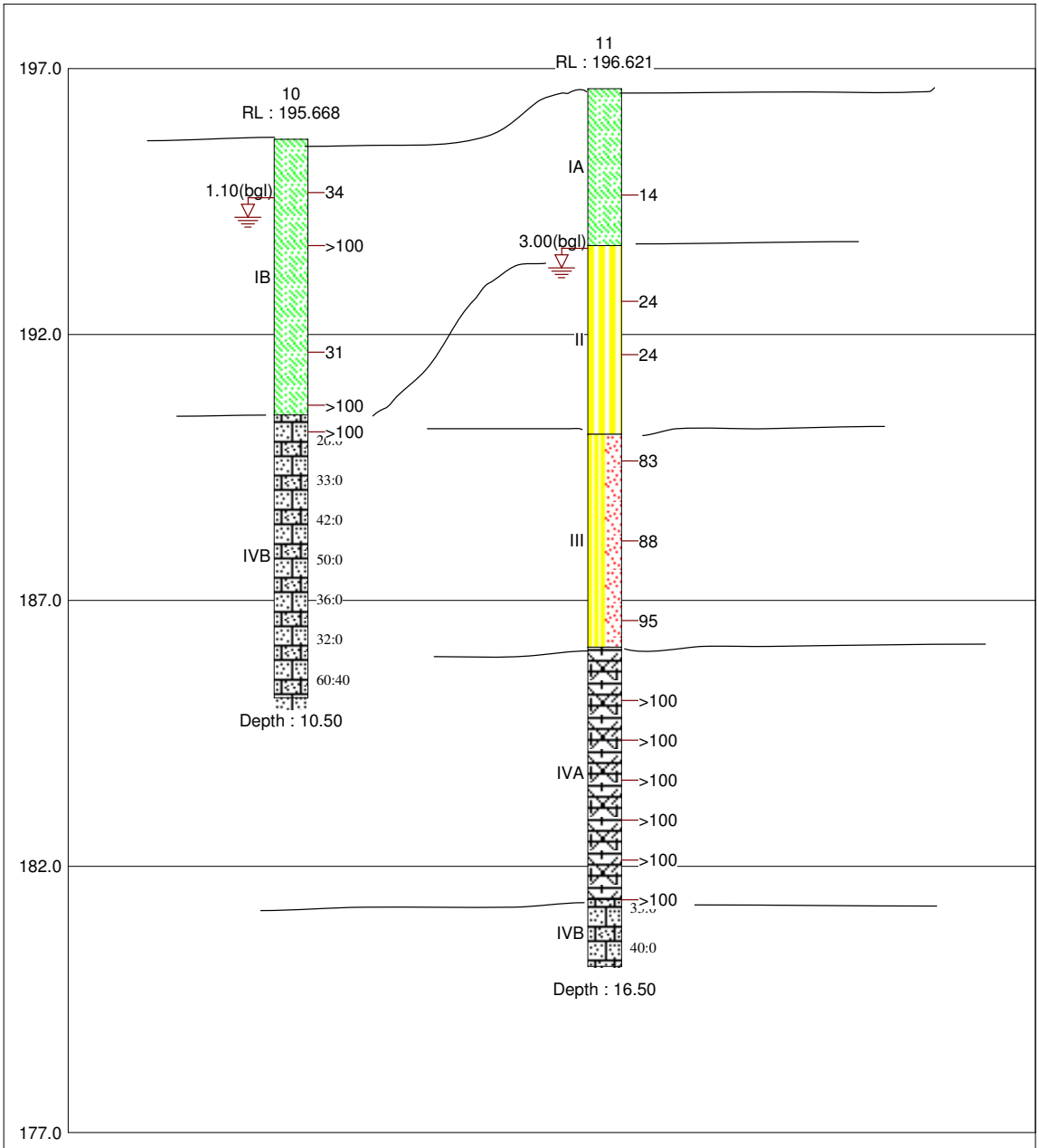
Standing Water Level : 10(bgl)

(RL)

CROSS SECTION OF SOIL PROFILE

Job No.: 30796

Sheet



LEGENDS

- Stiff to very stiff brownish grey sandy silty clay. [IA]
- Stiff to very stiff brownish grey sandy silty clay. [IB]
- Medium dense brownish yellow silty sand. [II]
- Very dense brownish yellow silty sand with mica flakes. [III]
- Completely weathered decomposed product of rock. [IVA]
- Highly weathered rock [IVB]

N Values Shown Thus : —>100

TCR:RQD Values Shown Thus: 40:0

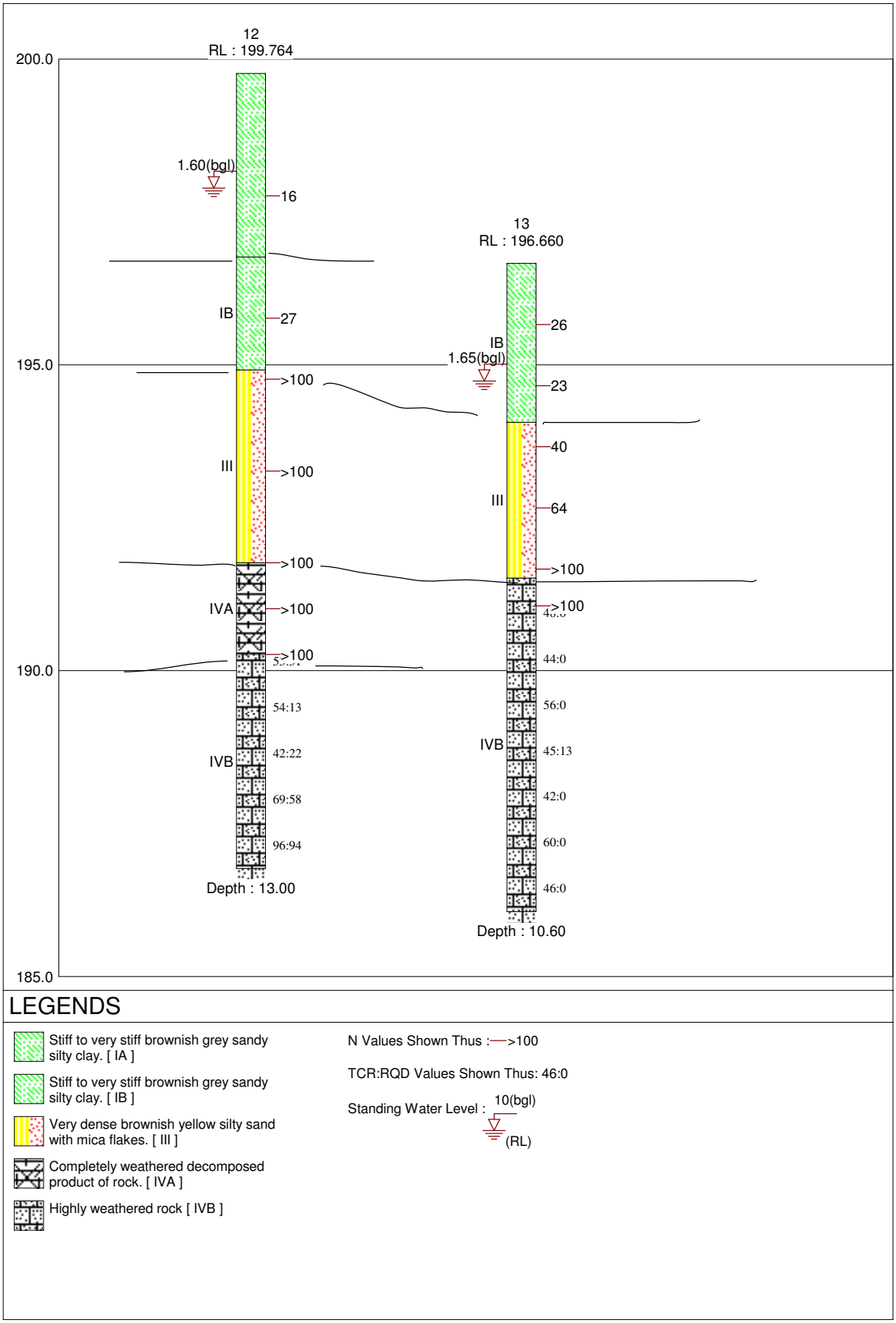
Standing Water Level : 10(bgl)

(RL)

CROSS SECTION OF SOIL PROFILE

Job No.: 30796

Sheet



LEGENDS

- Stiff to very stiff brownish grey sandy silty clay. [IA]
- Stiff to very stiff brownish grey sandy silty clay. [IB]
- Very dense brownish yellow silty sand with mica flakes. [III]
- Completely weathered decomposed product of rock. [IVA]
- Highly weathered rock [IVB]

N Values Shown Thus : —>100

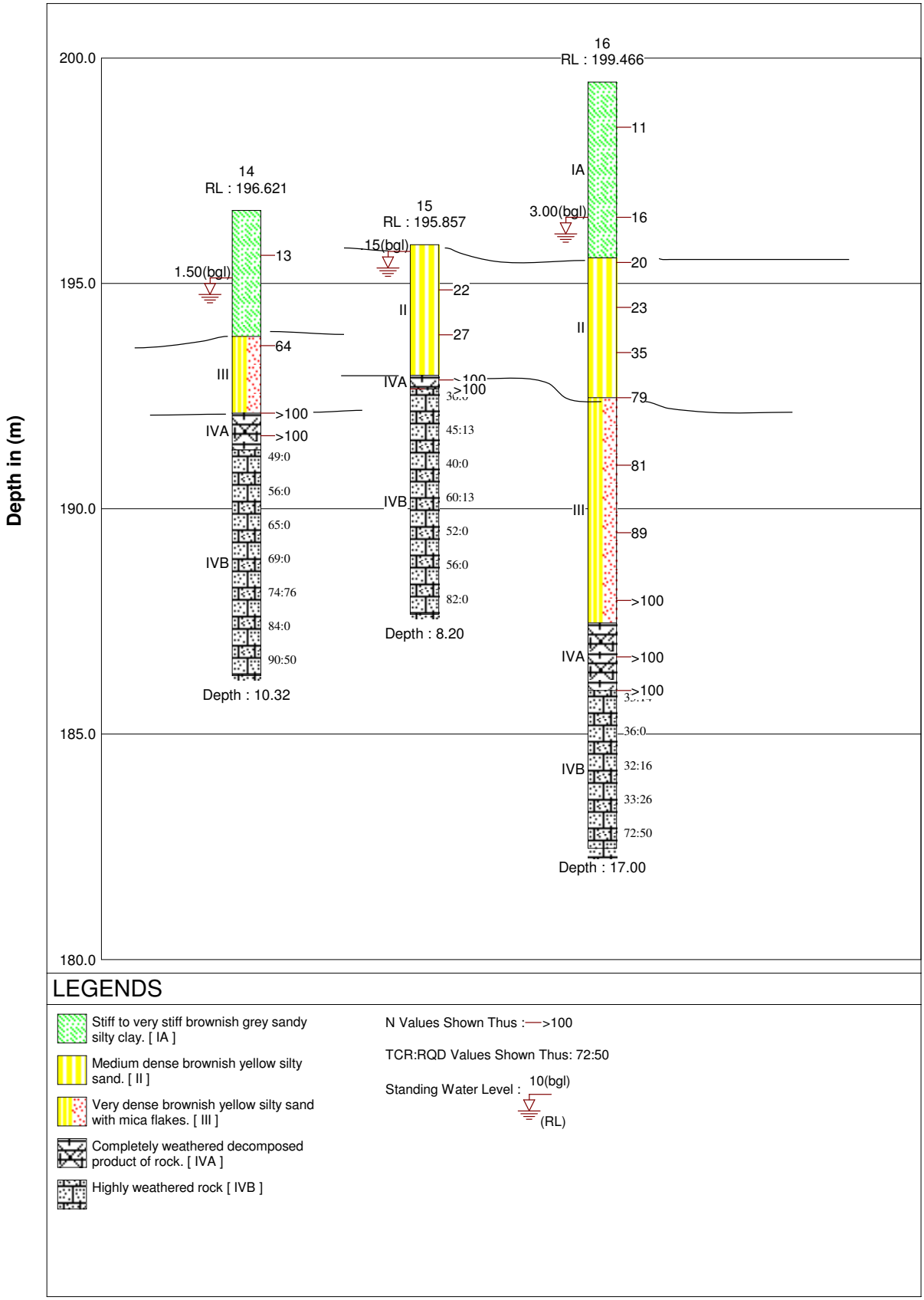
TCR:RQD Values Shown Thus: 46:0

Standing Water Level : 10(bgl) (RL)

CROSS SECTION OF SOIL PROFILE

Job No.: 30796

Sheet



LEGENDS

- Stiff to very stiff brownish grey sandy silty clay. [IA]
- Medium dense brownish yellow silty sand. [II]
- Very dense brownish yellow silty sand with mica flakes. [III]
- Completely weathered decomposed product of rock. [IVA]
- Highly weathered rock [IVB]

N Values Shown Thus : —>100

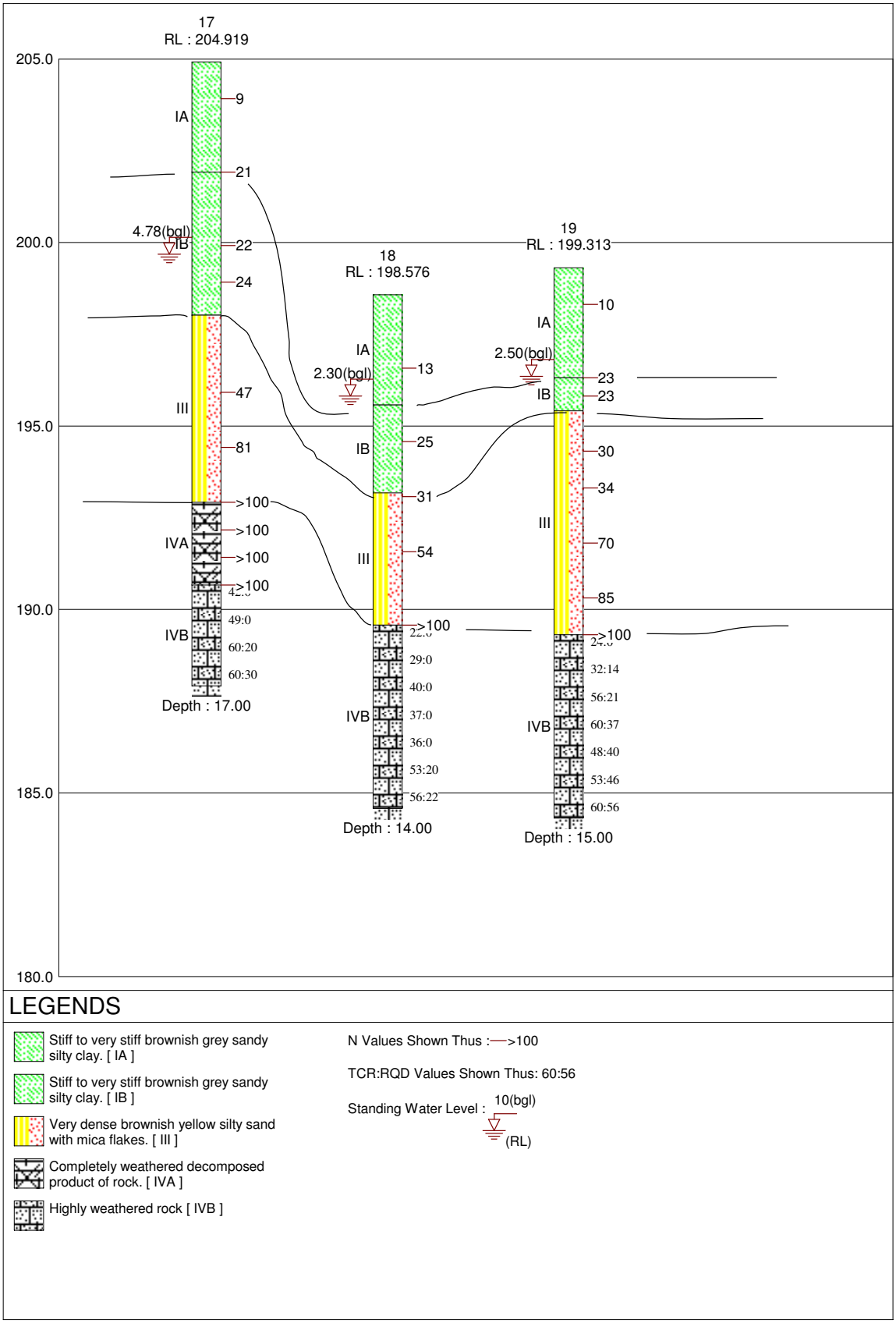
TCR:RQD Values Shown Thus: 72:50

Standing Water Level : 10(bgl) (RL)

CROSS SECTION OF SOIL PROFILE

Job No.: 30796

Sheet



LEGENDS

- Stiff to very stiff brownish grey sandy silty clay. [IA]
- Stiff to very stiff brownish grey sandy silty clay. [IB]
- Very dense brownish yellow silty sand with mica flakes. [III]
- Completely weathered decomposed product of rock. [IVA]
- Highly weathered rock [IVB]

N Values Shown Thus : —>100

TCR:RQD Values Shown Thus: 60:56

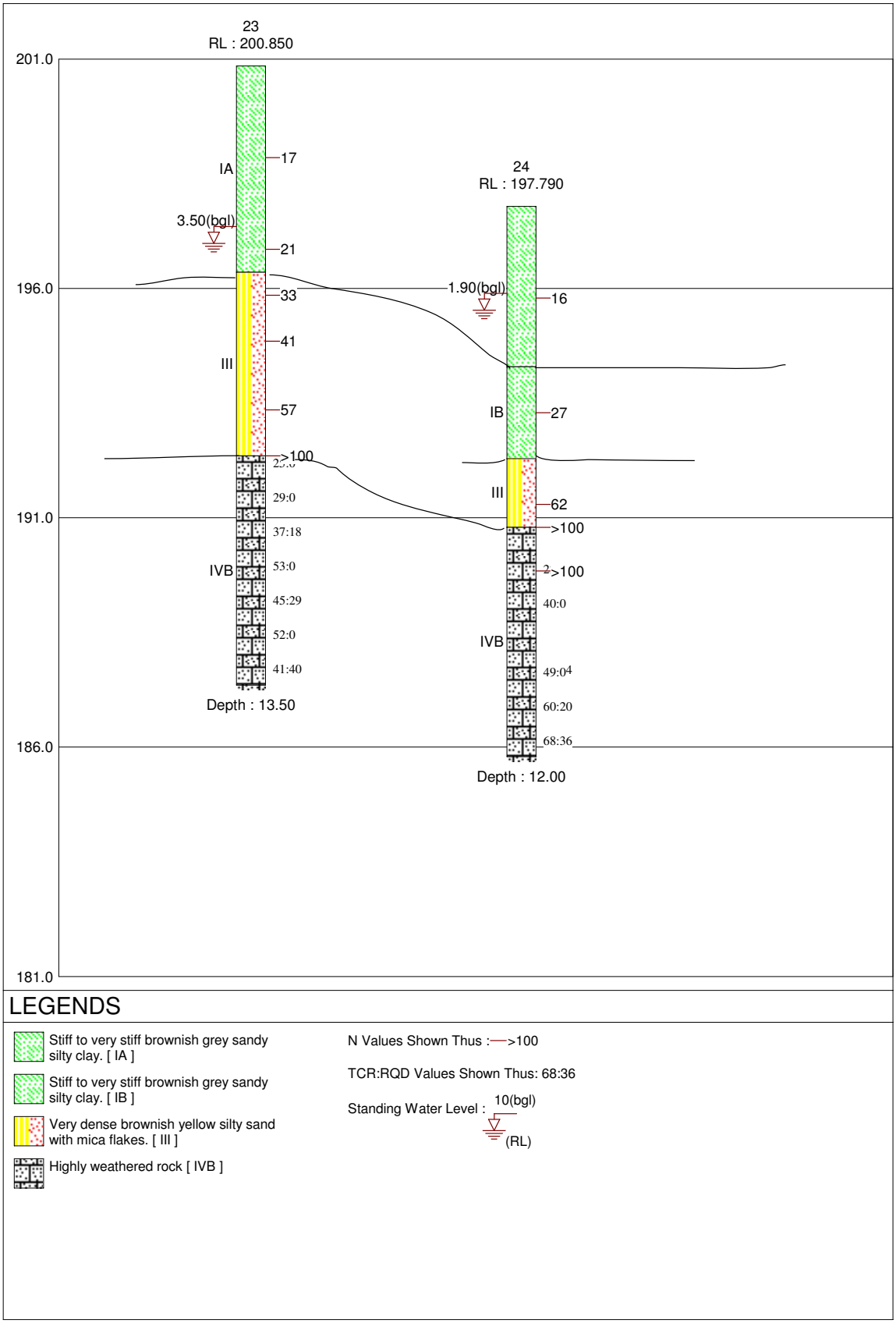
Standing Water Level : 10(bgl)

(RL)

CROSS SECTION OF SOIL PROFILE

Job No.: 30796

Sheet



LEGENDS

- Stiff to very stiff brownish grey sandy silty clay. [IA]
- Stiff to very stiff brownish grey sandy silty clay. [IB]
- Very dense brownish yellow silty sand with mica flakes. [III]
- Highly weathered rock [IVB]

N Values Shown Thus : —>100

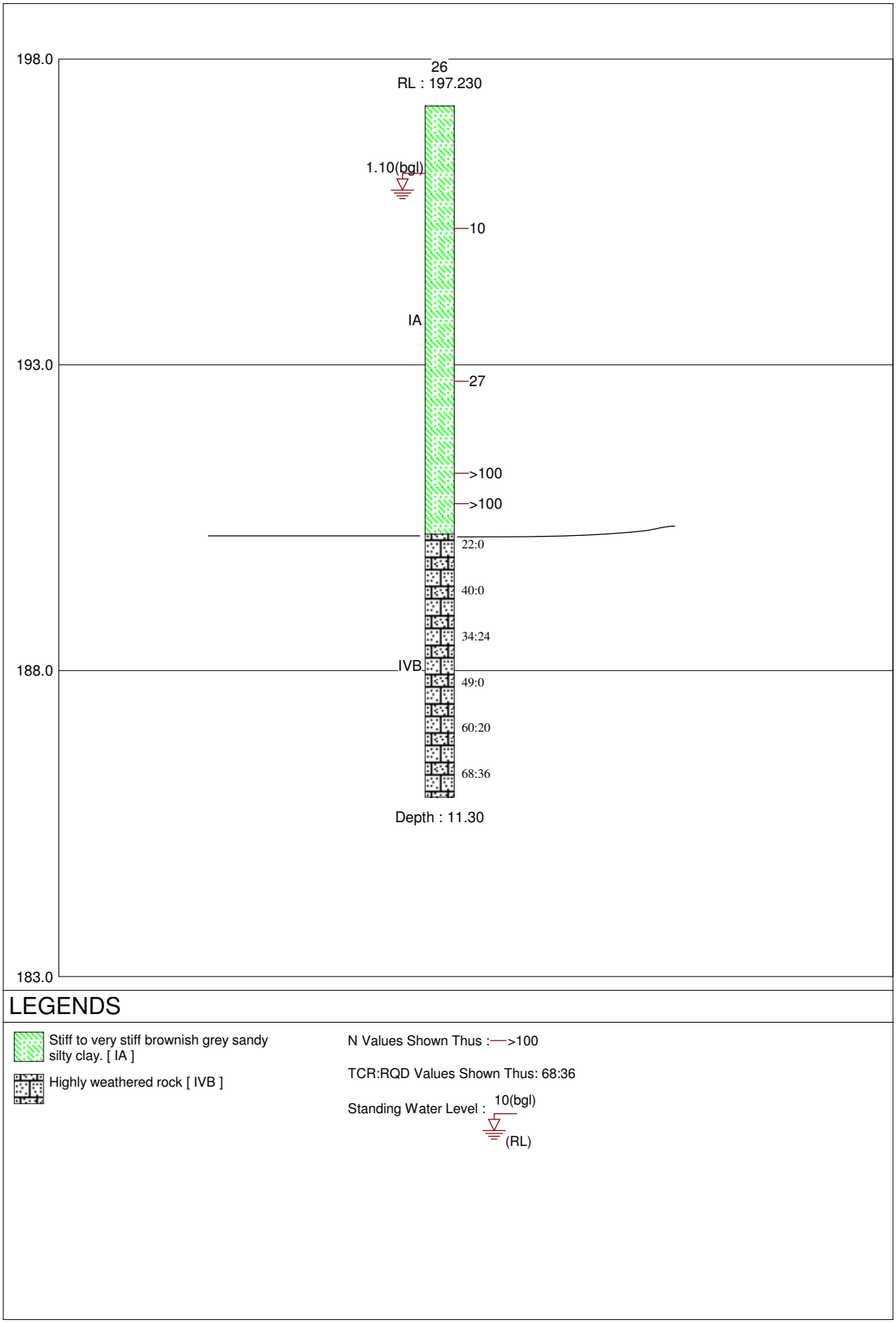
TCR:RQD Values Shown Thus: 68:36

Standing Water Level : 10(bgl) (RL)

CROSS SECTION OF SOIL PROFILE

Job No.: 30796

Sheet



LEGENDS

Stiff to very stiff brownish grey sandy silty clay. [IA]

Highly weathered rock [IVB]

N Values Shown Thus : —>100

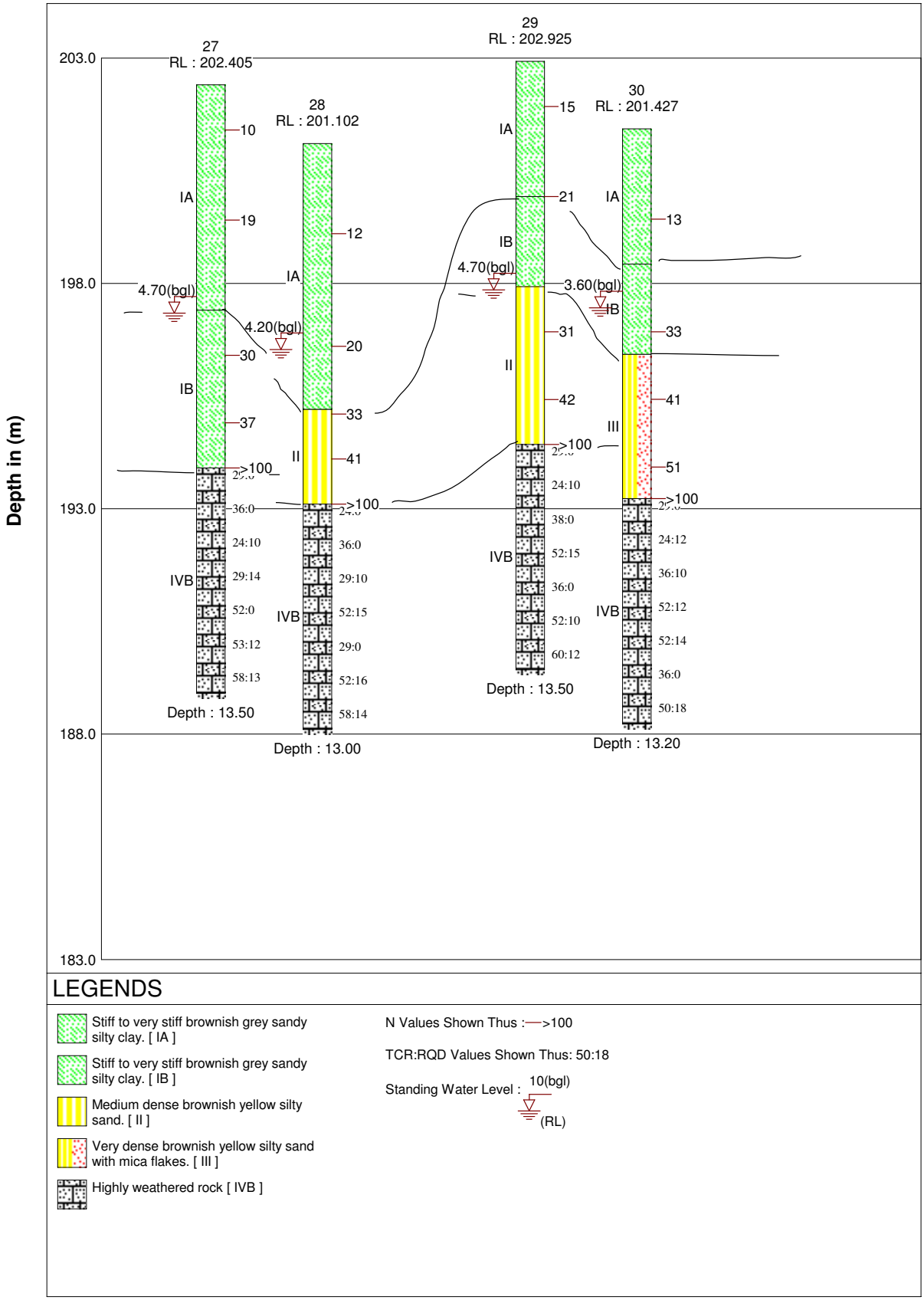
TCR:RQD Values Shown Thus: 68:36

Standing Water Level : 10(bgl) (RL)

CROSS SECTION OF SOIL PROFILE

Job No.: 30796

Sheet



LEGENDS

- Stiff to very stiff brownish grey sandy silty clay. [IA]
- Stiff to very stiff brownish grey sandy silty clay. [IB]
- Medium dense brownish yellow silty sand. [II]
- Very dense brownish yellow silty sand with mica flakes. [III]
- Highly weathered rock [IVB]

N Values Shown Thus : —>100

TCR:RQD Values Shown Thus: 50:18

Standing Water Level : 10(bgl) (RL)

CROSS SECTION OF SOIL PROFILE

Job No.: 30796

Sheet

BORELOG DATA SHEET

Boring Method : Shell Auger & NX Drilling.		**Site : Sambalpur**	**BH : 01**
Boring Diameter : 150 mm & NX			**Sheet : 1 of 2**
Casing Diameter : 150 mm & NX		**Co-Ordinate :E808575, N2411250**	**R.L. : 197.210**
Boring Equipment : Mechanical Cable Tools/NX Drilling.		**Orientation : Vertical**	**Date : 20.08.2018**

Sample In-situ Tests			Casing Depth(M)	N - Value	Date and Depth (m)	Depth (BGL) (m)	Description	R.L.(M)	Log
Depth (m)	Type	No.							
0.50 - 0.50	D	177120							
1.00 - 1.45	U	177121	0.90						
1.50 - 1.50	D	177122	0.90						
2.00 - 2.45	P	177123	1.90	11			Stiff greyish brown silty clay with occasionally a few nodules observed.	IA	
2.50 - 2.50	D	177124	1.90						
3.00 - 3.45	U	177125	2.90						
3.50 - 3.50	D	177126	2.90						
4.50 - 4.95	P	177127	4.40	14					
6.00 - 6.45	U	177128	5.90			6.00		191.21	
6.50 - 6.50	D	177129	5.90				Very stiff greyish brown silty clay with occasionally a few nodules observed.	IB	
7.50 - 7.95	P	177130	7.40	22					
9.00 - 9.45	P	177131	8.90	33		9.00		188.21	
10.50 - 10.95	P	177132	10.40	46			Dense to very dense yellowish grey silty sand with a few mica.	II	
12.00 - 12.35	P	177133	11.90	>100		12.00		185.21	
12.75 - 12.88	P	-	12.20	>100					
13.50 - 13.62	P	-	12.20	>100					
14.25 - 14.35	P	-	12.20	>100					
15.75 - 15.83	P	-		>100			Completely weathered yellowish grey decomposed product of rock.	IVA	
16.50 - 16.57	P	-		>100					
17.00 - 17.06	P	-		>100					
							Continued		

DRILLING

From To (m)	TCR %	RQD %	Water Loss	Color of Ret. Water	N Value
12.00 - 12.75	NIL	NIL	NO	Yelllowish grey	-

Water Level Observation

Date	Time (Hrs.)	W.L.(m) B.G.L.
21.02.2018	17.00	4.00
22.02.2017	17.00	4.20
23.02.2018	17.00	4.20

Remarks:

S.W.L. (m)

4.20

(BGL)

193.01

(RL)

D.D. Supervisor

D- Disturbed Sample
B- Bulk Sample
W- Water Sample
U- Undisturbed sample
P- Standard Penetration Test
V- Vane Test
PC- Cone Penetration Test

Job No: 30796

BORELOG DATA SHEET

Boring Method : Shell Auger & NX Drilling.		**Site : Sambalpur**	**BH : 01**
Boring Diameter : 150 mm & NX			**Sheet : 2 of 2**
Casing Diameter : 150 mm & NX		**Co-Ordinate :E808575, N2411250**	**R.L. : 197.210**
Boring Equipment : Mechanical Cable Tools/NX Drilling.			
DRILLING	**Date and Depth (m)**	**Depth (BGL) (m)**	**Orientation : Vertical**	**Date : 20.08.2018**

From To (m)	TCR %	RQD %	Water Loss	Color of Ret. Water	N Value	Description	R.L.(M)	Log
12.75 - 13.50	NIL	NIL	NO	Yelllowish grey	-			
13.50 - 14.25	NIL	NIL	NO	Yelllowish grey	-			
14.25 - 15.00	NIL	NIL	NO	Yelllowish grey	-			
15.00 - 15.75	NIL	NIL	NO	Yelllowish grey	-		IVA	
15.75 - 16.50	NIL	NIL	NO	Yelllowish grey	-			
16.50 - 17.00	NIL	NIL	NO	Yelllowish grey	-			
						17.06 End of BoreHole	180.15	

Water Level Observation

Date	Time (Hrs.)	W.L.(m) B.G.L.

Remarks:

S.W.L. (m)

4.20

(BGL)

193.01

(RL)

D.D. Supervisor

D- Disturbed Sample
B- Bulk Sample
W- Water Sample
U- Undisturbed sample
P- Standard Penetration Test
V- Vane Test
PC- Cone Penetration Test

Job No: 30796

BORELOG DATA SHEET

Boring Method : Shell Auger & NX Drilling.		**Site : Sambalpur**	**BH : 02**
Boring Diameter : 150 mm & NX			**Sheet : 1 of 3**
Casing Diameter : 150 mm & NX		**Co-Ordinate :E208625, N2411030**	**R.L. : 197.50**
Boring Equipment : Mechanical Cable Tools/NX Drilling.			
		Orientation : Vertical	**Date : 19.02.2018**

Sample In-situ Tests			Casing Depth(M)	N - Value	Date and Depth (m)	Depth (BGL) (m)	Description	R.L.(M)	Log
Depth (m)	Type	No.							
0.50 - 0.50	D	160121							
1.00 - 1.45	P	160122	0.90	7					
1.50 - 1.50	D	160123	1.90						
2.00 - 2.45	U	160124	1.90						
2.50 - 2.50	D	160125	1.90						
3.00 - 3.45	P	160126	2.90	9			Stiff greyish brown silty clay with occasionally a few nodules observed.	IA	
3.50 - 3.50	D	160127	2.90						
4.50 - 4.95	U	160128	4.40						
5.00 - 5.00	D	160129	4.40						
6.00 - 6.45	P	160130	5.90	14					
7.50 - 7.95	P	160131	7.40	16					
9.00 - 9.45	P	160132	8.90	30		9.00		188.50	
10.50 - 10.95	P	160133	10.40	48			Dense to very dense yellowish grey silty sand with a few boulder from 10.00m to 12.50m depth.	II	
12.00 - 12.45	P	160134	11.90	61					
13.50 - 13.60	P	160135	13.40	>100		13.50		184.00	
14.25 - 14.38	P	-	13.70	>100					
15.00 - 15.12	P	-	13.70	>100					
15.75 - 15.87	P	-	13.70	>100					
16.50 - 16.61	P	-		>100			Completely weathered yellowish grey decomposed product of rock.	IVA	
17.25 - 17.34	P	-		>100					
18.00 - 18.09	P	-		>100					
18.50 - 18.58	P	-		>100					
							Continued		

Water Level Observation

Date	Time (Hrs.)	W.L.(m) B.G.L.
19.02.2018	17.00	3.20
20.02.2018	17.00	4.30
21.02.2018	17.00	4.30

Remarks:

S.W.L. (m)

4.30

(BGL)

193.20

(RL)

D- Disturbed Sample
B- Bulk Sample
W- Water Sample
U- Undisturbed sample
P- Standard Penetration Test
V- Vane Test
PC- Cone Penetration Test

D.D. Supervisor

Job No: 30796

BORELOG DATA SHEET

Boring Method : Shell Auger & NX Drilling.		**Site : Sambalpur**	**BH : 02**
Boring Diameter : 150 mm & NX			**Sheet : 2 of 3**
Casing Diameter : 150 mm & NX		**Co-Ordinate :E208625, N2411030**	**R.L. : 197.50**
Boring Equipment : Mechanical Cable Tools/NX Drilling.			
DRILLING	**Date and Depth (m)**	**Depth (BGL) (m)**	**Orientation : Vertical**	**Date : 19.02.2018**

From To (m)	TCR %	RQD %	Water Loss	Color of Ret. Water	N Value	Description	R.L.(M)	Log
13.50 - 14.25	NIL	NIL	NO	Greyish Yellow	-			
14.25 - 15.00	NIL	NIL	NO	Greyish Yellow	-			
15.00 - 15.75	NIL	NIL	NO	Greyish Yellow	-			
15.75 - 16.50	NIL	NIL	NO	Greyish Yellow	-		IVA	
16.50 - 17.25	NIL	NIL	NO	Greyish Yellow	-			
17.25 - 18.00	NIL	NIL	NO	Greyish Yellow	-			
18.00 - 18.50	NIL	NIL	NO	Greyish Yellow	-			
						18.58 End of BoreHole	178.92	

Water Level Observation		
Date	Time (Hrs.)	W.L.(m) B.G.L.

Remarks:

S.W.L. (m)

4.30

(BGL)

193.20

(RL)

D.D. Supervisor

- D- Disturbed Sample
- B- Bulk Sample
- W- Water Sample
- U- Undisturbed sample
- P- Standard Penetration Test
- V- Vane Test
- PC- Cone Penetration Test

Job No: 30796

BORELOG DATA SHEET

Boring Method : Shell Auger & NX Drilling.		**Site :** Sambalpur	**BH** : 03
Boring Diameter : 150 mm & NX			**Sheet** : 1 of 2
Casing Diameter : 150 mm & NX		**Co-Ordinate :** E808685, N241080.30	**R.L.** : 198.50
Boring Equipment : Mechanical Cable Tools/NX Drilling.		**Orientation :** Vertical	**Date** : 21.01.2018

Sample In-situ Tests			Casing Depth(M)	N - Value	Date and Depth (m)	Depth (BGL) (m)	Description	R.L.(M)	Log
Depth (m)	Type	No.							
0.50 - 0.50	D	100868							
1.00 - 1.45	U	100869	0.90						
1.50 - 1.50	D	100870	0.90						
2.00 - 2.45	P	100871	1.90	8					
2.50 - 2.50	D	100872	1.90						
3.00 - 3.45	U	100873	2.90						
3.50 - 3.50	D	100874	2.90				Stiff brownish grey to dark grey silty clay with occasionally black spots and a few small nodules.	IA	
4.00 - 4.45	P	100875	3.90	9					
5.00 - 5.45	P	100876	4.90	10					
6.00 - 6.45	U	100877	5.90						
7.00 - 7.45	P	100878	6.90	12					
8.00 - 8.45	U	100879	7.90						
9.00 - 9.45	P	100880	8.90	14					
11.00 - 11.45	P	100881	10.90	15					
						12.50		186.00	
12.50 - 12.95	P	100882	12.40	60			Very dense brownish grey silty sand with a few nodules and clay lump observed.	III	
14.00 - 14.45	P	100883	13.90	89					
						14.50		184.00	
14.50 - 14.75	P	100884	13.90	>100					
15.25 - 15.35	P	-	17.40	>100					
16.00 - 16.09	P	-	17.40	>100					
16.75 - 16.83	P	-	17.40	>100			Completely weathered whitish grey decomposed product of rock.	IVA	
17.50 - 17.60	P	-	17.40	>100					
18.25 - 18.34	P	-	17.40	>100					
							Continued		

Water Level Observation

Date	Time (Hrs.)	W.L.(m) B.G.L.
23.01.2018	17.00	5.50
24.01.2018	16.50	4.60
25.01.2018	17.00	4.50
26.01.2018	17.00	4.50

Remarks:

S.W.L. (m)

4.50

(BGL)

194.00

(RL)

D.D.

Supervisor

D- Disturbed Sample
B- Bulk Sample
W- Water Sample
U- Undisturbed sample
P- Standard Penetration Test
V- Vane Test
PC- Cone Penetration Test

Job No: 30796

BORELOG DATA SHEET

Boring Method : Shell Auger & NX Drilling.		**Site : Sambalpur**	**BH : 03**
Boring Diameter : 150 mm & NX			**Sheet : 2 of 2**
Casing Diameter : 150 mm & NX		**Co-Ordinate :E808685, N241080.30**	**R.L. : 198.50**
Boring Equipment : Mechanical Cable Tools/NX Drilling.			
Sample In-situ Tests	**Casing Depth(M)** / **N - Value**	**Orientation : Vertical**	**Date : 21.01.2018**

Depth (m)	Type	No.	Casing Depth(M)	N - Value	Date and Depth (m)	Depth (BGL) (m)	Description	R.L.(M)	Log
19.00 - 19.05	P	-	17.40	>100					
19.50 - 19.60	P	-	17.40	>100					

DRILLING

From To (m)	TCR %	RQD %	Water Loss	Color of Ret. Water	N Value
14.50 - 15.25	NIL	NIL	NO	Whitish grey	-
15.25 - 16.00	NIL	NIL	NO	Whitish grey	-
16.00 - 16.75	NIL	NIL	NO	Whitish grey	-
16.75 - 17.50	NIL	NIL	NO	Whitish grey	-
17.50 - 18.25	NIL	NIL	NO	Whitish grey	-
18.25 - 19.00	NIL	NIL	NO	Whitish grey	-
19.00 - 19.50	NIL	NIL	NO	Whitish grey	-

IVA

19.60 — End of BoreHole — 178.90

Water Level Observation

Date	Time (Hrs.)	W.L.(m) B.G.L.

Remarks:

S.W.L. (m)

4.50 (BGL)

194.00 (RL)

D.D. Supervisor

D- Disturbed Sample
B- Bulk Sample
W- Water Sample
U- Undisturbed sample
P- Standard Penetration Test
V- Vane Test
PC- Cone Penetration Test

Job No: 30796

BORELOG DATA SHEET

Boring Method : Shell Auger & NX Drilling.		**Site :** Sambalpur	**BH** : 04
Boring Diameter : 150 mm & NX			**Sheet** : 1 of 4
Casing Diameter : 150 mm & NX		**Co-Ordinate :** E808970, N241130	**R.L.** : 194.729
Boring Equipment : Mechanical Cable Tools/NX Drilling.		**Orientation :** Vertical	**Date** : 13.11.2018

Sample In-situ Tests			Casing Depth(M)	N - Value	Date and Depth (m)	Depth (BGL) (m)	Description	R.L.(M)	Log
Depth (m)	Type	No.							
0.50 - 1.00	D	100900							
1.00 - 1.00	D	100901	0.90						
1.50 - 1.95	U	100902	1.40				Stiff brownish grey silty clay to clayey silt with silt lamination and shale rock fragments below 3.00m depth.	IA	
2.00 - 2.00	D	100903	1.40						
2.50 - 2.95	P	100904	2.40	16					
3.00 - 3.00	D	100905	2.40						
3.50 - 3.95	P	100906	3.40	31		3.00		191.73	
4.00 - 4.00	D	100907	3.40				Very stiff brownish grey silty clay to clayey silt with silt lamination and shale rock fragments below 3.00m depth.	IB	
5.00 - 5.45	P	100908	4.90	41		4.00		190.73	
5.60 - 5.80	P	100909	5.50	>100			Dense brownish grey silty sand.	II	
6.00 - 6.05	P	100910	5.50	>100		5.75		188.98	

DRILLING

From To (m)	TCR %	RQD %	Water Loss	Color of Ret. Water	N Value
6.00 - 6.75	32	NIL	NO	Dark yellowish	-
6.75 - 7.50	42.67	NIL	NO	Dark yellowish	-
7.50 - 8.25	54.67	NIL	NO	Dark yellowish	-
8.25 - 9.00	48.00	NIL	NO	Dark yellowish	-
9.00 - 9.75	45.33	NIL	NO	Dark yellowish	-
9.75 - 10.50	60.00	NIL	NO	Dark yellowish	-
10.50 - 11.00	62.00	NIL	NO	Dark yellowish	-

Highly to moderately weathered dark grey rock with water mark and occasionally silty sand lamination observed. — IVB

11.00 — End of BoreHole — 183.73

Water Level Observation

Date	Time (Hrs.)	W.L.(m) B.G.L.

Remarks:

S.W.L. (m)

0.80

(BGL)

(RL)

D.D. Supervisor

D- Disturbed Sample
B- Bulk Sample
W- Water Sample
U- Undisturbed sample
P- Standard Penetration Test
V- Vane Test
PC- Cone Penetration Test

Job No: 30796

BORELOG DATA SHEET

Boring Method : Shell Auger & NX Drilling.		**Site : Sambalpur**	**BH : 05**
Boring Diameter : 150 mm & NX			**Sheet : 1 of 5**
Casing Diameter : 150 mm & NX		**Co-Ordinate :E809045.00, N2411080.00**	**R.L. : 195.568**
Boring Equipment : Mechanical Cable Tools/NX Drilling.		**Orientation : Vertical**	**Date : 23.12.2017**

Sample In-situ Tests			Casing Depth(M)	N - Value	Date and Depth (m)	Depth (BGL) (m)	Description	R.L.(M)	Log
Depth (m)	Type	No.							
0.50 - 0.50	D	100451							
1.00 - 1.00	D	100452					Stiff brownish grey to dark grey silty clay to clayey silt with high % silt lamination and concreation with high % shale fragments at lower depth.	IA	
1.50 - 1.95	P	100453	1.40	12					
2.00 - 2.00	D	100454	1.90						
2.50 - 2.95	P	100455	2.40	38		2.00		193.57	
3.00 - 3.00	D	100456	2.90				Very stiff brownish grey to dark grey silty clay to clayey silt with high % silt lamination and concreation with high % shale fragments at lower depth.	IB	
3.50 - 3.95	P	100457	3.40	32					
4.00 - 4.00	D	100458	3.90						
4.50 - 4.95	P	100459	4.40	23		4.00		191.57	
5.00 - 5.00	D	100460	4.90				Medium dense brownish yellow residual soil comprised of clayey silty sand.	II	
5.50 - 5.50	D	100461	5.40						
6.00 - 6.30	P	100462	5.90	>100	23.12.2017	5.70	Completely weathered dark grey decomposed product of rock,	189.87 IVA	
					6.00	6.50		189.07	

DRILLING

From To (m)	TCR %	RQD %	Water Loss	Color of Ret. Water	N Value
6.50 - 7.25	34.66	NIL	NO	Dark grey	-
7.25 - 8.00	45.33	NIL	NO	Dark grey	-
8.00 - 8.75	57.33	NIL	NO	Dark grey	-
8.75 - 9.50	62.66	NIL	NO	Dark grey	-
9.50 - 10.25	68.00	NIL	NO	Dark grey	-
10.25 - 11.00	66.67	NIL	NO	Dark grey	-
11.00 - 11.50	80.00	22.00	NO	Dark grey	-

Highly to moderately weathered dark grey rock. — IVB

11.50 — End of BoreHole — 184.07

Water Level Observation

Date	Time (Hrs.)	W.L.(m) B.G.L.
28.12.2017	17.00	0.20

Remarks:

S.W.L. (m)
0.10
(BGL)

(RL)

D.D.
Supervisor

D- Disturbed Sample
B- Bulk Sample
W- Water Sample
U- Undisturbed sample
P- Standard Penetration Test
V- Vane Test
PC- Cone Penetration Test

Job No: 30796

BORELOG DATA SHEET

Boring Method : Shell Auger & NX Drilling.		**Site : Sambalpur**	**BH : 06**
Boring Diameter : 150 mm & NX			**Sheet : 1 of 6**
Casing Diameter : 150 mm & NX		**Co-Ordinate :E808975, N241097.90**	**R.L. : 197.394**
Boring Equipment : Mechanical Cable Tools/NX Drilling.			
Sample In-situ Tests	**Casing Depth(M)**	**Orientation : Vertical**	**Date : 16.01.2018**

Depth (m)	Type	No.	N - Value	Date and Depth (m)	Depth (BGL) (m)	Description	R.L.(M)	Log
0.50 - 0.50	D	105111						
1.00 - 1.45	U	105112	0.90			Stiff brownish grey to dark grey silty clay to clayey silt with high % silt lamination and concreation with high % shale fragments at lower depth.	IA	
1.50 - 1.50	D	105113	0.90					
2.00 - 2.45	P	105114	1.90	20	2.00		195.39	
2.50 - 2.50	D	105115	1.90			Very stiff greyish brown clayey silt with grey patches and high % of nodules and low % of sand.	IB	
3.00 - 3.45	P	105116	2.90	26				
3.50 - 3.50	D	105117	2.90					
4.00 - 4.45	P	105118	3.90	27	4.00		193.39	
5.00 - 5.00	D	105119	3.90			Medium dense greyish brown silty sand.	II	
6.80 - 6.92	P	105120	6.50	>100	6.75		190.64	
7.00 - 7.05	P	105121	6.90	>100				

DRILLING

From To (m)	TCR %	RQD %	Water Loss	Color of Ret. Water	N Value
7.00 - 7.75	62.67	NIL	NO	Greyish yellow	-
7.75 - 8.50	61.33	30.67	NO	Greyish yellow	-
8.50 - 9.25	85.33	80.00	NO	Greyish yellow	-
9.25 - 10.00	86.66	70.66	NO	Greyish yellow	-
10.00 - 10.75	76.00	74.67	NO	Greyish yellow	-
10.75 - 11.50	96.00	90.00	NO	Greyish yellow	-
11.50 - 12.00	90.00	90.00	NO	Greyish yellow	-

Moderately to slightly weathered greyish yellow rock. — IVC

12.00 — End of BoreHole — 185.39

Water Level Observation

Date	Time (Hrs.)	W.L.(m) B.G.L.
20.01.2018	17.00	2.35

Remarks:

S.W.L. (m)
2.35
(BGL)
195.04
(RL)

D.D. Supervisor

D- Disturbed Sample
B- Bulk Sample
W- Water Sample
U- Undisturbed sample
P- Standard Penetration Test
V- Vane Test
PC- Cone Penetration Test

Job No: 30796

BORELOG DATA SHEET

Boring Method : Shell Auger & NX Drilling.		**Site :** Sambalpur	**BH** : 07
Boring Diameter : 150 mm & NX			**Sheet :** 1 of 7
Casing Diameter : 150 mm & NX		**Co-Ordinate :** E808950, N2410929	**R.L.** : 197.499
Boring Equipment : Mechanical Cable Tools/NX Drilling.			
Sample In-situ Tests	**Casing Depth(M)**	**N - Value**	**Orientation :** Vertical	**Date** : 18.01.2018

Depth (m)	Type	No.	Casing Depth(M)	N - Value	Date and Depth (m)	Depth (BGL) (m)	Description	R.L.(M)	Log
0.50 - 0.50	D	105101							
1.00 - 1.45	P	105102	0.90	13					
1.50 - 1.50	D	105103	0.90				Stiff greyish brown silty clay with grey patches and high % of nodules.	IA	
2.00 - 2.45	U	105104	1.90						
2.50 - 2.50	D	105105	1.90						
3.00 - 3.45	P	105106	2.90	21		3.00		194.50	
4.00 - 4.00	D	105107	2.90				Very stiff greyish brown silty clay with grey patches and high % of nodules.	IB	
5.00 - 5.45	P	105108	4.90	23					
6.80 - 6.89	P	105109	6.50	>100		6.80		190.70	
7.00 - 7.05	P	105110	6.90	>100					

DRILLING

From To (m)	TCR %	RQD %	Water Loss	Color of Ret. Water	N Value	Description	R.L.(M)	Log
7.00 - 7.75	53.33	NIL	NO	Greyish yellow	-			
7.75 - 8.50	57.33	28.00	NO	Greyish yellow	-			
8.50 - 9.25	89.33	29.33	NO	Greyish yellow	-	Moderately to slightly weathered greyish yellow rock.	IVC	
9.25 - 10.00	82.67	82.67	NO	Greyish yellow	-			
10.00 - 10.75	93.33	64.00	NO	Greyish yellow	-			
10.75 - 11.50	80.00	80.00	NO	Greyish yellow	-			
11.50 - 12.00	96.00	96.00	NO	Greyish yellow	-			
						12.00 End of BoreHole	185.50	

Water Level Observation

Date	Time (Hrs.)	W.L.(m) B.G.L.
20.01.2018	17.00	2.40

Remarks:

S.W.L. (m)
2.40
(BGL)
195.10
(RL)

D.D. Supervisor

D- Disturbed Sample
B- Bulk Sample
W- Water Sample
U- Undisturbed sample
P- Standard Penetration Test
V- Vane Test
PC- Cone Penetration Test

Job No: 30796

BORELOG DATA SHEET

Boring Method : Shell Auger & NX Drilling.		**Site :** Sambalpur	**BH** : 08
Boring Diameter : 150 mm & NX			**Sheet :** 1 of 8
Casing Diameter : 150 mm & NX		**Co-Ordinate :** E809045.00, N2410803.00	**R.L.** : 199.264
Boring Equipment : Mechanical Cable Tools/NX Drilling.		**Orientation :** Vertical	**Date** : 08.11.2017

Sample In-situ Tests			Casing Depth(M)	N - Value	Date and Depth (m)	Depth (BGL) (m)	Description	R.L.(M)	Log
Depth (m)	Type	No.							
0.50 - 0.50	D	100967							
1.00 - 1.45	U	100968	0.90						
1.50 - 1.50	D	100969	0.90						
2.00 - 2.45	P	100970	1.90	14			Stiff greyish brown silty clay with grey patches and high % of nodules.	IA	
2.50 - 2.50	D	100971	1.90						
3.00 - 3.45	U	100972	2.90						
4.00 - 4.00	D	100973	2.90						
5.00 - 5.45	P	100974	4.90	23		4.00		195.26	
6.00 - 6.00	D	100975	5.90				Very stiff brownish grey to yellowish brown lateric clay to sandy silty clay with high % of nodules upto 3.00m depth and sand % increse at lower depth.	IB	
7.50 - 7.95	P	100976	7.40	81		6.00		193.26	
9.00 - 9.45	P	100977	8.90	83			Very dense greyish brown silty sand with mica.	III	
10.50 - 10.95	P	100978	10.40	93					
12.00 - 12.22	P	100979	11.90	>100		12.00		187.26	
12.75 - 12.80	P	-	11.90	>100			Completely weathered greyish yellow decomposed product of rock.	IVA	

DRILLING

From To (m)	TCR %	RQD %	Water Loss	Color of Ret. Water	N Value
12.00 - 12.75	NIL	NIL	NO	Greyish yellow	-
12.75 - 13.50	NIL	NIL	NO	Greyish yellow	-

Sample In-situ Tests			Casing Depth(M)	N - Value	Depth (BGL) (m)		
Depth (m)	Type	No.					
13.50 - 13.56	P	-	11.90	>100	13.50	185.76	
							Highly to moderately weathered greyish yellow rock. IVB

DRILLING

From To (m)	TCR %	RQD %	Water Loss	Color of Ret. Water	N Value
13.50 - 14.25	42.67	NIL	NO	Greyish yellow	-

Continued

Water Level Observation

Date	Time (Hrs.)	W.L.(m) B.G.L.
10.01.2018	17.00	3.40

Remarks:

S.W.L. (m)
3.30
(BGL)
195.96
(RL)

D.D.
Supervisor

D- Disturbed Sample
B- Bulk Sample
W- Water Sample
U- Undisturbed sample
P- Standard Penetration Test
V- Vane Test
PC- Cone Penetration Test

Job No: 30796

BORELOG DATA SHEET

Boring Method : Shell Auger & NX Drilling.		**Site : Sambalpur**	**BH : 08**
Boring Diameter : 150 mm & NX			**Sheet : 2 of 8**
Casing Diameter : 150 mm & NX		**Co-Ordinate :E809045.00, N2410803.00**	**R.L. : 199.264**
Boring Equipment : Mechanical Cable Tools/NX Drilling.			
DRILLING	**Date and Depth (m)**	**Depth (BGL) (m)**	**Orientation : Vertical**	**Date : 08.11.2017**

From To (m)	TCR %	RQD %	Water Loss	Color of Ret. Water	N Value	Description	R.L.(M)	Log
14.25 - 15.00	38.67	NIL	NO	Greyish yellow	-			
15.00 - 15.75	34.67	NIL	NO	Greyish yellow	-			
15.75 - 16.50	40.00	16.00	NO	Greyish yellow	-		IVB	
16.50 - 17.00	68.00	24.00	NO	Greyish yellow	-			
						17.00 End of BoreHole	182.26	

Water Level Observation		
Date	**Time (Hrs.)**	**W.L.(m) B.G.L.**

Remarks:

S.W.L. (m)

3.30

(BGL)

195.96

(RL)

D.D. Supervisor

D- Disturbed Sample
B- Bulk Sample
W- Water Sample
U- Undisturbed sample
P- Standard Penetration Test
V- Vane Test
PC- Cone Penetration Test

Job No: 30796

BORELOG DATA SHEET

Boring Method : Shell Auger & NX Drilling.		**Site : Sambalpur**	**BH : 09**
Boring Diameter : 150 mm & NX			**Sheet : 1 of 9**
Casing Diameter : 150 mm & NX		**Co-Ordinate :E808950.00, N2410790.00**	**R.L. : 198.215**
Boring Equipment : Mechanical Cable Tools/NX Drilling.		**Orientation : Vertical**	**Date : 12.01.2018**

Sample In-situ Tests			Casing Depth(M)	N - Value	Date and Depth (m)	Depth (BGL) (m)	Description	R.L.(M)	Log
Depth (m)	Type	No.							
0.50 - 0.50	D	100875							
1.00 - 1.45	P	100876	0.90	9					
1.50 - 1.50	D	100877	0.90						
2.00 - 2.45	U	100878	1.90				Stiff greyish brown lateritic clay with high % of small nodules and and black spots, sand % increased after 4.70m depth.	IA	
2.50 - 2.50	D	100879	1.90						
3.00 - 3.45	P	100880	2.90	15					
3.50 - 3.50	D	100881	2.90						
4.50 - 4.95	U	100882	4.40						
6.00 - 6.45	P	100883	5.90	31		5.00	Very stiff greyish brown lateritic clay with high % of small nodules and and black spots, sand	193.22	
7.50 - 7.95	P	100884	7.40	35		7.00		191.22	
8.50 - 8.50	D	100885	7.40				Dense yellowish grey clayey sand with high % of grey patches and silt lamination.	II	
9.00 - 9.45	P	100886	8.90	40					
10.00 - 10.00	D	100887	9.90						
10.50 - 10.95	P	100888	10.40	87		10.20		188.02	
13.00 - 13.45	P	100889	12.90	97			Very dense brownish yellow silty sand with mica.	III	
14.50 - 14.75	P	100890	14.40	>100		14.50		183.72	
15.25 - 15.31	P	-	14.70	>100					
16.00 - 16.09	P	-	14.70	>100					

DRILLING

From To (m)	TCR %	RQD %	Water Loss	Color of Ret. Water	N Value
14.50 - 15.25	NIL	NIL	NO	Greyish yellow	-
15.25 - 16.00	NIL	NIL	NO	Greyish yellow	-
16.00 - 16.75	NIL	NIL	NO	Greyish yellow	-

Completely weathered greyish yellow decomposed product of rock. — IVA

16.75 — Continued — 181.47

Water Level Observation

Date	Time (Hrs.)	W.L.(m) B.G.L.

Remarks:

S.W.L. (m)

2.85

(BGL)

195.37

(RL)

D.D. Supervisor

D- Disturbed Sample
B- Bulk Sample
W- Water Sample
U- Undisturbed sample
P- Standard Penetration Test
V- Vane Test
PC- Cone Penetration Test

Job No: 30796

BORELOG DATA SHEET

Boring Method : Shell Auger & NX Drilling.		**Site : Sambalpur**	**BH : 09**
Boring Diameter : 150 mm & NX			**Sheet : 2 of 9**
Casing Diameter : 150 mm & NX		**Co-Ordinate :E808950.00, N2410790.00**	**R.L. : 198.215**
Boring Equipment : Mechanical Cable Tools/NX Drilling.			
		Orientation : Vertical	**Date : 12.01.2018**

Sample In-situ Tests			Casing Depth(M)	N - Value	Date and Depth (m)	Depth (BGL) (m)	Description	R.L.(M)	Log
Depth (m)	Type	No.							
16.75 - 16.82	P	-	14.70	>100					

DRILLING

From To (m)	TCR %	RQD %	Water Loss	Color of Ret. Water	N Value			
16.75 - 17.50	22.67	NIL	NO	Greyish yellow	-		Highly weathered greyish yellow rock.	IVB	
17.50 - 18.25	25.33	NIL	NO	Greyish yellow	-				
18.25 - 19.00	36.00	NIL	NO	Greyish yellow	-				
19.00 - 19.50	42.67	NIL	NO	Greyish yellow	-	19.50	End of BoreHole	178.72	

Water Level Observation		
Date	Time (Hrs.)	W.L.(m) B.G.L.

Remarks:

S.W.L. (m)

2.85

(BGL)

195.37

(RL)

D.D.

Supervisor

D- Disturbed Sample
B- Bulk Sample
W- Water Sample
U- Undisturbed sample
P- Standard Penetration Test
V- Vane Test
PC- Cone Penetration Test

Job No: 30796

BORELOG DATA SHEET

Boring Method : Shell Auger & NX Drilling.		**Site : Sambalpur**	**BH : 10**
Boring Diameter : 150 mm & NX			**Sheet : 1 of 9**
Casing Diameter : 150 mm & NX		**Co-Ordinate :E809057, N2411175.00**	**R.L. : 195.668**
Boring Equipment : Mechanical Cable Tools/NX Drilling.			
		Orientation : Vertical	**Date : 02.01.2018**

Sample In-situ Tests			Casing Depth(M)	N - Value	Date and Depth (m)	Depth (BGL) (m)	Description	R.L.(M)	Log
Depth (m)	Type	No.							
0.50 - 0.50	D	100471							
1.00 - 1.45	P	100472	1.40	34					
1.50 - 1.50	D	100473	1.40						
2.00 - 2.45	P	100474	1.90	>100					
2.50 - 2.50	D	100475	1.90						
3.00 - 3.45	U	100476	2.90				Very stiff to hard yellowish brown silty clay to sandy clayey silt with silt lamination and grey patches, grass roots found upto 0.50m depth and boulder zone found 2.00m to 2.60m depth.	IB	
3.50 - 3.50	D	100477	2.90						
4.00 - 4.45	P	100478	3.90	31					
4.50 - 4.50	D	100479	3.90						
5.00 - 5.20	P	100480	4.90	>100					
5.50 - 5.54	P	100481	5.40	>100		5.18		190.49	

DRILLING

From To (m)	TCR %	RQD %	Water Loss	Color of Ret. Water	N Value
5.50 - 6.25	26.67	NIL	NO	Dark yellowish grey	-
6.25 - 7.00	33.33	NIL	NO	Dark yellowish grey	-
7.00 - 7.75	42.67	NIL	NO	Dark yellowish grey	-
7.75 - 8.50	50.67	NIL	NO	Dark yellowish grey	-
8.50 - 9.25	36.00	NIL	NO	Dark yellowish grey	-
9.25 - 10.00	32.00	NIL	NO	Dark yellowish grey	-
10.00 - 10.50	60.00	40.00	NO	Dark yellowish grey	-

Highly weathered brown to dark grey rock with water mark and occasionally silt sand lamination found from 7.00m depth. — IVB

10.50 — End of BoreHole — 185.17

Water Level Observation		
Date	Time (Hrs.)	W.L.(m) B.G.L.
03.01.2018	17.00	0.80
04.01.2018	17.00	1.10

Remarks:

S.W.L. (m)
1.10
(BGL)
194.57
(RL)

D.D.
Supervisor

D- Disturbed Sample
B- Bulk Sample
W- Water Sample
U- Undisturbed sample
P- Standard Penetration Test
V- Vane Test
PC- Cone Penetration Test

Job No: 30796

BORELOG DATA SHEET

Boring Method : Shell Auger & NX Drilling.		**Site : Sambalpur**	**BH : 11**
Boring Diameter : 150 mm & NX			**Sheet : 1 of 9**
Casing Diameter : 150 mm & NX		**Co-Ordinate :E809057.00, N2410722.00**	**R.L. : 196.621**
Boring Equipment : Mechanical Cable Tools/NX Drilling.			
		Orientation : Vertical	**Date : 11.01.2018**

Sample In-situ Tests			Casing Depth(M)	N - Value	Date and Depth (m)	Depth (BGL) (m)	Description	R.L.(M)	Log
Depth (m)	Type	No.							
0.50 - 0.50	D	100851							
1.00 - 1.45	U	100852	0.90						
1.50 - 1.50	D	100853	0.90				Stiff to very stiff brownish grey to yellowish brown lateric clay to silty sandy clay with high % of nodules (small) upto 3.40m depth and sand % increase from 4.00m depth.	IA	
2.00 - 2.45	P	100854	1.90	14					
2.50 - 2.50	D	100855	1.90						
3.00 - 3.45	U	100856	2.90			2.95		193.67	
3.50 - 3.50	D	100857	2.90				Medium dense to dense brownish yellow clayey silty sand.	II	
4.00 - 4.45	P	100858	3.90	24					
4.50 - 4.50	D	100859	3.90						
5.00 - 5.45	P	100860	3.90	24					
7.00 - 7.45	P	100861	6.90	83		6.50		190.12	
8.50 - 8.95	P	100862	8.40	88			Very dense brownish yellow silty sand with mica.	III	
10.00 - 10.45	P	100863	9.90	95					
11.50 - 11.75	P	100864	11.40	>100		10.50		186.12	
12.25 - 12.34	P	-	11.70	>100					
13.00 - 13.08	P	-	11.70	>100					
13.75 - 13.82	P	-	11.70	>100					
14.50 - 14.56	P	-	11.70	>100			Completely weathered greyish yellow decomposed product of rock.	IVA	
							Continued		

DRILLING

From To (m)	TCR %	RQD %	Water Loss	Color of Ret. Water	N Value
11.50 - 12.25	NIL	NIL	NO	Greyish yellow	-
12.25 - 13.00	NIL	NIL	NO	Greyish yellow	-
13.00 - 13.75	NIL	NIL	NO	Greyish yellow	-

Water Level Observation

Date	Time (Hrs.)	W.L.(m) B.G.L.
12.01.2018	17.00	3.20
13.01.2018	17.00	3.00

Remarks:

S.W.L. (m)
3.00
(BGL)
193.62
(RL)

D.D.
Supervisor

D- Disturbed Sample
B- Bulk Sample
W- Water Sample
U- Undisturbed sample
P- Standard Penetration Test
V- Vane Test
PC- Cone Penetration Test

Job No: 30796

BORELOG DATA SHEET

Boring Method : Shell Auger & NX Drilling.		**Site : Sambalpur**	**BH : 11**
Boring Diameter : 150 mm & NX			**Sheet : 2 of 9**
Casing Diameter : 150 mm & NX		**Co-Ordinate :E809057.00, N2410722.00**	**R.L. : 196.621**
Boring Equipment : Mechanical Cable Tools/NX Drilling.			
		Orientation : Vertical	**Date : 11.01.2018**

DRILLING

From To (m)	TCR %	RQD %	Water Loss	Color of Ret. Water	N Value
13.75 - 14.50	NIL	NIL	NO	Greyish yellow	-
14.50 - 15.25	NIL	NIL	NO	Greyish yellow	-

Sample In-situ Tests

Depth (m)	Type	No.	Casing Depth(M)	N - Value
15.25 - 15.30	P	-	11.70	>100

DRILLING

From To (m)	TCR %	RQD %	Water Loss	Color of Ret. Water	N Value
15.25 - 16.00	33.33	NIL	NO	Greyish yellow	-
16.00 - 16.50	40.00	NIL	NO	Greyish yellow	-

Date and Depth (m)	Depth (BGL) (m)	Description	R.L.(M)	Log
			IVA	
	15.25		181.37	
		Highly weathered greyish yellow rock.	IVB	
	16.50	End of BoreHole	180.12	

Water Level Observation

Date	Time (Hrs.)	W.L.(m) B.G.L.

Remarks:

S.W.L. (m)

3.00

(BGL)

193.62

(RL)

D.D. Supervisor

D- Disturbed Sample
B- Bulk Sample
W- Water Sample
U- Undisturbed sample
P- Standard Penetration Test
V- Vane Test
PC- Cone Penetration Test

Job No: 30796

BORELOG DATA SHEET

Boring Method : Shell Auger & NX Drilling.		**Site : Sambalpur**	**BH : 12**
Boring Diameter : 150 mm & NX			**Sheet : 1 of 9**
Casing Diameter : 150 mm & NX		**Co-Ordinate :E809098.00, N2410728.00**	**R.L. : 199.764**
Boring Equipment : Mechanical Cable Tools/NX Drilling.		**Orientation : Vertical**	**Date : 09.01.2017**

Sample In-situ Tests			Casing Depth(M)	N - Value	Date and Depth (m)	Depth (BGL) (m)	Description	R.L.(M)	Log
Depth (m)	Type	No.							
0.50 - 0.50	D	100977							
1.00 - 1.45	U	100978	0.90						
1.50 - 1.50	D	100979	0.90				Stiff grey to yellowish brown silty clay with grey patches a few nodules and high % of big pebbles.	IA	
2.00 - 2.45	P	100980	1.90	16					
2.50 - 2.50	D	100981	1.90						
3.00 - 3.45	U	100982	2.90			3.00		196.76	
3.50 - 3.50	D	100983	2.90				Very stiff grey to yellowish brown silty clay with grey patches a few nodules and high % of big pebbles.	IB	
4.00 - 4.45	P	100984	3.90	27					
5.00 - 5.25	P	100985	4.90	>100		4.85		194.91	
6.50 - 7.20	P	100986	6.40	>100			Very dense brown silty sand with mica.	III	
8.00 - 8.10	P	100987	7.90	>100		8.00		191.76	
8.75 - 8.84	P	-	8.20	>100					

DRILLING

From To (m)	TCR %	RQD %	Water Loss	Color of Ret. Water	N Value
8.00 - 8.75	NIL	NIL	NO	Greyish yellow	-
8.75 - 9.50	NIL	NIL	NO	Greyish yellow	-

Sample In-situ Tests			Casing Depth(M)	N - Value
Depth (m)	Type	No.		
9.50 - 9.57	P	-	8.20	>100

DRILLING

From To (m)	TCR %	RQD %	Water Loss	Color of Ret. Water	N Value
9.50 - 10.25	53.33	31.00	NO	Greyish yellow	-
10.25 - 11.00	54.67	13.33	NO	Greyish yellow	-
11.00 - 11.75	42.67	22.67	NO	Greyish yellow	-

		9.50	Highly to moderately weathered greyish yellow rock.
			Continued

			190.26	IVB
			191.76	IVA

Water Level Observation

Date	Time (Hrs.)	W.L.(m) B.G.L.

Remarks:

S.W.L. (m)

1.60 (BGL)

198.16 (RL)

D.D. Supervisor

D- Disturbed Sample
B- Bulk Sample
W- Water Sample
U- Undisturbed sample
P- Standard Penetration Test
V- Vane Test
PC- Cone Penetration Test

Job No: 30796

BORELOG DATA SHEET

Boring Method : Shell Auger & NX Drilling.		**Site : Sambalpur**	**BH : 12**
Boring Diameter : 150 mm & NX			**Sheet : 2 of 9**
Casing Diameter : 150 mm & NX		**Co-Ordinate :E809098.00, N2410728.00**	**R.L. : 199.764**
Boring Equipment : Mechanical Cable Tools/NX Drilling.			
DRILLING	**Date and Depth (m)**	**Depth (BGL) (m)**	**Orientation : Vertical**	**Date : 09.01.2017**

From To (m)	TCR %	RQD %	Water Loss	Color of Ret. Water	N Value	Description	R.L.(M)	Log
11.75 - 12.50	69.33	58.67	NO	Greyish yellow	-		IVB	
12.50 - 13.00	96.00	94.00	NO	Greyish yellow	-			
						13.00 End of BoreHole	186.76	

Water Level Observation		
Date	**Time (Hrs.)**	**W.L.(m) B.G.L.**

Remarks:

S.W.L. (m)

1.60

(BGL)

198.16

(RL)

D.D. Supervisor

D- Disturbed Sample
B- Bulk Sample
W- Water Sample
U- Undisturbed sample
P- Standard Penetration Test
V- Vane Test
PC- Cone Penetration Test

Job No: 30796

BORELOG DATA SHEET

Boring Method : Shell Auger & NX Drilling.		**Site :** Sambalpur	**BH** : 13
Boring Diameter : 150 mm & NX			**Sheet :** 1 of 9
Casing Diameter : 150 mm & NX		**Co-Ordinate :** E809098.00, N2411175.00	**R.L.** : 196.660
Boring Equipment : Mechanical Cable Tools/NX Drilling.			
Sample In-situ Tests	**Casing Depth(M)** / **N - Value**	**Date and Depth (m)**	**Depth (BGL) (m)**

Depth (m)	Type	No.	Casing Depth(M)	N - Value	Date and Depth (m)	Depth (BGL) (m)	Description	R.L.(M)	Log
0.50 - 0.50	D	100482							
1.00 - 1.45	P	100483	0.90	26					
1.50 - 1.50	D	100484	0.90				Very stiff mottled brown lateritic clay with high % of nodules _black spots.	IB	
2.00 - 2.45	P	100485	1.90	23					
2.50 - 2.50	D	100486	1.90						
3.00 - 3.45	P	100487	2.90	40		2.60		194.06	
3.50 - 3.50	D	100488	2.90						
4.00 - 4.45	P	100489	3.90	64			Dense to very dense yellowish grey sandy clayey silt with silt lamination and shale fragments observed.	III	
4.50 - 4.50	D	100490	3.90						
5.00 - 5.25	P	100491	4.90	>100					
5.60 - 5.65	P	100492	5.50	>100		5.15		191.51	

DRILLING

From To (m)	TCR %	RQD %	Water Loss	Color of Ret. Water	N Value
5.60 - 6.35	48.00	NIL	NO	Dark yellowish	-
6.35 - 7.10	44.00	NIL	NO	Dark yellowish	-
7.10 - 7.85	56.00	NIL	NO	Dark yellowish	-
7.85 - 8.60	45.33	13.33	NO	Dark yellowish	-
8.60 - 9.35	42.67	NIL	NO	Dark yellowish	-
9.35 - 10.10	60.00	NIL	NO	Dark yellowish	-
10.10 - 10.60	46.67	0.32	NO	Dark yellowish	-

Highly to moderately weathered dark yellowish grey rock with water mark and sand lamination observed. — IVB

10.60 — End of BoreHole — 186.06

Water Level Observation

Date	Time (Hrs.)	W.L.(m) B.G.L.

Remarks:

S.W.L. (m)

1.65 (BGL)

195.01 (RL)

D.D. Supervisor

D- Disturbed Sample
B- Bulk Sample
W- Water Sample
U- Undisturbed sample
P- Standard Penetration Test
V- Vane Test
PC- Cone Penetration Test

Job No: 30796

BORELOG DATA SHEET

Boring Method : Shell Auger & NX Drilling.		**Site :** Sambalpur	**BH** : 14
Boring Diameter : 150 mm & NX			**Sheet** : 1 of 9
Casing Diameter : 150 mm & NX		**Co-Ordinate :** E809083.00, N2411115.00	**R.L.** : 196.621
Boring Equipment : Mechanical Cable Tools/NX Drilling.		**Orientation :** Vertical	**Date** : 18.12.2017

Sample In-situ Tests			Casing Depth(M)	N - Value	Date and Depth (m)	Depth (BGL) (m)	Description	R.L.(M)	Log
Depth (m)	Type	No.							
0.50 - 0.50	D	100551							
1.00 - 1.45	P	100552	0.90	13					
1.50 - 1.50	D	100553	0.90				Stiff greyish brown to mottled brown sandy silty clay with grass roots upto 0.40m and small size nodules quartz boulders found from 1.00m depth.	IA	
2.00 - 2.45	U	100554	1.90						
2.50 - 2.50	D	100555	1.90						
3.00 - 3.45	P	100556	3.60	64		2.80		193.82	
3.50 - 3.50	D	100557	3.60				Very dense yellowish brown clayey sandy silt with fine mica flakes, blackish grey spots and silt lamination.	III	
4.00 - 4.00	D	100558	3.60						
4.50 - 4.80	P	100559	4.35	>100		4.50		192.12	
5.00 - 5.20	P	100560	4.35	>100			Completely weathered dark grey decomposed product of rock with rusty brown patches.	IVA	
						5.32		191.30	

DRILLING

From To (m)	TCR %	RQD %	Water Loss	Color of Ret. Water	N Value
5.32 - 6.07	49.33	NIL	NO	Brownish grey	-
6.07 - 6.82	56.00	NIL	NO	Brownish grey	-
6.82 - 7.57	65.33	NIL	NO	Brownish grey	-
7.57 - 8.32	69.33	NIL	NO	Dark grey	-
8.32 - 9.07	74.66	76.00	NO	Dark grey	-
9.07 - 9.82	84.00	NIL	NO	Dark grey	-
9.82 - 10.32	90.00	50.00	NO	Dark grey	-

Highly to moderately weathered brownish to dark grey rock with water mark. — IVB

10.32 — End of BoreHole — 186.30

Water Level Observation

Date	Time (Hrs.)	W.L.(m) B.G.L.
22.12.2017	17.00	0.80
23.12.2017	17.00	1.30
24.12.2017	17.00	1.47
25.12.2017	17.00	1.50

Remarks:

S.W.L. (m)

1.50 (BGL)

195.12 (RL)

R.M. Supervisor

D- Disturbed Sample
B- Bulk Sample
W- Water Sample
U- Undisturbed sample
P- Standard Penetration Test
V- Vane Test
PC- Cone Penetration Test

Job No: 30796

BORELOG DATA SHEET

Boring Method : Shell Auger & NX Drilling.		**Site : Sambalpur**	**BH : 15**
Boring Diameter : 150 mm & NX			**Sheet : 1 of 9**
Casing Diameter : 150 mm & NX		**Co-Ordinate :E809083.00, N2411055.00**	**R.L. : 195.857**
Boring Equipment : Mechanical Cable Tools/NX Drilling.			
		Orientation : Vertical	**Date : 29.12.2017**

Sample In-situ Tests			Casing Depth(M)	N - Value	Date and Depth (m)	Depth (BGL) (m)	Description	R.L.(M)	Log
Depth (m)	Type	No.							
0.50 - 0.50	D	100464							
1.00 - 1.45	P	100465	0.90	22					
1.50 - 1.50	D	100466	0.90				Medium dense light yellowish grey to dark grey clayey sandy silt with silt sand concreation and shale fragments found at 2.50m depth.	II	
2.00 - 2.45	P	100467	1.90	27					
2.50 - 2.50	D	100468	2.40						
3.00 - 3.10	P	100469	2.90	>100		2.90		192.96	
							Completely weathered dark grey decomposed product of rock.	IVA	
3.20 - 3.25	P	100470	2.90	>100		3.20		192.66	

DRILLING

From To (m)	TCR %	RQD %	Water Loss	Color of Ret. Water	N Value
3.20 - 3.95	36.00	NIL	NO	Dark grey	-
3.95 - 4.70	45.33	13.00	NO	Dark grey	-
4.70 - 5.45	40	NIL	NO	Dark grey	-
5.45 - 6.20	60	13.00	NO	Dark grey	-
6.20 - 6.95	52	NIL	NO	Dark grey	-
6.95 - 7.70	56	NIL	NO	Dark grey	-
7.70 - 8.20	82	0.28	NO	Dark grey	-

Highly weathered to moderately weathered dark grey rock. — IVB

8.20 — End of BoreHole — 187.66

Water Level Observation

Date	Time (Hrs.)	W.L.(m) B.G.L.

Remarks:

S.W.L. (m)

0.15

(BGL)

(RL)

D.D. Supervisor

D- Disturbed Sample
B- Bulk Sample
W- Water Sample
U- Undisturbed sample
P- Standard Penetration Test
V- Vane Test
PC- Cone Penetration Test

Job No: 30796

BORELOG DATA SHEET

Boring Method : Shell Auger & NX Drilling.		**Site :** Sambalpur	**BH** : 16
Boring Diameter : 150 mm & NX			**Sheet :** 1 of 9
Casing Diameter : 150 mm & NX		**Co-Ordinate :** E809083.00, N2410803.00	**R.L.** : 199.466
Boring Equipment : Mechanical Cable Tools/NX Drilling.			
Orientation : Vertical			**Date** : 06.01.2018

Sample In-situ Tests			Casing Depth(M)	N - Value	Date and Depth (m)	Depth (BGL) (m)	Description	R.L.(M)	Log
Depth (m)	Type	No.							
0.50 - 0.50	D	100951							
1.00 - 1.45	P	100952	1.40	11					
1.50 - 1.50	D	100953	1.40				Stiff brownish grey lateric clay with high % of nodules and grey patches.	IA	
2.00 - 2.45	U	100954	1.90						
2.50 - 2.50	D	100955	1.90						
3.00 - 3.45	P	100956	2.90	16					
4.00 - 4.45	P	100957	3.90	20		3.90		195.57	
5.00 - 5.45	P	100958	4.90	23			Medium dense brown clayey silty sand with grey silt lamination.	II	
5.50 - 5.50	D	100959	4.90						
6.00 - 6.45	P	100960	5.90	35					
6.50 - 6.50	D	100961	5.90						
7.00 - 7.45	P	100962	6.90	79		7.00		192.47	
8.50 - 8.95	P	100963	7.90	81			Very dense greyish brown silty sand with mica.	III	
10.00 - 10.45	P	100964	9.90	89					
11.50 - 11.80	P	100965	11.40	>100					
12.75 - 12.87	P	-	12.20	>100		12.00		187.47	

DRILLING

From To (m)	TCR %	RQD %	Water Loss	Color of Ret. Water	N Value
12.00 - 12.75	NIL	NIL	NO	Yellowish brown	-
12.75 - 13.50	NIL	NIL	NO	Yellowish brown	-

Sample In-situ Tests			Casing Depth(M)	N - Value				
Depth (m)	Type	No.						
13.50 - 13.59	P	-	12.20	>100		13.50	Highly to moderately weathered brownish yellow rock.	IVB

Complete weathered yellowish brown decomposed product of rock. — IVA — 185.97

Continued

Water Level Observation

Date	Time (Hrs.)	W.L.(m) B.G.L.
08.01.2018	17.00	2.50
09.01.2018	17.00	3.00
10.01.2018	17.00	3.00

Remarks:

S.W.L. (m)
3.00
(BGL)
196.47
(RL)

D- Disturbed Sample
B- Bulk Sample
W- Water Sample
U- Undisturbed sample
P- Standard Penetration Test
V- Vane Test
PC- Cone Penetration Test

D.D. Supervisor

Job No: 30796

BORELOG DATA SHEET

Boring Method : Shell Auger & NX Drilling.		**Site : Sambalpur**	**BH : 16**
Boring Diameter : 150 mm & NX			**Sheet : 2 of 9**
Casing Diameter : 150 mm & NX		**Co-Ordinate :E809083.00, N2410803.00**	**R.L. : 199.466**
Boring Equipment : Mechanical Cable Tools/NX Drilling.		**Orientation : Vertical**	**Date : 06.01.2018**

DRILLING						Date and Depth (m)	Depth (BGL) (m)	Description	R.L.(M)	Log
From To (m)	TCR %	RQD %	Water Loss	Color of Ret. Water	N Value					
13.50 - 14.25	33.33	14.67	NO	Yellowish brown	-					
14.25 - 15.00	36.00	NIL	NO	Yellowish brown	-					
15.00 - 15.75	32.00	16.00	NO	Yellowish brown	-				IVB	
15.75 - 16.50	33.33	26.67	NO	Yellowish brown	-					
16.50 - 17.00	72.00	50.00	NO	Yellowish brown	-					
							17.00	End of BoreHole	182.47	

Water Level Observation		
Date	Time (Hrs.)	W.L.(m) B.G.L.

Remarks:

S.W.L. (m)	D- Disturbed Sample
	B- Bulk Sample
3.00	W- Water Sample
(BGL)	U- Undisturbed sample
	P- Standard Penetration Test
196.47	
(RL)	V- Vane Test
	PC- Cone Penetration Test
D.D. Supervisor	

Job No: 30796

BORELOG DATA SHEET

Boring Method : Shell Auger & NX Drilling.		**Site :** Sambalpur	**BH** : 17
Boring Diameter : 150 mm & NX			**Sheet :** 1 of 9
Casing Diameter : 150 mm & NX		**Co-Ordinate :** E809375, N2410250	**R.L.** : 204.919
Boring Equipment : Mechanical Cable Tools/NX Drilling.		**Orientation :** Vertical	**Date** : 01.02.2018

Sample In-situ Tests			Casing Depth(M)	N - Value	Date and Depth (m)	Depth (BGL) (m)	Description	R.L.(M)	Log
Depth (m)	Type	No.							
0.50 - 0.50	D	100514							
1.00 - 1.45	P	100515	0.90	9					
1.50 - 1.50	D	100516	0.90				Stiff brownish grey to yellowish brown silty clay with low % of nodules and a few sand occasionally observed.	IA	
2.00 - 2.45	U	100517	1.90						
2.50 - 2.50	D	100518	1.90						
3.00 - 3.45	P	100519	2.90	21		3.00		201.92	
3.50 - 3.50	D	100520	2.90						
4.00 - 4.45	U	100521	3.90				Very stiff brownish grey to yellowish brown silty clay with low % of nodules and a few sand occasionally observed.	IB	
5.00 - 5.45	P	100522	4.90	22					
6.00 - 6.45	P	100523	5.90	24					
7.50 - 7.95	U	100524	7.40			6.90		198.02	
9.00 - 9.45	P	100525	8.90	47			Very dense yellowish grey silty sand with mica.	III	
10.00 - 10.00	D	100526	8.90						
10.50 - 10.95	P	100527	10.40	81					
12.00 - 12.22	P	100528	11.90	>100		12.00		192.92	
12.75 - 12.87	P	-	12.20	>100			Completely weathered greyish yellow decomposed product of rock.	IVA	
13.50 - 13.60	P	-	12.20	>100					
14.25						14.25		190.67	
							Highly to moderately weathered greyish yellow rock.	IVB	
							Continued		

DRILLING

From To (m)	TCR %	RQD %	Water Loss	Color of Ret. Water	N Value
12.00 - 12.75	NIL	NIL	NO	Greyish yellow	-
12.75 - 13.50	NIL	NIL	NO	Greyish yellow	-
13.50 - 14.25	NIL	NIL	NO	Greyish yellow	-

Water Level Observation

Date	Time (Hrs.)	W.L.(m) B.G.L.

Remarks:

S.W.L. (m)

4.78

(BGL)

200.14

(RL)

D.D.

Supervisor

D- Disturbed Sample
B- Bulk Sample
W- Water Sample
U- Undisturbed sample
P- Standard Penetration Test
V- Vane Test
PC- Cone Penetration Test

Job No: 30796

BORELOG DATA SHEET

Boring Method : Shell Auger & NX Drilling.		**Site : Sambalpur**	**BH : 17**
Boring Diameter : 150 mm & NX			**Sheet : 2 of 9**
Casing Diameter : 150 mm & NX		**Co-Ordinate :E809375, N2410250**	**R.L. : 204.919**
Boring Equipment : Mechanical Cable Tools/NX Drilling.			
Sample In-situ Tests	**Casing Depth(M)** / **N - Value** / **Date and Depth (m)** / **Depth (BGL) (m)**	**Orientation : Vertical**	**Date : 01.02.2018**

Depth (m)	Type	No.	Description	R.L.(M)	Log
14.25 - 14.34	P	-			

Casing Depth(M): 12.20 | N - Value: >100

DRILLING

From To (m)	TCR %	RQD %	Water Loss	Color of Ret. Water	N Value
14.25 - 15.00	42.66	NIL	NO	Greyish yellow	-
15.00 - 15.75	49.33	NIL	NO	Greyish yellow	-
15.75 - 16.50	60.00	20.00	NO	Greyish yellow	-
16.50 - 17.00	60.00	30.00	NO	Greyish yellow	-

IVB

17.00 — End of BoreHole — 187.92

Water Level Observation

Date	Time (Hrs.)	W.L.(m) B.G.L.

Remarks:

S.W.L. (m)

4.78

(BGL)

200.14

(RL)

D.D. Supervisor

D- Disturbed Sample
B- Bulk Sample
W- Water Sample
U- Undisturbed sample
P- Standard Penetration Test
V- Vane Test
PC- Cone Penetration Test

Job No: 30796

BORELOG DATA SHEET

Boring Method : Shell Auger & NX Drilling.		**Site : Sambalpur**	**BH : 18**
Boring Diameter : 150 mm & NX			**Sheet : 1 of 9**
Casing Diameter : 150 mm & NX		**Co-Ordinate :E808900, N2409980**	**R.L. : 198.576**
Boring Equipment : Mechanical Cable Tools/NX Drilling.		**Orientation : Vertical**	**Date : 02.02.2018**

Sample In-situ Tests			Casing Depth(M)	N - Value	Date and Depth (m)	Depth (BGL) (m)	Description	R.L.(M)	Log
Depth (m)	Type	No.							
0.50 - 0.50	D	100530							
1.00 - 1.45	U	100531	0.90						
1.50 - 1.50	D	100532	0.90				Stiff brownish grey to yellowish brown laterite with nodules and black spots.	IA	
2.00 - 2.45	P	100533	1.90	13					
2.50 - 2.50	D	100534	1.90						
3.00 - 3.45	U	100535	2.90			3.00		195.58	
3.50 - 3.50	D	100536	2.90				Very stiff brownish grey to yellowish brown laterite with nodules and black spots.	IB	
4.00 - 4.45	P	100537	3.90	25					
4.50 - 4.50	D	100538	3.90						
5.50 - 5.95	P	100539	5.40	31		5.40		193.18	
7.00 - 7.45	P	100540	6.90	54			Dense to Very dense whitish yellow silty sand with mica flakes.	III	
9.00 - 9.27	P	100541	8.90	>100		9.00		189.58	

DRILLING

From To (m)	TCR %	RQD %	Water Loss	Color of Ret. Water	N Value
9.00 - 9.75	22.67	NIL	Greyish yellow	NO	-
9.75 - 10.50	29.33	NIL	Greyish yellow	NO	-
10.50 - 11.25	40.00	NIL	Greyish yellow	NO	-
11.25 - 12.00	37.33	NIL	Greyish yellow	NO	-
12.00 - 12.75	36.00	NIL	Greyish yellow	NO	-
12.75 - 13.50	53.33	20.00	Greyish yellow	NO	-
13.50 - 14.00	56.00	22.00	Greyish yellow	NO	-

Highly to moderately weathered greyish yellow rock. — IVB

14.00 — End of BoreHole — 184.58

Water Level Observation

Date	Time (Hrs.)	W.L.(m) B.G.L.

Remarks:

S.W.L. (m)

2.30 (BGL)

196.28 (RL)

D.D. Supervisor

D- Disturbed Sample
B- Bulk Sample
W- Water Sample
U- Undisturbed sample
P- Standard Penetration Test
V- Vane Test
PC- Cone Penetration Test

Job No: 30796

BORELOG DATA SHEET

Boring Method : Shell Auger & NX Drilling.		**Site : Sambalpur**	**BH : 19**
Boring Diameter : 150 mm & NX			**Sheet : 1 of 9**
Casing Diameter : 150 mm & NX		**Co-Ordinate :E809083, N2410380.00**	**R.L. : 199.313**
Boring Equipment : Mechanical Cable Tools/NX Drilling.		**Orientation : Vertical**	**Date : 03.01.2018**

Sample In-situ Tests			Casing Depth(M)	N - Value	Date and Depth (m)	Depth (BGL) (m)	Description	R.L.(M)	Log
Depth (m)	Type	No.							
0.50 - 0.50	D	100500							
1.00 - 1.45	P	100501	0.90	10					
1.50 - 1.50	D	100502	0.90				Stiff brownish grey to yellowish brown lateric clay to silty sandy clay with high % of nodules in upper reaches and sand % incresed with depth.	IA	
2.00 - 2.45	U	100503	1.90						
2.50 - 2.50	D	100504	1.90						
3.00 - 3.45	P	100505	2.90	23		3.00		196.31	
3.50 - 3.50	D	100506	2.90	23			Very stiff brownish grey to yellowish brown lateric clay to silty sandy clay with high % of nodules in upper reaches and sand % incresed with depth.	IB	
4.00 - 4.45	U	100507	3.90			3.90		195.41	
4.50 - 4.50	D	100508	3.90						
5.00 - 5.45	P	100509	4.90	30					
6.00 - 6.45	P	100510	5.90	34			Dense to Very dense brownish yellow silty sand with mica.	III	
7.50 - 7.95	P	100511	6.90	70					
9.00 - 9.45	P	100512	8.90	85					
10.00 - 10.25	P	100513	9.90	>100		10.00		189.31	

DRILLING

From To (m)	TCR %	RQD %	Water Loss	Color of Ret. Water	N Value
10.00 - 10.75	24.00	NIL	Greyish yellow	NO	-
10.75 - 11.50	32.00	14.66	Greyish yellow	NO	-
11.50 - 12.25	56.00	21.33	Greyish yellow	NO	-
12.25 - 13.00	60.00	37.33	Greyish yellow	NO	-
13.00 - 13.75	48.00	40.00	Greyish yellow	NO	-
13.75 - 14.50	53.33	46.67	Greyish yellow	NO	-
14.50 - 15.00	60.00	56.00	Greyish yellow	NO	-

Highly to moderately weathered greyish yellow rock. — IVB

15.00 — Continued — 184.31

Water Level Observation

Date	Time (Hrs.)	W.L.(m) B.G.L.

Remarks:

S.W.L. (m)

2.50 (BGL)

196.81 (RL)

D- Disturbed Sample
B- Bulk Sample
W- Water Sample
U- Undisturbed sample
P- Standard Penetration Test
V- Vane Test
PC- Cone Penetration Test

D.D. Supervisor

Job No: 30796

BORELOG DATA SHEET

Boring Method : Shell Auger & NX Drilling.		**Site : Sambalpur**	**BH : 20**
Boring Diameter : 150 mm & NX			**Sheet : 1 of 9**
Casing Diameter : 150 mm & NX		**Co-Ordinate :E808700, N2409650**	**R.L. : 198.614**
Boring Equipment : Mechanical Cable Tools/NX Drilling.			
		Orientation : Vertical	**Date : 08.02.2018**

Sample In-situ Tests			Casing Depth(M)	N - Value	Date and Depth (m)	Depth (BGL) (m)	Description	R.L.(M)	Log
Depth (m)	Type	No.							
0.50 - 0.50	D	120100							
1.00 - 1.45	P	120101	0.90	12					
1.50 - 1.50	D	120102	0.90						
2.00 - 2.45	U	120103	1.90				Stiff brownish grey to yellowish brown silty clay with low % of nodules black spots. Note: sand % increase at 6.00m depth.	IA	
2.50 - 2.50	D	120104	1.90						
3.00 - 3.45	P	120105	2.90	19					
3.50 - 3.50	D	120106	2.90						
4.50 - 4.95	U	120107	4.40			4.00		194.61	
6.00 - 6.45	P	120108	5.90	40			Very stiff brownish grey to yellowish brown silty clay with low % of nodules black spots. Note: sand % increase at 6.00m depth.	IB	
7.00 - 7.00	D	120109	5.90						
7.50 - 7.70	P	120110	7.40	>100		7.50		191.11	
							Very dense greyish yellow silty sand with mica.	III	
						8.00		190.61	

DRILLING

From To (m)	TCR %	RQD %	Water Loss	Color of Ret. Water	N Value
8.00 - 8.75	24.00	NIL	NO	Greyish brown	-
8.75 - 9.50	29.33	NIL	NO	Greyish brown	-
9.50 - 10.25	22.67	13.00	NO	Greyish brown	-
10.25 - 11.00	36.00	NIL	NO	Greyish brown	-
11.00 - 11.75	53.33	12.00	NO	Greyish brown	-
11.75 - 12.50	52.00	17.00	NO	Greyish brown	-
12.50 - 13.00	38.67	18.00	NO	Greyish brown	-

Highly to moderately weathered greyish yellow rock. — IVB

13.00 — End of BoreHole — 185.61

Water Level Observation

Date	Time (Hrs.)	W.L.(m) B.G.L.

Remarks:

S.W.L. (m)

4.20

(BGL)

194.41

(RL)

D.D. Supervisor

D- Disturbed Sample
B- Bulk Sample
W- Water Sample
U- Undisturbed sample
P- Standard Penetration Test
V- Vane Test
PC- Cone Penetration Test

Job No: 30796

BORELOG DATA SHEET

Boring Method : Shell Auger & NX Drilling.		**Site : Sambalpur**	**BH : 21**
Boring Diameter : 150 mm & NX			**Sheet : 1 of 9**
Casing Diameter : 150 mm & NX		**Co-Ordinate :E809200, N2409550**	**R.L. : 201.101**
Boring Equipment : Mechanical Cable Tools/NX Drilling.			
		Orientation : Vertical	**Date : 09.02.2018**

Sample In-situ Tests			Casing Depth(M)	N - Value	Date and Depth (m)	Depth (BGL) (m)	Description	R.L.(M)	Log
Depth (m)	Type	No.							
0.50 - 0.50	D	120110					Stiff dark grey to yellowish brown silty clay with nodules and a few sand.	IA	
1.00 - 1.45	P	120111	0.90	10					
1.50 - 1.50	D	120112	0.90						
2.00 - 2.45	U	120113	1.90						
2.50 - 2.50	D	120114	1.90						
3.00 - 3.45	P	120115	2.90	12					
3.50 - 3.50	D	120116	2.90						
4.50 - 4.95	U	120117	4.40						
6.00 - 6.45	P	120118	5.90	23		5.00	Very stiff dark grey to yellowish brown silty clay with nodules and a few sand.	196.10 IB	
7.50 - 7.95	P	120119	7.40	32		7.40	Dense yellowish brown silty sand.	193.70 II	
8.50 - 8.58	P	120120	8.40	>100		8.40	Highly to moderately weathered yellowish grey rock.	192.70 IVB	
						13.50	End of BoreHole	187.60	

DRILLING

From To (m)	TCR %	RQD %	Water Loss	Color of Ret. Water	N Value
8.50 - 9.25	29.33	NIL	Greyish yellow	NO	-
9.25 - 10.00	36.00	NIL	Greyish yellow	NO	-
10.00 - 10.75	24.00	10.00	Greyish yellow	NO	-
10.75 - 11.50	29.33	14.00	Greyish yellow	NO	-
11.50 - 12.25	52.00	NIL	Greyish yellow	NO	-
12.25 - 13.00	53.33	12.00	Greyish yellow	NO	-
13.00 - 13.50	38.67	13.00	Greyish yellow	NO	-

Water Level Observation

Date	Time (Hrs.)	W.L.(m) B.G.L.

Remarks:

S.W.L. (m)

4.50

(BGL)

196.60

(RL)

D.D. Supervisor

D- Disturbed Sample
B- Bulk Sample
W- Water Sample
U- Undisturbed sample
P- Standard Penetration Test
V- Vane Test
PC- Cone Penetration Test

Job No: 30796

BORELOG DATA SHEET

Boring Method : Shell Auger & NX Drilling.		**Site :** Sambalpur	**BH** : 22
Boring Diameter : 150 mm & NX			**Sheet :** 1 of 9
Casing Diameter : 150 mm & NX		**Co-Ordinate :** E808900.00, N2409125.00	**R.L.** : 201.405
Boring Equipment : Mechanical Cable Tools/NX Drilling.		**Orientation :** Vertical	**Date** : 15.02.2018

Sample In-situ Tests			Casing Depth(M)	N - Value	Date and Depth (m)	Depth (BGL) (m)	Description	R.L.(M)	Log
Depth (m)	Type	No.							
0.50 - 0.50	D	165100							
1.00 - 1.45	U	165101	0.90						
1.50 - 1.50	D	165102	0.90				Stiff greyish brown silty clay to sandy clay with nodules silt concreation and sandy clay layer observed from 6.00m depth.	IA	
2.00 - 2.45	P	165103	1.90	9					
3.00 - 3.45	U	165105	2.90						
3.50 - 3.50	D	165106	2.90						
4.50 - 4.95	P	165107	4.40	24		4.00		197.41	
6.00 - 6.45	P	165108	5.90	28			Very stiff greyish brown silty clay to sandy clay with nodules silt concreation and sandy clay layer observed from 6.00m depth.	IB	
7.50 - 7.95	P	165109	7.40	34		6.50		194.91	
8.20 - 8.30	P	165110	8.10	>100			Medium dense greyish brown silty sand.	II	
						8.20		193.21	

DRILLING

From To (m)	TCR %	RQD %	Water Loss	Color of Ret. Water	N Value
8.20 - 8.95	29.33	NIL	NO	Greyish yellow	-
8.95 - 9.70	36.00	NIL	NO	Greyish yellow	-
9.70 - 10.45	24.00	10.00	NO	Greyish yellow	-
10.45 - 11.20	29.33	14.00	NO	Greyish yellow	-
11.20 - 11.95	52.00	NIL	NO	Greyish yellow	-
11.95 - 12.70	53.33	12.00	NO	Greyish yellow	-
12.70 - 13.20	38.67	13.00	NO	Greyish yellow	-

Highly to moderately weathered yellowish grey rock. — IVB

13.20 — End of BoreHole — 188.21

Water Level Observation

Date	Time (Hrs.)	W.L.(m) B.G.L.

Remarks:

S.W.L. (m)

4.30

(BGL)

197.10

(RL)

D.D.

Supervisor

D- Disturbed Sample
B- Bulk Sample
W- Water Sample
U- Undisturbed sample
P- Standard Penetration Test
V- Vane Test
PC- Cone Penetration Test

Job No: 30796

BORELOG DATA SHEET

Boring Method : Shell Auger & NX Drilling.		**Site :** Sambalpur	**BH** : 23
Boring Diameter : 150 mm & NX			**Sheet :** 1 of 9
Casing Diameter : 150 mm & NX		**Co-Ordinate :** E809100.00, N2411450	**R.L.** : 200.850
Boring Equipment : Mechanical Cable Tools/NX Drilling.		**Orientation :** Vertical	**Date** : 03.02.2018

Sample In-situ Tests			Casing Depth(M)	N - Value	Date and Depth (m)	Depth (BGL) (m)	Description	R.L.(M)	Log
Depth (m)	Type	No.							
0.50 - 0.50	D	100250							
1.00 - 1.45	U	100251	0.90						
1.50 - 1.50	D	100252	0.90						
2.00 - 2.45	P	100253	1.90	17			Very stiff mottled brown lateritic clay with high % of nodules and black spots.	IA	
2.50 - 2.50	D	100254	1.90						
3.00 - 3.45	U	100255	2.90						
3.50 - 3.50	D	100256	2.90						
4.00 - 4.45	P	100257	3.90	21					
5.00 - 5.45	P	100258	4.90	33		4.50		196.35	
6.00 - 6.45	P	100259	5.90	41			Dense to very dense yellowish brown silty sand.	III	
7.50 - 7.95	P	100260	7.40	57					
8.50 - 8.75	P	100261	8.40	>100		8.50		192.35	

DRILLING

From To (m)	TCR %	RQD %	Water Loss	Color of Ret. Water	N Value
8.50 - 9.25	25.33	NIL	Darkish yellow	NO	-
9.25 - 10.00	29.33	NIL	Darkish yellow	NO	-
10.00 - 10.75	37.33	18.67	Darkish yellow	NO	-
10.75 - 11.50	53.33	NIL	Darkish yellow	NO	-
11.50 - 12.25	45.33	29.33	Darkish yellow	NO	-
12.25 - 13.00	52.00	NIL	Darkish yellow	NO	-
13.00 - 13.50	41.33	40.00	Darkish yellow	NO	-

Highly to moderately weathered dark yellow rock. — IVB

13.50 — End of BoreHole — 187.35

Water Level Observation

Date	Time (Hrs.)	W.L.(m) B.G.L.

Remarks:

S.W.L. (m)

3.50 (BGL)

197.35 (RL)

D.D. Supervisor

D- Disturbed Sample
B- Bulk Sample
W- Water Sample
U- Undisturbed sample
P- Standard Penetration Test
V- Vane Test
PC- Cone Penetration Test

Job No: 30796

BORELOG DATA SHEET

Boring Method : Shell Auger & NX Drilling.		**Site :** Sambalpur	**BH** : 24
Boring Diameter : 150 mm & NX			**Sheet :** 1 of 9
Casing Diameter : 150 mm & NX		**Co-Ordinate :** E808950.00, N2411560.00	**R.L.** : 197.790
Boring Equipment : Mechanical Cable Tools/NX Drilling.			
Sample In-situ Tests	**Casing Depth(M)**	**N - Value**	**Orientation :** Vertical	**Date** : 08.02.2018

Depth (m)	Type	No.	Casing Depth(M)	N - Value	Date and Depth (m)	Depth (BGL) (m)	Description	R.L.(M)	Log
0.50 - 0.50	D	100101							
1.00 - 1.45	U	100102	0.90						
1.50 - 1.50	D	100103	0.90						
2.00 - 2.45	P	100104	1.90	16			Stiff mottled brown lateritic clay with high % of nodules.	IA	
2.50 - 2.50	D	100105	1.90						
3.00 - 3.45	U	100106	2.90						
3.50 - 3.50	D	100107	2.90						
4.50 - 4.95	P	100108	4.40	27		3.50		194.29	
5.00 - 5.00	D	100109	4.40				Very stiff mottled brown lateritic clay with high % of nodules.	IB	
6.50 - 6.95	P	100110	6.40	62		5.50	Dense to very dense clayey sandy silt with a few small quatz pieces.	192.29 III	
7.00 - 7.20	P	100111	6.90	>100		7.00		190.79	
7.95 - 8.07	P	-	7.21	>100					

DRILLING

From To (m)	TCR %	RQD %	Water Loss	Color of Ret. Water	N Value
7.00 - 7.75	NIL	NIL	NO	Greyish yellow	-
7.75 - 8.50	22.67	NIL	NO	Greyish yellow	-
8.50 - 9.95	40.00	NIL	NO	Greyish yellow	-
9.95 - 10.00	34.67	24.00	NO	Greyish yellow	-
10.00 - 10.75	49.33	NIL	NO	Greyish yellow	-
10.75 - 11.50	60.00	20.00	NO	Greyish yellow	-
11.50 - 12.00	68.00	36.00	NO	Greyish yellow	-

Completely to highly weathered rock. — IVB

12.00 — End of BoreHole — 185.79

Water Level Observation

Date	Time (Hrs.)	W.L.(m) B.G.L.

Remarks:

S.W.L. (m)

1.90 (BGL)

195.89 (RL)

D.D. Supervisor

D- Disturbed Sample
B- Bulk Sample
W- Water Sample
U- Undisturbed sample
P- Standard Penetration Test
V- Vane Test
PC- Cone Penetration Test

Job No: 30796

BORELOG DATA SHEET

Boring Method : Shell Auger & NX Drilling.		**Site : Sambalpur**	**BH : 25**
Boring Diameter : 150 mm & NX			**Sheet : 1 of 9**
Casing Diameter : 150 mm & NX		**Co-Ordinate :E208490.00, N2411560.00**	**R.L. : 197.00**
Boring Equipment : Mechanical Cable Tools/NX Drilling.			
		Orientation : Vertical	**Date : 16.02.2018**

Sample In-situ Tests			Casing Depth(M)	N - Value	Date and Depth (m)	Depth (BGL) (m)	Description	R.L.(M)	Log
Depth (m)	Type	No.							
0.50 - 0.50	D	170019							
1.00 - 1.45	U	170020	0.90						
2.00 - 2.45	P	170021	1.90	9					
2.00 - 2.45	P	170022	1.90	9					
2.50 - 2.50	D	170023	1.90						
3.00 - 3.45	U	170024	2.90				Stiff to very stiff greyish brown silty clay with occasionally with a few nodules.	IA	
3.50 - 3.50	D	170025	2.90						
4.50 - 4.95	P	170026	4.40	15					
6.00 - 6.45	U	170027	5.90						
6.50 - 6.50	D	170028	5.90						
7.50 - 7.95	P	170029	7.40	21					
9.00 - 9.45	P	170030	8.90	33		9.00		188.00	
10.50 - 10.95	P	170031	10.40	51			Dense to very dense yellowish grey silty sand with a few mica.	II	
12.75 - 12.88	P	-	12.20	>100		12.00		185.00	
13.50 - 13.62	P	-	12.20	>100					
14.25 - 14.36	P	-	12.20	>100					
15.00 - 15.10	P	-		>100					
15.75 - 15.84	P	-		>100			Completely weathered yellowish grey decomposed product of rock.	IVA	
16.50 - 16.58	P	-		>100					
17.00 - 17.07	P	-		>100					
							Continued		

DRILLING

From To (m)	TCR %	RQD %	Water Loss	Color of Ret. Water	N Value
12.00 - 12.75	NIL	NIL	NO	Greyish Yellow	-

Water Level Observation

Date	Time (Hrs.)	W.L.(m) B.G.L.
17.02.2018	17.00	4.00
18.02.2018	17.00	4.35
19.02.2018	17.00	4.35

Remarks:

S.W.L. (m)

4.35

(BGL)

192.65

(RL)

D.D. Supervisor

- D- Disturbed Sample
- B- Bulk Sample
- W- Water Sample
- U- Undisturbed sample
- P- Standard Penetration Test
- V- Vane Test
- PC- Cone Penetration Test

Job No: 30796

BORELOG DATA SHEET

Boring Method : Shell Auger & NX Drilling.		**Site : Sambalpur**	**BH : 25**
Boring Diameter : 150 mm & NX			**Sheet : 2 of 9**
Casing Diameter : 150 mm & NX		**Co-Ordinate :E208490.00, N2411560.00**	**R.L. : 197.00**
Boring Equipment : Mechanical Cable Tools/NX Drilling.			
DRILLING	**Date and Depth (m)**	**Depth (BGL) (m)**	**Orientation : Vertical**	**Date : 16.02.2018**

From To (m)	TCR %	RQD %	Water Loss	Color of Ret. Water	N Value	Description	R.L.(M)	Log
12.75 - 13.50	NIL	NIL	NO	Greyish Yellow	-			
13.50 - 14.25	NIL	NIL	NO	Greyish Yellow	-			
14.25 - 15.00	NIL	NIL	NO	Greyish Yellow	-			
15.00 - 15.75	NIL	NIL	NO	Greyish Yellow	-		IVA	
15.75 - 16.50	NIL	NIL	NO	Greyish Yellow	-			
16.50 - 17.00	NIL	NIL	NO	Greyish Yellow	-			
						17.07 End of BoreHole	179.93	

Water Level Observation		
Date	**Time (Hrs.)**	**W.L.(m) B.G.L.**

Remarks:

S.W.L. (m)

4.35

(BGL)

192.65

(RL)

D.D. Supervisor

D- Disturbed Sample
B- Bulk Sample
W- Water Sample
U- Undisturbed sample
P- Standard Penetration Test
V- Vane Test
PC- Cone Penetration Test

Job No: 30796

BORELOG DATA SHEET

Boring Method : Shell Auger & NX Drilling.		**Site : Sambalpur**	**BH : 26**
Boring Diameter : 150 mm & NX			**Sheet : 1 of 9**
Casing Diameter : 150 mm & NX		**Co-Ordinate :E810400.00, N2411400.00**	**R.L. : 197.230**
Boring Equipment : Mechanical Cable Tools/NX Drilling.			
		Orientation : Vertical	**Date : 13.02.2018**

Sample In-situ Tests			Casing Depth(M)	N - Value	Date and Depth (m)	Depth (BGL) (m)	Description	R.L.(M)	Log
Depth (m)	Type	No.							
0.50 - 0.50	D	182155							
1.00 - 1.45	U	182156	0.90						
1.50 - 1.50	D	182157	0.90						
2.00 - 2.45	P	182158	1.90	10					
2.50 - 2.50	D	182159	1.90						
3.00 - 3.45	U	182160	2.90				Stiff to very stiff greyish brown silty clay with occasionally with a few nodules.	IA	
3.50 - 3.50	D	182161	2.90						
4.50 - 4.95	P	182162	4.40	27					
6.00 - 6.35	P	182163	5.90	>100					
6.50 - 6.55	P	-	6.50	>100					
						7.00		190.23	

DRILLING

From To (m)	TCR %	RQD %	Water Loss	Color of Ret. Water	N Value
6.30 - 7.05	NIL	NIL	NO	Greyish yellow	-
7.05 - 7.80	22.67	NIL	NO	Greyish yellow	-
7.80 - 8.55	40.00	NIL	NO	Greyish yellow	-
8.55 - 9.30	34.67	24.00	NO	Greyish yellow	-
9.30 - 10.05	49.33	NIL	NO	Greyish yellow	-
10.05 - 10.80	60.00	20.00	NO	Greyish yellow	-
10.80 - 11.30	68.00	36.00	NO	Greyish yellow	-

Highly to moderately weathered yellowish grey rock. — IVB

11.30 — End of BoreHole — 185.93

Water Level Observation

Date	Time (Hrs.)	W.L.(m) B.G.L.
15.02.2018	17.00	1.90
16.02.2018	17.00	1.10
17.02.2018	17.00	1.10

Remarks:

S.W.L. (m)

1.10 (BGL)

196.13 (RL)

D.D. Supervisor

D- Disturbed Sample
B- Bulk Sample
W- Water Sample
U- Undisturbed sample
P- Standard Penetration Test
V- Vane Test
PC- Cone Penetration Test

Job No: 30796

BORELOG DATA SHEET

Boring Method : Shell Auger & NX Drilling.		**Site : Sambalpur**	**BH : 27**
Boring Diameter : 150 mm & NX			**Sheet : 1 of 9**
Casing Diameter : 150 mm & NX		**Co-Ordinate :E810500.00, N2409500.00**	**R.L. : 202.405**
Boring Equipment : Mechanical Cable Tools/NX Drilling.		**Orientation : Vertical**	**Date : 20.02.2018**

Sample In-situ Tests			Casing Depth(M)	N - Value	Date and Depth (m)	Depth (BGL) (m)	Description	R.L.(M)	Log
Depth (m)	Type	No.							
0.50 - 0.50	D	170660							
1.00 - 1.45	P	170661	0.90	10					
1.50 - 1.50	D	170662	0.90						
2.00 - 2.45	U	170663	1.90						
2.50 - 2.50	D	170664	1.90				Stiff brownish grey silty clay to clayey silt with a few silt concreation.	IA	
3.00 - 3.45	P	170665	2.90	19					
3.50 - 3.50	D	170666	2.90						
4.50 - 4.95	U	170667	4.40						
6.00 - 6.45	P	170668	5.90	30		5.00		197.41	
7.50 - 7.95	P	170669	7.40	37			Hard brownish grey silty clay to clayey silt with a few silt concreation.	IB	
8.50 - 8.59	P	170670	8.40	>100		8.50		193.91	

DRILLING

From To (m)	TCR %	RQD %	Water Loss	Color of Ret. Water	N Value
8.50 - 9.25	29.33	NIL	NO	Greyish Yellow	-
9.25 - 10.00	36.00	NIL	NO	Greyish Yellow	-
10.000 - 10.75	24.00	10.00	NO	Greyish Yellow	-
10.75 - 11.50	29.33	14.00	NO	Greyish Yellow	-
11.50 - 12.25	52.00	NIL	NO	Greyish Yellow	-
12.25 - 13.00	53.33	12.00	NO	Greyish Yellow	-
13.00 - 13.50	58.00	13.00	NO	Greyish Yellow	-

Highly to moderately weathered yellowish grey rock. — IVB

13.50 — End of BoreHole — 188.91

Water Level Observation

Date	Time (Hrs.)	W.L.(m) B.G.L.
22.02.2018	17.00	3.90
23.02.2018	17.00	4.70
24.02.2018	17.00	4.70

Remarks:

S.W.L. (m)

4.70

(BGL)

197.71

(RL)

D- Disturbed Sample
B- Bulk Sample
W- Water Sample
U- Undisturbed sample
P- Standard Penetration Test
V- Vane Test
PC- Cone Penetration Test

D.D. Supervisor

Job No: 30796

BORELOG DATA SHEET

Boring Method : Shell Auger & NX Drilling.		**Site : Sambalpur**	**BH : 28**
Boring Diameter : 150 mm & NX			**Sheet : 1 of 9**
Casing Diameter : 150 mm & NX		**Co-Ordinate :E810850.00, N2409050.00**	**R.L. : 201.102**
Boring Equipment : Mechanical Cable Tools/NX Drilling.		**Orientation : Vertical**	**Date : 02.02.2018**

Sample In-situ Tests			Casing Depth(M)	N - Value	Date and Depth (m)	Depth (BGL) (m)	Description	R.L.(M)	Log
Depth (m)	Type	No.							
0.50 - 0.50	D	160770							
1.00 - 1.45	U	160771	0.90						
1.50 - 1.50	D	160772	0.90						
2.00 - 2.45	P	160773	1.90	12			Stiff brownish grey silty clay to sandy silty clay with a few nodules at upper reaches only.	IA	
2.50 - 2.50	D	160774	2.50						
3.00 - 3.45	U	160775	2.90						
3.50 - 3.50	D	160776	2.90						
4.50 - 4.95	P	160777	4.40	20					
6.00 - 6.45	P	160778	5.90	33		5.90		195.20	
7.00 - 7.45	P	160779	6.90	41			MEdium dense to dense silty sand.	II	
8.00 - 8.10	P	160780	7.50	>100		8.00		193.10	

DRILLING

From To (m)	TCR %	RQD %	Water Loss	Color of Ret. Water	N Value	Description	R.L.(M)	Log
8.00 - 8.75	24.00	NIL	NO	Greyish yellow	-			
8.75 - 9.50	36.00	NIL	NO	Greyish yellow	-			
9.50 - 10.25	29.33	10.00	NO	Greyish yellow	-	Highly to moderately weathered yellowish grey rock.	IVB	
10.25 - 11.00	52.00	15.00	NO	Greyish yellow	-			
11.00 - 11.75	29.33	NIL	NO	Greyish yellow	-			
11.75 - 12.50	52.00	16.00	NO	Greyish yellow	-			
12.50 - 13.00	58.00	14.00	NO	Greyish yellow	-			
						13.00 End of BoreHole	188.10	

Water Level Observation

Date	Time (Hrs.)	W.L.(m) B.G.L.
23.02.2018	17.00	3.50
24.02.2018	17.00	4.20
25.02.2018	17.00	4.20

Remarks:

S.W.L. (m)

4.20

(BGL)

196.90

(RL)

D- Disturbed Sample
B- Bulk Sample
W- Water Sample
U- Undisturbed sample
P- Standard Penetration Test
V- Vane Test
PC- Cone Penetration Test

D.D. Supervisor

Job No: 30796

BORELOG DATA SHEET

Boring Method : Shell Auger & NX Drilling.		**Site : Sambalpur**	**BH : 29**
Boring Diameter : 150 mm & NX			**Sheet : 1 of 9**
Casing Diameter : 150 mm & NX		**Co-Ordinate :E810200.00, N2408750.00**	**R.L. : 202.925**
Boring Equipment : Mechanical Cable Tools/NX Drilling.		**Orientation : Vertical**	**Date : 22.02.2018**

Sample In-situ Tests			Casing Depth(M)	N - Value	Date and Depth (m)	Depth (BGL) (m)	Description	R.L.(M)	Log
Depth (m)	Type	No.							
0.50 - 0.50	D	130151							
1.00 - 1.45	P	130152	0.90	15					
1.50 - 1.50	D	130153	0.90				Stiff brownish grey silty clay to clayey silt with a few silt concreation.	IA	
2.00 - 2.45	U	130154	1.90						
2.50 - 2.50	D	130155	1.90						
3.00 - 3.45	P	130156	2.90	21		3.00		199.93	
3.50 - 3.50	D	130157	2.90				Very stiff brownish grey silty clay to clayey silt with a few silt concreation.	IB	
4.50 - 4.95	U	130158	4.40						
6.00 - 6.45	P	130159	5.90	31		5.00		197.93	
7.50 - 7.95	P	130160	7.40	42			Dense brownish grey silty sand.	II	
8.50 - 8.60	P	130161	8.40	>100		8.50		194.43	

DRILLING

From To (m)	TCR %	RQD %	Water Loss	Color of Ret. Water	N Value
8.50 - 9.25	29.33	NIL	NO	Greyish yellow	-
9.25 - 10.00	24.00	10.00	NO	Greyish yellow	-
10.00 - 10.75	38.67	NIL	NO	Greyish yellow	-
10.75 - 11.50	52.00	15.00	NO	Greyish yellow	-
11.50 - 12.25	36.00	NIL	NO	Greyish yellow	-
12.25 - 13.00	52.00	10.00	NO	Greyish yellow	-
13.00 - 13.50	60.00	12.00	NO	Greyish yellow	-

Highly to moderately weathered yellowish grey rock. — IVB

13.50 — End of BoreHole — 189.43

Water Level Observation

Date	Time (Hrs.)	W.L.(m) B.G.L.
23.02.2018	17.00	3.50
24.02.2018	17.00	4.70
25.02.2018	17.00	4.70

Remarks:

S.W.L. (m)

4.70

(BGL)

198.23

(RL)

D.D.

Supervisor

D- Disturbed Sample
B- Bulk Sample
W- Water Sample
U- Undisturbed sample
P- Standard Penetration Test
V- Vane Test
PC- Cone Penetration Test

Job No: 30796

BORELOG DATA SHEET

Boring Method : Shell Auger & NX Drilling.		**Site : Sambalpur**	**BH : 30**
Boring Diameter : 150 mm & NX			**Sheet : 1 of 9**
Casing Diameter : 150 mm & NX		**Co-Ordinate :E810650.00, N2408400.00**	**R.L. : 201.427**
Boring Equipment : Mechanical Cable Tools/NX Drilling.			
		Orientation : Vertical	**Date : 23.02.2018**

Sample In-situ Tests			Casing Depth(M)	N - Value	Date and Depth (m)	Depth (BGL) (m)	Description	R.L.(M)	Log
Depth (m)	Type	No.							
0.50 - 0.50	D	180110							
1.00 - 1.45	U	180111	0.90						
1.50 - 1.50	D	180112	0.90				Stiff to very stiff brownish grey silty clay to sandy clay with a few nodules at upper reaches only.	IA	
2.00 - 2.45	P	180113	1.90	13					
2.50 - 2.50	D	180114	1.90						
3.00 - 3.45	U	180115	2.90			3.00		198.43	
3.50 - 3.50	D	180116	2.90				Very stiff to very stiff brownish grey silty clay to sandy clay with a few nodules at upper reaches only.	IB	
4.50 - 4.95	P	180117	4.40	33					
6.00 - 6.45	P	180118	5.90	41		5.00		196.43	
7.50 - 7.95	P	180119	7.40	51			Dense to very dense yellowish brown silty sand.	III	
8.20 - 8.29	P	180120	8.00	>100		8.20		193.23	

DRILLING

From To (m)	TCR %	RQD %	Water Loss	Color of Ret. Water	N Value
8.20 - 8.95	29.33	NIL	NO	Greyish yellow	-
8.95 - 9.70	24.00	12.00	NO	Greyish yellow	-
9.70 - 10.45	36.00	10.00	NO	Greyish yellow	-
10.45 - 11.20	52.00	12.00	NO	Greyish yellow	-
11.20 - 11.95	52.00	14.00	NO	Greyish yellow	-
11.95 - 12.70	36.00	NIL	NO	Greyish yellow	-
12.70 - 13.20	50.00	18.00	NO	Greyish yellow	-

Highly to moderately weathered yellowish grey rock. — IVB

13.20 — End of BoreHole — 188.23

Water Level Observation

Date	Time (Hrs.)	W.L.(m) B.G.L.
25.02.2018	17.00	3.60
26.02.2018	17.00	4.70
27.02.2018	17.00	4.70

Remarks:

S.W.L. (m)

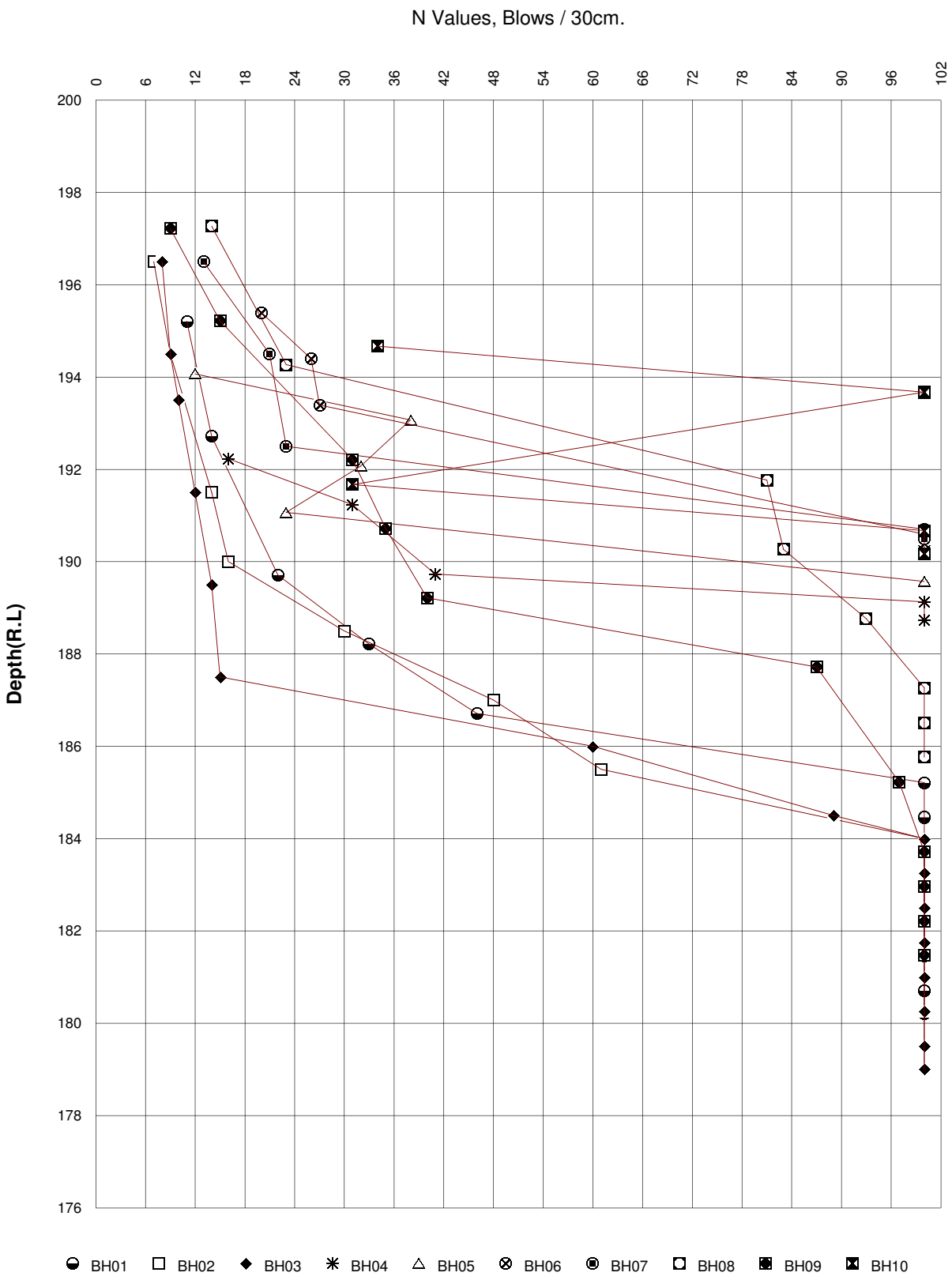
3.60 (BGL)

197.83 (RL)

D.D. Supervisor

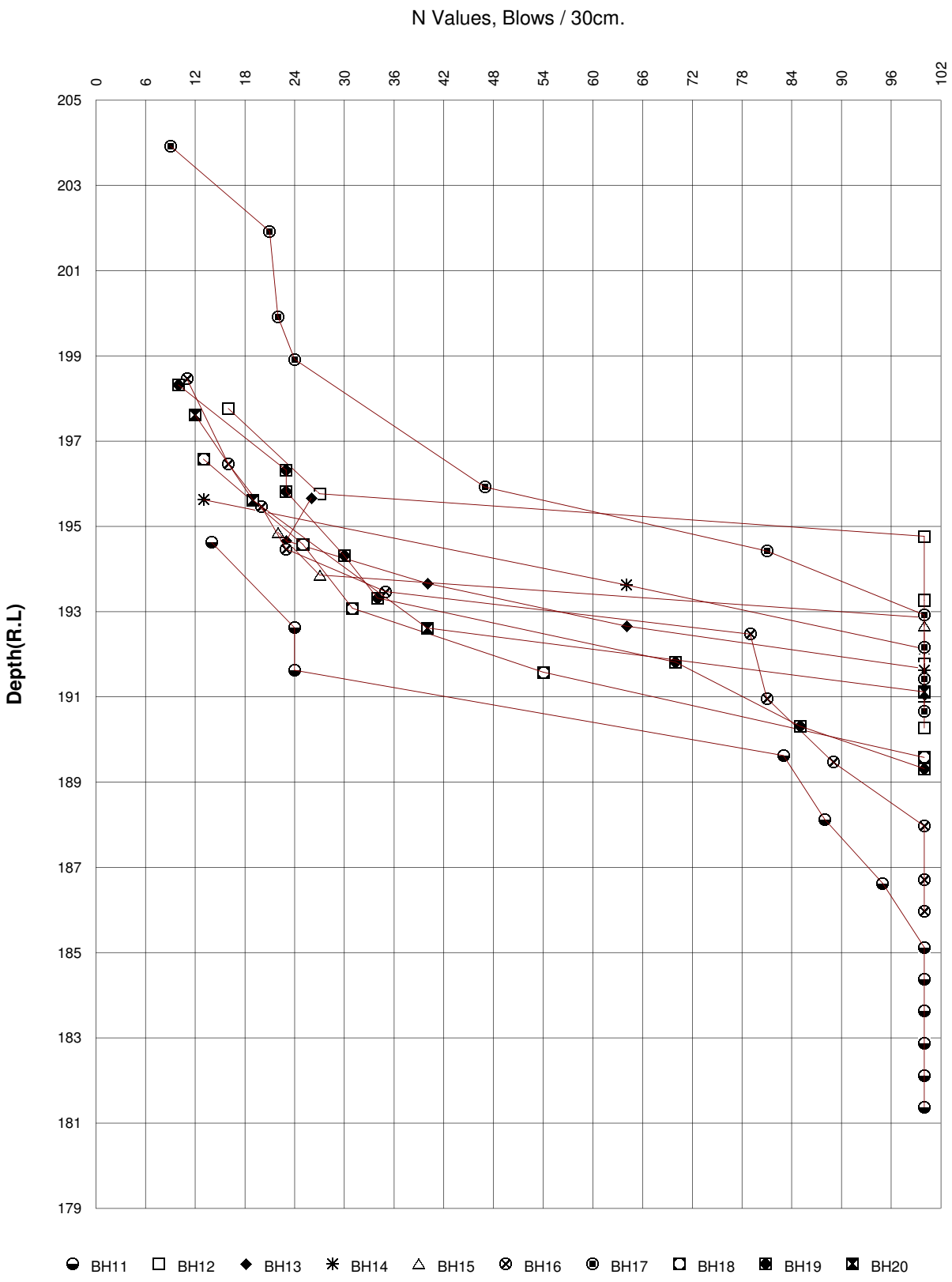
D- Disturbed Sample
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Job No: 30796



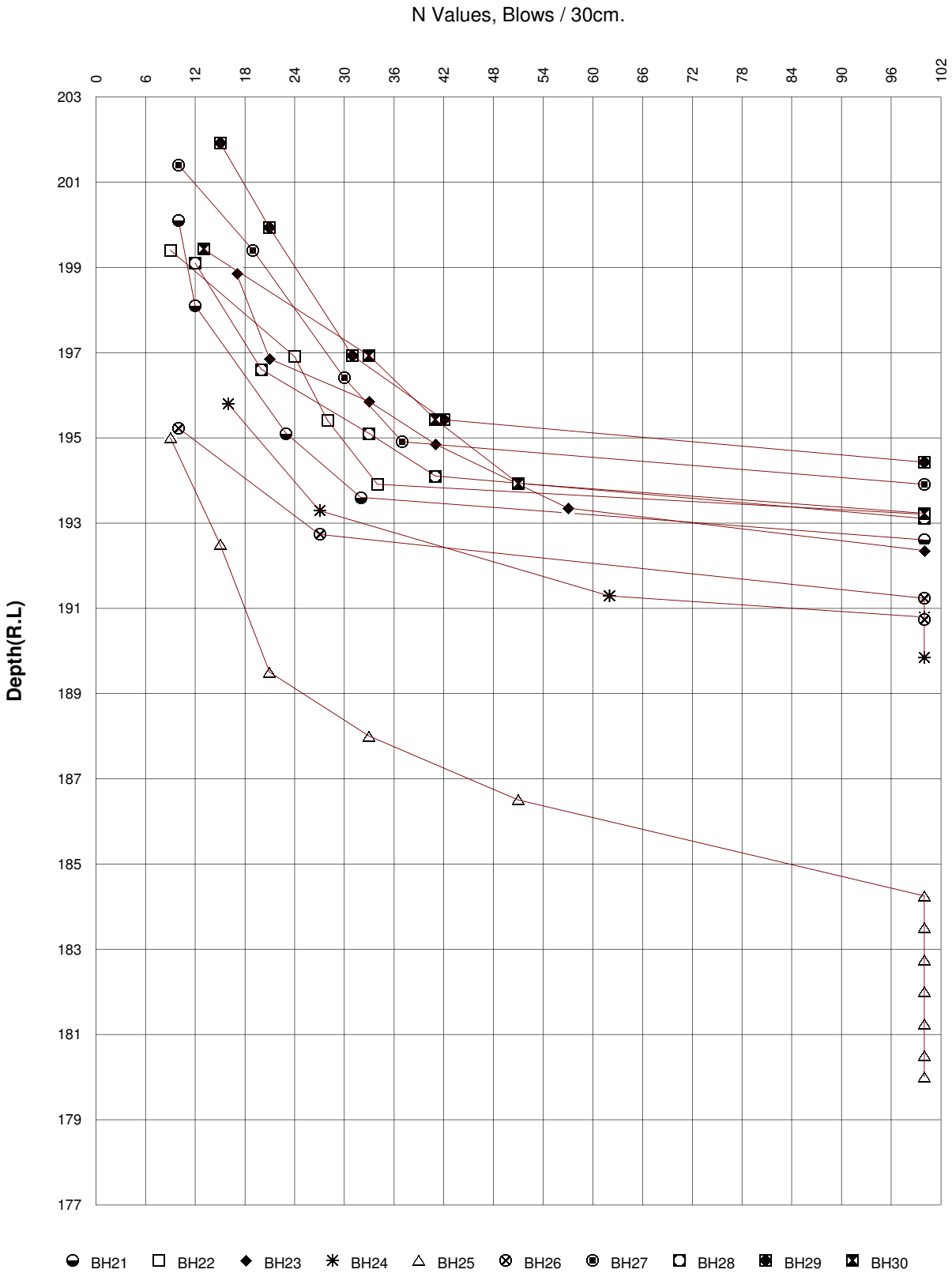
GRAPHICAL VIEW OF STANDARD PENETRATION TEST

Job No: 30796



GRAPHICAL VIEW OF STANDARD PENETRATION TEST

Job No: 30796

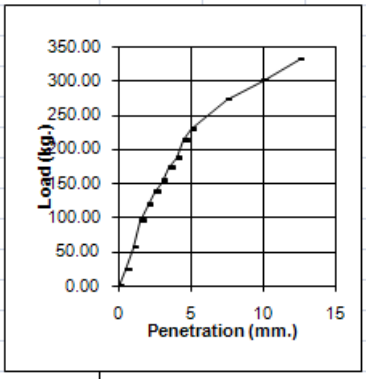


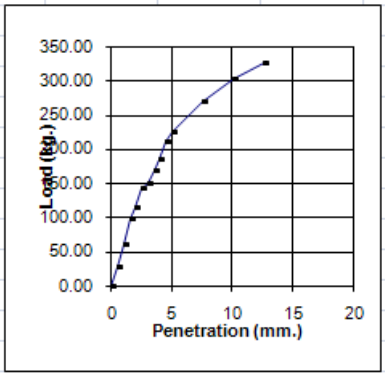
GRAPHICAL VIEW OF STANDARD PENETRATION TEST

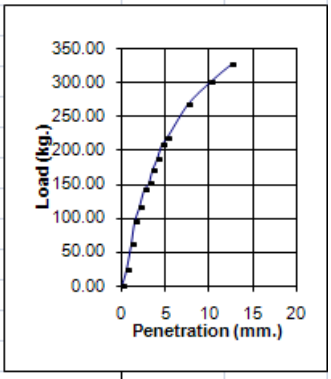
Job No: 30796

Test Number	:	CBR.1		Depth of Test	:	0.50m below G.L.
Location	:	TP-4				
Surcharge Weight Used :						-
During Test :		5 kg.			:	
Proving Ring Constant :		2.36	kg/div.	Date of Test	:	07.3.18

Penetration (mm)	Proving Ring Dial Gauge Reading (Division)			Load in (kg.)			Remarks
	1st	2nd	3rd	1st	2nd	3rd	
0	0	0	0	0.00	0.00	0.00	
0.5	10	11	10	23.60	25.96	23.60	
1	24	25	26	56.64	59.00	61.36	
1.5	40	41	40	94.40	96.76	94.40	
2	50	48	49	118.00	113.28	115.64	
2.5	58	60	60	136.88	141.60	141.60	
3	65	63	64	153.40	148.68	151.04	
3.5	73	71	72	172.28	167.56	169.92	
4	79	78	79	186.44	184.08	186.44	
4.5	90	89	88	212.40	210.04	207.68	
5	97	95	92	228.92	224.20	217.12	
7.5	115	114	113	271.40	269.04	266.68	
10	127	128	127	299.72	302.08	299.72	
12.5	140	138	138	330.40	325.68	325.68	





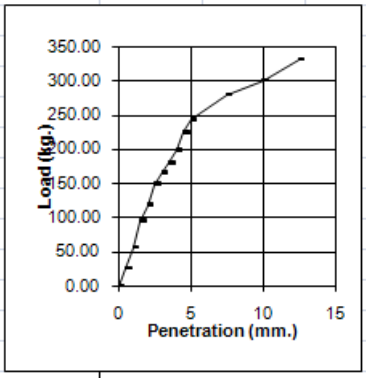


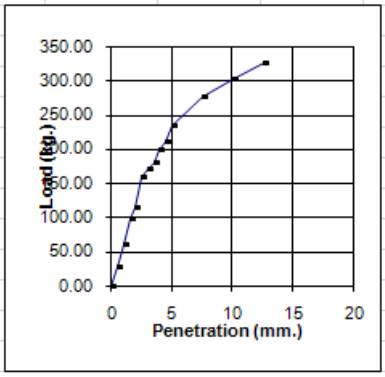
C.B.R. Test Results

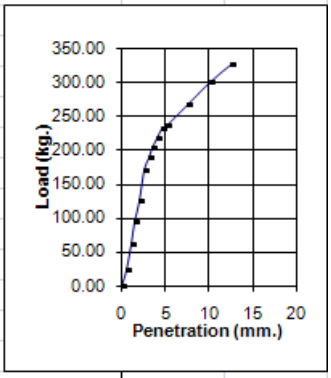
Penetration (mm)	Bearing Ratio (%)			Average (%)
2.5	9.99	10.34	10.34	10.34
5	11.14	10.91	10.57	10.74

Test Number	:	CBR.2		Depth of Test	:	0.50m below G.L.
Location	:	TP-9				
Surcharge Weight Used :						
During Test :		5 kg.				
Proving Ring Constant :		2.36	kg/div.	Date of Test	:	07.3.18

Penetration (mm)	Proving Ring Dial Gauge Reading (Division)			Load in (kg.)			Remarks
	1st	2nd	3rd	1st	2nd	3rd	
0	0	0	0	0.00	0.00	0.00	
0.5	11	11	10	25.96	25.96	23.60	
1	24	25	26	56.64	59.00	61.36	
1.5	40	41	40	94.40	96.76	94.40	
2	50	48	53	118.00	113.28	125.08	
2.5	63	67	72	148.68	158.12	169.92	
3	70	72	80	165.20	169.92	188.80	
3.5	76	76	86	179.36	179.36	202.96	
4	84	84	92	198.24	198.24	217.12	
4.5	95	89	98	224.20	210.04	231.28	
5	103	99	100	243.08	233.64	236.00	
7.5	118	117	113	278.48	276.12	266.68	
10	127	128	127	299.72	302.08	299.72	
12.5	140	138	138	330.40	325.68	325.68	





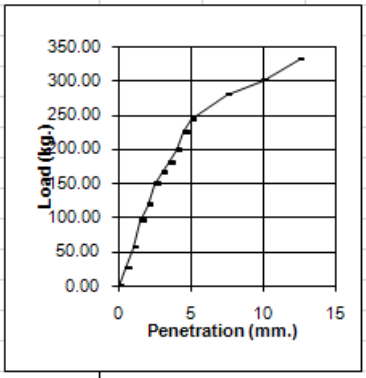


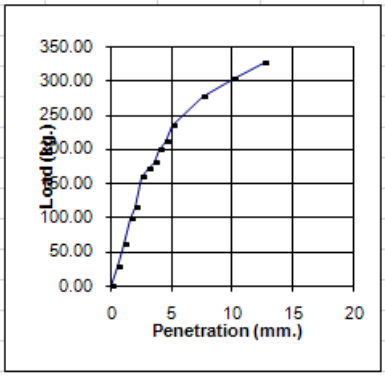
C.B.R. Test Results

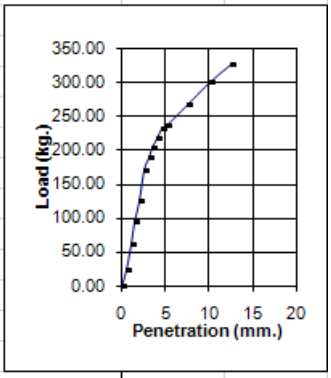
Penetration (mm)	Bearing Ratio (%)			Average (%)
2.5	10.85	11.54	12.40	11.97
5	11.83	11.37	11.48	11.43

Test Number	:	CBR.3		Depth of Test	:	0.50m below G.L.
Location	:	TP-11				
Surcharge Weight Used :						
During Test :		5 kg.				
Proving Ring Constant :		2.36	kg/div.	Date of Test	:	08.3.18

Penetration (mm)	Proving Ring Dial Gauge Reading (Division)			Load in (kg.)			Remarks
	1st	2nd	3rd	1st	2nd	3rd	
0	0	0	0	0.00	0.00	0.00	
0.5	11	11	10	25.96	25.96	23.60	
1	24	25	26	56.64	59.00	61.36	
1.5	40	41	40	94.40	96.76	94.40	
2	50	48	53	118.00	113.28	125.08	
2.5	63	67	72	148.68	158.12	169.92	
3	70	72	80	165.20	169.92	188.80	
3.5	76	76	86	179.36	179.36	202.96	
4	84	84	92	198.24	198.24	217.12	
4.5	95	89	98	224.20	210.04	231.28	
5	103	99	100	243.08	233.64	236.00	
7.5	118	117	113	278.48	276.12	266.68	
10	127	128	127	299.72	302.08	299.72	
12.5	140	138	138	330.40	325.68	325.68	





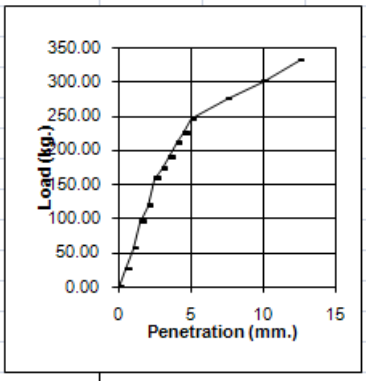


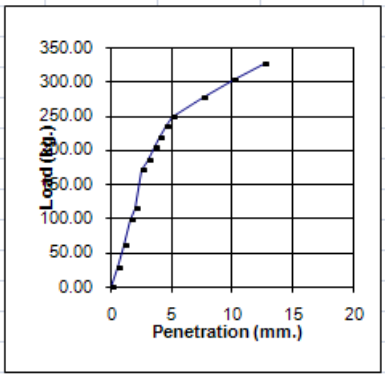
C.B.R. Test Results

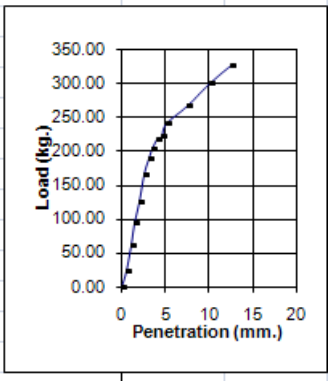
Penetration (mm)	Bearing Ratio (%)			Average (%)
2.5	10.85	11.54	12.40	11.97
5	11.83	11.37	11.48	11.43

Test Number	:	CBR.4		Depth of Test	:	0.50m below G.L.
Location	:	TP-15				
Surcharge Weight Used :						
During Test :		5 kg.				
Proving Ring Constant :		2.36	kg/div.	Date of Test	:	13.3.18

Penetration (mm)	Proving Ring Dial Gauge Reading (Division)			Load in (kg.)			Remarks
	1st	2nd	3rd	1st	2nd	3rd	
0	0	0	0	0.00	0.00	0.00	
0.5	11	11	10	25.96	25.96	23.60	
1	24	25	26	56.64	59.00	61.36	
1.5	40	41	40	94.40	96.76	94.40	
2	50	48	53	118.00	113.28	125.08	
2.5	67	72	70	158.12	169.92	165.20	
3	73	78	80	172.28	184.08	188.80	
3.5	80	86	86	188.80	202.96	202.96	
4	89	92	92	210.04	217.12	217.12	
4.5	95	99	94	224.20	233.64	221.84	
5	104	105	102	245.44	247.80	240.72	
7.5	116	117	113	273.76	276.12	266.68	
10	127	128	127	299.72	302.08	299.72	
12.5	140	138	138	330.40	325.68	325.68	





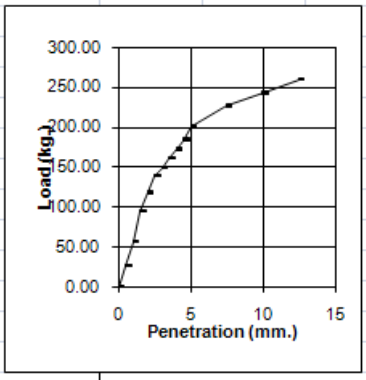


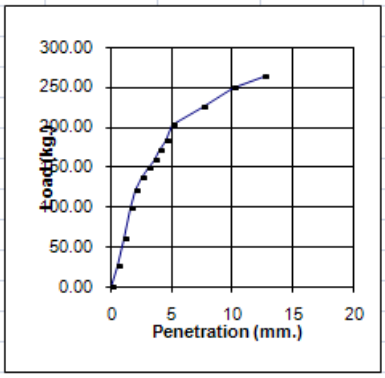
C.B.R. Test Results

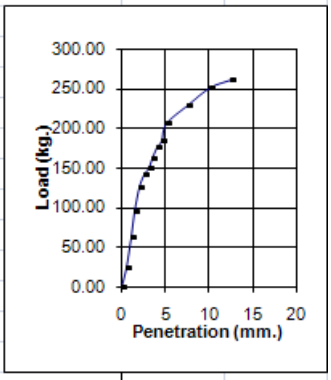
Penetration	Bearing Ratio (%)			Average (%)
2.5	11.54	12.40	12.06	12.23
5	11.94	12.06	11.71	11.89

Test Number	:	CBR.5		Depth of Test	:	0.50m below G.L.
Location	:	TP-2				
Surcharge Weight Used :						
During Test :		5 kg.				
Proving Ring Constant :		2.36	kg/div.	Date of Test	:	09.3.18

Penetration (mm)	Proving Ring Dial Gauge Reading (Division)			Load in (kg.)			Remarks
	1st	2nd	3rd	1st	2nd	3rd	
0	0	0	0	0.00	0.00	0.00	
0.5	11	11	10	25.96	25.96	23.60	
1	24	25	26	56.64	59.00	61.36	
1.5	40	41	40	94.40	96.76	94.40	
2	50	51	53	118.00	120.36	125.08	
2.5	59	58	60	139.24	136.88	141.60	
3	63	63	63	148.68	148.68	148.68	
3.5	68	67	68	160.48	158.12	160.48	
4	73	72	74	172.28	169.92	174.64	
4.5	78	77	78	184.08	181.72	184.08	
5	85	86	87	200.60	202.96	205.32	
7.5	96	95	97	226.56	224.20	228.92	
10	103	105	106	243.08	247.80	250.16	
12.5	110	111	110	259.60	261.96	259.60	

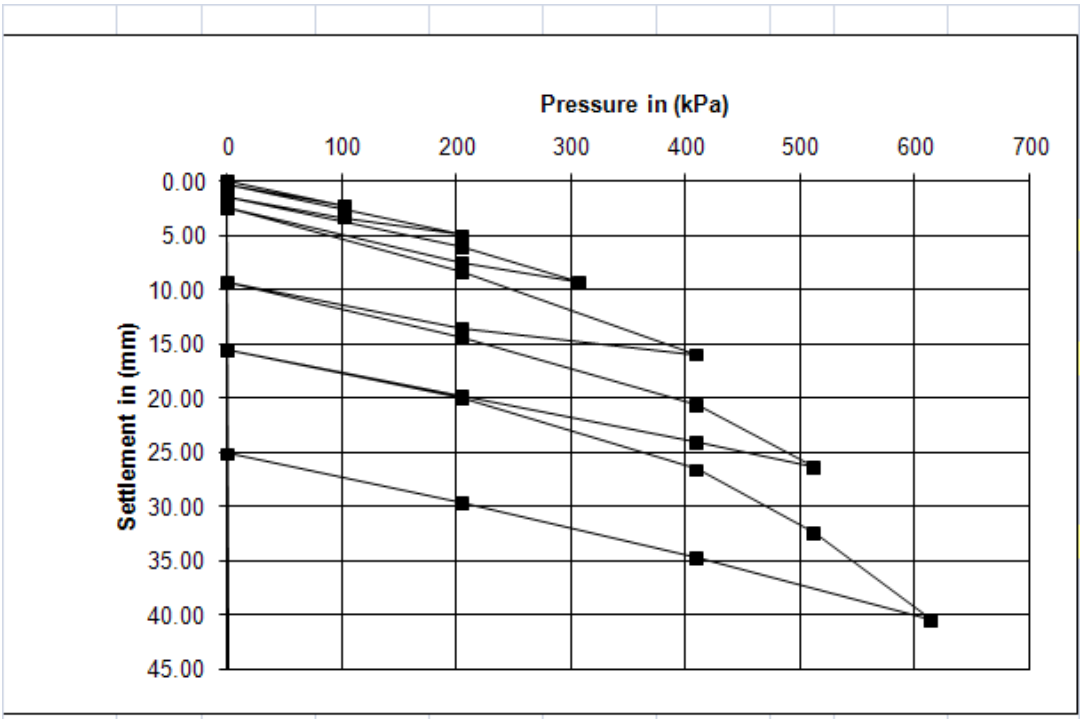






C.B.R. Test Results

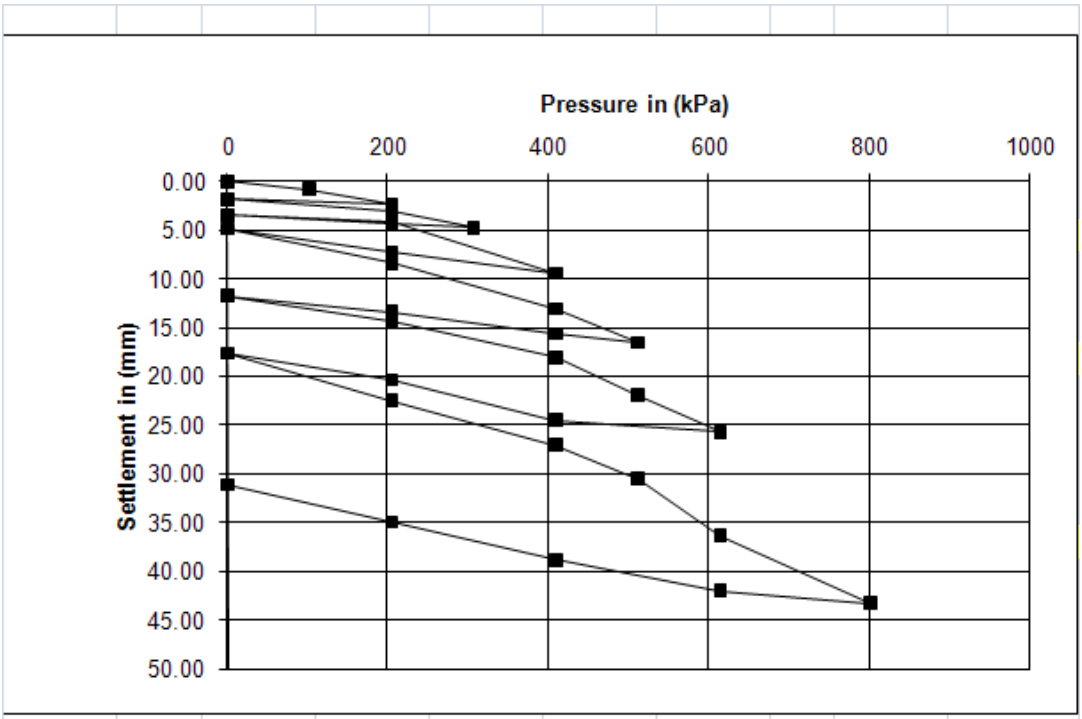
Penetration (mm)	Bearing Ratio (%)			Average (%)
2.5	10.16	9.99	10.34	10.16
5	9.76	9.88	9.99	9.93



Test No.	: CPLT.-01	R.L. of G.L.	198.5m
Plate Size	: 600mm x 600mm.	Dial Gauge Constant	: 0.01mm.
Pit Size	: 3 m x 3 m (Bottom)	L.C. of Pressure Gauge	: 5 kg/cm2
Depth of Test	: 2.50 m. b.g.l.	Ram Dia.	: 12.5cm.
Date of Test	: 12.02.2018	Site	: Sambalpur
Location of Test	N: 2410807.00, 808685.00		

CYCLIC PLATE LOAD TEST

TEST NO. : CPLT - 01

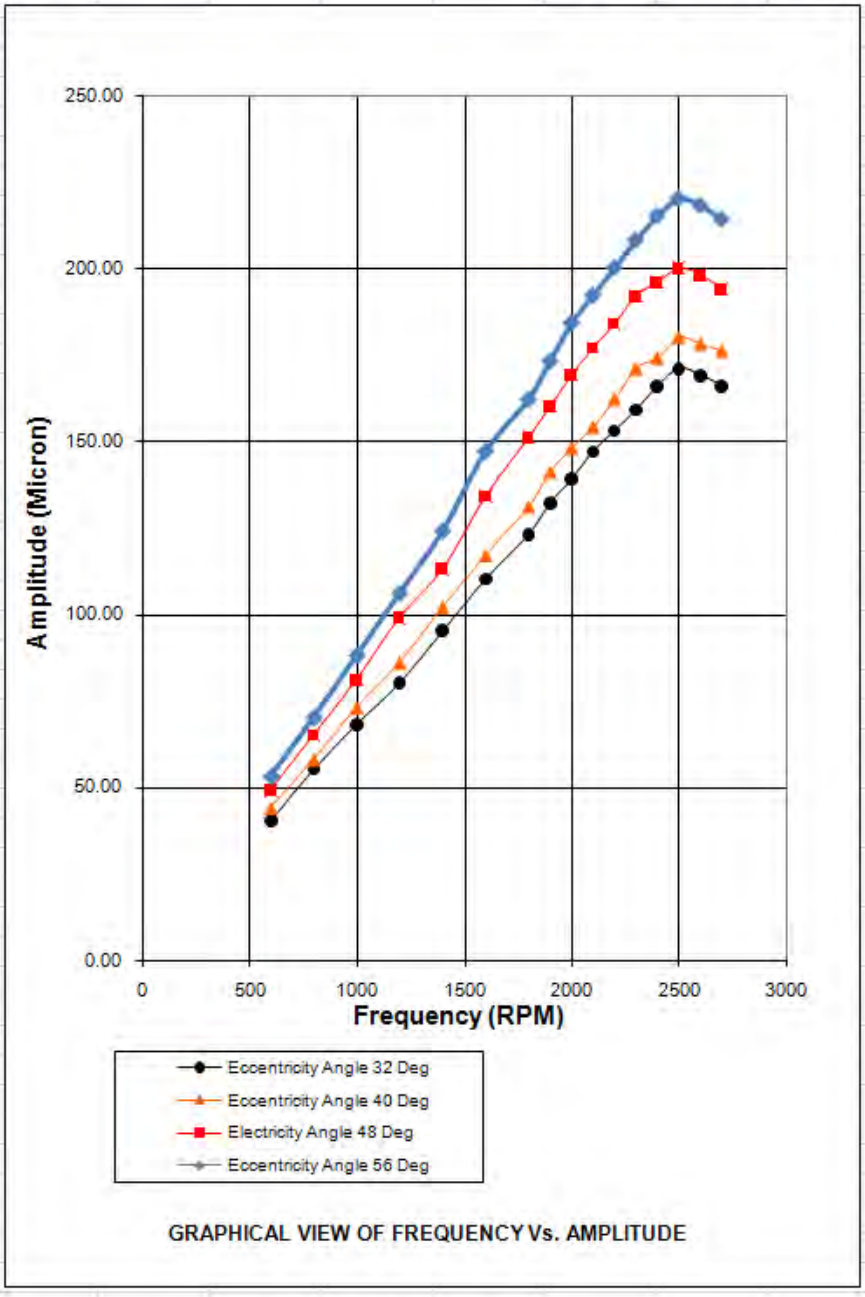


Test No.	: CPLT.-02	R.L. of G.L.	196.621m
Plate Size	: 600mm x 600mm.	Dial Gauge Constant	: 0.01mm.
Pit Size	: 3 m x 3 m (Bottom)	L.C. of Pressure Gauge	: 5 kg/cm2
Depth of Test	: 2.25 m. b.g.l.	Ram Dia.	: 12.5cm.
Date of Test	: 12.02.2018	Site	: Sambalpur
Location of Test	N: 2411120.00, 809085.00		

CYCLIC PLATE LOAD TEST

TEST NO. : CPLT - 02

Test No.	BVT-1		
Site :	NLC		
Date :	08.02.2018	Depth :	2.20m m below Egl
Block Size	1.50mx0.75mx1.00m	Soil Type: :	Sandy silt
RL:	195.857m	SWL:	0.15
		Location:	N: 2411065, E: 809083



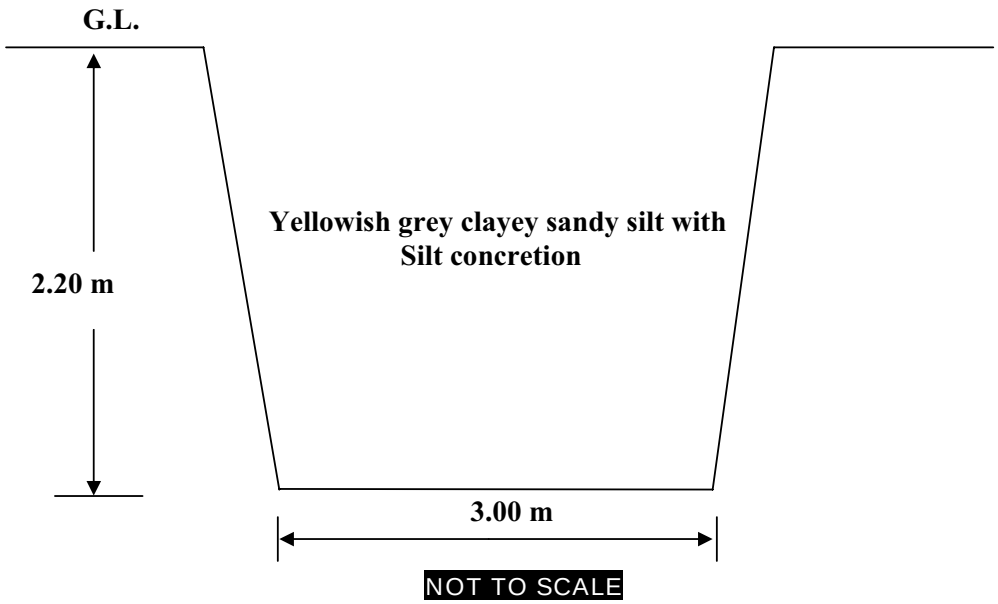
BLOCK VIBRATION TEST

BVT Pit Log

BVT Pit –1 (One)

Site : NLC, Sambalpur
Pit Volume: 5.0m x 3.0m x 2.2m
Date : 08.02.2018

RL : 195.857m
Depth : 2.20m
Co-Ordinate: N: 2411065, E: 809083



Dynamic Cone Penetration Test (DCPT)

DCPT : 1
Co-ordinate : N =2410807 / E= 808688
R.L. (m) : 198.50 **Near : BH-03**
Depth (m) : 12.60m **Date : 04.02.2018**

Depth (m)	No of blows	N-value	Depth (m)	No of blows	N-value
0.10	1		4.30	4	
0.20	1	3	4.40	6	17
0.30	1		4.50	7	
0.40	1		4.60	5	
0.50	1	5	4.70	6	18
0.60	3		4.80	7	
0.70	2		4.90	5	
0.80	2	7	5.00	6	18
0.90	3		5.10	7	
1.00	2		5.20	5	
1.10	2	7	5.30	6	18
1.20	3		5.40	7	
1.30	3		5.50	5	
1.40	3	10	5.60	6	19
1.50	4		5.70	8	
1.60	3		5.80	6	
1.70	4	11	5.90	6	19
1.80	4		6.00	7	
1.90	4		6.10	6	
2.00	4	12	6.20	6	19
2.10	4		6.30	7	
2.20	4		6.40	6	
2.30	4	12	6.50	6	19
2.40	4		6.60	7	
2.50	4		6.70	6	
2.60	4	12	6.80	6	19
2.70	4		6.90	7	
2.80	4		7.00	6	
2.90	4	14	7.10	6	20
3.00	6		7.20	8	
3.10	4		7.30	6	
3.20	4	15	7.40	7	21
3.30	7		7.50	8	
3.40	4		7.60	6	
3.50	5	15	7.70	7	21
3.60	6		7.80	8	
3.70	4		7.90	7	
3.80	5	16	8.00	7	23
3.90	7		8.10	9	
4.00	4		8.20	7	
4.10	5	16	8.30	8	23
4.20	7		8.40	8	

Dynamic Cone Penetration Test (DCPT)

DCPT : 1
Co-ordinate : N =2410807 / E= 808688
R.L. (m) : 198.50 **Near : BH-03**
Depth (m) : 12.60m **Date : 04.02.2018**

Depth (m)	No of blows	N-value	Depth (m)	No of blows	N-value
8.50	8		11.80	25	
8.60	8	24	11.90	29	86
8.70	8		12.00	32	
8.80	8		12.10	39	
8.90	9	26	12.20	43	137
9.00	9		12.30	55	
9.10	8		12.40	59	
9.20	9	26	12.50	63	190
9.30	9		12.60	68	
9.40	8				
9.50	9	26			
9.60	9				
9.70	9				
9.80	9	27			
9.90	9				
10.00	9				
10.10	9	28			
10.20	10				
10.30	9				
10.40	9	28			
10.50	10				
10.60	9				
10.70	10	29			
10.80	10				
10.90	9				
11.00	10	29			
11.10	10				
11.20	10				
11.30	17	47			
11.40	20				
11.50	13				
11.60	22	59			
11.70	24				

Dynamic Cone Penetration Test (DCPT)

DCPT : 2
Co-ordinate : N =2411135 / E= 808965
R.L. (m) : 194.729 **Near : BH-04**
Depth (m) : 5.40m **Date : 04.02.2018**

Depth (m)	No of blows	N-value	Depth (m)	No of blows	N-value
0.10	3		4.30	20	
0.20	3	9	4.40	21	65
0.30	3		4.50	24	
0.40	4		4.60	20	
0.50	7	18	4.70	23	68
0.60	7		4.80	25	
0.70	5		4.90	20	
0.80	8	22	5.00	23	68
0.90	9		5.10	25	
1.00	5		5.20	29	
1.10	8	22	5.30	61	161
1.20	9		5.40	71	
1.30	5		5.50		
1.40	9	23	5.60		
1.50	9		5.70		
1.60	6		5.80		
1.70	9	24	5.90		
1.80	9		6.00		
1.90	6		6.10		
2.00	9	24	6.20		
2.10	9		6.30		
2.20	8		6.40		
2.30	9	26	6.50		
2.40	9		6.60		
2.50	9		6.70		
2.60	9	28	6.80		
2.70	10		6.90		
2.80	11		7.00		
2.90	13	38	7.10		
3.00	14		7.20		
3.10	14		7.30		
3.20	14	42	7.40		
3.30	14		7.50		
3.40	14		7.60		
3.50	16	48	7.70		
3.60	18		7.80		
3.70	15		7.90		
3.80	17	53	8.00		
3.90	21		8.10		
4.00	16		8.20		
4.10	17	57	8.30		
4.20	24		8.40		



Dynamic Cone Penetration Test (DCPT)

DCPT : 3
Co-ordinate : N =2411085/ E= 809048
R.L. (m) : 195.568 **Near : BH-05**
Depth (m) : 6.00m **Date : 04.02.2018**

Depth (m)	No of blows	N-value	Depth (m)	No of blows	N-value
0.10	1		4.30	14	
0.20	2	6	4.40	14	45
0.30	3		4.50	17	
0.40	3		4.60	15	
0.50	4	12	4.70	16	47
0.60	5		4.80	16	
0.70	4		4.90	22	
0.80	5	14	5.00	29	80
0.90	5		5.10	29	
1.00	4		5.20	39	
1.10	5	14	5.30	24	90
1.20	5		5.40	27	
1.30	6		5.50	39	
1.40	6	22	5.60	25	92
1.50	10		5.70	28	
1.60	11		5.80	39	
1.70	12	38	5.90	43	151
1.80	15		6.00	69	
1.90	13		6.10	72	
2.00	13	40	6.20		
2.10	14		6.30		
2.20	15		6.40		
2.30	19	56	6.50		
2.40	22		6.60		
2.50	16		6.70		
2.60	20	58	6.80		
2.70	22		6.90		
2.80	16		7.00		
2.90	20	58	7.10		
3.00	22		7.20		
3.10	16		7.30		
3.20	20	58	7.40		
3.30	22		7.50		
3.40	16		7.60		
3.50	20	58	7.70		
3.60	22		7.80		
3.70	14		7.90		
3.80	20	56	8.00		
3.90	22		8.10		
4.00	14		8.20		
4.10	16	50	8.30		
4.20	20		8.40		



Dynamic Cone Penetration Test (DCPT)

DCPT : 4
Co-ordinate : N =2410982/ E= 808979
R.L. (m) : 195.568 **Near : BH-06**
Depth (m) : 6.90m **Date : 05.02.2018**

Depth (m)	No of blows	N-value	Depth (m)	No of blows	N-value
0.10	3		4.30	16	
0.20	3	11	4.40	17	50
0.30	5		4.50	17	
0.40	5		4.60	20	
0.50	5	16	4.70	24	77
0.60	6		4.80	33	
0.70	6		4.90	25	
0.80	7	24	5.00	26	78
0.90	11		5.10	27	
1.00	7		5.20	27	
1.10	10	27	5.30	27	82
1.20	10		5.40	28	
1.30	10		5.50	30	
1.40	10	30	5.60	32	96
1.50	10		5.70	34	
1.60	10		5.80	40	
1.70	10	30	5.90	42	124
1.80	10		6.00	42	
1.90	10		6.10	42	
2.00	10	32	6.20	42	136
2.10	12		6.30	52	
2.20	12		6.40	43	
2.30	12	37	6.50	47	142
2.40	13		6.60	52	
2.50	13		6.70	57	
2.60	14	42	6.80	68	193
2.70	15		6.90	68	
2.80	13		7.00		
2.90	14	42	7.10		
3.00	15		7.20		
3.10	14		7.30		
3.20	14	43	7.40		
3.30	15		7.50		
3.40	15		7.60		
3.50	15	45	7.70		
3.60	15		7.80		
3.70	15		7.90		
3.80	15	45	8.00		
3.90	15		8.10		
4.00	15		8.20		
4.10	15	46	8.30		
4.20	16		8.40		



Dynamic Cone Penetration Test (DCPT)

DCPT : 5
Co-ordinate : N =2410933/ E= 808954
R.L. (m) : 197.499 **Near : BH-07**
Depth (m) : 6.90m **Date : 05.02.2018**

Depth (m)	No of blows	N-value	Depth (m)	No of blows	N-value
0.10	2		4.30	13	
0.20	3	8	4.40	13	40
0.30	3		4.50	14	
0.40	3		4.60	13	
0.50	4	12	4.70	13	40
0.60	5		4.80	14	
0.70	5		4.90	13	
0.80	5	17	5.00	14	41
0.90	7		5.10	14	
1.00	8		5.20	19	
1.10	8	24	5.30	37	101
1.20	8		5.40	45	
1.30	8		5.50	45	
1.40	8	25	5.60	45	136
1.50	9		5.70	46	
1.60	8		5.80	46	
1.70	8	25	5.90	39	124
1.80	9		6.00	39	
1.90	9		6.10	45	
2.00	9	27	6.20	45	139
2.10	9		6.30	49	
2.20	10		6.40	46	
2.30	10	31	6.50	46	142
2.40	11		6.60	50	
2.50	11		6.70	54	
2.60	11	34	6.80	66	187
2.70	12		6.90	67	
2.80	12		7.00		
2.90	12	36	7.10		
3.00	12		7.20		
3.10	12		7.30		
3.20	12	37	7.40		
3.30	13		7.50		
3.40	12		7.60		
3.50	12	37	7.70		
3.60	13		7.80		
3.70	12		7.90		
3.80	13	38	8.00		
3.90	13		8.10		
4.00	12		8.20		
4.10	13	38	8.30		
4.20	13		8.40		

Dynamic Cone Penetration Test (DCPT)

DCPT : 6
Co-ordinate : N =2410807/ E= 809049
R.L. (m) : 199.264 **Near : BH-08**
Depth (m) : 10.50m **Date : 05.02.2018**

Depth (m)	No of blows	N-value	Depth (m)	No of blows	N-value
0.10	2		4.30	13	
0.20	2	6	4.40	14	41
0.30	2		4.50	14	
0.40	2		4.60	13	
0.50	3	11	4.70	14	41
0.60	6		4.80	14	
0.70	6		4.90	14	
0.80	6	18	5.00	14	42
0.90	6		5.10	14	
1.00	6		5.20	15	
1.10	6	18	5.30	21	59
1.20	6		5.40	23	
1.30	6		5.50	21	
1.40	6	20	5.60	23	67
1.50	8		5.70	23	
1.60	7		5.80	27	
1.70	7	22	5.90	33	100
1.80	8		6.00	40	
1.90	7		6.10	33	
2.00	7	22	6.20	33	100
2.10	8		6.30	34	
2.20	8		6.40	34	
2.30	8	26	6.50	34	102
2.40	10		6.60	34	
2.50	9		6.70	34	
2.60	10	29	6.80	36	111
2.70	10		6.90	41	
2.80	11		7.00	36	
2.90	12	35	7.10	37	111
3.00	12		7.20	38	
3.10	12		7.30	40	
3.20	12	36	7.40	42	128
3.30	12		7.50	46	
3.40	12		7.60	40	
3.50	13	38	7.70	42	128
3.60	13		7.80	46	
3.70	12		7.90	40	
3.80	13	38	8.00	43	129
3.90	13		8.10	46	
4.00	13		8.20	41	
4.10	13	40	8.30	43	130
4.20	14		8.40	46	

Dynamic Cone Penetration Test (DCPT)

DCPT : 6
Co-ordinate : N =2410807/ E= 809049
R.L. (m) : 199.264 **Near : BH-08**
Depth (m) : 10.50m **Date : 05.02.2018**

Depth (m)	No of blows	N-value	Depth (m)	No of blows	N-value
8.50	41				
8.60	43	130			
8.70	46				
8.80	43				
8.90	45	136			
9.00	48				
9.10	44				
9.20	45	138			
9.30	49				
9.40	44				
9.50	45	138			
9.60	49				
9.70	45				
9.80	45	140			
9.90	50				
10.00	48				
10.10	48	149			
10.20	53				
10.30	57				
10.40	62	181			
10.50	62				
8.50	41				
8.60	43	130			
8.70	46				
8.80	43				
8.90	45	136			
9.00	48				
9.10	44				
9.20	45	138			
9.30	49				
9.40	44				
9.50	45	138			
9.60	49				
9.70	45				
9.80	45	140			
9.90	50				
10.00	48				
10.10	48	149			
10.20	53				
10.30	57				
10.40	62	181			
10.50	62				

Dynamic Cone Penetration Test (DCPT)

DCPT : 7
Co-ordinate : N =2410795/ E= 808950
R.L. (m) : 198.215 **Near : BH-09**
Depth (m) : 10.50m **Date : 06.02.2018**

Depth (m)	No of blows	N-value	Depth (m)	No of blows	N-value
0.10	1		4.30	11	
0.20	1	4	4.40	12	35
0.30	2		4.50	12	
0.40	1		4.60	12	
0.50	2	5	4.70	12	37
0.60	2		4.80	13	
0.70	2		4.90	14	
0.80	3	10	5.00	10	37
0.90	5		5.10	13	
1.00	4		5.20	13	
1.10	5	14	5.30	13	39
1.20	5		5.40	13	
1.30	7		5.50	13	
1.40	10	28	5.60	13	40
1.50	11		5.70	14	
1.60	12		5.80	14	
1.70	13	37	5.90	16	48
1.80	12		6.00	18	
1.90	13		6.10	18	
2.00	17	51	6.20	18	49
2.10	21		6.30	13	
2.20	17		6.40	15	
2.30	19	57	6.50	15	48
2.40	21		6.60	18	
2.50	7		6.70	15	
2.60	11	33	6.80	16	50
2.70	15		6.90	19	
2.80	10		7.00	15	
2.90	10	30	7.10	16	52
3.00	10		7.20	21	
3.10	10		7.30	15	
3.20	10	30	7.40	17	53
3.30	10		7.50	21	
3.40	9		7.60	16	
3.50	10	30	7.70	17	54
3.60	11		7.80	21	
3.70	11		7.90	19	
3.80	11	31	8.00	20	60
3.90	9		8.10	21	
4.00	10		8.20	21	
4.10	10	32	8.30	21	63
4.20	12		8.40	21	



Dynamic Cone Penetration Test (DCPT)

DCPT : 7
Co-ordinate : N =2410795/ E= 808950
R.L. (m) : 198.215 **Near : BH-09**
Depth (m) : 10.50m **Date : 06.02.2018**

Depth (m)	No of blows	N-value	Depth (m)	No of blows	N-value
8.50	21				
8.60	22	66			
8.70	23				
8.80	21				
8.90	22	68			
9.00	25				
9.10	28				
9.20	34	103			
9.30	41				
9.40	30				
9.50	36	111			
9.60	45				
9.70	43				
9.80	46	139			
9.90	50				
10.00	45				
10.10	48	146			
10.20	53				
10.30	59				
10.40	61	186			
10.50	66				
8.50	21				
8.60	22	66			
8.70	23				
8.80	21				
8.90	22	68			
9.00	25				
9.10	28				
9.20	34	103			
9.30	41				
9.40	30				
9.50	36	111			
9.60	45				
9.70	43				
9.80	46	139			
9.90	50				
10.00	45				
10.10	48	146			
10.20	53				
10.30	59				
10.40	61	186			
10.50	66				

Dynamic Cone Penetration Test (DCPT)

DCPT : 8
Co-ordinate : N =2411180/ E= 809059
R.L. (m) : 195.668 **Near : BH-10**
Depth (m) : 5.40m **Date : 06.02.2018**

Depth (m)	No of blows	N-value	Depth (m)	No of blows	N-value
0.10	4		4.30	20	
0.20	6	17	4.40	24	76
0.30	7		4.50	32	
0.40	8		4.60	33	
0.50	8	26	4.70	34	111
0.60	10		4.80	44	
0.70	10		4.90	45	
0.80	12	37	5.00	45	146
0.90	15		5.10	56	
1.00	18		5.20	61	
1.10	19	56	5.30	68	197
1.20	19		5.40	68	
1.30	20		5.50		
1.40	23	70	5.60		
1.50	27		5.70		
1.60	33		5.80		
1.70	42	128	5.90		
1.80	53		6.00		
1.90	41		6.10		
2.00	46	138	6.20		
2.10	51		6.30		
2.20	30		6.40		
2.30	36	111	6.50		
2.40	45		6.60		
2.50	23		6.70		
2.60	10	43	6.80		
2.70	10		6.90		
2.80	12		7.00		
2.90	12	45	7.10		
3.00	21		7.20		
3.10	13		7.30		
3.20	16	45	7.40		
3.30	16		7.50		
3.40	16		7.60		
3.50	14	43	7.70		
3.60	13		7.80		
3.70	13		7.90		
3.80	14	46	8.00		
3.90	19		8.10		
4.00	13		8.20		
4.10	14	46	8.30		
4.20	19		8.40		



Dynamic Cone Penetration Test (DCPT)

DCPT : 9
Co-ordinate : N =2410725/ E= 809060
R.L. (m) : 198.621 **Near : BH-11**
Depth (m) : 11.40m **Date : 06.02.2018**

Depth (m)	No of blows	N-value	Depth (m)	No of blows	N-value
0.10	3		4.30	14	
0.20	3	9	4.40	14	47
0.30	3		4.50	19	
0.40	3		4.60	14	
0.50	4	11	4.70	15	47
0.60	4		4.80	18	
0.70	3		4.90	17	
0.80	4	11	5.00	17	51
0.90	4		5.10	17	
1.00	6		5.20	17	
1.10	6	18	5.30	19	64
1.20	6		5.40	28	
1.30	6		5.50	17	
1.40	6	20	5.60	24	71
1.50	8		5.70	30	
1.60	6		5.80	24	
1.70	6	20	5.90	25	80
1.80	8		6.00	31	
1.90	7		6.10	30	
2.00	8	23	6.20	30	91
2.10	8		6.30	31	
2.20	8		6.40	30	
2.30	9	26	6.50	30	91
2.40	9		6.60	31	
2.50	9		6.70	31	
2.60	9	28	6.80	31	93
2.70	10		6.90	31	
2.80	9		7.00	33	
2.90	9	28	7.10	37	109
3.00	10		7.20	39	
3.10	10		7.30	34	
3.20	10	32	7.40	37	110
3.30	12		7.50	39	
3.40	10		7.60	36	
3.50	11	34	7.70	39	116
3.60	13		7.80	41	
3.70	13		7.90	40	
3.80	13	39	8.00	40	120
3.90	13		8.10	40	
4.00	13		8.20	40	
4.10	14	44	8.30	40	120
4.20	17		8.40	40	



Dynamic Cone Penetration Test (DCPT)

DCPT : 9
Co-ordinate : N =2410725/ E= 809060
R.L. (m) : 198.621 **Near : BH-11**
Depth (m) : 11.40m **Date : 06.02.2018**

Depth (m)	No of blows	N-value	Depth (m)	No of blows	N-value
8.50	42		9.50	44	131
8.60	43	128	9.60	44	
8.70	43		9.70	45	
8.80	43		9.80	45	137
8.90	43	130	9.90	47	
9.00	44		10.00	45	
9.10	43		10.10	46	140
9.20	44	131	10.20	49	
9.30	44		10.30	46	
9.40	43		10.40	47	143
9.50	44	131	10.50	50	
9.60	44		10.60	47	
9.70	45		10.70	47	144
9.80	45	137	10.80	50	
9.90	47		10.90	48	
10.00	45		11.00	49	148
10.10	46	140	11.10	51	
10.20	49		11.20	57	
10.30	46		11.30	57	180
10.40	47	143	11.40	66	
10.50	50		11.50	69	
10.60	47				
10.70	47	144			
10.80	50				
10.90	48				
11.00	49	148			
11.10	51				
11.20	57				
11.30	57	180			
11.40	66				
11.50	69				
8.50	42				
8.60	43	128			
8.70	43				
8.80	43				
8.90	43	130			
9.00	44				
9.10	43				
9.20	44	131			
9.30	44				
9.40	43				

Dynamic Cone Penetration Test (DCPT)

DCPT : 10
Co-ordinate : N =2410730/ E= 809099
R.L. (m) : 199.764 **Near : BH-10**
Depth (m) : 5.70m **Date : 07.02.2018**

Depth (m)	No of blows	N-value	Depth (m)	No of blows	N-value
0.10	2		4.30	22	
0.20	2	6	4.40	47	129
0.30	2		4.50	60	
0.40	3		4.60	39	
0.50	4	12	4.70	44	129
0.60	5		4.80	46	
0.70	4		4.90	41	
0.80	5	16	5.00	47	136
0.90	7		5.10	48	
1.00	6		5.20	49	
1.10	7	20	5.30	49	148
1.20	7		5.40	50	
1.30	6		5.50	57	
1.40	7	20	5.60	61	191
1.50	7		5.70	73	
1.60	7				
1.70	7	22			
1.80	8				
1.90	8				
2.00	8	26			
2.10	10				
2.20	8				
2.30	9	27			
2.40	10				
2.50	8				
2.60	9	27			
2.70	10				
2.80	10				
2.90	10	32			
3.00	12				
3.10	12				
3.20	12	36			
3.30	12				
3.40	13				
3.50	13	40			
3.60	14				
3.70	13				
3.80	14	41			
3.90	14				
4.00	14				
4.10	14	44			
4.20	16				

Dynamic Cone Penetration Test (DCPT)

DCPT : 11
Co-ordinate : N =2411180/ E= 809098
R.L. (m) : 196.550 **Near : BH-13**
Depth (m) : 5.40m **Date : 07.02.2018**

Depth (m)	No of blows	N-value	Depth (m)	No of blows	N-value
0.10	3		4.30	40	
0.20	3	11	4.40	42	126
0.30	5		4.50	44	
0.40	4		4.60	41	
0.50	4	14	4.70	43	130
0.60	6		4.80	46	
0.70	6		4.90	46	
0.80	12	34	5.00	47	141
0.90	16		5.10	48	
1.00	12		5.20	53	
1.10	14	42	5.30	59	181
1.20	16		5.40	69	
1.30	14		5.50		
1.40	14	42	5.60		
1.50	14		5.70		
1.60	14				
1.70	14	42			
1.80	14				
1.90	14				
2.00	14	42			
2.10	14				
2.20	14				
2.30	15	46			
2.40	17				
2.50	17				
2.60	17	51			
2.70	17				
2.80	18				
2.90	22	62			
3.00	22				
3.10	23				
3.20	23	70			
3.30	24				
3.40	24				
3.50	25	77			
3.60	28				
3.70	27				
3.80	28	86			
3.90	31				
4.00	28				
4.10	29	88			
4.20	31				

Dynamic Cone Penetration Test (DCPT)

DCPT : 12
Co-ordinate : N =2411120/ E= 809086
R.L. (m) : 196.621 **Near : BH-14**
Depth (m) : 4.80m **Date : 07.02.2018**

Depth (m)	No of blows	N-value	Depth (m)	No of blows	N-value
0.10	4		4.30	44	
0.20	6	17	4.40	46	138
0.30	7		4.50	48	
0.40	7		4.60	53	
0.50	7	21	4.70	59	183
0.60	7		4.80	71	
0.70	7				
0.80	7	22			
0.90	8				
1.00	7				
1.10	8	26			
1.20	11				
1.30	10				
1.40	11	32			
1.50	11				
1.60	10				
1.70	11	32			
1.80	11				
1.90	12				
2.00	13	41			
2.10	16				
2.20	17				
2.30	17	53			
2.40	19				
2.50	23				
2.60	29	81			
2.70	29				
2.80	29				
2.90	29	89			
3.00	31				
3.10	32				
3.20	32	96			
3.30	32				
3.40	32				
3.50	32	96			
3.60	32				
3.70	33				
3.80	33	101			
3.90	35				
4.00	38				
4.10	41	122			
4.20	43				

Dynamic Cone Penetration Test (DCPT)

DCPT : 13
Co-ordinate : N =2411050/ E= 809080
R.L. (m) : 195.857 **Near : BH-15**
Depth (m) : 3.30m **Date : 07.02.2018**

Depth (m)	No of blows	N-value	Depth (m)	No of blows	N-value
0.10	5				
0.20	7	20			
0.30	8				
0.40	8				
0.50	8	24			
0.60	8				
0.70	8				
0.80	9	27			
0.90	10				
1.00	11				
1.10	11	34			
1.20	12				
1.30	12				
1.40	12	36			
1.50	12				
1.60	12				
1.70	13	39			
1.80	14				
1.90	13				
2.00	14	41			
2.10	14				
2.20	15				
2.30	18	56			
2.40	23				
2.50	24				
2.60	24	72			
2.70	24				
2.80	36				
2.90	43	134			
3.00	55				
3.10	57				
3.20	60	180			
3.30	63				

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Dynamic Cone Penetration Test (DCPT)

DCPT : 14
Co-ordinate : N =2410806/ E= 809080
R.L. (m) : 199.466 **Near : BH-16**
Depth (m) : 11.10m **Date : 08.02.2018**

Depth (m)	No of blows	N-value	Depth (m)	No of blows	N-value
0.10	3		4.30	11	
0.20	3	9	4.40	12	35
0.30	3		4.50	12	
0.40	3		4.60	12	
0.50	5	14	4.70	12	36
0.60	6		4.80	12	
0.70	4		4.90	13	
0.80	5	16	5.00	14	42
0.90	7		5.10	15	
1.00	6		5.20	15	
1.10	6	19	5.30	17	49
1.20	7		5.40	17	
1.30	6		5.50	17	
1.40	6	19	5.60	18	56
1.50	7		5.70	21	
1.60	7		5.80	19	
1.70	7	22	5.90	19	58
1.80	8		6.00	20	
1.90	8		6.10	23	
2.00	8	24	6.20	27	79
2.10	8		6.30	29	
2.20	8		6.40	30	
2.30	8	24	6.50	32	96
2.40	8		6.60	34	
2.50	8		6.70	34	
2.60	8	25	6.80	34	102
2.70	9		6.90	34	
2.80	9		7.00	34	
2.90	9	28	7.10	35	106
3.00	10		7.20	37	
3.10	10		7.30	36	
3.20	10	31	7.40	36	108
3.30	11		7.50	36	
3.40	11		7.60	37	
3.50	11	33	7.70	40	118
3.60	11		7.80	41	
3.70	11		7.90	38	
3.80	11	34	8.00	40	120
3.90	12		8.10	42	
4.00	11		8.20	39	
4.10	11	34	8.30	41	124
4.20	12		8.40	44	



Dynamic Cone Penetration Test (DCPT)

DCPT : 14
Co-ordinate : N =2410806/ E= 809080
R.L. (m) : 199.466 **Near : BH-16**
Depth (m) : 11.10m **Date : 08.02.2018**

Depth (m)	No of blows	N-value	Depth (m)	No of blows	N-value
8.50	40				
8.60	42	128			
8.70	46				
8.80	41				
8.90	44	130			
9.00	45				
9.10	41				
9.20	45	131			
9.30	45				
9.40	41				
9.50	45	131			
9.60	45				
9.70	45				
9.80	47	140			
9.90	48				
10.00	45				
10.10	48	141			
10.20	48				
10.30	48				
10.40	49	146			
10.50	49				
10.60	48				
10.70	48	148			
10.80	52				
10.90	52				
11.00	56	168			
11.10	60				

Dynamic Cone Penetration Test (DCPT)

DCPT : 15
Co-ordinate : N =2410255/ E= 809372
R.L. (m) : 204.919 **Near : BH-17**
Depth (m) : 12.00m **Date : 08.02.2018**

Depth (m)	No of blows	N-value	Depth (m)	No of blows	N-value
0.10	2		4.30	13	
0.20	2	7	4.40	13	40
0.30	3		4.50	14	
0.40	3		4.60	13	
0.50	3	9	4.70	13	40
0.60	3		4.80	14	
0.70	3		4.90	13	
0.80	4	12	5.00	13	40
0.90	5		5.10	14	
1.00	5		5.20	13	
1.10	5	16	5.30	14	41
1.20	6		5.40	14	
1.30	6		5.50	14	
1.40	8	24	5.60	14	42
1.50	10		5.70	14	
1.60	7		5.80	14	
1.70	10	28	5.90	14	42
1.80	11		6.00	14	
1.90	7		6.10	14	
2.00	10	28	6.20	14	43
2.10	11		6.30	15	
2.20	9		6.40	14	
2.30	10	30	6.50	14	43
2.40	11		6.60	15	
2.50	9		6.70	15	
2.60	11	32	6.80	15	46
2.70	12		6.90	16	
2.80	12		7.00	16	
2.90	13	38	7.10	16	48
3.00	13		7.20	16	
3.10	13		7.30	16	
3.20	13	39	7.40	16	48
3.30	13		7.50	16	
3.40	12		7.60	16	
3.50	13	38	7.70	18	52
3.60	13		7.80	18	
3.70	13		7.90	18	
3.80	13	39	8.00	18	54
3.90	13		8.10	18	
4.00	13		8.20	18	
4.10	13	40	8.30	19	57
4.20	14		8.40	20	

Dynamic Cone Penetration Test (DCPT)

DCPT : 15
Co-ordinate : N =2410255/ E= 809372
R.L. (m) : 204.919 **Near : BH-17**
Depth (m) : 12.00m **Date : 08.02.2018**

Depth (m)	No of blows	N-value	Depth (m)	No of blows	N-value
8.50	20				
8.60	21	62			
8.70	21				
8.80	21				
8.90	21	64			
9.00	22				
9.10	22				
9.20	22	66			
9.30	22				
9.40	22				
9.50	23	70			
9.60	25				
9.70	26				
9.80	28	83			
9.90	29				
10.00	30				
10.10	32	94			
10.20	32				
10.30	33				
10.40	36	107			
10.50	38				
10.60	33				
10.70	36	111			
10.80	42				
10.90	40				
11.00	41	123			
11.10	42				
11.20	43				
11.30	47	138			
11.40	48				
11.50	48				
11.60	49	146			
11.70	49				
11.80	49				
11.90	56	168			
12.00	63				

Dynamic Cone Penetration Test (DCPT)

DCPT : 16
Co-ordinate : N =2409980/ E= 808905
R.L. (m) : 198.576 **Near : BH-18**
Depth (m) : 10.20m **Date : 09.02.2018**

Depth (m)	No of blows	N-value	Depth (m)	No of blows	N-value
0.10	8		4.30	13	
0.20	8	24	4.40	14	42
0.30	8		4.50	15	
0.40	8		4.60	1	
0.50	12	34	4.70	44	59
0.60	14		4.80	14	
0.70	15		4.90	15	
0.80	20	57	5.00	16	47
0.90	22		5.10	16	
1.00	22		5.20	16	
1.10	23	68	5.30	16	48
1.20	23		5.40	16	
1.30	23		5.50	16	
1.40	25	73	5.60	16	49
1.50	25		5.70	17	
1.60	7		5.80	16	
1.70	7	22	5.90	17	51
1.80	8		6.00	18	
1.90	8		6.10	17	
2.00	8	24	6.20	18	53
2.10	8		6.30	18	
2.20	8		6.40	18	
2.30	8	24	6.50	22	63
2.40	8		6.60	23	
2.50	8		6.70	23	
2.60	8	24	6.80	23	70
2.70	8		6.90	24	
2.80	8		7.00	25	
2.90	9	26	7.10	26	78
3.00	9		7.20	27	
3.10	9		7.30	27	
3.20	10	30	7.40	27	82
3.30	11		7.50	28	
3.40	10		7.60	28	
3.50	11	32	7.70	29	86
3.60	11		7.80	29	
3.70	11		7.90	29	
3.80	12	36	8.00	32	93
3.90	13		8.10	32	
4.00	12		8.20	34	
4.10	13	38	8.30	39	120
4.20	13		8.40	47	



Dynamic Cone Penetration Test (DCPT)

DCPT : 16
Co-ordinate : N =2409980/ E= 808905
R.L. (m) : 198.576 **Near : BH-18**
Depth (m) : 10.20m **Date : 09.02.2018**

Depth (m)	No of blows	N-value	Depth (m)	No of blows	N-value
8.50	39				
8.60	39	120			
8.70	42				
8.80	41				
8.90	41	124			
9.00	42				
9.10	42				
9.20	46	135			
9.30	47				
9.40	48				
9.50	49	146			
9.60	49				
9.70	49				
9.80	49	148			
9.90	50				
10.00	53				
10.10	56	169			
10.20	60				

Dynamic Cone Penetration Test (DCPT)

DCPT : 17
Co-ordinate : N =2410376/ E= 809083
R.L. (m) : 199.313 **Near : BH-19**
Depth (m) : 10.20m **Date : 09.02.2018**

Depth (m)	No of blows	N-value	Depth (m)	No of blows	N-value
0.10	2		4.30	14	
0.20	2	7	4.40	14	42
0.30	3		4.50	14	
0.40	3		4.60	14	
0.50	3	9	4.70	15	46
0.60	3		4.80	17	
0.70	3		4.90	15	
0.80	4	12	5.00	15	46
0.90	5		5.10	16	
1.00	5		5.20	16	
1.10	5	15	5.30	16	48
1.20	5		5.40	16	
1.30	5		5.50	16	
1.40	6	17	5.60	17	50
1.50	6		5.70	17	
1.60	6		5.80	17	
1.70	8	22	5.90	18	54
1.80	8		6.00	19	
1.90	8		6.10	19	
2.00	9	26	6.20	20	62
2.10	9		6.30	23	
2.20	10		6.40	21	
2.30	10	30	6.50	22	68
2.40	10		6.60	25	
2.50	11		6.70	24	
2.60	11	34	6.80	25	74
2.70	12		6.90	25	
2.80	11		7.00	26	
2.90	12	35	7.10	27	81
3.00	12		7.20	28	
3.10	12		7.30	28	
3.20	13	38	7.40	28	86
3.30	13		7.50	30	
3.40	13		7.60	31	
3.50	13	39	7.70	32	97
3.60	13		7.80	34	
3.70	13		7.90	31	
3.80	13	39	8.00	33	99
3.90	13		8.10	35	
4.00	13		8.20	32	
4.10	13	40	8.30	35	102
4.20	14		8.40	35	



Dynamic Cone Penetration Test (DCPT)

DCPT : 17
Co-ordinate : N =2410376/ E= 809083
R.L. (m) : 199.313 **Near : BH-19**
Depth (m) : 10.20m **Date : 09.02.2018**

Depth (m)	No of blows	N-value	Depth (m)	No of blows	N-value
8.50	36				
8.60	36	110			
8.70	38				
8.80	36				
8.90	37	111			
9.00	38				
9.10	40				
9.20	42	124			
9.30	42				
9.40	42				
9.50	45	132			
9.60	45				
9.70	46				
9.80	48	142			
9.90	48				
10.00	47				
10.10	52	158			
10.20	59				

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Dynamic Cone Penetration Test (DCPT)

DCPT : 18
Co-ordinate : N =2411025/ E= 808688
R.L. (m) : 197.50 **Near : BH-2**
Depth (m) : 11.70m **Date : 19.02.2018**

Depth (m)	No of blows	N-value	Depth (m)	No of blows	N-value
0.10	1		4.30	4	
0.20	1	3	4.40	6	17
0.30	1		4.50	7	
0.40	1		4.60	6	
0.50	2	5	4.70	5	18
0.60	2		4.80	7	
0.70	2		4.90	5	
0.80	3	7	5.00	6	18
0.90	2		5.10	7	
1.00	2		5.20	6	
1.10	3	7	5.30	7	18
1.20	2		5.40	5	
1.30	2		5.50	6	
1.40	4	10	5.60	5	19
1.50	4		5.70	8	
1.60	3		5.80	6	
1.70	4	11	5.90	6	19
1.80	4		6.00	7	
1.90	4		6.10	6	
2.00	4	12	6.20	8	22
2.10	4		6.30	8	
2.20	4		6.40	6	
2.30	4	13	6.50	7	21
2.40	5		6.60	8	
2.50	5		6.70	7	
2.60	3	12	6.80	7	22
2.70	4		6.90	8	
2.80	4		7.00	7	
2.90	5	14	7.10	7	24
3.00	5		7.20	10	
3.10	4		7.30	8	
3.20	5	15	7.40	8	24
3.30	6		7.50	8	
3.40	4		7.60	7	
3.50	5	15	7.70	8	23
3.60	6		7.80	8	
3.70	5		7.90	9	
3.80	5	16	8.00	9	27
3.90	6		8.10	9	
4.00	5		8.20	8	
4.10	4	16	8.30	9	27
4.20	7		8.40	10	



Dynamic Cone Penetration Test (DCPT)

DCPT : 18
Co-ordinate : N =2411025/ E= 808688
R.L. (m) : 197.50 **Near : BH-2**
Depth (m) : 11.70m **Date : 19.02.2018**

Depth (m)	No of blows	N-value	Depth (m)	No of blows	N-value
8.50	9				
8.60	9	29			
8.70	11				
8.80	9				
8.90	9	30			
9.00	12				
9.10	12				
9.20	13	39			
9.30	14				
9.40	11				
9.50	14	38			
9.60	13				
9.70	12				
9.80	17	47			
9.90	18				
10.00	15				
10.10	21	60			
10.20	24				
10.30	20				
10.40	25	72			
10.50	27				
10.60	25				
10.70	29	86			
10.80	32				
10.90	26				
11.00	31	91			
11.10	34				
11.20	39				
11.30	43	137			
11.40	55				
11.50	55				
11.60	63	186			
11.70	68				

SKM Geosurvey

Dynamic Cone Penetration Test (DCPT)

DCPT : 19
Co-ordinate : N =2411255/ E= 808577
R.L. (m) : 197.210 **Near : BH-1**
Depth (m) : 11.10m **Date : 20.02.2018**

Depth (m)	No of blows	N-value	Depth (m)	No of blows	N-value
0.10	1		4.30	4	
0.20	1	4	4.40	6	17
0.30	2		4.50	7	
0.40	1		4.60	5	
0.50	1	4	4.70	6	18
0.60	2		4.80	7	
0.70	2		4.90	5	
0.80	2	6	5.00	6	19
0.90	2		5.10	8	
1.00	2		5.20	5	
1.10	2	7	5.30	6	18
1.20	3		5.40	7	
1.30	2		5.50	5	
1.40	4	10	5.60	6	19
1.50	4		5.70	8	
1.60	4		5.80	6	
1.70	3	11	5.90	6	19
1.80	4		6.00	7	
1.90	4		6.10	6	
2.00	4	13	6.20	8	22
2.10	5		6.30	8	
2.20	4		6.40	6	
2.30	4	12	6.50	7	21
2.40	4		6.60	8	
2.50	4		6.70	7	
2.60	5	14	6.80	8	22
2.70	5		6.90	7	
2.80	3		7.00	7	
2.90	4	13	7.10	8	25
3.00	6		7.20	10	
3.10	4		7.30	8	
3.20	5	15	7.40	9	28
3.30	6		7.50	11	
3.40	4		7.60	11	
3.50	4	15	7.70	12	37
3.60	7		7.80	14	
3.70	5		7.90	12	
3.80	5	16	8.00	13	40
3.90	6		8.10	15	
4.00	5		8.20	13	
4.10	4	16	8.30	16	47
4.20	7		8.40	18	

Dynamic Cone Penetration Test (DCPT)

DCPT : 19
Co-ordinate : N =2411255/ E= 808577
R.L. (m) : 197.210 **Near : BH-1**
Depth (m) : 11.10m **Date : 20.02.2018**

Depth (m)	No of blows	N-value	Depth (m)	No of blows	N-value
8.50	15				
8.60	19	57			
8.70	23				
8.80	15				
8.90	21	60			
9.00	24				
9.10	20				
9.20	25	72			
9.30	27				
9.40	22				
9.50	26	78			
9.60	30				
9.70	23				
9.80	28	85			
9.90	34				
10.00	22				
10.10	29	88			
10.20	37				
10.30	26				
10.40	31	91			
10.50	34				
10.60	36				
10.70	40	122			
10.80	46				
10.90	52				
11.00	64	185			
11.10	69				

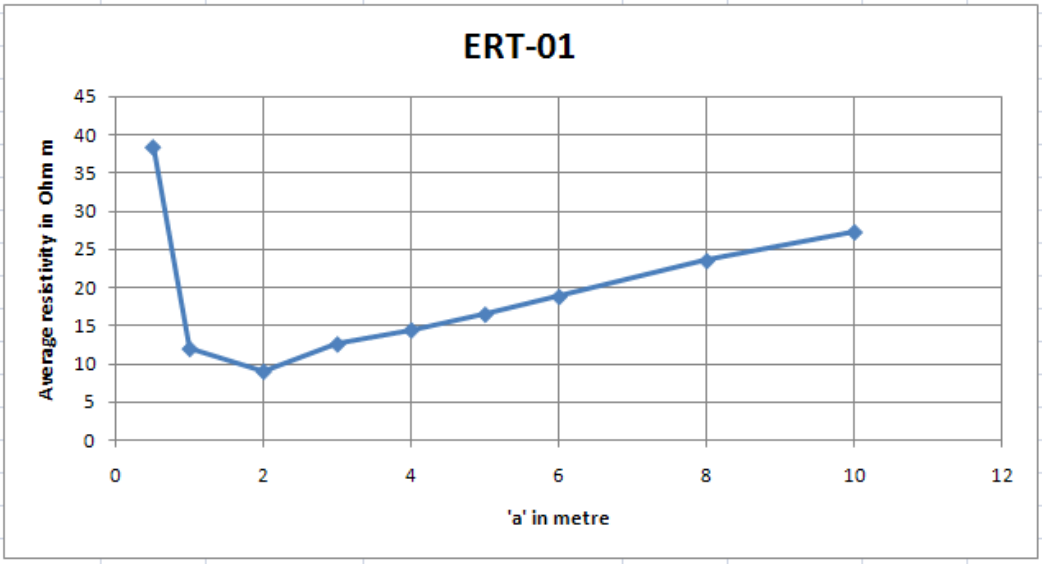
SKM Geosurvey

Dynamic Cone Penetration Test (DCPT)

DCPT : 20
Co-ordinate : N =2409655/ E= 878703
R.L. (m) : 198.614 **Near : BH-20**
Depth (m) : 8.10m **Date : 21.02.2018**

Depth (m)	No of blows	N-value	Depth (m)	No of blows	N-value
0.10	2		4.30	14	
0.20	2	7	4.40	14	42
0.30	3		4.50	14	
0.40	3		4.60	16	
0.50	3	9	4.70	17	50
0.60	3		4.80	17	
0.70	3		4.90	17	
0.80	4	12	5.00	18	54
0.90	5		5.10	19	
1.00	5		5.20	19	
1.10	5	15	5.30	20	62
1.20	5		5.40	23	
1.30	6		5.50	21	
1.40	6	18	5.60	22	68
1.50	6		5.70	25	
1.60	8		5.80	24	
1.70	8	24	5.90	25	74
1.80	8		6.00	25	
1.90	8		6.10	26	
2.00	9	26	6.20	27	81
2.10	9		6.30	28	
2.20	10		6.40	31	
2.30	10	30	6.50	33	99
2.40	10		6.60	35	
2.50	11		6.70	36	
2.60	11	34	6.80	36	110
2.70	12		6.90	38	
2.80	11		7.00	40	
2.90	12	35	7.10	42	124
3.00	12		7.20	42	
3.10	12		7.30	42	
3.20	13	38	7.40	45	132
3.30	13		7.50	45	
3.40	13		7.60	47	
3.50	13	39	7.70	48	143
3.60	13		7.80	48	
3.70	13		7.90	47	
3.80	13	39	8.00	52	158
3.90	13		8.10	59	
4.00	13				
4.10	13	40			
4.20	14				

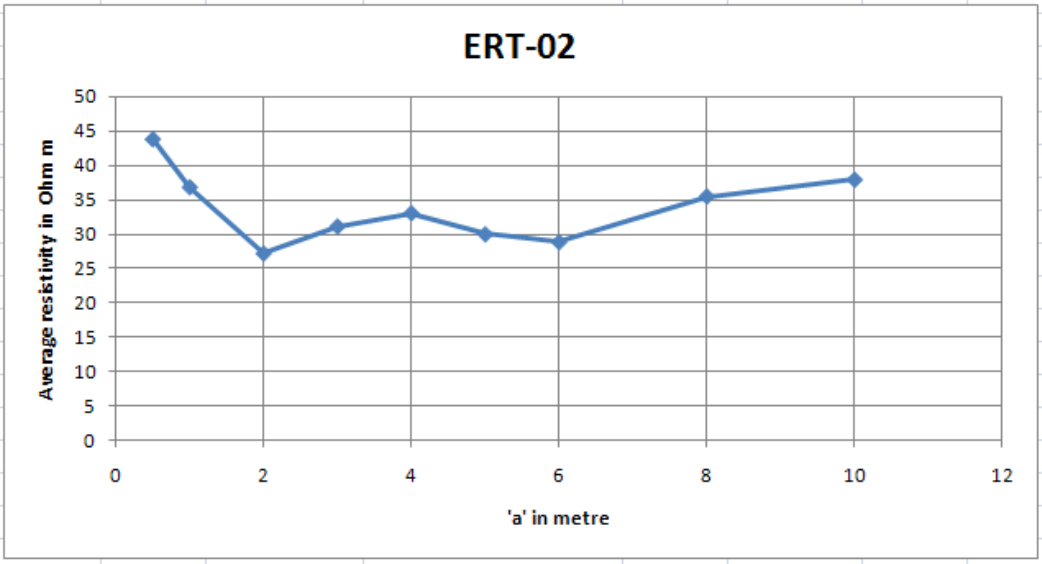
ERT TEST CURVE



ERT-01	Location:	N: 2411023		E: 808690	RL. 197.50m
Sl No.	S(m)	N-S	E-W	NE-SW	SE-NW
1	0.5	38.32	38.48	38.16	38.48
2	1	12.00	12.00	12.09	12.00
3	2	8.86	9.11	9.11	9.05
4	3	12.35	12.72	12.53	12.82
5	4	14.07	14.33	14.45	14.95
6	5	15.86	16.49	16.65	16.96
7	6	18.10	18.47	19.04	19.60
8	8	22.87	23.88	23.37	23.88
9	10	26.07	27.33	27.33	28.27

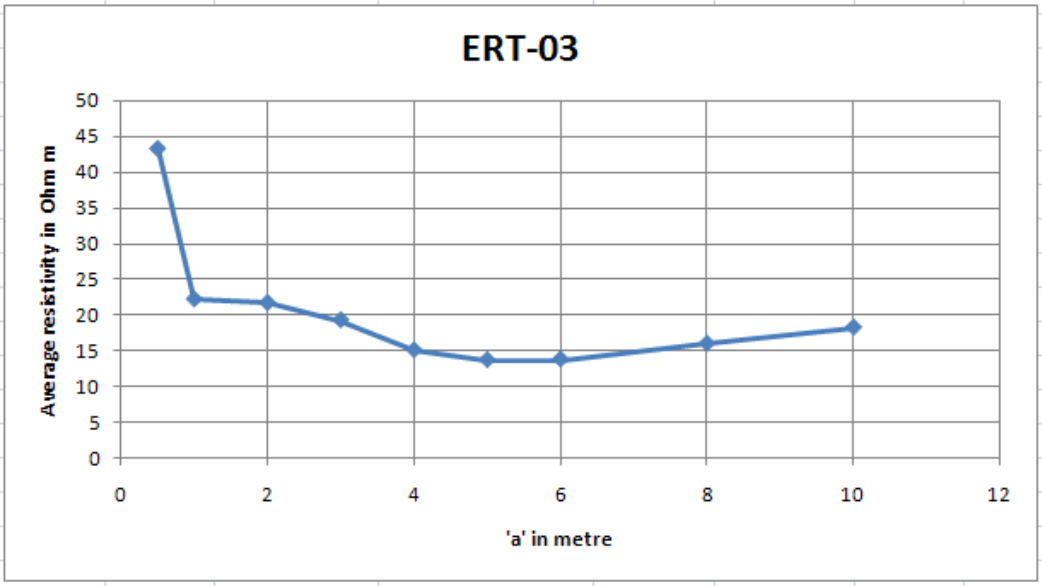
Sl No.	Spacing(m)	Mean Resistivity(ohm.m)
1	Upto 0.50m	38.35
2	0.50-8.00	13.9
3	8.00-10.00	25.37

ERT TEST CURVE



ERT-02	Location:	N: 2411135		E: 808965		RL. 194.729	
Sl No.	**S(m)**	**N-S**	**E-W**	**NE-SW**	**SE-NW**		
1	0.5	43.66	43.66	43.66	43.82		
2	1	36.72	36.76	36.76	36.85		
3	2	27.14	27.14	27.14	27.33		
4	3	31.01	31.19	31.194.	31.10		
5	4	33.17	32.92	32.92	33.05		
6	5	29.37	29.84	30.32	30.32		
7	6	28.46	28.46	28.65	29.78		
8	8	34.93	35.19	35.94	35.69		
9	10	37.38	38.64	37.70	37.70		
					Mean Resitivity:	33.76292	Ohm m

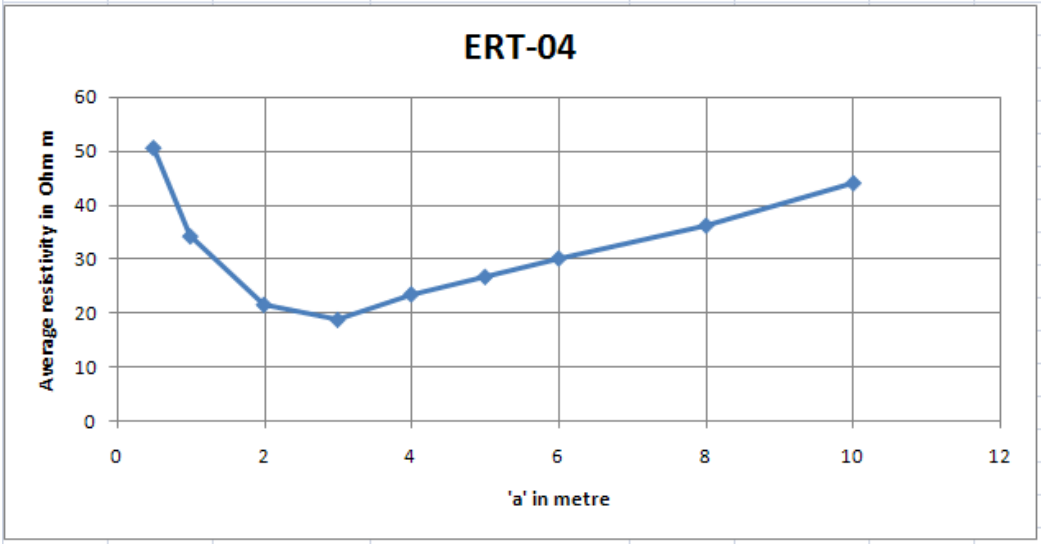
ERT TEST CURVE



ERT-03	Location:	N: 2410805		E: 809050		RL. 199.264	
Sl No.	**S(m)**	**N-S**	**E-W**	**NE-SW**	**SE-NW**		
1	0.5	43.19	43.03	43.66	42.87		
2	1	22.18	22.18	22.08	22.15		
3	2	21.49	21.93	21.68	21.49		
4	3	19.13	19.23	19.23	19.41		
5	4	15.08	15.33	15.08	14.70		
6	5	13.51	13.82	13.51	13.82		
7	6	13.38	13.76	14.14	13.76		
8	8	15.58	15.58	16.08	16.59		
9	10	17.59	17.59	18.53	19.16		
					Mean Resitivity:	20.31969	Ohm m

Sl No.	Spacing(m)	Mean Resistivity (ohm.m)
1	Upto 0.50m	43.18
2	0.50-10.00	17.46

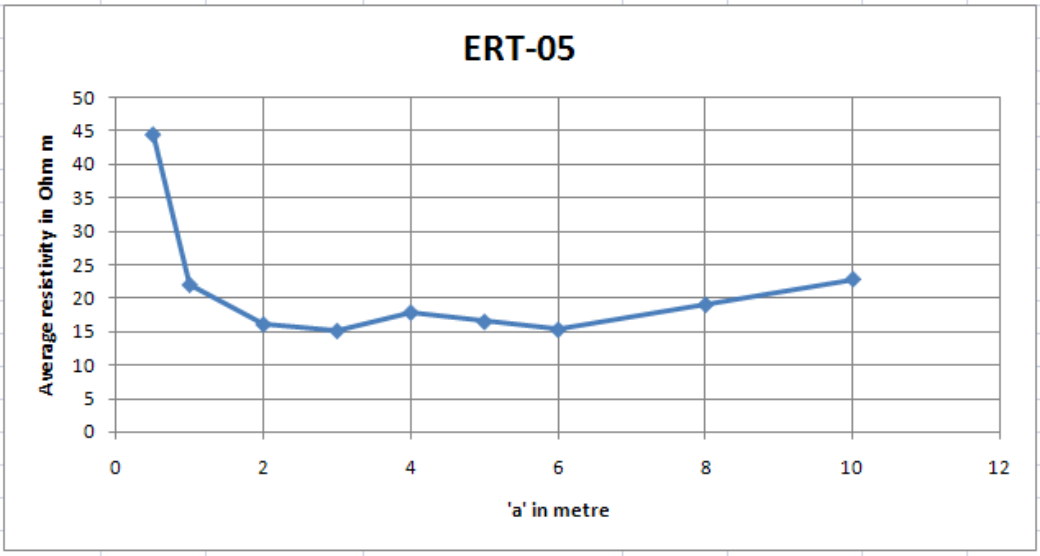
ERT TEST CURVE



ERT-04	Location:	N: 2410805		E: 809050	RL. 197.394
Sl No.	**S(m)**	**N-S**	**E-W**	**NE-SW**	**SE-NW**
1	0.5	50.57	50.57	50.41	50.26
2	1	34.31	34.15	34.12	34.02
3	2	21.36	21.49	21.61	21.55
4	3	18.47	18.75	18.85	18.85
5	4	23.25	23.50	23.50	23.50
6	5	26.39	26.86	26.70	26.70
7	6	29.78	30.35	30.16	29.97
8	8	35.69	36.69	36.44	35.69
9	10	43.35	44.61	44.30	43.67

Sl No.	Spacing(m)	Mean Resistivity(ohm.m)
1	Upto 1.00m	42.29
2	1.00-5.00	22.58
3	5.00-10.00	36.72

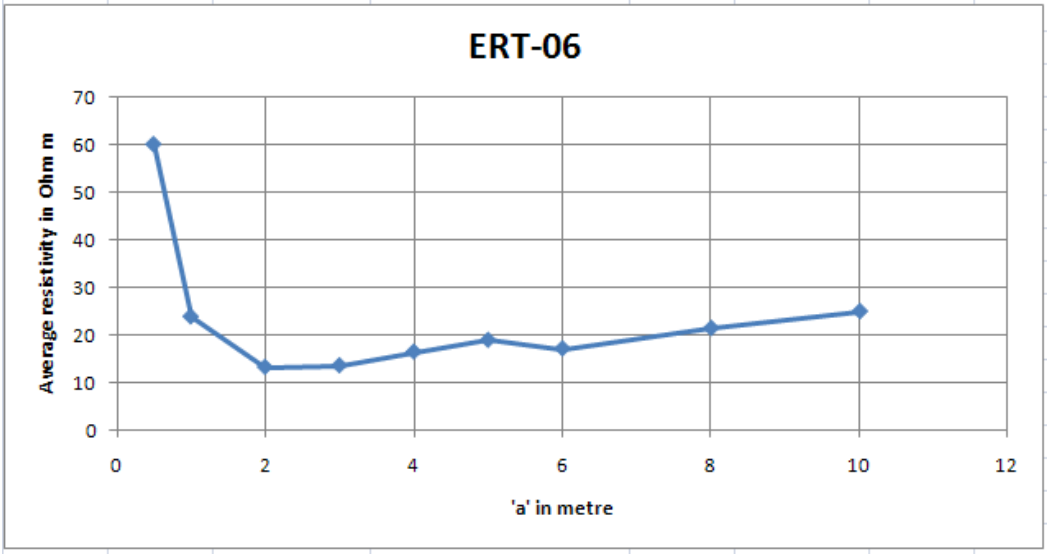
ERT TEST CURVE



ERT-05	Location:	N: 2410727		E: 809065		RL. 196.621m
Sl No.	**S(m)**	**N-S**	**E-W**	**NE-SW**	**SE-NW**	
1	0.5	44.60	44.45	44.29	44.13	
2	1	22.02	21.96	21.96	22.08	
3	2	15.96	16.15	16.08	16.27	
4	3	15.17	15.08	15.17	15.08	
5	4	17.47	17.97	18.10	17.97	
6	5	16.34	16.65	16.34	16.65	
7	6	15.64	14.89	15.64	15.08	
8	8	19.85	19.10	18.35	18.85	
9	10	22.62	22.62	23.25	22.93	

Sl No.	Spacing(m)	Mean Resistivity(ohm.m)
1	Upto 0.50m	44.36
2	0.50-10.00	18.1

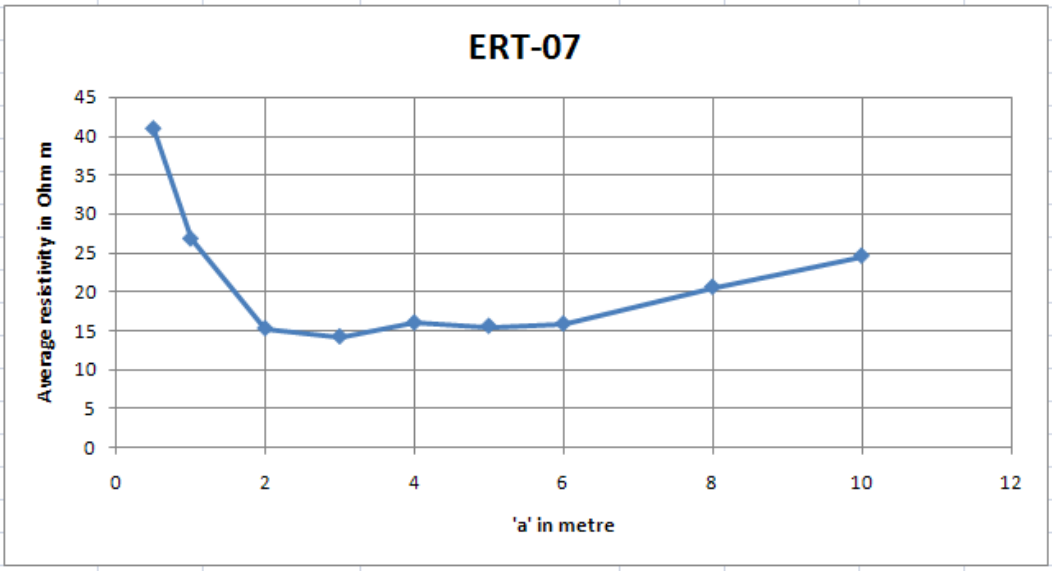
ERT TEST CURVE



ERT-06	Location:	N: 2410732		E: 809099		RL. 199.764m
Sl No.	S(m)	N-S	E-W	NE-SW	SE-NW	
1	0.5	60.31	60.15	60.15	60.31	
2	1	23.94	23.94	23.94	23.91	
3	2	13.19	13.38	13.32	13.32	
4	3	13.57	13.38	13.85	13.76	
5	4	16.59	16.59	16.59	16.34	
6	5	18.69	19.01	19.32	19.01	
7	6	16.96	16.40	17.53	17.91	
8	8	21.36	21.11	21.36	22.12	
9	10	24.82	25.13	25.13	25.13	

Sl No.	Spacing(m)	Mean Resistivity(ohm.m)
1	Upto 0.50m	60.23
2	0.50-10.00	18.77

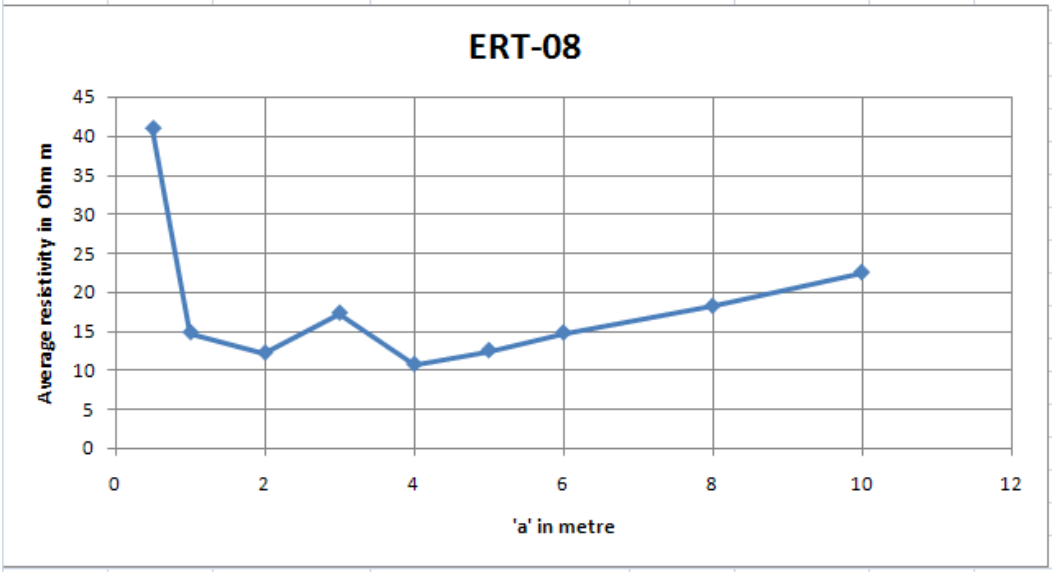
ERT TEST CURVE



ERT-07	Location:	N: 2411060		E: 809080	RL. 195.857m
Sl No.	S(m)	N-S	E-W	NE-SW	SE-NW
1	0.5	40.99	41.15	40.99	40.68
2	1	26.77	26.83	26.77	26.86
3	2	15.08	15.33	15.27	15.46
4	3	13.76	14.32	14.23	14.61
5	4	15.83	16.21	15.83	16.21
6	5	15.39	15.55	15.71	15.71
7	6	15.64	15.83	16.21	15.83
8	8	20.11	19.85	20.86	21.61
9	10	24.50	24.50	24.00	25.45

Sl No.	Spacing(m)	Mean Resistivity(ohm.m)
1	Upto 1.00m	33.87
2	1.00-10.00	17.46

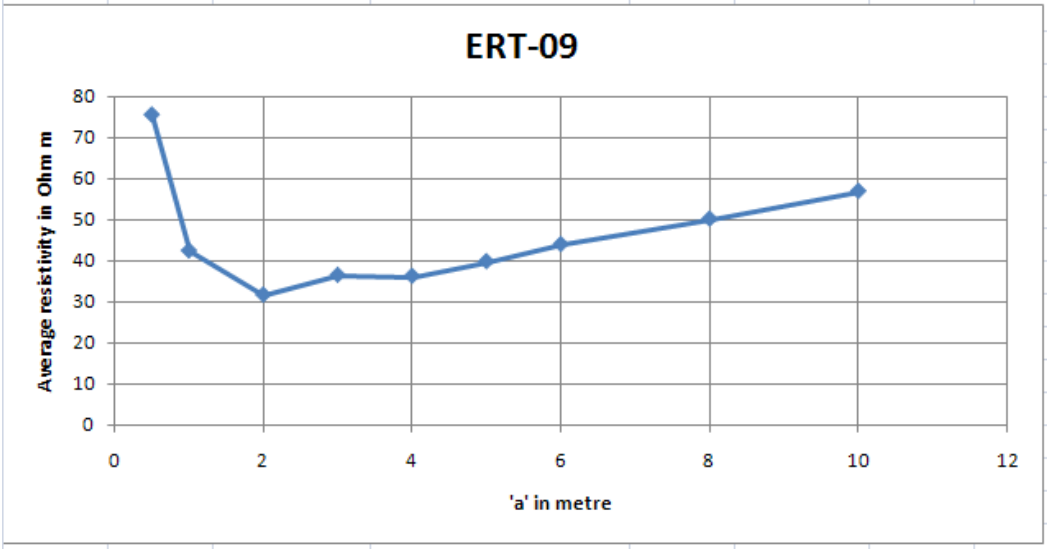
ERT TEST CURVE



ERT-08	Location:	N: 2411060		E: 809080		RL. 198.576
Sl No.	S(m)	N-S	E-W	NE-SW	SE-NW	
1	0.5	40.83	40.99	41.15	41.15	
2	1	14.83	14.83	14.83	14.86	
3	2	12.00	12.13	12.25	12.50	
4	3	16.96	17.25	17.53	17.62	
5	4	10.81	10.81	10.43	10.93	
6	5	12.25	12.57	12.41	12.88	
7	6	14.70	14.70	15.46	14.33	
8	8	17.59	18.35	19.10	17.84	
9	10	21.68	22.62	23.88	21.99	

Sl No.	Spacing(m)	Mean Resistivity(ohm.m)
1	Upto 0.50m	41.03
2	0.50-10.00	15.4

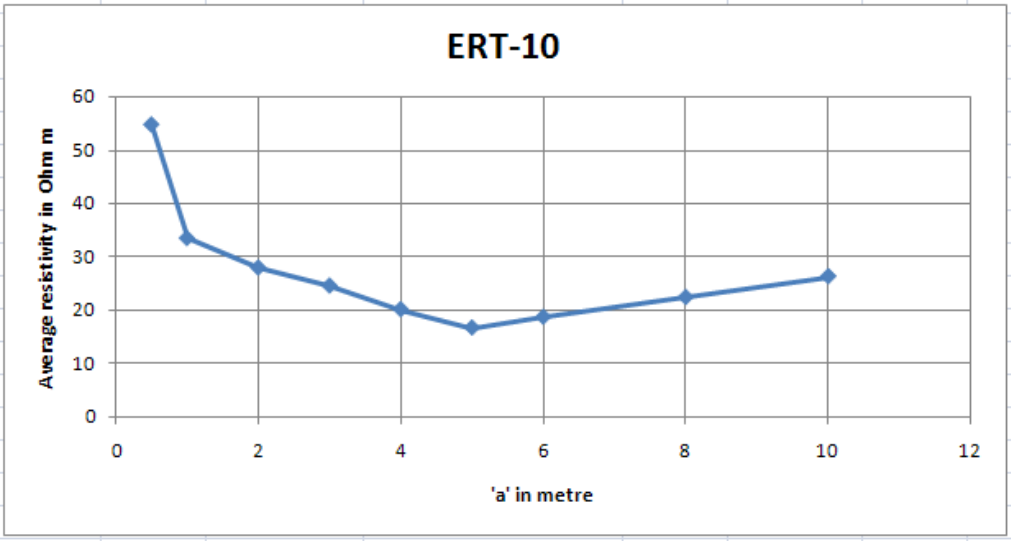
ERT TEST CURVE



ERT-09	Location:	N: 2411455		E: 809100		RL. 200.85
Sl No.	**S(m)**	**N-S**	**E-W**	**NE-SW**	**SE-NW**	
1	0.5	75.54	75.23	75.38	75.70	
2	1	42.35	42.28	42.35	42.32	
3	2	31.54	31.48	31.60	31.54	
4	3	36.38	36.28	36.19	36.66	
5	4	35.69	36.32	36.06	36.44	
6	5	39.11	39.90	39.74	40.05	
7	6	43.35	43.92	43.73	44.48	
8	8	49.76	49.76	50.01	50.77	
9	10	55.92	56.86	56.86	57.80	

Sl No.	Spacing(m)	Mean Resistivity(ohm.m)
1	Upto 1.00m	58.89
2	1.00-8.00	37.52
3	8.00-10.00	53.47

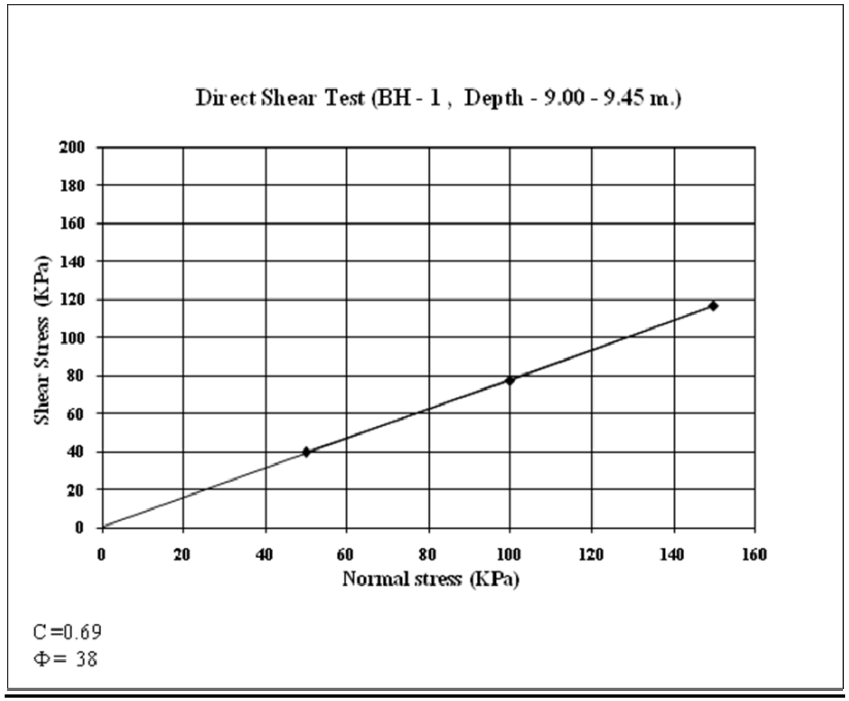
ERT TEST CURVE



ERT-10	Location:	N: 2411405		E: 810400	RL. 197.23m
Sl No.	S(m)	N-S	E-W	NE-SW	SE-NW
1	0.5	54.03	54.97	54.65	54.81
2	1	33.27	33.33	33.39	33.43
3	2	27.58	27.77	27.90	28.08
4	3	24.50	24.31	24.60	24.41
5	4	19.85	20.23	19.85	20.23
6	5	16.34	16.65	16.81	16.65
7	6	17.91	18.47	19.41	18.66
8	8	22.12	22.87	22.12	22.12
9	10	26.70	27.02	25.45	25.76

Sl No.	Spacing(m)	Mean Resistivity(ohm.m)
1	Upto 0.50m	54.613
2	0.50-4.00	28.55
3	4.00-10.00	20.76

DIRECT SHEAR TEST RESULTS



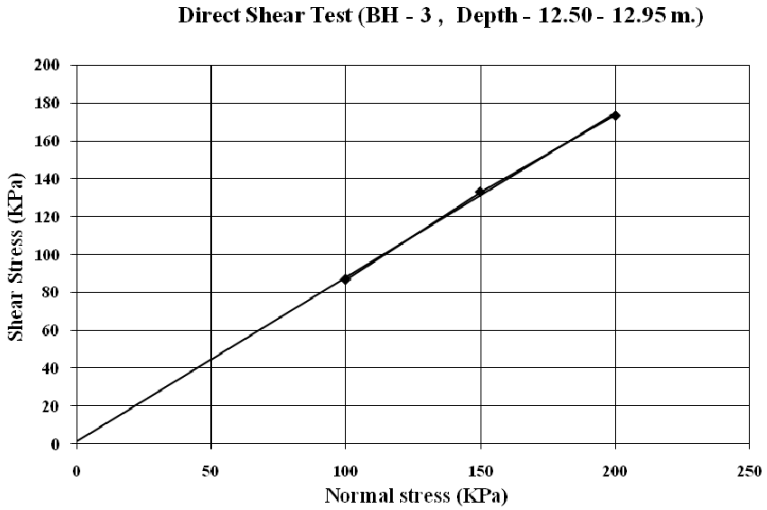
BH No.	Depth (m)	Type of Test	Bulk Density (KN/m^3)	Dry Density (KN/m^3)	Water Content (%)	Cohesion (kPa)	Angle of Internal Friction (Degrees)
01	9.00-9.45	DS	20.10	16.60	21	0.69	38

Note: DS: DIRECT SHEAR TEST

JOB NO. 30796

SKM Geosurvey

DIRECT SHEAR TEST RESULTS



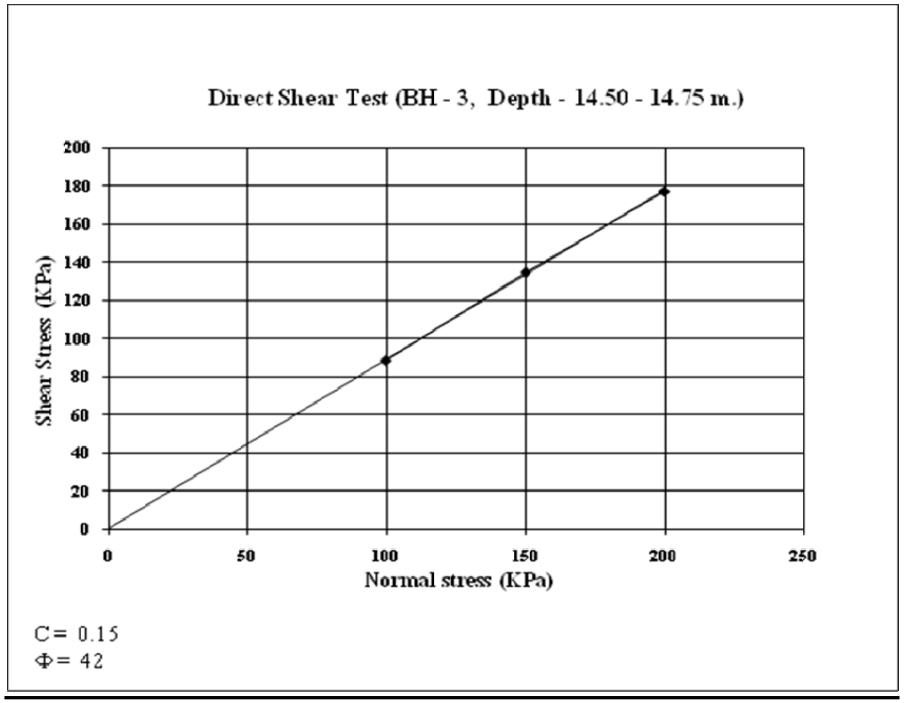
BH No.	Depth (m)	Type of Test	Bulk Density (KN/m^3)	Dry Density (KN/m^3)	Water Content (%)	Cohesion (kPa)	Angle of Internal Friction (Degrees)
03	12.50-12.95	DS	20.40	17.00	20	0.98	41

Note: DS: DIRECT SHEAR TEST

JOB NO. 30796

SKM Geosurvey

DIRECT SHEAR TEST RESULTS



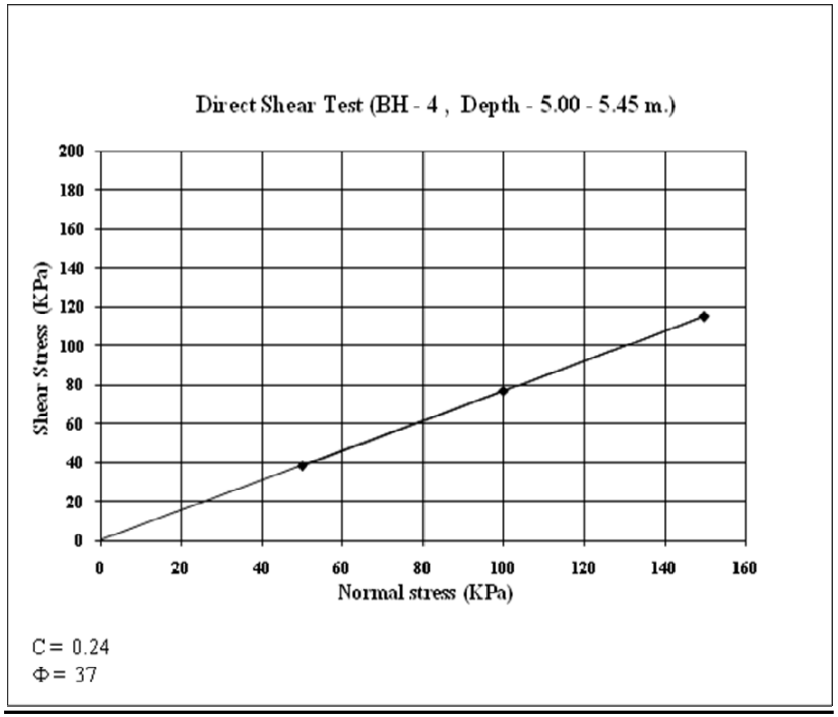
BH No.	Depth (m)	Type of Test	Bulk Density (KN/m^3)	Dry Density (KN/m^3)	Water Content (%)	Cohesion (kPa)	Angle of Internal Friction (Degrees)
03	14.50-14.75	DS	20.50	17.20	19	0.15	42

Note: DS: DIRECT SHEAR TEST

JOB NO. 30796

SKM Geosurvey

DIRECT SHEAR TEST RESULTS



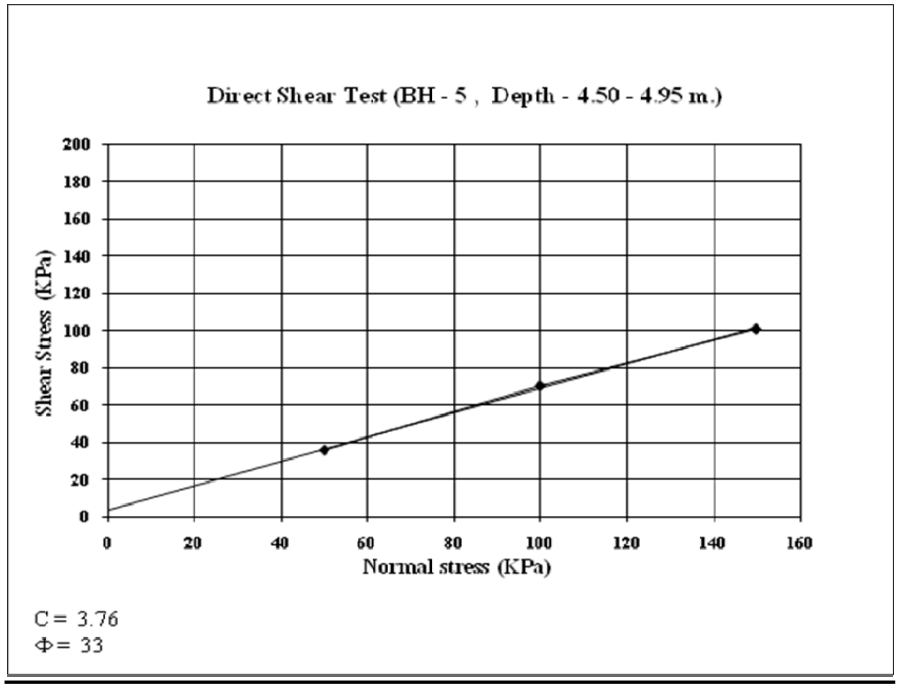
BH No.	Depth (m)	Type of Test	Bulk Density (KN/m^3)	Dry Density (KN/m^3)	Water Content (%)	Cohesion (kPa)	Angle of Internal Friction (Degrees)
04	5.00-5.45	DS	19.70	15.90	24	0.24	37

Note: DS: DIRECT SHEAR TEST

JOB NO. 30796

SKM Geosurvey

DIRECT SHEAR TEST RESULTS



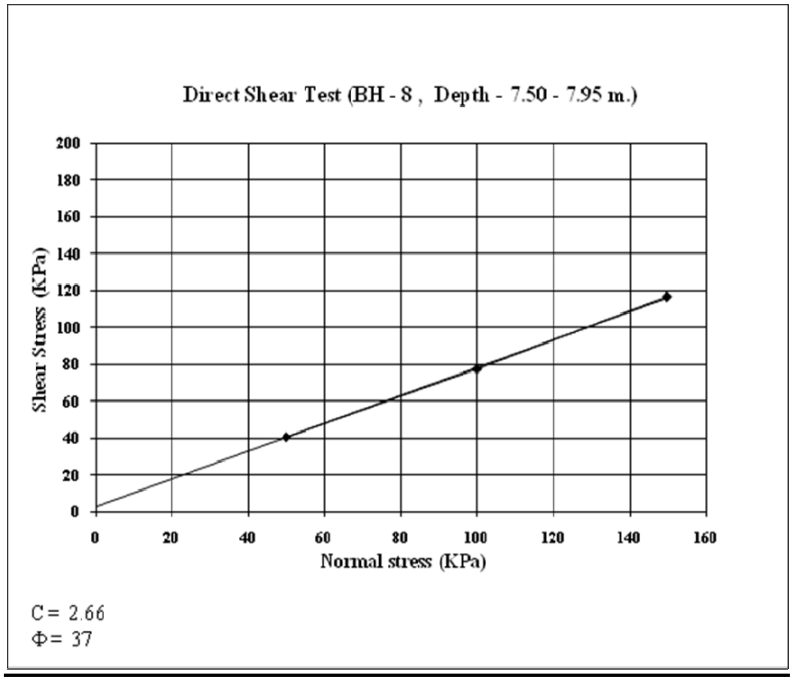
BH No.	Depth (m)	Type of Test	Bulk Density (KN/m^3)	Dry Density (KN/m^3)	Water Content (%)	Cohesion (kPa)	Angle of Internal Friction (Degrees)
05	4.50-4.95	DS	19.60	15.70	25	3.76	33

Note: DS: DIRECT SHEAR TEST

JOB NO. 30796

SKM Geosurvey

DIRECT SHEAR TEST RESULTS



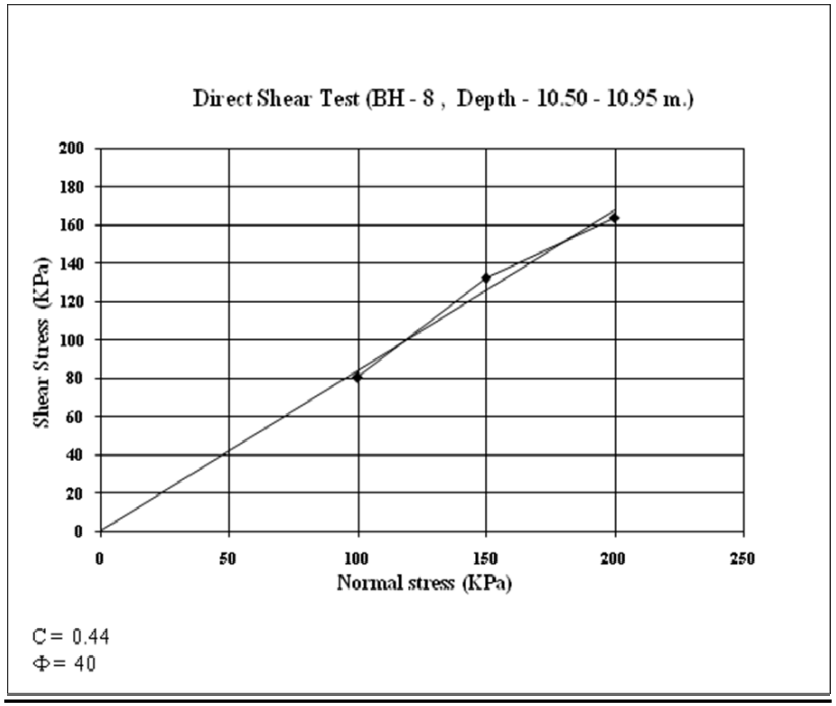
BH No.	Depth (m)	Type of Test	Bulk Density (KN/m^3)	Dry Density (KN/m^3)	Water Content (%)	Cohesion (kPa)	Angle of Internal Friction (Degrees)
08	7.50-7.95	DS	20.20	16.60	22	2.66	37

Note: DS: DIRECT SHEAR TEST

JOB NO. 30796

SKM Geosurvey

DIRECT SHEAR TEST RESULTS



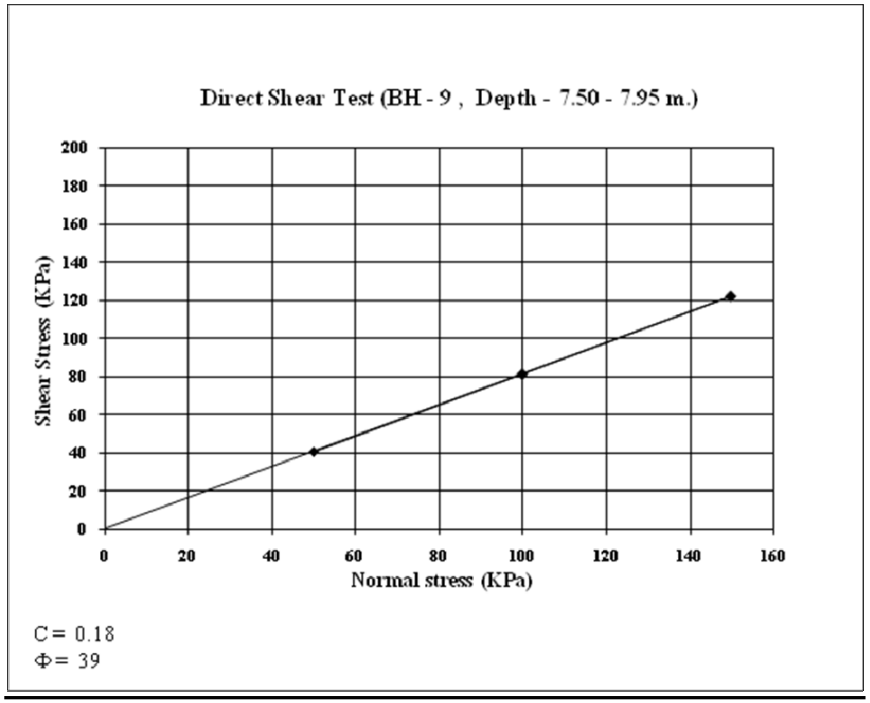
BH No.	Depth (m)	Type of Test	Bulk Density (KN/m^3)	Dry Density (KN/m^3)	Water Content (%)	Cohesion (kPa)	Angle of Internal Friction (Degrees)
08	10.50-10.95	DS	20.30	16.90	20	0.44	40

Note: DS: DIRECT SHEAR TEST

JOB NO. 30796

SKM Geosurvey

DIRECT SHEAR TEST RESULTS



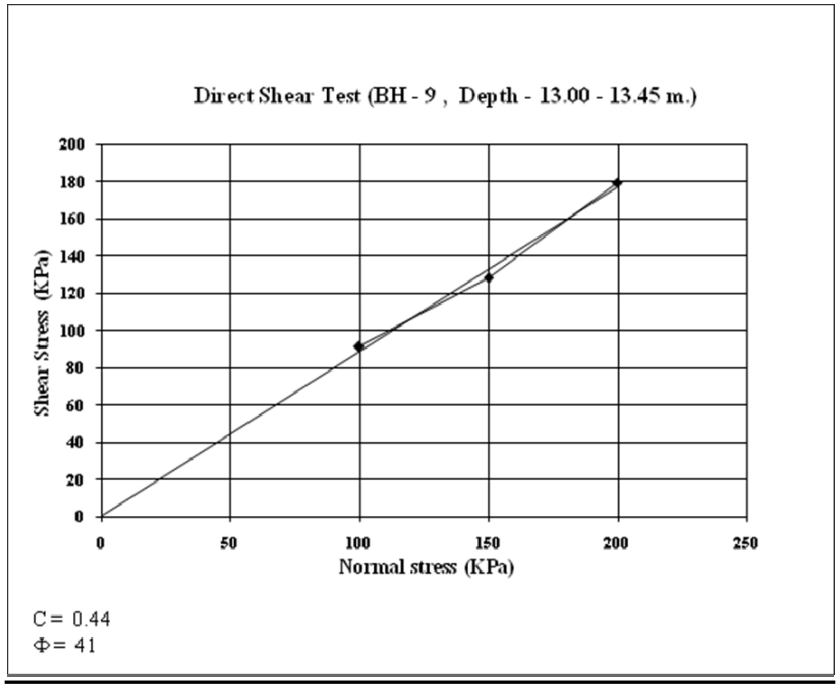
BH No.	Depth (m)	Type of Test	Bulk Density (KN/m^3)	Dry Density (KN/m^3)	Water Content (%)	Cohesion (kPa)	Angle of Internal Friction (Degrees)
09	7.50-7.95	DS	20.10	16.30	23	0.18	39

Note: DS: DIRECT SHEAR TEST

JOB NO. 30796

SKM Geosurvey

DIRECT SHEAR TEST RESULTS



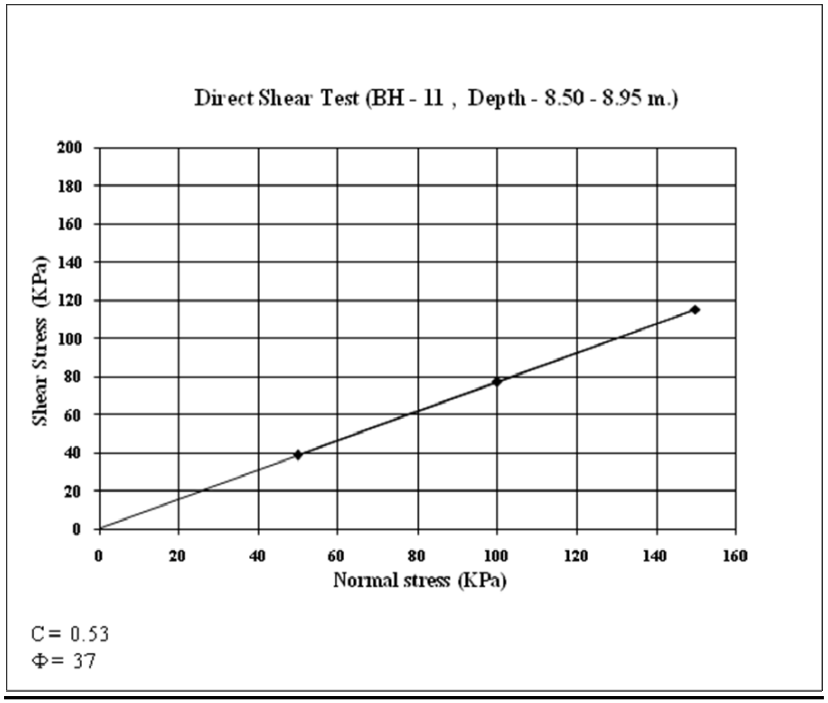
BH No.	Depth (m)	Type of Test	Bulk Density (KN/m^3)	Dry Density (KN/m^3)	Water Content (%)	Cohesion (kPa)	Angle of Internal Friction (Degrees)
09	13.00-13.45	DS	20.40	17.10	19	0.44	41

Note: DS: DIRECT SHEAR TEST

JOB NO. 30796

SKM Geosurvey

DIRECT SHEAR TEST RESULTS



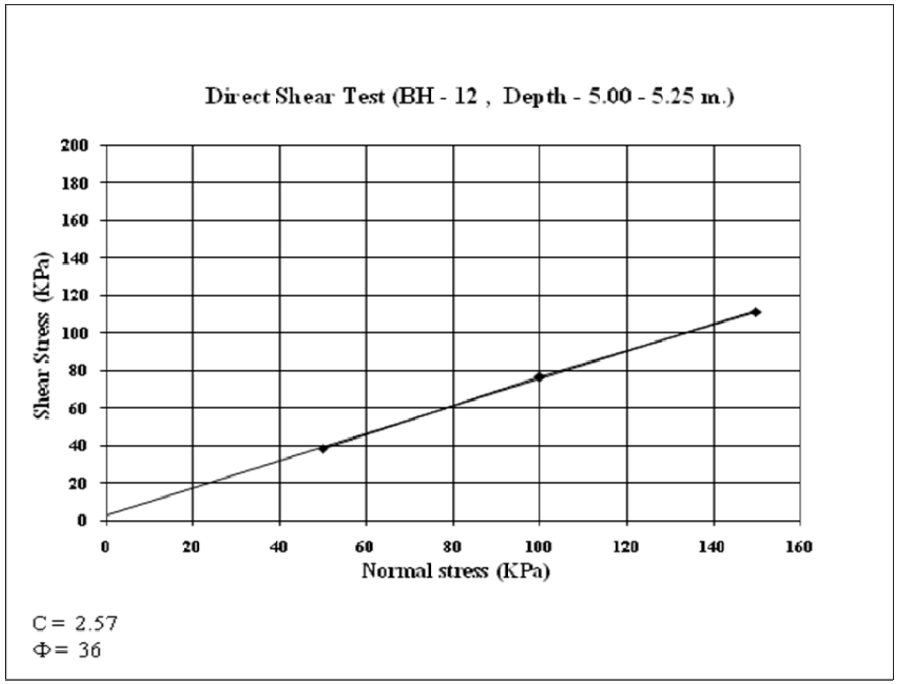
BH No.	Depth (m)	Type of Test	Bulk Density (KN/m^3)	Dry Density (KN/m^3)	Water Content (%)	Cohesion (kPa)	Angle of Internal Friction (Degrees)
11	8.50-8.95	DS	20.20	16.40	23	0.53	37

Note: DS: DIRECT SHEAR TEST

JOB NO. 30796

SKM Geosurvey

DIRECT SHEAR TEST RESULTS



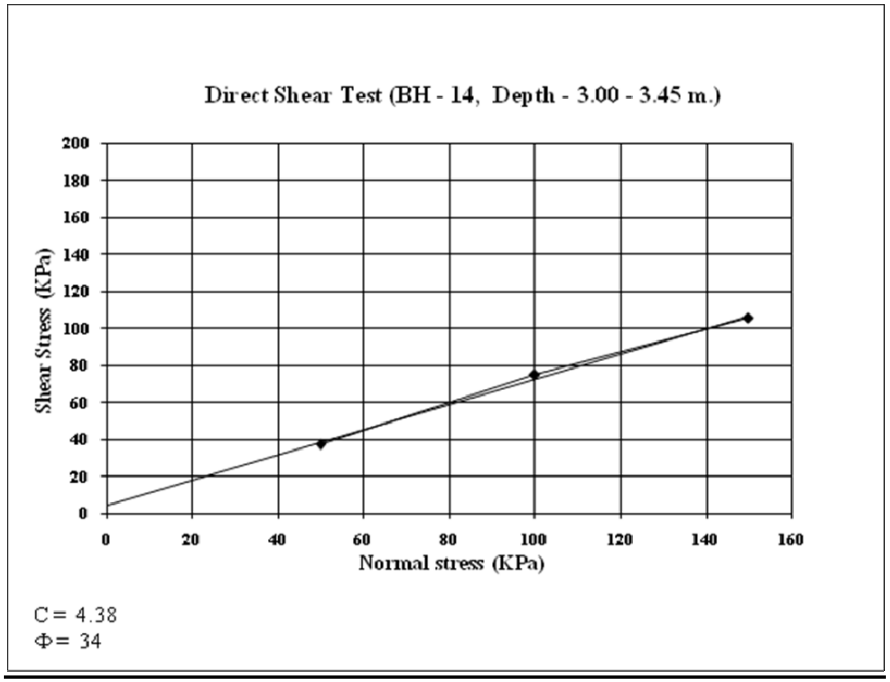
BH No.	Depth (m)	Type of Test	Bulk Density (KN/m^3)	Dry Density (KN/m^3)	Water Content (%)	Cohesion (kPa)	Angle of Internal Friction (Degrees)
12	5.00-5.25	DS	19.80	16.10	23	2.57	36

Note: DS: DIRECT SHEAR TEST

JOB NO. 30796

SKM Geosurvey

DIRECT SHEAR TEST RESULTS



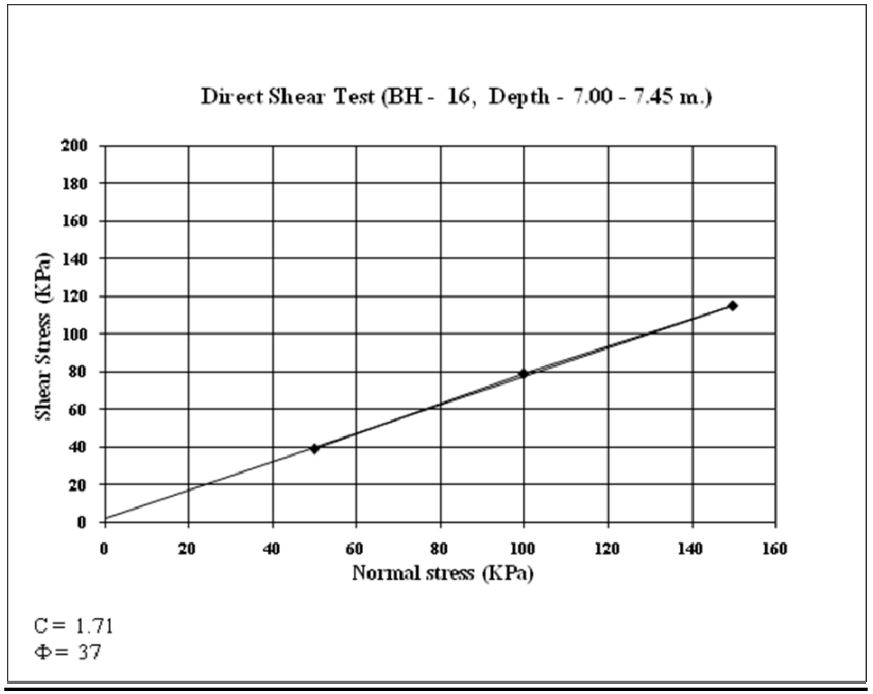
BH No.	Depth (m)	Type of Test	Bulk Density (KN/m^3)	Dry Density (KN/m^3)	Water Content (%)	Cohesion (kPa)	Angle of Internal Friction (Degrees)
14	3.00-3.45	DS	19.70	15.80	25	4.38	34

Note: DS: DIRECT SHEAR TEST

JOB NO. 30796

SKM Geosurvey

DIRECT SHEAR TEST RESULTS



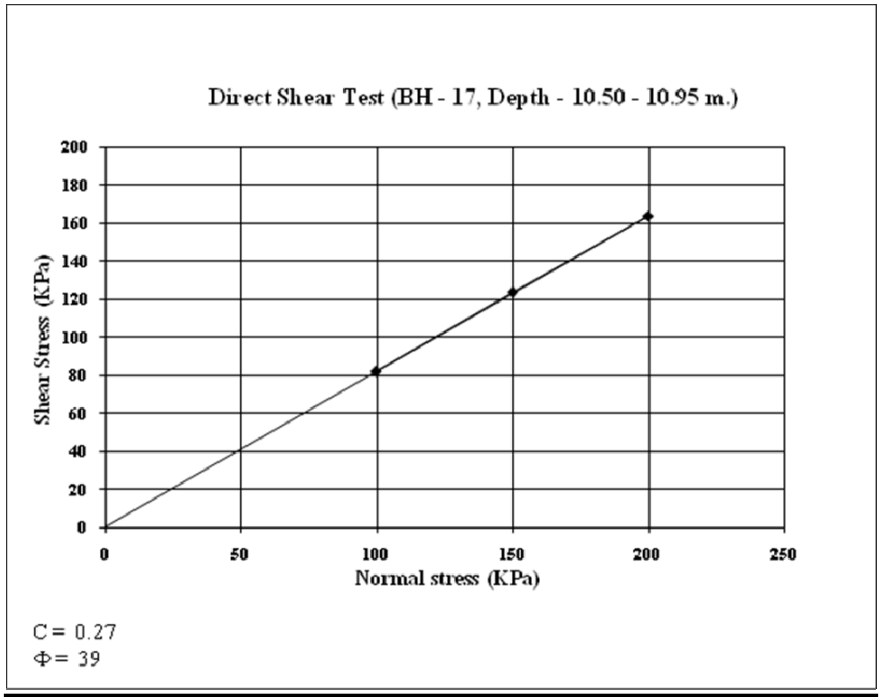
BH No.	Depth (m)	Type of Test	Bulk Density (KN/m^3)	Dry Density (KN/m^3)	Water Content (%)	Cohesion (kPa)	Angle of Internal Friction (Degrees)
16	7.00-7.45	DS	20.00	16.40	22	1.71	37

Note: DS: DIRECT SHEAR TEST

JOB NO. 30796

SKM Geosurvey

DIRECT SHEAR TEST RESULTS



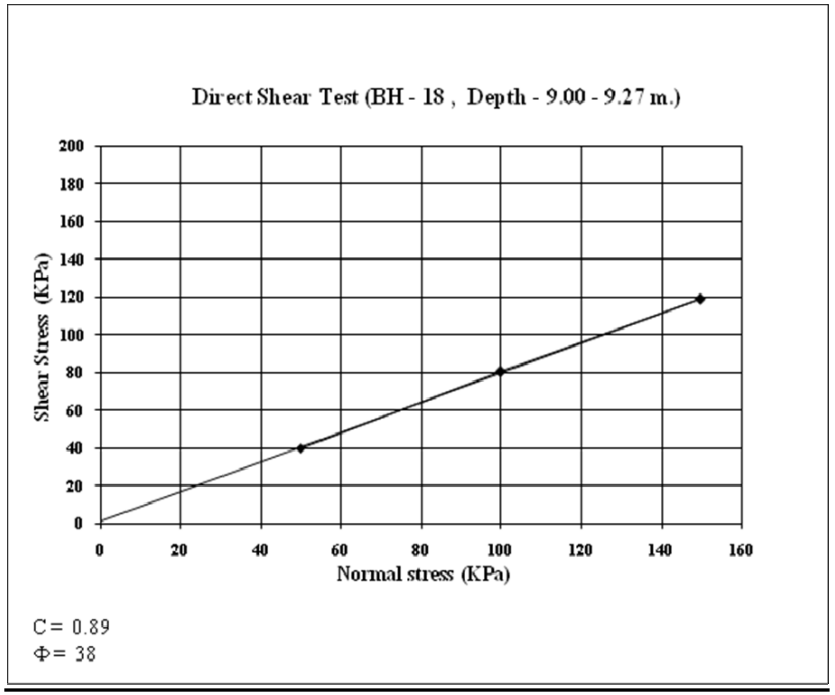
BH No.	Depth (m)	Type of Test	Bulk Density (KN/m^3)	Dry Density (KN/m^3)	Water Content (%)	Cohesion (kPa)	Angle of Internal Friction (Degrees)
17	10.50-10.95	DS	20.30	16.80	21	0.27	39

Note: DS: DIRECT SHEAR TEST

JOB NO. 30796

SKM Geosurvey

DIRECT SHEAR TEST RESULTS



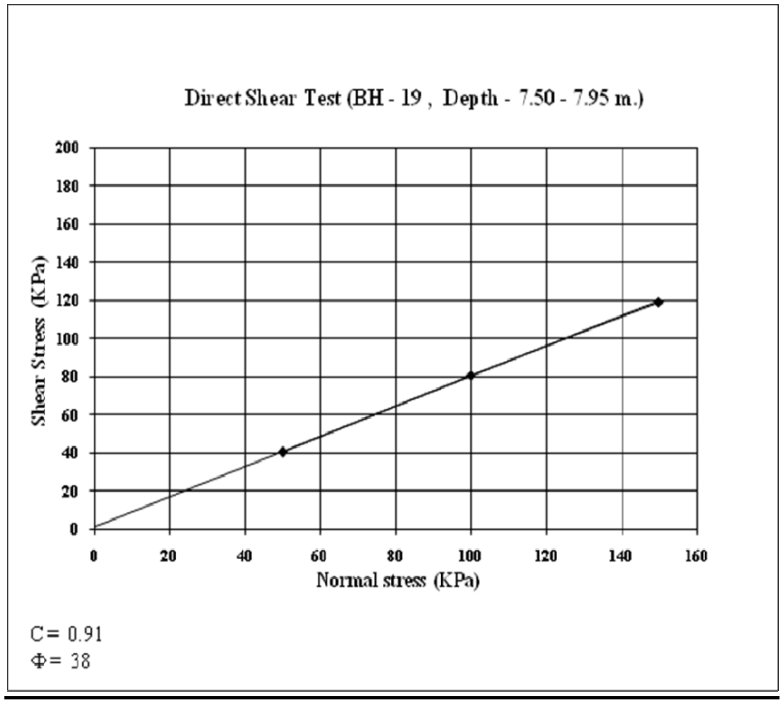
BH No.	Depth (m)	Type of Test	Bulk Density (KN/m^3)	Dry Density (KN/m^3)	Water Content (%)	Cohesion (kPa)	Angle of Internal Friction (Degrees)
18	9.00-9.27	DS	20.20	16.70	21	0.89	38

Note: DS: DIRECT SHEAR TEST

JOB NO. 30796

SKM Geosurvey

DIRECT SHEAR TEST RESULTS



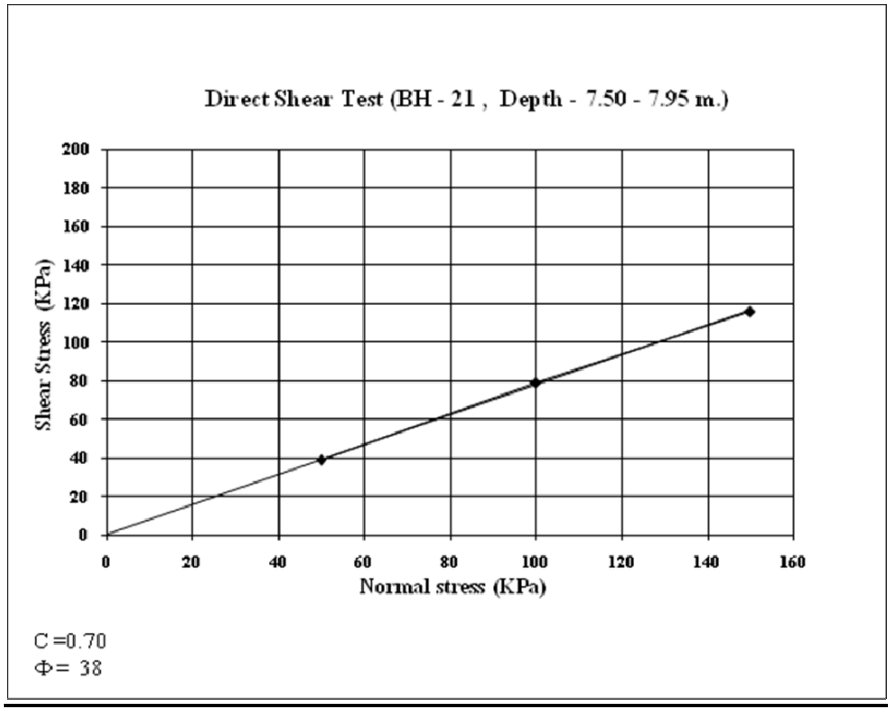
BH No.	Depth (m)	Type of Test	Bulk Density (KN/m^3)	Dry Density (KN/m^3)	Water Content (%)	Cohesion (kPa)	Angle of Internal Friction (Degrees)
19	7.50-7.95	DS	20.00	16.30	23	0.91	38

Note: DS: DIRECT SHEAR TEST

JOB NO. 30796

SKM Geosurvey

DIRECT SHEAR TEST RESULTS



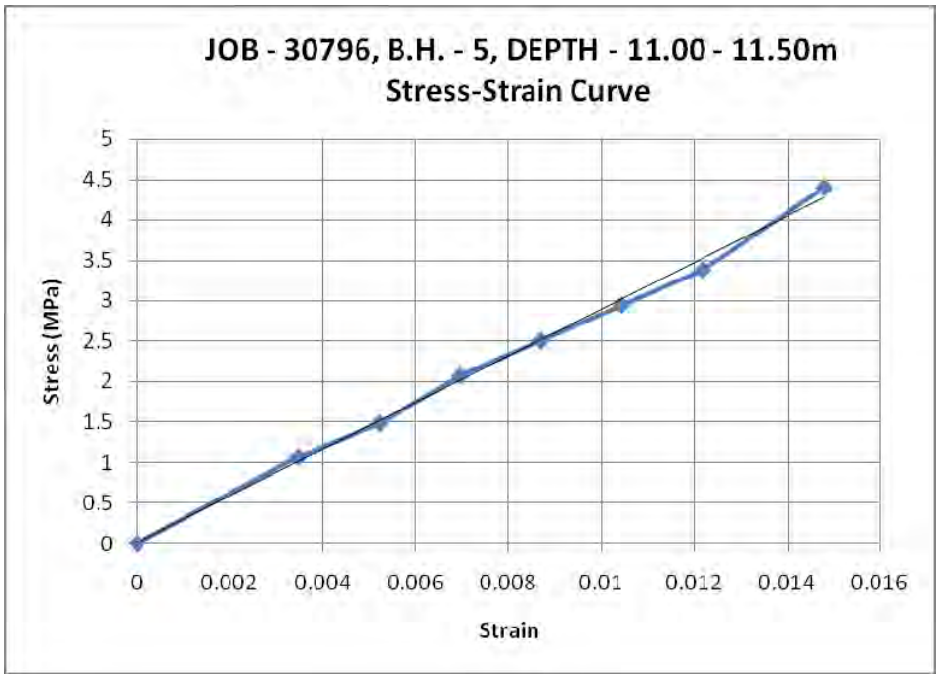
BH No.	Depth (m)	Type of Test	Bulk Density (KN/m^3)	Dry Density (KN/m^3)	Water Content (%)	Cohesion (kPa)	Angle of Internal Friction (Degrees)
21	7.50-7.95	DS	20.10	16.50	22	0.70	38

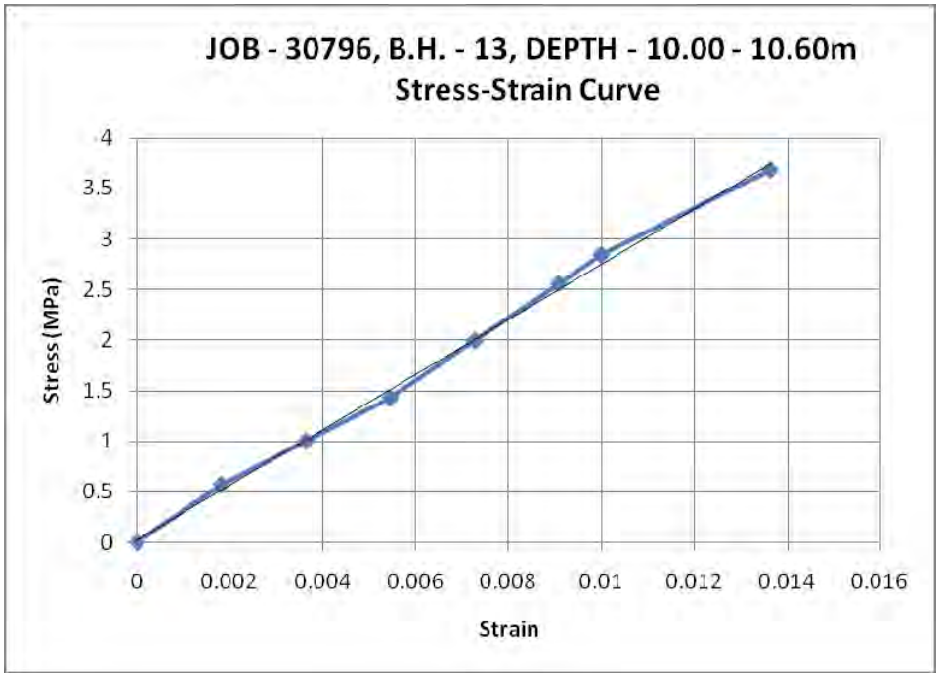
Note: DS: DIRECT SHEAR TEST

JOB NO. 30796

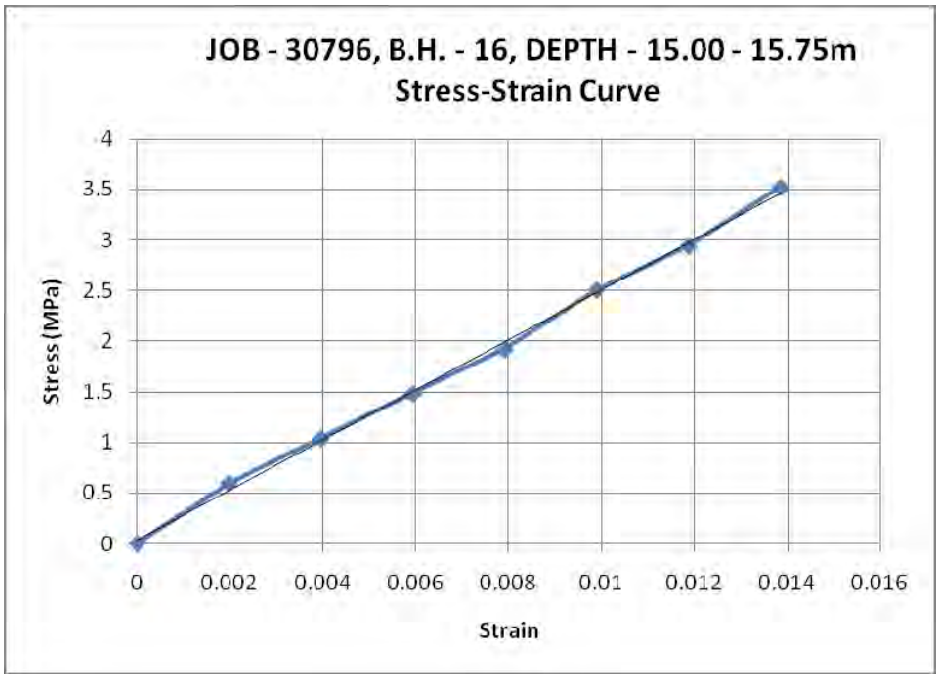
SKM Geosurvey

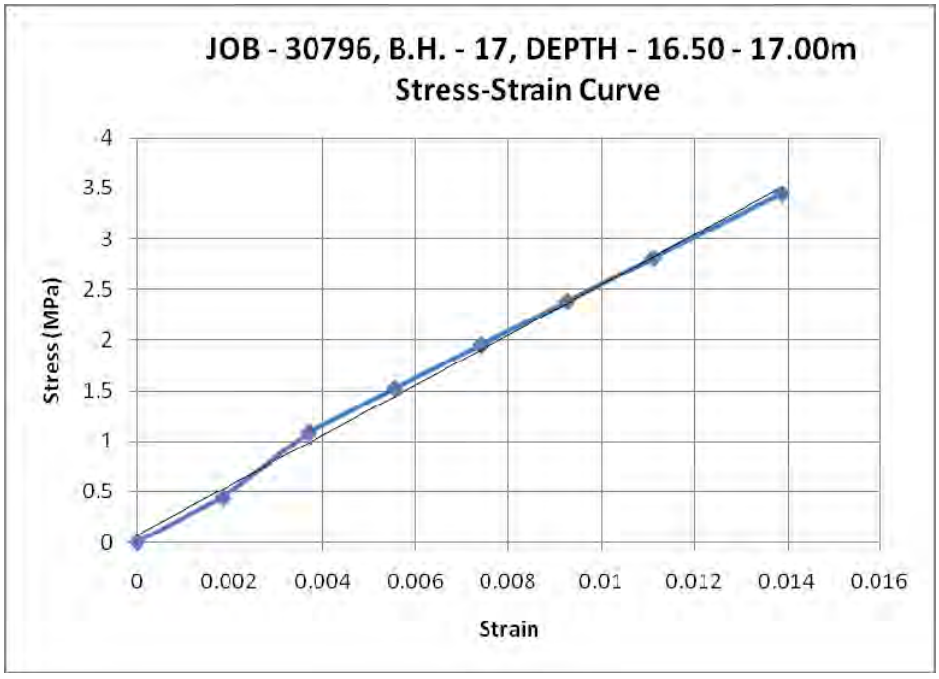
Stress-Strain Curve of Rock



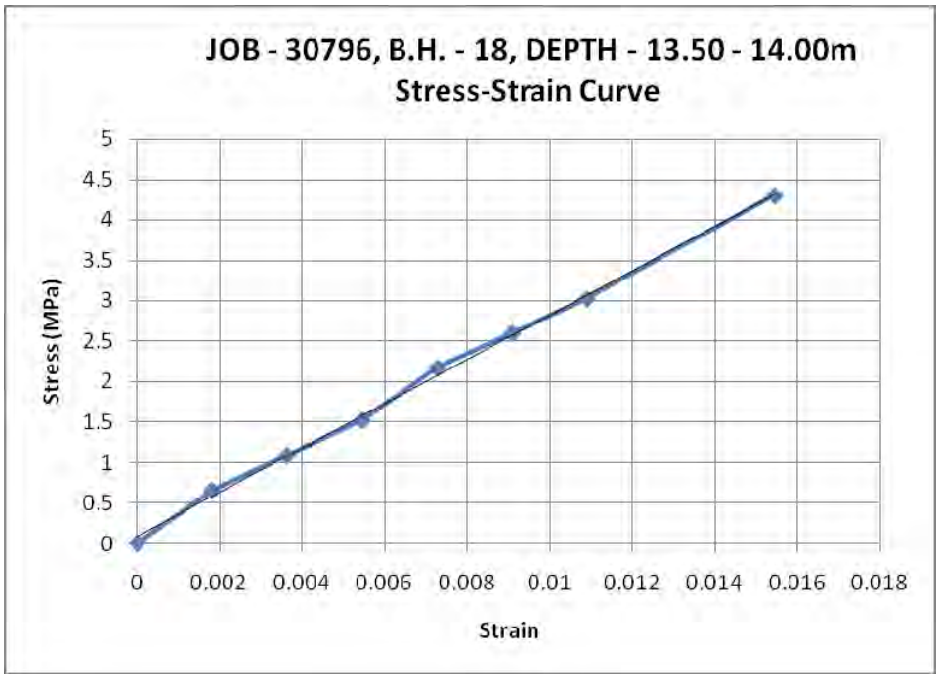


Stress-Strain Curve of Rock



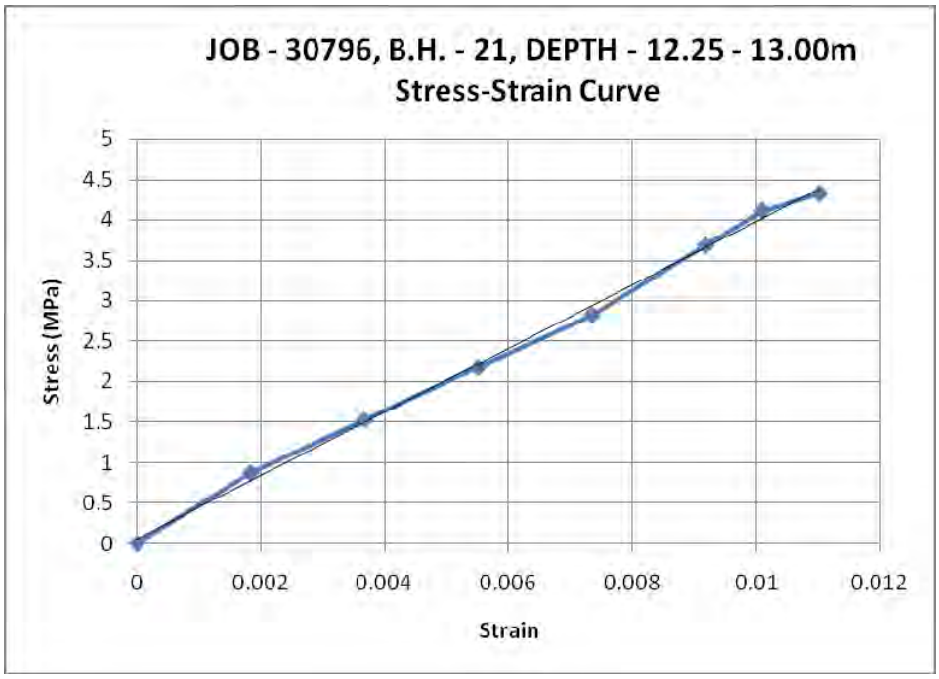


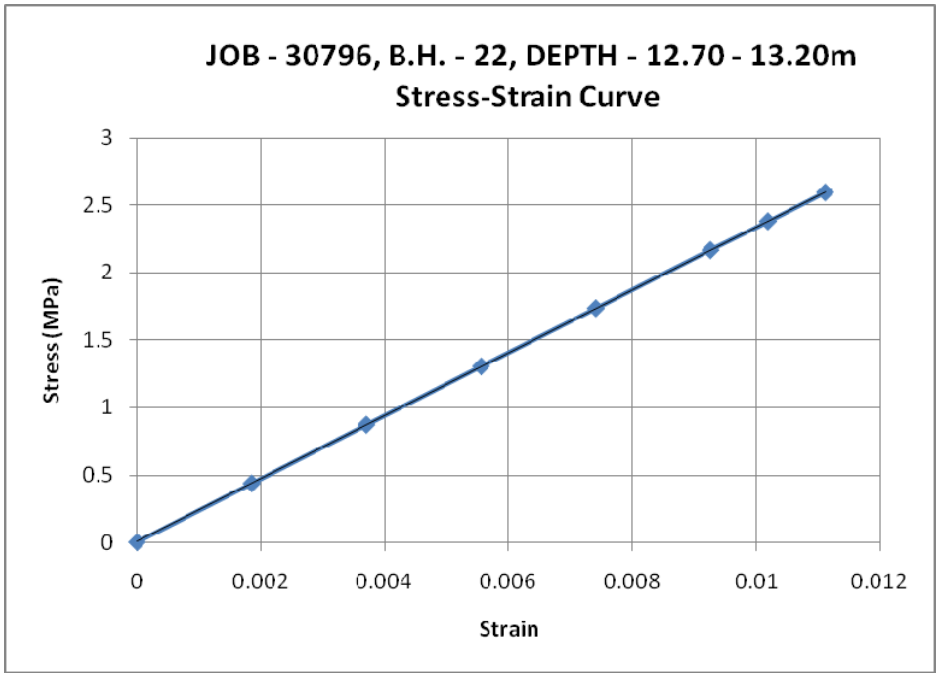
Stress-Strain Curve of Rock



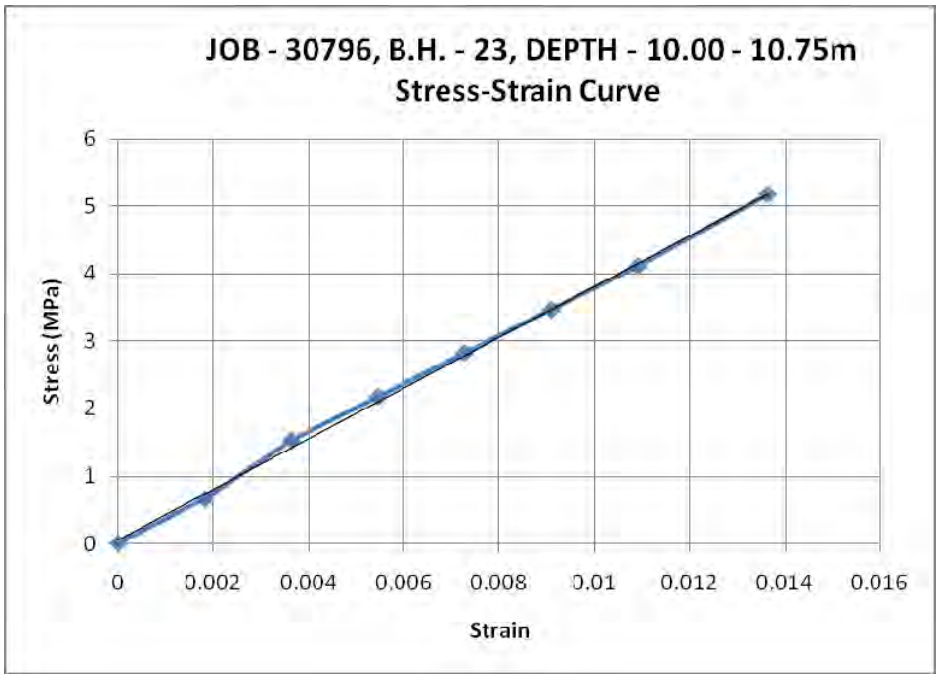


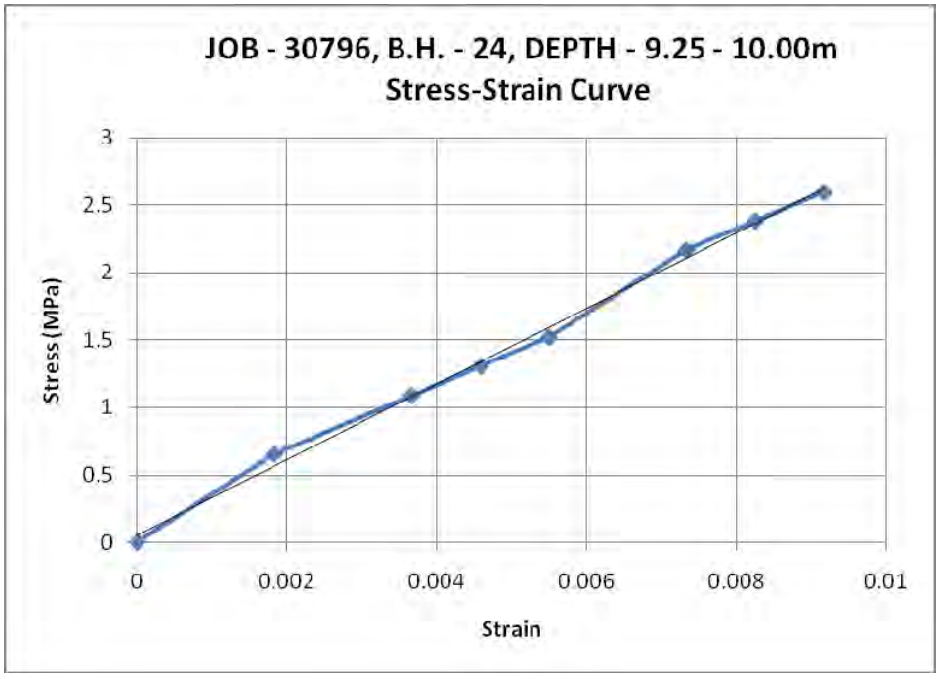
Stress-Strain Curve of Rock





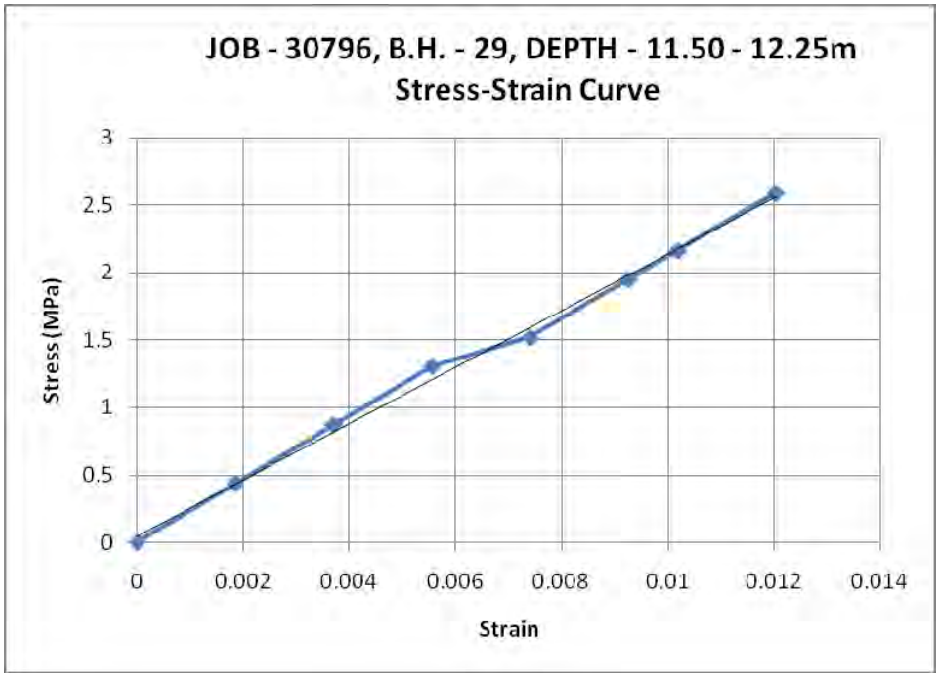
Stress-Strain Curve of Rock

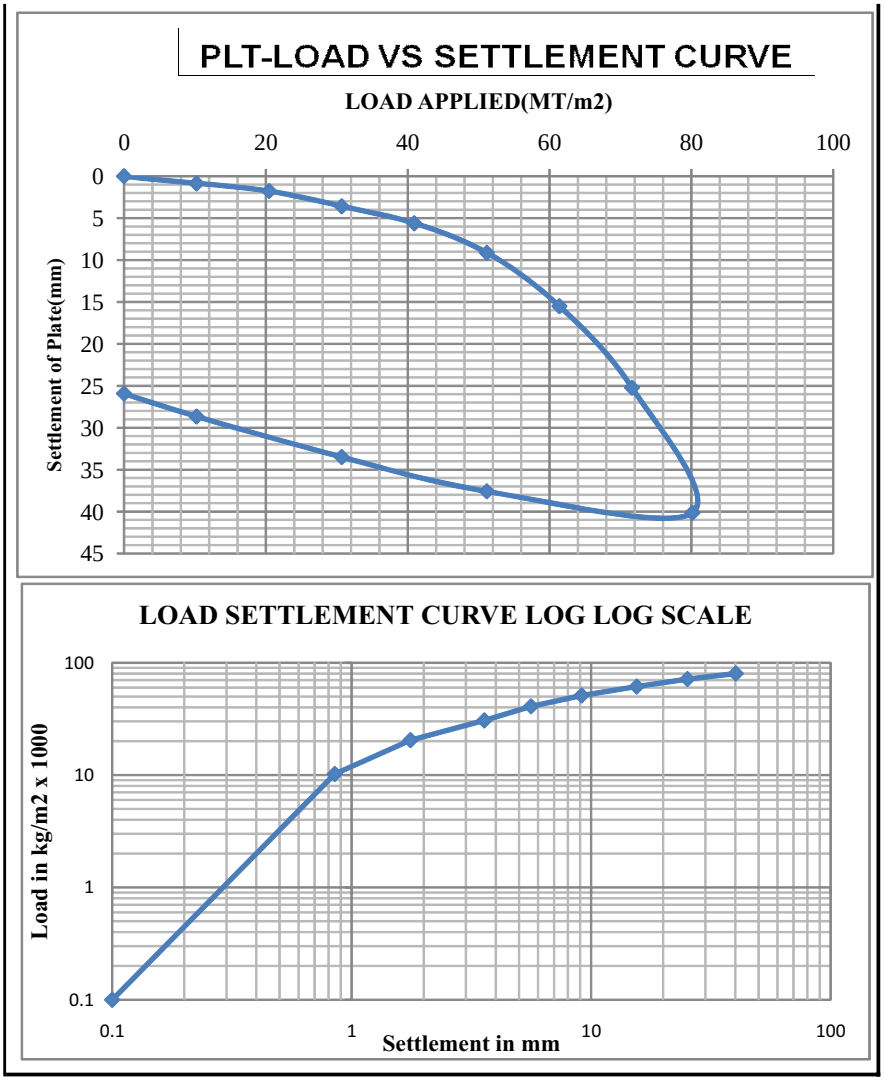




Stress-Strain Curve of Rock



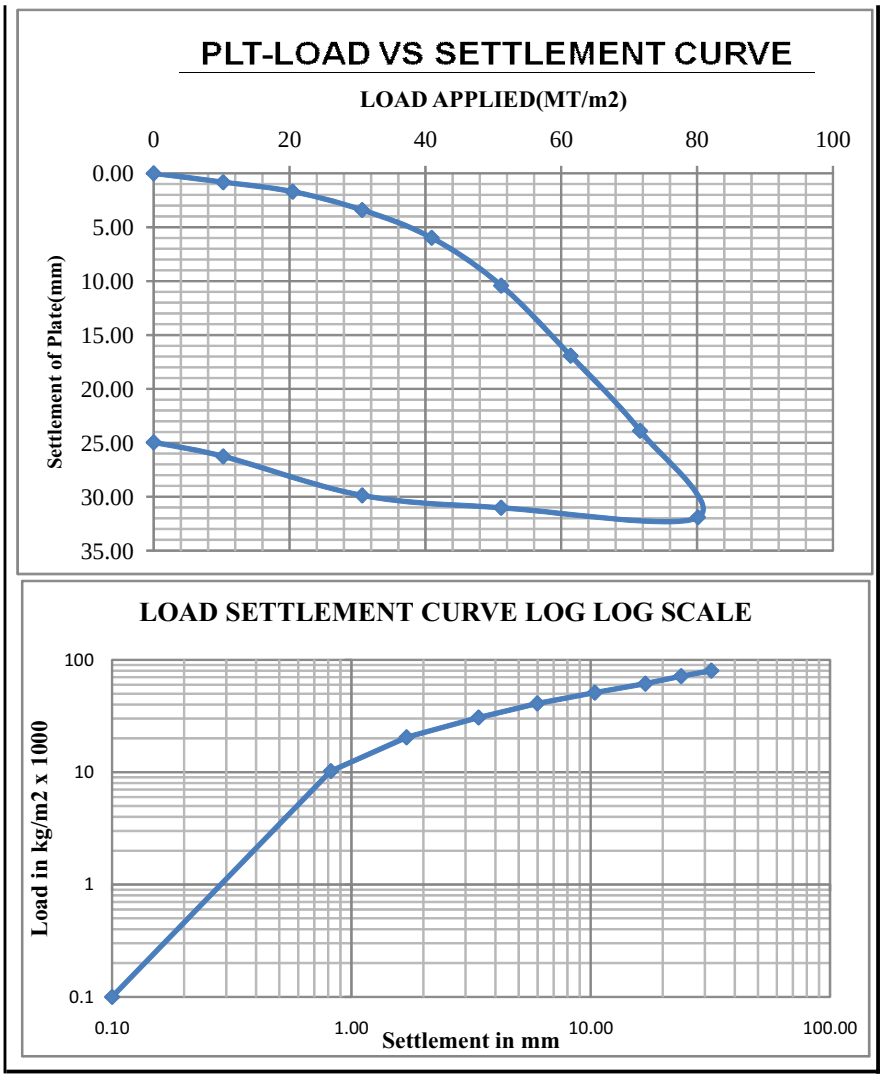




Test No.	**: PLT.01**	**R.L. of G.L.**	**: 197.50m**
Plate Size	**: 60cm x 60cm.**	**Dial Gauge Constant**	**: 0.01mm.**
Pit Size	**: 3 m x 3 m**	**L.C. of Pressure Gauge**	**: 5 kg/cm2**
Depth of Test	**: 2.50m. b.g.l.**	**Ram Dia.**	**: 12.5cm.**
Date of Test	**: 05.02.2018**	**Site**	**: Sambalpur**
Location of Test	**: N: 2411027.00, E: 8**	**Client**	**: NLC India Ltd.**
Soil Type: Silty clay			

PLATE LOAD TEST

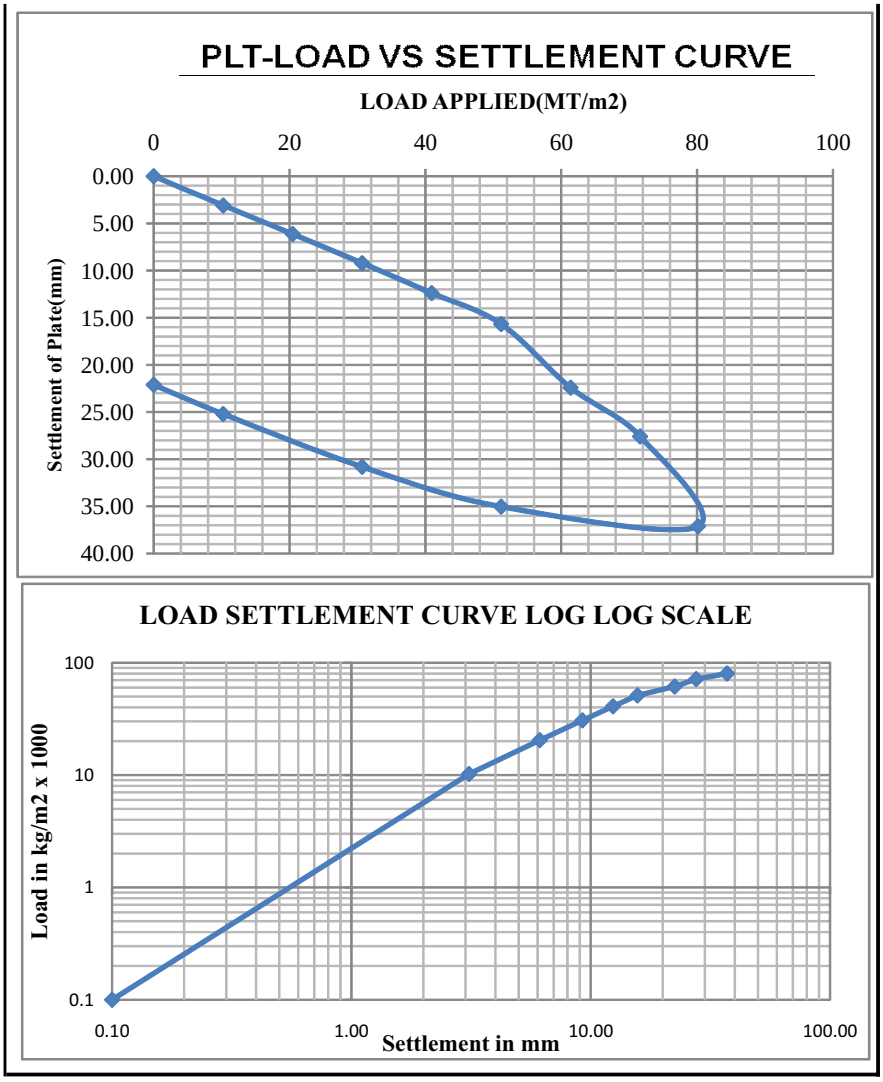
TEST NO. : PLT - 01



Test No.	**: PLT.02**	**R.L. of G.L.**	**: 199.466m**
Plate Size	**: 60cm x 60cm.**	**Dial Gauge Constant**	**: 0.01mm.**
Pit Size	**: 3 m x 3 m**	**L.C. of Pressure Gauge**	**: 5 kg/cm2**
Depth of Test	**: 2.00m. b.g.l.**	**Ram Dia.**	**: 12.5cm.**
Date of Test	**: 08.02.2018**	**Site**	**: Sambalpur**
Location of Test	**: N: 241087.00, E: 8(**	**Client**	**: NLC India Ltd.**
Soil Type: Silty clay			

PLATE LOAD TEST

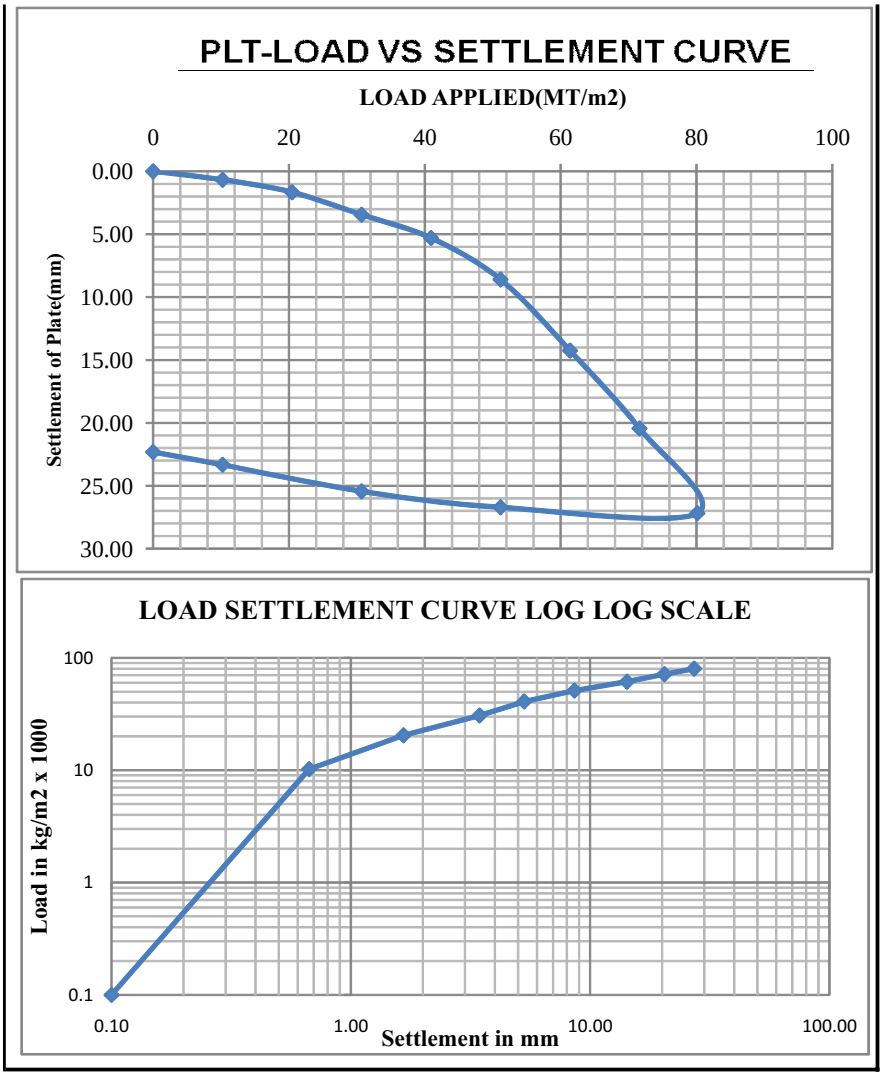
TEST NO. : PLT - 02



Test No.	**: PLT.03**	**R.L. of G.L.**	**: 197.394m**
Plate Size	**: 60cm x 60cm.**	**Dial Gauge Constant**	**: 0.01mm.**
Pit Size	**: 3 m x 3 m**	**L.C. of Pressure Gauge**	**: 5 kg/cm2**
Depth of Test	**: 2.50m. b.g.l.**	**Ram Dia.**	**: 12.5cm.**
Date of Test	**: 08.02.2018**	**Site**	**: Sambalpur**
Location of Test	**: N: 2410983.00, E: 8**	**Client**	**: NLC India Ltd.**
Soil Type: Silty clay			

PLATE LOAD TEST

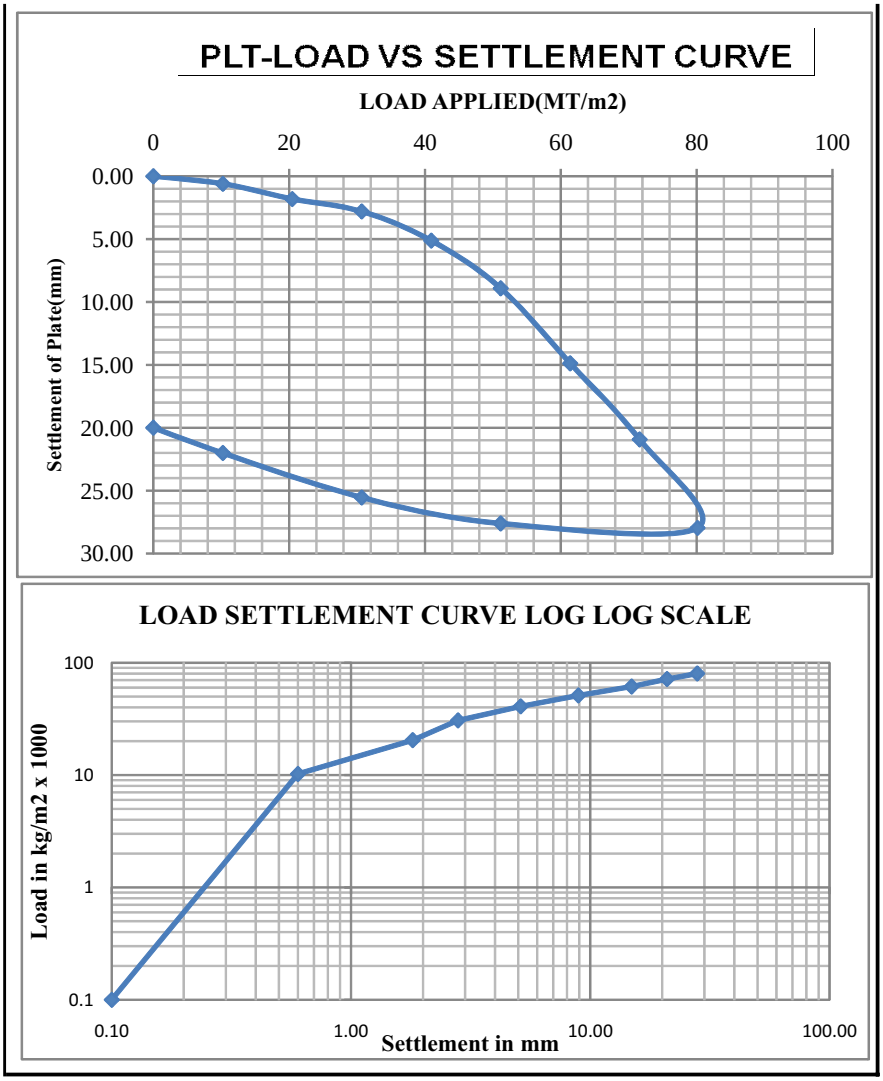
TEST NO. : PLT - 03



Test No.	**: PLT.04**	**R.L. of G.L.**	**: 198.215m**
Plate Size	**: 60cm x 60cm.**	**Dial Gauge Constant**	**: 0.01mm.**
Pit Size	**: 3 m x 3 m**	**L.C. of Pressure Gauge**	**: 5 kg/cm2**
Depth of Test	**: 2.50m. b.g.l.**	**Ram Dia.**	**: 12.5cm.**
Date of Test	**: 16.02.2018**	**Site**	**: Sambalpur**
Location of Test	**: N: 2410785.00, E: 8**	**Client**	**: NLC India Ltd.**
Soil Type: Silty clay			

PLATE LOAD TEST

TEST NO. : PLT - 04



Test No.	**: PLT.05**	**R.L. of G.L.**	**: 200.850m**
Plate Size	**: 60cm x 60cm.**	**Dial Gauge Constant**	**: 0.01mm.**
Pit Size	**: 3 m x 3 m**	**L.C. of Pressure Gauge**	**: 5 kg/cm2**
Depth of Test	**: 2.50m. b.g.l.**	**Ram Dia.**	**: 12.5cm.**
Date of Test	**: 16.02.2018**	**Site**	**: Sambalpur**
Location of Test	**: N: 2411452.00, E: 8**	**Client**	**: NLC India Ltd.**
Soil Type: Silty clay			

PLATE LOAD TEST

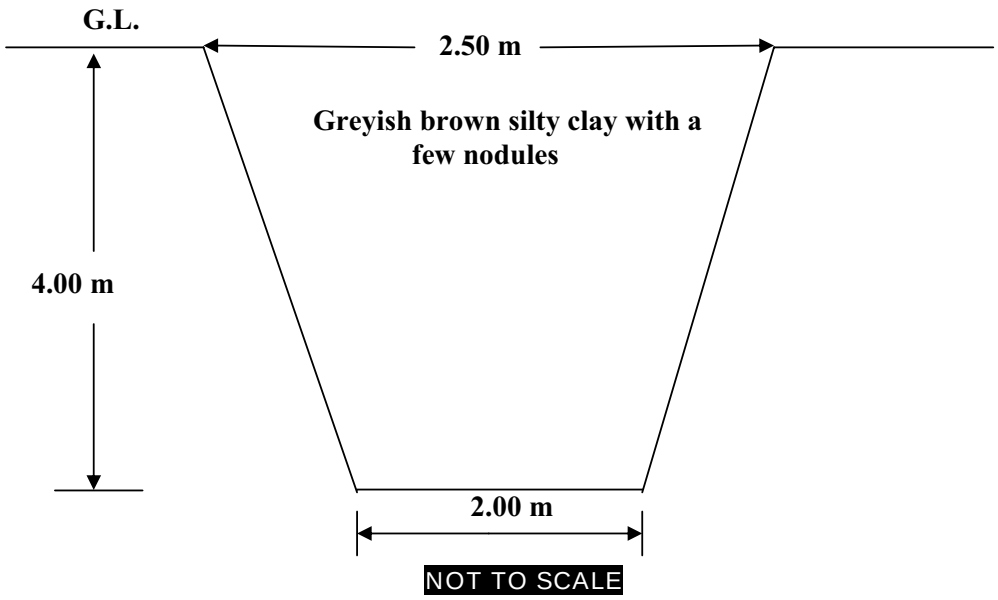
TEST NO. : PLT - 05

Trial Pit Log

Trial Pit –1 (One)

Site : NLC, Sambalpur
Pit Volume: 2.0m x 2.0m x 4m
Date : 19.02.2018

RL : 197.210m
Depth : 4.00m
Co-Ordinate: N: 2411240, E: 808580



Sample Collected

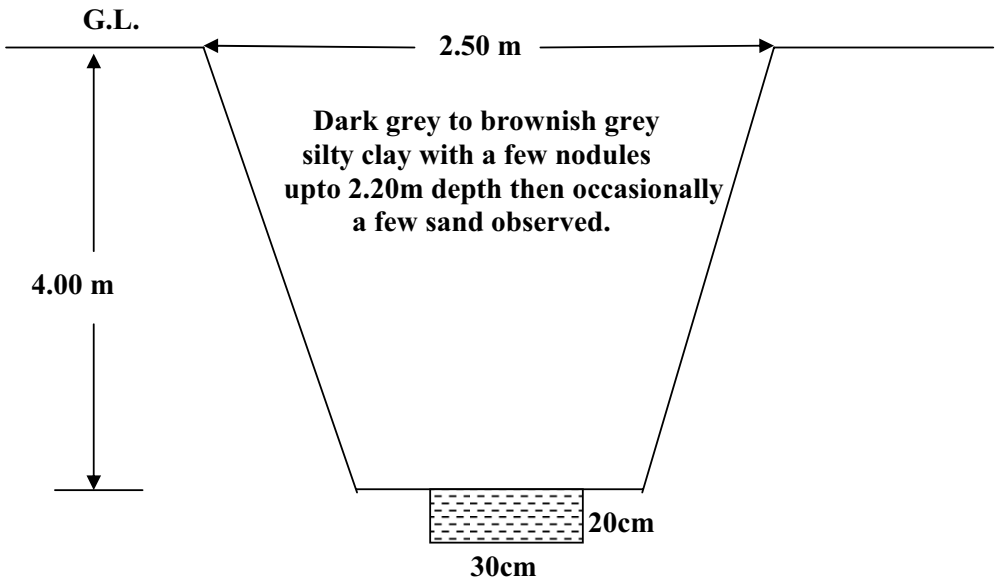
Date	Type of sample	Ref No.	Depth (m)	Remarks
19.02.2018	DS	162191	1.00	Silty clay
19.02.2018	UDS	162192	2.00	Silty clay
19.02.2018	DS	162193	3.00	Silty clay
19.02.2018	UDS	169194	4.00	Silty clay

Trial Pit Log

Trial Pit –2 (Two)

Site : NLC, Sambalpur
Pit Volume: 2.0m x 2.0m x 4m
Date : 03.02.2018

RL : 197.50m
epth : 4.00m
Co-Ordinate: N: 2411020, E: 808690



Time (Sec)	10	20	30	40	60	180	300	600	900	3600	7200
Water Level (cm)	0	0	0	1	1	2	2	3	4	4	4

Percolation rate = 0.787 inch/hr.

Sample Collected

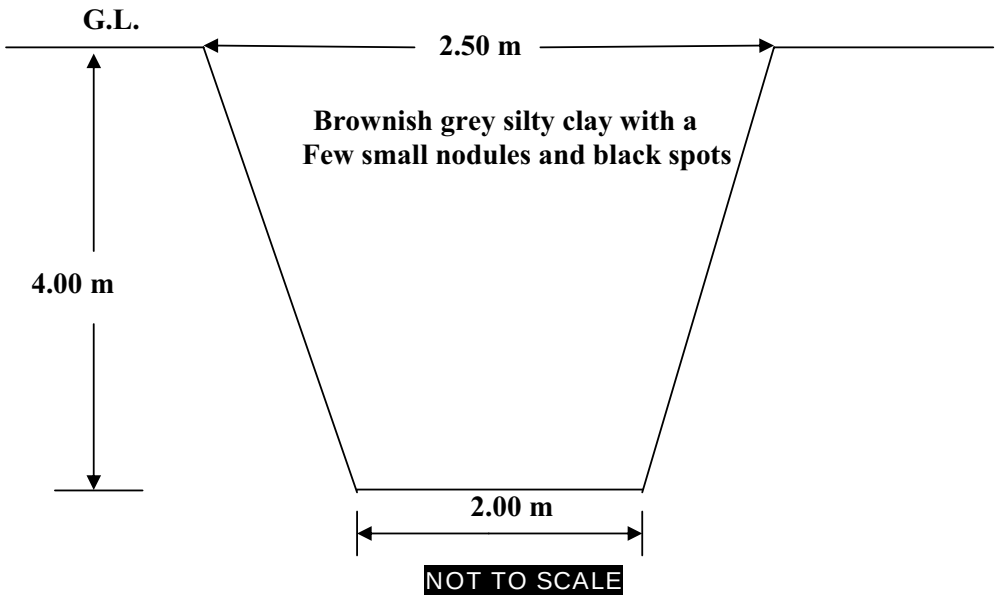
Date	Type of sample	Ref No.	Depth (m)	Remarks
03.02.2018	DS	100675	1.00	Silty clay
03.02.2018	UDS	100676	2.00	Silty clay
03.02.2018	DS	100677	3.00	Silty clay
03.02.2018	UDS	100678	4.00	Silty clay

Trial Pit Log

Trial Pit –3 (Three)

Site : NLC, Sambalpur
Pit Volume: 2.0m x 2.0m x 4m
Date : 01.02.2018

RL : 198.50m
Depth : 4.00m
Co-Ordinate: N: 2410815, E: 808692



Sample Collected

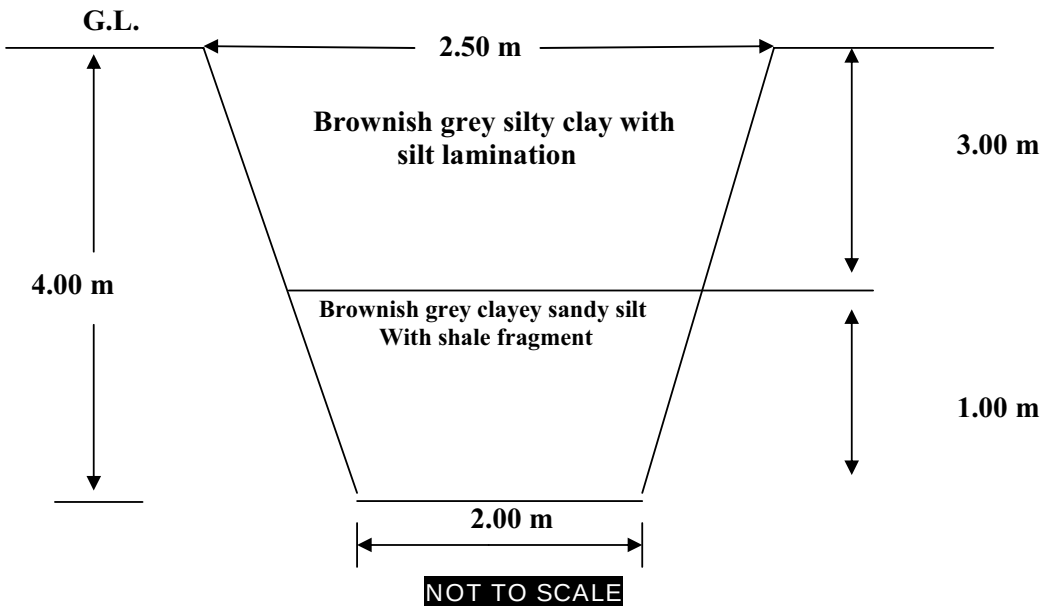
Date	Type of sample	Ref No.	Depth (m)	Remarks
01.02.2018	DS	106100	1.00	Silty clay
01.02.2018	UDS	106101	2.00	Silty clay
01.02.2018	DS	106102	3.00	Silty clay
01.02.2018	UDS	106103	4.00	Silty clay

Trial Pit Log

Trial Pit – 4 (Four)

Site : NLC, Sambalpur
Pit Volume: 2.0m x 2.0m x 4m
Date : 01.02.2018

RL : 194.729m
Depth : 4.00m
Co-Ordinate: N: 2411140, E: 808965



Sample Collected

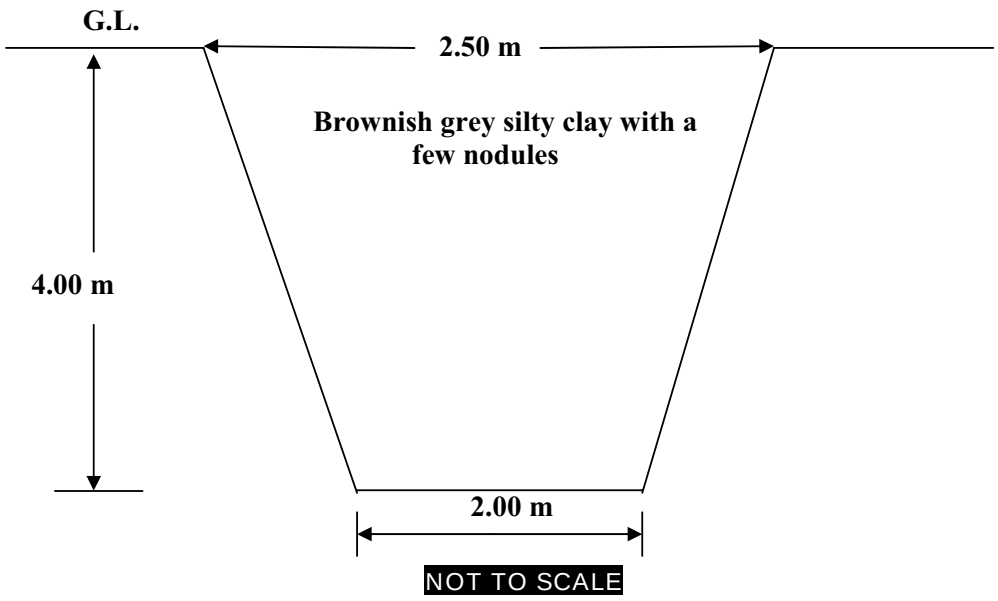
Date	Type of sample	Ref No.	Depth (m)	Remarks
01.02.2018	DS	106104	1.00	Silty clay
01.02.2018	UDS	106105	2.00	Silty clay
01.02.2018	DS	106106	3.00	Sandy clayey silt
01.02.2018	UDS	106107	4.00	Sandy clayey silt

Trial Pit Log

Trial Pit –5 (Five)

Site : NLC, Sambalpur
Pit Volume: 2.0m x 2.0m x 4m
Date : 19.02.2018

RL : 202.405m
Depth : 4.00m
Co-Ordinate: N: 2409510, E: 810500



Sample Collected

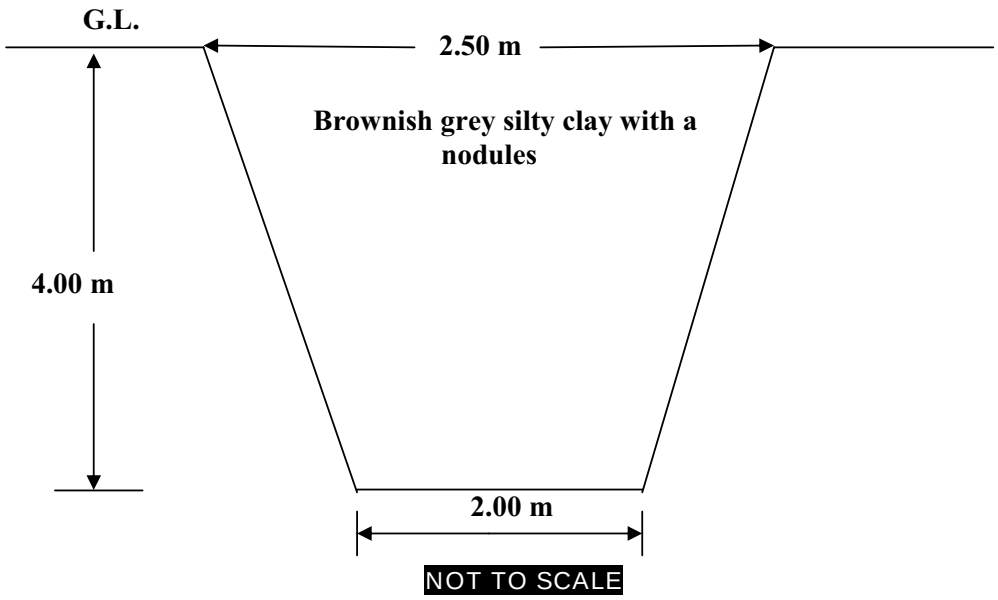
Date	Type of sample	Ref No.	Depth (m)	Remarks
19.02.2018	UDS	151251	1.00	Silty clay
19.02.2018	DS	151252	2.00	Silty clay
19.02.2018	UDS	151253	3.00	Silty clay
19.02.2018	DS	151254	4.00	Silty clay

Trial Pit Log

Trial Pit –6 (Six)

Site : NLC, Sambalpur
Pit Volume: 2.0m x 2.0m x 4m
Date : 19.02.2018

RL : 202.925m
Depth : 4.00m
Co-Ordinate: N: 2408758, E: 810205



Sample Collected

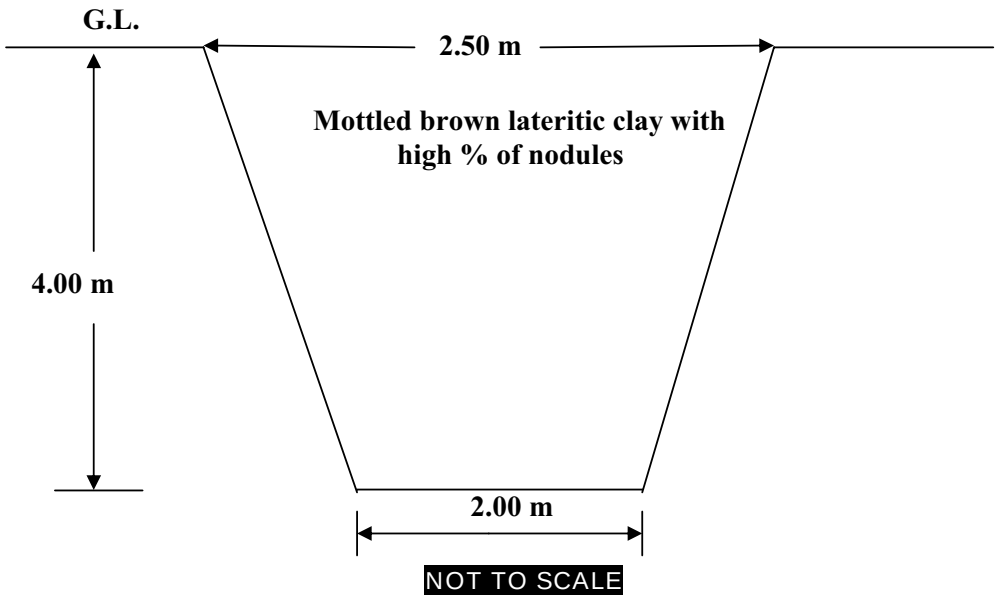
Date	Type of sample	Ref No.	Depth (m)	Remarks
19.02.2018	UDS	171620	1.00	Silty clay
19.02.2018	DS	171621	2.00	Silty clay
19.02.2018	UDS	171622	3.00	Silty clay
19.02.2018	DS	171623	4.00	Silty clay

Trial Pit Log

Trial Pit –7 (Seven)

Site : NLC, Sambalpur
Pit Volume: 2.0m x 2.0m x 4m
Date : 03.02.2018

RL : 200.850m
Depth : 4.00m
Co-Ordinate: N: 2411457, E: 809105



Sample Collected

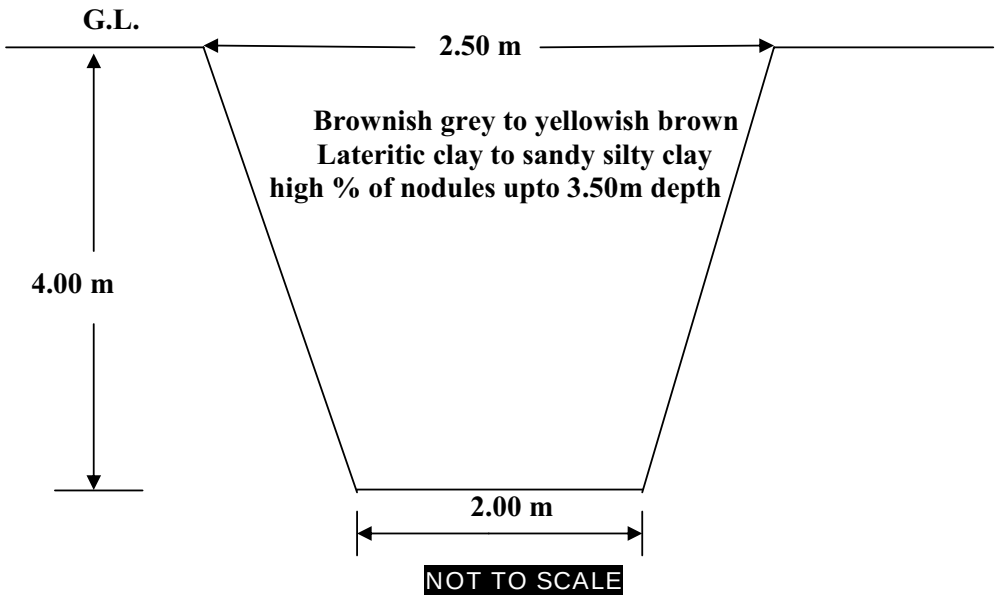
Date	Type of sample	Ref No.	Depth (m)	Remarks
03.02.2018	DS	100710	1.00	Lateritic clay
03.02.2018	UDS	100711	2.00	Lateritic clay
03.02.2018	DS	100712	3.00	Lateritic clay
03.02.2018	DS	100713	4.00	Lateritic clay

Trial Pit Log

Trial Pit –8 (Eight)

Site : NLC, Sambalpur
Pit Volume: 2.0m x 2.0m x 4m
Date : 31.02.2018

RL : 199.264m
Depth : 4.00m
Co-Ordinate: N: 2410810, E: 809050



Sample Collected

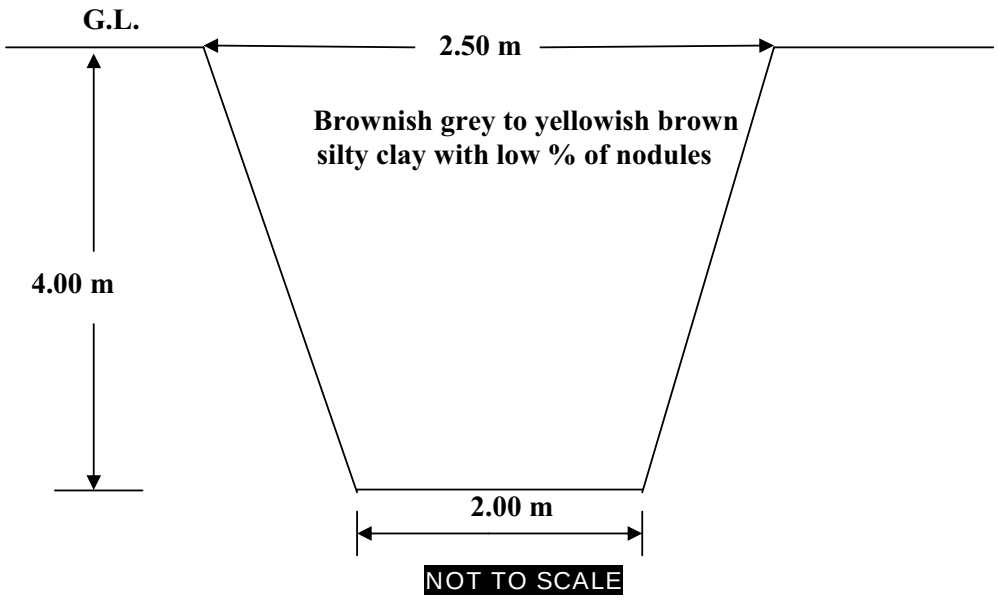
Date	Type of sample	Ref No.	Depth (m)	Remarks
31.02.2018	DS	105129	1.00	Lateritic clay
31.02.2018	UDS	105130	2.00	Lateritic clay
31.02.2018	UDS	105131	3.00	Lateritic clay
31.02.2018	DS	105132	4.00	Lateritic clay

Trial Pit Log

Trial Pit –9 (Nine)

Site : NLC, Sambalpur
Pit Volume: 2.0m x 2.0m x 4m
Date : 04.02.2018

RL : 198.614m
Depth : 4.00m
Co-Ordinate: N: 2409655, E: 808710



Sample Collected

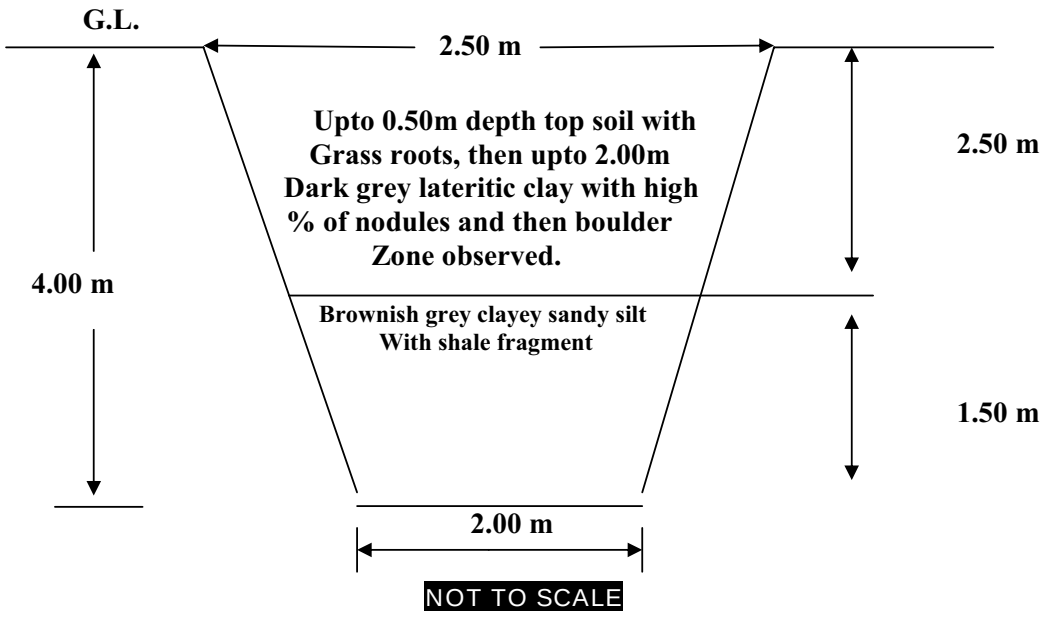
Date	Type of sample	Ref No.	Depth (m)	Remarks
04.02.2018	UDS	120150	1.00	Silty clay
04.02.2018	DS	120151	2.00	Silty clay
04.02.2018	UDS	120152	3.00	Clayey silt
04.02.2018	DS	120153	4.00	Clayey silt

Trial Pit Log

Trial Pit – 10 (Ten)

Site : NLC, Sambalpur
Pit Volume: 2.0m x 2.0m x 4m
Date : 31.01.2018

RL : 195.668m
Depth : 4.00m
Co-Ordinate: N: 2411180, E: 809065



Sample Collected

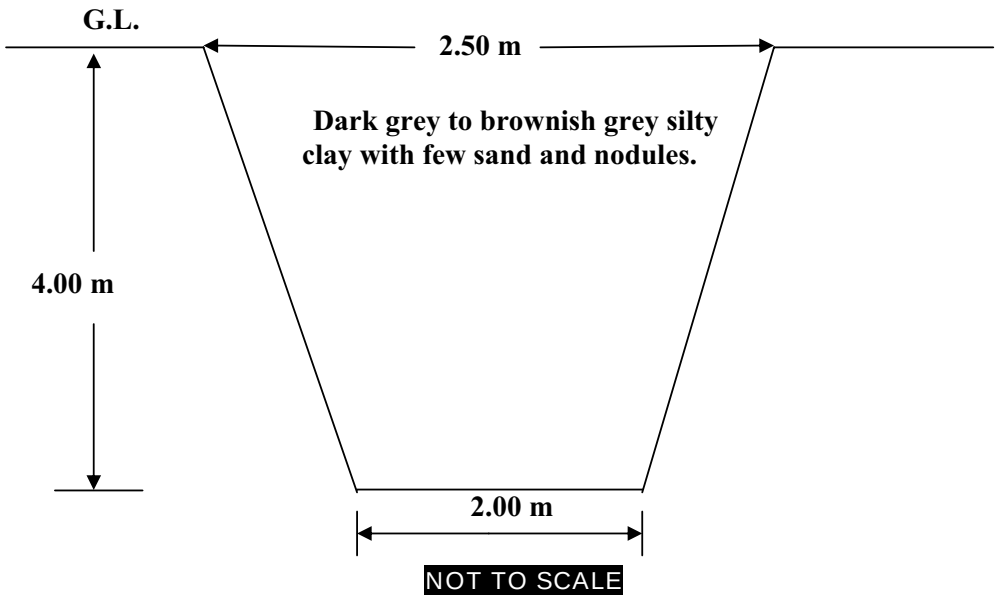
Date	Type of sample	Ref No.	Depth (m)	Remarks
31.01.2018	DS	105133	1.00	Lateritic soil
31.01.2018	DS	105134	2.00	Boulders
31.01.2018	UDS	105135	3.00	Silty clay
31.01.2018	DS	105136	4.00	Sandy clayey silt

Trial Pit Log

Trial Pit –11 (Eleven)

Site : NLC, Sambalpur
Pit Volume: 2.0m x 2.0m x 4m
Date : 04.02.2018

RL : 201.101m
Depth : 4.00m
Co-Ordinate: N: 2409560, E: 809200



Sample Collected

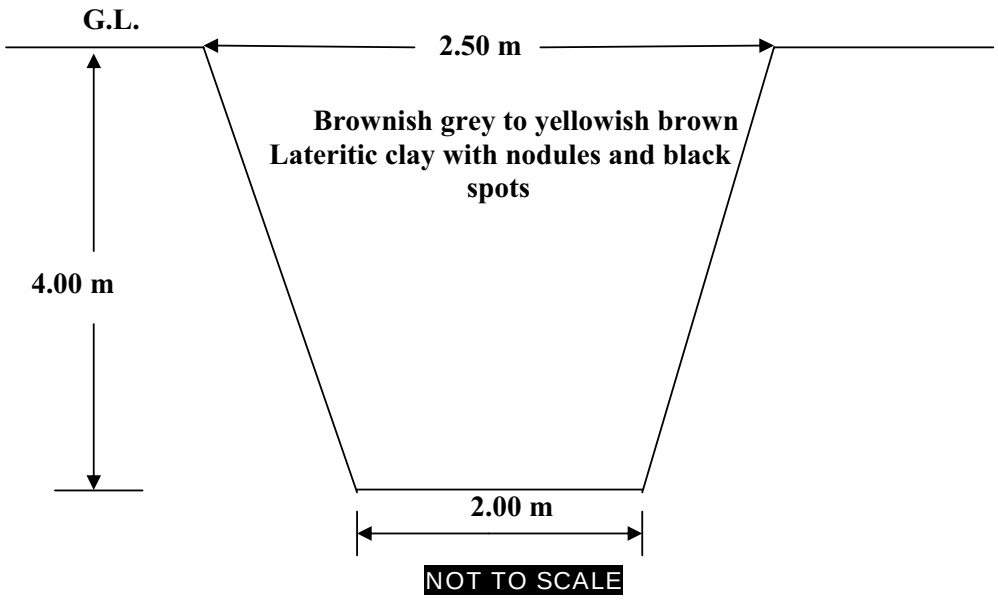
Date	Type of sample	Ref No.	Depth (m)	Remarks
04.02.2018	UDS	150122	1.00	Silty clay
04.02.2018	DS	150123	2.00	Silty clay
04.02.2018	UDS	150124	3.00	Clayey silt
04.02.2018	DS	150125	4.00	Clayey silt

Trial Pit Log

Trial Pit –12 (Twelve)

Site : NLC, Sambalpur
Pit Volume: 2.0m x 2.0m x 4m
Date : 02.02.2018

RL : m
Depth : 4.00m
Co-Ordinate: N:, E:



Sample Collected

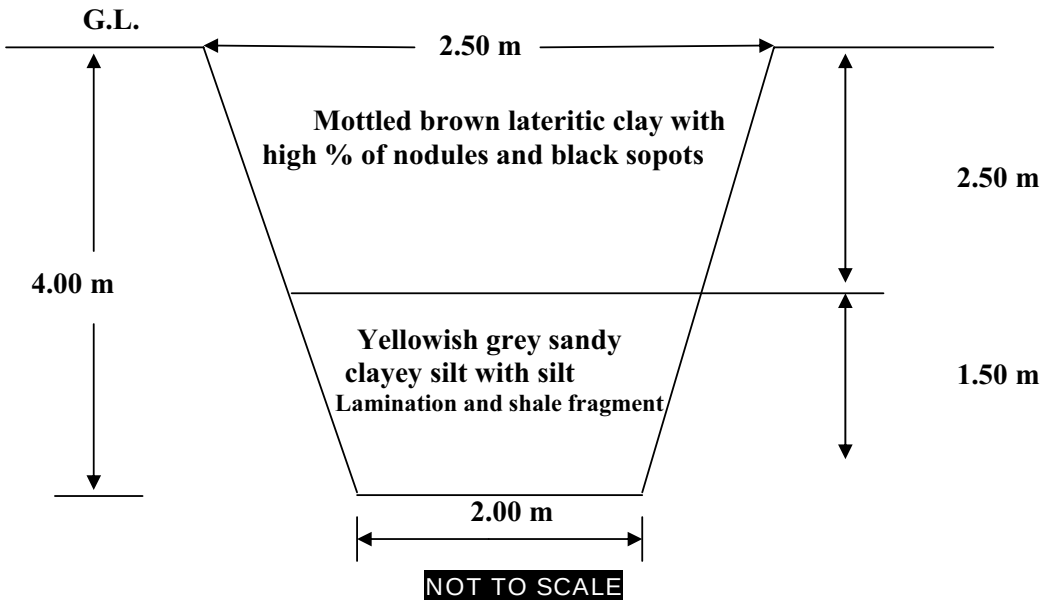
Date	Type of sample	Ref No.	Depth (m)	Remarks
02.02.2018	UDS	106112	1.00	Lateritic clay
02.02.2018	DS	106113	2.00	Lateritic clay
02.02.2018	UDS	106114	3.00	Lateritic clay
02.02.2018	DS	106115	4.00	Lateritic clay

Trial Pit Log

Trial Pit –13 (Thirteen)

Site : NLC, Sambalpur
Pit Volume: 2.0m x 2.0m x 4m
Date : 31.01.2018

RL : 196.660m
Depth : 4.00m
Co-Ordinate: N:2411180, E: 8090105



Sample Collected

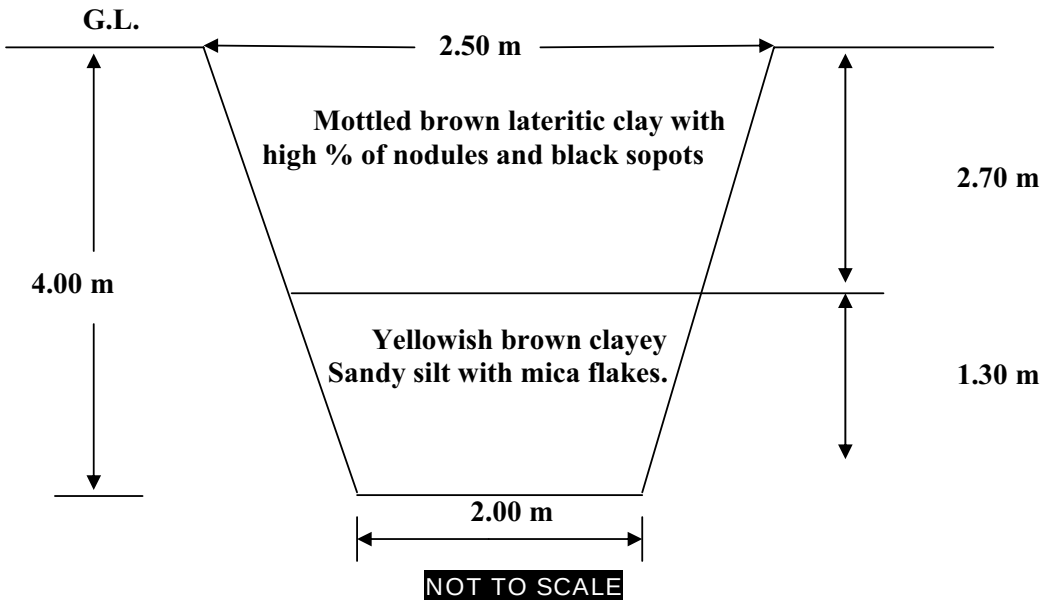
Date	Type of sample	Ref No.	Depth (m)	Remarks
31.01.2018	DS	105121	1.00	Lateritic clay
31.01.2018	DS	105122	2.00	Lateritic clay
31.01.2018	DS	105123	3.00	Sandy clayey silt
31.01.2018	DS	105124	4.00	Sandy clayey silt

Trial Pit Log

Trial Pit –14 (fourteen)

Site : NLC, Sambalpur
Pit Volume: 2.0m x 2.0m x 4m
Date : 31.01.2018

RL : 196.621m
Depth : 4.00m
Co-Ordinate: N:2411125, E: 809070



Sample Collected

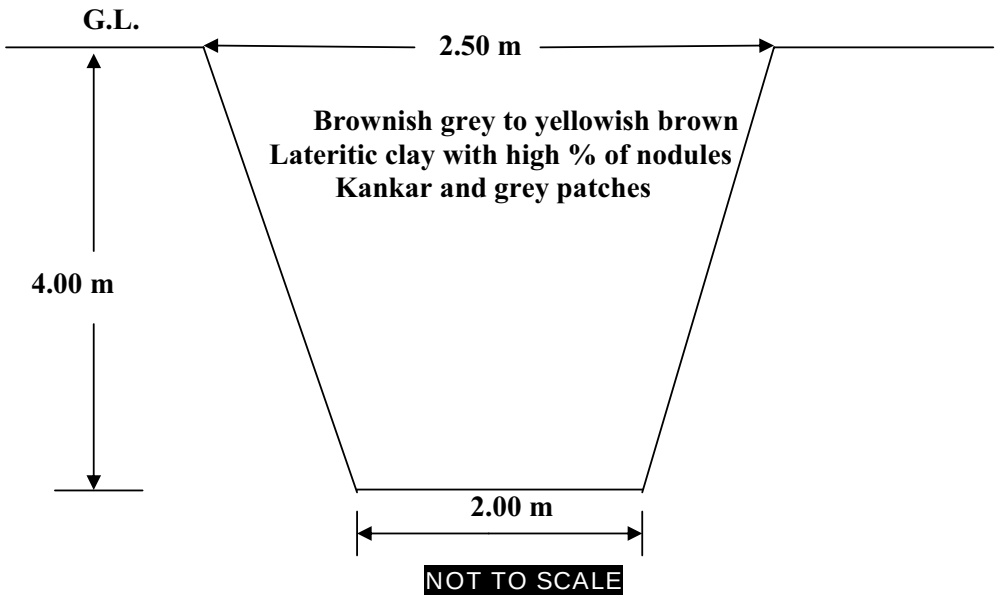
Date	Type of sample	Ref No.	Depth (m)	Remarks
31.01.2018	DS	105125	1.00	Sandy silty clay
31.01.2018	UDS	105126	2.00	Sandy silty clay
31.01.2018	DS	105127	3.00	Clayey sandy silt
31.01.2018	DS	105128	4.00	Clayey sandy silt

Trial Pit Log

Trial Pit –15 (Fifteen)

Site : NLC, Sambalpur
Pit Volume: 2.0m x 2.0m x 4m
Date : 02.02.2018

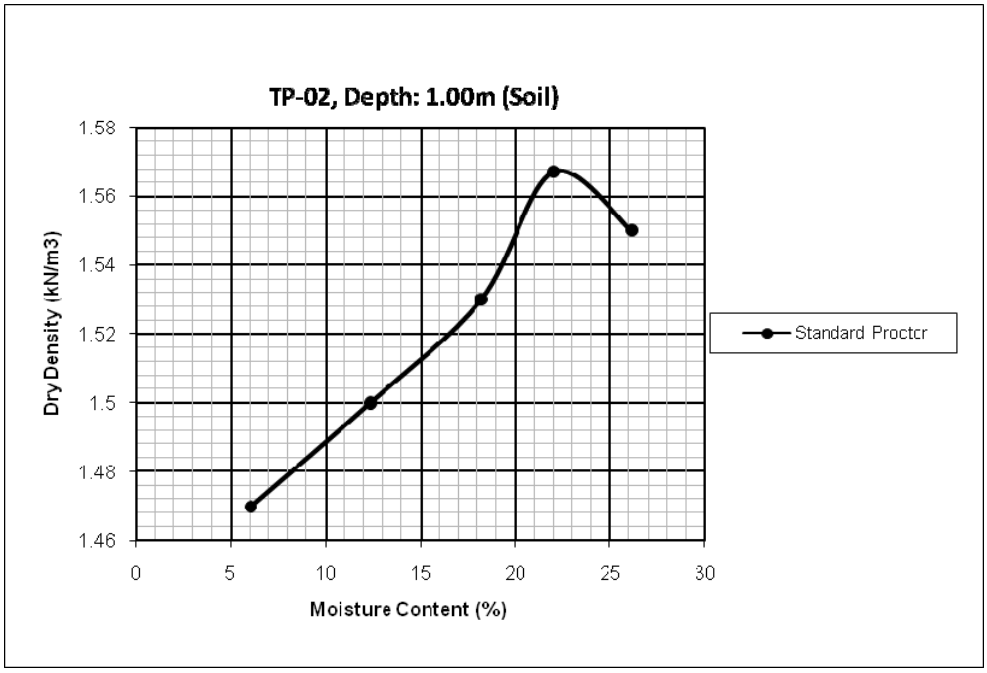
RL : 199.466m
Depth : 4.00m
Co-Ordinate: N:2410812, E: 809090



Sample Collected

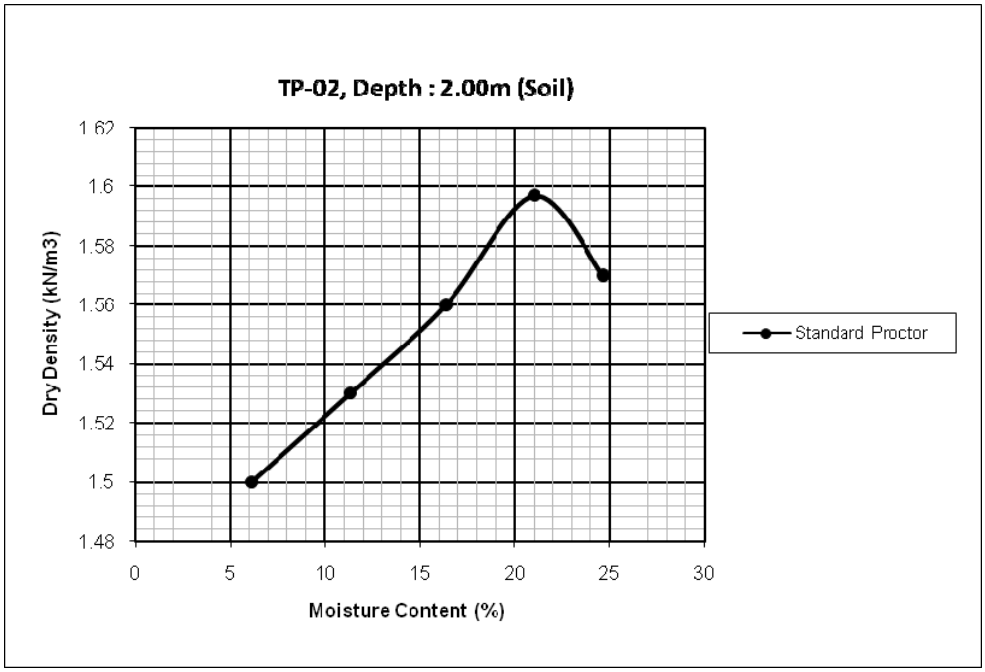
Date	Type of sample	Ref No.	Depth (m)	Remarks
02.02.2018	UDS	106108	1.00	Lateritic clay
02.02.2018	DS	106109	2.00	Lateritic clay
02.02.2018	UDS	106110	3.00	Lateritic clay
02.02.2018	DS	106111	4.00	Lateritic clay

PROCTOR CURVE



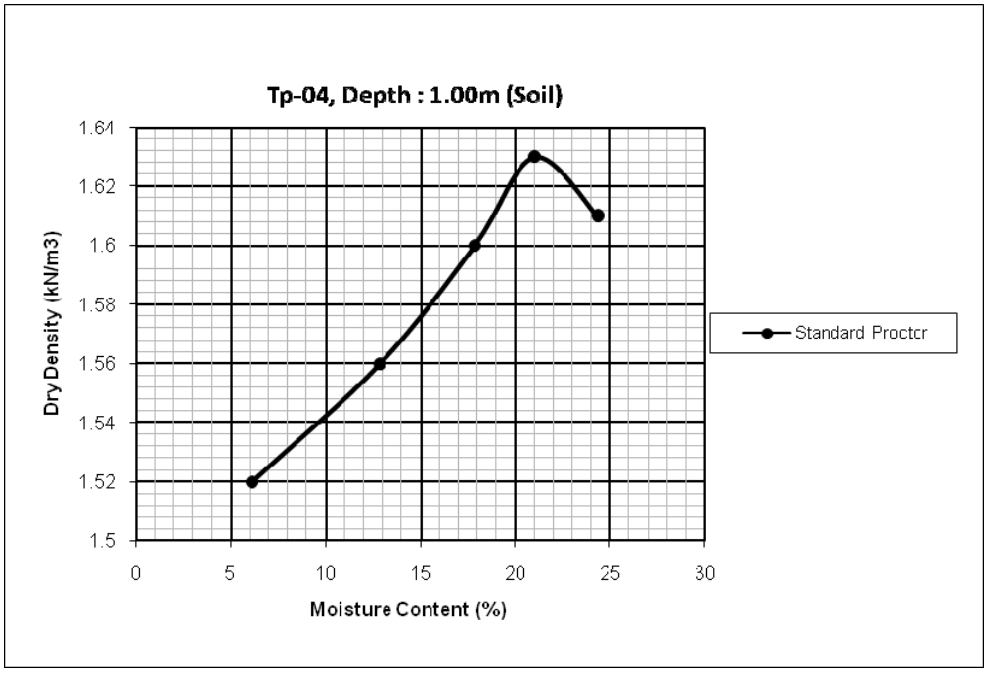
OMC(%)	MDD (KN/m^3)
22	1.567

PROCTOR CURVE



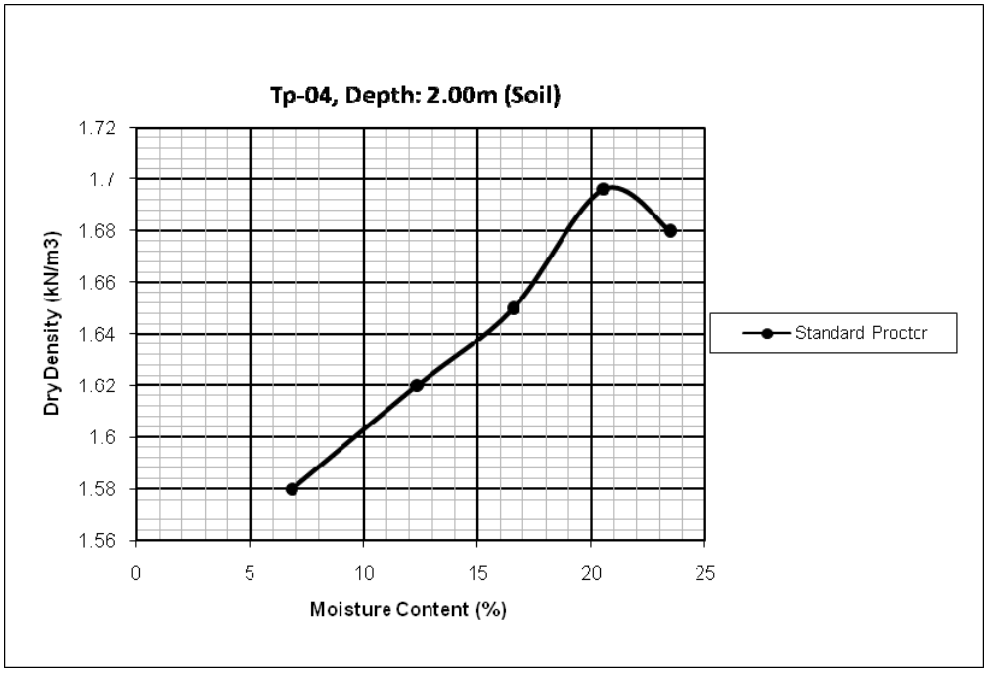
OMC(%)	MDD (KN/m^3)
21	1.597

PROCTOR CURVE



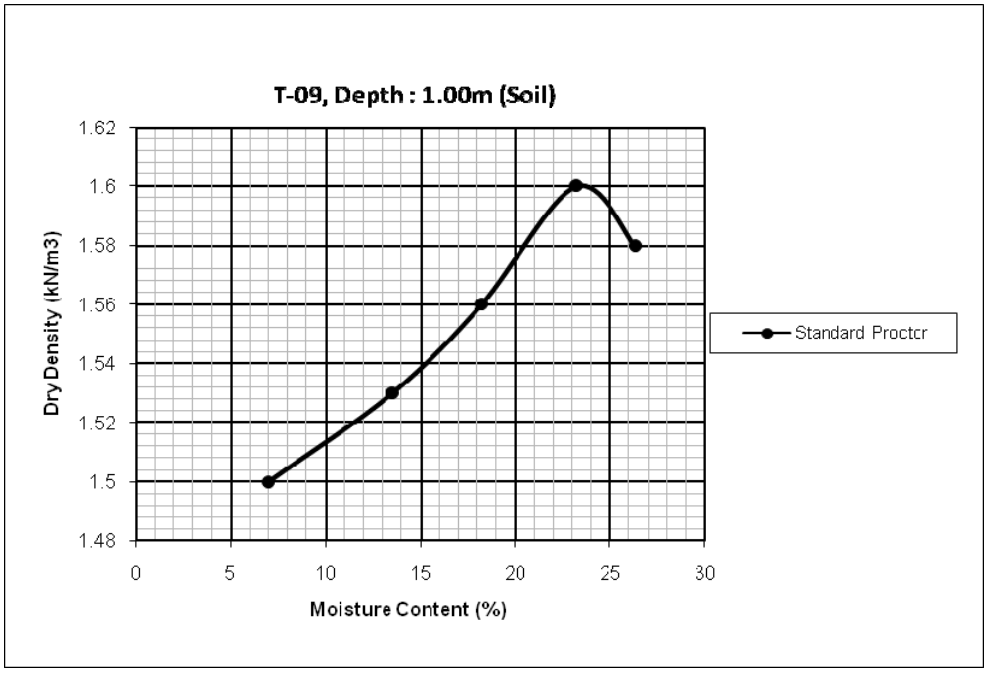
OMC(%)	MDD (KN/m^3)
21	1.63

PROCTOR CURVE



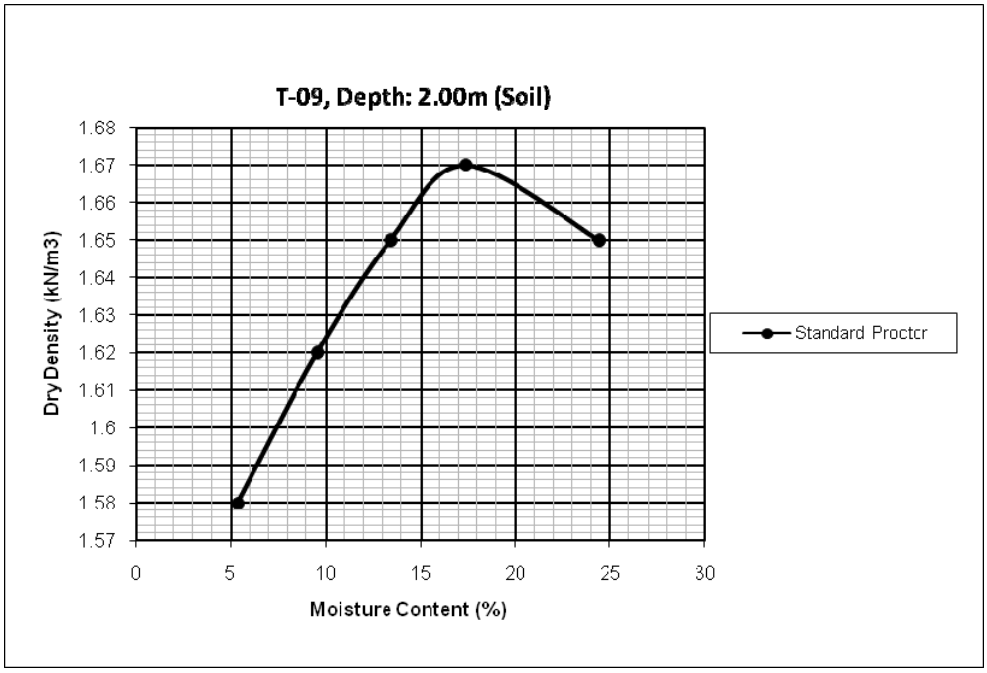
OMC(%)	MDD (KN/m^3)
20.5	1.696

PROCTOR CURVE



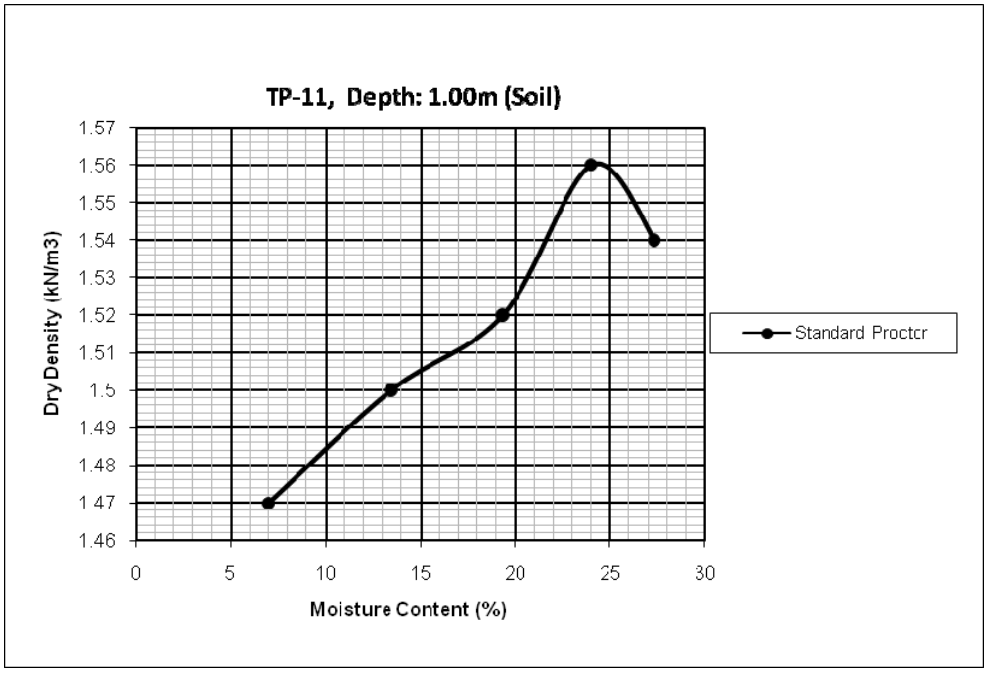
OMC(%)	MDD (KN/m^3)
23.2	1.6

PROCTOR CURVE



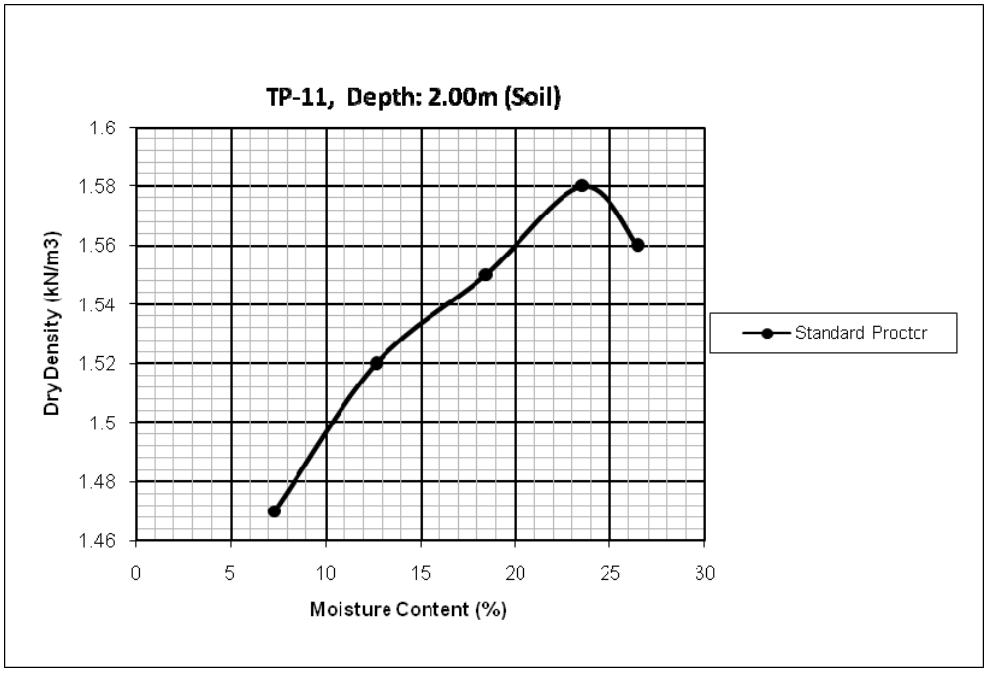
OMC(%)	MDD (KN/m^3)
17.36	1.67

PROCTOR CURVE



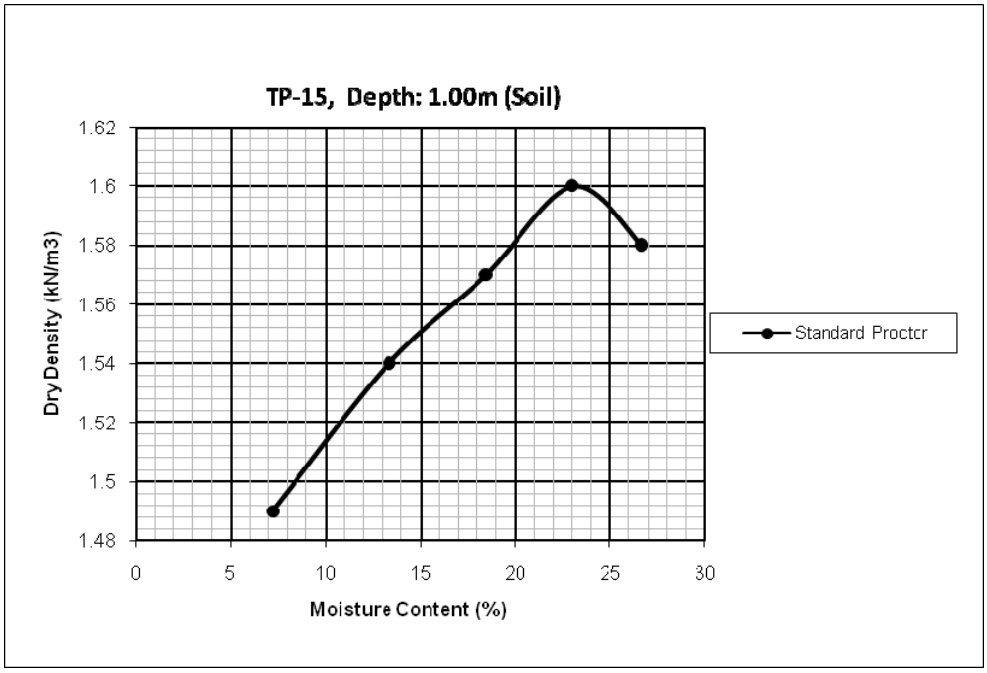
OMC(%)	MDD (KN/m^3)
24	1.56

PROCTOR CURVE



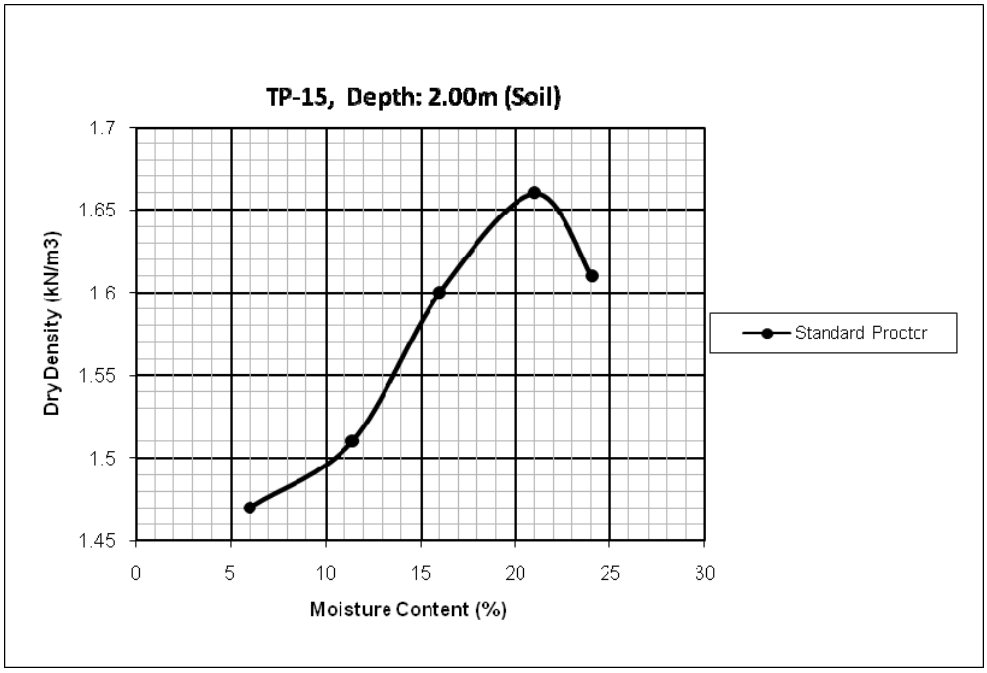
OMC(%)	MDD (KN/m^3)
23.5	1.58

PROCTOR CURVE



OMC(%)	MDD (KN/m^3)
23	1.6

PROCTOR CURVE



OMC(%)	MDD (KN/m^3)
21	1.66

BH No.	Depth (m)	Sample Number	Type	Description	NMC (%)	LL (%)	PL (%)	SL (%)	Grain Size Analysis (%)				Shear Test (kPa)				Density (KN/m³)		SC	SW. Pr.	FR. SW.	Stratum
									Gravel	Sand	Silt	Clay	UC	UU	CU	ϕ°	Bulk	Dry				
01	1.00 - 1.45	177121	U	Stiff to very stiff brownish grey sandy silty clay.	14	58	20							45		1	18.90	16.60	CH			I
01	3.00 - 3.45	177125	U		23	43	17	13	2	6	70	22	63				19.20	15.60	CI			I
01	6.00 - 6.45	177128	U		19	30	16							83		9	19.70	16.60	CL			I
01	9.00 - 9.45	177131	P	Medium dense brownish yellow silty sand.		NP	NP			80	20								SM			II
02	1.00 - 1.45	160122	P	Stiff to very stiff brownish grey sandy silty clay.	24	51	20						38				19.00	15.30	CH			I
02	4.50 - 4.95	160128	U		21	36	17			5	76	19			4	32	19.40	16.00	CI			I
02	7.50 - 7.95	160131	P			NP	NP															I
02	9.00 - 9.45	160132	P	Medium dense brownish yellow silty sand.		NP	NP												SM			II
02	12.00 - 12.45	160134	P							78	22											II
03	1.00 - 1.45	100869	U	Stiff to very stiff brownish grey sandy silty clay.	13	63	17	15		11	53	36		40		0	18.60	16.50	CH	NIL	40	I
03	3.00 - 3.45	100873	U		15	66	18	16		10	54	36	36				18.80	16.30	CH			I
03	6.00 - 6.45	100877	U		20	55	18	14		12	56	32	40				18.80	15.70	CH	NIL	30	I
03	8.00 - 8.45	100879	U		19	58	17			14	52	34			CD=3	25	19.20	16.10	CH			I
03	11.00 - 11.45	100881	P			64	20			5	61	34							CH			I

NMC : Natural Moisture Content. LL : Liquid Limit. PL : Plastic Limit. UC : Unconfined Compression Test. UU : Unconsolidated Undrained Tri-axial Shear Test. CU : Consolidated Undrained Tri-axial Shear Test. Sp. Gr. : Specific Gravity. Sw. Pr. : Swelling Pressure. Fr.Sw. : Free Swell. O : Disturbed sample. P : Disturbed sample. U : Undisturbed sample. NP : Non-Plastic.

CD : Consolidation Drained, SC : Soil Classification

LABORATORY TEST RESULTS

Job No.: 30796

SKM Geosurvey

BH No.	Depth (m)	Sample Number	Type	Description	NMC (%)	LL (%)	PL (%)	SL (%)	Grain Size Analysis (%)				Shear Test (kPa)				Density (KN/m³)		SC	SW. Pr.	FR. SW.	Stratum
									Gravel	Sand	Silt	Clay	UC	UU	CU	ϕ°	Bulk	Dry				
03	12.50 - 12.95	100882	P	Very dense brownish yellow silty sand with mica flakes.		NP	NP		3	77	20								SM			III
03	14.50 - 14.75	100884	P	Completely weathered decomposed product of rock.		NP	NP															IVA
04	1.50 - 1.95	100902	U	Stiff to very stiff brownish grey sandy silty clay.	18	48	16	12		1	75	24		47		0	18.90	16.00	CI	NIL	20	I
04	3.50 - 3.95	100906	P			NP	NP			49	47	4							SM			I
04	5.00 - 5.45	100908	P	Medium dense brownish yellow silty sand.		NP	NP			81	19								SM			II
05	1.50 - 1.95	100453	P	Stiff to very stiff brownish grey sandy silty clay.		59	20	13		1	65	34							CH			I
05	3.50 - 3.95	100457	P			61	21			5	61	34							CH			I
05	4.50 - 4.95	100459	P	Medium dense brownish yellow silty sand.		32	17			37	48	15							CL			II
06	1.00 - 1.45	105112	U	Stiff to very stiff brownish grey sandy silty clay.	16	44	15	12	5	5	68	22			46	11	19.10	16.50	CI	NIL	30	I
06	3.00 - 3.45	105116	P			30	16			34	53	13							CL			I
06	4.00 - 4.45	105118	P			NP	NP			78	22								SM			II
07	1.00 - 1.45	105102	P	Stiff to very stiff brownish grey sandy silty clay.		58	19		1	27	37	35							CH			I
07	2.00 - 2.45	105104	U		20	40	17	12	1	31	46	22	52				19.00	15.80	CI	NIL	20	I
07	5.00 - 5.45	105108	P			29	18			55	32	13							CL			I

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LABORATORY TEST RESULTS

Job No.: 30796

SKM Geosurvey

BH No.	Depth (m)	Sample Number	Type	Description	NMC (%)	LL (%)	PL (%)	SL (%)	Grain Size Analysis (%)				Shear Test (kPa)				Density (KN/m³)		SC	SW. Pr.	FR. SW.	Stratum
									Gravel	Sand	Silt	Clay	UC	UU	CU	ϕ°	Bulk	Dry				
08	1.00 - 1.45	100968	U	Stiff to very stiff brownish grey sandy silty clay.	14	58	19	15		32	34	34			5	27	18.90	16.60	CH			I
08	3.00 - 3.45	100972	U		17	46	15	12		35	43	22			7	32	19.40	16.60	CI			I
08	7.50 - 7.95	100976	P	Very dense brownish yellow silty sand with mica flakes.		NP	NP			67	30	3							SM			III
08	10.50 - 10.95	100978	P			NP	NP															III
09	2.00 - 2.45	100878	U	Stiff to very stiff brownish grey sandy silty clay.	25	62	21	16	3	14	48	35		52		0	18.90	15.10	CH	NIL	40	I
09	4.50 - 4.95	100882	U		20	40	17								42	12	19.60	16.30	CI			I
09	7.50 - 7.95	100884	P	Medium dense brownish yellow silty sand.		NP	NP			77	23											II
09	13.00 - 13.45	100889	P	Very dense brownish yellow silty sand with mica flakes.		NP	NP			77	23								SM			III
10	1.00 - 1.45	100472	P	Stiff to very stiff brownish grey sandy silty clay.		30	17		8	61	17	14							CL			I
10	3.00 - 3.45	100476	U		24	44	18	12		12	67	21	91				19.50	15.70	CI	NIL	20	I
11	1.00 - 1.45	100852	U	Stiff to very stiff brownish grey sandy silty clay.	15	42	14	11		9	73	18			51	10	19.00	16.50	CI			I
11	3.00 - 3.45	100856	U		24	NP	NP							80		9	19.30	15.60				II
11	5.00 - 5.45	100860	P			NP	NP			74	25	1							SM			II
11	8.50 - 8.95	100862	P	Very dense brownish yellow silty sand with mica flakes.		NP	NP			77	23								SM			III

NMC : Natural Moisture Content. LL : Liquid Limit. PL : Plastic Limit. UC : Unconfined Compression Test. UU : Unconsolidated Undrained Tri-axial Shear Test. CU : Consolidated Undrained Tri-axial Shear Test. Sp. Gr. : Specific Gravity. Sw. Pr. : Swelling Pressure. Fr.Sw. : Free Swell. O : Disturbed sample. P : Disturbed sample. U : Undisturbed sample. NP : Non-Plastic.

CD : Consolidation Drained, SC : Soil Classification

LABORATORY TEST RESULTS

Job No.: 30796

SKM Geosurvey

BH No.	Depth (m)	Sample Number	Type	Description	NMC (%)	LL (%)	PL (%)	SL (%)	Grain Size Analysis (%)				Shear Test (kPa)				Density (KN/m³)		SC	SW. Pr.	FR. SW.	Stratum
									Gravel	Sand	Silt	Clay	UC	UU	CU	ϕ°	Bulk	Dry				
12	1.00 - 1.45	100978	U	Stiff to very stiff brownish grey sandy silty clay.	18	64	19	15							7	26	19.00	16.10	CH			I
12	3.00 - 3.45	100982	U		23	39	17	16	10	44	28	17	79				19.60	15.90	CI			I
12	5.00 - 5.25	100985	P	Very dense brownish yellow silty sand with mica flakes.		NP	NP			67	30	3							SM			III
13	2.00 - 2.45	100485	P	Stiff to very stiff brownish grey sandy silty clay.	50	19			9	30	32	29							CI			I
13	4.00 - 4.45	100489	P	Medium dense brownish yellow silty sand.		44	18			2	78	20							CI			III
14	2.00 - 2.45	100554	U	Stiff to very stiff brownish grey sandy silty clay.	14	46	17	13	1	13	64	22	74				18.90	16.60	CI	NIL	30	I
14	3.00 - 3.45	100556	P	Medium dense brownish yellow silty sand.		48	17			12	63	25							CI			III
15	1.00 - 1.45	100465	P	Medium dense brownish yellow silty sand.		50	19			2	73	25							CI			II
15	2.00 - 2.45	100467	P			47	18												CI			II
16	2.00 - 2.45	100954	U	Stiff to very stiff brownish grey sandy silty clay.	20	63	18	16		33	32	35		50		1	18.90	15.80	CH	NIL	40	I
16	5.00 - 5.45	100958	P	Medium dense brownish yellow silty sand.		33	16			59	26	15							CL			II
16	7.00 - 7.45	100962	P	Very dense brownish yellow silty sand with mica flakes.		NP	NP			66	31	3							SM			III
16	10.00 - 10.45	100964	P			NP	NP															III

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CD : Consolidation Drained, SC : Soil Classification

LABORATORY TEST RESULTS

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SKM Geosurvey

BH No.	Depth (m)	Sample Number	Type	Description	NMC (%)	LL (%)	PL (%)	SL (%)	Grain Size Analysis (%)				Shear Test (kPa)				Density (KN/m³)		SC	SW. Pr.	FR. SW.	Stratum
									Gravel	Sand	Silt	Clay	UC	UU	CU	ϕ°	Bulk	Dry				
17	1.00 - 1.45	100515	P	Stiff to very stiff brownish grey sandy silty clay.		60	20	15		1	65	34							CH			I
17	2.00 - 2.45	100517	U		24	56	20							47		1	18.70	15.10	CH	NIL	30	I
17	4.00 - 4.45	100521	U		21	43	17			2	78	20	102				19.30	16.00	CI			I
17	7.50 - 7.95	100524	U		18	NP	NP			78	22				2	33	19.70	16.70	SM			III
17	10.50 - 10.95	100527	P	Very dense brownish yellow silty sand with mica flakes.		NP	NP			79	21								SM			III
18	1.00 - 1.45	100531	U	Stiff to very stiff brownish grey sandy silty clay.	15	60	20	15		21	46	33	48				18.90	16.40	CH			I
18	3.00 - 3.45	100535	U		23	36	18								CD= 3	23	19.10	15.50	CI	NIL	20	I
18	5.50 - 5.95	100539	P			NP	NP			62	36	2							SM			III
18	9.00 - 9.27	100541	P	Highly weathered rock		NP	NP															IVB
19	2.00 - 2.45	100503	U	Stiff to very stiff brownish grey sandy silty clay.	23	50	19	13	1	9	61	29	53				19.00	15.40	CI-CH			I
19	4.00 - 4.45	100507	U		20	NP	NP			76	24			113		9	19.50	16.30	SM			III
19	7.50 - 7.95	100511	P	Very dense brownish yellow silty sand with mica flakes.		NP	NP			78	22								SM			III
20	2.00 - 2.45	120103	U	Stiff to very stiff brownish grey sandy silty clay.	23	43	17	12		2	78	20					19.20	15.60	CI	NIL	20	I
20	4.50 - 4.95	120106	U		19	29	16			5	80	15	108				19.60	16.50	CL			I

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BH No.	Depth (m)	Sample Number	Type	Description	NMC (%)	LL (%)	PL (%)	SL (%)	Grain Size Analysis (%)				Shear Test (kPa)				Density (KN/m³)		SC	SW. Pr.	FR. SW.	Stratum
									Gravel	Sand	Silt	Clay	UC	UU	CU	ϕ°	Bulk	Dry				
21	1.00 - 1.45	120111	P	Stiff to very stiff brownish grey sandy silty clay.		58	20	11		11	55	34							CH			I
21	2.00 - 2.45	120113	U		22	40	17						52				19.00	15.60	CH			I
21	4.50 - 4.95	120117	U		19	29	16			6	79	15	93				19.70	16.60	CL	NIL	NIL	I
21	7.50 - 7.95	120119	P			NP	NP			77	23								SM			II
22	1.00 - 1.45	165101	U	Stiff to very stiff brownish grey sandy silty clay.	15	60	19			5	59	36	46				18.80	16.30	CH			I
22	3.00 - 3.45	165105	U		22	44	18							56		2	19.30	15.80	CI			I
22	7.50 - 7.95	165109	P			NP	NP			80	20								SM			II
23	1.00 - 1.45	100251	U	Stiff to very stiff brownish grey sandy silty clay.	16	57	19	15	1	6	60	33		66		1	19.00	16.40	CH	NIL	40	I
23	3.00 - 3.45	100254	U		24	39	17								54	9	19.2	15.5	CI			I
23	5.00 - 5.45	100257	P			NP	NP															I
23	6.00 - 6.45	100258	P							78	22								SM			I
23	7.50 - 7.95	100259	P			NP	NP															III
23	8.50 - 8.75	100260	P	Highly weathered rock						78	22								SM			IVB
24	1.00 - 1.45	100102	U	Stiff to very stiff brownish grey sandy silty clay.	14	45	18	13	2	13	61	24			CD= 4	33	18.80	16.50	CI			I
24	3.00 - 3.45	100106	U		24	30	17							104		7	19.10	15.40	CL	NIL	10	I

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BH No.	Depth (m)	Sample Number	Type	Description	NMC (%)	LL (%)	PL (%)	SL (%)	Grain Size Analysis (%)				Shear Test (kPa)				Density (KN/m³)		SC	SW. Pr.	FR. SW.	Stratum
									Gravel	Sand	Silt	Clay	UC	UU	CU	ϕ°	Bulk	Dry				
24	5.00 - 5.00	100109	D	Stiff to very stiff brownish grey sandy silty clay.		30	16			51	35	14							CL			I
25	1.00 - 1.45	170020	U	Stiff to very stiff brownish grey sandy silty clay.	15	59	20	14	1	6	60	33		39		1	18.60	16.20	CH			I
25	3.00 - 3.45	170024	U		24	50	18						56				19.20	15.50	CI			I
25	6.00 - 6.45	170027	U		20	31	17			44	41	15			54	9	19.60	16.30	CL			I
26	1.00 - 1.45	182156	U	Stiff to very stiff brownish grey sandy silty clay.	16	58	20			4	63	33	49				18.90	16.30	CH			I
26	3.00 - 3.45	182160	U		23	47	18							62		2	19.10	15.50	CI			I
27	4.50 - 4.95	170667	U	Stiff to very stiff brownish grey sandy silty clay.	19	36	17			23	59	18			2	32	19.5	16.4	CI	NIL	10	I
28	1.00 - 1.45	160771	U	Stiff to very stiff brownish grey sandy silty clay.	16	51	19			26	44	30	51				19.90	16.30	CH			I
28	3.00 - 3.45	160775	U		24	37	17	14							47	10	19.30	15.60	CL			I
28	6.00 - 6.45	160778	P	Very dense brownish yellow silty sand with mica flakes.		NP	NP			59	38	3							SM			II
29	2.00 - 2.45	130154	U	Stiff to very stiff brownish grey sandy silty clay.	20	50	19		2	25	44	29		58		0	19.10	15.70	CI			I
29	4.50 - 4.95	130158	U		20	32	17	15					107				19.50	16.30	CL			I
29	7.50 - 7.95	130160	P			NP	NP			60	37	3							SM			II
30	1.00 - 1.45	180111	U	Stiff to very stiff brownish grey sandy silty clay.	15	55	19	13		14	55	31		50		1	19.00	16.50	CH			I
30	3.00 - 3.45	180115	U		24	38	17						73				19.30	15.60	CI	NIL	20	I

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LABORATORY TEST RESULTS

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TRIAL PIT LAB TEST RESULTS

BH-No.	Depth	Sample Number	Type	NMC	L.L. %	P.L. %	Grain Size Analysis %				Shear Test (kPa_		Density (KN/m3)	
							Gravel %	Sand %	Silt %	Clay %	UU	Φ	Bulk	Dry
TP1	2.00	162192	U	22	50	19		6	68	26	45	1	19.20	15.70
TP1	4.00	162194	U	19	35	16		5	78	17	72	5	20.00	16.80
TP-2	2.00	100676	U	21	52	18		7	67	26	37	1	19.30	16.00
TP-2	4.00	100678	U	20	42	17		4	77	19	64	2	20.00	16.70
TP-3	2.00	106101	U	22	64	20		4	60	36	33	1	19.10	15.70
TP-3	4.00	106103	U	18	61	19		3	62	35	36	0	19.30	16.40
TP-4	2.00	106105	U	20	38	17		1	81	18	58	4	20.30	16.90
TP-5	1.00	151251	U	13	53	19		6	64	30	50	1	19.20	15.60
TP-5	3.00	151253	U	19	44	17		9	69	22	74	3	20.00	16.80
TP-6	1.00	171620	U	23	54	20		6	64	30	47	1	19.40	15.80
TP-6	3.00	171622	U	20	43	18		7	73	20	84	2	20.50	17.10
TP-7	2.00	100711	U	20	44	17	1	4	74	21	63	3	20.60	17.20
TP-8	2.00	105130	U	21	54	19	1	18	50	31	59	1	20.00	16.50
TP-8	3.00	105131	U	20	46	17		25	54	21	72	2	20.60	17.20
TP-9	1.00	120150	U	23	48	18		3	76	21	50	1	19.60	15.90
TP-9	3.00	120152	U	19	34	16		19	66	15	75	8	20.80	17.50
TP-10	3.00	105135	U	18	44	16		10	70	20	93	4	21.60	18.30
TP-11	1.00	150122	U	24	58	20		11	55	34	44	1	19.30	15.60
TP-11	3.00	150124	U	21	34	16		7	78	15	88	9	19.60	16.20
TP-12	1.00	106112	U	19	60	18	1	10	55	34	44	0	20.30	17.10
TP-12	3.00	106114	U	19	55	17		6	62	32	59	3	21.20	17.90
TP-14	2.00	105126	U	21	46	17		18	61	21	54	2	20.60	17.00
TP-15	1.00	106108	U	23	64	20	2	34	31	33	45	0	19.60	15.90
TP-15	3.00	106110	U	20	43	18	2	10	67	21	79	2	20.30	16.90

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LABORATORY TEST RESULTS ON ROCK SAMPLES

BH NO.	DEPTH (m)	Stratum	NMC (%)	BULK DENSITY (KN/m3)	Porosity (%)	Absorption (%)	Rock Strength (MPa)					Specific Gravity	Soundness(%)	Slake Durability Index	Impact Value(%)
							Point Load Index (Mpa)		Unconfined Compressive Strength		Modulus of Elasticity (E)				
							Soaked	Un Soaked	Soaked	Un Soaked					
04	6.75-7.50	IVB		22.60				2.26					63		
04	9.75-10.50	IVB	1.65	22.80	D	D		3.52				2.68			
05	7.25-8.00	IVB	10.03	21.80	D	D		1.17						Very poor	
05	8.00-8.75	IVB		22.80				1.13				2.69	56		
05	9.50-10.25	IVB		23.70				2.26							
05	11.00-11.50	IVB	6.16	23.10	15.91	7.38				4.39	287.90				49
06	7.75-8.50	IVC	0.69	22.50	9.52	4.40				15.48					
06	10.75-11.50	IVC		22.00						18.38		2.71	46		
07	7.75-8.50	IVC		22.60						20.09					
07	11.50-12.00	IVC		22.00	9.67	4.42				11.61				Poor	
08	14.25-15.00	IVB		23.30				2.64					53		
08	15.75-16.50	IVB		21.10				1.49						very poor	
08	16.50-17.00	IVB	1.66	21.90	D	D		1.70				2.68			
09	16.75-17.50	IVB		21.90	D	D		2.26							
09	19.00-19.50	IVB		22.30				3.39				2.70	51		
10	5.50-6.25	IVB	9.38	21.00	D	D		1.17							54
10	7.00-7.75	IVB		23.50				2.26				2.69		Very poor	
10	9.25-10.00	IVB		22.10				3.39							
10	10.00-10.50	IVB		23.70						7.74					
11	16.00-16.50	IVB		22.10	D	D		2.34					61		
12	9.50-10.25	IVB	3.31	21.90	D	D				6.02					
12	11.00-11.75	IVB	22.00					2.64				2.67			
12	12.50-13.00	IVB	1.51	21.10	D	D		1.43						Very poor	
13	5.60-6.35	IVB		22.50				1.13							
13	7.85-8.60	IVB	6.97	21.70	D	D		1.13				2.68	65		
13	8.60-9.35	IVB		22.40				2.26							56
13	10.10-10.60	IVB		23.10						3.67	272.60		39		
14	5.32-6.07	IVB	7.41	20.70	D	D		2.34							
14	7.57-8.32	IVB		22.10				2.26				2.68			
14	9.07-9.82	IVB		22.20				6.79						Poor to very poor	

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LABORATORY TEST RESULTS ON ROCK SAMPLES

BH NO.	DEPTH (m)	Stratum	NMC (%)	BULK DENSITY (KN/m3)	Porosity (%)	Absorption (%)	Rock Strength (MPa)				Modulus of Elasticity (E)	Specific Gravity	Soundness(%)	Slake Durability Index	Impact Value(%)
							Point Load Index (Mpa)		Unconfined Compressive Strength						
							Soaked	Un Soaked	Soaked	Un Soaked					
15	3.95-4.70	IVB	10.39	20.60	D	D		1.22							
15	7.70-8.20	IVB		22.40						4.83			41		
16	13.50-14.25	IVB	2.56	21.60	D	D		2.74							
16	15.00-15.75	IVB		21.70						3.52	247.80				
16	16.50-17.00	IVB		20.80						6.77		2.68		Poor to very poor	
17	14.25-15.00	IVB		23.40	13.26	5.88		4.52							
17	15.75-16.50	IVB		21.40						5.02					
17	16.50-17.00	IVB	2.05	22.50	D	D				3.44	248.20	2.68	46		
18	9.75-11.50	IVB	1.95	22.10	D	D		2.34						Very poor	
18	12.25-13.00	IVB		21.50						6.02					
18	13.75-14.50	IVB	7.75	21.80	D	D				4.30	274.00	2.69			42
19	10.75-11.50	IVB		23.20	11.76	5.19				9.67					
19	12.25-13.00	IVB		22.50				2.34				2.68			
19	13.75-14.50	IVB		21.80	D	D				5.80				Poor to Very poor	
20	8.00-8.75	IVB		22.90				3.39							
20	9.50-10.25	IVB		23.80	15.91	7.38				6.89	535.80			Poor	
20	12.50-13.00	IVB		21.90						7.74			38		
21	8.50-9.25	IVB		22.50				2.34							
21	10.00-10.75	IVB	4.40	23.50						8.70				Poor	
21	12.25-13.00	IVB		21.40						4.32	391.60				
21	13.00-13.50	IVB		21.90	D	D				6.02		2.70			
22	8.20-8.95	IVB		22.30	D	D		2.26							
22	10.45-11.20	IVB		23.10						7.74		2.70	48		
22	12.70-13.20	IVB		22.50						2.58	233.20				
23	9.25-10.00	IVB		22.30				2.26				2.69			58
23	10.00-10.75	IVB		23.20						5.17	376.50			Very poor	
23	11.50-12.25	IVB	1.50	22.30	D	D		3.39							
23	13.00-13.50	IVB		22.60						4.01		2.70			
24	7.75-8.50	IVB		21.90	D	D		2.26				2.68	57		
24	9.25-10.00	IVB		22.20						2.59	280.70				
24	11.50-12.00	IVB		22.40						4.83					

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LABORATORY TEST RESULTS ON ROCK SAMPLES

BH NO.	DEPTH (m)	Stratum	NMC (%)	BULK DENSITY (KN/m3)	Porosity (%)	Absorption (%)	Rock Strength (MPa)					Specific Gravity	Soundness(%)	Slake Durability Index	Impact Value(%)
							Point Load Index (Mpa)		Unconfined Compressive Strength		Modulus of Elasticity (E)				
							Soaked	Un Soaked	Soaked	Un Soaked					
26	7.80-8.55	IVB	9.20	21.70	D	D				5.80				Very poor to poor	
26	10.05-10.80	IVB		22.60				2.26							
27	9.25-10.00	IVB	0.95	22.30	D	D		1.13					66		
27	12.25-13.00	IVB		21.50						1.73	178.60				
28	9.50-10.25	IVB		22.70						6.77			53		
28	12.50-13.00	IVB	0.65	22.90	D	D		2.26				2.69		Very poor	
29	8.50-9.25	IVB	1.01	22.00	D	D		2.34							
29	11.50-12.25	IVB		22.70						2.58	209.00		56		
30	8.95-9.70	IVB		22.40						3.87				Very poor	
30	11.95-12.70	IVB	2.05	22.80	D	D				5.80		2.69			

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PERMEABILITY TEST RESULTS

Test No.	BH No.	Depth of Test (m)	Coefficient of Permeability,k (cm/sec)
1	01	1.00	1.00×10^{-8}
2	01	2.00	5.00×10^{-8}
3	02	3.00	4.00×10^{-8}
4	02	5.00	2.00×10^{-7}
5	11	1.00	1.00×10^{-6}
6	11	3.00	3.00×10^{-6}
7	04	2.50	2.00×10^{-8}
8	06	4.00	3.00×10^{-6}
9	07	3.00	2.00×10^{-7}
10	08	1.00	4.00×10^{-5}
11	09	3.00	4.00×10^{-6}
12	10	4.00	5.00×10^{-4}
13	12	6.50	1.00×10^{-4}
14	13	3.00	6.00×10^{-5}
15	14	2.00	4.00×10^{-6}
16	15	2.00	6.00×10^{-5}
17	16	4.00	2.00×10^{-3}
18	17	3.00	4.00×10^{-6}
19	18	4.00	3.00×10^{-5}
20	19	2.50	2.00×10^{-6}

CHEMICAL TEST RESULTS

Borehole Number	Sample Number	Depth (m)	Type of Sample	PH at °C	Value	Chloride		Sulphate	
						%	(ppm)	SO_3 (%)	SO_3 (ppm)
03	-	-	Water	30.4	6.5	ND	ND	ND	ND
05	100455	2.50-2.95	Soil	31.0	6.5	ND	ND	ND	ND
05	150901	0.10	Water	31.9	6.5	0.0010	9.894	0.0007	6.859
07	150902	2.40	Water	31.9	6.5	ND	ND	ND	ND
08	100970	2.00-2.45	Soil	31.0	6.5	ND	ND	ND	ND
08	150903	3.30	Water	31.9	6.5	0.0010	9.894	ND	ND
09	150904	2.85	Water	31.9	6.5	ND	ND	0.0007	6.859
13	100487	3.00-3.45	Soil	31.0	6.5	ND	ND	ND	ND
13	-	-	Water	30.4	6.5	ND	ND	ND	ND
17	150906	4.78	Water	31.9	6.5	0.0010	9.894	0.0007	6.859
20	150907	4.20	Water	31.6	6.5	ND	ND	ND	ND
21	-	-	Water	30.4	6.5	ND	ND	ND	ND
23	150909	3.50	Water	31.6	6.5	0.0010	9.894	ND	ND

ND: NOT DETECTED

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SKM Geosurvey

CHEMICAL TEST RESULTS

Borehole Number	Sample Number	Depth (m)	Type of Sample	ORGANIC MATTER MATTER		CARBONATE		NITRATE		TURBIDITY
				(%)	(ppm)	(%)	(ppm)	(%)	(ppm)	(NUT)
03	-	-	Water	0.016	160.0	ND	ND	0.00003	0.17795	26.8
05	150901	0.10	Water	0.018	180.0	ND	ND	0.00002	0.1853	26.6
07	150902	2.40	Water	0.017	170.0	ND	ND	0.00003	0.17795	26.5
08	150903	3.30	Water	0.016	160.0	ND	ND	0.00002	0.1853	25.9
09	150904	2.85	Water	0.016	160.0	ND	ND	0.00004	0.3706	26.1
13	-	-	Water	0.018	180.0	ND	ND	0.00002	0.1853	26.8
17	150906	4.78	Water	0.019	190.0	ND	ND	0.00003	0.17795	25.9
20	150907	4.20	Water	0.016	160.0	ND	ND	0.00003	0.17795	26.6
21	-	-	Water	0.018	180.0	ND	ND	0.00002	0.1853	26.1
23	150909	3.50	Water	0.017	170.0	ND	ND	0.00004	0.3706	25.5

ND: NOT DETECTED

JOB NO. 30796

SKM Geosurvey

m_v Value(m^2/KN x 10^{-4})

BH No.	Depth (m)	00-10	10-25	25-50	50-100	100-200	200-400	400-800	800-1600	Sp.Gr.
		Range (kPa)								
1	6.00	0.55	0.73	1.10	1.21	1.32	1.37	1.22		2.64
2	2.00	1.11	1.11	1.11	1.56	1.67	1.72	1.52		2.64
3	1.00	0.55	0.74	1.11	1.11	1.28	1.25	1.11		2.68
3	6.00	0.55	1.09	1.31	1.20	1.09	1.15	1.04		2.64
4	1.50	0.54	0.72	0.86	0.97	0.91	0.97	0.95		2.64
6	1.00	0.54	1.08	1.29	1.18	1.24	1.21	1.05		2.67
7	2.00	0.54	1.08	1.30	1.51	1.57	1.46	1.15		2.65
8	3.00	1.08	1.44	1.51	1.51	1.40	1.35	1.01		2.64
9	2.00	0.01	0.36	0.86	1.07	1.12	1.07	0.88		2.68
9	4.50	0.52	0.69	0.62	0.73	0.83	0.93	0.88		2.67
10	3.00	0.55	1.09	1.31	1.31	1.48	1.37	1.20		2.67
11	1.00	0.55	1.10	1.54	1.43	1.32	1.32	1.26		2.65
11	3.00	0.54	0.36	0.65	0.65	0.86	1.00	0.95		2.65
12	1.00	0.01	0.35	0.63	0.74	0.89	1.05	1.04		2.68
14	2.00	1.11	1.48	1.78	1.67	1.61	1.56	1.31		2.67
16	2.00	1.07	1.07	1.28	1.39	1.34	1.28	1.02		2.68
17	2.00	1.11	1.48	1.78	1.67	1.67	1.58	1.22		2.64
17	7.50	0.53	0.71	0.64	0.85	0.96	1.04	0.96		2.65
18	3.00	0.53	0.71	0.64	0.85	0.96	1.04	0.96		2.66
19	4.00	0.53	0.70	1.05	1.05	1.05	1.05	0.90		2.65
20	2.00	0.56	0.75	1.12	1.24	1.24	1.29	1.18		2.67
21	4.50	1.10	1.47	1.76	1.65	1.65	1.51	1.16		2.65

JOB NO. 30796

SKM Geosurvey

m_v Value(m^2/KN x 10^{-4})

BH No.	Depth (m)	00-10	10-25	25-50	50-100	100-200	200-400	400-800	800-1600	Sp.Gr.
		Range (kPa)								
22	1.00	0.53	1.06	1.28	1.17	1.28	1.22	1.04		2.68
23	1.00	0.54	0.72	0.86	0.97	1.08	1.29	1.08		2.68
24	3.00	0.54	0.72	1.09	1.20	1.14	1.17	1.06		2.66
25	6.00	0.54	0.72	0.87	0.87	1.03	1.05	1.04		2.65
26	3.00	0.54	1.09	1.30	1.20	1.36	1.41	1.13		2.64
27	2.00	0.54	0.72	0.86	0.97	1.08	1.13	0.98		2.64
28	3.00	0.52	1.04	1.46	1.35	1.35	1.41	1.03		2.67
29	2.00	0.56	1.11	1.11	1.33	1.45	1.39	1.14		2.64
30	1.00	0.54	0.71	1.07	1.18	1.23	1.20	1.02		2.68
TP-3	2.00	0.55	1.10	1.32	1.43	1.54	1.59	1.35		2.68
TP-6	1.00	0.54	0.72	1.08	1.08	1.03	1.11	1.05		2.64
TP-9	3.00	0.53	0.70	1.26	1.37	1.32	1.24	0.95		2.65
TP-12	3.00	0.53	0.70	0.63	0.74	0.84	0.90	0.79		2.67
TP-15	1.00	1.06	1.06	1.27	1.38	1.32	1.27	1.01		2.68

SKM Geosurvey

JOB NO. 30796

DEPTH: 6.00-6.45m

BOREHOLE NO. 01

Pressure Range kPa	Pressure Increment kPa	Increase in thickness cm.	Change in Void Ratio Δe	Equilibrium Void Ratio e	av (m^2/KN)	$mv \times 10^{-4}$ (m^2/KN)
0 - 10	10.000	-0.00100	-0.00088	0.59282	0.0000876	0.5497526
10 - 25	15.000	-0.00200	-0.00175	0.59107	0.0001168	0.7330035
25 - 50	25.000	-0.00500	-0.00438	0.58669	0.0001751	1.0995052
50 - 100	50.000	-0.01100	-0.00963	0.57706	0.0001926	1.2094557
100 - 200	100.000	-0.02400	-0.02102	0.55604	0.0002102	1.3194063
200 - 400	200.000	-0.05000	-0.04378	0.51226	0.0002189	1.3743815
400 - 800	400.000	-0.08900	-0.07793	0.43433	0.0001948	1.2231996
800-200	-600.000	0.01500	0.01313	0.44746	-0.0000219	-0.1374382
200-0	-200.000	0.06000	0.05254	0.50000		

DEPTH: 1.00-1.45m

BOREHOLE NO. 03

Pressure Range kPa	Pressure Increment kPa	Increase in thickness cm.	Change in Void Ratio Δe	Equilibrium Void Ratio e	av (m^2/KN)	mv×10^{-4} (m^2/KN)
0 - 10	10.000	-0.00100	-0.00090	0.61942	0.0000900	0.5558644
10 - 25	15.000	-0.00200	-0.00180	0.61762	0.0001200	0.7411525
25 - 50	25.000	-0.00500	-0.00450	0.61312	0.0001800	1.1117287
50 - 100	50.000	-0.01000	-0.00900	0.60412	0.0001800	1.1117287
100 - 200	100.000	-0.02300	-0.02070	0.58341	0.0002070	1.2784880
200 - 400	200.000	-0.04500	-0.04051	0.54291	0.0002025	1.2506948
400 - 800	400.000	-0.08000	-0.07201	0.47089	0.0001800	1.1117287
800-200	-600.000	0.01000	0.00900	0.47989	-0.0000150	-0.0926441
200-0	-200.000	0.03900	0.03511	0.51500		

DEPTH: 1.00-1.45m

BOREHOLE NO. 06

Pressure Range kPa	Pressure Increment kPa	Increase in thickness cm.	Change in Void Ratio Δe	Equilibrium Void Ratio e	av (m^2/KN)	$mv \times 10^{-4}$ (m^2/KN)
0 - 10	10.000	-0.00100	-0.00087	0.61906	0.0000871	0.5379236
10 - 25	15.000	-0.00300	-0.00261	0.61645	0.0001742	1.0758472
25 - 50	25.000	-0.00600	-0.00523	0.61122	0.0002090	1.2910167
50 - 100	50.000	-0.01100	-0.00958	0.60164	0.0001916	1.1834320
100 - 200	100.000	-0.02300	-0.02003	0.58161	0.0002003	1.2372243
200 - 400	200.000	-0.04500	-0.03919	0.54242	0.0001960	1.2103281
400 - 800	400.000	-0.07800	-0.06793	0.47449	0.0001698	1.0489510
800-200	-600.000	0.01200	0.01045	0.48494	-0.0000174	-0.1075847
200-0	-200.000	0.04600	0.04006	0.52500		

DEPTH: 3.00-3.45m

BOREHOLE NO. 10

Pressure Range kPa	Pressure Increment kPa	Increase in thickness cm.	Change in Void Ratio Δe	Equilibrium Void Ratio e	av (m^2/KN)	mv×10^{-4} (m^2/KN)
0 - 10	10.000	-0.00100	-0.00093	0.69767	0.0000928	0.5467469
10 - 25	15.000	-0.00300	-0.00278	0.69489	0.0001856	1.0934937
25 - 50	25.000	-0.00600	-0.00557	0.68932	0.0002228	1.3121925
50 - 100	50.000	-0.01200	-0.01114	0.67818	0.0002228	1.3121925
100 - 200	100.000	-0.02700	-0.02506	0.65312	0.0002506	1.4762165
200 - 400	200.000	-0.05000	-0.04641	0.60671	0.0002320	1.3668671
400 - 800	400.000	-0.08800	-0.08168	0.52503	0.0002042	1.2028431
800-200	-600.000	0.01400	0.01299	0.53802	-0.0000217	-0.1275743
200-0	-200.000	0.05600	0.05198	0.59000		

Job No.: 30796

DEPTH: 2.00-2.45m

BOREHOLE NO. 14

Pressure Range kPa	Pressure Increment kPa	Increase in thickness cm.	Change in Void Ratio Δe	Equilibrium Void Ratio e	av (m^2/KN)	mv×10^{-4} (m^2/KN)
0 - 10	10.000	-0.00200	-0.00179	0.60633	0.0001787	1.1123471
10 - 25	15.000	-0.00400	-0.00357	0.60276	0.0002382	1.4831294
25 - 50	25.000	-0.00800	-0.00715	0.59561	0.0002859	1.7797553
50 - 100	50.000	-0.01500	-0.01340	0.58221	0.0002680	1.6685206
100 - 200	100.000	-0.02900	-0.02591	0.55630	0.0002591	1.6129032
200 - 400	200.000	-0.05600	-0.05003	0.50627	0.0002502	1.5572859
400 - 800	400.000	-0.09400	-0.08398	0.42229	0.0002099	1.3070078
800-200	-600.000	0.01300	0.01161	0.43390	-0.0000194	-0.1205043
200-0	-200.000	0.04600	0.04110	0.47500		

Job No.: 30796

DEPTH: 2.00-2.45m

BOREHOLE NO. 17

Pressure Range kPa	Pressure Increment kPa	Increase in thickness cm.	Change in Void Ratio Δe	Equilibrium Void Ratio e	av (m^2/KN)	mv×10^{-4} (m^2/KN)
0 - 10	10.000	-0.00200	-0.00194	0.74836	0.0001945	1.1123471
10 - 25	15.000	-0.00400	-0.00389	0.74447	0.0002593	1.4831294
25 - 50	25.000	-0.00800	-0.00778	0.73669	0.0003112	1.7797553
50 - 100	50.000	-0.01500	-0.01459	0.72210	0.0002917	1.6685206
100 - 200	100.000	-0.03000	-0.02917	0.69293	0.0002917	1.6685206
200 - 400	200.000	-0.05700	-0.05543	0.63750	0.0002771	1.5850945
400 - 800	400.000	-0.08800	-0.08557	0.55193	0.0002139	1.2235818
800-200	-600.000	0.01500	0.01459	0.56652	-0.0000243	-0.1390434
200-0	-200.000	0.05500	0.05348	0.62000		

DEPTH: 2.00-2.45m

BOREHOLE NO. 20

Pressure Range kPa	Pressure Increment kPa	Increase in thickness cm.	Change in Void Ratio Δe	Equilibrium Void Ratio e	av (m^2/KN)	mv×10^{-4} (m^2/KN)
0 - 10	10.000	-0.00100	-0.00096	0.71037	0.0000961	0.5621135
10 - 25	15.000	-0.00200	-0.00192	0.70845	0.0001282	0.7494847
25 - 50	25.000	-0.00500	-0.00481	0.70364	0.0001923	1.1242271
50 - 100	50.000	-0.01100	-0.01058	0.69307	0.0002115	1.2366498
100 - 200	100.000	-0.02200	-0.02115	0.67192	0.0002115	1.2366498
200 - 400	200.000	-0.04600	-0.04423	0.62769	0.0002211	1.2928612
400 - 800	400.000	-0.08400	-0.08076	0.54693	0.0002019	1.1804384
800-200	-600.000	0.01600	0.01538	0.56231	-0.0000256	-0.1498969
200-0	-200.000	0.06000	0.05769	0.62000		

DEPTH: 3.00-3.45m

BOREHOLE NO. 24

Pressure Range kPa	Pressure Increment kPa	Increase in thickness cm.	Change in Void Ratio Δe	Equilibrium Void Ratio e	av (m^2/KN)	mv×10^{-4} (m^2/KN)
0 - 10	10.000	-0.00100	-0.00094	0.73095	0.0000941	0.5437738
10 - 25	15.000	-0.00200	-0.00188	0.72906	0.0001255	0.7250317
25 - 50	25.000	-0.00500	-0.00471	0.72436	0.0001882	1.0875476
50 - 100	50.000	-0.01100	-0.01035	0.71400	0.0002071	1.1963023
100 - 200	100.000	-0.02100	-0.01977	0.69424	0.0001977	1.1419250
200 - 400	200.000	-0.04300	-0.04047	0.65376	0.0002024	1.1691136
400 - 800	400.000	-0.07800	-0.07342	0.58035	0.0001835	1.0603589
800-200	-600.000	0.01600	0.01506	0.59541	-0.0000251	-0.1450063
200-0	-200.000	0.05800	0.05459	0.65000		

Job No.: 30796

DEPTH: 1.00-1.45m

BOREHOLE NO. 30

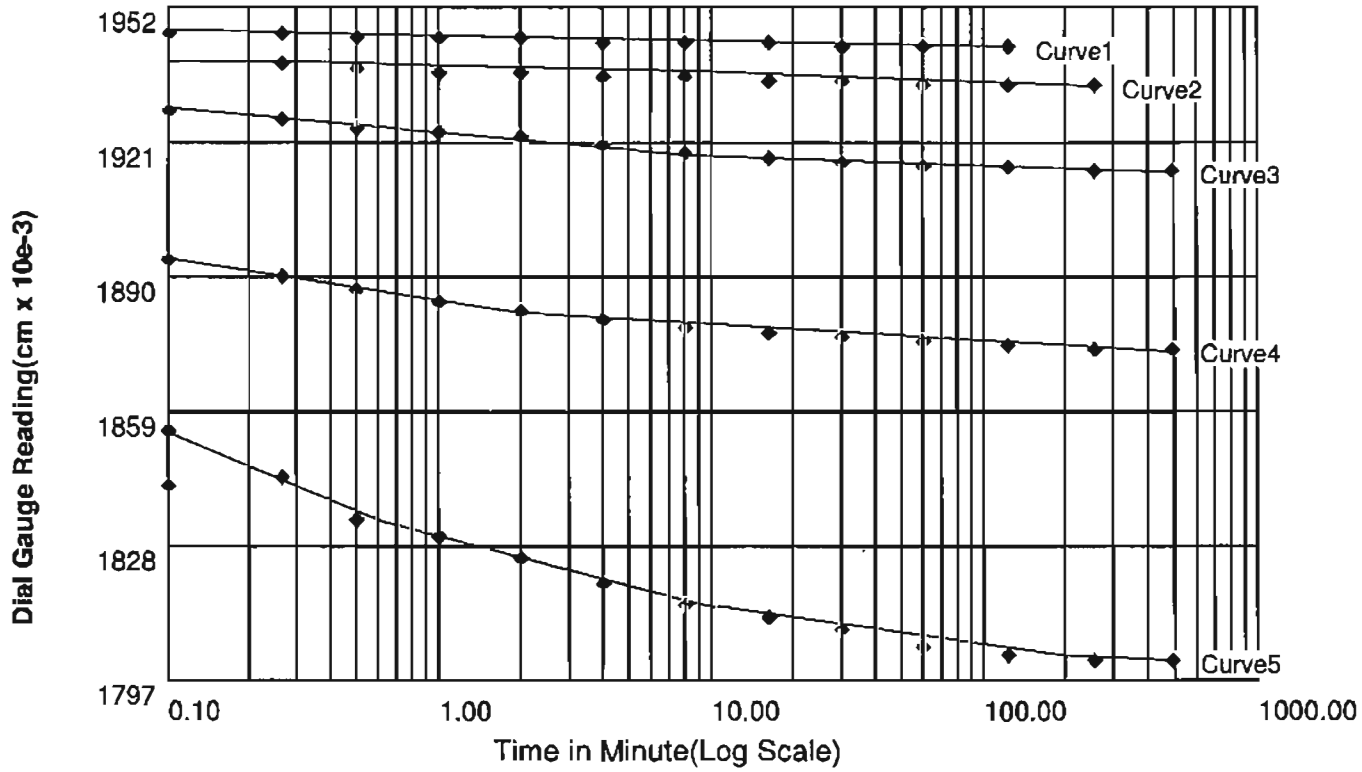
Pressure Range kPa	Pressure Increment kPa	Increase in thickness cm.	Change in Void Ratio Δe	Equilibrium Void Ratio e	av (m^2/KN)	$mv \times 10^{-4}$ (m^2/KN)
0 - 10	10.000	-0.00100	-0.00087	0.61781	0.0000866	0.5350455
10 - 25	15.000	-0.00200	-0.00173	0.61608	0.0001154	0.7133940
25 - 50	25.000	-0.00500	-0.00433	0.61175	0.0001731	1.0700910
50 - 100	50.000	-0.01100	-0.00952	0.60223	0.0001904	1.1771001
100 - 200	100.000	-0.02300	-0.01991	0.58232	0.0001991	1.2306046
200 - 400	200.000	-0.04500	-0.03895	0.54337	0.0001948	1.2038523
400 - 800	400.000	-0.07600	-0.06579	0.47759	0.0001645	1.0165864
800-200	-600.000	0.01100	0.00952	0.48711	-0.0000159	-0.0980917
200-0	-200.000	0.03800	0.03289	0.52000		

Job No.: 30796

SKM Geosurvey

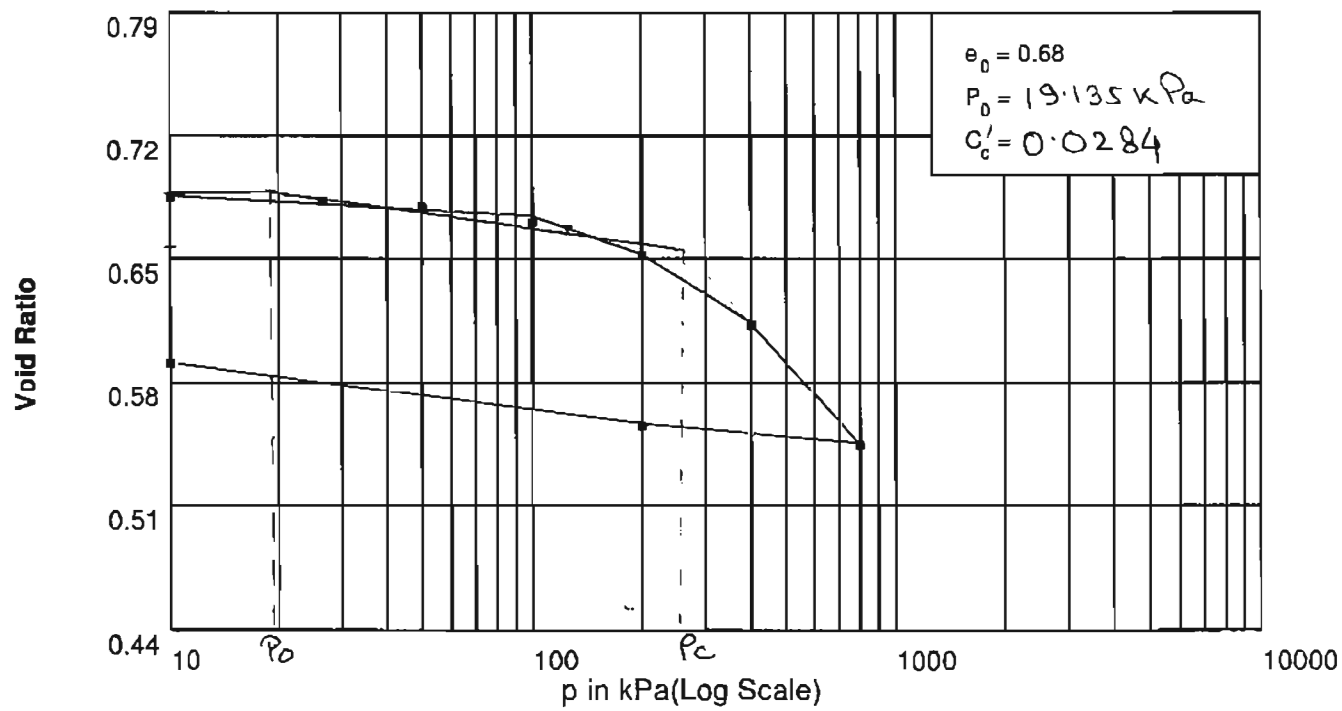
Borehole No :27 Depth(m) :2.00-2.45 Sample No. :170663

LOG TIME VS SETTLEMENT CURVE



◆ Curve1 :25 - 50 kPa ◆ Curve2 :50 - 100 kPa ◆ Curve3 :100 - 200 kPa
◆ Curve4 :200 - 400 kPa ◆ Curve5 :400 - 800 kPa

e Vs LOG(P)

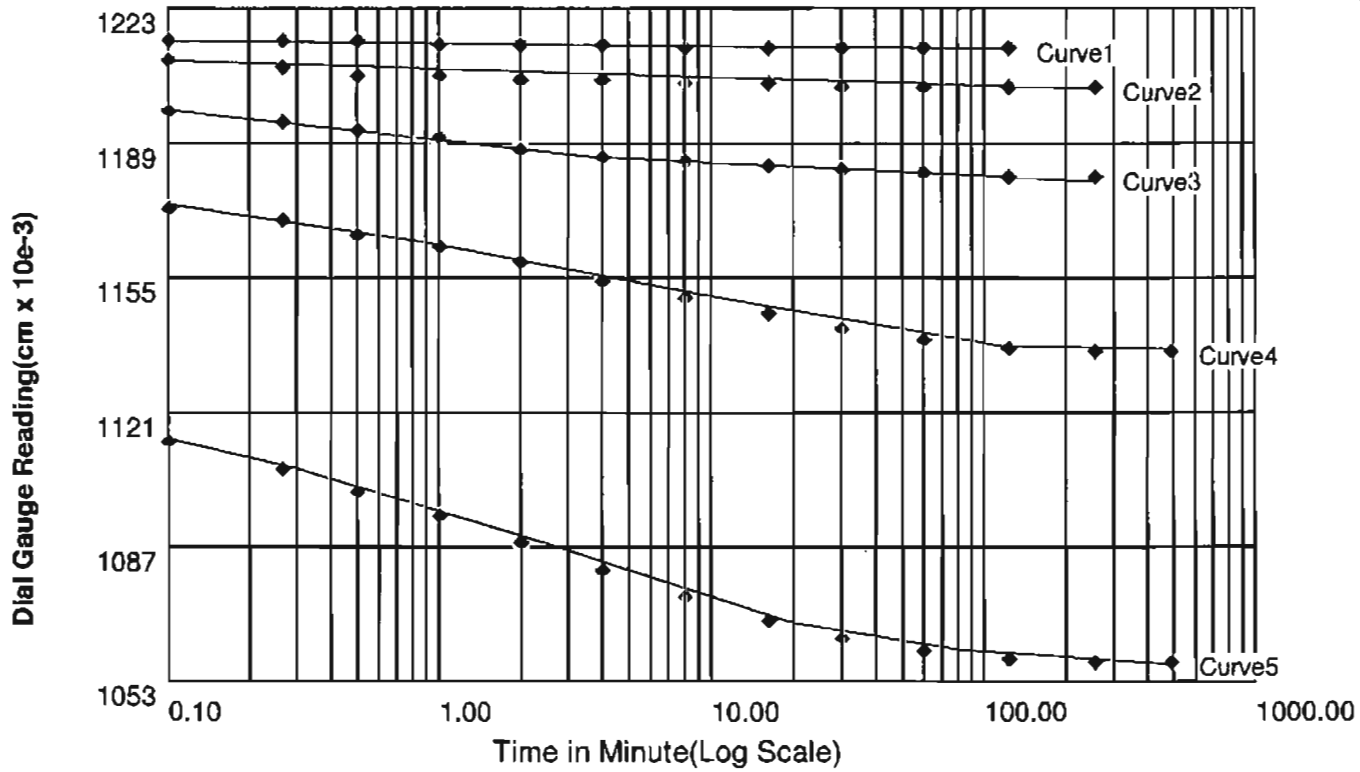


CONSOLIDATION TEST CURVES

Job No. :30796

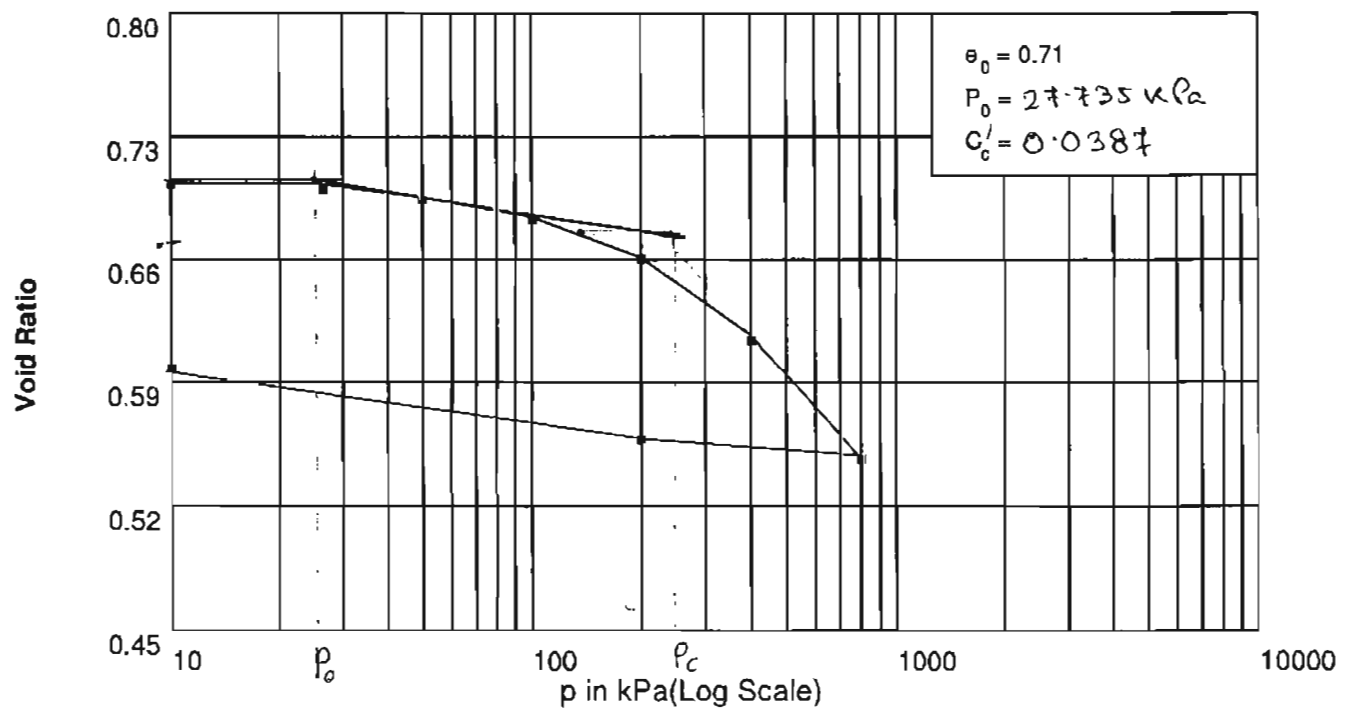
Borehole No :28 Depth(m) :3.00-3.45 Sample No. :160775

LOG TIME VS SETTLEMENT CURVE



◆ Curve1 :25 - 50 kPa ◆ Curve2 :50 - 100 kPa ◆ Curve3 :100 - 200 kPa
◆ Curve4 :200 - 400 kPa ◆ Curve5 :400 - 800 kPa

e Vs LOG(P)



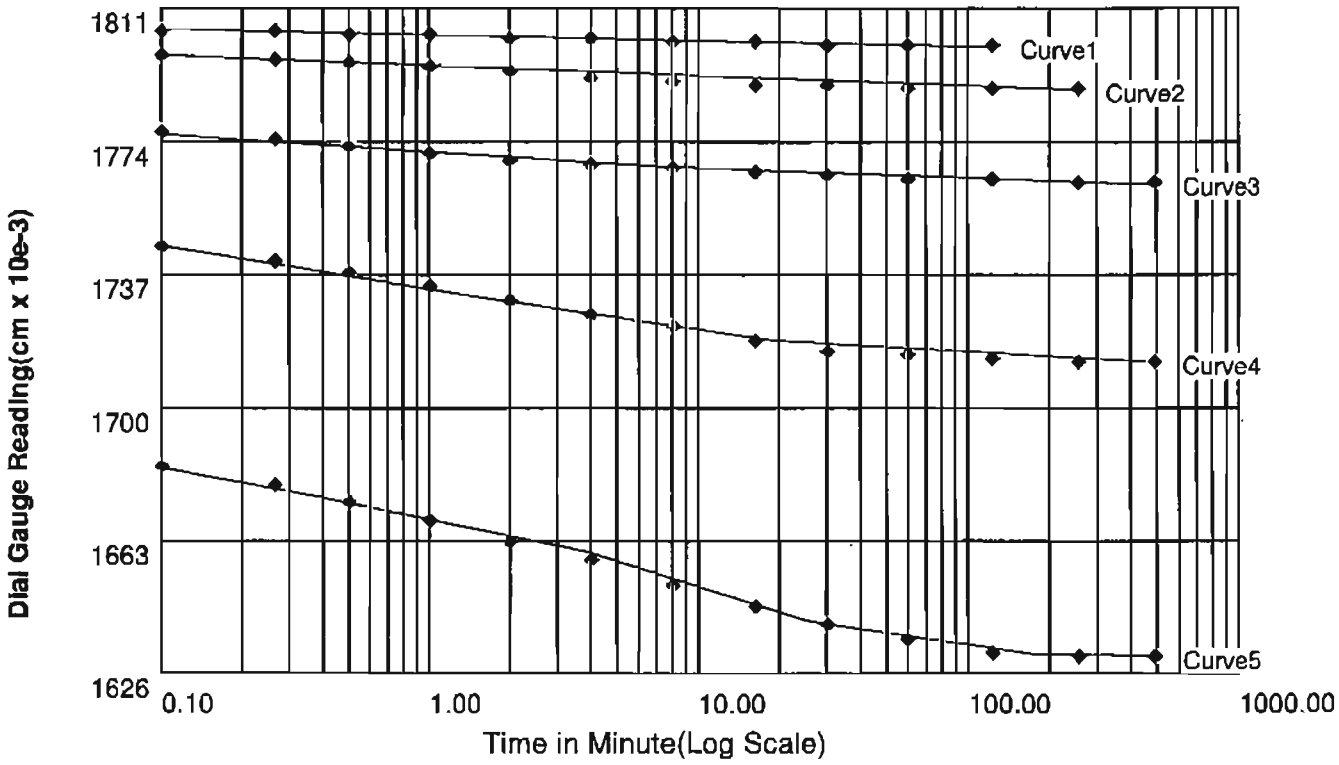
CONSOLIDATION TEST CURVES

Job No. :30796

SKM Geosurvey

Borehole No :29 Depth(m) :2.00-2.45 Sample No. :130154

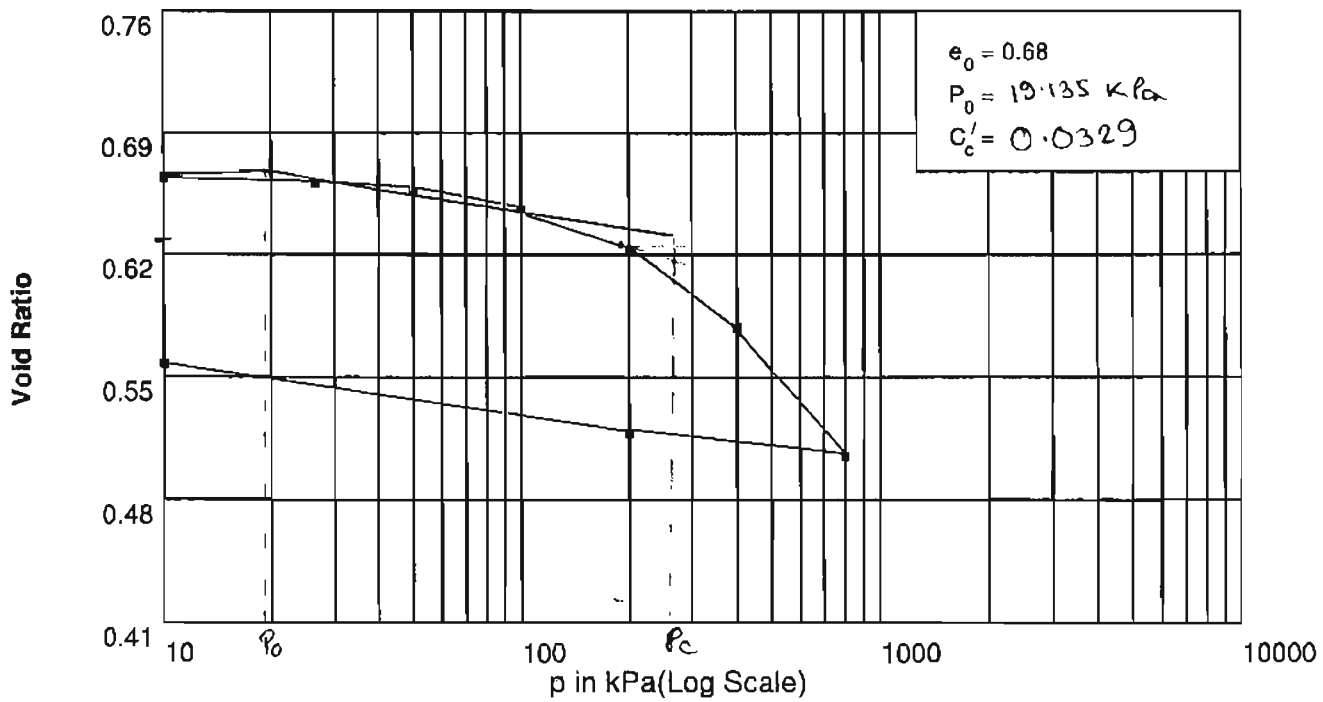
LOG TIME VS SETTLEMENT CURVE



◆ Curve1 :25 - 50 kPa ◆ Curve2 :50 - 100 kPa ◆ Curve3 :100 - 200 kPa

◆ Curve4 :200 - 400 kPa ◆ Curve5 :400 - 800 kPa

e Vs LOG(P)

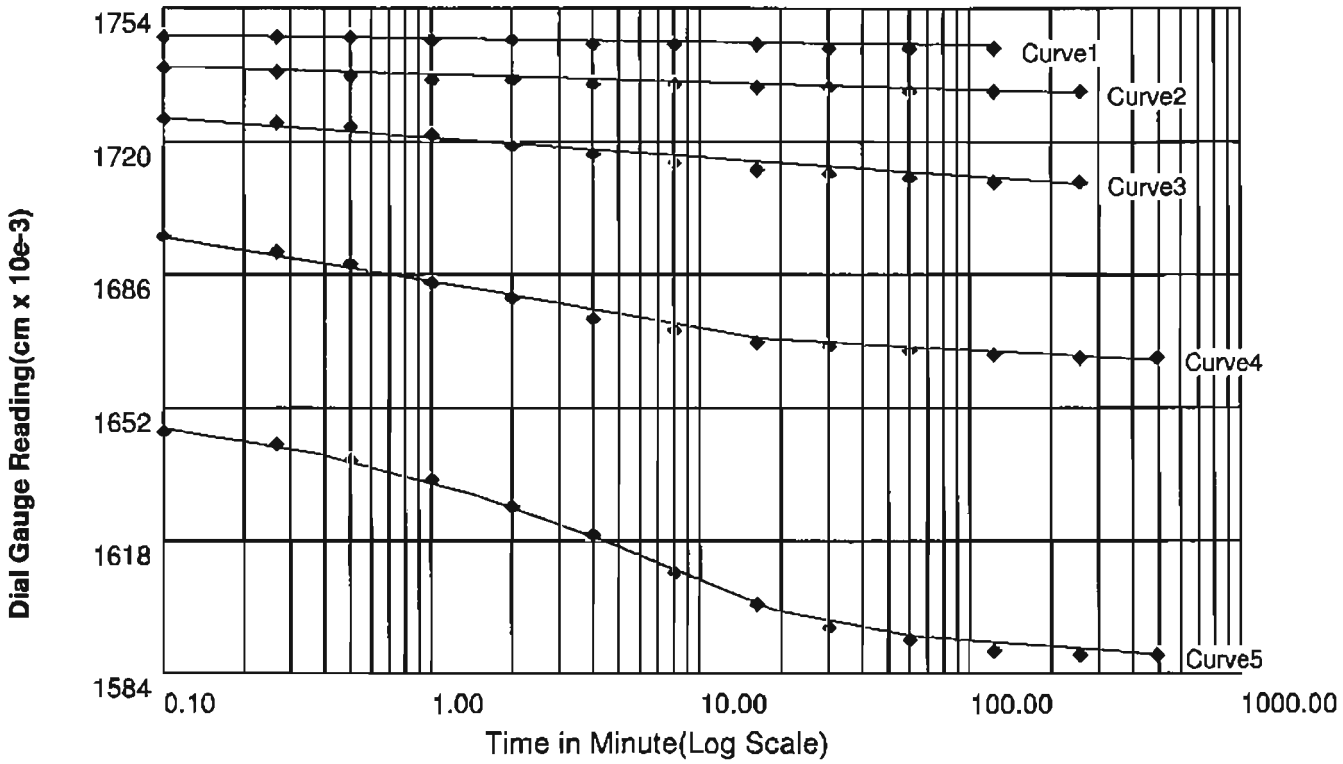


CONSOLIDATION TEST CURVES

Job No. :30796

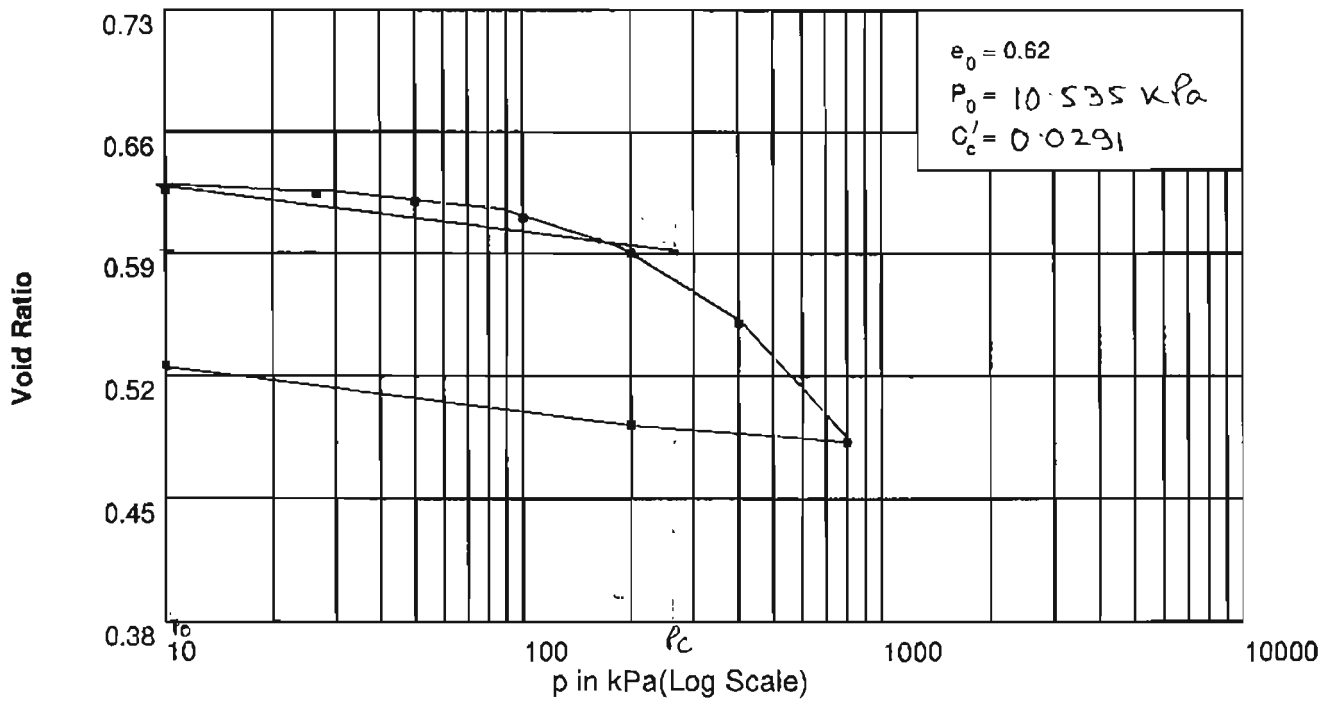
Borehole No :30 Depth(m) :1.00-1.45 Sample No. :180111

LOG TIME VS SETTLEMENT CURVE



◆ Curve1 :25 - 50 kPa ◆ Curve2 :50 - 100 kPa ◆ Curve3 :100 - 200 kPa
◆ Curve4 :200 - 400 kPa ◆ Curve5 :400 - 800 kPa

e Vs LOG(P)

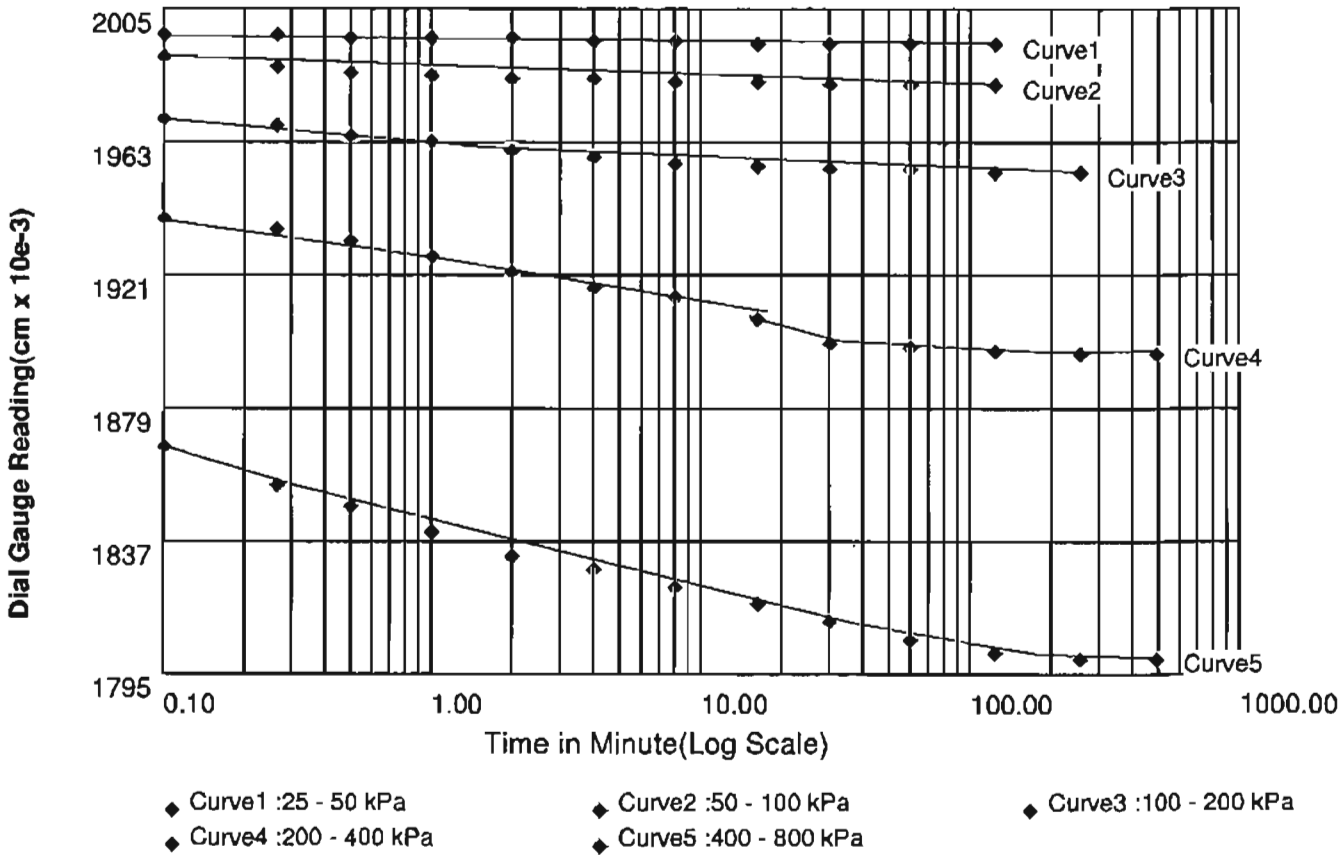


CONSOLIDATION TEST CURVES

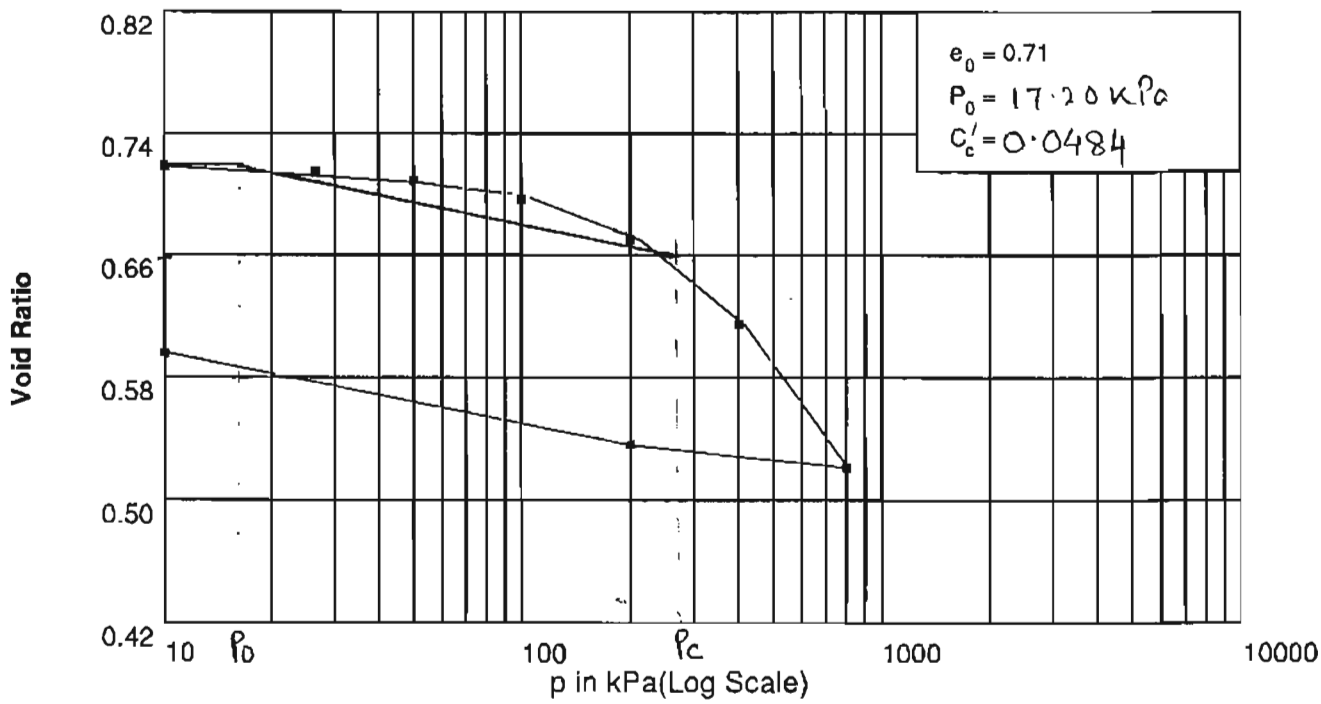
Job No. :30796

Borehole No :TP-3 Depth(m) :2.00 Sample No. :106101

LOG TIME VS SETTLEMENT CURVE



e Vs LOG(P)

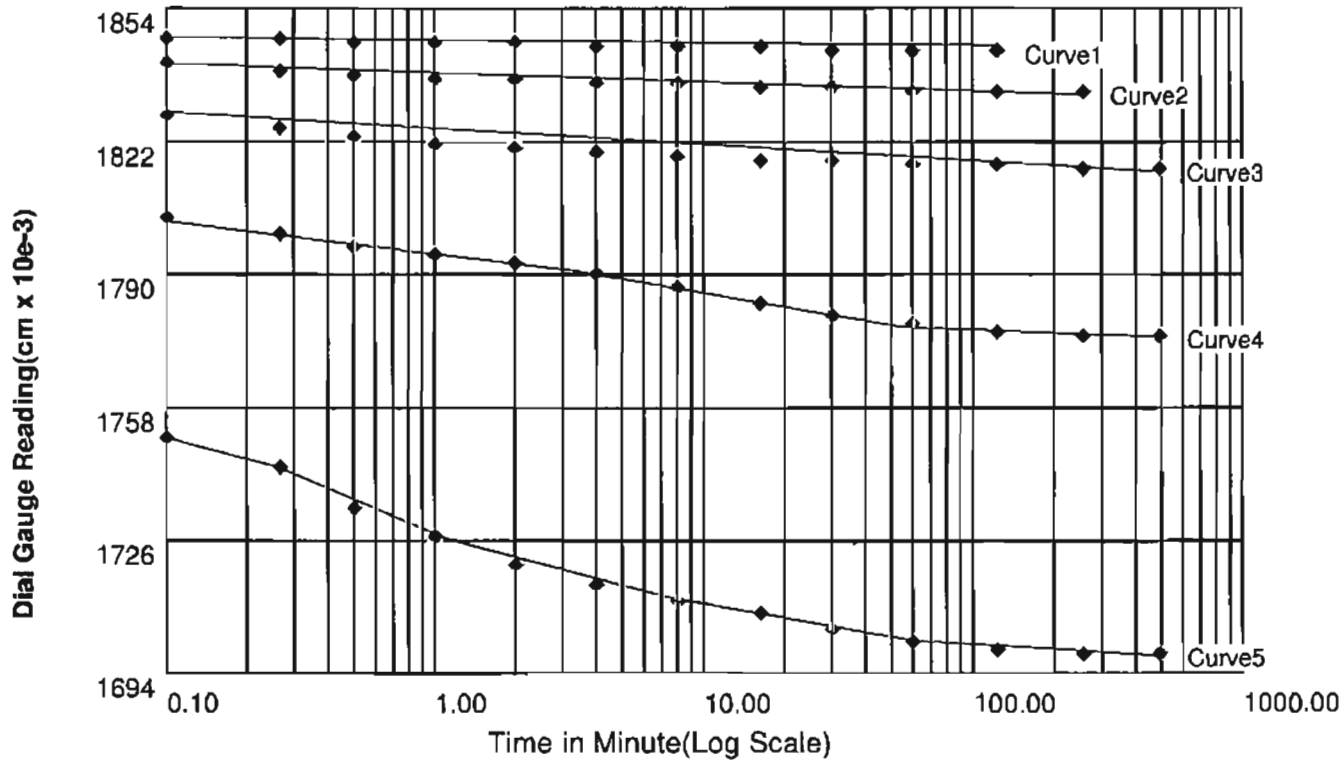


CONSOLIDATION TEST CURVES

Job No. :30796-

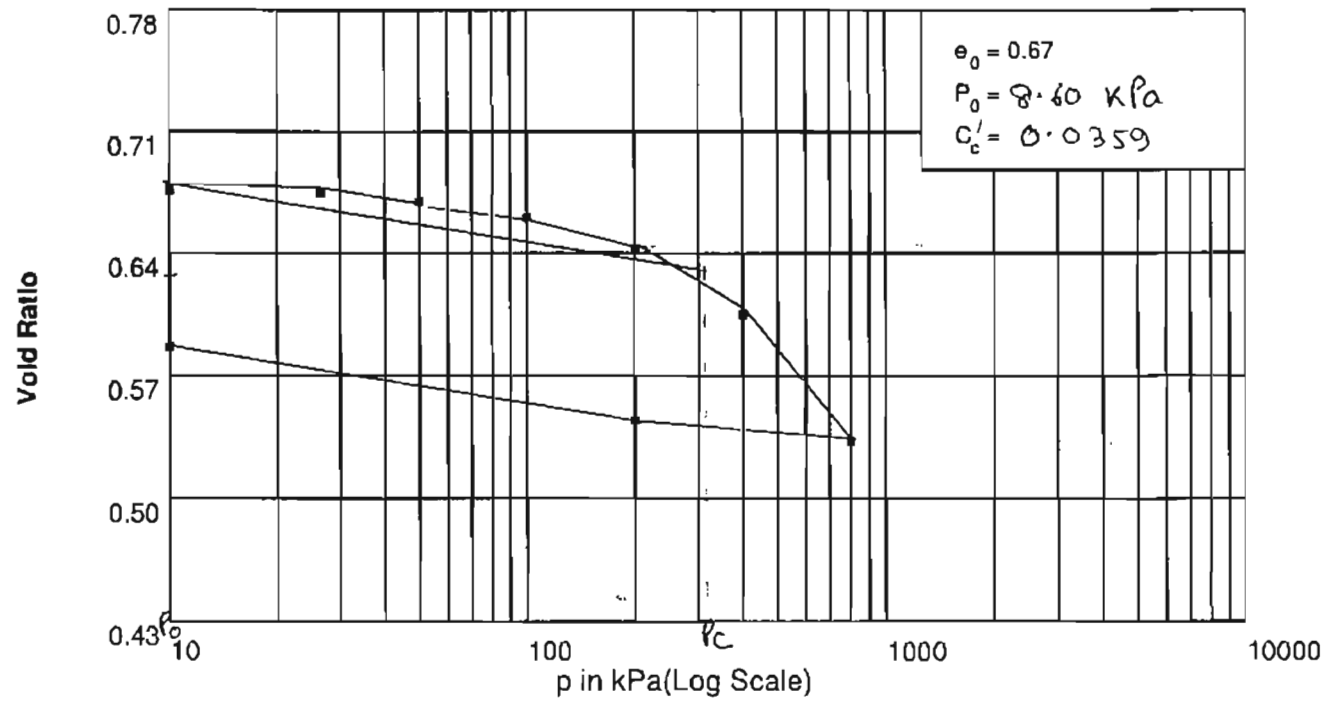
Borehole No :TP-6 Depth(m) :1.00 Sample No. :171620

LOG TIME VS SETTLEMENT CURVE



◆ Curve1 :25 - 50 kPa ◆ Curve2 :50 - 100 kPa ◆ Curve3 :100 - 200 kPa
◆ Curve4 :200 - 400 kPa ◆ Curve5 :400 - 800 kPa

e Vs LOG(P)



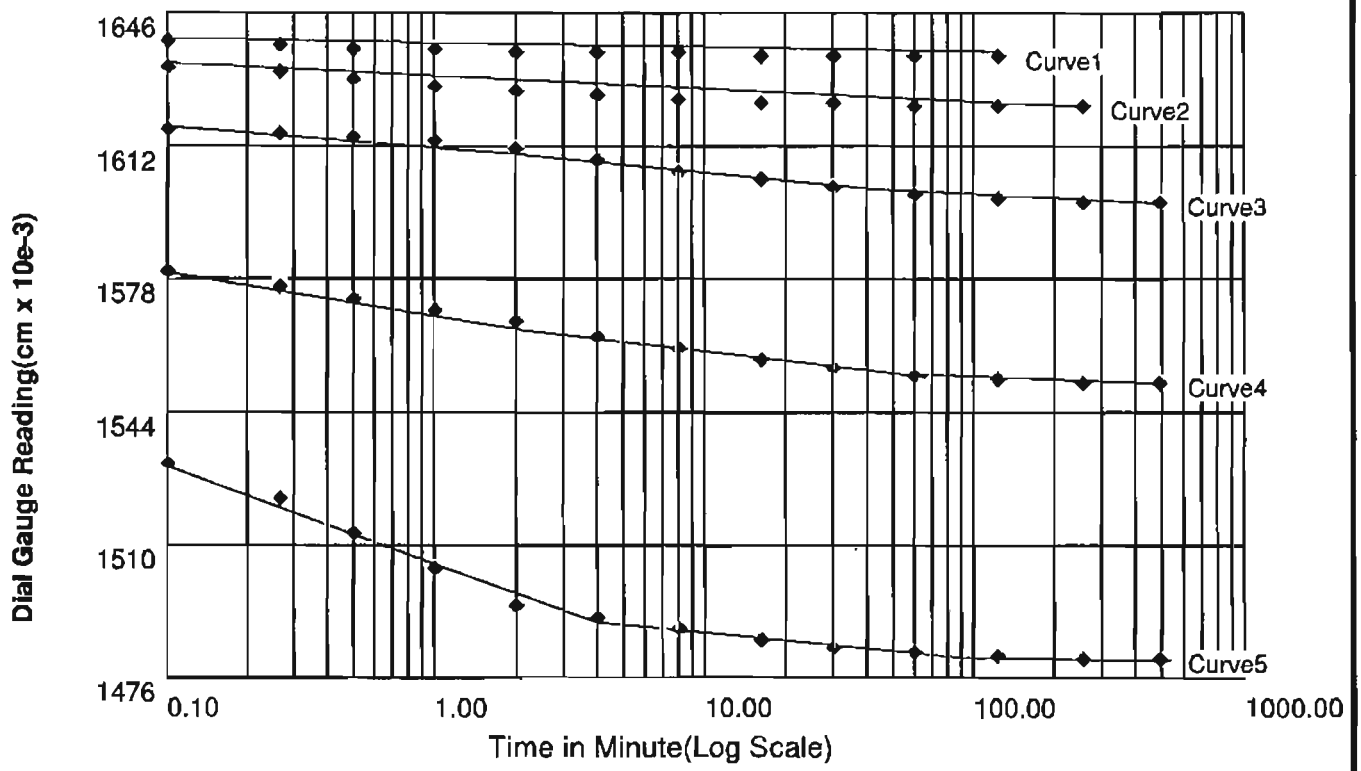
CONSOLIDATION TEST CURVES

Job No. :30796-

SKM Geosurvey

Borehole No :TP-9 Depth(m) :3.00 Sample No. :120152

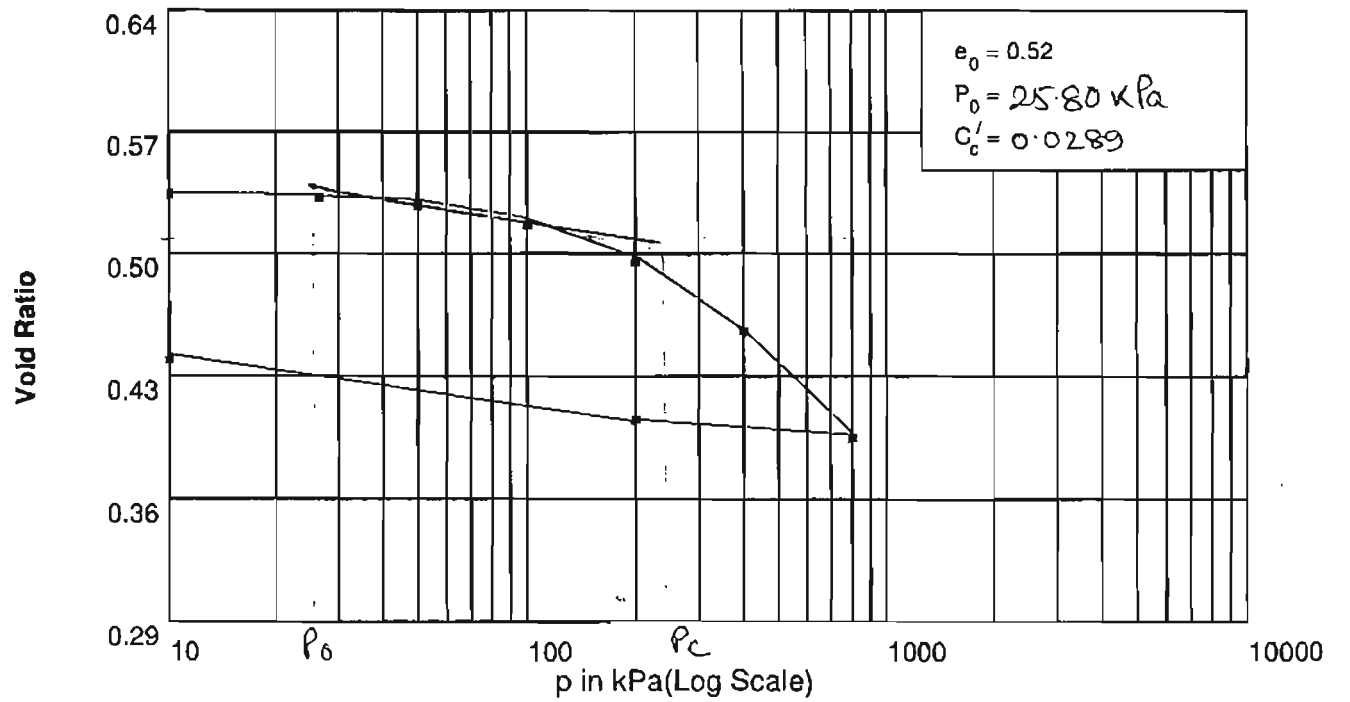
LOG TIME VS SETTLEMENT CURVE



◆ Curve1 :25 - 50 kPa ◆ Curve2 :50 - 100 kPa ◆ Curve3 :100 - 200 kPa

◆ Curve4 :200 - 400 kPa ◆ Curve5 :400 - 800 kPa

e Vs LOG(P)



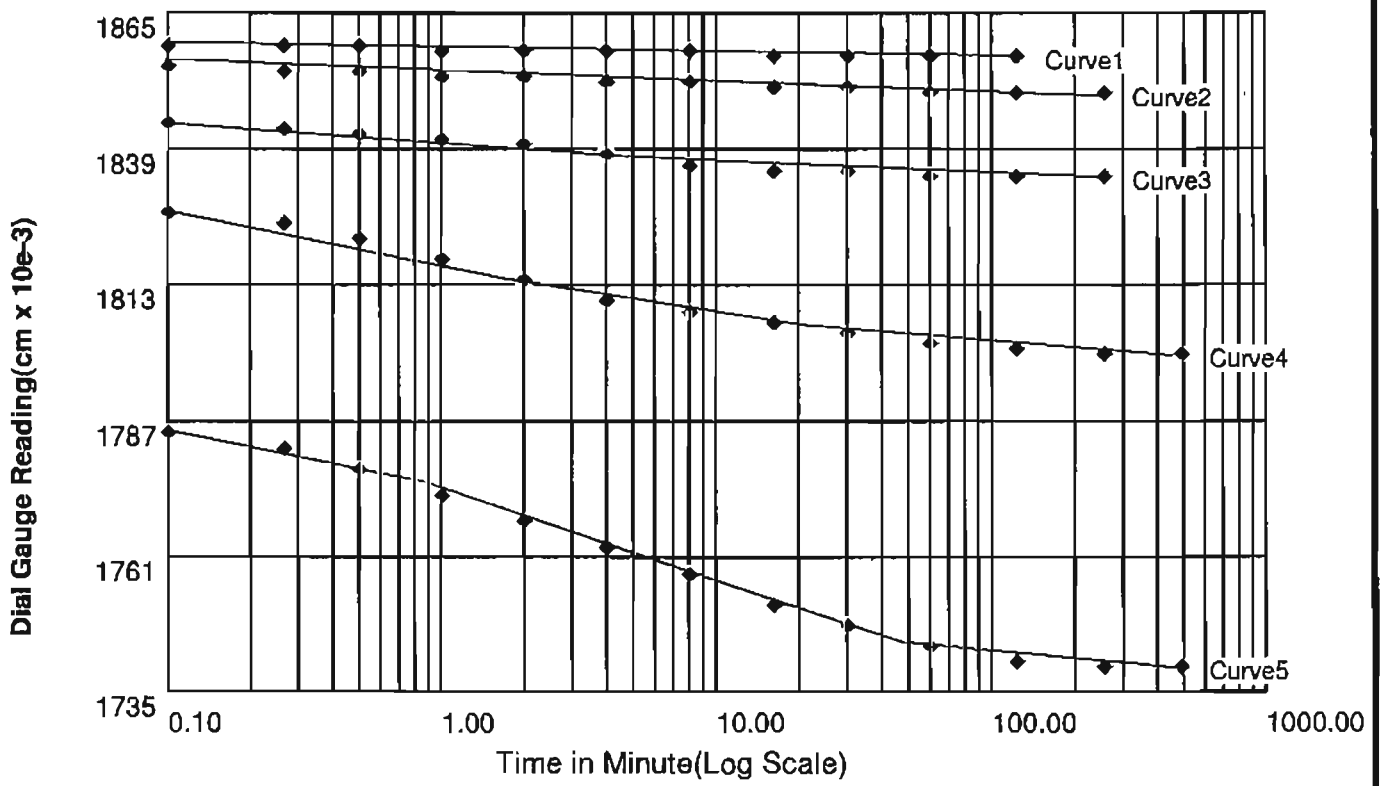
CONSOLIDATION TEST CURVES

Job No. :30796-

SKM Geosurvey

Borehole No :TP-12 Depth(m) :3.00 Sample No. :106114

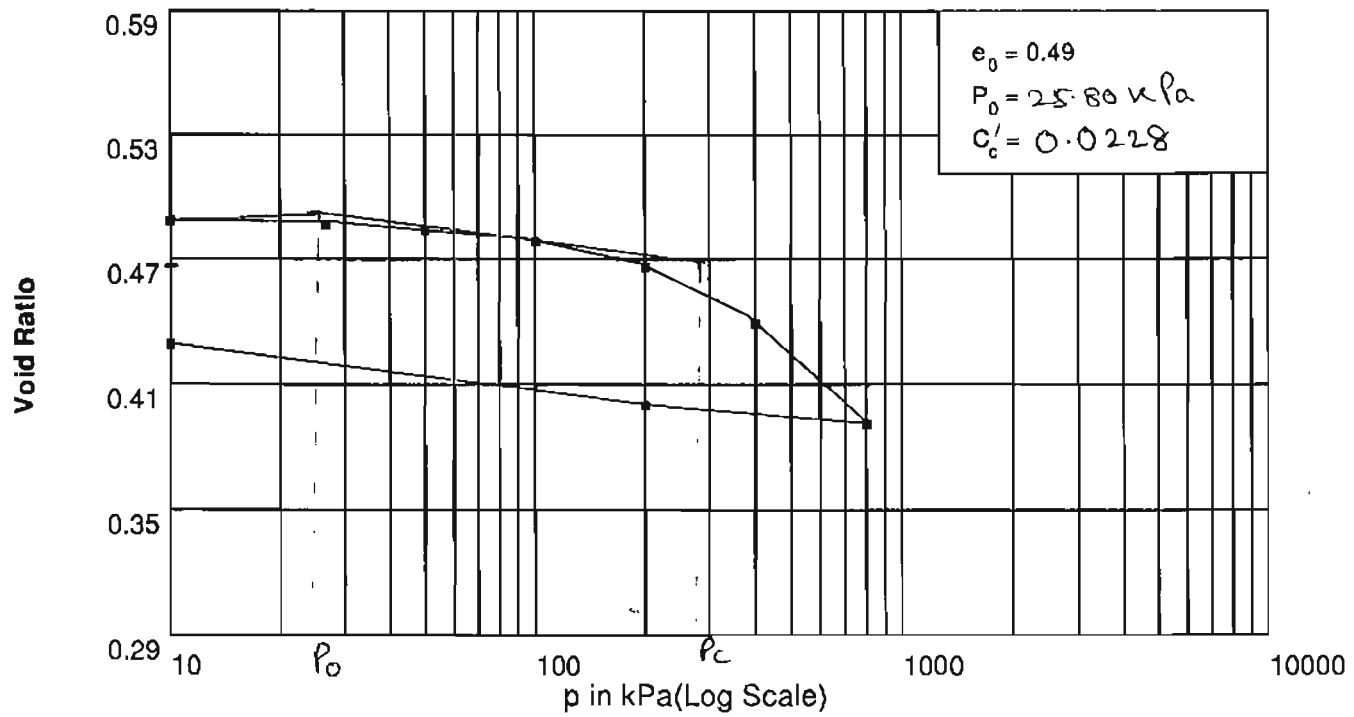
LOG TIME VS SETTLEMENT CURVE



◆ Curve1 :25 - 50 kPa ◆ Curve2 :50 - 100 kPa ◆ Curve3 :100 - 200 kPa

◆ Curve4 :200 - 400 kPa ◆ Curve5 :400 - 800 kPa

e Vs LOG(P)

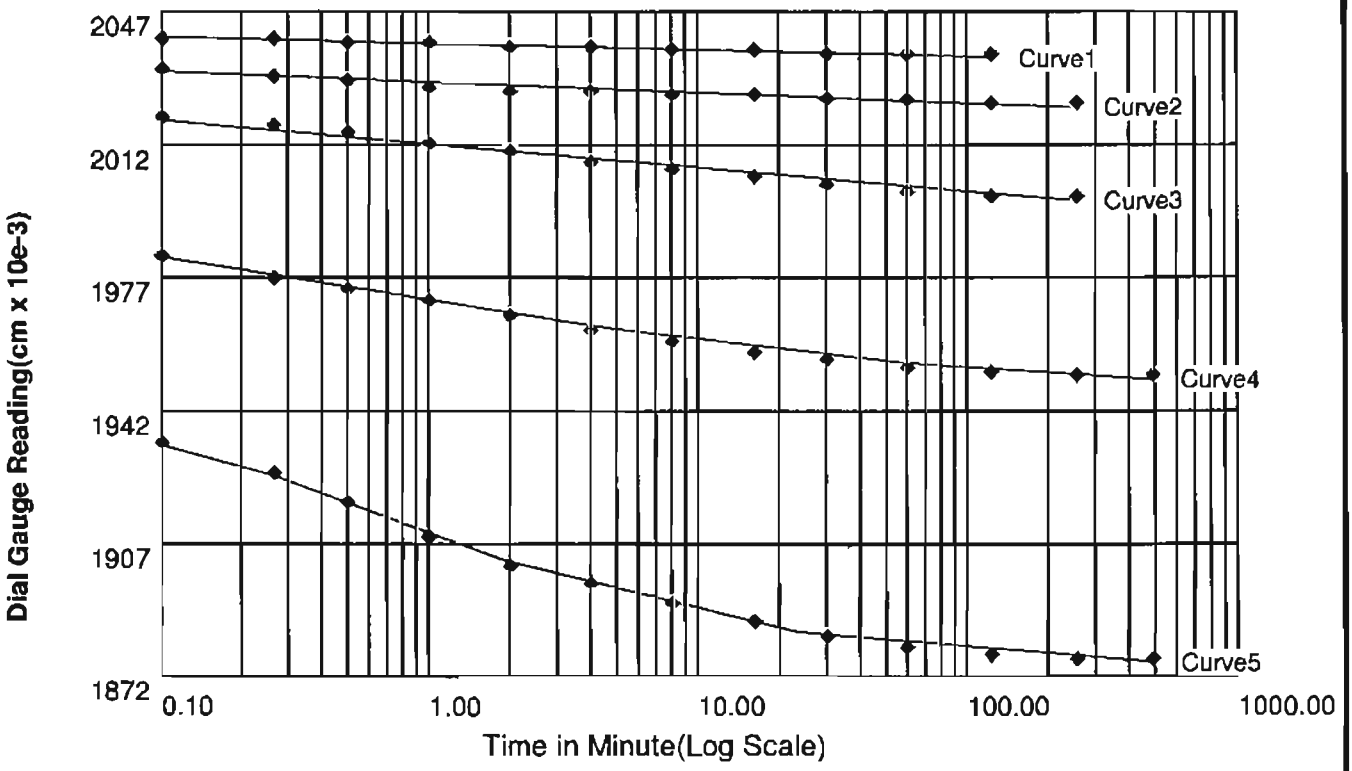


CONSOLIDATION TEST CURVES

Job No. :30796-

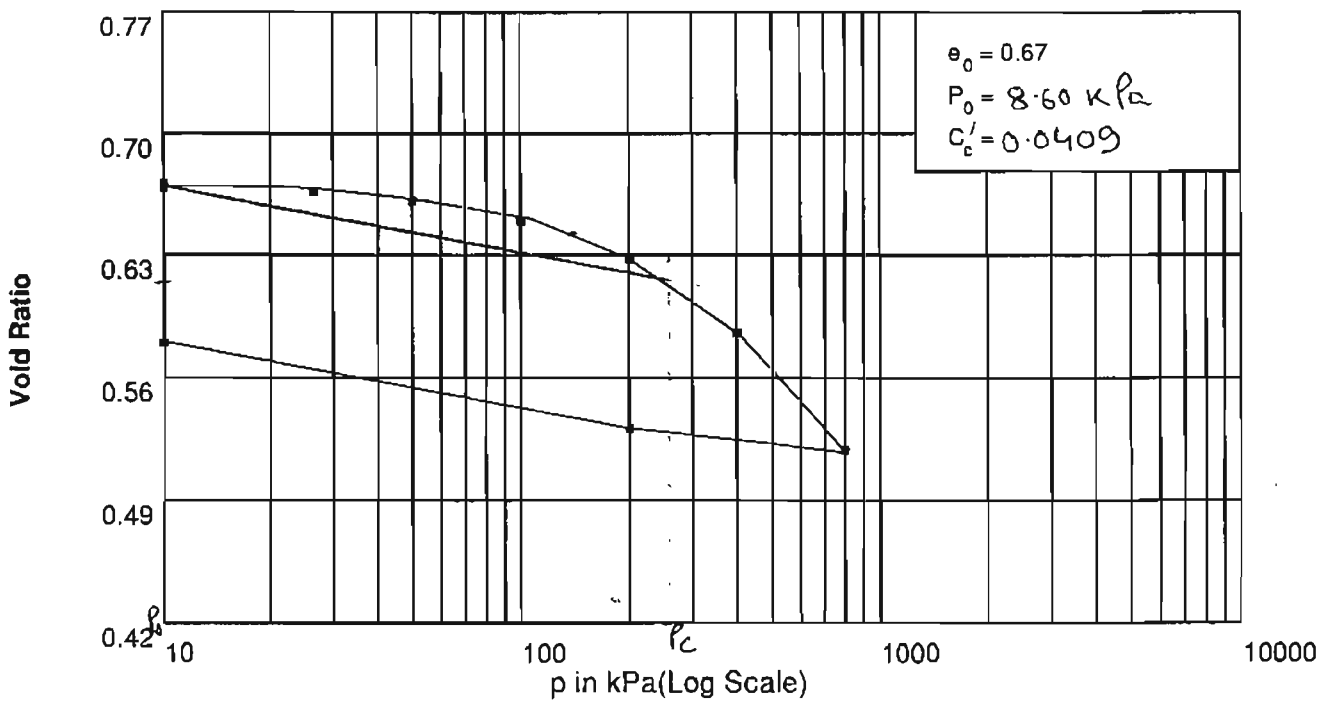
Borehole No :TP-15 Depth(m) :1.00 Sample No. :106108

LOG TIME VS SETTLEMENT CURVE



◆ Curve1 :25 - 50 kPa ◆ Curve2 :50 - 100 kPa ◆ Curve3 :100 - 200 kPa
◆ Curve4 :200 - 400 kPa ◆ Curve5 :400 - 800 kPa

e Vs LOG(P)

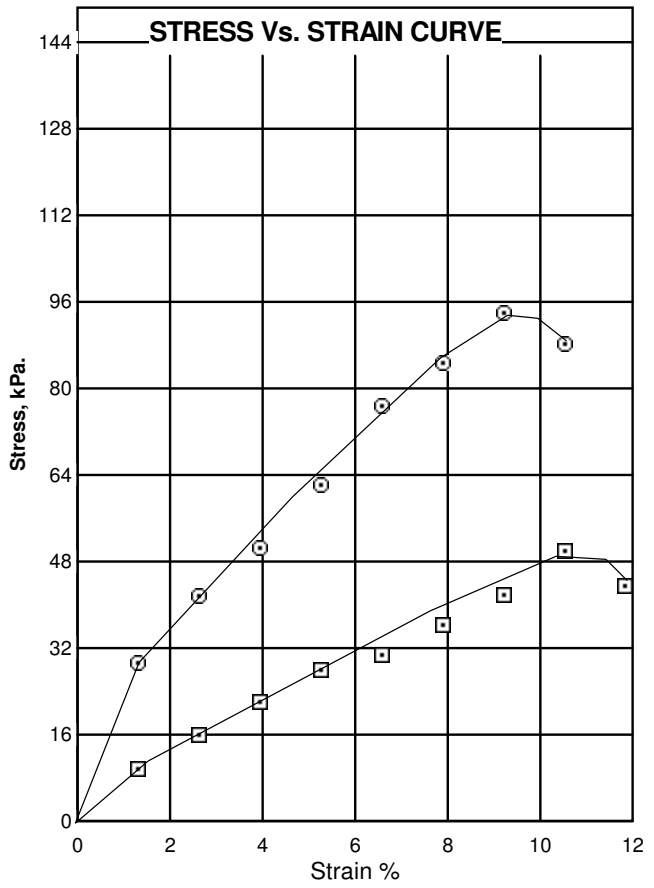


CONSOLIDATION TEST CURVES

Job No. :30796-

Sample Number : 170667
Sample Depth : 4.50 - 4.95m.
Bore Hole Number : 27

Site :
Type of Test : cd



Mode of Failure :

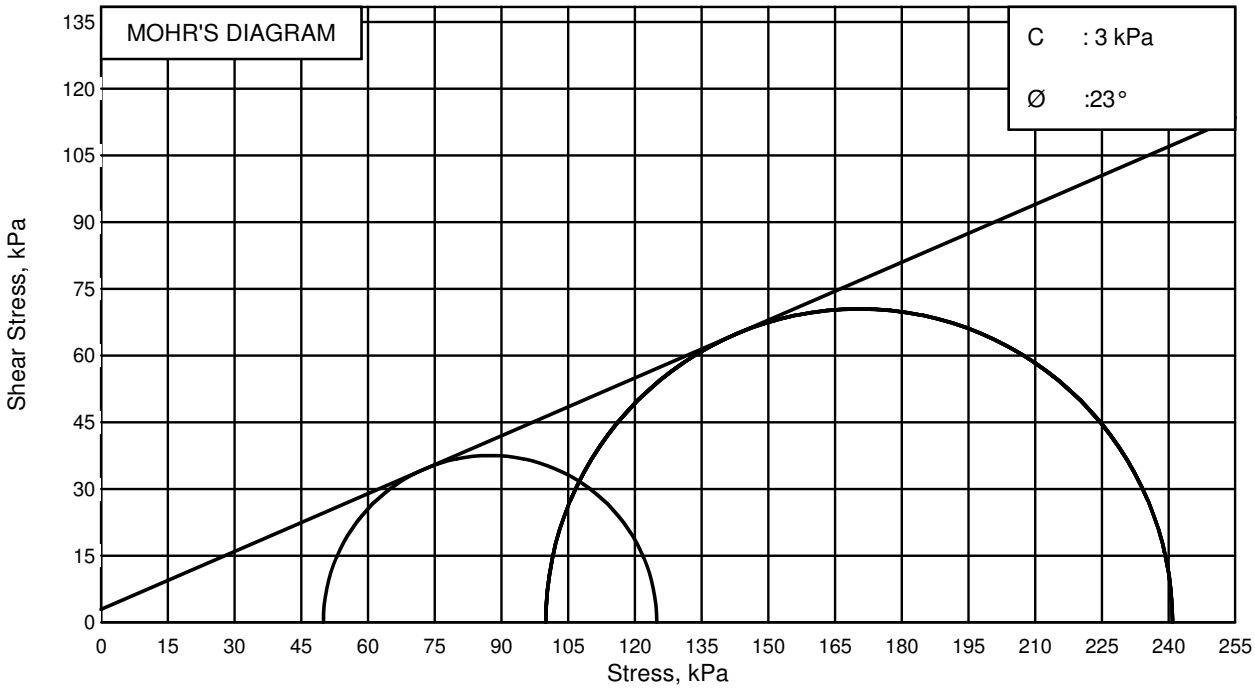
Specimen : 1 ⊡

Cell Pressure : 50 kPa

Mode of Failure :

Specimen : 2 ⊙

Cell Pressure : 100 kPa

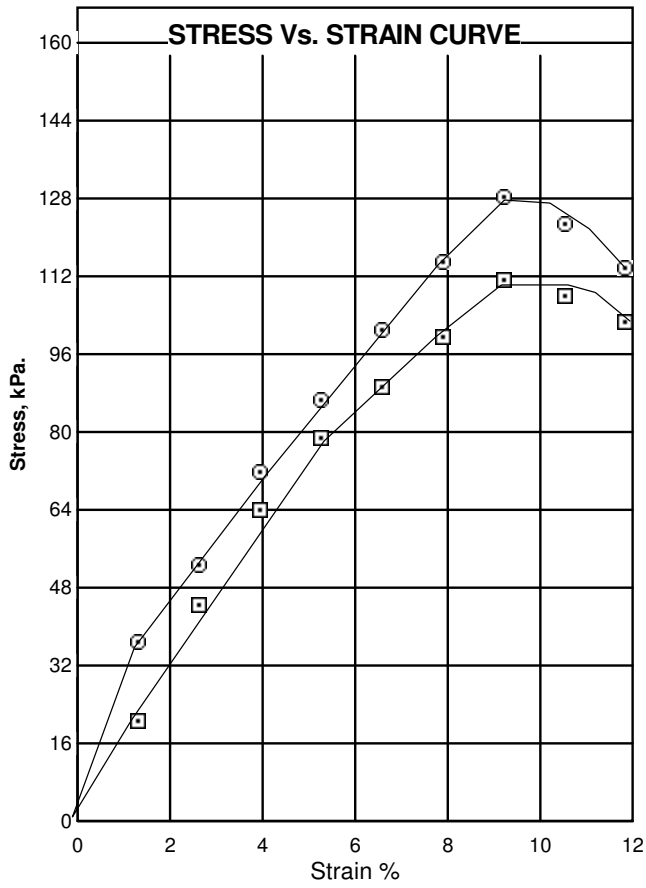


TRIAXIAL TEST CURVES

Job No. : 30796

Sample Number : 160775
Sample Depth : 3.00 - 3.45m.
Bore Hole Number : 28

Site :
Type of Test : cu



Mode of Failure :

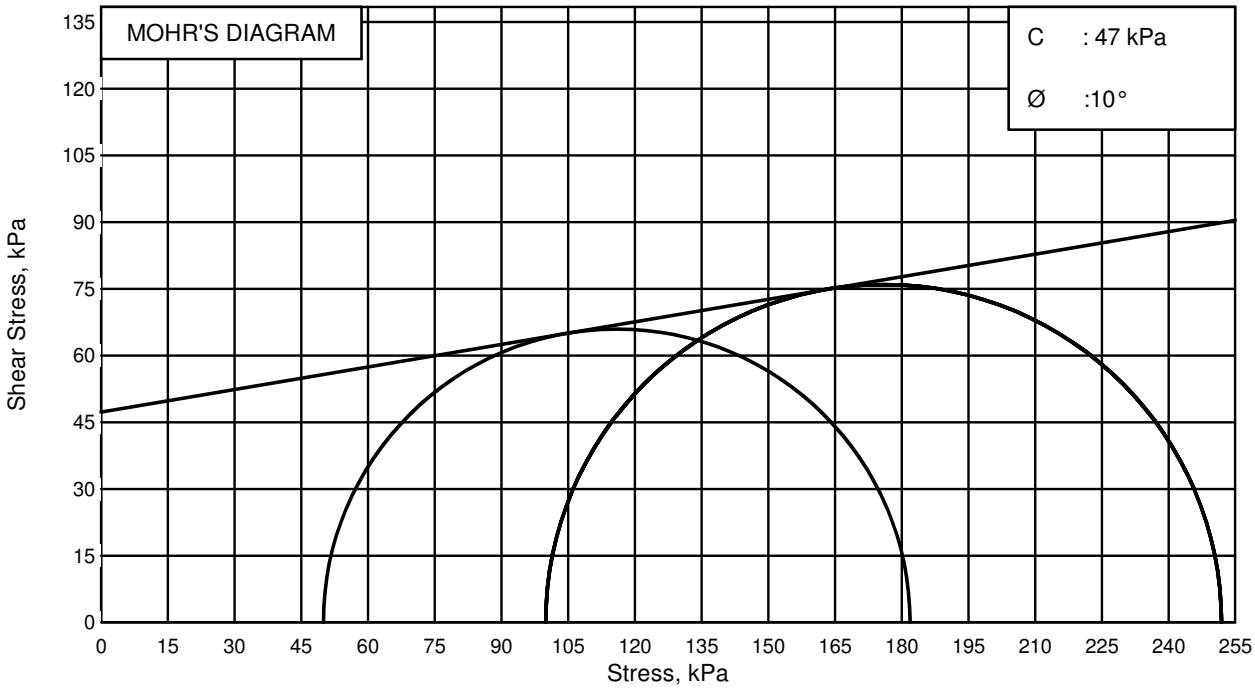
Specimen : 1 ⊡

Cell Pressure : 50 kPa

Mode of Failure :

Specimen : 2 ⊙

Cell Pressure : 100 kPa

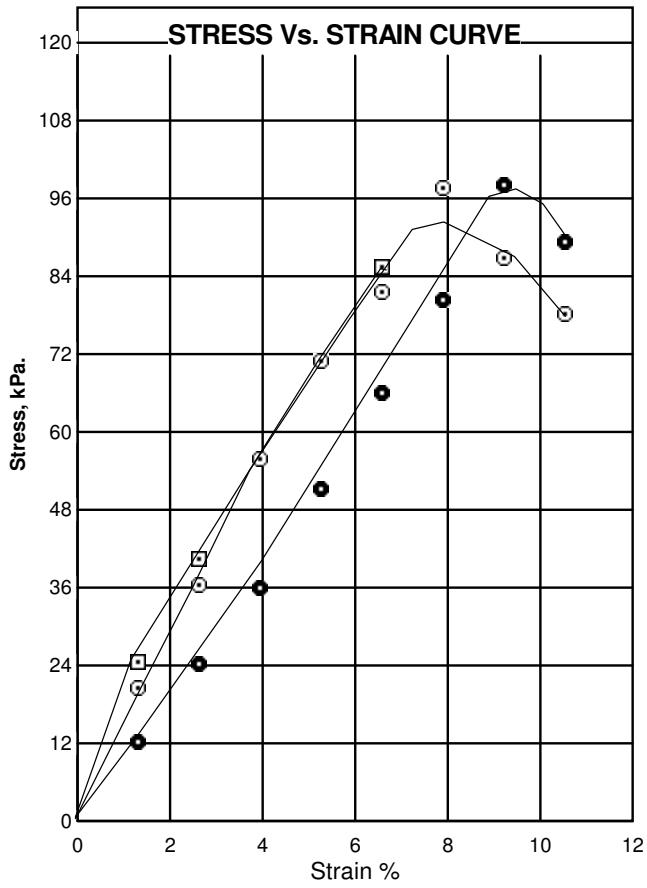


TRIAXIAL TEST CURVES

Job No. : 30796

Sample Number : 130154
Sample Depth : 2.00 - 2.45m.
Bore Hole Number : 29

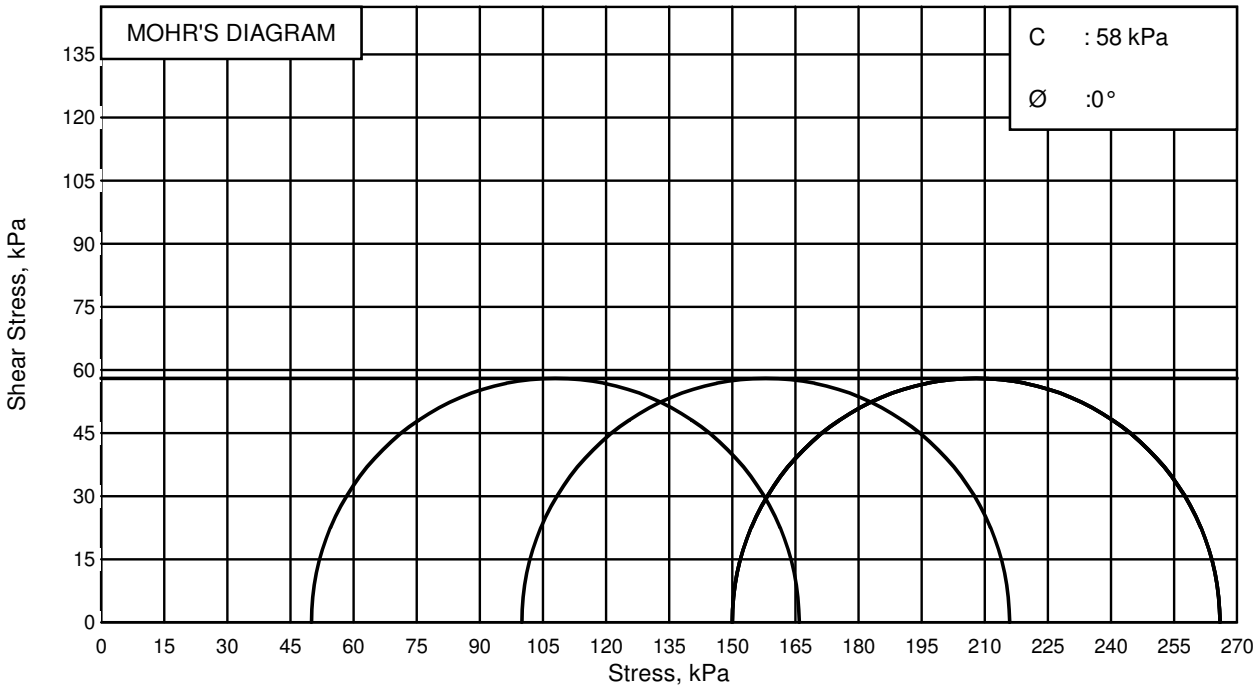
Site :
Type of Test : uu



Mode of Failure :
Specimen : 1 ⊡
Cell Pressure : 50 kPa

Mode of Failure :
Specimen : 2 ⊙
Cell Pressure : 100 kPa

Mode of Failure :
Specimen : 3 ⊙
Cell Pressure : 150 kPa

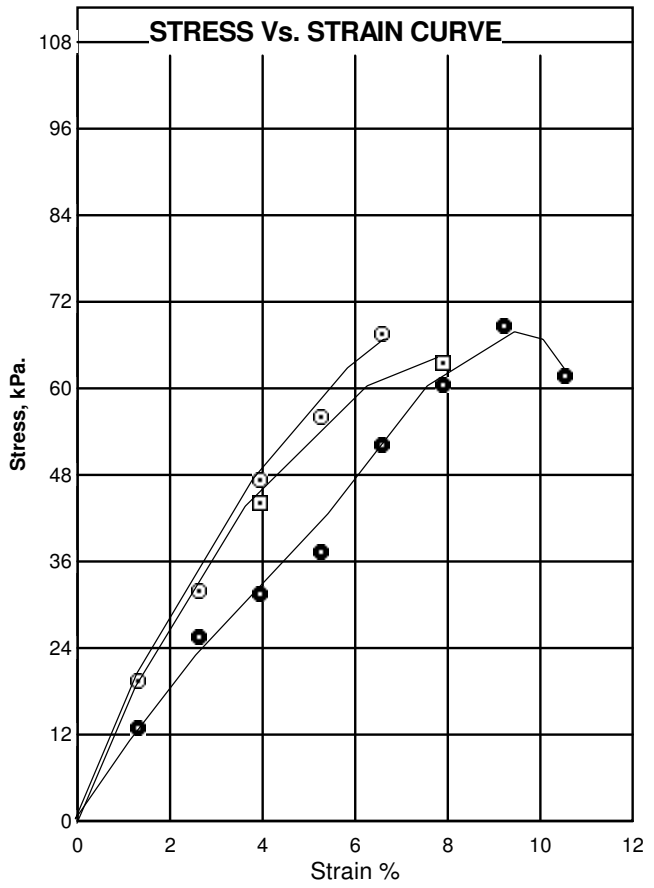


TRIAXIAL TEST CURVES

Job No. : 30796

Sample Number : 180111
Sample Depth : 1.00 - 1.45m.
Bore Hole Number : 30

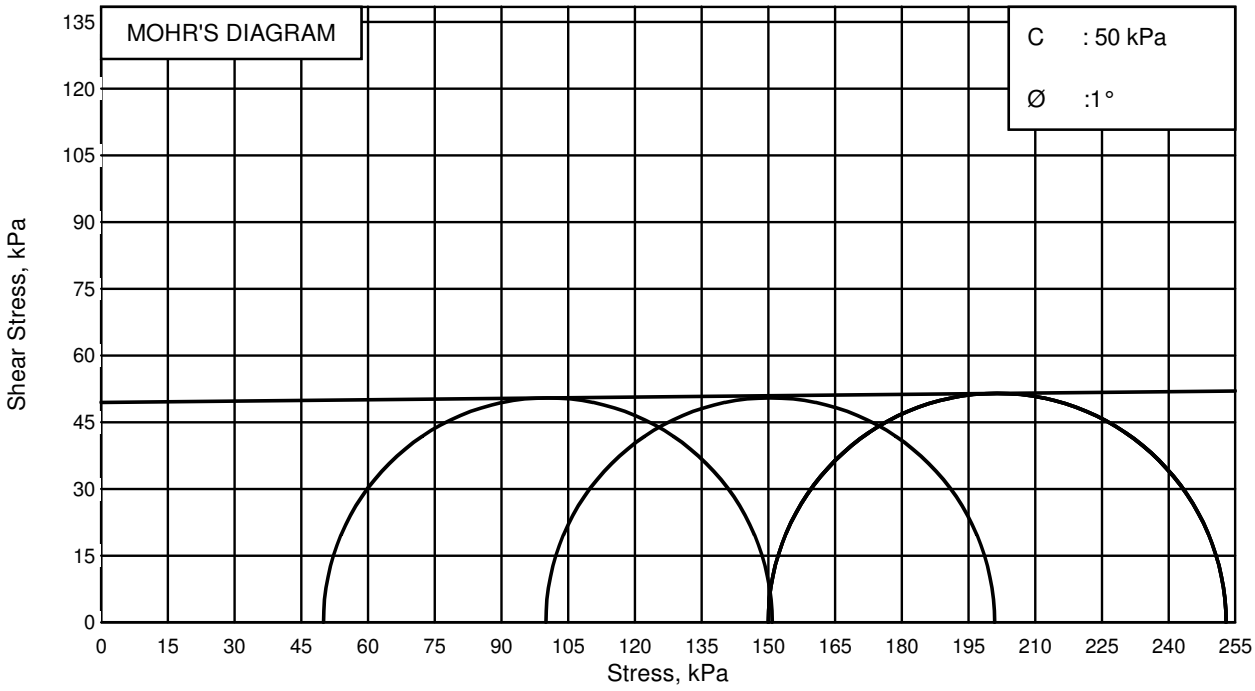
Site :
Type of Test : uu



Mode of Failure :
Specimen : 1 ⊡
Cell Pressure : 50 kPa

Mode of Failure :
Specimen : 2 ⊙
Cell Pressure : 100 kPa

Mode of Failure :
Specimen : 3 ⊙
Cell Pressure : 150 kPa

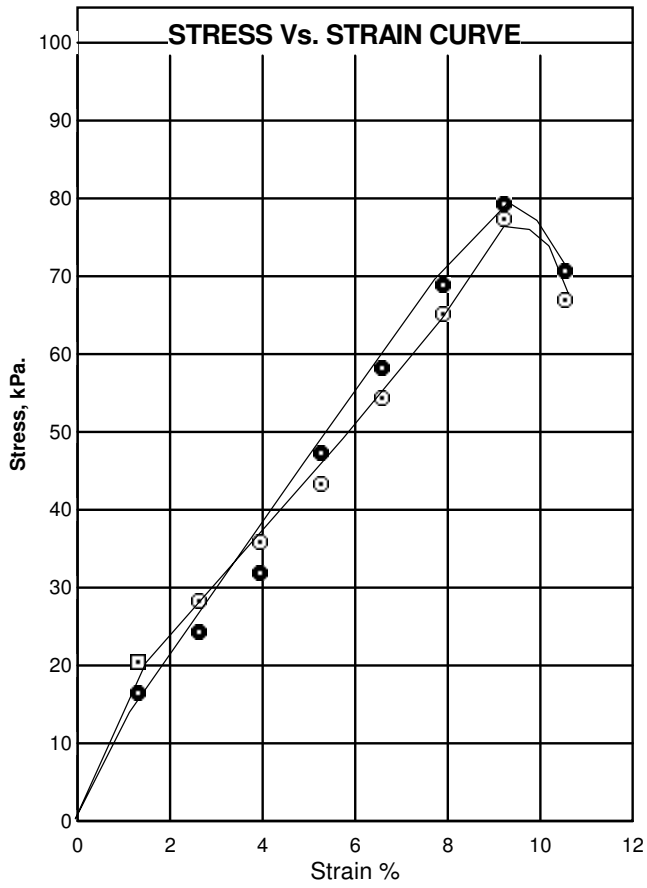


TRIAXIAL TEST CURVES

Job No. : 30796

Sample Number : 162192
Sample Depth : 2.00m.
Bore Hole Number : TP-1

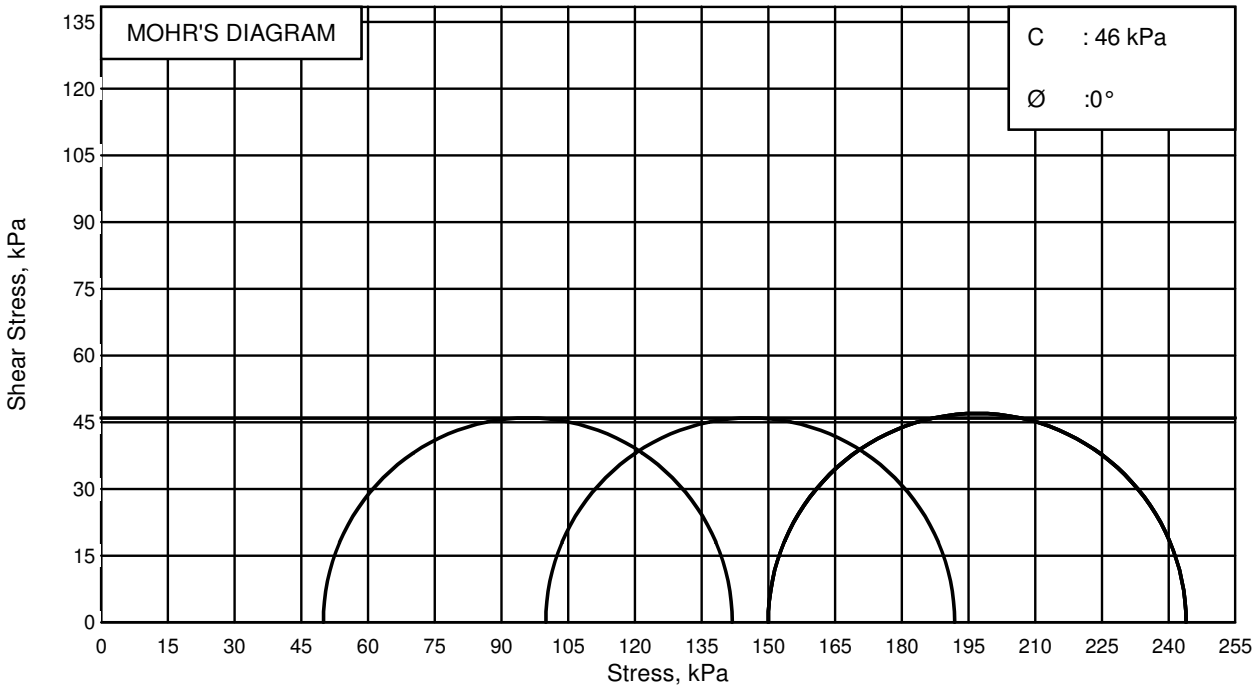
Site :
Type of Test : uu



Mode of Failure :
Specimen : 1 ⊡
Cell Pressure : 50 kPa

Mode of Failure :
Specimen : 2 ⊙
Cell Pressure : 100 kPa

Mode of Failure :
Specimen : 3 ⊙
Cell Pressure : 150 kPa

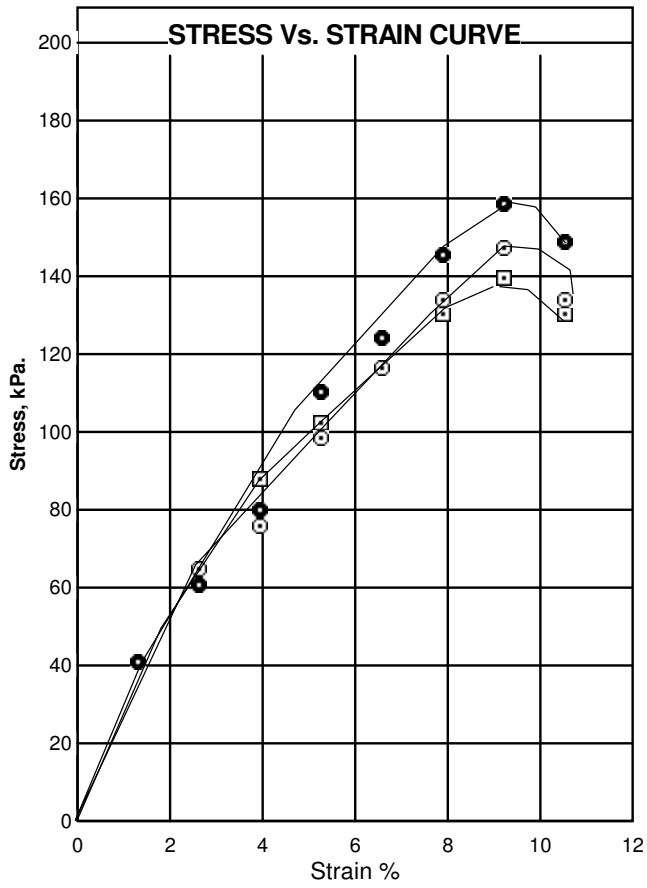


TRIAXIAL TEST CURVES

Job No. : 30796-TP

Sample Number : 162194
Sample Depth : 4.00m.
Bore Hole Number : TP-1

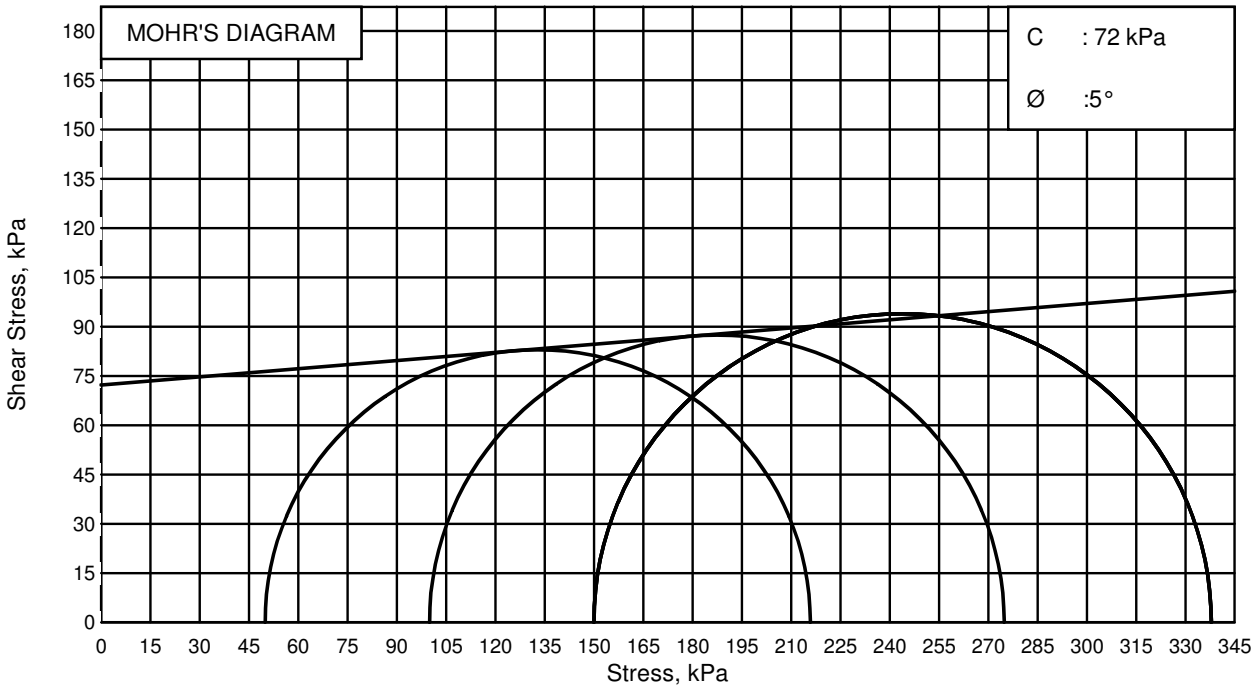
Site :
Type of Test : uu



Mode of Failure :
Specimen : 1 ⊡
Cell Pressure : 50 kPa

Mode of Failure :
Specimen : 2 ⊙
Cell Pressure : 100 kPa

Mode of Failure :
Specimen : 3 ⊙
Cell Pressure : 150 kPa

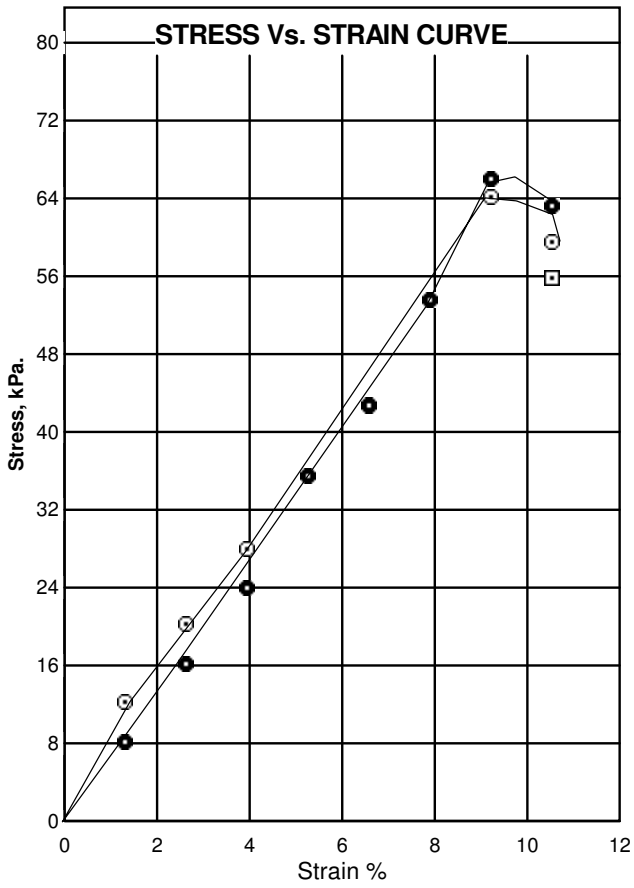


TRIAXIAL TEST CURVES

Job No. : 30796-TP

Sample Number : 100676
Sample Depth : 2.00m.
Bore Hole Number : TP-2

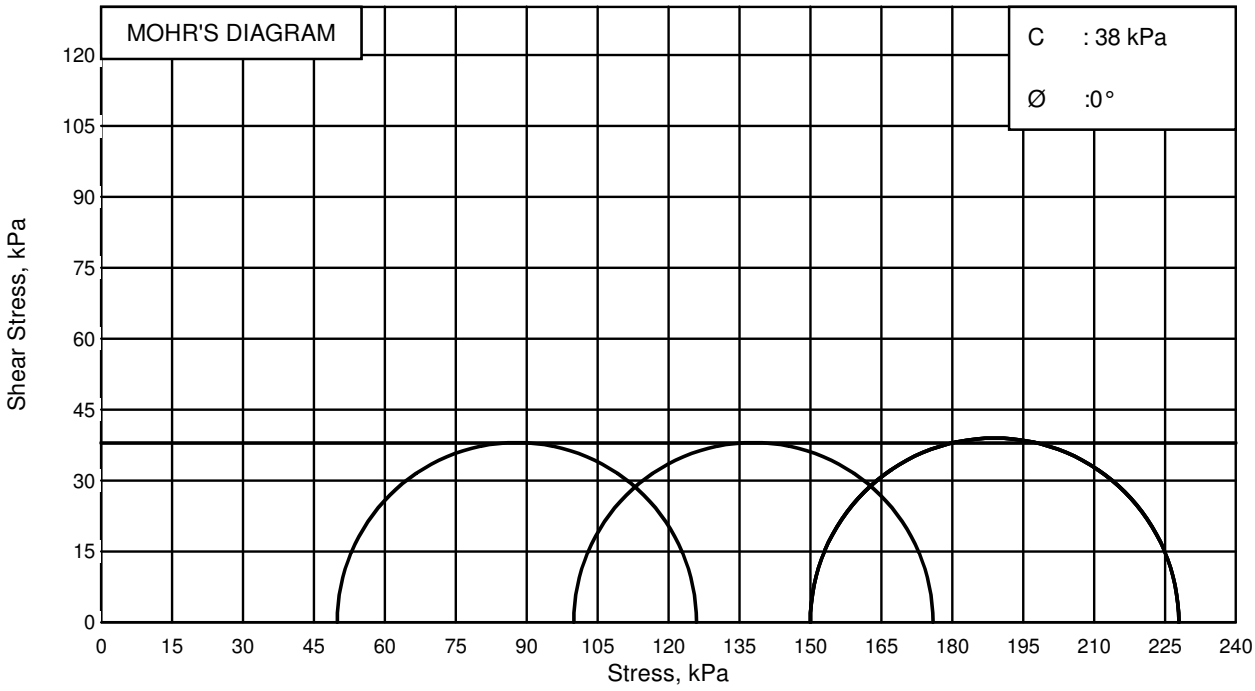
Site :
Type of Test : uu



Mode of Failure :
Specimen : 1
Cell Pressure : 50 kPa

Mode of Failure :
Specimen : 2
Cell Pressure : 100 kPa

Mode of Failure :
Specimen : 3
Cell Pressure : 150 kPa

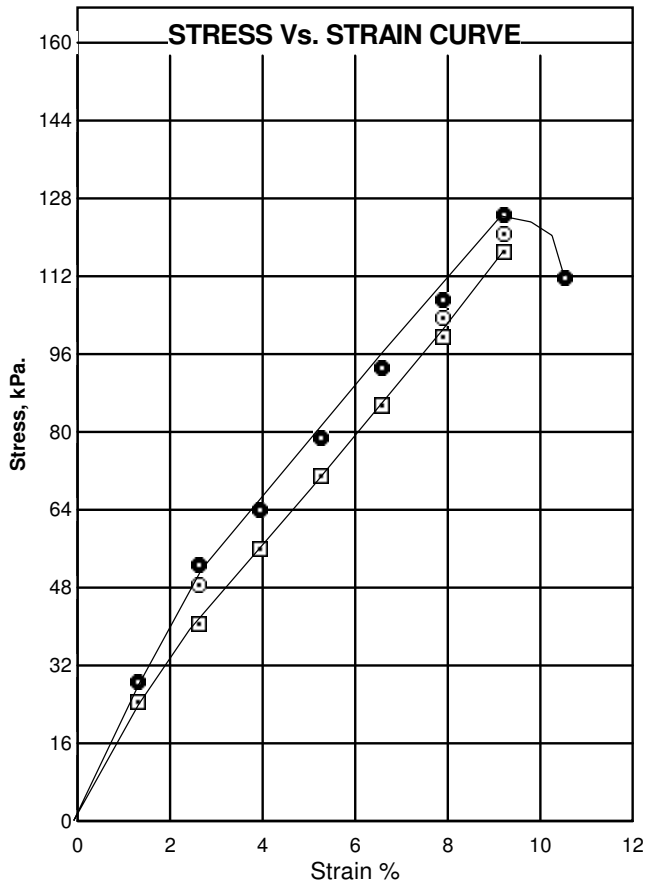


TRIAXIAL TEST CURVES

Job No. : 30796-TP

Sample Number : 100678
Sample Depth : 4.00m.
Bore Hole Number : TP-2

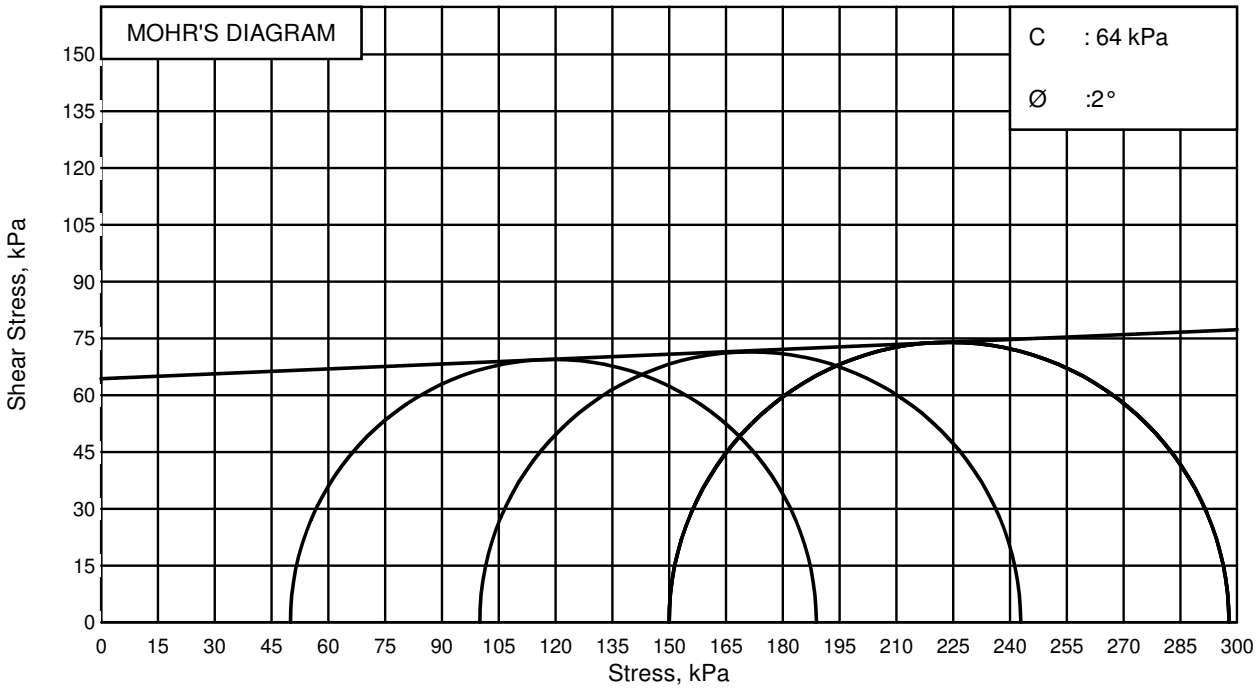
Site :
Type of Test : uu



Mode of Failure :
Specimen : 1 ⊡
Cell Pressure : 50 kPa

Mode of Failure :
Specimen : 2 ⊙
Cell Pressure : 100 kPa

Mode of Failure :
Specimen : 3 ⊙
Cell Pressure : 150 kPa

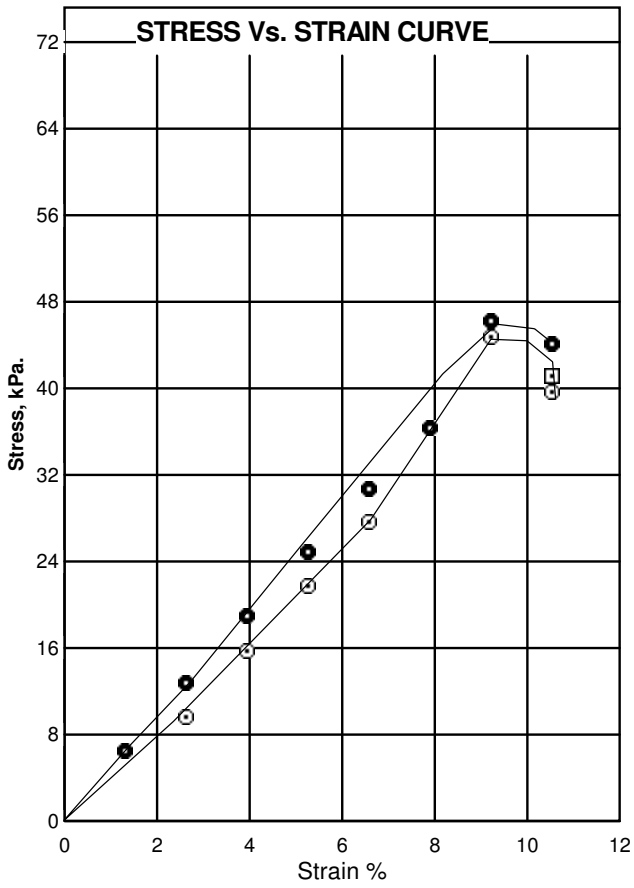


TRIAXIAL TEST CURVES

Job No. : 30796-TP

Sample Number : 106101
Sample Depth : 2.00m.
Bore Hole Number : TP-3

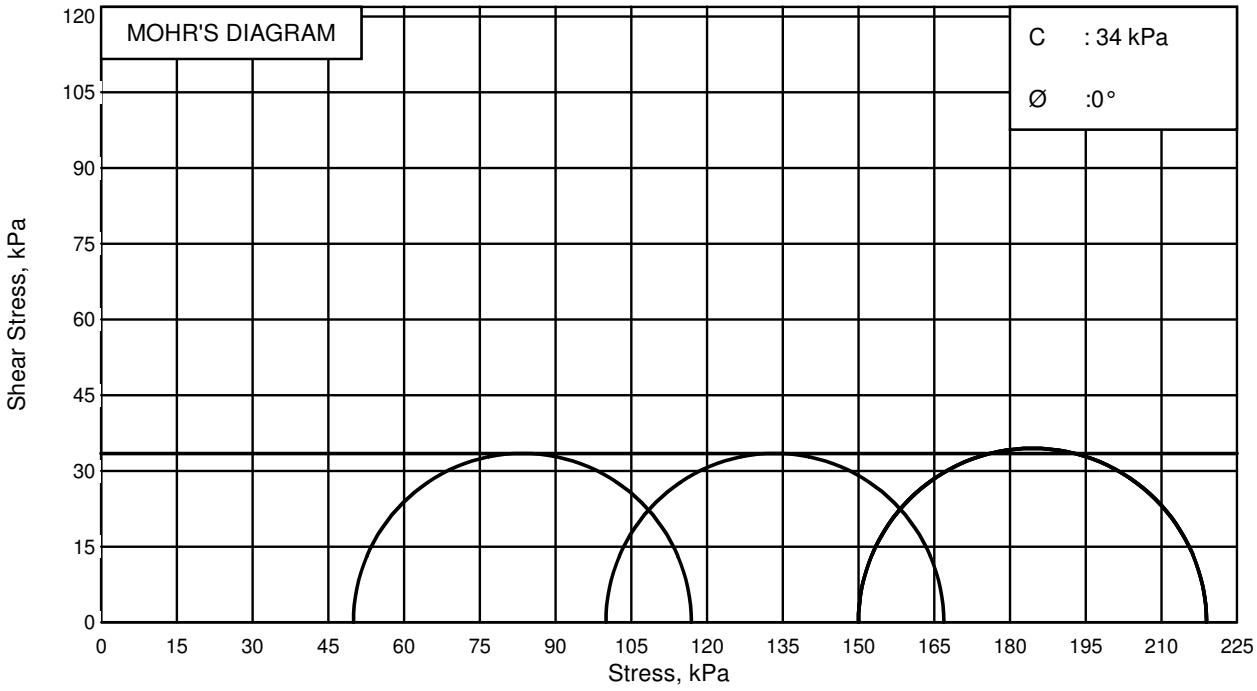
Site :
Type of Test : uu



Mode of Failure :
Specimen : 1 ⊡
Cell Pressure : 50 kPa

Mode of Failure :
Specimen : 2 ⊙
Cell Pressure : 100 kPa

Mode of Failure :
Specimen : 3 ●
Cell Pressure : 150 kPa

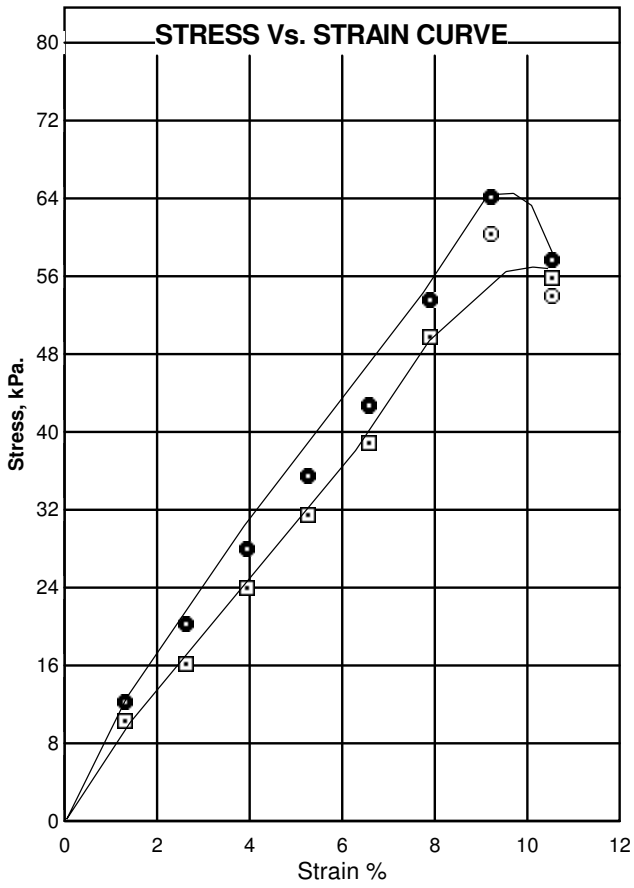


TRIAXIAL TEST CURVES

Job No. : 30796-TP

Sample Number : 106103
Sample Depth : 4.00m.
Bore Hole Number : TP-3

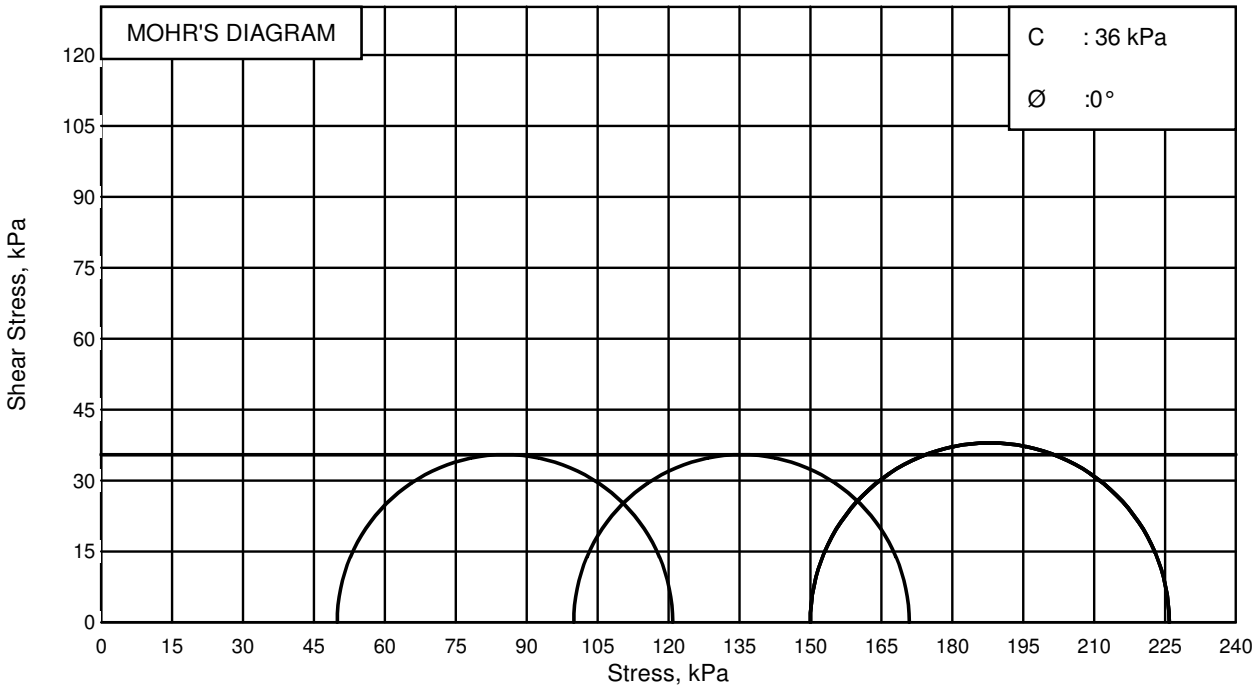
Site :
Type of Test : uu



Mode of Failure :
Specimen : 1 ⊡
Cell Pressure : 50 kPa

Mode of Failure :
Specimen : 2 ⊙
Cell Pressure : 100 kPa

Mode of Failure :
Specimen : 3 ●
Cell Pressure : 150 kPa

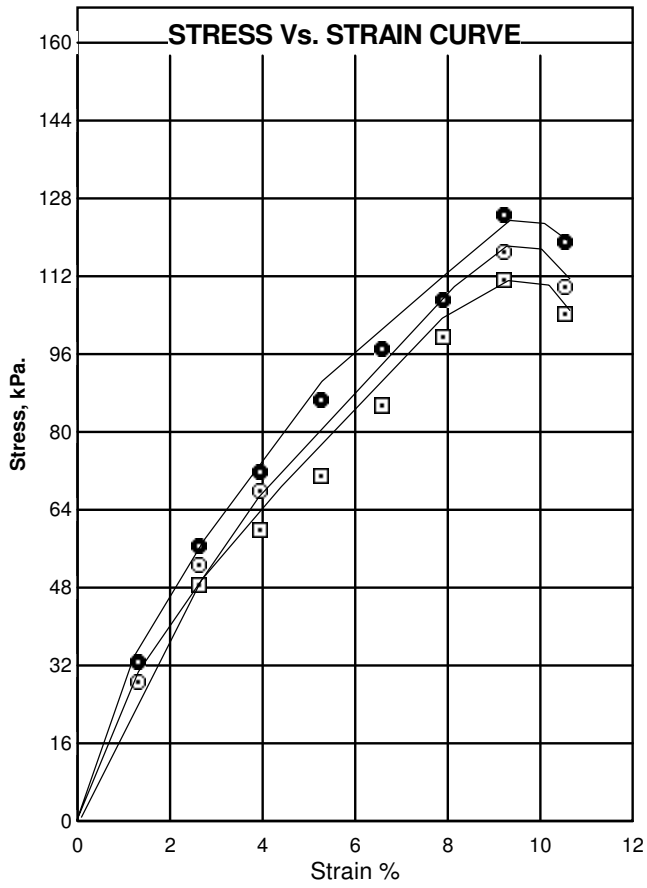


TRIAXIAL TEST CURVES

Job No. : 30796-TP

Sample Number : 106105
Sample Depth : 2.00m.
Bore Hole Number : TP-4

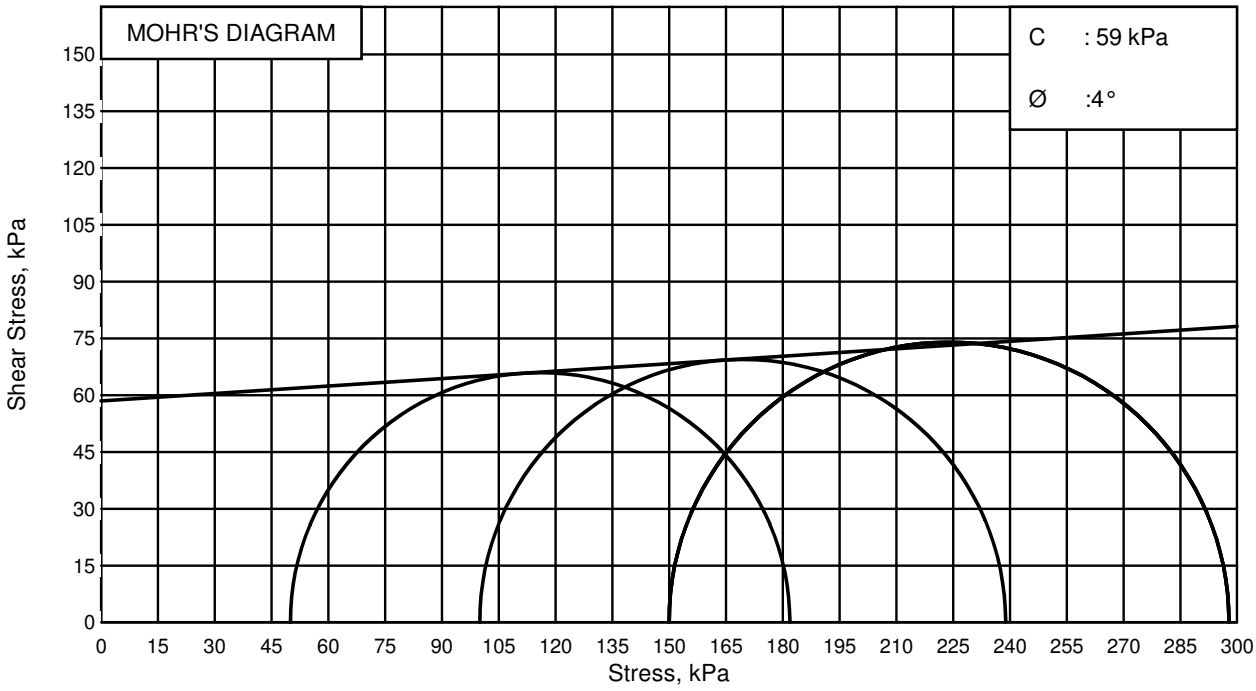
Site :
Type of Test : uu



Mode of Failure :
Specimen : 1 ⊡
Cell Pressure : 50 kPa

Mode of Failure :
Specimen : 2 ⊙
Cell Pressure : 100 kPa

Mode of Failure :
Specimen : 3 ⊙
Cell Pressure : 150 kPa

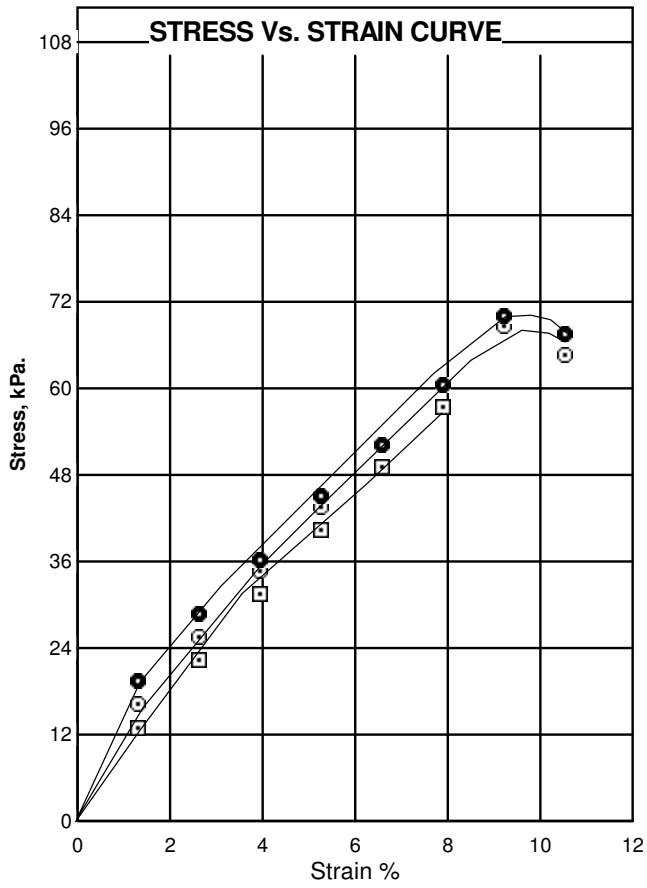


TRIAXIAL TEST CURVES

Job No. : 30796-TP

Sample Number : 151251
Sample Depth : 1.00m.
Bore Hole Number : TP-5

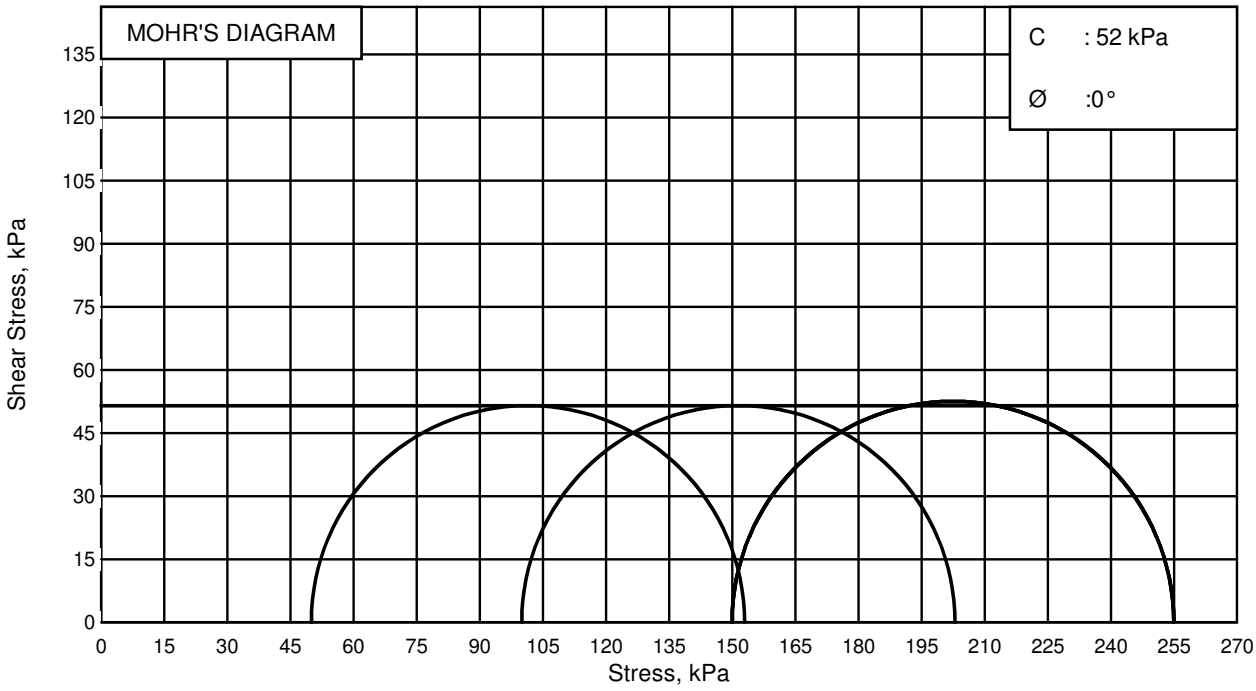
Site :
Type of Test : uu



Mode of Failure :
Specimen : 1 ⊡
Cell Pressure : 50 kPa

Mode of Failure :
Specimen : 2 ⊙
Cell Pressure : 100 kPa

Mode of Failure :
Specimen : 3 ⊙
Cell Pressure : 150 kPa

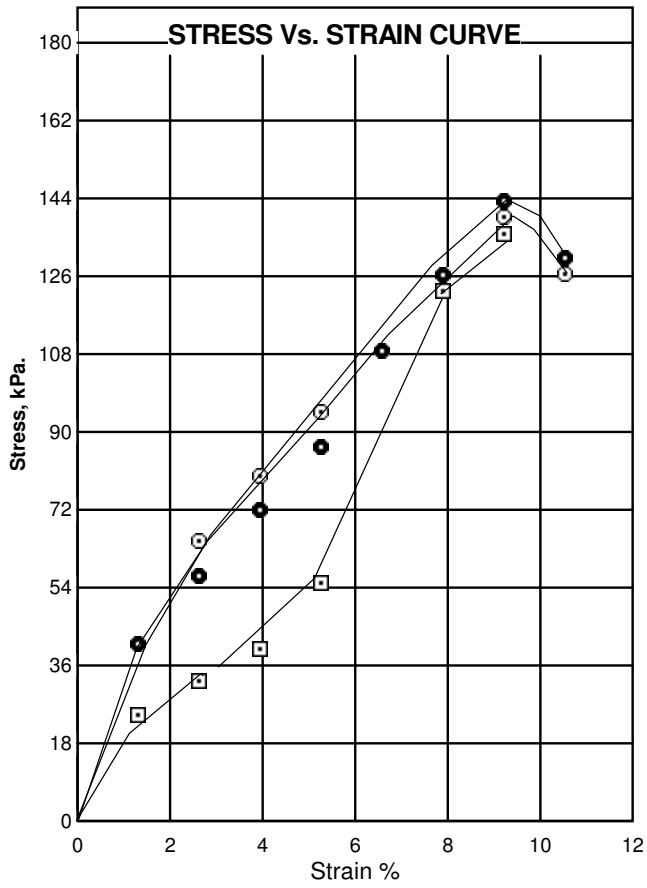


TRIAXIAL TEST CURVES

Job No. : 30796-TP

Sample Number : 151253
Sample Depth : 3.00 m.
Bore Hole Number : TP-5

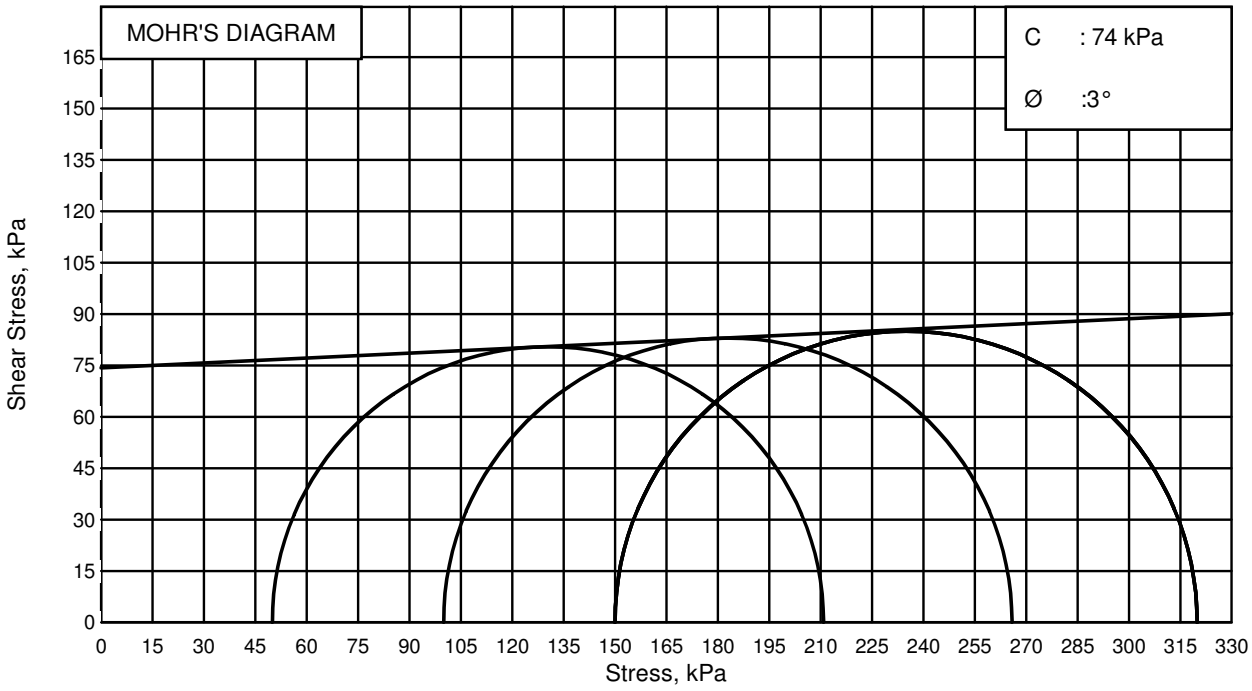
Site :
Type of Test : uu



Mode of Failure :
Specimen : 1 ⊡
Cell Pressure : 50 kPa

Mode of Failure :
Specimen : 2 ⊙
Cell Pressure : 100 kPa

Mode of Failure :
Specimen : 3 ●
Cell Pressure : 150 kPa

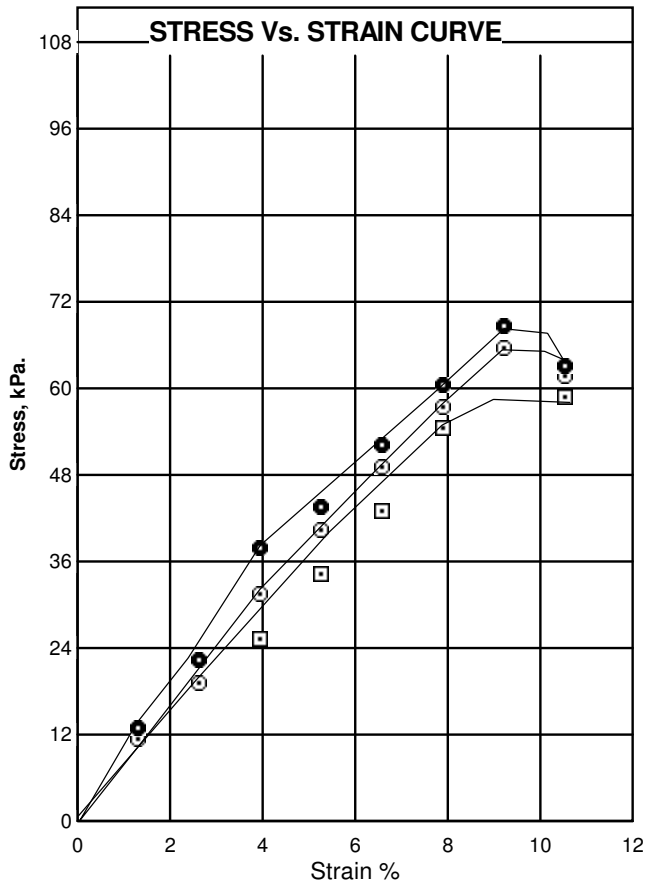


TRIAXIAL TEST CURVES

Job No. : 30796-TP

Sample Number : 171620
Sample Depth : 1.00m.
Bore Hole Number : TP-6

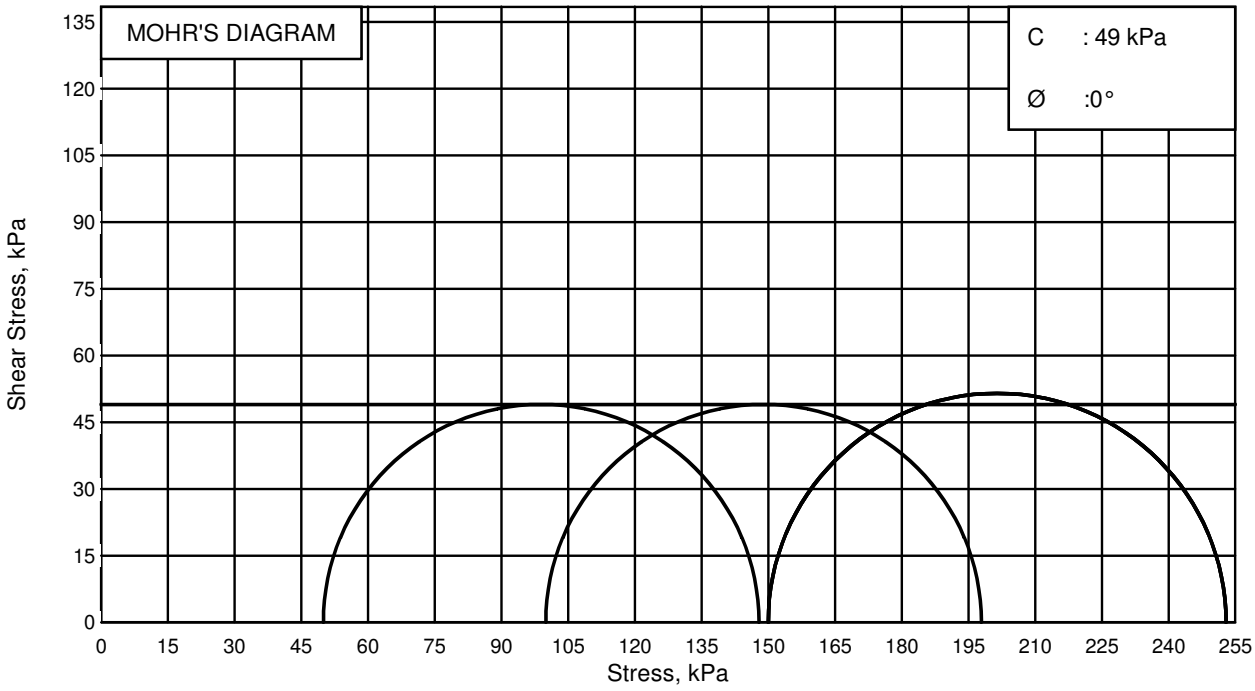
Site :
Type of Test : uu



Mode of Failure :
Specimen : 1 ⊡
Cell Pressure : 50 kPa

Mode of Failure :
Specimen : 2 ⊙
Cell Pressure : 100 kPa

Mode of Failure :
Specimen : 3 ⊙
Cell Pressure : 150 kPa

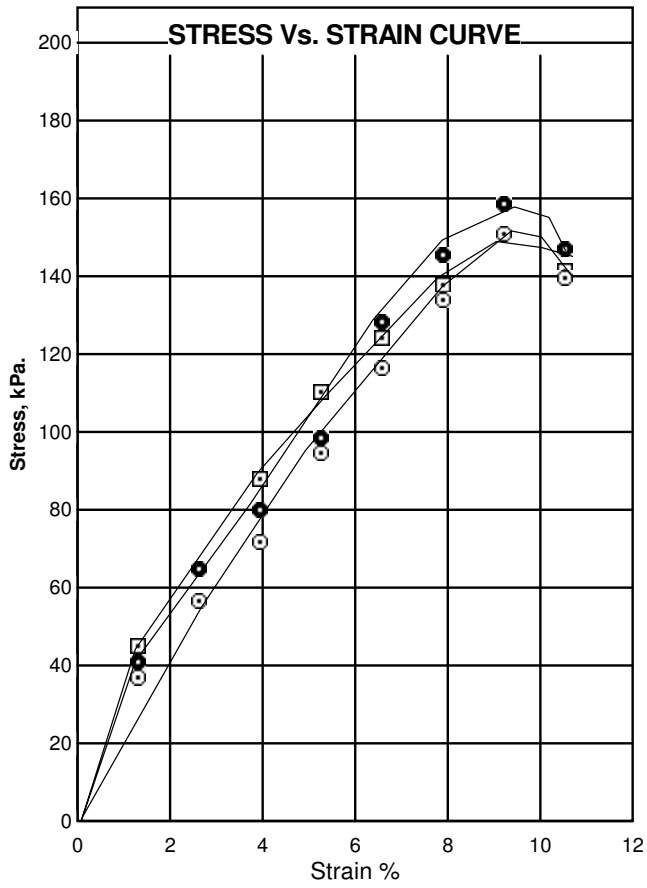


TRIAXIAL TEST CURVES

Job No. : 30796-TP

Sample Number : 171622
Sample Depth : 3.00m.
Bore Hole Number : TP-6

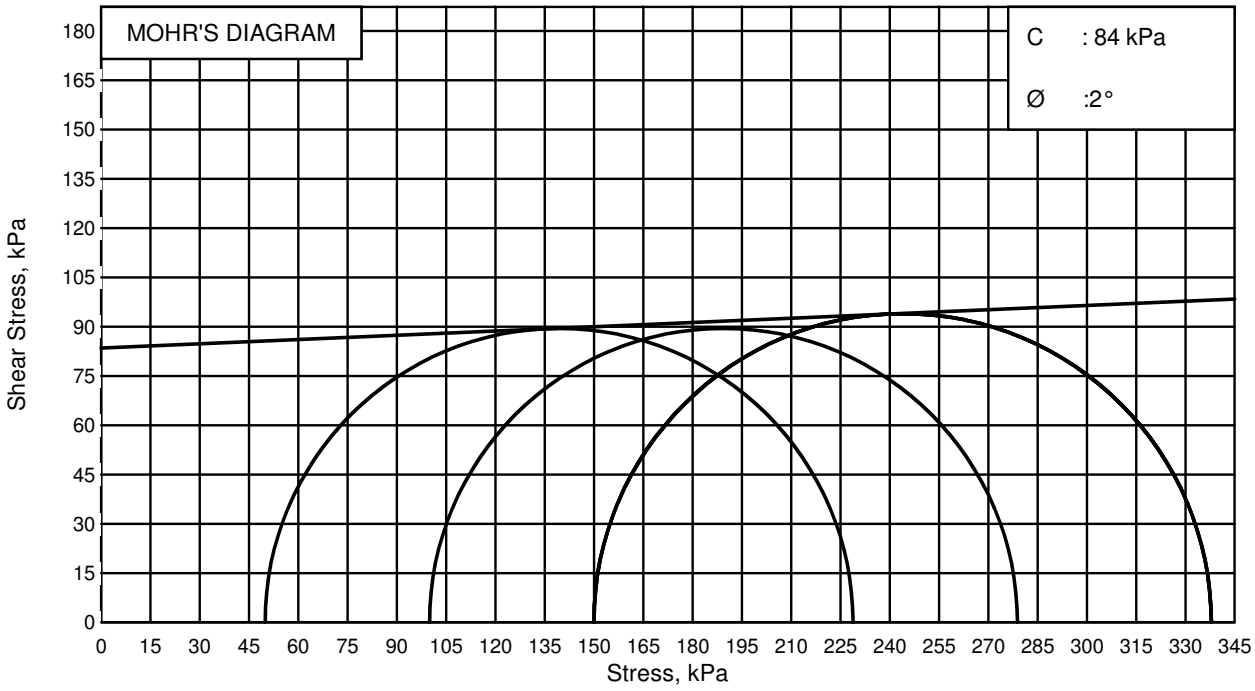
Site :
Type of Test : uu



Mode of Failure :
Specimen : 1 ⊡
Cell Pressure : 50 kPa

Mode of Failure :
Specimen : 2 ⊙
Cell Pressure : 100 kPa

Mode of Failure :
Specimen : 3 ⊙
Cell Pressure : 150 kPa

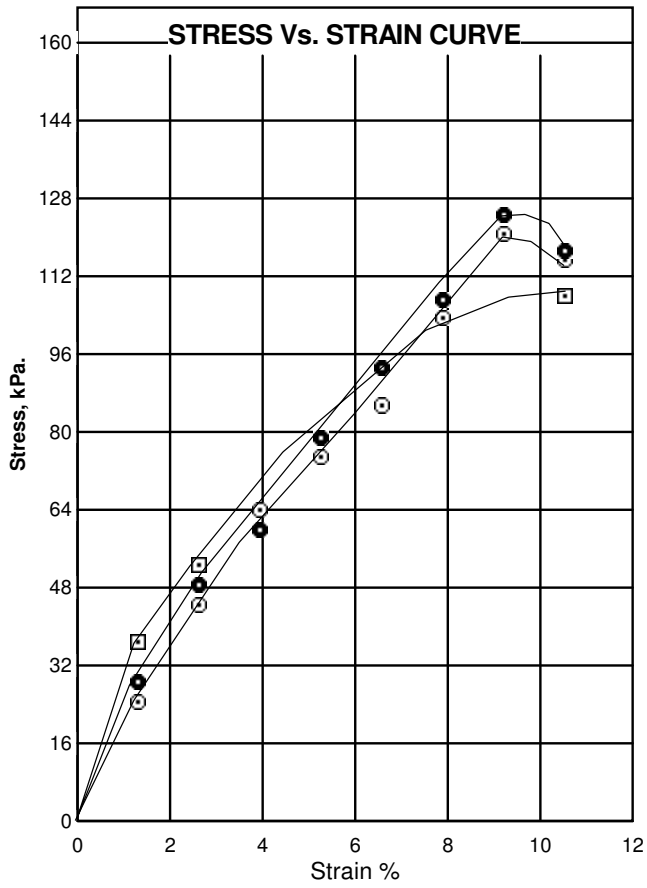


TRIAXIAL TEST CURVES

Job No. : 30796-TP

Sample Number : 100711
Sample Depth : 2.00m.
Bore Hole Number : TP-7

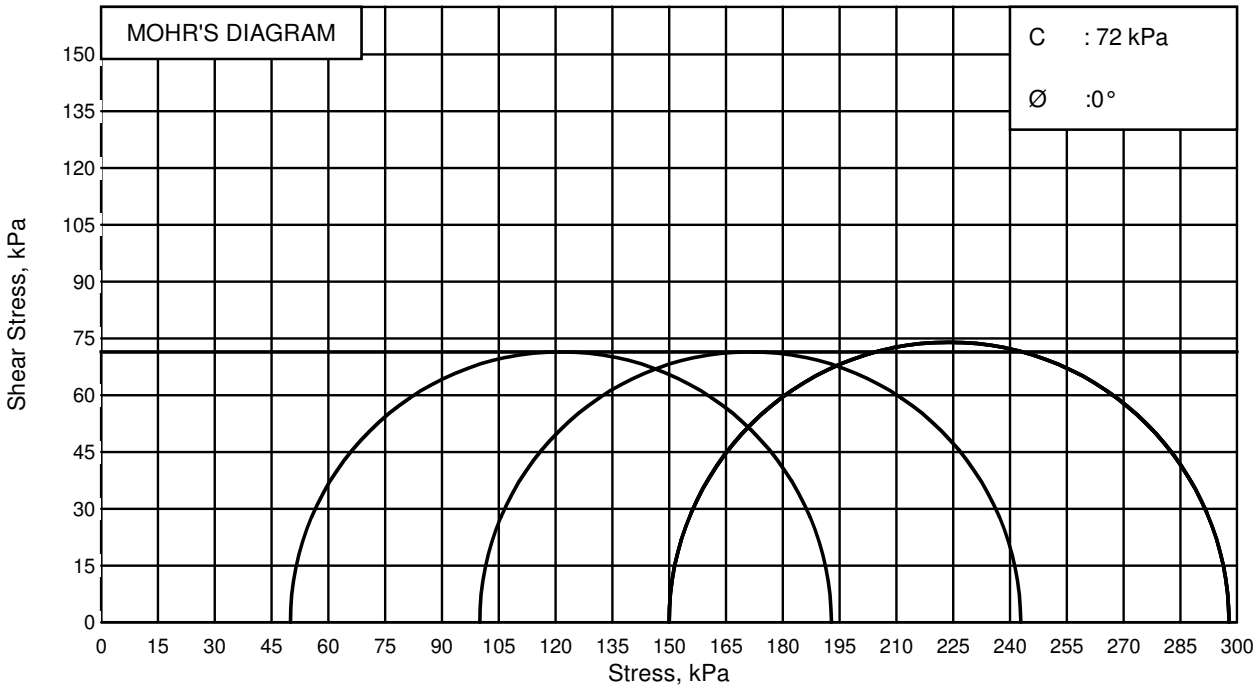
Site :
Type of Test : uu



Mode of Failure :
Specimen : 1 ⊡
Cell Pressure : 50 kPa

Mode of Failure :
Specimen : 2 ⊙
Cell Pressure : 100 kPa

Mode of Failure :
Specimen : 3 ●
Cell Pressure : 150 kPa

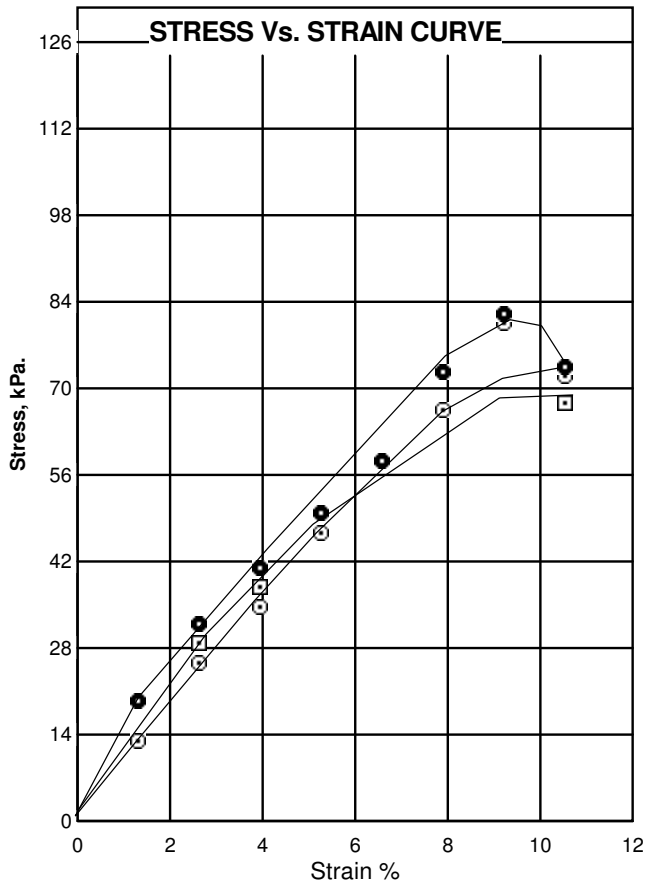


TRIAXIAL TEST CURVES

Job No. : 30796-TP

Sample Number : 105130
Sample Depth : 2.00m.
Bore Hole Number : TP-8

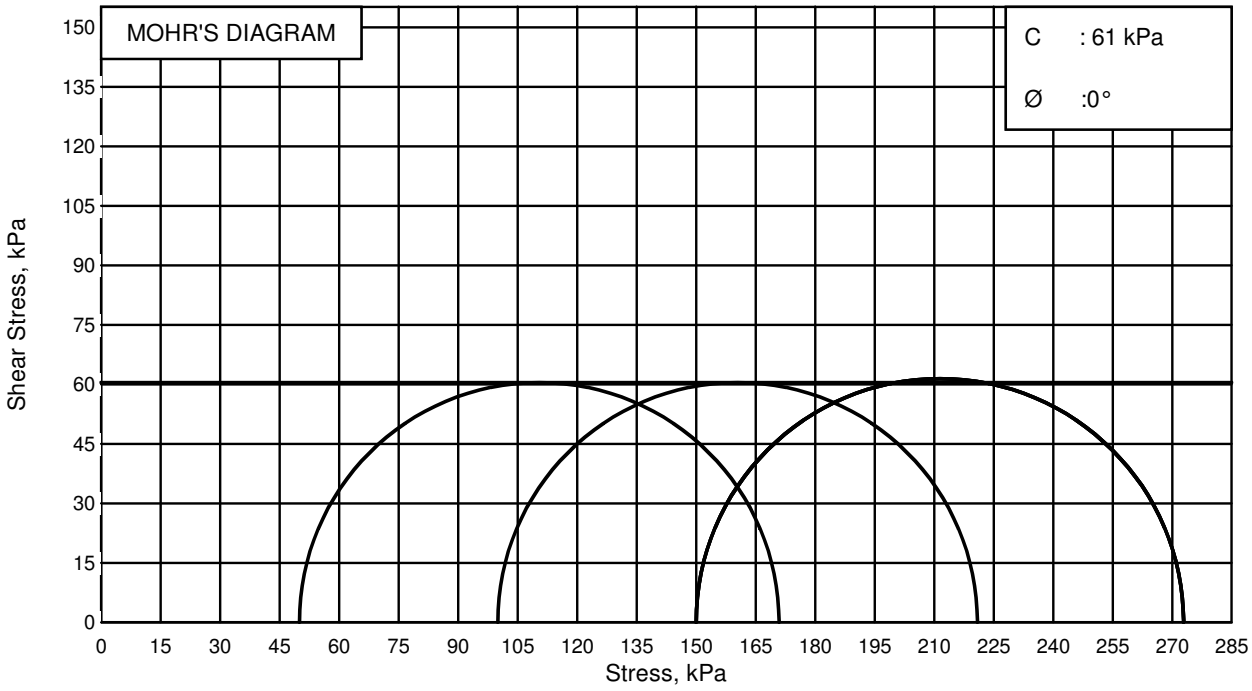
Site :
Type of Test : uu



Mode of Failure :
Specimen : 1 ⊡
Cell Pressure : 50 kPa

Mode of Failure :
Specimen : 2 ⊙
Cell Pressure : 100 kPa

Mode of Failure :
Specimen : 3 ⊙
Cell Pressure : 150 kPa

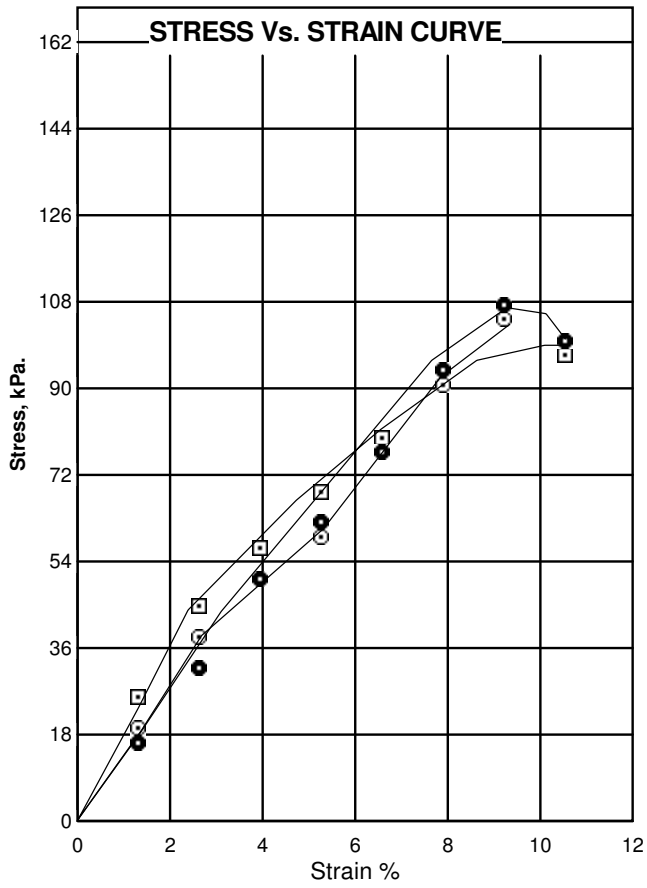


TRIAXIAL TEST CURVES

Job No. : 30796-TP

Sample Number : 105131
Sample Depth : 3.00m.
Bore Hole Number : TP-8

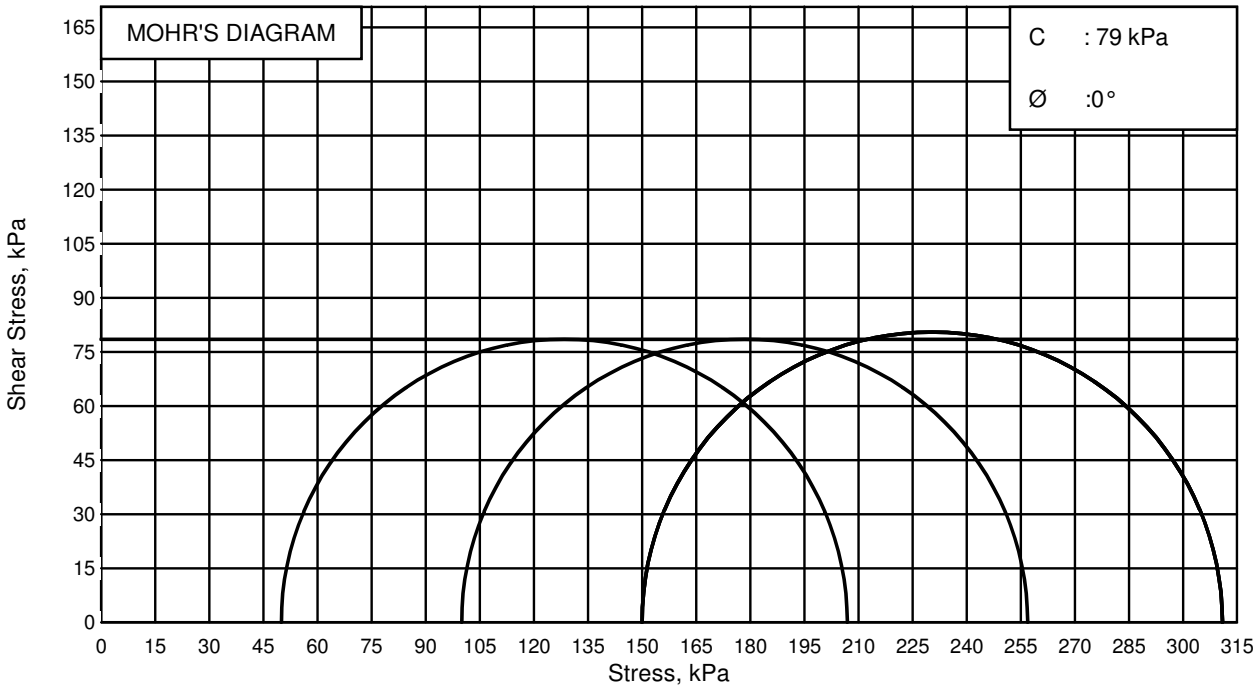
Site :
Type of Test : uu



Mode of Failure :
Specimen : 1 ⊡
Cell Pressure : 50 kPa

Mode of Failure :
Specimen : 2 ⊙
Cell Pressure : 100 kPa

Mode of Failure :
Specimen : 3 ⊙
Cell Pressure : 150 kPa

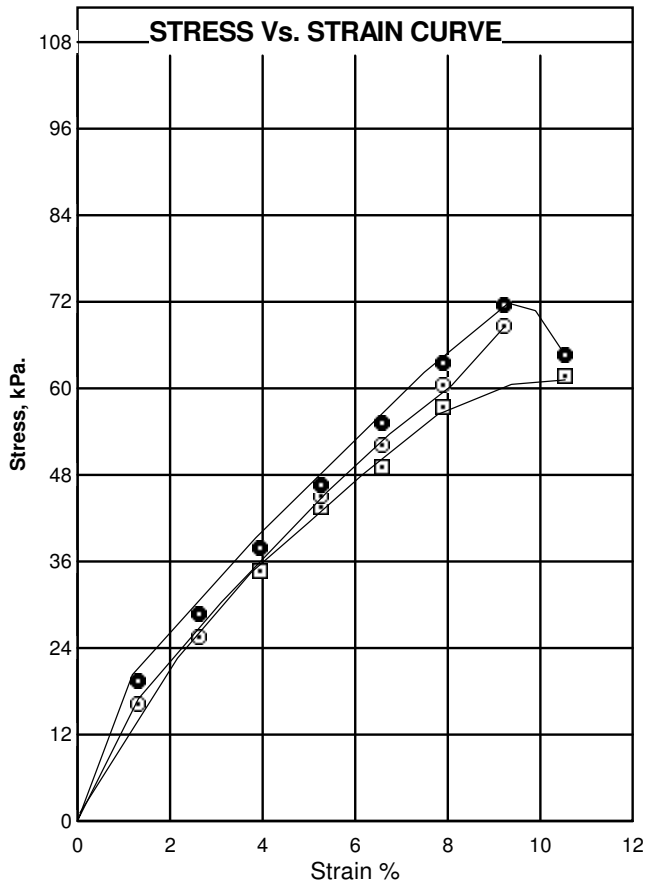


TRIAXIAL TEST CURVES

Job No. : 30796-TP

Sample Number : 120150
Sample Depth : 1.00m.
Bore Hole Number : TP-9

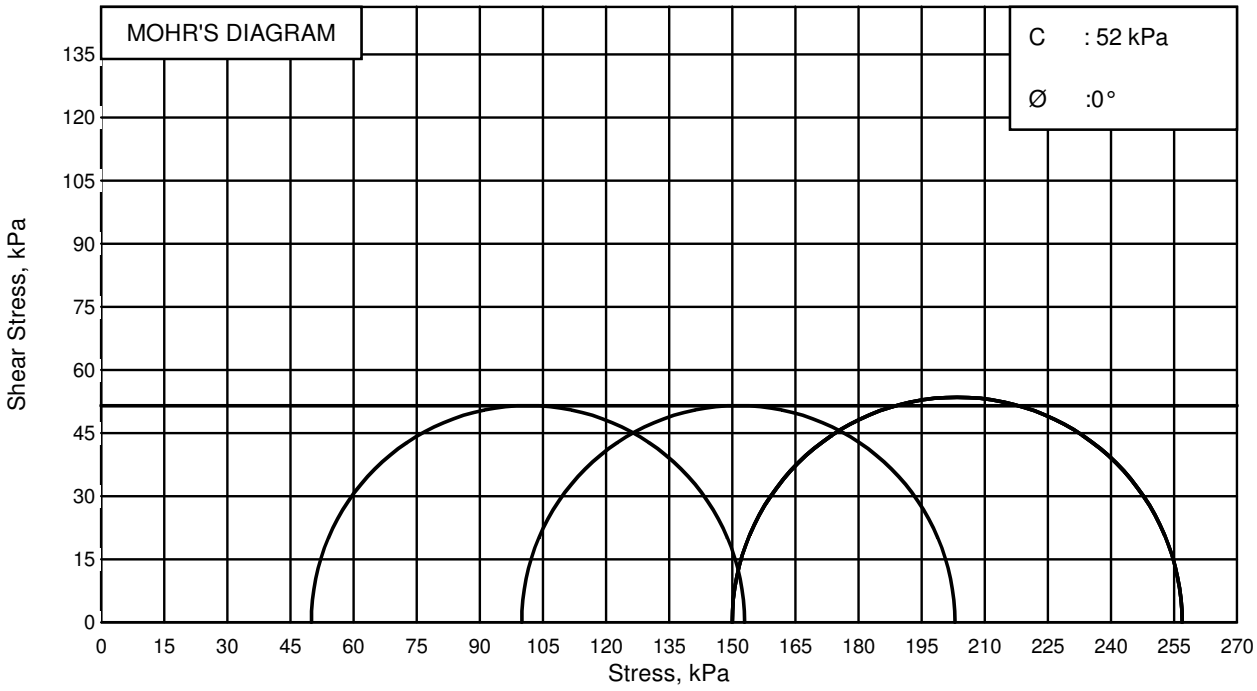
Site :
Type of Test : uu



Mode of Failure :
Specimen : 1 ⊡
Cell Pressure : 50 kPa

Mode of Failure :
Specimen : 2 ⊙
Cell Pressure : 100 kPa

Mode of Failure :
Specimen : 3 ⊙
Cell Pressure : 150 kPa

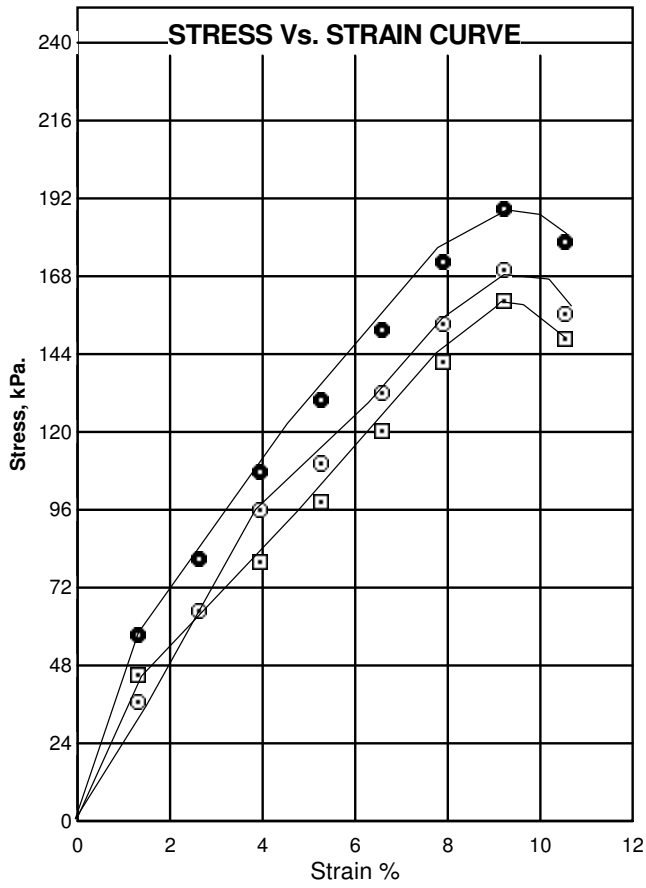


TRIAXIAL TEST CURVES

Job No. : 30796-TP

Sample Number : 120152
Sample Depth : 3.00m.
Bore Hole Number : TP-9

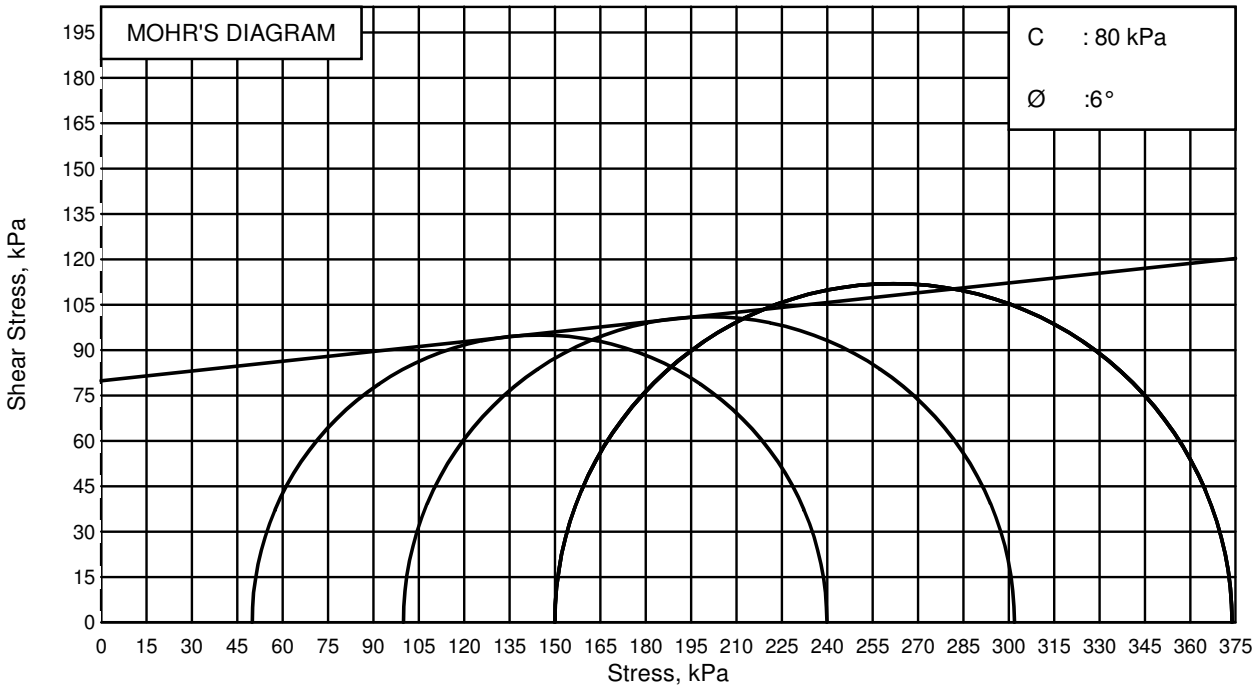
Site :
Type of Test : uu



Mode of Failure :
Specimen : 1 ⊡
Cell Pressure : 50 kPa

Mode of Failure :
Specimen : 2 ⊙
Cell Pressure : 100 kPa

Mode of Failure :
Specimen : 3 ●
Cell Pressure : 150 kPa

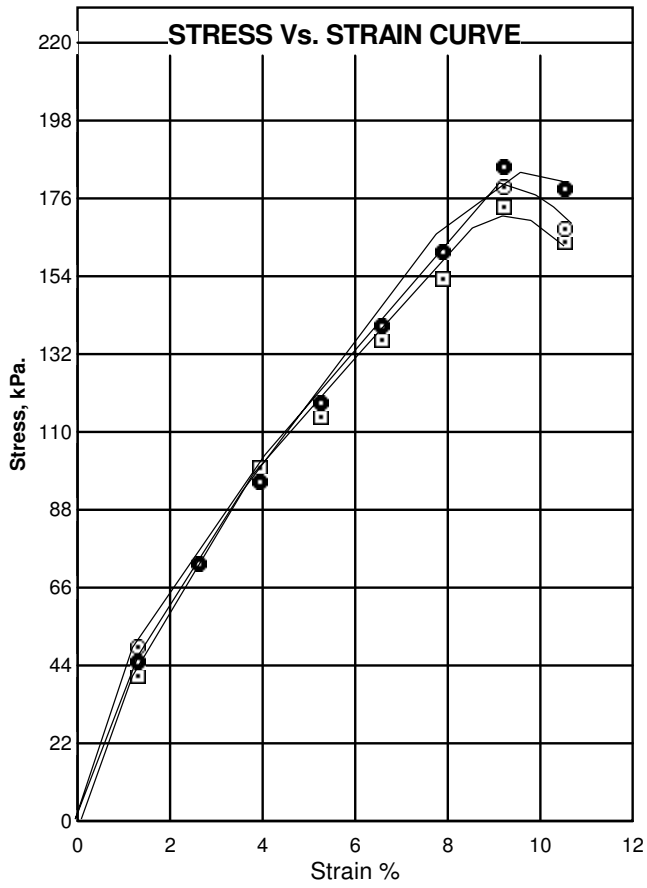


TRIAXIAL TEST CURVES

Job No. : 30796-TP

Sample Number : 105135
Sample Depth : 3.00m.
Bore Hole Number : TP-10

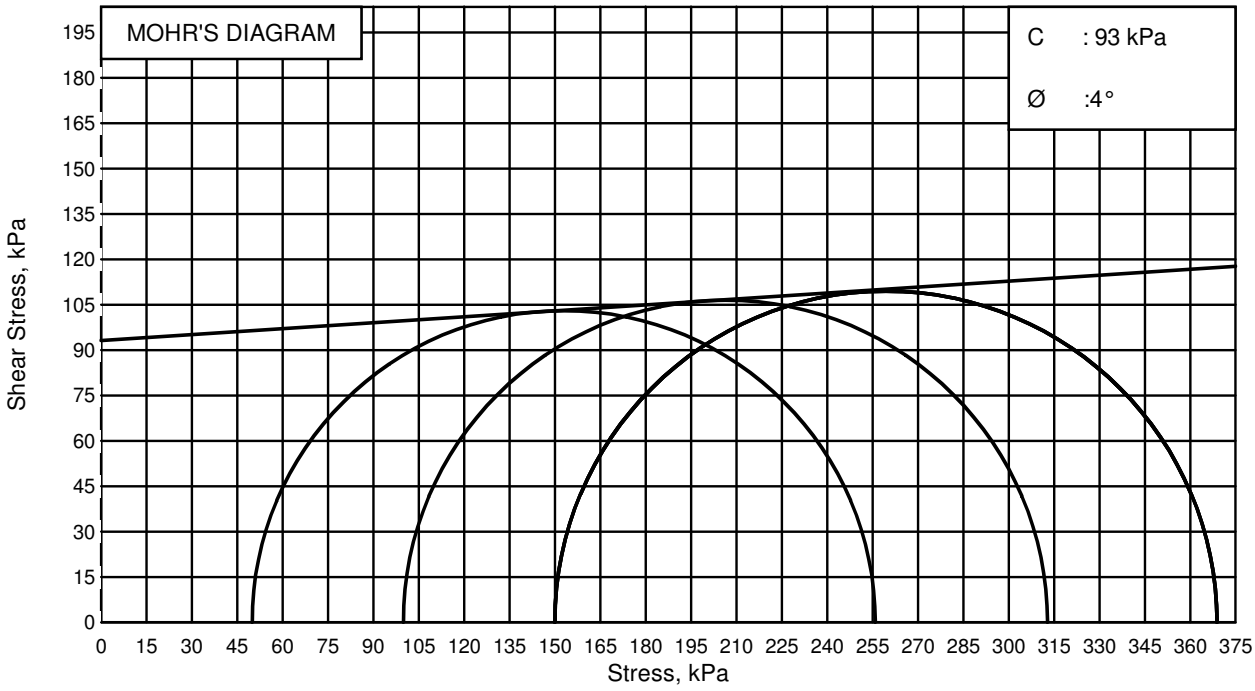
Site :
Type of Test : uu



Mode of Failure :
Specimen : 1 ⊡
Cell Pressure : 50 kPa

Mode of Failure :
Specimen : 2 ⊙
Cell Pressure : 100 kPa

Mode of Failure :
Specimen : 3 ⊙
Cell Pressure : 150 kPa

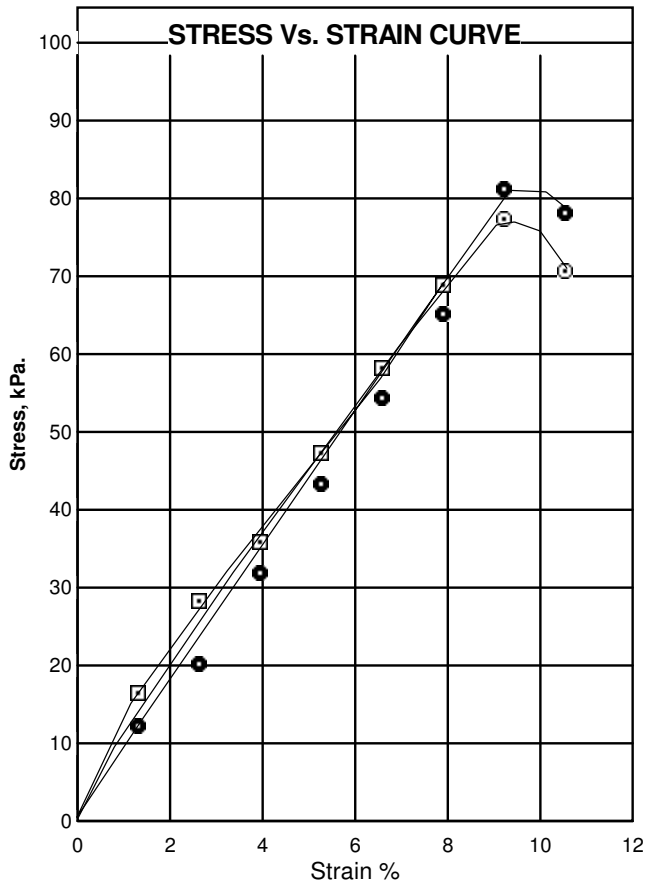


TRIAXIAL TEST CURVES

Job No. : 30796-TP

Sample Number : 150122
Sample Depth : 1.00m.
Bore Hole Number : TP-11

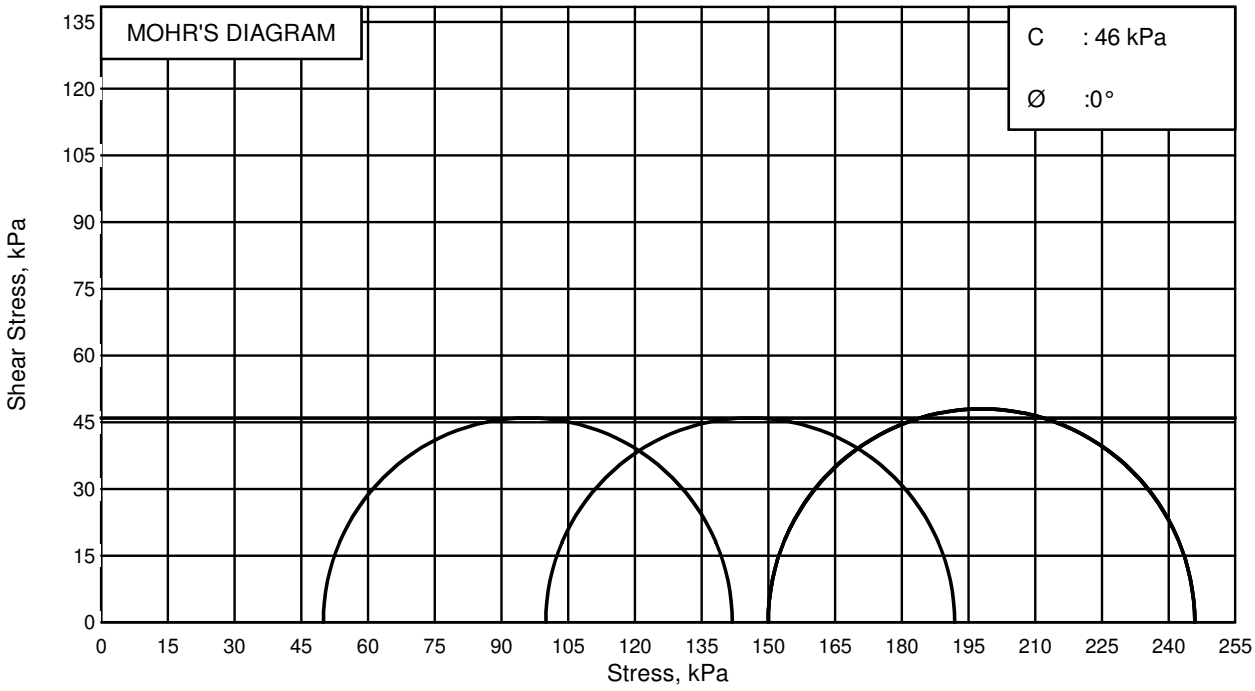
Site :
Type of Test : uu



Mode of Failure :
Specimen : 1 ⊡
Cell Pressure : 50 kPa

Mode of Failure :
Specimen : 2 ⊙
Cell Pressure : 100 kPa

Mode of Failure :
Specimen : 3 ●
Cell Pressure : 150 kPa

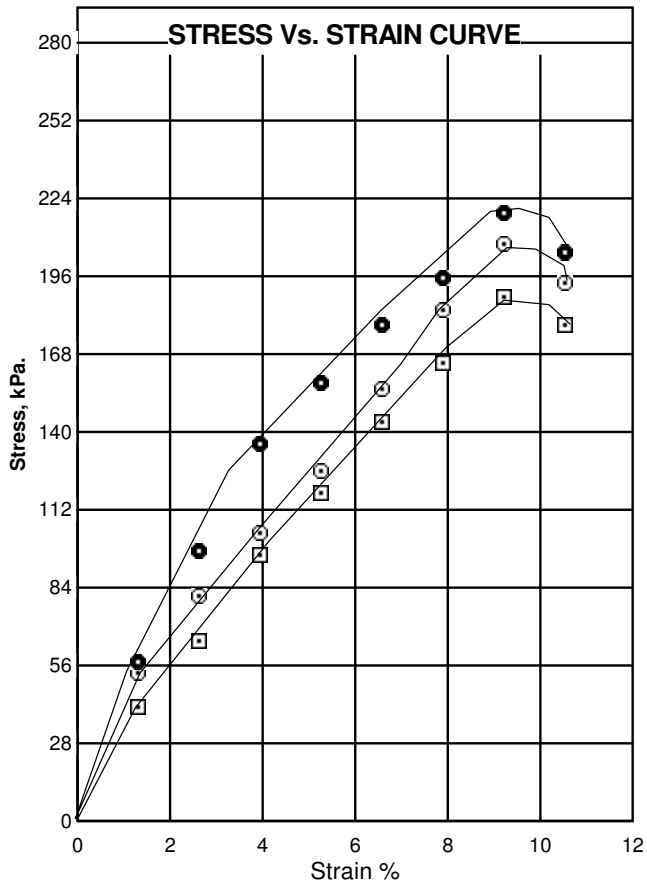


TRIAXIAL TEST CURVES

Job No. : 30796-TP

Sample Number : 150124
Sample Depth : 3.00m.
Bore Hole Number : TP-11

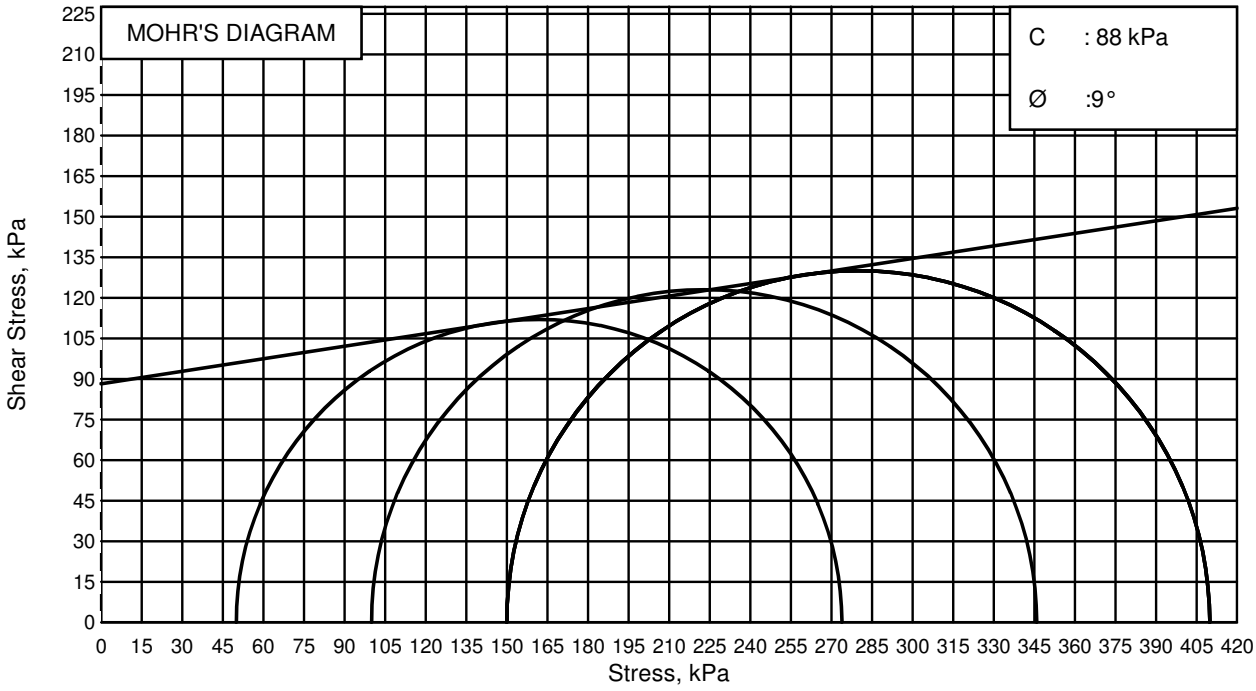
Site :
Type of Test : uu



Mode of Failure :
Specimen : 1 ⊡
Cell Pressure : 50 kPa

Mode of Failure :
Specimen : 2 ⊙
Cell Pressure : 100 kPa

Mode of Failure :
Specimen : 3 ●
Cell Pressure : 150 kPa

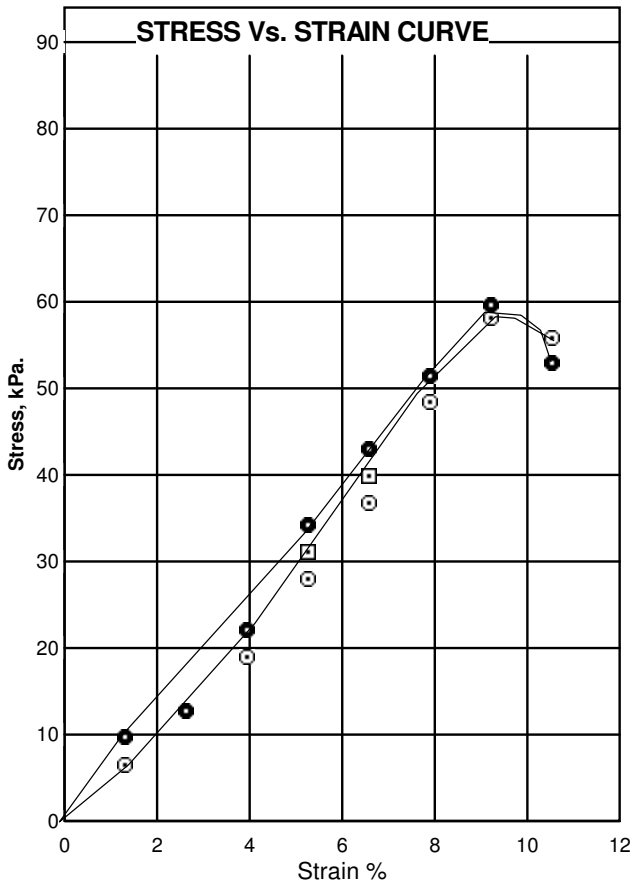


TRIAXIAL TEST CURVES

Job No. : 30796-TP

Sample Number : 106112
Sample Depth : 1.00m.
Bore Hole Number : TP-12

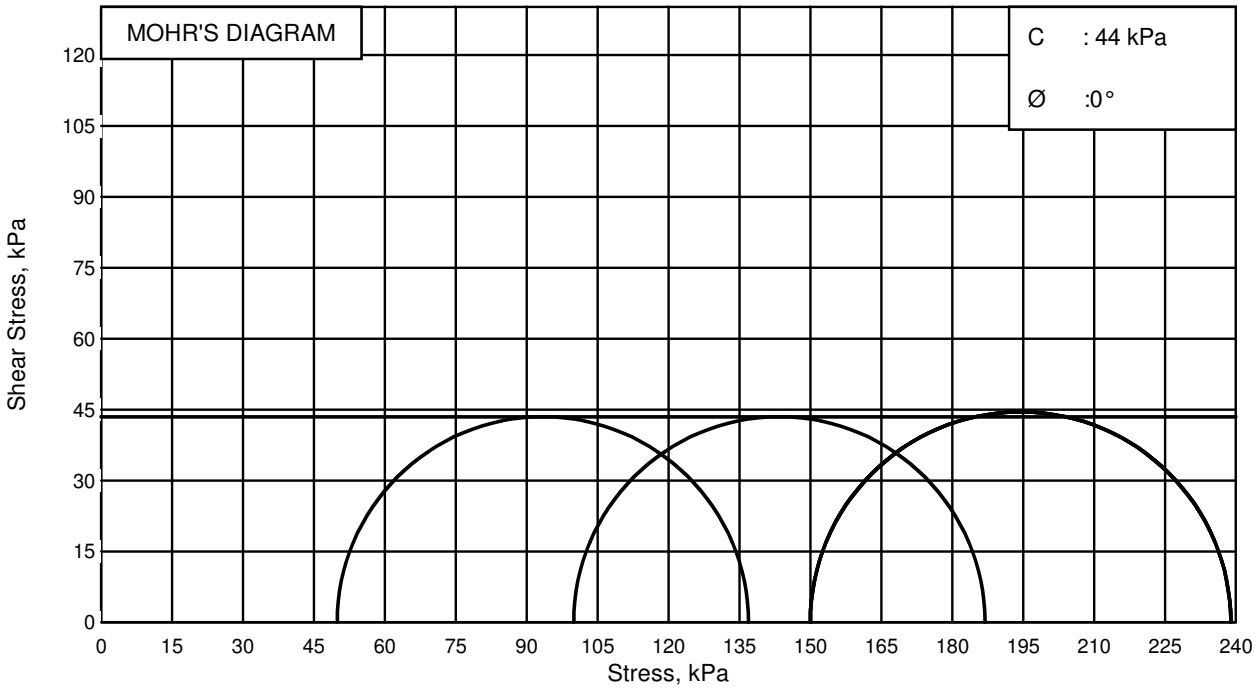
Site :
Type of Test : uu



Mode of Failure :
Specimen : 1 ⊡
Cell Pressure : 50 kPa

Mode of Failure :
Specimen : 2 ⊙
Cell Pressure : 100 kPa

Mode of Failure :
Specimen : 3 ●
Cell Pressure : 150 kPa

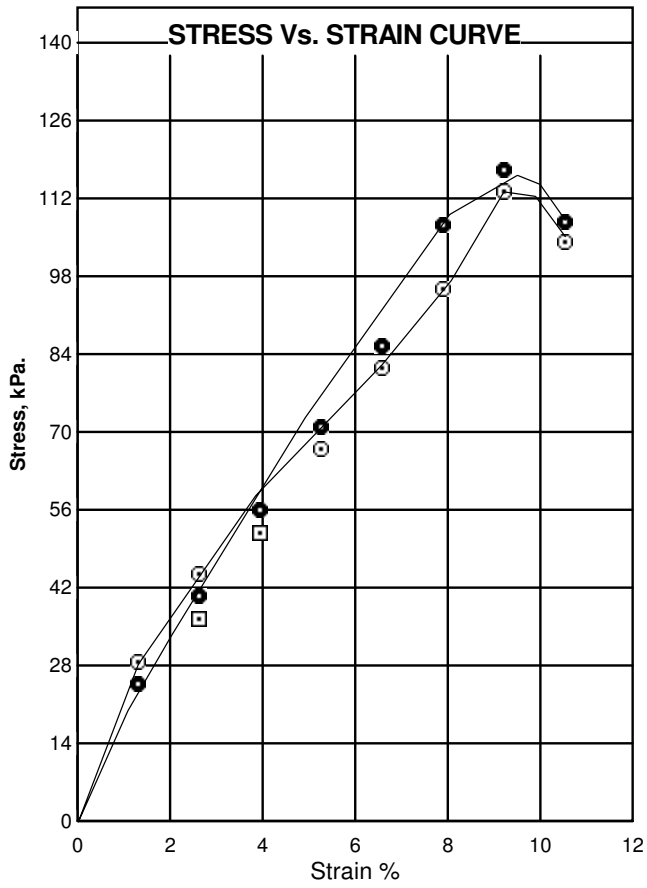


TRIAXIAL TEST CURVES

Job No. : 30796-TP

Sample Number : 106114
Sample Depth : 3.00m.
Bore Hole Number : TP-12

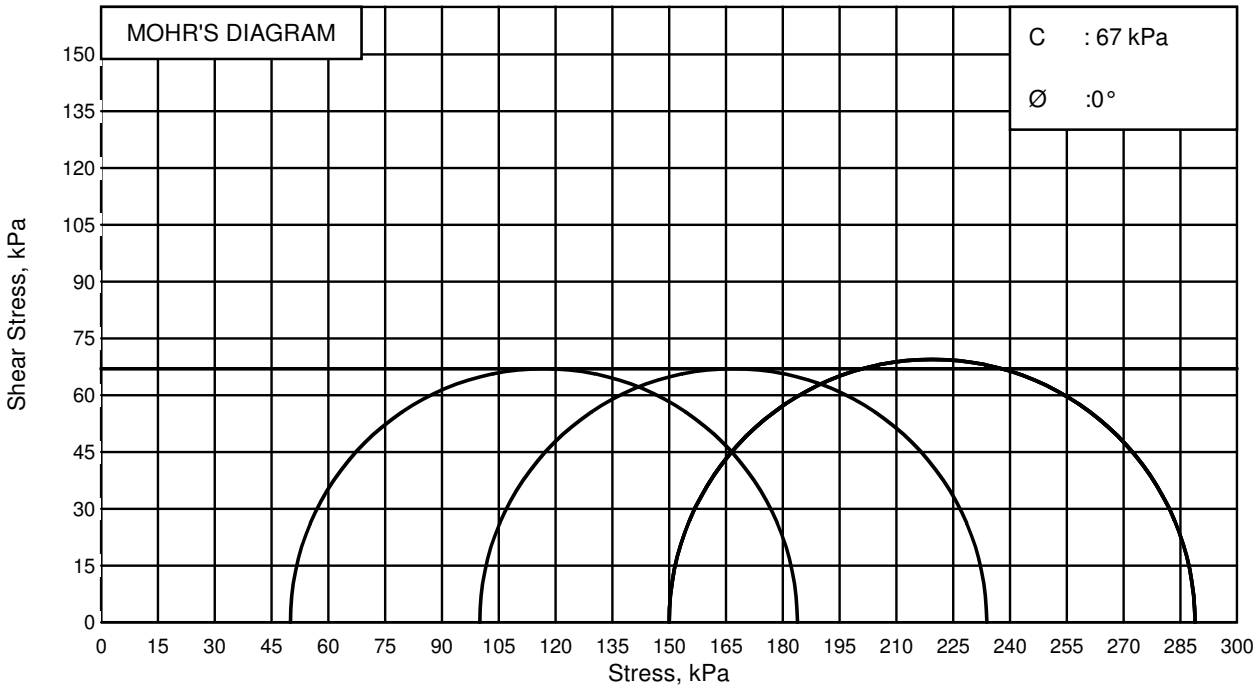
Site :
Type of Test : uu



Mode of Failure :
Specimen : 1 ⊡
Cell Pressure : 50 kPa

Mode of Failure :
Specimen : 2 ⊙
Cell Pressure : 100 kPa

Mode of Failure :
Specimen : 3 ⊙
Cell Pressure : 150 kPa

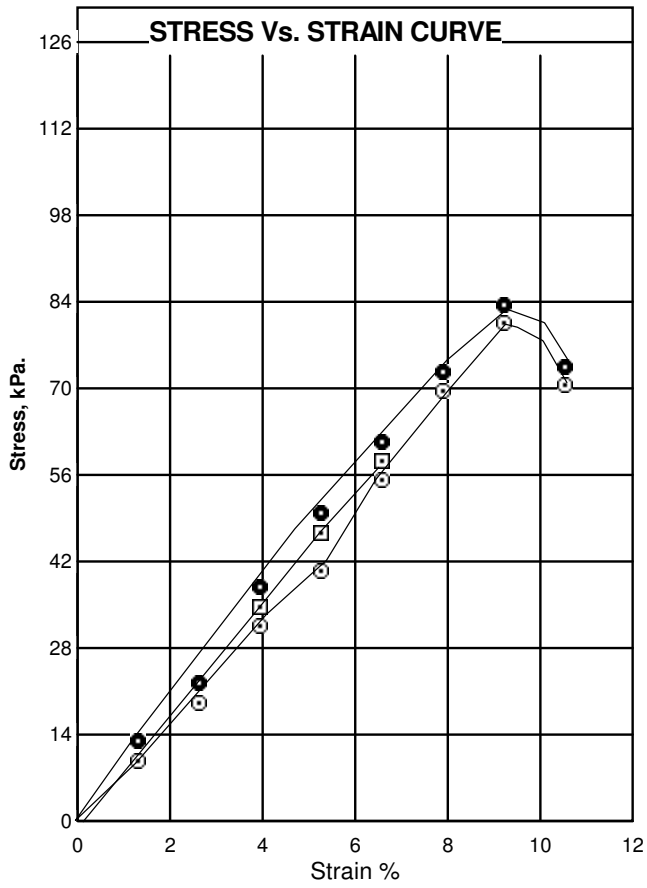


TRIAXIAL TEST CURVES

Job No. : 30796-TP

Sample Number : 105126
Sample Depth : 2.00m.
Bore Hole Number : TP-14

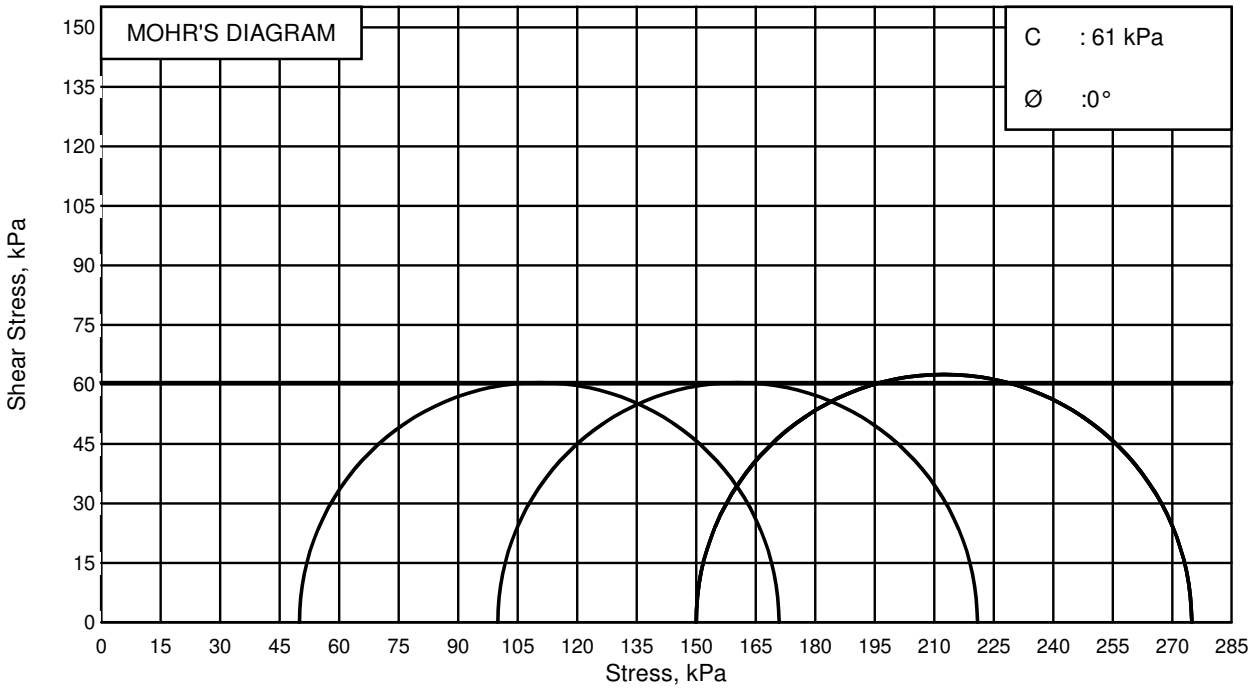
Site :
Type of Test : uu



Mode of Failure :
Specimen : 1 ⊡
Cell Pressure : 50 kPa

Mode of Failure :
Specimen : 2 ⊙
Cell Pressure : 100 kPa

Mode of Failure :
Specimen : 3 ⊙
Cell Pressure : 150 kPa

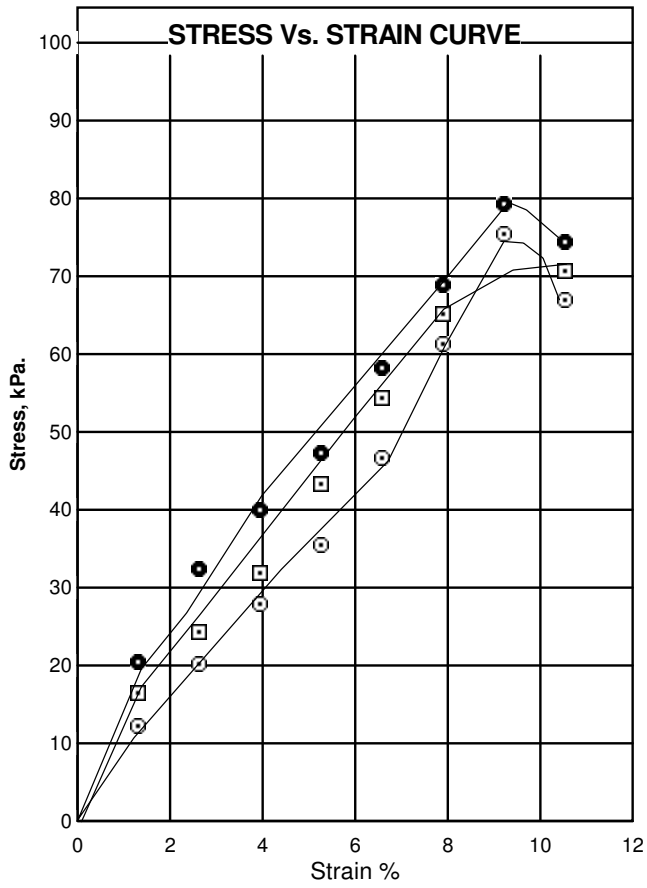


TRIAXIAL TEST CURVES

Job No. : 30796-TP

Sample Number : 106108
Sample Depth : 1.00m.
Bore Hole Number : TP-15

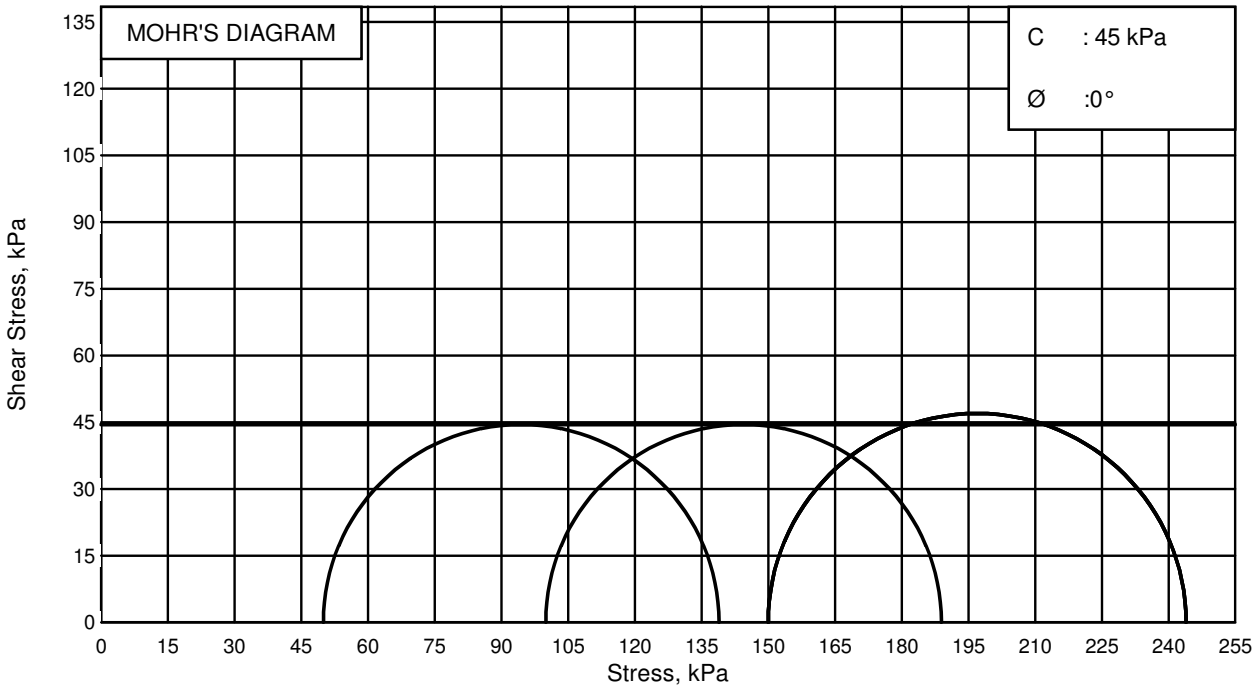
Site :
Type of Test : uu



Mode of Failure :
Specimen : 1 ⊡
Cell Pressure : 50 kPa

Mode of Failure :
Specimen : 2 ⊙
Cell Pressure : 100 kPa

Mode of Failure :
Specimen : 3 ●
Cell Pressure : 150 kPa

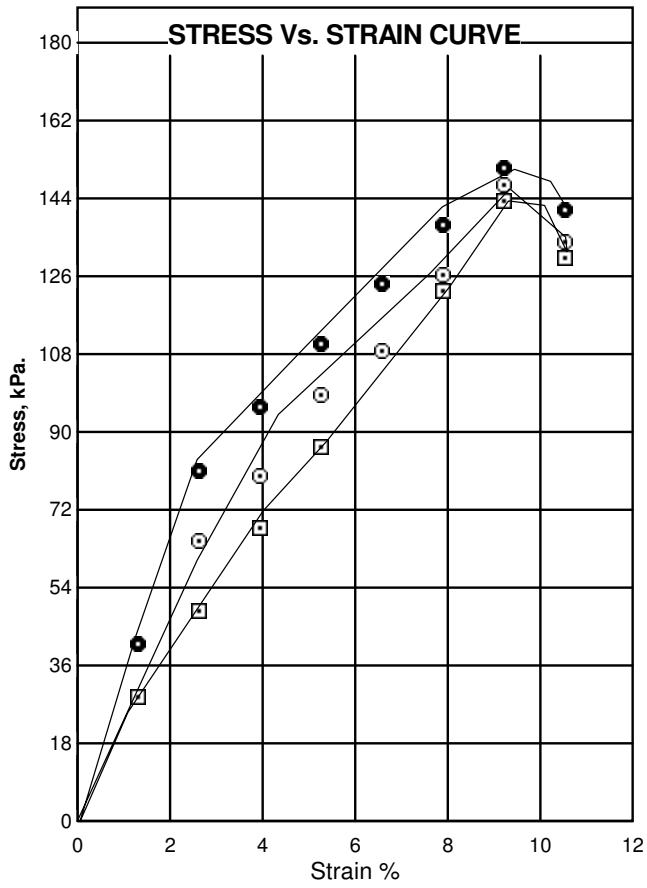


TRIAXIAL TEST CURVES

Job No. : 30796-TP

Sample Number : 106110
Sample Depth : 3.00m.
Bore Hole Number : TP-15

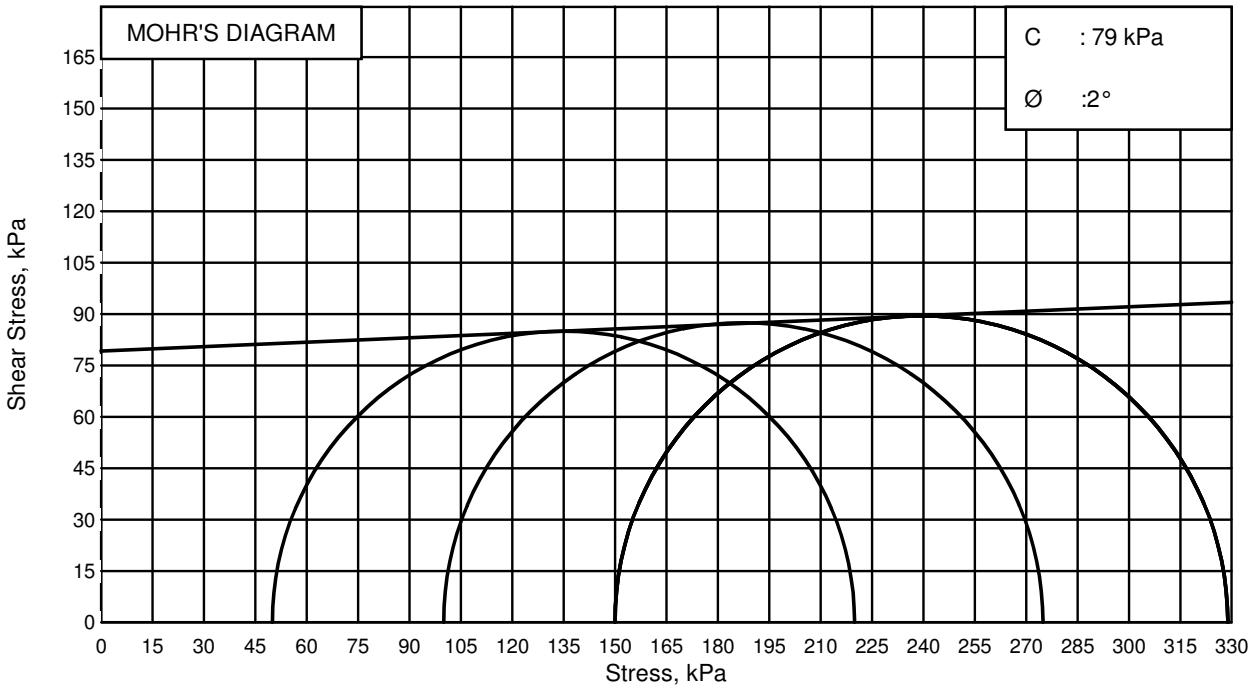
Site :
Type of Test : uu



Mode of Failure :
Specimen : 1
Cell Pressure : 50 kPa

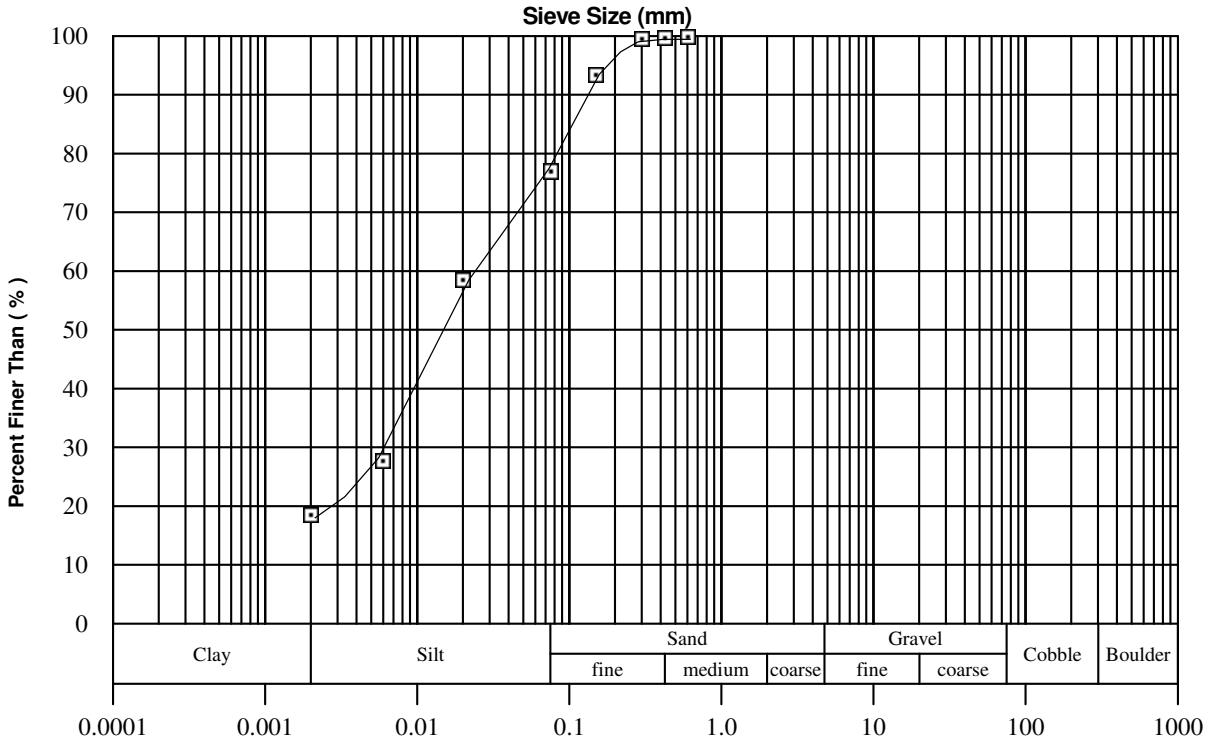
Mode of Failure :
Specimen : 2
Cell Pressure : 100 kPa

Mode of Failure :
Specimen : 3
Cell Pressure : 150 kPa

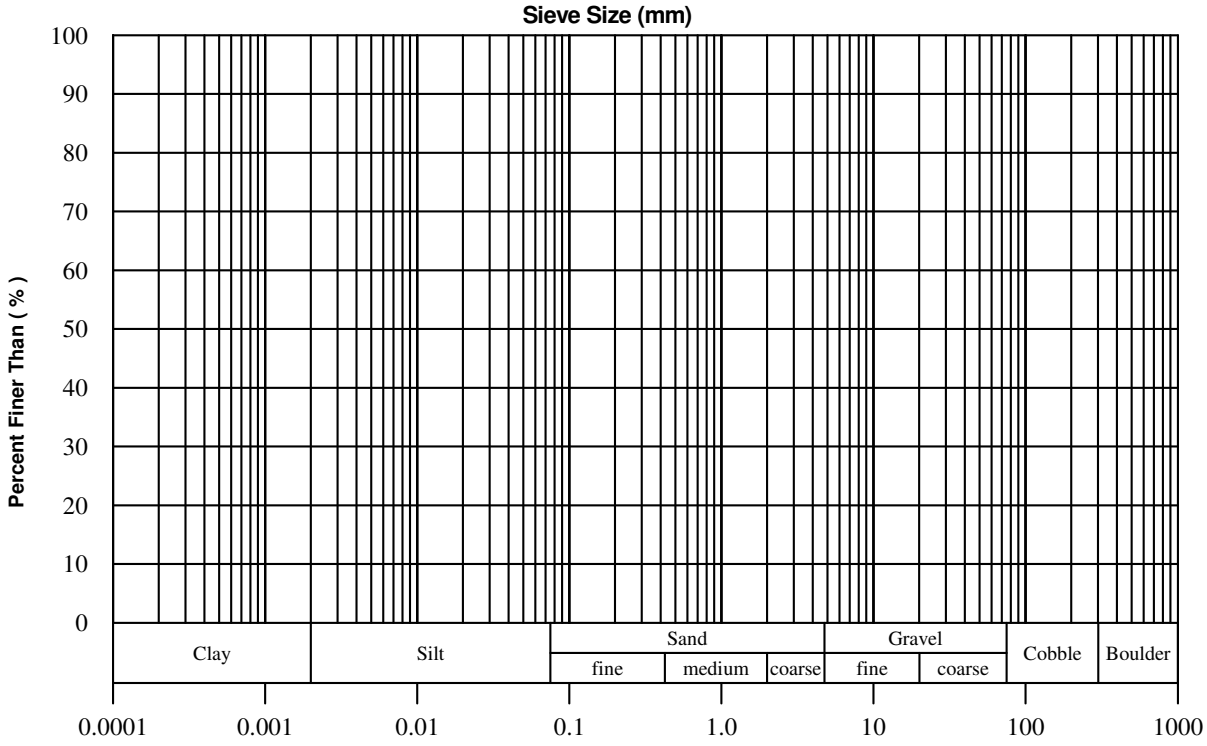


TRIAXIAL TEST CURVES

Job No. : 30796-TP



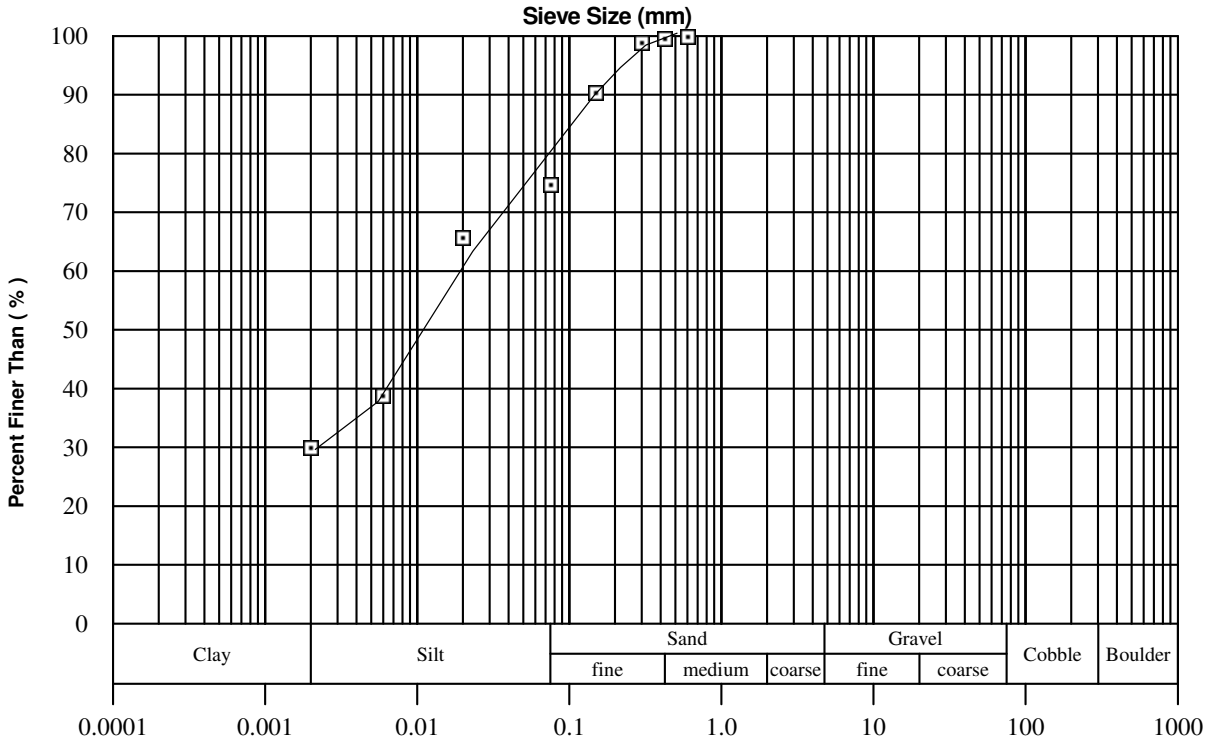
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	27	170667	4.50-4.95		23.00	58.52	18.48



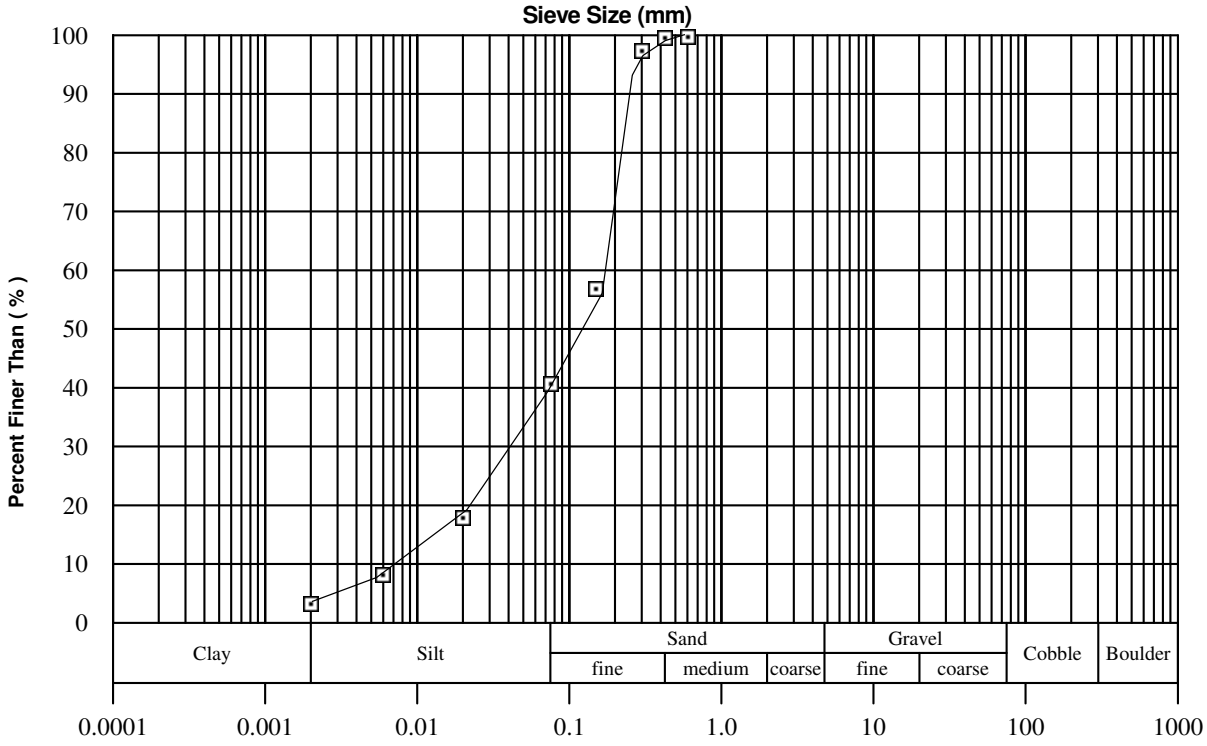
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



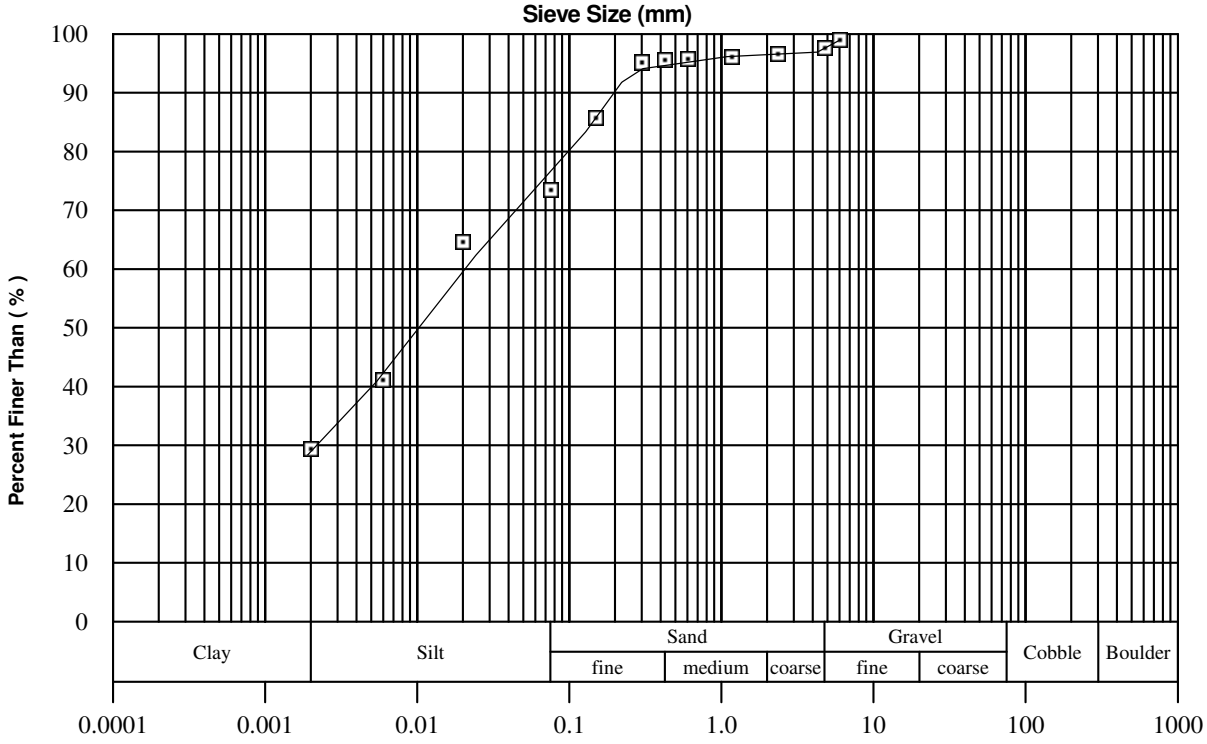
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	28	160771	1.00-1.45		25.30	44.82	29.88



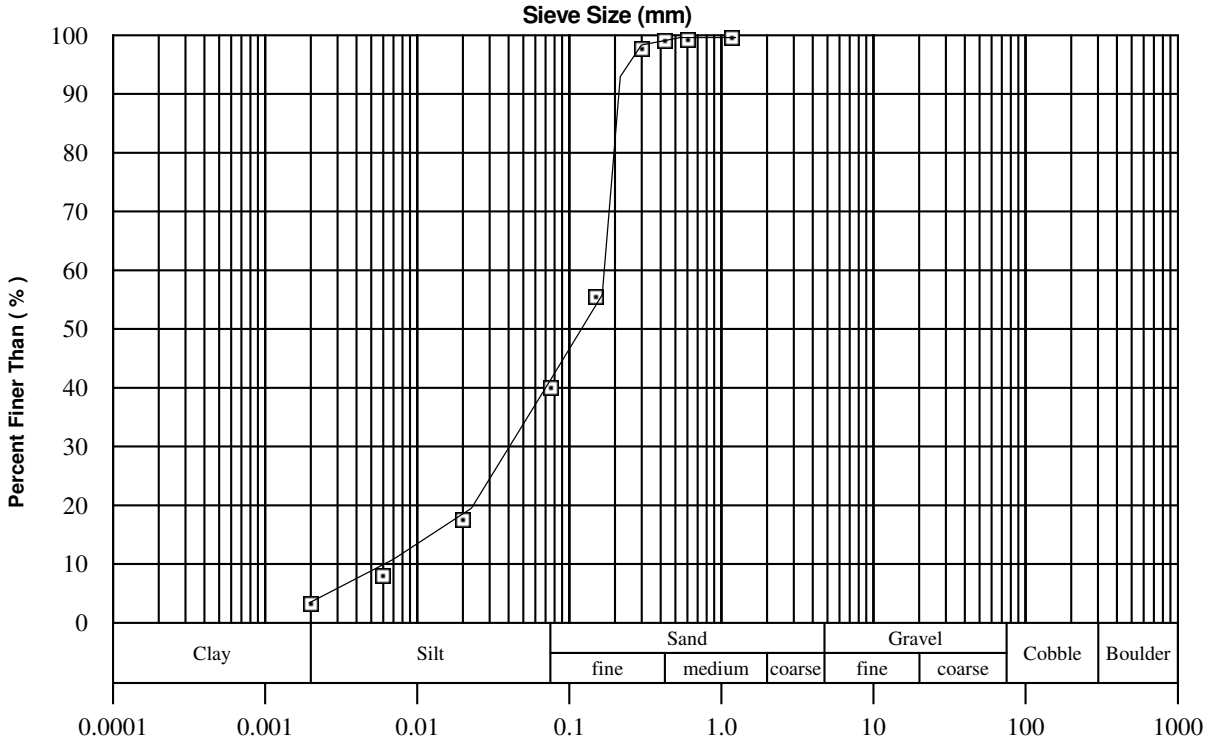
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	28	160778	6.00-6.45		59.30	37.44	3.26

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



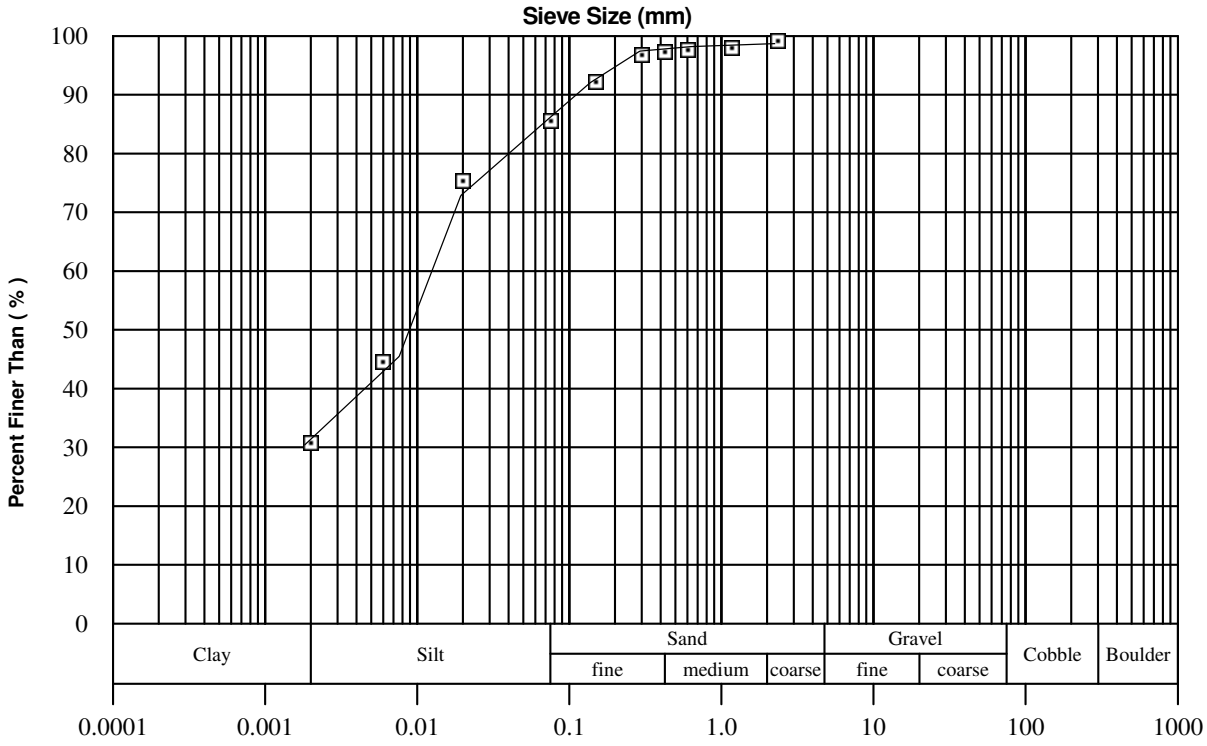
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	29	130154	2.00-2.45	2.40	24.10	44.10	29.40



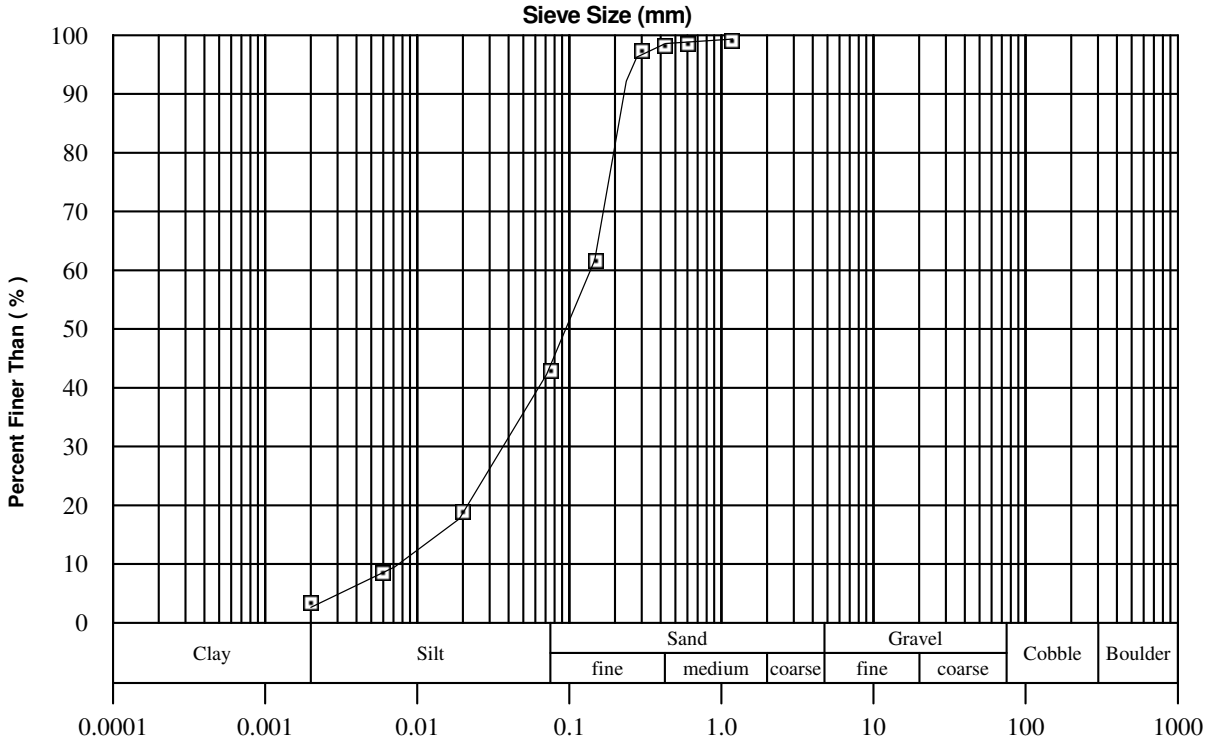
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	29	130160	7.50-7.95		59.90	36.89	3.21

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



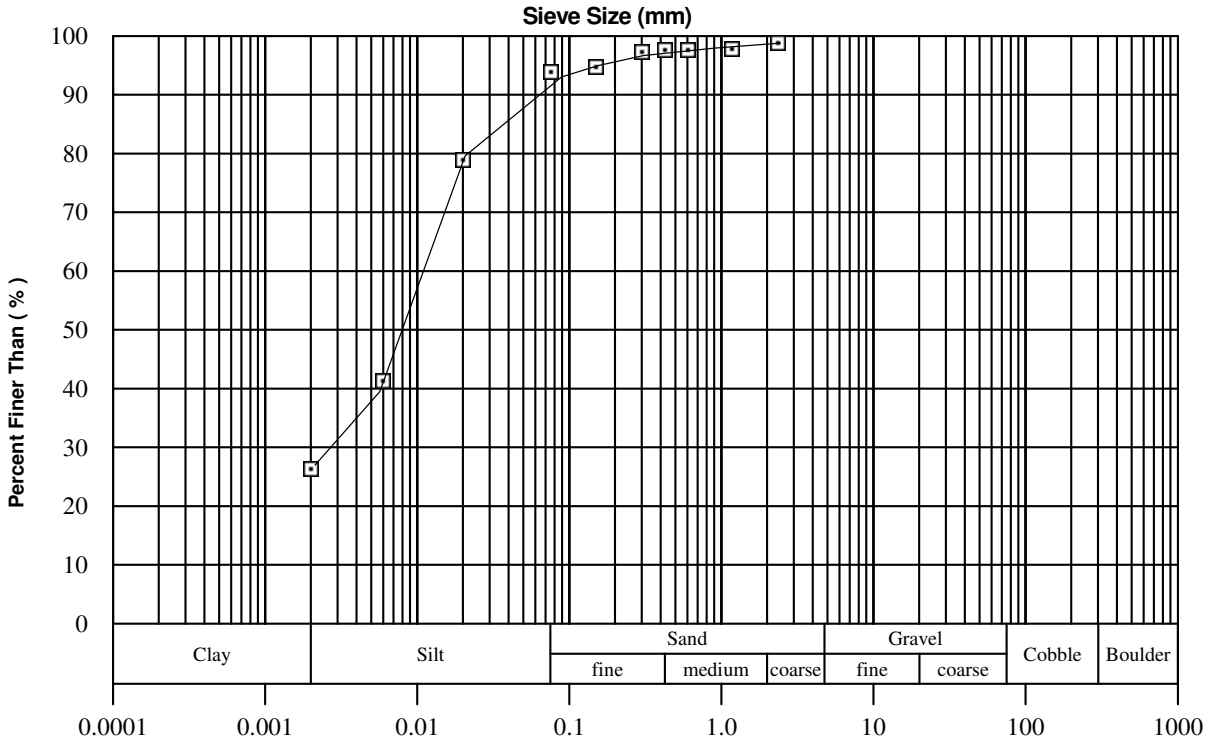
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	30	186111	1.00-1.45		14.40	54.78	30.82



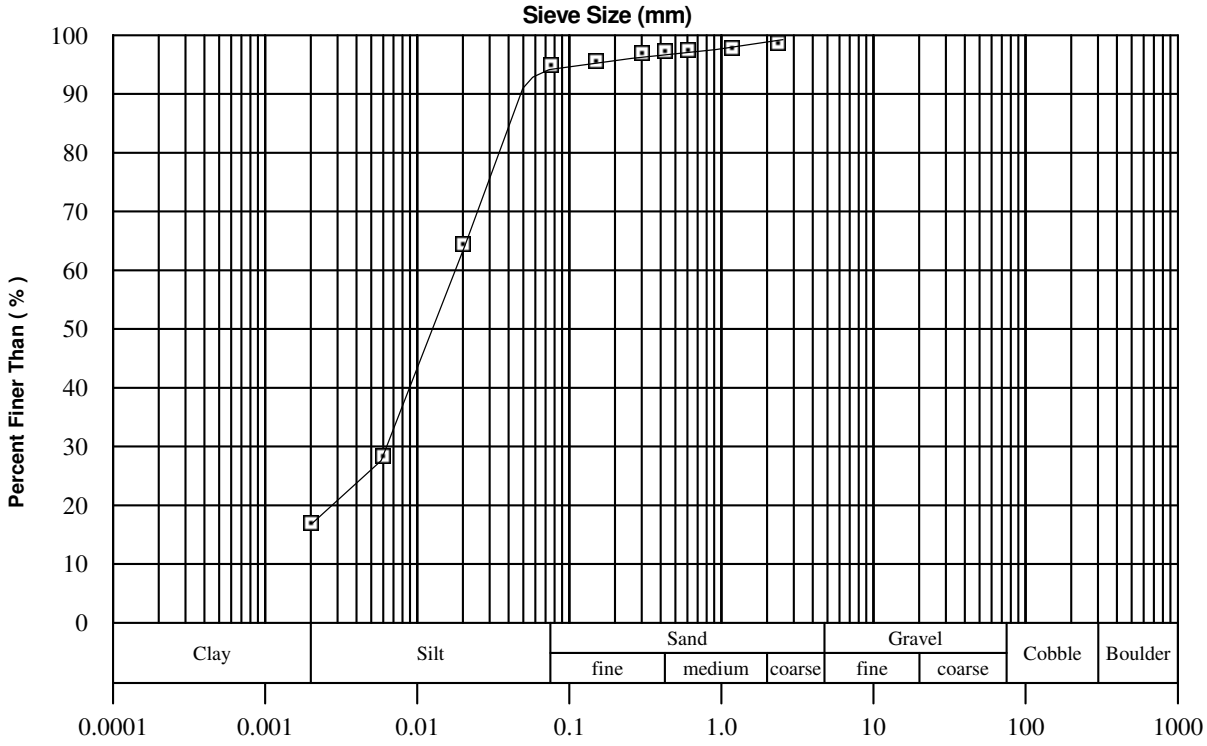
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	30	180118	6.00-6.45		57.00	39.56	3.44

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



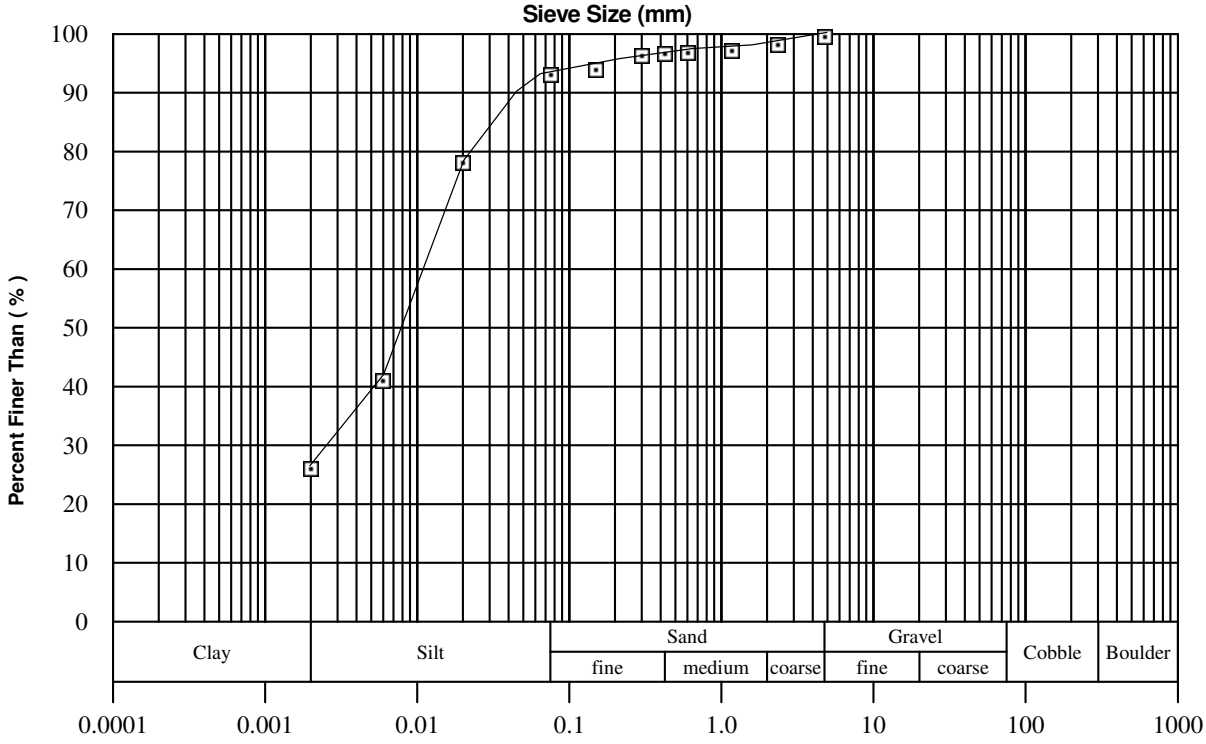
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	TP-1	-	2.00		6.10	67.61	26.29



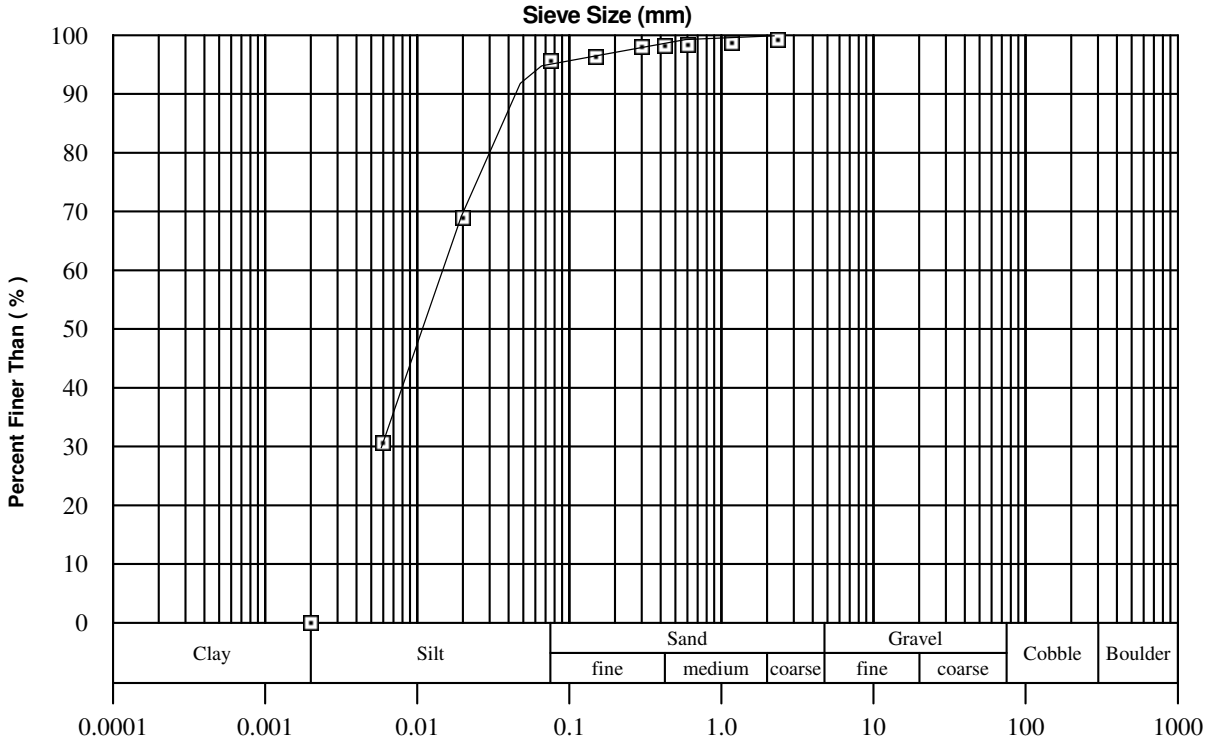
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	TP-1	--	4.00		5.00	77.90	17.10

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



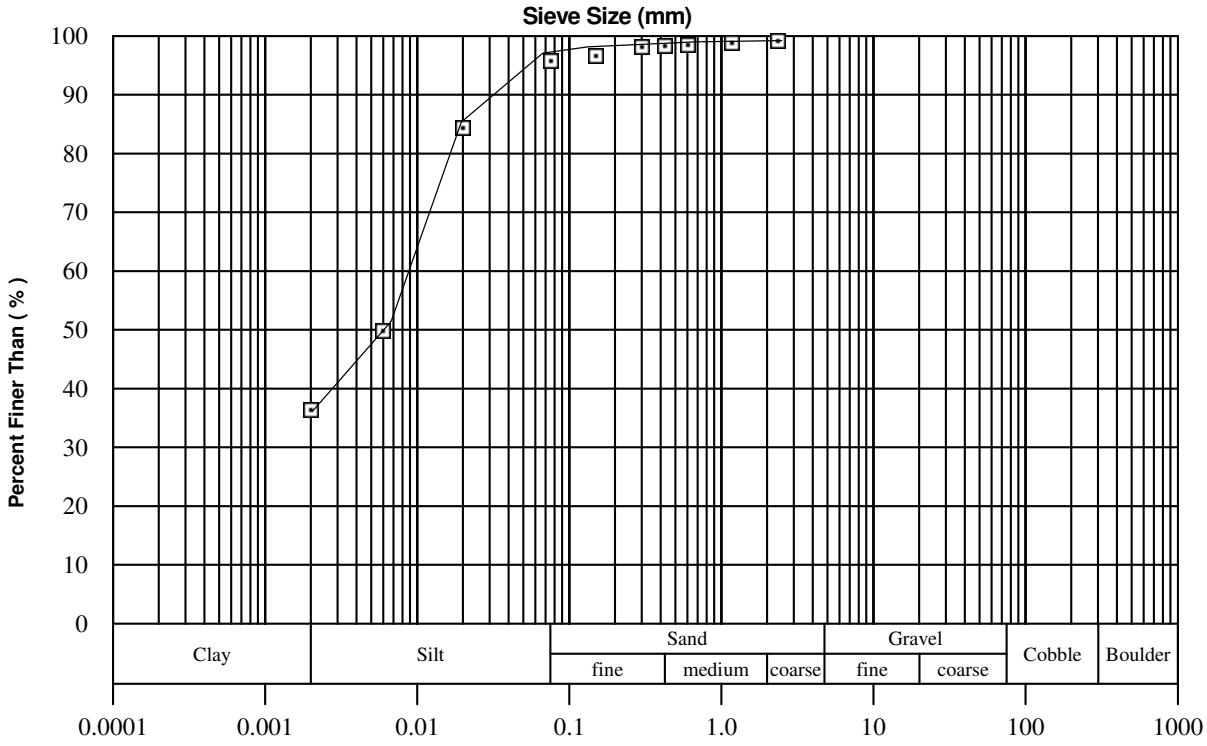
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	TP-2	-	2.00	0.50	6.40	67.03	26.07



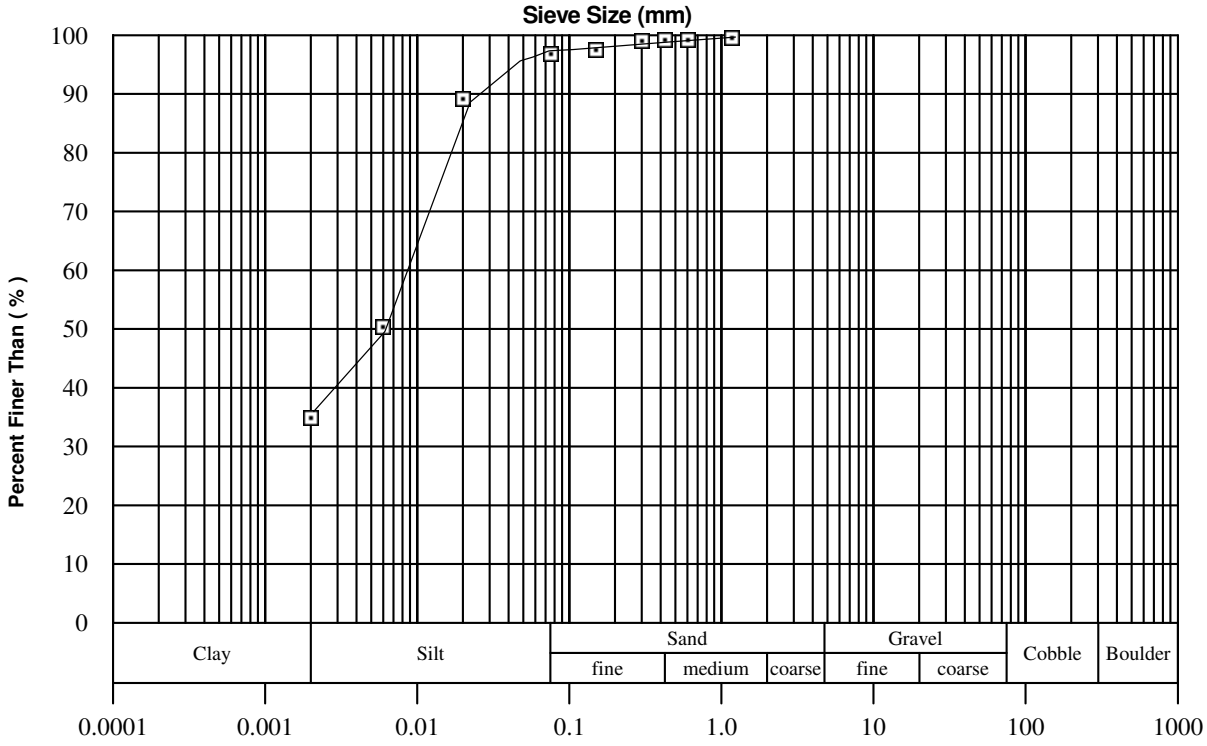
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	TP-2	--	4.00		4.30	95.70	

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



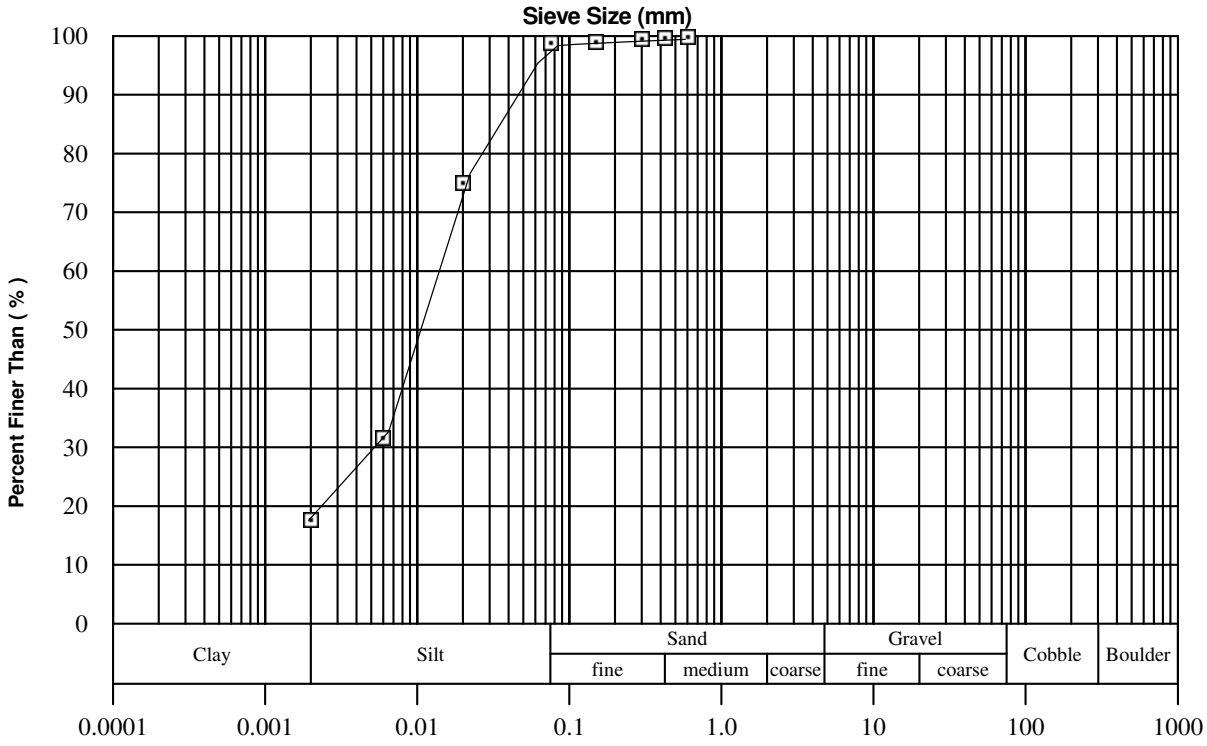
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	TP-3	-	2.00		4.10	59.46	36.44



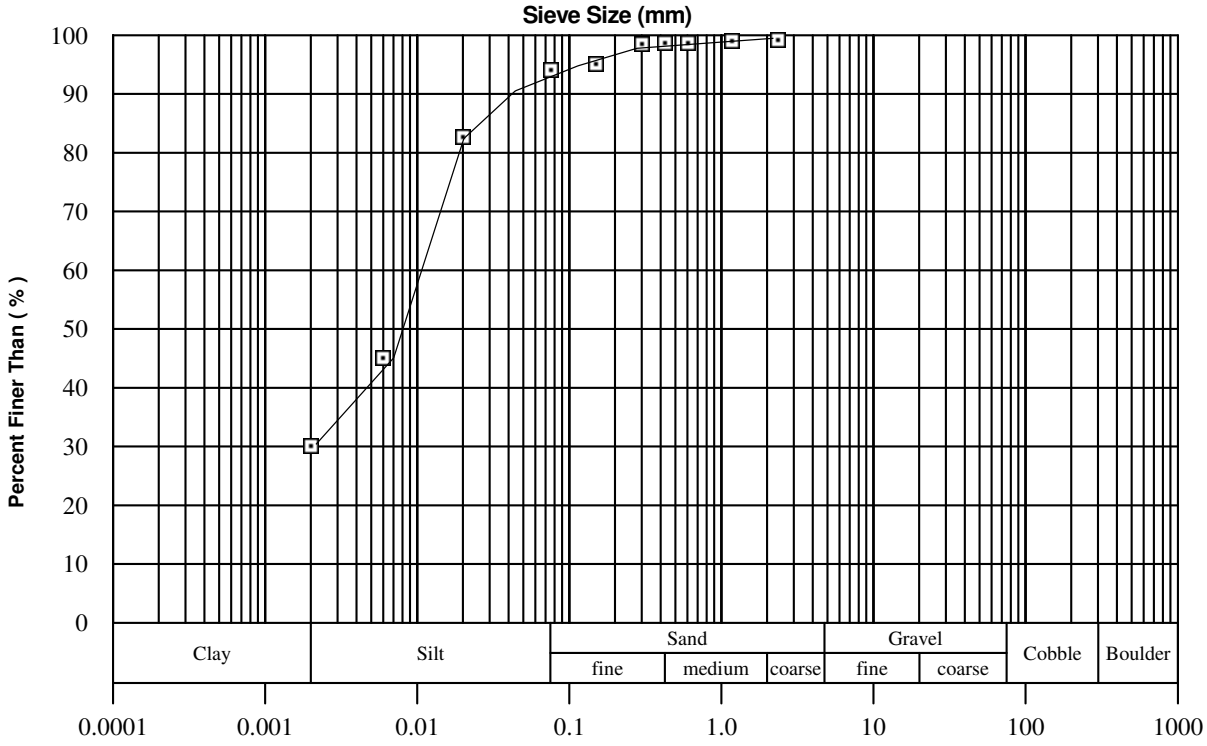
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	TP-3	--	100.00		3.10	62.02	34.88

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



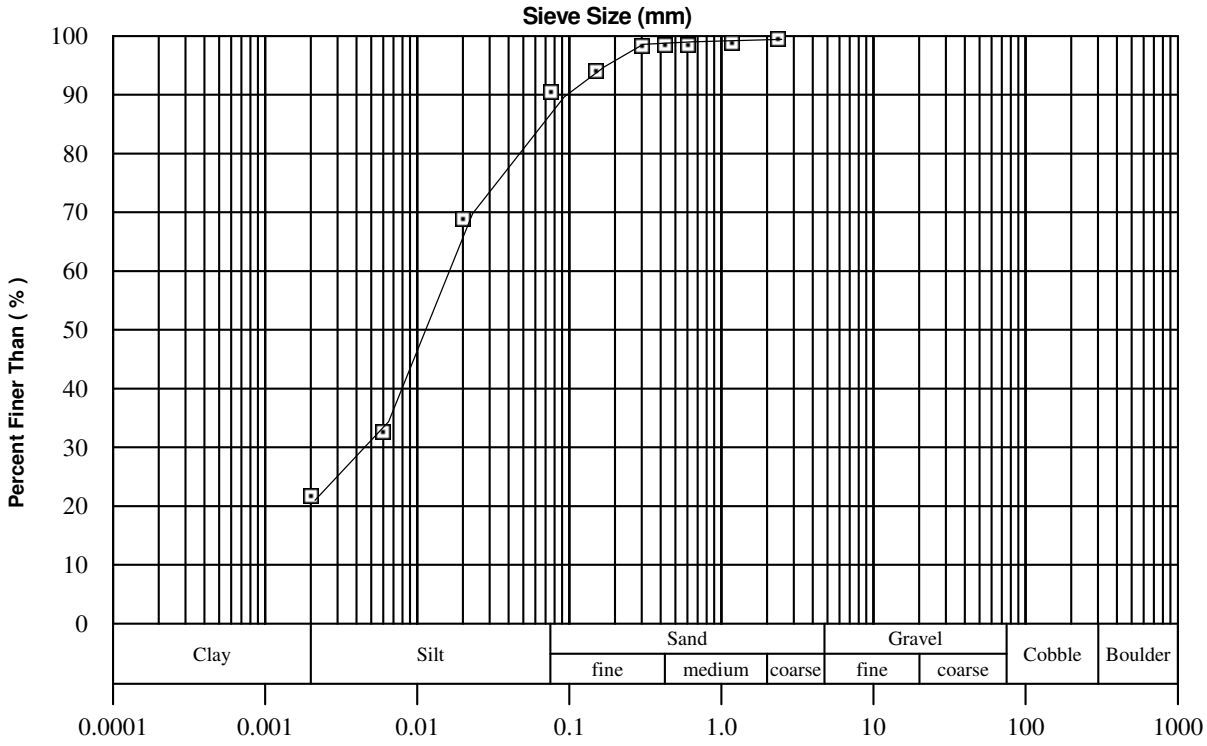
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	TP-4	-	2.00		1.20	81.02	17.78



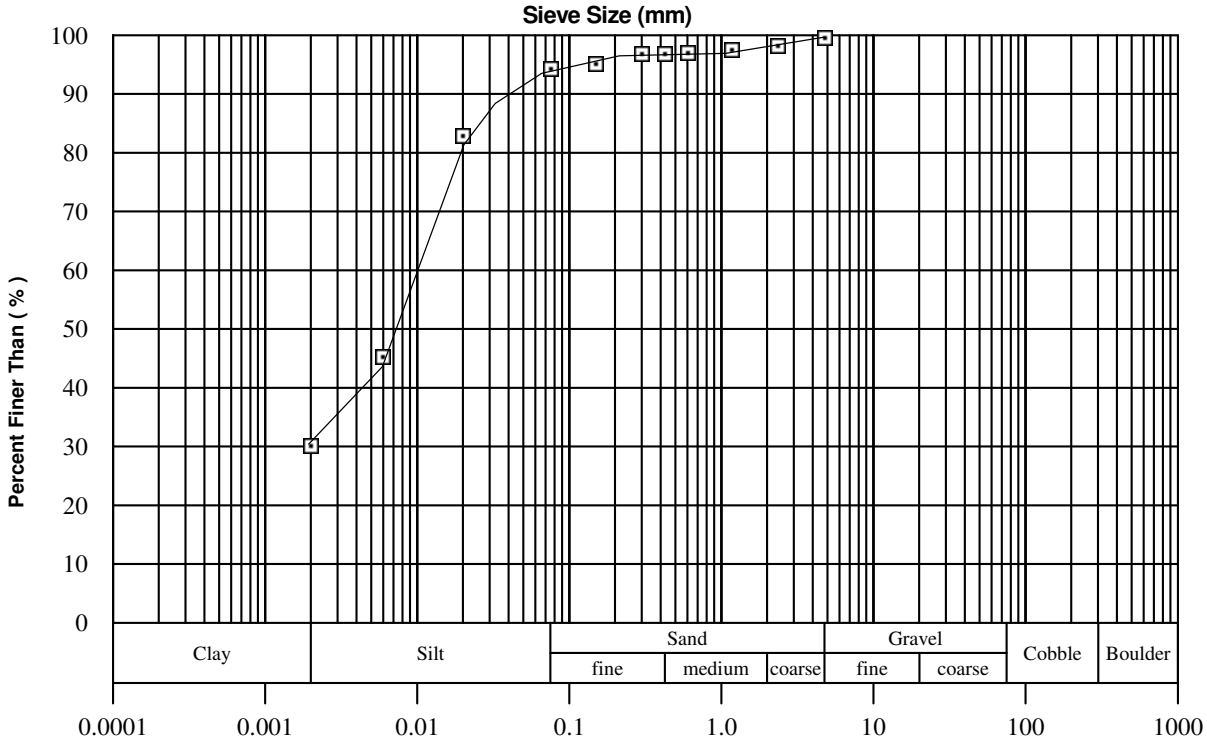
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	TP-5	-	1.00		5.90	63.99	30.11

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



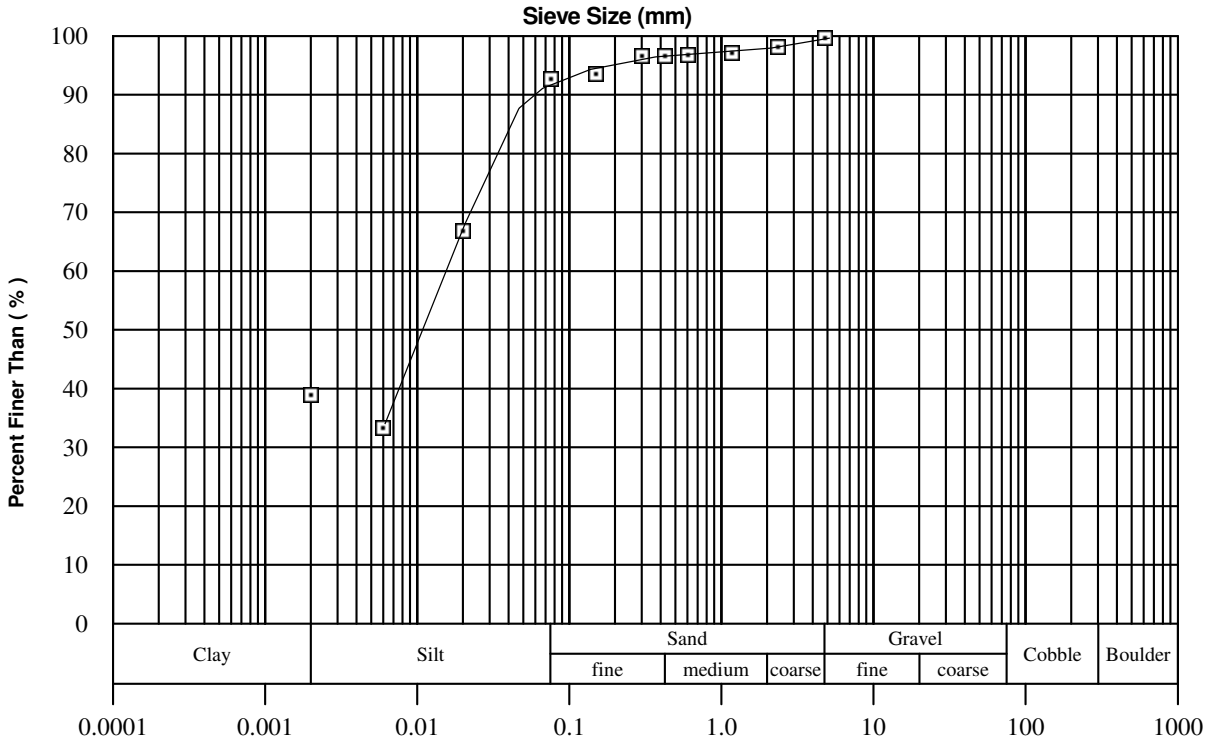
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	TP-5	--	3.00		9.40	68.86	21.74



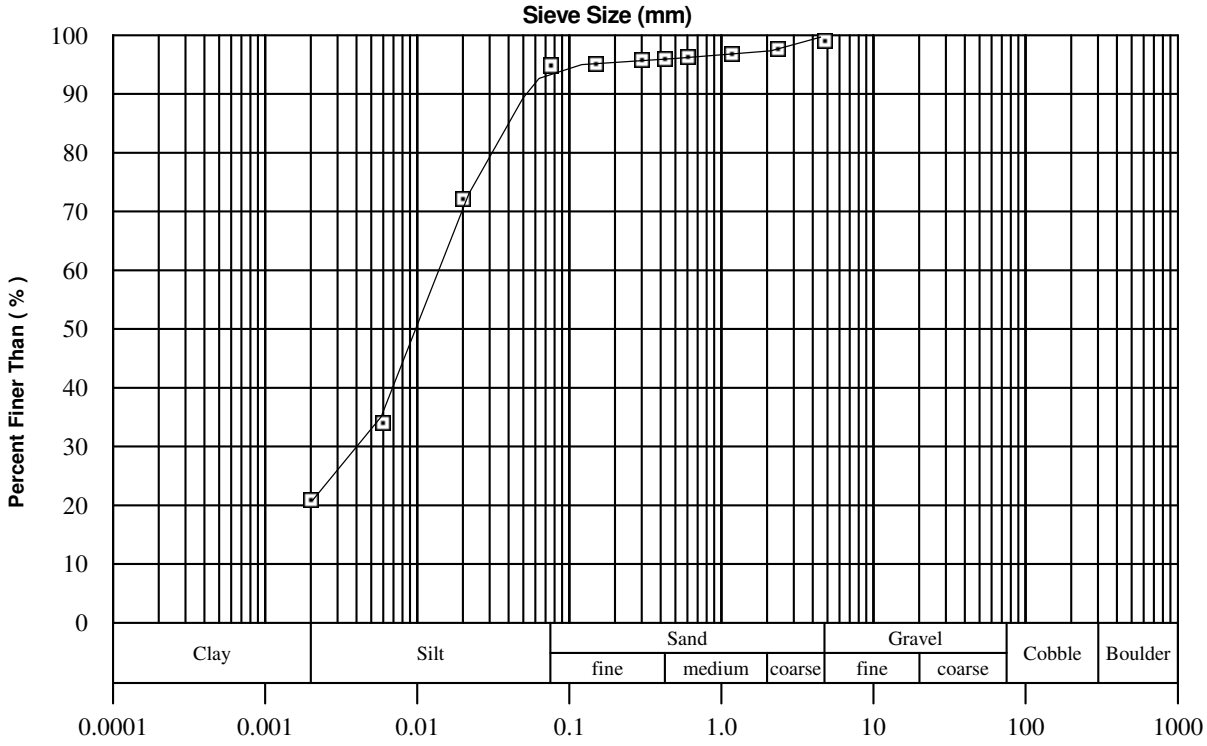
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	TP-6	-	1.00	0.50	5.20	64.12	30.18

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



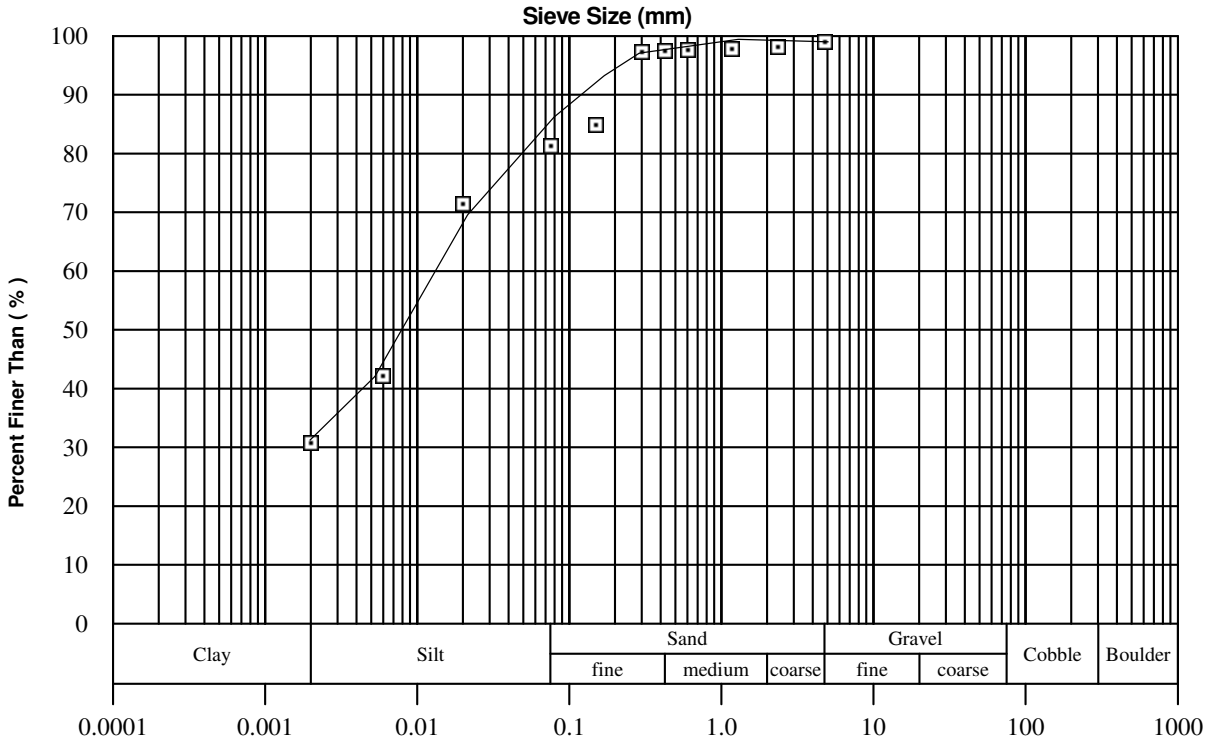
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	TP-6	--	3.00	0.30	6.90	53.82	38.98



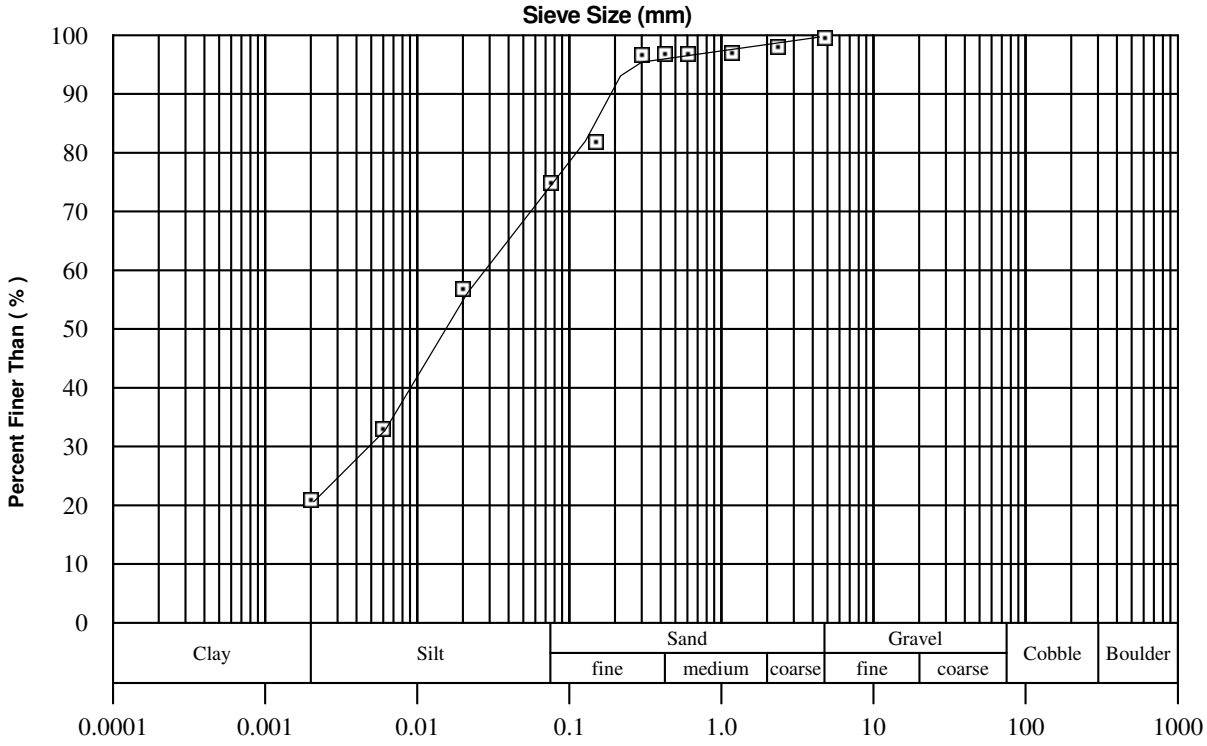
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	TP-7	-	2.00	0.90	4.20	74.02	20.88

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



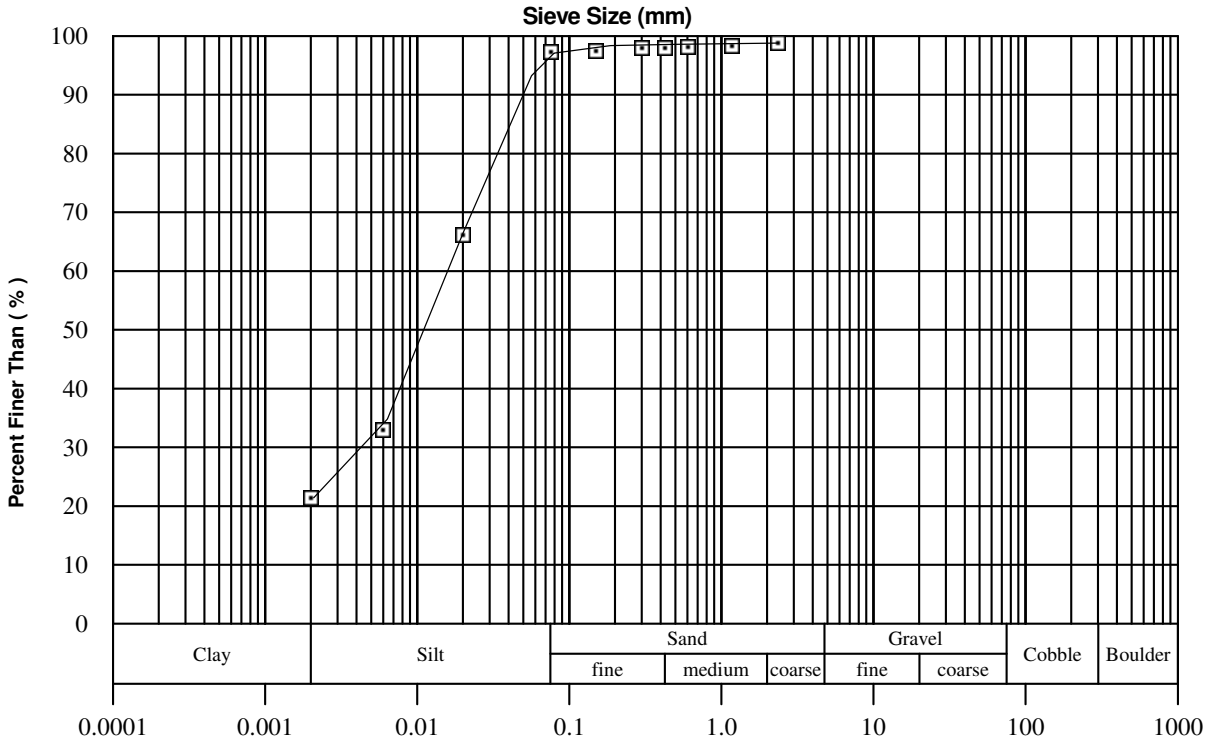
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	TP-8	-	2.00	1.00	17.70	50.41	30.89



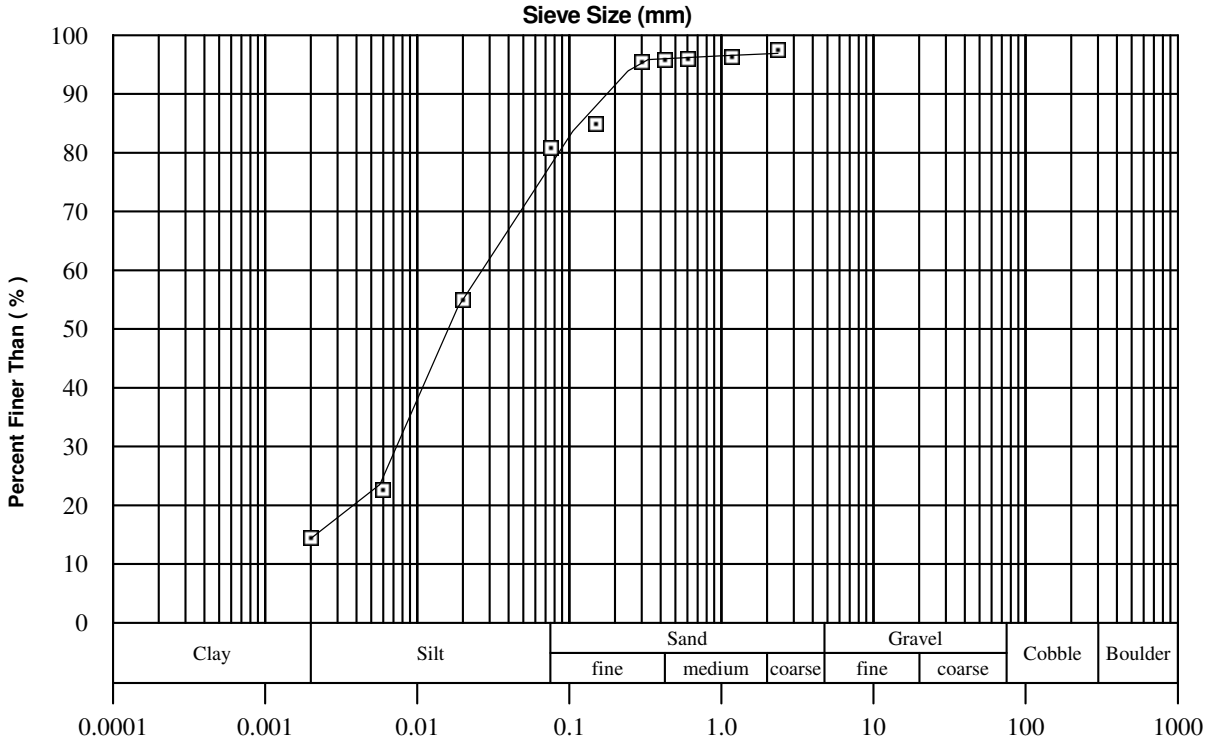
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	TP-8	--	3.00	0.50	24.60	53.93	20.97

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



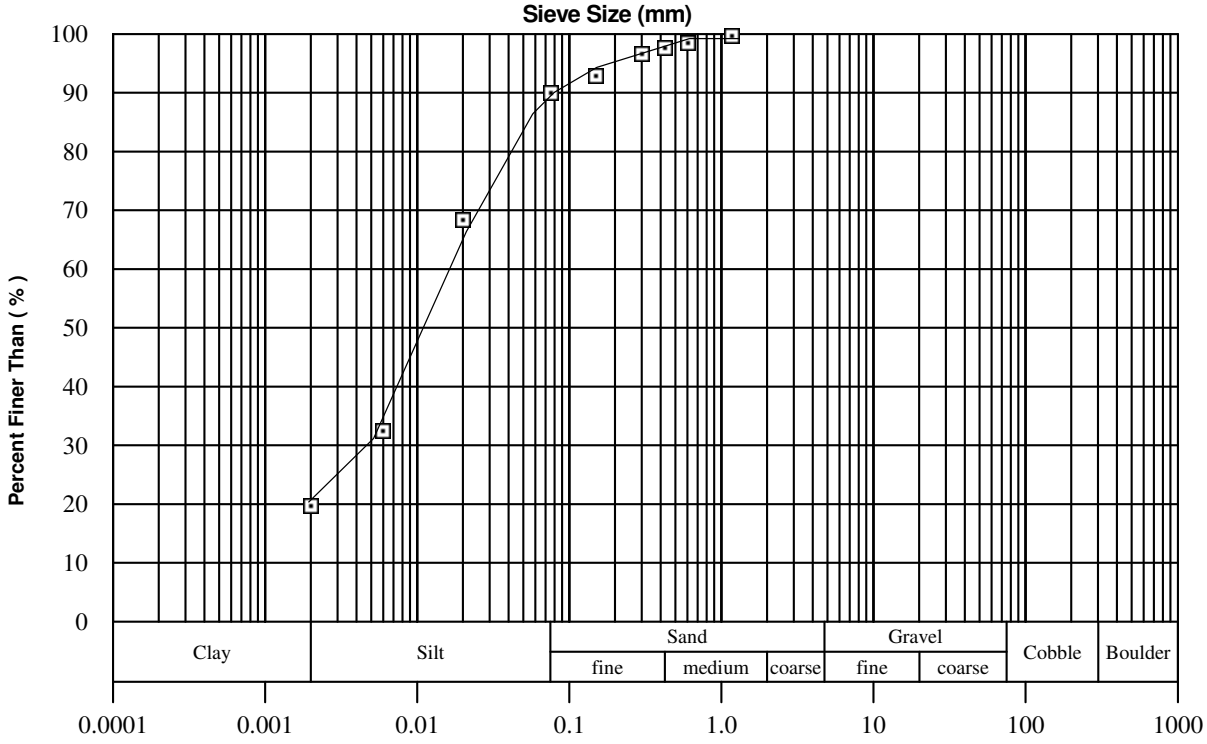
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	TP-9	-	1.00		2.70	75.89	21.41



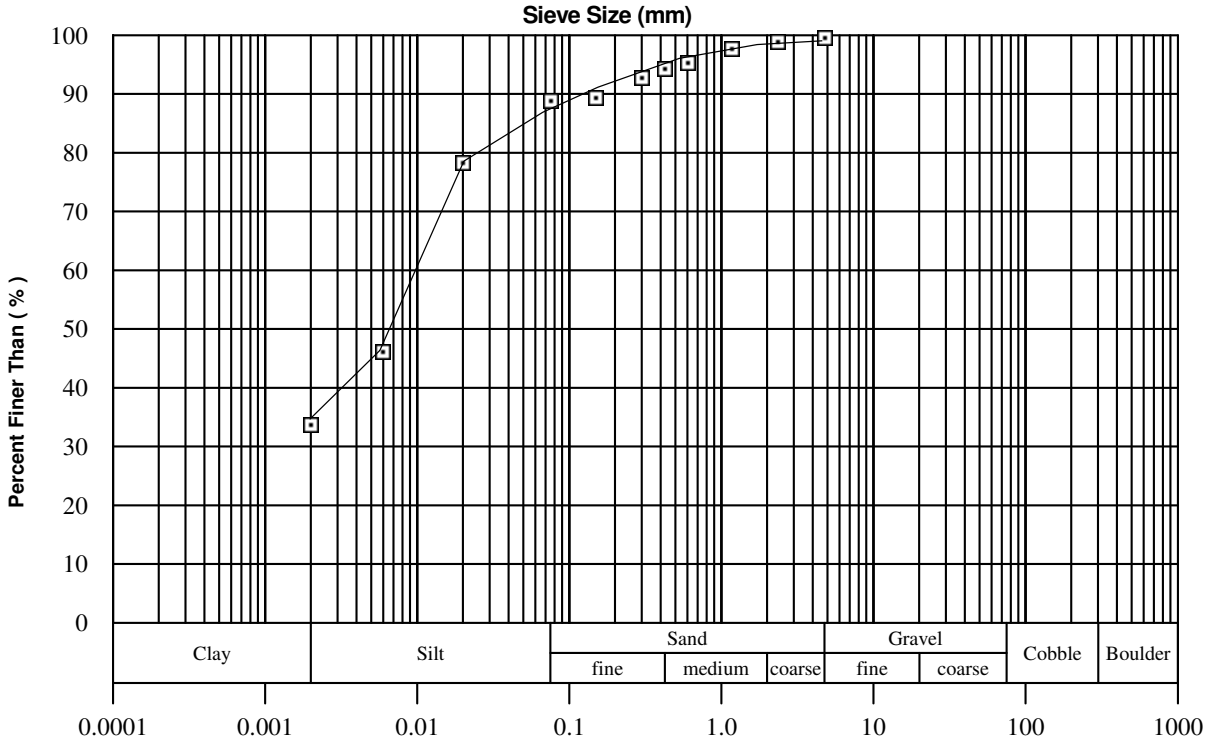
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	TP-9	--	3.00		19.20	66.26	14.54

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



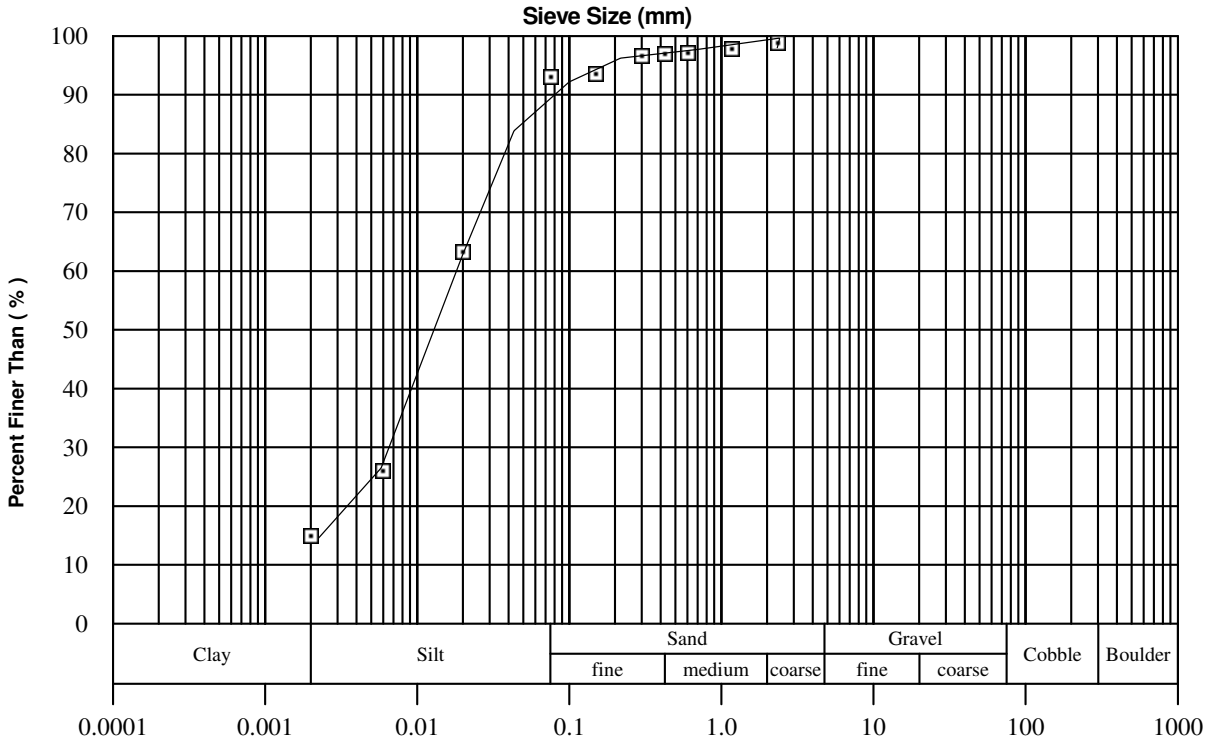
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	TP-10	-	3.00		9.90	70.28	19.82



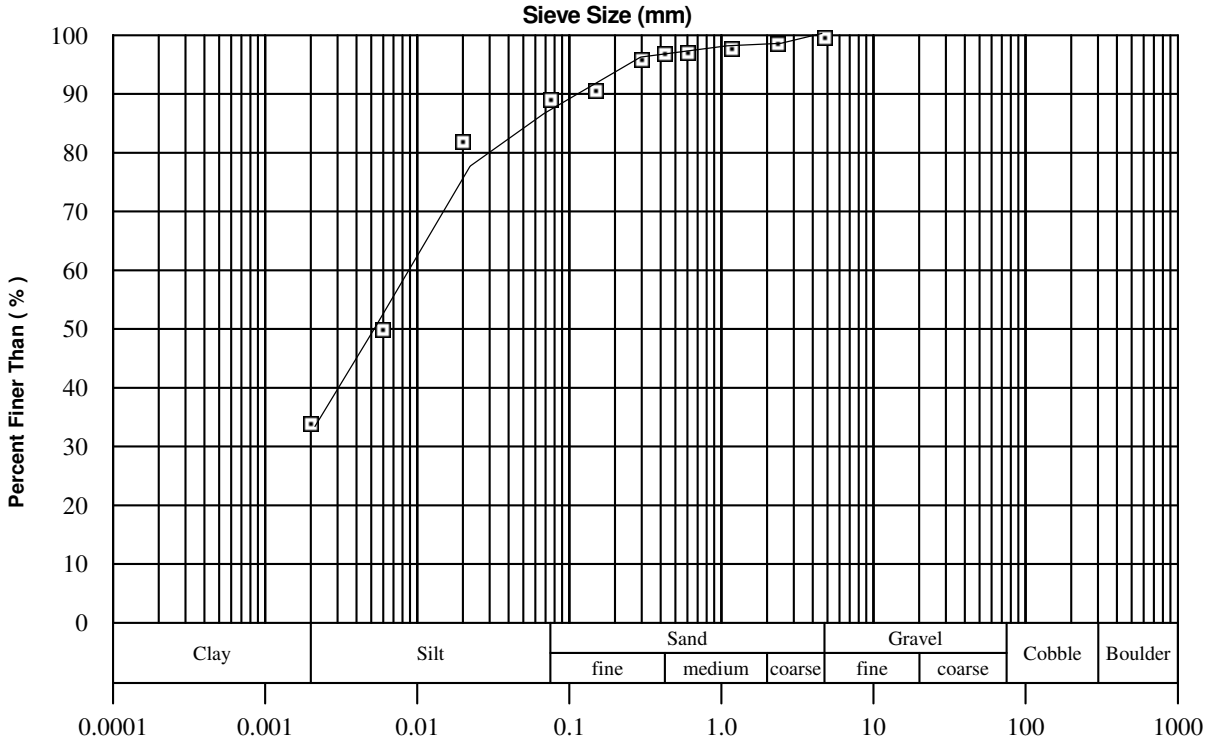
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	TP-11	--	1.00	0.50	10.60	55.12	33.78

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



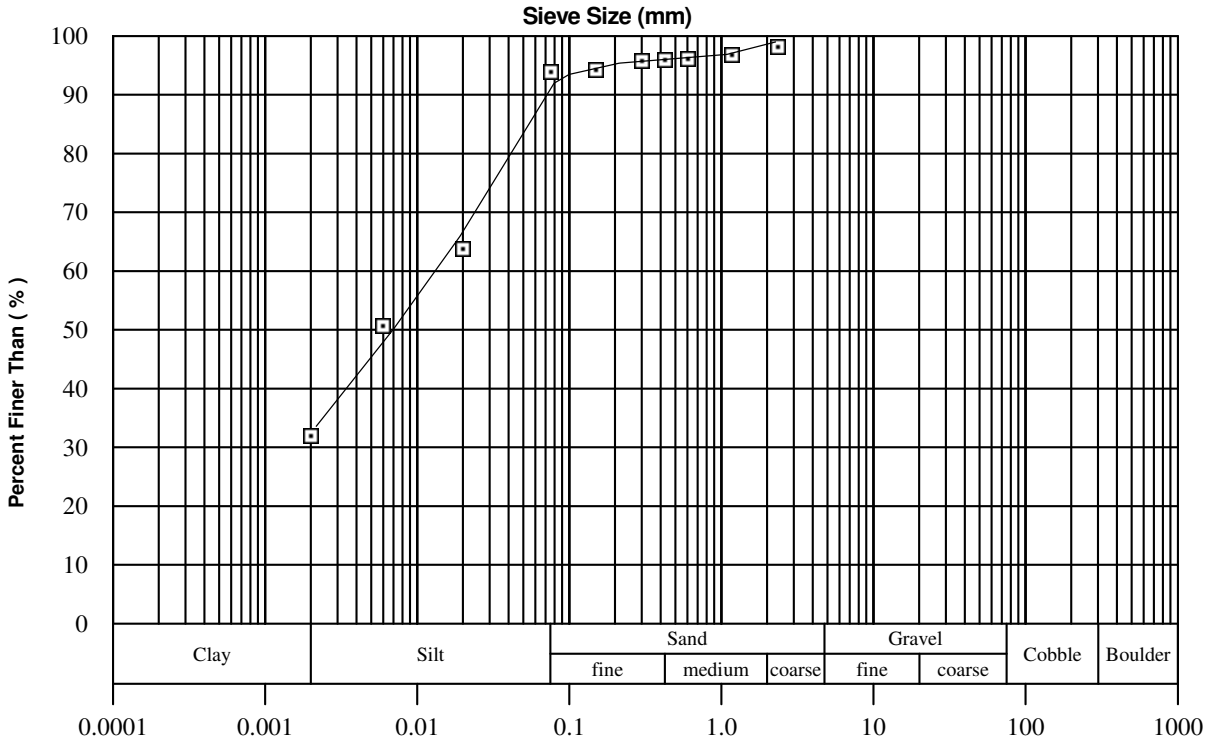
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	TP-11	---	3.00		6.90	78.20	14.90



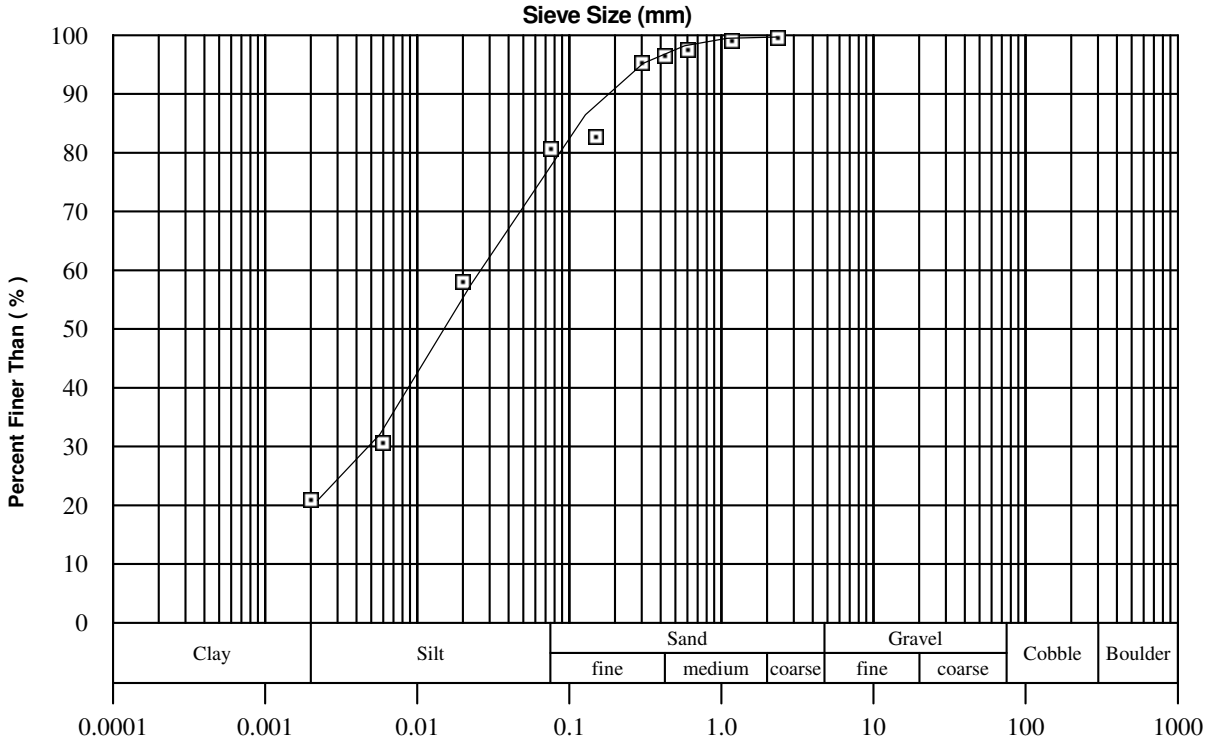
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	TP-12	-	1.00	0.40	10.60	55.18	33.82

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



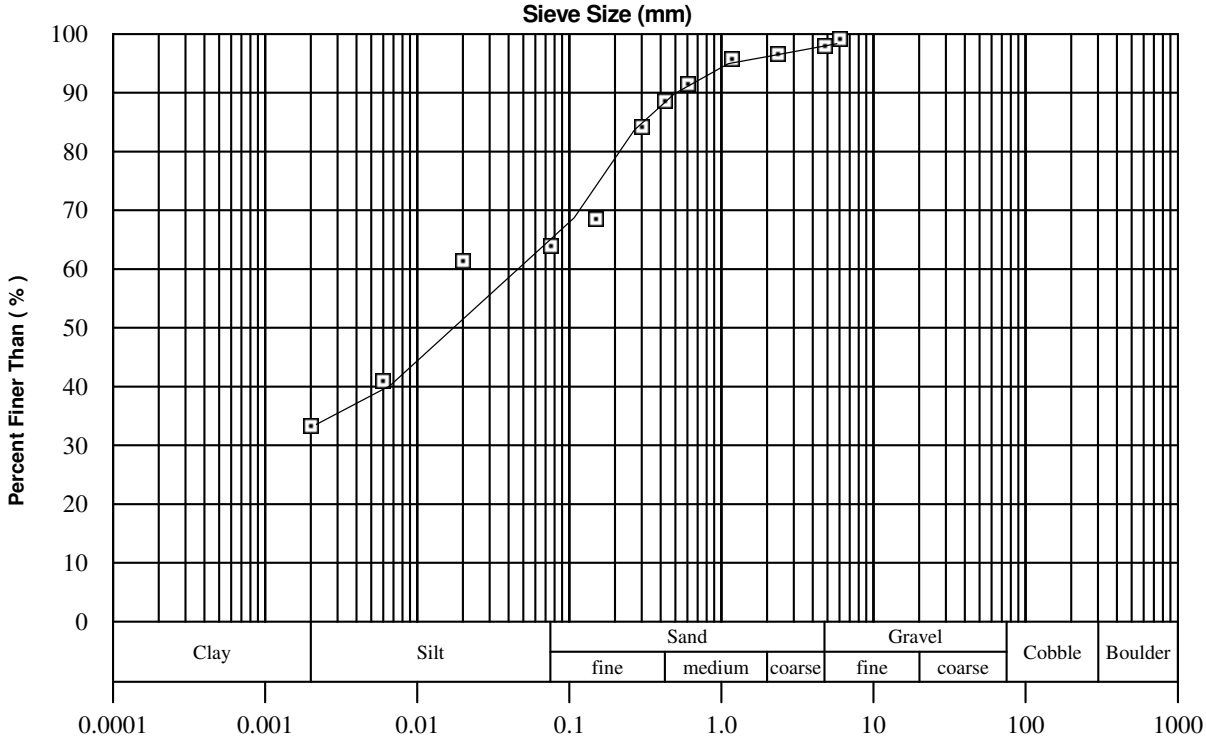
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	TP-12	--	3.00		6.10	61.97	31.93



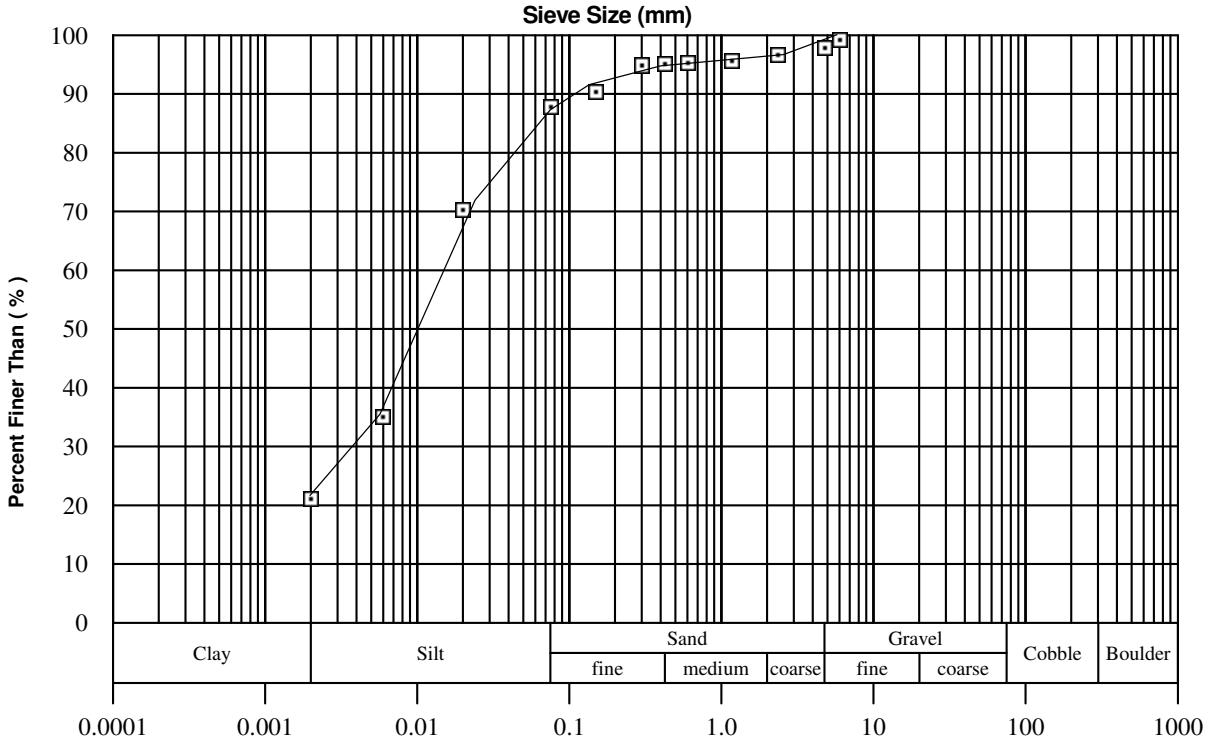
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	TP-14	-	2.00		19.30	59.72	20.98

PARTICLE SIZE DISTRIBUTION CURVES

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Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	TP-15	--	1.00	1.90	34.10	30.72	33.28



Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	TP-15	---	3.00	2.10	10.00	66.80	21.10

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796

CALCULATION FOR BEARING CAPACITY AND SETTLEMENT OF SHALLOW FOUNDATIONS: (BH-01)

Stratum	Thickness (m)	Bulk Density (KN/m^3)	Shear Strength (c/φ)(kPa/degree)	m_v(m^2/KN) x 10^{-4}			Young's Modulus(E) (kPa)	Poisson's Ratio(μ)
				25-50 (kPa)	50-100 (kPa)	100-200 (kPa)		
I	6.00	18.60	C = 57 kPa	1.51	1.57	1.46	28500	0.50
	3.00	19.00	C = 91 kPa	1.09	1.20	1.14	45500	0.50
II	3.00	19.00	Φ = 33*	-			30000	0.35
IVA	>5.06	21.00	Φ = 37*	-			70000	0.30

WIDTH x LENGTH x DEPTH OF FOOTING
Bf = 3.00 m, Lf = 3.00 m, Df = 3.00m

A. CALCULATION FOR BEARING CAPACITY

Depth considered for bearing capacity parameters is 0.50 x width of foundation = 1.50 m below Foundation

(Considering General Shear Failure Condition)

Weighted Average
Cav.= 57 kPa
Øav.= 0

q_1 ult = $c.N_c.s_c.d_c.i_c + q\ (N_q-1)\ S_q\ d_q\ i_q + 0.5\ \gamma\ B\ N_\gamma\ S_\gamma\ d_\gamma\ i_\gamma\ w'$ [using IS:6403, general shear condition]

= $c.N_c.s_c.d_c.i_c$

= 457.05 kPa

q_{safe} (general) = q ult/F.S. = **152.35 kPa**

where Nc = 5.14, s_c=1.30, d_c=1+0.2(D_f/B). (N_Φ)^0.5 = 1.20, i_c = 1.00

where
i_c ,i_q, iγ are the inclination factors
Sc, Sq, Sγ are the shape factors
dγ,dq,dc are the depth factors
Nc,Nq and Nγ are the inclination factors
γ_{av} = weighted bulk density(KN/m^3)
B= width of the foundation (m)
C = cohesion value of soil (kPa)
W' = correction factor for water level

B. CALCULATION FOR SETTLEMENT

==========

Settlement calculated for 152 kPa bearing pressure

Depth considered for settlement calculation 2 x width of foundation = **6.00m below Foundation**

Rigidity Factor (RF) = neglected, Depth Factor (DF) = 0.75 (IS: 8009(pt-1)1976, fig.12,

Lamda factor = 0.90(Stratum-I) Part-A

The thickness of stratum-I below the foundation is = 3.00m

ΔP is calculated at the centre of this stratum considering 2:1 dispersion = 3.00/2= 1.50m

Therefore ΔP = 152 x (3.00 x 3.00) / {(3.00+1.50) x (3.00+1.50)} = 152 x 0.44447 = 67.56 kPa

Total Settlement for Stratum-I Part-A

= **Consolidated Settlement + Immediate Settlement**

Part I

Immediate Settlement = p x B x $(1-\mu^2)$ x If / Es

H immd at centre = 4 x p x (B/2) x $(1- \mu^2)$ x If / Es

Which is = **2 x p x B x $(1- \mu^2)$ x If / Es**

= 2 x 152 x 3.00 x $(1-0.5^2)$ x 0.31 /28500

= 7.44 mm

Where p = imposed loading = 152 kPa

Influence Factor If = 0.31 [as per IS: 8009 Part-1, Fig. 11, H = 3.00, for centre H/[B/2] = 2H/B = 2x3.00/3.00 = 2, L/B = 1]

B = width of foundation = 3.00m

μ = poisson's ratio = 0.50

E_{av} = 28500 kPa obtained as [E = 500 x Cu] (Ref Winterkorn & Fang (1975), Foundation Design by NV Nayak 4th Edition pg-111)

Part – II

Consolidated Settlement

Sc = m_v x ΔP x H = 1.45 x 10^{-4} x 67.56 x 3.00 = 0.02938m = 29.38mm

Applying correction for lamda factor = 29.38 x 0.90 = 26.442

Total Settlement = Immediate Settlement + Consolidated Settlement

= 7.44 + 26.442

= 33.882 **mm**

Total Settlement for Stratum-I Part-B

Lamda factor considered = 0.65

ΔP is calculated at the centre of this stratum considering 2:1 dispersion = 3.00 + 3.00/2= 4.50m

Therefore ΔP = 152 x (3.00 x 3.00) / {(3.00+4.50) x (3.00+4.50)} = 152 x 0.16 = 24.32 kPa

= **Consolidated Settlement + Immediate Settlement**

Part I

Immediate Settlement = p x B x $(1-\mu^2)$ x If / Es

H immd at centre = 4 x p x (B/2) x $(1- \mu^2)$ x If / Es

Which is = **2 x p x B x $(1- \mu^2)$ x If / Es**

= 2 x 152 x 3.00 x $(1-0.5^2)$ x 0.1 /45500

= 1.503 mm

Where p = imposed loading = 152 kPa

Influence Factor If = 0.41 [as per IS: 8009 Part-1, Fig. 11, H = 6.00(from the base of the foundation, for centre H/ [B/2] = 2H/B = 2x6.00/3.00 = 4, L/B = 1]

Therfore Influence factor only for Part B of Stratum – I

If = (0.41 – 0.31) = 0.10

B = width of foundation = 3.00m

μ = poisson's ratio = 0.50

E_{av} = 45500 kPa obtained as [E = 500 x Cu] (Ref Winterkorn & Fang (1975), Foundation Design by NV Nayak 4th Edition pg-111)

Part – II

Consolidated Settlement

Sc = m_v x ΔP x H = 1.20 x 10^{-4} x 24.32 x 3.00 = 0.0087552m = 8.75mm

Applying correction for lamda factor = 8.75 x 0.65 = 5.68mm

Total Settlement = Immediate Settlement + Consolidated Settlement

= 1.503 + 5.68

= 7.183 **mm**

Applying correction for depth factor and rigidity factor over total settlement= (33.882 + 7.183) x 0.75 x 0.80 = **24.639 mm**

Calculations for Foundation resting directly within Stratum-IVB giving a minimum embedment of 0.50m within it using RMR Method.

ROCK MASS SYSTEM (AFTER BIENIAWSKI 1989)

Parameter Type	Value obtained from rock samples	Rating
Strength of intact rock material	3.50 MPa	1
Drilling core Quality, RQD	<25%	3
Spacing of discontinuities	60-200mm	8
Condition of discontinuities	Slicken gauge> 5mm thick or Separation 1-5 mm continuous	5
Ground water	Wet	7
Rating adjustment for discontinuity orientation	Fair	-7
	Total RMR=	17

Based upon the above table as per Table.3 of IS 12070 – 1987 reaffirmed 2010 the RMR of 17 in very poor category. The corresponding Net Safe Bearing Capacity may be considered as

= 30 + {(45-30) / (20-0) x 17}

= 42.75 MT/m^2 the settlement of which is restricted within 12mm as per IS 12070 Clause 5.30

It may also be noted that the net safe bearing capacity of open foundations placed within rocky strata is independent of the size of the foundation.

SAMPLE CALCULATION FOR OPEN FOUNDATION PLACED WITHIN STRATUM-IVB

The Bearing capacity of open foundation can be determined using the design parameters presented in the table showing recommended engineering properties of rock and using the relation given in text book "*Foundation Design Manual for Practicing Engineers and Civil Engineering Students" by N.V. Nayak; (3rd Edition 1985),* and bearing capacity equation given in IS: 12070-1987.

The net safe bearing capacity of shallow foundations on rock can be written as:

$$q_s = q_c N_j$$

where,

q_c = Average Uni-axial compressive strength of rock cores
= 3.50 MPa.

N_j = Empirical coefficient depending on the spacing of discontinuities.
= 0.25 (for spacing & discontinuities of about 100 – 300m)

For getting the allowable bearing capacity, calculated net safe bearing capacity should be multiplied with the following correction factor (s) according to the geological condition.

1) *Submerged condition under water table:*

Rock with continuous joints with opening 1 to 5 mm wide and filled with clay = ¾ to ½

Slope
a) Fair orientation of continuous joints in the slope = 1 to 1/2

Gross Safe Bearing Capacity = 3500 x 0.25 x 0.75 x 0.75

= 492.187 kPa

PILE CAPACITY CALCULATION FOR 500MM DIAMETER BORED CAST-IN-SITU PILES FOR PILE TIP RESTING WITHIN STRATUM-IVB:

(Refer: *IS 14593: 1998 "Design and Construction of Bored Cast-in-Situ Piles Founded on Rocks-Guidelines"*)

Skin friction of pile shaft in rock is given by:

$$f_s = q_{uc}. \Pi.D. l_s . \alpha . \beta$$

Where, f_s = safe skin friction

α = rock socket slide resistance reduction factor = 0.18

β = rock socket correction factor = 0.50

q_{uc} = unconfined compression strength of rock

= 3.50 MPa = 350 T/m^2

Substituting above values : f_s = 31.50T/m^2 in Stratum IVB.

Unit safe skin friction per meter of pile shaft in Strata IVB:

$F_s = \pi . D . f_s$

Where D = Pile diameter in mm

Therefore, $F_s = \pi . D. l. 31.50$

$= 49.48.l$ T/m

Hence giving a rock socketing of 3.50D times the dia of the pile it comes= (49.48 x 1.75) = 86.59 T

For end bearing in stratum-IVB

$Qs = q_c.N_j.N_d.A_p$ = 350 x 0.10 x 1.50 x 0.1963 = 10.30 T

Where,

q_c = unconfined compression strength of rock = 3.50 MPa = 350 T/m^2

N_d = depth factor = 0.80 + 0.20l_s/D, limited to 2 = 1.50

$A_p = \pi D^2/4$ = 0.1963m^2

N_j = Values as per Fig. 2 of IS: 12070 = 0.10

Total safe carrying capacity in compression = Skin Friction + End Bearing = 86.59 + 10.30 = 96.89 ~ 95 MT

Tension Capacity of Piles:

= 50% of the skin friction

= 86.59/2 ~ 40 MT

Computation for Lateral Capacity of Pile.
(Consider cut off level 1.50m)

Basic Assumptions

1) Reference codes IS 2911 (Part I/Section 2) – 2010, IS 14593: 1996 – 1998 & IS 456 – 2000.
2) Modulus of Subgrade reaction has been taken assuming the sub-soil as soft to medium stiff Clay under submerged condition.
3) Concrete Grade of piles has been assumed as M25.

List of Notations.

I = Moment of Inertia of Pile Section (m^4)
E= Modulus of Elasticity of concrete (MN/m^2)
R= Relative Stiffness Factor.
z_f= Depth to point of Fixity in m
K_1= Modulus of Sub-grade Reaction of Clay (MN/m^3) (Refer IS-2911, Appendix – C)
H= Lateral Load in (KN)
Y= Maximum displacement allowed at Final load = 5mm = 0.005m
e= cantilever length above ground/ bed to the point of load application in m.

Lateral Load for fixed head piles

1) Pile Geometry

Dia = 500mm = 50cm Moment of Interia
$I = (\prod/64) \times (0.50)^4 = 3.07 \times 10^{-3}\ m^4$

2) Properties of Pile Material- Concrete Grade M25

Modulus of Elasticity (E) = $5000\sqrt{f_{ck}}$ [where f_{ck} = characteristic strength in N/mm^2]
$=5000\ \sqrt{25}$
$= 25 \times 10^3$ MPa
$= 25 \times 10^6$ KPa

Flexural Stiffness $EI = 7.67 \times 10^4\ kN\text{-}m^2$

c. Depth of Fixity for free head condition

Value of z_f/R, from fig 4, of IS – 2911-2010 for (e/R=0), $z_f/R = 1.90$

Computing, value of Relative Stiffness Factor as per relationship given in Clause C-2.3.2 of Appendix C, IS: 2911

$R = \sqrt[4]{(5EI/K_1)}$ [where K_1 has been obtained as 20.52×10^3 from Table-4 IS: 2911 in kN/m^3]

$R = \sqrt[4]{(5 \times 7.67 \times 10^4/20.52 \times 10^3)}$
$= 2.08$ m

Now,
$z_f/R = 1.90$
$z_f = 1.90 \times 2.08$

$z_f = 3.95$ m

b) **Lateral Load Capacity for free head condition**

Computation has been based on equation given on cl C-4.2 of IS 2911 as follows.

$Y = \{H (e + z_f)^3/3EI\}$
$H = 3EI.Y/(e + z_f)^3$

Where
$e = 0$
$EI = 7.67 \times 10^4$
$z_f = 3.95$ m
$Y = 0.005$ m

$\therefore Q = (3 \times 7.67 \times 10^4 \times 0.005) / (3.95)^3 =$ **19 kN**

c) **Depth of Fixity for fixed head condition**

Value of z_f/R, from fig 4, of IS – 2911 for $(e/R=0)$, $z_f/R = 2.20$

$R = 2.08$m

Now,
$z_f/R = 2.20$
$z_f = 2.20 \times 2.08$

$z_f = 4.57$m

d. Lateral Load Capacity for fixed head condition

Computation has been based on equation given on cl C-4.2 of IS 2911 as follows.

$Y = \{H (e + z_f)^3/12EI\}$
$H = 12EI.Y/(e + z_f)^3$

Where
$e = 0$
$EI = 7.67 \times 10^4$
$z_f = 4.57$ m
$Y = 0.005$ m

$\therefore Q = (12 \times 7.67 \times 10^4 \times 0.005)/(4.57)^3 =$ **48 kN**

Sample Computation of Vertical Load Carrying Capacity of 500MM Diameter Bored Pile(Considering BH-01)
(Cut-off level-1.50m)

1. PILE GEOMETRY:

Dia (mm)	(Bored) 500mm
Perimeter (π x D) m	3.14 x 0.50= 1.570m

2. SUBSOIL PARAMETERS:

(Refer from general soil profile)

Subsoil Strata	γ (KN/m^3)	Cohesion (kPa)	φ (Deg)	Values of α/K as per IS:2911 (Part1/Sec2)	Embedment Length (m)
I	18.60	57	-	-	6.00
	19.00	91	-	-	3.00
II	19.00	-	33	K = 1.15	3.00
IVA	21.00	-	37	K = 1.50	6.50

2. OVERBURDEN PRESSURES :

Stratum-II	Upto 17.5D	Upto 8.75m = P_{Di} = (6.00 x 8.60) + (2.75 x 9.00) = 76.35 kPa
Stratum-IVA	Upto 20D	Upto 10.0m = P_{Di} = (6.00 x 8.60) + (3.00 x 9.00) + (1.00 x 9.00) = 87.60 kPa

Skin friction = α x C x A_S [(Using formula for Pile in cohesive soil) IS: 2911(Part I/ Sec 2)-2010]

Skin friction = $\sum_{i=1}^{n} K x P_{Di} x \tan\delta x A_{si}$ [(Using formula for Pile in granular soil) IS: 2911(Part I/ Sec 2)-2010]

Here, $\sum_{i=1}^{n}$ = Summation for n layers in which pile is installed

K = Coefficient of earth pressure

P_{Di} = Effective overburden pressure

A_{si} = Surface area of pile stem

For 500mm Dia Pile

Skin friction

a. Skin friction in stratum I(1^{st} part) (F_1) $= \alpha \times C \times A_S$
$= 0.75 \times 57 \times 1.57 \times 4.50$
$= 302.028$ KN

b. Skin friction in stratum I(2^{nd} Part) (F_2) $= \alpha \times C \times A_S$
$= 0.50 \times 91 \times 1.57 \times 3.00$
$= 214.305$ KN

c. Skin friction in stratum II (F_3) $= K \times \tan\delta \times P_{Di} \times A_{si}$
$= 1.15 \times 76.35 \times \tan 33^0 \times 1.57 \times 3.00$
$= 268.56$ KN

d. Skin friction for Stratum – IVA(F_4) $= K \times \tan\delta \times P_{Di} \times A_{si}$
$= 1.50 \times 87.60 \times \tan 37^0 \times 1.57 \times 6.50$
$= 1010.469$ KN

e. End bearing for Stratum-IVA(F_5) $= A_p \times P_{dn} \times N_q$
$N_q = 70$ for $\varphi = 37^0$
$= 0.19625 \times 87.60 \times 70$
$= 1203.405$ KN

Total ultimate load $= F_1 + F_2 + F_3 + F_4 + F_5$
$= (302.071 + 214.31 + 268.56 + 1010.47 + 1203.41)$ KN
$= 3099.46$ KN
Safe vertical capacity in compression $= 2998.821/2.50$
$= 1199.528$ KN ≈ 1150 KN

Safe Uplift capacity of pile $= Q_f = (302.071 + 214.31 + 268.56 + 1010.47) / 3.0$

$= 598.47$ KN ≈ 500 KN

PILE CAPACITY CALCULATION FOR 500MM DIAMETER BORED CAST-IN-SITU PILES FOR PILE TIP RESTING WITHIN STRATUM-IVC:

(Refer: *IS 14593: 1998 "Design and Construction of Bored Cast-in-Situ Piles Founded on Rocks-Guidelines"*)

Skin friction of pile shaft in rock is given by:

$$f_s = q_{uc}.\ \Pi.D.\ l_s\ .\ \alpha\ .\ \beta$$

Where, f_s = safe skin friction

α = rock socket slide resistance reduction factor = 0.14

β = rock socket correction factor = 0.50

q_{uc} = unconfined compression strength of rock

= 6.00 MPa = 600 T/m^2

Substituting above values : f_s = 42 T/m^2 in Stratum IVC.

Unit safe skin friction per meter of pile shaft in Strata IVC.

$F_s = \pi\ .\ D\ .\ f_s$

Where D = Pile diameter in mm

Therefore, $F_s = \pi\ .\ D.\ l.\ 42.00$

$= 65.97.l$ T/m

Hence giving a rock socketing of 2.50D times the dia of the pile it comes= (65.97 x 1.25) = 82.463 T

For end bearing in stratum-IVC

$Qs = q_c.N_j.N_d.A_p$ = 600 x 0.10 x 1.30 x 0.1964 = 15.31 T

Where,

q_c = unconfined compression strength of rock = 6.00 MPa = 600 T/m^2

N_d = depth factor = $0.80 + 0.20l_s/D$, limited to 2 = 1.30

$A_p = \pi D^2/4$ = 0.1963m^2

N_j = Values as per Fig. 2 of IS: 12070 = 0.10

Total safe carrying capacity in compression = Skin Friction + End Bearing = 82.463 + 15.31 = 97.773 ~ 95 MT

Tension Capacity of Piles:

= 50% of the skin friction

= 82.463/2 ~ 40 MT

California Bearing Ratio Test

No field CBR/lab CBR have been carried out at this site however on request, based upon our experiences and referring to various standard books providing CBR values for different subsoil conditions. We would like to suggest a CBR value of 6% in soaked condition.

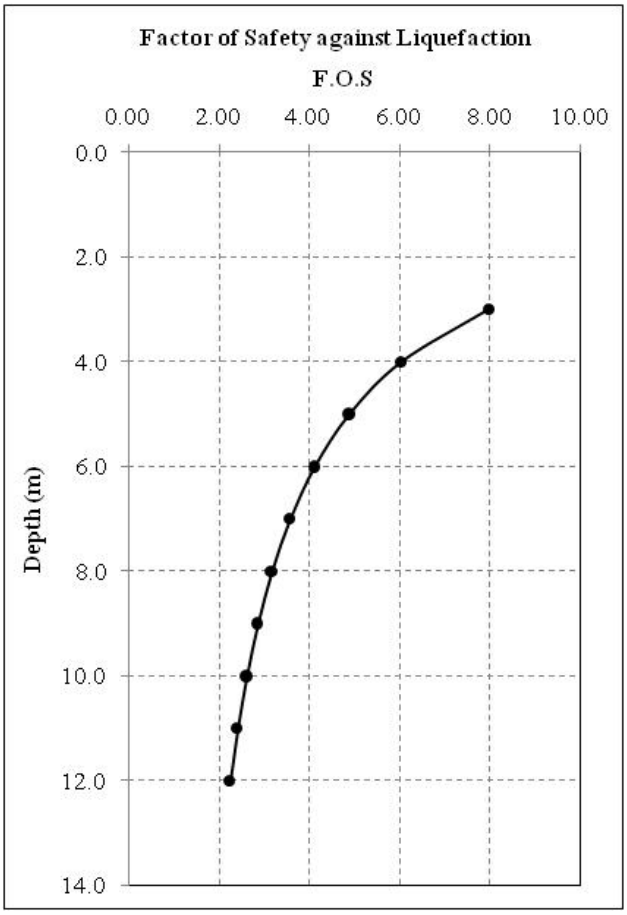
Earthquake magnitude, M **7.5**

Peak ground acceleration amax **0.16** g

Bh-03

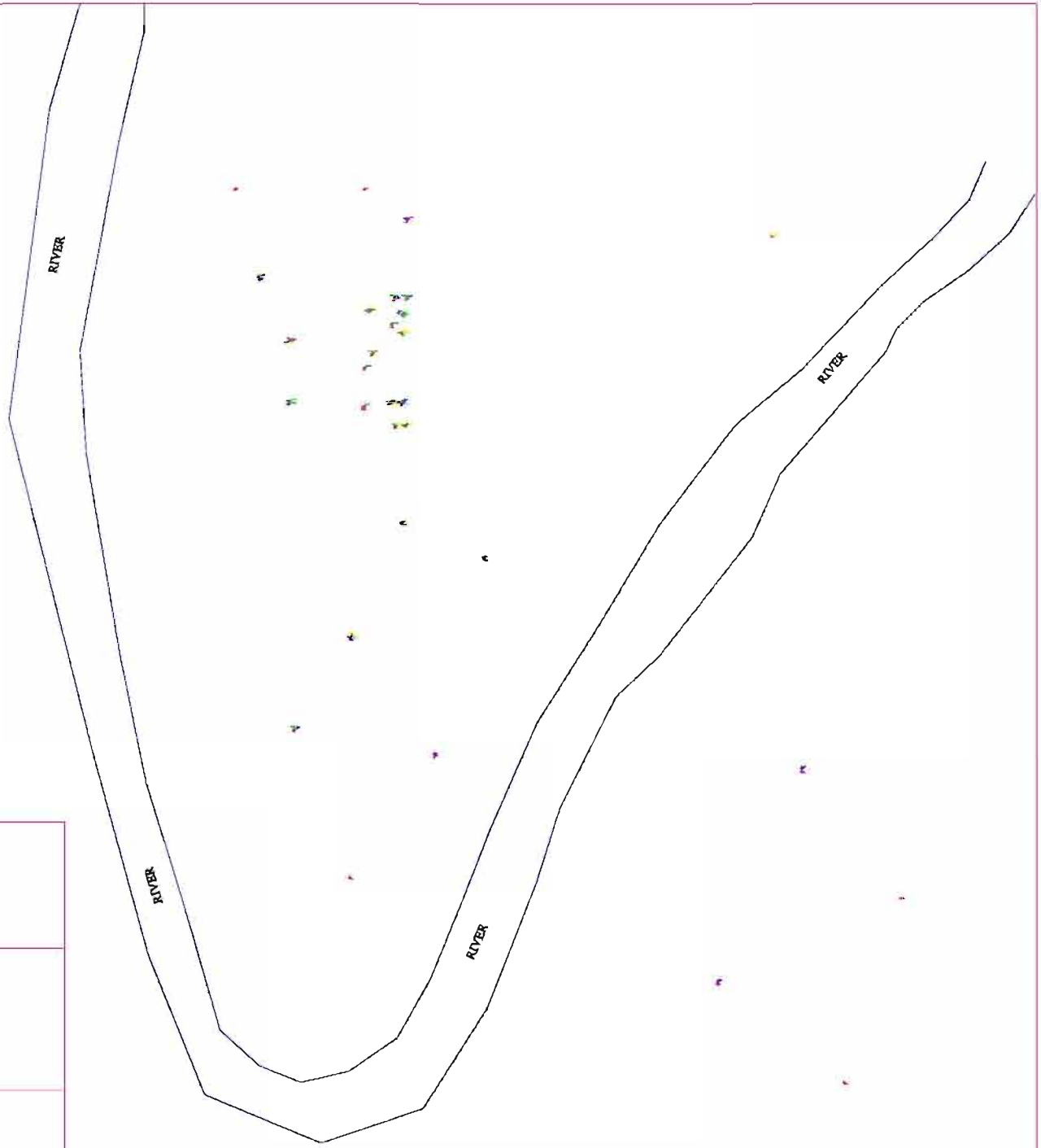
For Clayey Soil

Strata	Description	Thickness (m)	LP determined for depth, z (m)	Unit weight γ (kN/m^3)	Cohesion (kPa)	Total vertical stress, σ_v	Eff. vertical stress, σ'_v	K_α	MSF	$CRR_{M=7.5}$	Cyclci Stress Ratio induced by Earthquake, CSR	Cyclic Resistance Ratio, CRR	FOS	Check
I	Silty clay	12.0	1.00	18.60	57.0	18.6	8.6	1.00	1.00	5.28	0.225	5.280	23.49	**Not Liquefiable**
			2.00	18.60	57.0	37.2	17.2	1.00	1.00	2.64	0.223	2.640	11.84	**Not Liquefiable**
			3.00	18.60	57.0	55.8	25.8	1.00	1.00	1.76	0.221	1.760	7.97	**Not Liquefiable**
			4.00	18.60	57.0	74.4	34.4	1.00	1.00	1.32	0.219	1.320	6.04	**Not Liquefiable**
			5.00	18.60	57.0	93.0	43	1.00	1.00	1.06	0.216	1.056	4.89	**Not Liquefiable**
			6.00	18.60	57.0	111.6	51.6	1.00	1.00	0.88	0.213	0.880	4.12	**Not Liquefiable**
			7.00	18.60	57.0	130.2	60.2	1.00	1.00	0.75	0.211	0.754	3.58	**Not Liquefiable**
			8.00	18.60	57.0	148.8	68.8	1.00	1.00	0.66	0.208	0.660	3.18	**Not Liquefiable**
			9.00	18.60	57.0	167.4	77.4	1.00	1.00	0.59	0.205	0.587	2.87	**Not Liquefiable**
			10.00	18.60	57.0	186.0	86	1.00	1.00	0.53	0.202	0.528	2.62	**Not Liquefiable**
			11.00	18.60	57.0	204.6	94.6	1.00	1.00	0.48	0.198	0.480	2.42	**Not Liquefiable**
			12.00	18.60	57.0	223.2	103.2	1.00	1.00	0.44	0.195	0.440	2.26	**Not Liquefiable**



SAMPLE CALCULATION FOR LIQUEFACTION





BH LOCATION

.....

.....

.....

SKM GEOSURVEY

An ISO 9001 : 2015 Certified Organisation
BK-130, Salt Lake City, Kolkata-700 091.

Job No. -30796

Date - DEC'17 REV-01

NLC INDIA LIMITED
NLC TALABIRA THERMAL
POWER PROJECT- 3x800 MW
JHARSUGUDA, ODISHA

BIDDING DOCUMENT
FOR
SINGLE PACKAGE ENGINEERING, PROCUREMENT AND CONSTRUCTION

SPECIFICATION NO : 18A03-SPC-G-001

SECTION-B

VOLUME: II-G/2

TECHNICAL SPECIFICATIONS
FOR
CIVIL, STRUCTURAL & ARCHITECTURAL WORKS

DEVELOPMENT CONSULTANTS PRIVATE LIMITED
CONSULTING ENGINEERS
BLOCK DG-4, SECTOR-II, SALT LAKE CITY
KOLKATA- 700 091, INDIA

November, 2020

NLC INDIA LIMITED
NLC TALABIRA THERMAL
POWER PROJECT- 3x800 MW
JHARSUGUDA, ODISHA

SPECIFICATION NO : 18A03-SPC-G-001

SINGLE PACKAGE ENGINEERING, PROCUREMENT AND CONSTRUCTION

VOLUME: II-G/2

TECHNICAL SPECIFICATIONS
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CIVIL, STRUCTURAL & ARCHITECTURAL WORKS

DEVELOPMENT CONSULTANTS PRIVATE LIMITED
CONSULTING ENGINEERS
BLOCK DG-4, SECTOR-II, SALT LAKE CITY
KOLKATA- 700 091, INDIA

JOB NO. : 18A03
DATED : NOVEMBER, 2020

NLC INDIA LIMITED
NLC TALABIRA THERMAL
POWER PROJECT- 3x800 MW
JHARSUGUDA, ODISHA

TENDER SPECIFICATION

PACKAGE NAME	:	SINGLE PACKAGE ENGINEERING, PROCUREMENT AND CONSTRUCTION
SPECIFICATION NUMBER	:	18A03-SPC-G-001
JOB NUMBER	:	DCPL-18A03
3CLIENT	:	NLC INDIA LIMITED

VOLUME : II-G/2

TECHNICAL SPECIFICATIONS
FOR
CIVIL, STRUCTURAL & ARCHITECTURAL WORKS

ISSUE	DATE	PREPARED	REVIEWED	APPROVED
FINAL	12.11.2020	R. Moitra	B. Chakraborty	B. Lahiri
FINAL DRAFT	07.11.2020	R. Moitra	B. Chakraborty	B. Lahiri
DRAFT	08.10.2020	R. Moitra	B. Chakraborty	B. Lahiri

CONSULTANT

DEVELOPMENT CONSULTANTS PRIVATE LIMITED
DEVELOPMENT CONSULTANT HOUSE
BLOCK DG-4, SECTOR-II, SALT LAKE CITY, KOLKATA – 700 091, INDIA

NLC INDIA LIMITED
NLC TALABIRA THERMAL
POWER PROJECT- 3x800 MW
JHARSUGUDA, ODISHA

SINGLE PACKAGE ENGINEERING, PROCUREMENT AND CONSTRUCTION

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VOLUME II-D1	:	Technical Specifications for Power Cycle Piping, Valves & Specialties
VOLUME II-D2	:	Technical Specifications for Large Diameter & Low Pressure Piping, Valves & Specialties
VOLUME II-E	:	Technical Specifications for Instrumentation & Control
VOLUME II-F/1 & F/2	:	Technical Specifications for Electrical Equipment & Accessories In Two Volumes]
VOLUME II-G/1 & VOLUME-II-G/2	:	Technical Specifications for Civil, Structural and Architectural Works [In Two Volumes]
VOLUME II-H1	:	Technical Specifications for Ash Handling System
VOLUME II-H2	:	Technical Specifications for Coal Handling System
VOLUME II-H3	:	Technical Specifications for Wet Limestone Based Flue Gas Desulphurization System
VOLUME II-IA	:	Technical Specifications for Main Cooling Water System, Auxiliary Cooling Water System and DM Closed Cycle Cooling Water System & Accessories
VOLUME II-IB/1	:	Technical Specifications for Water Intake and Transportation System
VOLUME II-IB/2	:	Technical Specifications for Raw Water Pre-Treatment Plant
VOLUME II-IB/3	:	Technical Specifications for Demineralization Plant and Potable Water Treatment Plant

VOLUME II-IB/4	:	Technical Specifications for Waste Water Management System
VOLUME II-J	:	Technical Specifications for Auxiliary Systems Viz. Compressed Air, Fire Protection, Ventilation & Air-Conditioning, DG Set and Hydrogen Generation Plant.
VOLUME II-K	:	Technical Specifications for Sump Pumps, Miscellaneous Cranes & Hoists, Elevators, Workshop and Laboratory Equipment etc.
VOLUME II-L	:	Tender Drawings

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TECHNICAL SPECIFICATIONS
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GUIDELINE
FOR
CIVIL AND STRUCTURAL WORK

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GUIDELINE FOR CIVIL AND STRUCTURAL WORK

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SECTION-II	:	Guideline for Geotechnical Investigation
SECTION-III	:	Guideline for Area Grading
SECTION-IV	:	Guideline for Earth Work in Excavation and Backfilling
SECTION-V	:	Guideline For Bored Cast In Situ Concrete Pile
SECTION-VI	:	Guideline for Cement Concrete (Plain and Reinforced)
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SECTION-I

GUIDELINE
FOR
LAND SURVEY AND ESTABLISHING REFERENCE GRIDS AND BENCH MARK PILLARS

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SECTION-I

GUIDELINE
FOR
LAND SURVEY AND ESTABLISHING REFERENCE GRIDS AND BENCH MARK PILLARS

1.00.00 SCOPE

This specification is intended to cover topographical surveys and preparation of plans (maps) showing all permanent features including buildings, large trees, pucca & kutchha nullas, ditches, (with or without water), nearby roads / approaches, railway track, culverts, overhead transmission & communication lines, ridges, boundary wall, fencing, demarcation line etc. of the project area as well as sectional views of the drains, ditches, creek, culverts and similar items (with all dimensions and invert levels). Carrying of the Bench Mark (existing reference BM outside the project area) to project site by levelling, establishing bench marks and grids in the field, spot level survey at specified intervals and on change points, contouring, constructing and fixing of bench mark pillars & grid pillars in the field, clearing of jungles & debris and cutting of trees (to the minimum extent as required for the work and as per instruction of the Owner) etc. shall also form a part of the scope of work. In addition, the true north, magnetic north, construction north and the angle between the grid lines (established at site) shall be indicated in all drawings.

It may also be necessary to interconnect the existing grid lines (with measured angles and distances) and level references as well as a few permanent buildings and permanent roads adjacent / near the specified project site area during the proposed survey work and thus incorporate the same in the survey plans / maps.

The Plot Plan gives location of the project and an indication of the project area to be surveyed. These drawings are preliminary and do not cover the entire scope of work. These may be modified, survey area increased / decreased, and any new drawing may be given before award of the Work or during execution of the work (keeping sufficient time for field survey work and plotting).

Permanent features and levels of a few existing items as given in the above drawings shall not be used as reference without verification by actual survey with precision instruments by the successful bidder and plotted in his maps / drawings accordingly.

The grid pillars and B.M. pillars shall be maintained and checked frequently to ensure the correctness of the value of the pillar till the completion of the job

and handing them over to the Owner. It shall be responsibility of the successful bidder to check the pillars jointly with Owner / Engineer at the time of final handing over of the work to the Owner.

The tenderers shall visit the project site, at their own cost, before quoting rates for this tender. No extra claim (in terms of extension of time or revision in rates, etc.) shall be entertained at a later date on the ground of insufficient knowledge about the site or for lack of clarifications on this specification.

2.00.00 GENERAL

2.01.00 Work to be provided for by the successful bidder

2.01.01 Work to be provided by the successful bidder, unless specified otherwise, shall include but not be limited to the following:

a) Furnish necessary instruments and all other tools and materials including pegs, marking plates for reference grid and bench mark pillars, construction materials for pillars, labour & skilled surveyors, supervision by competent engineers, services, necessary transport, full insurance and all other incidental items as may be necessary for on-time and successful completion of the surveying and mapping work.

b) Furnish original field & level books, notes taken on special features and field drawings with readings & relevant features plotted.

c) Preparation, thorough checking & cross checking in the field and submission of completed survey plans / maps and drawings in specified scale incorporating sectional views and details as included under Section - 1.0.

d) Construction and installation of reference grids and bench mark pillars at specified locations.

2.02.00 Work to be provided for by others

No work under this specification shall be provided by any agency other than the successful bidder unless specifically mentioned elsewhere in the Contract.

2.03.00 Information to be Submitted by the successful bidder.

2.03.01 After Award

The successful bidder shall furnish to Owner the number of different surveying instruments (with make and year of manufacture), skilled & experienced surveyors, and competent engineers that shall be deployed at the site for this work. His experience during last five years in similar survey

work shall be detailed which shall also include his present commitments.

The successful bidder shall inform and satisfy the Engineer regarding deployment of personnel engaged by him for quality work under an agreed time-frame for completion of the work under this Contract.

He shall also prepare, discuss with Owner / Engineer and submit an agreed work programme and he shall also mobilize his instruments, tools, personnel at the project site.

The survey documents shall be submitted to the Owner / Engineer by the successful bidder progressively during execution of the Work in order to enable him to review the work and, if necessary, cross-check at site along with successful bidder's surveyor and engineer and point out the deficiencies / discrepancies, if any, therein. However, the successful bidder shall be still responsible for the correctness of the entire work and shall resurvey and replot any portion of the Work which may be found to be defective later on. During such checking / cross-checking as well as supervision during execution of the entire work, the successful bidder shall extend all facilities including proper instruments, tools, other materials, surveyors & labour, etc. to the Owner / Engineer.

The successful bidder shall engage qualified engineers, surveyors, drafting persons, etc. for executing the work under this Contract.

3.00.00 INSTRUMENTS AND CONSTRUCTION MATERIALS

3.01.00 Instruments

The entire field surveying shall be done with the combination of transit / optic Theodolites (which can read upto 20 seconds or less), Prismatic Compass, Precision Levelling Instruments with well-graduated & accurate staff, Chain, Measuring Steel Tapes, Total Station and Plane Table Survey by Clinometer with the help of Clinograph Scale, ranging rods, etc.

Theodolite shall be optically centered and the levels shall be tilting type. Measuring tapes shall be used with calibrated tension. The calibration charts for the instruments shall be submitted before the start of the Work.

High quality surveying instruments (particularly, theodolites & levels) of reputed manufacturers shall be deployed for accurate and dependable survey work. Electronic instruments, if available with the successful bidder, shall be preferred.

3.02.00 Construction Materials for Reference Grid and Bench Mark Pillars

Concrete for pillars shall be of mix 1:2:4 (one cement: two coarse sand: four 20 mm down stone aggregates). All the component materials shall be of best & acceptable quality and conforming to the provisions of the latest version of

the Indian Standards.

Steel plates for engraving B.M. value and reference grids shall be of mild steel, conforming to IS: 2062.

4.00.00 EXECUTION

4.01.00 Permanent Adjustments

All permanent adjustments of the instruments shall be made before starting the work, to the satisfaction of the Owner / Engineer.

4.02.00 Contour Intervals and Scale of Drawings

4.02.01 Contour Intervals

For contouring, spot levels shall be taken at 5 m horizontal intervals or less in both directions to establish the contours at 0.25 m intervals for nearly flat terrains and at 0.5 m intervals for undulating hilly terrains, as per the direction of the Owner / Engineer.

4.02.02 Scale of Drawings

Depending upon the area to be covered, survey maps shall be prepared in the scale of 1 : 500 or 1 : 1000, and all permanent features (as indicated under Section - 1.0), grid pillars, bench mark pillars, reference grid and bench mark pillars, contours (as specified in 4.2.1 above) etc. shall be plotted.

Sectional views of the drains, ditches, culverts, roads, etc., however, can be prepared in a scale suitable for furnishing all pertinent dimensions, levels and information, and in a separate drawing sheet.

4.03.00 Submission of Drawings and Documents

The following documents shall be submitted to the Owner / Engineer:

4.03.01 Original field & level books with notes taken on special features, plus a photo-copy each of the above documents.

4.03.02 Field drawings with readings and relevant features and sectional views plotted - three (3) copies for review by Owner / Engineer. (One copy shall be returned to the successful bidder with comments, if any).

4.03.03 Original and one (1) copy of the above field drawings (item 4.3.2 above) after field verification of the comments and incorporating the corrected features.

4.03.04 Original tracing and four (4) prints of the final survey maps and drawings showing other details, all prepared in ink and in clear legible form. Format of

and title block on the drawing / map shall be as per direction of Owner / Engineer.

4.04.00 **Time of Completion**

Time shall be deemed to be the essence of the Contract. The entire survey work including submission of the final survey maps and drawings as well as other documents (ref. Cl 4.03.00 above) shall be completed within a period in the following manner.

a) Mobilization and firming up time schedule and survey groups... :

b) Completion of field survey work and submission of three (3) copies of the field drawings and a photo-copy of the field & level books and the field notes, etc. (Items 4.3.1 & 4.3.2 above). :

c) Submission of the final survey maps & drawings and other documents (item 4.3.1, 4.3.3 & 4.3.4 above). :

The time schedule/period shall be as per L2 PERT and as mutually agreed by the successful bidder and owner.

Construction and installation of grid and bench marks pillars, however, are to be subsequently completed within weeks of the clearance from Owner / Engineer.

If the Owner / Engineer feel that the progress of the work is not satisfactory, he shall notify the successful bidder to take necessary measures to complete the Work on time. If the successful bidder fails to comply with the Owner's directive or fails to complete the Work on time, Owner shall be at liberty to get the Work done by any other agency and forfeit the amount related to unfinished works and the Earnest Money / Security Deposit of the successful bidder.

4.05.00 **Security Rules and Statutory Regulations**

The successful bidder shall strictly follow at site all security rules and regulations enforced by Owner from time to time regarding movement of materials, equipment / instrument, personnel to and from site, issue of identity cards, badges, control of entry and all similar matters.

The successful bidder, his employees and agents shall not disclose any information or drawings prepared by him or furnished to him by the Owner / Engineer.

He shall also follow all safety rules and regulations and shall take sufficient measures to adhere to the same.

The successful bidder shall conform in all respects with the provisions of any statute, ordinance law, rules, regulations, by-laws of Central, State, Local or

other duly constituted Authority. The successful bidder shall give all notices and fees to be given or paid.

In respect of labour, the successful bidder shall comply with all rules framed by the Government for the protection of health, wages, welfare and safety of the workers. The successful bidder shall be responsible for effective insurance under the Indian Workman's Compensation Act., Third Party Liability Insurance, etc. in accordance with the Indian Law and Regulation at his own cost.

In fine, the successful bidder shall keep the Owner and Engineer indemnified against all penalties and liabilities of every kind.

5.00.00 TECHNICAL SPECIFICATIONS

5.01.00 Establishing of Bench Marks

At least two permanent bench marks at approved locations shall be established from the existing bench marks. While carrying the bench mark, levels shall be established on permanent objects as directed by the Engineer. Levelling survey shall be done in the forward and reverse direction and the closing error shall not be more than ± 05 mm.

5.02.00 Establishing of Grid Pillars

Permanent grid pillars shall be established in either direction at every 100 m intervals or as directed. *One reference pillar and one reference grid direction shall be provided by the Owner. For carrying reference pillars, additional station points shall be established for traversing or triangulation as directed by the Engineer. The closing error for any closed traverse shall not exceed the specified limits as per clause 5.01. The maximum tolerance for any grid location shall be ± 1 mm. Generally for all angular measurements, transit of theodolite shall be done. Measurement shall be verified by cross-checking the diagonal angle as directed by the Engineer. For observing bearing from magnetic north, care shall be taken that no magnetic substance to influence the bearing reading is there. The magnetic north shall also be periodically verified.

Reference shall be taken from the existing permanent objects identifying from the Cadastral map for establishing the new grid line and shall be related to true north line where grids do not exist.

5.03.00 Reference Grid Pillars and Bench Marks

All reference grid pillars and permanent bench marks shall be 900 mm x 200 mm x 200 mm cement-concrete pillars with 150 mm projecting above ground. 150 mm square x 12 mm thick steel plates (with two L-shaped 20 cm long M.S. lugs welded to the plate) or 150mm square x 6 mm thick aluminium plates with bolts shall be embedded or bolted on top of the pillars. Grid points

& lines shall be accurately punched on the plates as also the numerical values of grid lines and levels. Grid lines and levels as required shall be painted.

5.04.00 Topographical Surveying and Mapping

Positions, both in plan and elevation, of all natural and artificial features of the area in question (including permanent objects) are to be established and subsequently delineating them on survey maps by means of conventional symbols (preferably those of Survey of India maps). Necessary levelling work of the project area shall be combined with methods of establishing horizontal location so that location and sketching of contours for the area can be done at specified intervals and in specified scales on maps. Rock outcrops, springs / falls (if any) and other unusual ground formations / conditions shall be noted and locations plotted on the maps.

The field work shall be done in the following steps:-

a) Establishing horizontal and vertical controls and locating reference grids and bench marks in the area.

b) Levelling and plotting contours.

c) Surveying and locating the natural, artificial and permanent features in details as described earlier.

d) Taking of longitudinal and cross-sections of the corridors for pipe line and road / rail and drains, ditches, waterbodies, culverts, etc.

All survey work shall be related with true north and true north shall be established at site beforehand.

5.05.00 Traversing and Ground Controls

Triangulation or Traversing or a combination of the two methods shall be adopted for the purpose of establishing horizontal controls, in order to determine the exact relationships between various existing points / features on ground, so that surveys required under the present scope of work and in future may be correlated and tied together.

Before commencement of work, the plan showing base lines and the grid lines and their spacings shall be got approved by the Owner / Engineer at site. First, a traverse covering the entire survey area shall be established with reference to a permanent object / reference grid pillar already existing at Site (as instructed by the Owner / Engineer).

The closing error in traverse (primary / secondary) shall not exceed one in three thousand in terms of length or, L $\sqrt{N}$ second (total) in angular measurement, whichever is less. (Where, L = the least count of the instrument and N = the number of stations).

5.06.00 **Contouring**

Spot level surveying at specified intervals shall be adopted for contouring the area, so that accurate contouring can be done. At places of sharp curvature or abrupt changes in direction and elevation, points selected shall be close to represent the actual ground configuration.

Levelling operation shall always start on a control station / nearby bench mark and end on the same.

5.07.00 **Route Survey**

Route Survey shall be conducted along a narrow strip / belt of the terrain selected after field reconnaissance or as directed by Owner / Engineer at Site. Topographical survey for existing storm drainage lines as well as for routing pipe lines, transportation and communication lines, etc. shall be conducted. Longitudinal profiles as well as cross-sections shall be taken at 50 m intervals or less in nearly flat / undulating terrains and at 20 m intervals in hilly terrains, as per direction of the owner / Engineer. All cross-sections shall be with reference to centre line of corridor showing levels at every 2 - 5 metre intervals and all breaks in the profile. The width of strip / corridor shall be as specified in the drawing or as directed by Owner / Engineer.

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PART-A

SECTION: II

GUIDELINE
FOR
GEOTECHNICAL INVESTIGATION

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PART-A

SECTION: II

GUIDELINE
FOR
GEOTECHNICAL INVESTIGATION

1.00.00 SCOPE

This specification covers the complete soil exploration work including carrying out field tests and laboratory tests to evaluate static as well as dynamic parameters of soil/rock and preparation of detailed report including the recommendations regarding founding level, type of foundation for different kinds of structures/machines and methods of deep excavation.

2.00.00 GENERAL

The successful bidder shall perform all work under the purview of this specification along with all incidentals and related work including setting out, staging, approach to test locations, successful bidder's office, stores and protection of adjacent buildings, structures or services / facilities. No separate payments shall be made on such accounts. The tenderer shall therefore take into account all such relevant items while quoting his bid. The boreholes shall be selected such that all the founding structures including RCC roads and Concrete pavements are represented.

2.01.00 Work to be provided for the successful bidder

The work to be provided by the successful bidder, unless specified otherwise shall include but not be limited to the following.

a) Furnish necessary plant and equipment, tools and tackles, instruments, necessary power, fuel, water, labour, supervisions by qualified and experienced engineers and supervisors specialised in the type of investigation, transport of materials, men and equipment etc., services, full insurance and all other incidental items as may be necessary for entire and successful completion of the work as per tender terms, drawings, specifications and instruction of the owner / engineer.

b) Locate in the field and in layout drawing all boreholes and other field investigation items.

c) Furnish progressively and periodically field bore logs, investigation observations, test results with relevant data and features in triplicate.

d) Prepare and submit draft (in duplicate) and final (after incorporating comments, if any) sub soil investigation report as per specification and instructions of the owner / his engineer.

2.02.00 **Work to be provided by others**

No work under this specification shall be provided by any agency other than the successful bidder unless specifically mentioned elsewhere in the contract.

2.03.00 **Location and Levels**

Location of all boreholes and field test points and levels of the existing ground at such locations shall be established by the successful bidder at his own cost from two reference grids and one bench mark given by the owner/ his engineer and these shall be subsequently plotted in the layout plan, bore logs and other relevant field test data sheets / tables to be incorporated in the report by the successful bidder.

Making bench mark pillar (s) and reference line pillars (whatever are required for the work) and maintaining them up to the completion of the work shall be the responsibility of the successful bidder at no extra cost by the owner.

2.04.00 **Codes and Standards**

The following is the general list of IS Codes to be used for the soil investigation work and preparation of report. In all cases latest revision along with amendments, if any, shall be referred to.

IS:1498	-	Classification and identification of soils for General Engineering purposes.
IS:1888	-	Method of load tests on soils
IS:1892	-	Subsurface investigation for foundation
IS:1904	-	Structural safety of buildings : shallow foundations
IS:2131	-	Method for standard penetration test for soils
IS:2132	-	Code of Practice for thin walled tube sampling of soils
IS:2720	-	Methods of tests for soils
IS:2809	-	Glossary of terms and symbols relating to Soil Engineering.
IS:2810	-	Glossary of terms relating to soil dynamics
IS:3025	-	Methods of sampling and testing for water used in industry

IS:3043	-	Code of Practice for earthing
IS:4078	-	Indexing and storage of drill cores
IS:4434	-	Code of Practice for in-situ vane shear test for soils
IS:4453	-	Code of Practice for exploration by pits, trenches, drifts and shafts
IS:4464	-	Presentation of drilling information and core description in foundation investigation
IS:4968 (Part-II)	-	Dynamic Cone Penetration Test.
IS:4968 (Part-III)	-	Static Cone Penetration Test.
IS:5249	-	Method of test for determination of dynamic properties of soil.
IS:5313	-	Guide for core drilling observations
IS:5529 (Part I)	-	In situ permeability tests - tests in over-burden
IS:5529 (Part II)	-	In situ permeability tests - tests in bed rock
IS:6403	-	Determination of allowable bearing pressure on shallow foundations.
IS:6926	-	Diamond core drilling for site investigation for river valley projects.
IS:6935	-	Method of determination of water level in boreholes
IS:7746	-	In situ shear test on rock
IS:8009	-	Calculation of settlement of foundations -
(Part-I)		Shallow foundations subjected to symmetrical static vertical loads
(Part-II)		Deep foundations subjected to symmetrical static vertical loading.
IS:8763	-	Guide for undisturbed sampling of sands
IS:8764	-	Method for determination of point load strength index of rocks

IS:9143	-	Method for the determination of unconfined compressive strength of rock materials
IS:9179	-	Method for preparation of rock specimen for laboratory testing
IS:9214	-	Method of determination of modulus of subgrade reaction (k-value) of soils in field
IS:9221	-	Method for determination of modulus of elasticity and poisson's ratio of rock materials in uniaxial compression.
IS:9259	-	Liquid limit apparatus for soils
IS:9640	-	Specification for split spoon sampler
IS:10108	-	Sampling of soils by thin wall samples with stationary piston
IS:10589	-	Equipment for subsurface sounding of soils
IS:10837	-	Specification of moulds for determination of relative density and its accessories
IS:11229	-	Specification for shear box testing of soils
IS:11315 (Part II)	-	Description of discontinuities in rock mass - core recovery and rock quality
IS:2911 (Part I/Sec-1)	-	Code of practice for design and construction of pile foundations - Concrete piles/Driven cast in-situ concrete piles
IS:2911 (Part I/Sec-2)	-	Code of practice for design and construction of pile foundations - Concrete piles/Bored cast in-situ concrete Piles
IS:2911 (Part I/Sec-3)	-	Code of practice for design and construction of pile foundations - Concrete piles/Driven precast concrete piles
IS:2911 (Part 1/Sec-4)	-	Code of practice for design and construction of pile foundations - Concrete piles/Bored precast concrete piles
IS:2911 (Part II)	-	Code of practice for design and construction of pile foundations - Timber piles
IS:2911 (Part III)	-	Code of practice for design and construction of pile foundations - Under-reamed piles

IS:2911 (Part 4) - Code of practice for design and construction of pile foundations - Load test on piles

3.00.00 SOIL EXPLORATION

3.01.00 Test Boring

Test Boring through different layers of soil shall be carried out by the successful bidder at the locations which shall be marked by the successful bidder based on the approved plot plan and/or at such other locations as directed by the Engineer-in-charge. The borehole locations shall cover all the major structures/buildings under the scope of EPC package bidder.

Various methods of boring as described in IS: 1892 may be adopted. The successful bidder shall furnish the complete details of the equipment and the method he proposes to follow. Minimum diameter of boring shall be 150 mm.

During the boring operations if rock strata are not encountered, the boring shall be continued up to 30 m depth for two bore holes and up to 20m depth for the remaining boreholes unless stated otherwise. Incase rock strata is encountered within the above depths, boring operations shall be discontinued and drilling operation as enumerated in clause 4.0 below shall be resorted to. If the present formation level is above the natural ground with filled-up soil, the depth of boring mentioned above shall exclude such filled-up soil.

The successful bidder shall describe in detail the equipment and method of boring he proposes to use. In the absence of dry boring equipment, wash boring at the discretion of the Engineer may be allowed, but the particular way of cleaning the casing by washing has to be approved by the Engineer. However, if the engineer, at any time, feels that the washing process is disturbing the samples to be taken, he may stop the work and the successful bidder shall have no claim whatsoever on this score. If the successful bidder can, however, improve the method to the satisfaction of the Engineer, he may be allowed to resume the wash boring work.

When boring cannot be advanced due to presence of hard material, it shall be checked whether there is continuous strata of hard material below before resorting to drilling methods. If only a local boulder is present it shall be chopped using suitable chopping bits and the debris removed and normal boring continued.

Ground water level for each bore hole shall be checked during boring operation and shall be recorded in bore log. Sub-soil water samples shall also be collected from each borehole and recorded.

Where possible, completed boreholes shall be capped and a G.I. pipe inserted in order to preserve them for future ground water level observation. The successful bidder shall use his own materials for this and the scope shall be inclusive of the same. These bore holes after completion of observation shall be handed over to the owner in such condition as to enable future observation of ground water possible. The other boreholes not used for

observation shall be backfilled by the successful bidder using sand fill as and when directed by the Engineer.

3.02.00 **Stabilization of Boreholes**

Boreholes shall be stabilized, whenever required, against caving of the sides of the drill hole and heaving of the bottom of the hole. especially in cases where the hole is carried below the ground water level, by use of drive pipe or casing or by means of drilling fluids (water or mixtures of water and colloidal, gel forming thixotropic clays such as bentonite), grouting (in rack) or other suitable methods.

3.03.00 **Open Trial Pits**

The open trial pits shall be carried out by successful bidder at the locations which shall be marked by the successful bidder based on the approved plot plan and/or at such other locations as directed by the Engineer-in-charge. If the present formation level is above the natural ground level with filled-up soil, the depth of trial pits shall be upto a depth of 3.5m below natural ground level or not below the ground water table or as directed by the Engineer. In no case, the depth shall be extended over 5m. The size of pits shall be 3.0m x 3.0m or as directed by the Engineer. Samples of undisturbed soil shall be obtained preferably at every 1.5m or where a change in strata is noticed.

The successful bidder shall provide a suitable access to the bottom of the pits. Sampling in trial pits shall be done as directed by the engineer.

The successful bidder shall include the scope of trial pit with earthwork in excavation, necessary side slope, backfilling and shoring/ sheeting for side protection, if required.

After completion of the test, sampling and visual examination, the pit shall be suitably backfilled as directed by the engineer. Unless otherwise specified, excavated soil shall be used for this purpose.

3.04.00 **NOT USED**

3.05.00 **Rock Drilling**

During boring operation, once rock strata is encountered, the normal method of boring operation as described under clause 3.01.00 earlier shall have to be stopped and drilling operation shall be resorted to for determining depth and nature of rock strata, in a manner as described below.

Rotary core drilling technique with continuous core recovery shall be adopted for drilling through rock. The behavior of rock mass is governed more significantly by the nature of fractures in the rock then by the type and hardness of the material composing the rock itself. Hence, good drilling technique shall be adopted to obtain an intact sample truly representative of the in-situ material and for achieving highest percentage of recovery possible.

Variations in the speed of rotation, the downward pressure on the core barrel, the pressure at which the drilling fluid is introduced into the hole and the length of hole drilled (run length) prior to removal of the core are major items which must be controlled by the driller. In general, coring shall be initiated with short runs both because the upper portions of rock masses are commonly highly fractured and also because the elevations at which core losses occur can be more accurately determined. If conditions indicate that it is possible, the length of the runs may be determined by the length of the core barrel.

In zones which are highly fractured or where the barrel continuously becomes blocked it is essential that short runs be used even though this means removal of the entire string of drilling tools every 300 mm or less. Reduced bit pressure shall be resorted to when rod vibration or chatter occurs. The pressure under which the drilling fluid shall be introduced into the hole shall be the minimum to be consistent with adequate removal of cuttings from the hole and proper cooling of the bit. To minimise the erosive action of the drilling fluid on the core and thereby to improve core recovery, double tube core barrels shall be used. The casing and core barrel to be used shall be of designation BX or NX.

During the drilling operation for each bore-hole the successful bidder shall record the rate of sinking of drill rods, ground water table elevations, if any, nature, type and sequence of rock drilled. From the recovered cores the successful bidder shall determine nature of fractures and degree of weathering of rock for each bore hole. The successful bidder shall also note and record any appreciable loss of drilling fluid throughout the entire drilling operations for each bore hole. The successful bidder shall also determine the percentage recovery ratio and rock quality designation from the recovered cores for each stage of core advance and for all the bore-holes. Rock quality designation is defined as the ratio of cumulative lengths of intact pieces of core greater than 10 cm to the length of core advance.

The successful bidder shall furnish all the information mentioned above fully verified and signed by the Engineer at site and submit them in triplicate to the Engineer. All the field works shall be verified and signed by the Engineer (owner's) at site.

The drilling operation shall be terminated when more than 75% of the core recovery is possible. If core recovery is lower and the nature of rock is weathered, drilling must be continued up to 30m for two bore holes and 20m for the remaining boreholes below the natural ground level.

In addition to the above mentioned points the successful bidder shall also take into consideration the provisions of the latest revisions of the following Codes of Practice:

a) IS: 6926 - Code of practice for diamond core drilling for site investigation for river valley projects (optional).

b) IS: 4078 - Code of Practice for indexing and storage of drill cores.

c) IS: 4464 - Code of Practice for presentation of drilling information and core description in foundation investigation.

3.06.00 **Adits and Test shafts**

An exploratory adit is a horizontal or near horizontal excavation made by mining methods in rock. The term "test shaft" is used to refer to a vertical excavation, generally in rock and to very deep test pits. These are used for in-situ examination of the nature of the rock and its structural features such as joints, fractures, faults and shear zones. Adits may also be used for in-situ tests to determine the modulus of deformation of rock.

3.07.00 **Sampling**

Bored soil shall be collected continuously during boring to note any change of strata. Samples of undisturbed soil shall be obtained preferably at every 1.5 m where a change in strata is indicated by the slurry flowing out. In no case shall the depth between successive sampling be more than 3.0 m and a sample shall be obtained on the average for every 2.0 m depth of boring, since it is intended to ascertain the characteristics of the soil at various depths. If, however, there is fair uniformity in the characteristics of the soil for certain depths the engineer may limit the number of samples stipulated above.

3.07.01 **Tube Sampling**

For obtaining undisturbed samples in its simplest from, an open drive thin wall tube sampler shall be attached to a rod and shall be lowered to the bottom after completely cleaning the borehole bottom by washing. The samplers to be used shall have area ratio less than 13 percent and preferably less than 10 percent. The head shall have check valve and ports to permit easy escape of drilling fluid or air from the sample tube as the sample enters it.

Sampling shall be accomplished by jacking or driving the tube depending on the type of soil to be sampled. Upon completion of the sampling operation the sampler shall be withdrawn from the borehole and the sample of soil carefully taken out. Approximately on inch length of soil is to be removed from each end for identification. If there is any surface water on the sample, this shall be wiped off with soaking paper, all sludge of cuttings from advancement of borehole removed and the sample immediately packed in an airtight, close fitting container marked with respective test bore numbers, elevation at which the sample was taken and other relevant information as per IS:1892. The size of soil test samples shall preferably be 65 mm dia x 200 mm high, but not less than 50 mm dia. x 150 mm high.

Representative / disturbed samples shall also be taken in different strata for visual classification, water content, grain size analysis, Atterberg limits, determination of specific gravity and compaction tests.

3.07.02 **Chunk Samples**

In cohesive soils, undisturbed samples of regular shapes shall be collected. The samples shall be cut and trimmed to a suitable size (0.3 x 0.3 x 0.3 m). A square area (0.35 x 0.35 m) shall be marked at the centre of the levelled surface at the bottom of the pit. Without disturbing the soil inside the marked area, the soil around this marking shall be carefully removed upto a depth of 0.35 m. The four vertical faces of the soil block protruding at the centre shall be trimmed slowly so that its size reduced to 0.3 x 0.3 m. Wax paper cut to suitable size shall be wrapped uniformly and covered with two layers of thin cloth over all the 5 exposed surfaces of the soil block and sealed properly using molten wax. A firmly constructed wooden box of size 0.35m x 0.35m (internal dimensions) with the top and bottom open shall be placed around the soil block and held in such a manner that its top edge protrudes just above the surface of the block. The space between the soil block and the box shall be filled uniformly and tightly with moist saw dust. The top surface shall also be covered with saw dust before nailing the wooden lid to cover the box firmly taking care that the soil block is not disturbed. The area of contact between the bottom portion of the block and the ground shall be reduced slowly by removing soil in small quantities using small rods, so that the block can be separated from the ground slowly without disturbance. After inverting the wooden box along with the soil block, the bottom portion shall be trimmed and covered with wax paper, cloth and sealed with molten wax. A wooden lid shall be nailed to the box after providing proper saw dust cushion below it. An arrow mark shall be made on the vertical face of the wooden box to indicate the top surface along with the coordinates and depth of sampling.

3.07.03 **Sampling in rock**

Sampling in rock shall be accomplished during the drilling process by employing double tube core barrels for continuous core recovery. The drilling procedure to be followed shall be the one which brings about the highest percent recovery and the exact procedure must be determined in the field.

3.08.00 **Record of Boring**

Detailed chronological record of drilling and sampling operations shall be maintained in the field log and shall be submitted to the owner after completion of boring work at site. The final log showing pertinent subsurface information and results of field and laboratory testing shall be submitted with the soil report.

The field log shall contain at least the following information:

a) Reference information like project number, title and location, exploration number and location by coordinates, inclination of the boring and if inclined the bearing or azimuth of the dip of the hole, reference level and datum.

b) Personnel information - name of drilling contractor, driller and inspecting engineer.

c) Equipment data - manufacturer's name and model designation.

d) Sampling and coring information:

i) General : Sample type and number, sampler dimension, depth at start and completion of sampling, length of sample, recovery ratio and complete visual description of each sample in "as retrieved" state.

ii) Drive samplers : weight and height of drop of hammer and number of blows for each 150 mm penetration.

iii) Push samplers : hydraulic pressure and rate of penetration.

iv) Soil or rock coring : average rotational speed, down-ward hydraulic pressure and rate of penetration.

v) Rock coring : Rock quality designation (R Q D)

e) Description of material penetrated but not sampled.

f) Casing information - size, depth at which required, length and depth of bottom of casing; weight and height of drop of hammer and number of blows for each 300 mm of penetration for driven casing, and average rotational speed and downward pressure on casing and average rate of penetration for drilled casing.

g) Seepage pressure test information-depth and duration of test.

h) Groundwater information - depth to water surface recorded daily and continued till water level has stabilized.

I) Artesian pressure information - depth at which encountered, measured head and lime at which each measurement is made.

j) Elevation of top and bottom of hole and top of rock

k) Date and time of all operations and delays with reasons.

l) Miscellaneous information to aid interpretation of sub-surface conditions.

m) Additional pertinent information.

The final log shall be a condensation of the field log refined on the basis of field and laboratory tests. The final log shall present a clear, concise and accurate picture of subsurface conditions to be utilized by the engineer.

4.00.00 PENETRATION TESTS

Penetration tests using various types of equipment as specified shall be conducted to measure the resistance of soil to penetration.

4.01.00 **Standard Penetration Test**

Standard penetration test (SPT) shall be carried out in accordance with IS:2131 at every change in strata or at 1.5 m intervals or as directed by the engineer. The successful bidder shall record the number of blows for each 150 mm penetration of the standard split spoon sampler over a depth of 450 mm. The number of blows for the first 150 mm of penetration shall not be considered in evaluating the penetration resistance. Hammer used for driving the sampler rod shall be 65 kg and drops of 750 mm shall be maintained. Records of the test including depth at which driving is initiated and the number of blows for each 150 mm penetrating shall be shown in the field log, the final log shall indicate the actual SPT value (sum of number of blows for last 300 mm of penetration) at appropriate depths.

4.02.00 **Static Cone Penetration Test**

The test shall be carried out by successful bidder at the locations which shall be marked by the successful bidder based on the approved plot plan and/or at such other locations as directed by the Engineer-in-charge. A steel cone with an apex angle of 60 deg. and overall base diameter of 35.7 mm giving a cross-sectional area of 10 Sq.cm shall be pushed through soil strata through a distance in accordance with the design of the equipment and cone resistance is noted. Thereafter the cone and the friction jacket with 36 mm OD are pushed together for a distance depending upon the design of the cone and the friction jacket assembly and combined values of cone and friction resistance noted. The procedure shall be repeated upto the desired depth. Rate of penetration shall be 1 cm/sec approximately so as to advance the cone only to a depth which is possible with the cone assembly available.

The driving mechanism shall have a capacity of not less than 10 tonne for the mechanically operated equipment. If approved by the Engineer, manually operated equipment may be used for shallow depths (Not greater than 10 m) in case of soft clay layer.

The successful bidder shall get the dial and pressure gauges calibrated by an approved testing laboratory before commencing the actual test and produce the test certificates to the Engineer.

The test shall be carried out in accordance with IS:4968 (Part-III), latest edition. Cone resistance and frictional resistance shall be separately provided in the report together with a borehole log.

4.03.00 **Dynamic Cone Penetration Test**

Dynamic cone penetration test shall be conducted to predict stratification, density, bearing capacity etc. of soils. The test shall be conducted by driving a standard size cone attached to the bottom of a string of drill rods. The test shall be conducted upto the specified depth or terminated earlier if the number of blows exceeds 35 for 100 mm penetration when the cone is driven dry and 20 for 100 mm penetration when the cone is penetrated by circulating bentonite, in order to avoid damage to the equipment.

The specification for the equipment and accessories for performing this test, test procedure, field observations and reporting or results shall conform to IS:4968 Part – II, the driving system shall comprise of a 65 kg. drive mass having a free fall of 0.75m. The cone shall be of 62.5 mm diameter provided with vents for continuous flow of bentonite slurry through the cane and rods in order to avoid friction between the rods and soil. The use of bentonite slurry may not be necessary when the investigation required is upto a depth of 6m only. On completion of the test, the results shall be presented as a continuous record of the number of blows required for every 300 mm penetration of the cone into the soil in a suitable chart supplemented by a graphical plot of blow count for 300 mm penetration vs. depth.

5.00.00 GROUND WATER INVESTIGATION

Groundwater investigation shall comprise determination of groundwater levels and pressures and permeability of subsurface materials. The effect of tidal variations (if applicable for the site) on ground water level shall also be observed by noting the water level in boreholes during high and low tide periods.

5.01.00 Ground water level observation

The successful bidder shall make necessary arrangements to prepare the boreholes for ground water observation. Completed boreholes shall be capped and a G.I. pipe inserted in order to preserve them for future ground water observation. These observations shall be taken by the successful bidder during the period of investigation. At the end of the site investigation work, these boreholes shall be handed over to the owner in such a condition that further observations can be taken by the owner for a period of at least a year.

Piezometers shall have to be installed in boreholes as directed by the owner. A piezometer consisting of either a simple standpipe of PVC tubing with a slotted end and surrounded by granular filter of plastic fabrics shall be used for granular soils or permeable rocks. In impermeable soils, hydraulic piezometer consisting of a porous element connected by twin small-bore plastic tubing to a remote reading station shall be used.

5.02.00 In-Situ Permeability Test

In-situ permeability test shall be performed in the boreholes specified and/or at such other locations at specified depths as directed by the Engineer for determination of the permeability co-efficient of the soil. The type of test shall be either pump-in or pump-out test depending on the sub-soil and ground water conditions. Pump-in test shall be conducted whether ground water in the borehole exists or not. Pump-out test with piezometer installations shall be conducted to obtain data for dewatering purposes when ground water is met in the borehole.

The specification for the equipment required for the test and the procedure of testing shall be in accordance with IS:5529, Part-I. The successful bidder shall provide all necessary equipment (diesel operated). When it is required to carry out the permeability test for a particular section of the soil strata above the ground water table, bentonite slurry shall not be used while boring.

5.02.01 **Pump - in Test**

Pump-in test shall be conducted in the borehole/trial pit by allowing water to percolate into the soil. Choice of the method of testing shall depend on the soil permeability and prevailing ground water level. Only clear water shall be used for conducting the test. Before conducting the test, the bore hole shall be cleaned. Water shall be allowed to percolate through the test section for sufficient period of time to saturate the soil before starting the observation.

a) **Constant Head Method (in borehole)**

This test shall be conducted in boreholes where soils have a high permeability. Water shall be allowed into the bore hole through a metering system ensuring gravity flow at constant head so as to maintain a steady water level in the bore hole. A reference mark shall be made at a convenient level which can be easily seen in the casing pipe to note down the fluctuations of water level. The fluctuations shall be counteracted by varying the quantity of water flowing into the bore hole. The elevation of water shall be observed at every 5 minute interval. When three consecutive readings show constant level of water surface above test depth, diameter of casing pipe, etc. shall be noted and recorded as per the proforma recommended in IS : 5529, Part-I, Appendix-A.

b) **Falling Head Method (in borehole)**

This method shall be adopted for soils of low permeability and which can stand without casing. The test section shall be sealed by the bottom of the boreholes and a packer at the top of test section. If the test has to be conducted at an intermediate section of pre-bored hole then, double packers shall be used. Access to the test section through the packer shall be by means of a pipe which shall extend to above the ground level. Water shall be filled into the pipe upto the level marked just below the top of the pipe and water allowed to drain into the test section. The water level in the pipe shall be recorded at regular intervals as mentioned in IS : 5529, Part-I, Appendix-B. The test shall be repeated till constant records of water level are achieved.

c) **Percolation test (in trial pit)**

Percolation test shall be conducted in the trial pit in areas where effluent is stored / discharged in ground level tanks. The loss of water due to percolation into the soil shall be estimated by the soil absorption capacity. This test shall be conducted in trial pits as per the procedure given in IS : 2470-Part-I, Appendix-A.

5.02.02 **Pump - Out Test**

This test shall be adopted to determine accurate values of permeability of soil below water table. Observation pipes of 50 mm dia shall be installed at regular intervals along three radial lines extending from the borehole at 120 degrees to each other. Length of these pipes shall depend on the ground level and estimated lowering of the ground water table. The test shall be carried out by pumping out the water to a known depth and recording the water levels in the observation pipes at regular intervals of time till the water level is stabilized. The observations shall be recorded as specified in IS : 5529, Part-I, Appendix-D.

6.00.00 FIELD TESTS

In situ tests shall be performed as desired by the engineer to measure properties of soil during the field investigation work.

6.01.00 **Menard Pressure meter test**

This test shall be carried out as per clause 3.7 of IS:1892 in the bore holes specified and/or at such other locations as directed by the Engineer to the full depth of bore holes, to assess the co-efficient of earth pressure at rest and the stress-strain modulus of soil. The tests shall be carried out at every 3.0 m intervals.

The successful bidder shall submit, for approval of the Engineer detailed arrangement drawings for the tests including the detail of the equipment he proposes to use and satisfy the Engineer about its adequacy. The successful bidder shall also check and confirm whether the equipment he proposes to use shall be suitable for carrying out this test in bore holes of size specified under Clause 3.01.00 of this section. If not, separate bore holes of suitable diameter shall be made at locations approved by Engineer for conducting this test.

6.02.00 **Direct Load Tests on Soils**

The direct load tests on soil shall be carried out in the trial pits specified and/or at such other locations as directed by the Engineer. This test is to be carried out at 2.5m/3.5m below the natural ground level as directed by the Engineer. The plate sizes to be used shall depend on the nature of the soil, a 45 cm square plate shall be used in clayey soil and in sandy soils, three plates of size varying between 30 cm to 75 cm shall be used. The test shall be carried out in a manner as to give dependable assessment of bearing capacities of the soils at particular level. The results of the test shall also be used for arriving at the modulus of sub-grade reaction and deformation modulus of soil.

The excavation and side protection during the test and back- filling after the test shall be carried out by the successful bidder. If ground water table is at a depth higher than the specified test depth, the ground water table shall be

lowered and maintained at the test depth for the entire duration of the test. The cost of dewatering shall be borne by the successful bidder.

The successful bidder shall submit, for approval of the Engineer, a detailed arrangement drawing for the tests and satisfy the Engineer about its adequacy in respect of strength and safety and of its being capable of giving accurate data. However, the successful bidder shall have to modify the arrangement at his own cost if it is ultimately found to be deficient.

The successful bidder must get the dial and pressure gauges calibrated by an approved testing laboratory before commencing the direct load tests at the site and produce the certificates of the tests to the Engineer. There shall be adequate number of standby gauges available at the site for quick replacement of faulty gauges. The successful bidder shall bring not less than two dial gauges and one pressure gauge as standby.

In no case settlement observations by means of level and staff shall be accepted.

The tests shall be carried out as described in IS:1888 unless otherwise specifically directed. The application of load may be by gravity or by reaction as detailed out in the above standard.

The test plate shall be preloaded with a load of 700 Kg/ sq.m. retained for a reasonable period and then replaced to take out all slacks of the arrangement. All settlement observations shall start thereafter. Unless the ultimate bearing capacity can be calculated from the available soil data, the successful bidder shall assess ultimate bearing capacity of the soil under test. Increments of the load shall be of about one fifth of the ultimate bearing capacity. The increments shall continue to an extent that allows locating the 'Yield Value of the Soil' as defined in IS:1888 or upto practicable limit of testing.

While releasing the loads, the rebounds are to be observed in a similar manner as the settlement observations.

The observations shall be recorded directly in log books, proforma of which has to be approved by the Engineer, who shall also be present to check the data. The Engineer shall be notified well in advance of the detailed programme of the test and shall also be informed prior to start of releasing the load so that the total settlement can be checked by him.

In addition to carrying out plate load tests, undisturbed/disturbed soil samples shall also be collected at regular intervals during excavation.

Each test shall include all costs inclusive of earthwork in excavation upto 3.5m depth below natural ground level, shoring for side protection, if necessary, and back filling after the test. For the depths over 3.5m shall also be considered by the bidder if the site condition warrants. If water table is required to be lowered during the test, necessary diesel operated pumping arrangement shall have to be provided by the successful bidder himself.

6.03.00 **Vane Shear Tests**

Vane shear test shall be conducted for measuring the strength of soft clay in-situ at all depths from the surface to at least 30m and at locations as specified. The test shall be conducted by pushing into the clay a small four-bladed vane of suitable size (75mm or 100 mm diameter depending upon the soil condition), attached to the end of a rod and then measuring the maximum torque necessary to cause rotation. This torque is a measure of the moment developed by the shear strength of the clay acting over the surface of the cylinder.

The test can be performed at desired depths either inside boreholes or by direct penetration from ground surface. If cuttings at the test depth in the bore hole show any presence of gravel, sand, shells, decomposed wood etc., which are likely to influence the test results, the test at that particular depth may be omitted with the permission of the engineer.

The specification for the equipment and accessories required for performing this test procedure, field observations and reporting of results shall conform to IS:4434.

6.04.00 **Determination of Dry-Density of Soils**

In place dry density of soil is required for assessment of bearing capacity of soils analysis for stability of natural slopes and in settlement calculations for estimating overburden pressure at different depths. The following methods depending on the scope of application in different types of soils shall be adopted as directed by the engineer for determination of in-place dry density of soils.

6.04.01 **Sand Replacement Method**

This method is suitable for fine, medium and coarse grained soils. Small sand pouring cylinder shall be used when the soil consists of fine to medium size grains while for soils containing stones where difficulties would be encountered with this method, a large sand pouring cylinder shall be used. The sand used for filling shall be clean, uniformly graded natural sand, passing 1.00 mm IS sieve and retained on 600 micron IS sieve. It shall be free from organic matter, oven dried and stored for suitable period to allow its water content to reach equilibrium with atmospheric humidity.

Equipment and accessories, test procedure, observations and reporting of results shall conform to IS:2720 (Part XXVIII)

6.04.02 **Core-cutter Method**

The specification for this test shall be as per IS:2720 (Part XXIX). The method shall be applied for fine grained soil, free from aggregates. Fine grained soils for the purpose of application of this method are defined as soil with not less than 90 percent passing 4.75 mm IS sieve.

6.04.03 **Ring and Water Replacement Method**

The specification for equipment, test procedure, observation and reporting of results for this test shall conform to IS:2720 (Part XXXIII). The test equipment shall consist of a circular ring placed at the surface of the ground and plastic film inserted in the hole to retain the water. The method shall be applied in coarse grained soils including gravels, cobbles, boulders and rock. Density can be determined for either the total material or material smaller than specified or given size.

6.04.04 **Rubber balloon Method**

The equipment, testing method, observations and reporting of results shall be as per IS:2720 (Part XXXIV). This method shall be applied for firmly bonded soils, it is unsuitable for very soft soils which shall deform under slight pressure or in which the volume of the hole cannot be maintained at a constant value.

6.05.00 **In-situ Block Shear / Wedge Shear Test**

The test shall be carried out in a manner as to give a dependable assessment of shear resistance of rock, when at a shallow depth, rock is encountered.

The test in the trial pits shall be carried out by successful bidder at the locations which shall be marked by the successful bidder based on the approved plot plan and/or at such other locations as directed by the Engineer-in-charge. The interpretation of test data and report shall be as per the provisions of IS: 7746. The set up without an arrangement for direct application of normal load as detailed in the above standard shall be followed.

Regarding the approval of detailed arrangement drawings for the test, adequacy of conducted test, dial gauges to be used for the test and recording of observations for the test the provisions as laid down for direct load tests on soils shall hold good.

6.06.00 **Test for Measurement of soil Resistivity**

For designing the earthing system for the project it is necessary to find out the electric resistivity of the soil at some representative locations of the project site.

Soil resistivity is determined in Ohmmeter by using "WENNER's FOUR ELECTRODE METHOD". The principle of the above method is generally as under :

Four electrodes are driven into the earth along a straight line at equal intervals of 'S'. This distance 'S' can be varied and different readings taken for electrode spacing S = 5, 10, 15, 20 metres etc. to detect the vertical variations of resistivity at a certain location. A current I is passed through the two outer electrodes and the earth. The voltage difference, V, between the two inner electrodes is measured. The current I flowing into the earth produces an

electric field proportional to its density and to the resistivity of the soil. The voltage V measured between the inner electrodes is, therefore, proportional to this field. Consequently, the resistivity shall be proportional to the ratio of voltage to current.

If the depth of burial of electrodes in the ground is negligible compared to the spacing between the electrodes , then the soil resistivity.

= 2 X 3.14 X S.V / I

Where, Resistivity of soil in Ohm-meter

S = Spacing between electrodes in metre

V = Voltage difference between two inner electrodes in volts.

= Current flowing through two outer electrodes in amp.

Earth testers normally used for the above purpose comprise the current source and meters in a single instrument and directly read the resistance. Such an instrument is known as four terminal meggar. Using such meggar for measurement , above formula becomes

= 2 X 3.14 X S.R.

where R is meggar reading in Ohms.

Depth of burial of electrodes shall not be more than 1/20 or the spacing between the electrodes.

Correction of the test results shall be done, if necessary, using the method outlined in IS: 3043.

The location and number of the test points are shown in the plant layout. The number shall be increased if the test results obtained in different locations show a significant difference.

7.00.00 TESTS FOR DYNAMIC PROPERTIES

For evaluation of in-situ dynamic and damping properties of soils, Block Vibration Test, Cyclic Plate Load Test and Wave Propagation Test shall be conducted. The tri-axial test method using repeated static loading shall also be carried out for arriving at the value of the Young's Modulus.

The locations at which such tests are to be carried out as indicated and/or at such locations as directed by the Engineer. If the present formation level is above the natural ground level with filled-up soil, the depth of trial pits shall exclude such filled-up soil.

The tests shall be carried out as described in IS:5249 or IS:1888 as applicable. The successful bidder shall submit, for approval of the Engineer, a detailed arrangement drawing for the tests and satisfy the Engineer about its

adequacy in respect of strength and safety and of it being capable of giving accurate data. However, the successful bidder shall have to modify the arrangement at his own cost if it is ultimately found to be deficient.

The observations shall be recorded directly in log books, proforma of which has to be approved by the Engineer, who shall also be present to check the data. The Engineer shall be notified well in advance of the detailed programme of the test and shall also be informed prior to the start of releasing the load so that the total settlement can be checked by him.

The scope shall include earthwork in excavation, shoring for side protection (if necessary) construction/curing of plain concrete test block, supply and embedment of foundation bolts etc. and backfilling after the test.

7.01.00 **Block Vibration Test**

Test pits of size 4.5m x 2.75m at the bottom shall have to be made. Then at the bottom of the pit a Plain Cement Concrete block of grade M15 and of size 1.5m x 0.75m x 0.70m shall be constructed. Suitable foundation bolts shall be embedded in the concrete block during casting for fixing the oscillator assembly. The concrete block shall be cured for a minimum of fifteen days and then the following Block Forced/Free vibration Test shall be carried out as per the recommendations of IS:5249 :

a) Vertical Vibration Test

b) Longitudinal Horizontal Vibration Test

c) Free Vertical Vibration Test

d) Horizontal Free Vibration Test.

7.02.00 **Wave Propagation Test**

The wave propagation test for determination of shear modulus shall be conducted both by exciting the block to steady state vibrations in the vertical direction and by making seismic waves to pass through the ground by impact of hammer and determining the time of travel of these waves between two points at a known distance apart.

7.03.00 **Cyclic Plate Load Test**

The test shall be carried out in a manner as to give a dependable assessment of load-deformation characteristics within the soil mass.

The provisions of IS: 1888 shall be followed for conducting the test. The application of load may be by gravity or by reaction as detailed out in the above Standard.

The successful bidder must get the dial gauges and pressure gauges calibrated by an approved testing laboratory before commencing the test at

site and produce the certificates of the test to the Engineer. There shall be adequate number of standby gauges available at the site for quick replacement of faulty gauges. The successful bidder shall bring not less than two dial gauges and one pressure gauge as standby.

The successful bidder shall provide a layer of cement-sand mortar (1:1 mix) below the bearing plate to level-off any uneven parts and interstices on the rock surface. Also to achieve a uniform distribution of pressure over the loaded surface, the successful bidder shall provide a flexible layer in the form of rubber pad over the loaded surface.

For conducting the load test the successful bidder shall apply cyclic loading and unloading, with four or five cycles, increasing in successive of 20% to 25% of full load. While releasing the loads the rebounds to be observed in a similar manner as the settlement observations. The range of cyclic loading shall be decided only after the static net bearing capacity is established by conventional plate load tests.

8.00.00 FIELD DETERMINATION OF CALIFORNIA BEARING RATIO

The test shall be carried out by successful bidder at the locations which shall be marked by the successful bidder based on the approved plot plan and/or at such other locations as directed by the Engineer-in-charge. The test shall be carried out at a depth of 500 mm below the finished ground level.

The successful bidder shall submit, for approval of the Engineer complete detail of the equipment and the method he proposes to use. However, the successful bidder shall have to modify the arrangement at his own cost if it is ultimately found to be deficient.

The surface area to be tested shall be exposed, cleaned of all loose and dried material, levelled and then soaked till saturation with a surcharge weight of 15 kg. After soaking is complete, the test surface shall be drained of all free water and allowed to stand for at least 15 minutes before starting further operations.

The test shall be carried out strictly in accordance with the provisions as laid down is IS:2720 (Part XXXI) latest edition. Surcharge weights of 15 kg including that of the annular weight of 5 kg shall be applied before application of load on the penetration piston. Load shall be applied on the penetration piston such that the penetration is approximately 1.25 mm/min. The load readings shall be recorded at penetrations of 0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 4.0, 5.0, 7.5, 10.0 and 12.5 mm. The maximum load and penetration shall be recorded if it occurs for a penetration of less than 12.5 mm.

After completion of the test, a sample of soil shall be taken from the point of penetration for moisture content determination. In place density shall also be determined.

From the plot of load penetration curve, after necessary correction, the bearing ratios shall be calculated for penetrations of 2.5 mm and 5 mm. If the

bearing ratio at 2.5 mm penetration is greater than that at 5 mm penetration the former shall be taken as the bearing ratio. If bearing ratio at 2.5 mm penetration is less than that at 5 mm penetration, the test shall be repeated and if the ratio at 5 mm penetration is consistently greater than that at 2.5 mm penetration, the ratio at 5 mm penetration shall be taken.

9.00.00 LABORATORY TESTS ON SOIL SAMPLES / ROCK CORES

The successful bidder shall carry out the tests as listed out and as decided by the Engineer, in laboratory. He shall furnish the name/s of laboratories where he proposes to have the tests carried out and have them approved by the Engineer.

Following laboratory tests shall be conducted: (preferably on Undisturbed soil samples and if UDS is not possible, on re-moulded soil samples)

i) Grain size analysis
   a) Hydrometer analysis
   b) Sieve analysis

ii) Field density and moisture content.

iii) Specific gravity.

iv) Chemical analysis of soil and ground water including sulphates, chlorides, pH value etc.

v) Chemical analysis of 2:1, water:soil extract of the samples giving SO3 content.

vi) Consistency Index: Liquid limit, plastic limit, plasticity index, shrinkage ratio.

vii) Consolidation test giving all relevant information.

viii) Swelling pressure and free swell index for expansive soils.

ix) Unconfined compressive strength on undisturbed soil samples

x) Direct shear test.

xi) Tri-axial compressive strength tests:

   a) Unconsolidated undrained test
   b) Consolidated undrained test
   c) Consolidated drained test

xii) Moisture density relations for Standard Proctor and Modified Proctor tests.

xiii) Crushing strength, specific gravity, unit weight, water absorption test of rock specimens of NX size.

xiv) Permeability test.

The owner shall have the right of access to successful bidder's laboratory and/or any other laboratory where tests have been arranged to be carried out during the progress of this investigation.

Adequate volume of test samples of soil/rock cores shall have to be collected from site and stored, labelled and transported carefully to the approved laboratory for carrying out the tests. The method, number, type and procedure of testing to be followed shall be as per the relevant Indian Standard Codes of Practice. The results of the tests shall be submitted to the Engineer in sextuplicate duly signed by the laboratory-in-charge. In tests for rock cores L/D = 1.0 of samples must be maintained.

10.00.00 REPORT ON SUB-SOIL INVESTIGATION

This specification covers furnishing, installation, repairing, finishing, curing, protection, maintenance and handing over of masonry and allied works for use in structures and locations covered under the scope of the Contract.

10.01.00 General

a) On completion of all the field (all the field works shall be certified by the owner) and laboratory work, the successful bidder shall submit a formal report containing geological information of the region, procedure adopted for investigation, field observations, summarised test data, conclusion and recommendations. The report shall include detailed borelogs, subsoil sections, field test results, laboratory observations and test results both in tabular as well as graphical form, practical and theoretical considerations for the interpretation of test results, the supporting calculation for the conclusions drawn etc. Initially, the successful bidder shall submit ----- copies of the report in draft form for the owner's review.

b) The successful bidder's qualified geotechnical engineer shall visit the owner's corporate office for a detailed discussion on the owner's comments on his draft report. During the discussions, it shall be decided as to the modifications that need to be done in the draft report. Thereafter the successful bidder shall incorporate in his report the agreed modifications and after getting the amended draft report approved, ----- copies of the detailed final report shall be submitted along with one set of reproducibles of the graphs, tables, etc.

c) The detailed final report based on field observations, in-situ and laboratory tests shall encompass theoretical as well as practical considerations for foundations for different type of structures envisaged in the area under investigations. The successful bidder

shall acquaint himself about the type of structures, foundations loads and other information required from the Engineer.

10.02.00 **Data to be furnished**

The report shall include the enlisted items but not be limited to them.

a) Purpose and scope of investigation

b) Authorization enabling the successful bidder to carry out the work at the site.

c) Project description including proposed facilities and construction materials required for the works.

d) Description of the site which shall include :

i) Location of the site and existing facilities.

ii) Topography of the site

iii) Drainage Characteristics

e) A plot plan showing the locations and reduced levels of all field tests e.g., boreholes, trial pits, static cone penetration tests, dynamic cone penetration tests, plate load tests etc., properly drawn to scale and dimensioned with reference to the established grid lines.

f) A true cross section of all individual bore holes and trial pits with reduced levels and coordinates showing the classification and thickness of individual stratum, position of ground water table, various in-situ tests conducted and samples collected at different depths and the rock stratum, if met with.

g) A set of longitudinal and transverse profiles connecting various boreholes shall be presented in order to give a clear picture of the site, how soil/rock strata is varying vertically and horizontally.

h) Geological information

i) Regional geology - geologic province, topographic position of site, processes of formation of subsurface materials at site.

ii) Description of overburden and bedrock at the site (if applicable for the site)

iii) Comments on texture and structure of rock, joints, bedding planes, fissures, weathering condition etc (of applicable for the site)

iv) Effect of geologic features on design.

i) Past observations and historical data, if available, for the area or for other areas with similar profile or for similar structures in the nearby area.

j) Bore hole & trial pit logs on standard proforma showing the depths, extent of various soil strata etc.

k) Plot of SPT (N) value (both uncorrected and corrected) with depth.

l) Procedure of investigations employed - field tests and laboratory investigation.

m) Results of all laboratory test summarised (i) for each sample as well as (ii) for each layer along with all the relevant charts, tables, graphs, figures, supporting calculations, conclusions and photographs of representative rock cores.

n) For all triaxial shear tests stress vs. strain diagrams as well as Mohr's circle envelopes shall be furnished. If back pressure is applied for saturation, the magnitude of the same shall be indicated. The value of modulus of elasticity E shall be furnished for all tests along with relevant calculations.

o) For all consolidation tests, the following curves shall be furnished :
e vs. log p
e vs. p and

compression vs. log t or **Compression vs. square root of t (depending upon the shape of the plot for proper determination of co-efficient of consolidation).**

The point showing the initial conditions (e, P) of the soil shall be marked on the curves.

p) The procedure adopted for calculating the compression index from the field curve and settlement of soil strata shall be clearly specified. The time required for 50% and 90% primary consolidation along with secondary settlements, if significant, shall also be calculated.

q) For pressure meter tests, the following curves shall be furnished :

Field pressure meter, creep and air calibration curves indicating Po, Pf and P1.

Corrected pressure meter and creep curves indicating P'o, P'f & P'1.

r) From the pressure meter test results the value of cohesion, angle of internal friction, pressure meter modulus, shear modulus and coefficient of subgrade reaction shall be furnished along with sample calculation. Calculation for allowable bearing pressures and corresponding total settlements, for shallow foundations mentioned below and capacity calculation of piles in various modes shall also be included.

10.03.00 **Recommendations**

Recommendations shall be given area wise duly considering the type of soil, structure and foundation in the area. The recommendations shall include but not be limited to the following:

a) Type of foundations to be adopted for various structures, duly considering the sub soil characteristics, water table, total settlements permissible for structures and equipment. Minimum depth and width of foundation shall also be recommended. The provision in relevant IS codes indicated in clause 2.04.00 shall be considered.

b) For shallow foundations, the following shall be indicated with comprehensive supporting calculations:

i) Net safe allowable bearing pressure for isolated square and continuous strip footings of different sizes at different founding depths below ground level considering both shear failure and settlement criteria, giving reasons for type of shear failure adopted in the calculation.

ii) Net safe allowable bearing pressure for mat foundations at different founding depths below ground level considering both shear failure and settlement criteria.

iii) Rate and magnitude of settlement expected of the structure.

iv) Modulus of subgrade reaction, modulus of elasticity, deformation modulus from plate load test results along with time-settlement and load-settlement curves for the various footing sizes at different founding levels indicated above. The recommended values shall include the effect of size, shape and depth of foundation.

d) Recommendations on foundations for special structures like tanks, transformers, sub-station structures, conveyor trestles, silo/stack like structures, etc.

e) Recommendations regarding bases of roads and pavements.

10.04.00 **Additional Recommendations**

a) Co-efficient of permeability of various sub soil and rock strata based on in-situ permeability tests.

b) Cone resistance, frictional resistance, total resistance, relation between cone resistance and SPT(N) value and settlement analysis for different footing sizes based on CPT/SPT.

c) Electricity resistivity of sub-soil based on electrical resistivity tests including electrode spacing vs cumulative resistivity curve.

d) Evaluation of design parameters for design and analysis based on dynamic parameters of soil like Amplitude vs. Frequency curves, co-efficient of elastic uniform compression and elastic uniform shear of soil, co-efficient of elastic non-uniform compression, co-efficient of elastic non-uniform shear, value of damping co-efficient, elastic and shear modulus of soil and Poisson's ratio of soils.

e) Co-efficient of earth pressure at rest and stress strain modulus of soil from Menard pressure meter test.

f) Recommendations regarding earth pressure as a function of depth below grade as applied to side walls of underground structures. Values of co-efficient of permeability shall be included in the report.

g) Recommendations regarding method and slope of deep excavations.

h) Recommendations regarding stability of slopes, during excavations, etc.

i) Potential of rock slides and methods of stabilisation of sides for very steep cut.

j) If expansive soil is met with recommendation on removal or detainment of the same under the structures/roads etc. shall be given. In the latter case detailed specification of any special treatment required including specification for materials to be used, construction method, equipment to be deployed etc. shall be furnished.

k) Susceptibility of sub soil strata to liquefaction in the event of earthquake and recommendation on remedial measures, if necessary.

l) Information of special significance like dewatering schemes etc. which may have a bearing on design and construction.

m) Aggressiveness of percolating water through sub-soil/ rock fissures to reinforced concrete foundation/sub- structures and also recommended protective measures, if required.

n) Recommendation for the type of cement to be used and any treatment to the underground concrete structures based on the chemical composition of soil and sub-soil water.

o) Recommendation on suitability of the overburden soil as material of construction of earthen embankments and in back filling of excavated pits / trenches.

p) Recommendation on the use of rock available as construction material.

q) Recommendation on the availability of material for use as aggregates at the site.

r) Recommendation for additional investigation beyond the scope of the present work if the successful bidder considers it necessary.

s) **Plates**

i) General plan showing location of site, and areal geology.
ii) Plan showing existing features, proposed facilities, contours and locations of boring and other investigations.
iii) Geologic sections and soil profiles.

t) **Appendices**

i) Logs of subsurface explorations
ii) Field test results
iii) Laboratory test results

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SECTION-III

GUIDELINE
FOR
AREA GRADING

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SECTION-III

GUIDELINE
FOR
AREA GRADING

1.00.00 SCOPE

This specification shall govern all clearing, grubbing, excavating, area filling, grading and compacting soils for areas designated on the drawings. The work shall include clearing and grubbing, stripping and storage of top soil, excavation, , hauling, dumping and spreading of soil, undercutting to remove unstable soil areas, compacting existing soil surfaces and bottom of excavated areas to receive fills, compacting excavated areas for sub-grade, placing and compacting soils in fills, dealing with surface water, pumping to keep excavated areas and areas to be filled dry, final grading of areas within the power plant, disposing of unsuitable and excess excavated materials and incidentals thereof.

2.00.00 GENERAL

2.01.00 Work to be provided for by the Successful bidder

Initial site leveling & Area Grading works of the entire plant area, ash dyke, raw water reservoir, raw water intake system and all other areas under EPC Package v shall be carried out by bidder. Final micro leveling is to be done by the successful Bidder as the area may get disturbed due to construction and monsoon activities.

The work to be provided for by the Successful bidder, unless specified otherwise, shall include but not be limited to the followings:

a) Furnish all labour, supervision, services, earth-moving machineries and equipment, compaction plant and equipment, tools and plants, survey instruments, transportation etc. required for the work.

b) Prepare and submit working drawings showing the approaches, slopes, berms, sumps for dewatering, space for temporary stacking of soils, disposal area, borrow pits, fencing etc. and all other details as may be required by the Engineer.

c) To carry out and submit to the Engineer, results of soil compaction tests whenever required by the Engineer to assess the degree of compaction.

d) Blasting will not be permitted.

2.02.00 **Work to be provided for by others**

No work under this specification will be provided by any agency other than the Successful bidder unless specifically mentioned elsewhere in the Contract.

2.03.00 **Codes and Standards**

All work under this specification, unless specified otherwise, shall conform to the latest revision and/or replacements of the following or any other relevant Indian Standard Specifications and Codes of Practice. In case any particular aspect of work is not covered specifically by Indian Standard Specification any other standard practice as may be specified by the Engineer shall be followed:

IS : 1200	:	Method of Measurement of Building and Civil Engineering work, Part-I Earthwork
IS : 2720 (Part-II)	:	Determination of Moisture Content
IS : 2720 (Part-IV)	:	Grain Size Analysis
IS : 2720 (Part-VII)	:	Determination of Moisture Content/Dry
IS : 2720 (Part-VIII)	:	Determination of Moisture Content/Dry
IS : 2720 (Part-XIV)	:	Determination of Density Index (Relative
IS : 2720 (Part-XXIV)	:	Determination of Dry Density, in place,
IS : 2720 (Part-XXVIII)	:	Determination of Dry Density of Soils,
IS : 3764	:	Safety Code for Excavation Work
IRC : SP-11	:	Hand book of quality control for construction of roads and runways
IRC : 36	:	Construction of Earth Embankments for Road Work

2.04.00 **Conformity with Designs**

The Successful bidder shall carry out the work as per the drawings issued to him and/or Successful bidder's drawings which are approved by the Engineer and/or the Engineer's instructions.

2.05.00 **Materials to be used**

2.05.01 General

All materials required for the work shall be of best commercial variety and as approved by the Owner.

2.05.02 Borrow Material

Borrow material if required for area filling shall be excavated from approved locations and levels within a lead of 20Km, and shall consist of selected material, approved by the Owner, free from roots, vegetations, decayed organic matter, harmful salts and chemicals, free from lumps and clods. Clean graded sand, free from harmful and deleterious materials from approved quarries, shall be used as fill material at places approved during detail Engineering stage.

Necessary arrangement shall be done by the Successful Bidder for locating and using the borrow areas after approval as the source of supply of filling material.

The depth of borrow pits shall be so regulated that the borrow pits do not cut an imaginary line having a slope of 1 vertical in 4 horizontal projected from the edge of final section of the adjacent embankment of stack of excavated soil.

2.06.00 Quality Control

The Successful Bidder shall establish and maintain quality control for the various aspects of the work, method, materials and equipment used. The quality control operation shall include but not be limited to the following items of work:

a)	Lines, Levels and Grades:	i)	Periodic Surveys
		ii)	Establishment of markers, Boards etc.
		iii)	Checking levels and slopes of the graded surface.
b)	Area filling :	i)	Checking the quality of fill material

ii) Checking moisture content of the fill.

iii) Checking the degree of compaction.

2.06.01 Any work which fails to conform to the specifications shall be subject to the issue of a Non-conformance Report in line with the Quality Control Procedure to be implemented at site. Corrective or remedial action, design modifications or product rejection shall be reviewed in accordance with the site Quality Plan.

3.00.00 EXECUTION

3.01.00 General

The work shall be undertaken in accordance with the lines, levels, grades and details shown on the drawings, specification and the approved method of work.

The works shall be carried out in a workman like manner without endangering the safety of nearby structures, roads, railway tracks, cable, pipelines, etc. and without causing hindrance to construction activities.

Suitable approaches, fencing, area lighting and temporary works required for the works shall be provided by the Successful Bidder. Sturdy and elegant fencing is to be provided around the top edge of the excavation as well as the bottom of the fill at the surplus disposal area where damping from a high bench is in progress, if directed by the Owner. Adequate area lighting shall be provided by the Successful Bidder, if night work is undertaken.

The Successful Bidder shall submit a proposal covering the proposed excavation and placement of fill material for approval of the Owner. The proposal shall include but not be limited to the following.

a) Mobilization and demobilization of plant

b) Proposed plant and equipment, labour resources & supervision.

c) Details of proposed method of clearing and grubbing for each area of cut and fill.

d) Drawings showing the areas for placement of material.

e) Management of excavation and filling works i.e., control of setting out, testing procedures, handling, temporary stockpiles, etc.

f) Temporary works proposals

g) Excavation, filling and compaction by mechanical plant

h) Dealing with surface water

i) Dewatering

j) Disposal of materials

k) Safety precautions, fencing and lighting

l) Calculations as appropriate to support work proposal

3.02.00 Setting Out

The Successful Bidder shall prepare and submit to the Owner/Consultant, detailed drawings of the excavation and filling work necessary, as proposed to be executed by him, showing the dimensions as per drawings and specification, adding his proposals for slopes, approaches, dewatering sumps, berms etc. On receiving the approval from the Owner/Consultant with modifications and corrections if necessary, the Successful Bidder shall set out the work from the control points furnished by the Owner and fix permanent points and markers for future checking. These permanent points and markers shall be checked by the Owner and certified by him after which the Successful Bidder shall proceed with the work. It shall be noted that this checking by the Owner prior to start of the work shall in no way absolve the Successful Bidder of his responsibility of carrying out the work to true lines, levels and grades as per drawing and subsequent corrections, if any. In case any errors are noticed in the Successful Bidder's work at any stage, the same shall be remedied by the Successful Bidder.

3.03.00 Initial Levels

Initial levels either in a definite grid pattern or as directed by the Owner shall be taken by the Successful Bidder jointly with the Owner over the original ground prior to starting actual grading work and after setting out. These initial levels and cross-sections shall be jointly signed by the Successful Bidder and the Owner before commencement of work.

3.04.00 Clearing and Grubbing etc.

The area to be excavated or filled shall be cleared out of fences, trees, logs, stumps, bush, vegetation, rubbish, slush, etc. if any and leveled up.

Before grading is started, all the spoils and unserviceable materials and rubbish shall be removed from the site to approved disposal areas within a lead of 5Km as specified. Useful materials, saleable timber, firewood, etc. shall be the property of the Owner and shall be stacked properly at the worksite in a manner as directed by the Owner. Disposal shall be carried out as per cl 3.08.02 of this volume

3.05.00 **Classification**

Materials involved in grading shall be classified under the following categories. No distinction will be made whether the material is dry or wet. The Engineer's decision in regard to such classification shall be final and binding on the Successful bidder:

a) **Ordinary and hard soil**

This shall include clay, silt, sand, moorum, shingle, kankar, gravel, loam, peat, ash and other similar materials in soft, hard or dense state which can generally be excavated with ordinary spade, pick axe, shovel etc. and does not require the use of wedges, pneumatic breaking equipment and/or blasting for removal. It shall also include loose rock boulders present in the soil, with dimensions not exceeding 500 mm in any direction. Breaking of consolidated brick ballast and mud concrete shall be considered equivalent to excavation work under this type of soil.

b) **Soft and Decomposed Rock**

This shall include rocks like chalk, slate, mica schist, laterite and other similar materials which in the opinion of the Engineer is rock, but does not require blasting for removal and could be removed with picks, hammers, crow bars, wedges, pneumatic breaking equipment etc. It shall also include boulders with dimensions greater than 500 mm but not exceeding 1000 mm in any direction.

c) **Hard Rock**

This shall include rocks occurring in large masses which cannot be removed except by blasting. Harder varieties of rock such as trap, with or without veins and secondary mineral which in the opinion of the Engineer require blasting for removal shall also be considered as hard rock. It shall also include boulders bigger than 1000 mm in any direction. Construction in concrete, both reinforced and unreinforced, which is required to be dismantled during earthwork.

3.06.00 **Earthwork in Excavation**

3.06.01 General

Before commencement of excavation/filling the existing ground surface shall be cleared in accordance with Clause no. 3.4.0.

All excavation shall be done to the minimum dimensions as required for safety and working facility. Prior approval of the Owner shall be obtained by the Successful Bidder, in each individual case, for the method he proposes to adopt for the excavation including dimension, side slopes, dewatering, disposal, etc.

This approval, however, shall not in any way make the Owner responsible for any consequent loss or damage. The excavation must be carried out in the most expeditious and efficient manner.

Prior to starting the excavation, the ground level at the location shall be checked jointly with the Owner.

The rough excavation may be carried up to a maximum depth of 150 mm above the final level. The balance shall be excavated with special care. If directed by the Owner, soft and undesirable spots shall be removed even below the final level and the same shall be filled with suitable filling materials as directed by the owner/consultant and well compacted.

3.06.02 Excavation in Ordinary Soil, Hard Soil & Soft and Decomposed Rock

The excavation in ordinary soil, hard soil and soft and decomposed rock shall be carried out as per the approved proposal, modified and corrected where necessary by the Owner. The work shall be carried out in a workmanlike manner without endangering the safety of nearby structures or roads, railway tracks, cables, pipelines, drains, trenches etc. if any, and without causing hindrance to other activities in the area. As the excavation reaches the required dimensions, lines, levels and grades, the work shall be checked by the Owner thoroughly and the balance work shall be carried out carefully to avoid any over-excavation.

On completion, the work shall be finally checked and approved by the Owner. Further work shall be resumed after getting clearance from the Owner.

3.06.03 Excavation in Hard Rock

Overburden, if any, consisting of top soil, ordinary and hard soil, soft and decomposed rock as per classification of soil, which do not require blasting shall be completely stripped off and the levels of the hard rock surface shall be taken to enable measurement. Further work in hard rock shall be resumed after clearance from the Owner.

Personnel deployed for rock excavations shall be protected from all hazards such as loose rock/boulder rolling down and from general slips of excavated surfaces. Where the excavated surface is such that it is not stable against sliding, necessary supports, props, bracings or bulkheads shall be provided and maintained during the period of construction. Where danger exists of loose rock/boulder falling from the excavated surfaces deeper than 2 metres, steel mesh anchored to the lower edge of excavation and extending over and above the rock face, adequate to retain the dislodged material shall be provided and maintained.

Blasting is not allowed. The excavation shall be carried out by chiseling, wedging with pneumatic equipments or any other approved method. All loose or loosened rock in the sides shall be removed by barring, wedging, etc.

3.06.04 NOT USED

3.06.05 **Disposal**

The excavated spoils shall be disposed off within the specified lead of 5Km in any or a combination of some of the following manners, as directed by the Owner :

a) By stacking separately the materials suitable for area filling and materials not suitable.

b) By stacking it temporarily for use in backfilling at a later date.

c) i) by either spreading, or

ii) Spreading and compacting at designated filling areas and/or disposal areas.

Disposal shall be carried out as per cl 3.08.02 of this volume

3.06.06 **Dewatering**

All areas shall be kept free of water. Grading in the vicinity of excavations shall be controlled to prevent surface water running into excavated areas. The Successful Bidder shall remove by pumping or other means approved by the Owner, any water inclusive of rain water and subsoil water accumulated in the area. Method of dewatering shall be got approved by the Owner.

Any special dewatering system like well point dewatering required for lowering the ground water table to facilitate construction work of sub-structure / super structure in a water free condition is in the scope of contractor. Dewatering will be planned and continued till backfilling is completed. For discharge of sub-soil water / rain water, a suitable piping system with pumping arrangement will be provided by the contractor with prior approval of purchaser to the nearby sump/drain. Bidder has to deploy dewatering diesel driven pumps/ DG sets of suitable capacity to take care of any exigencies in case of power disruption to the electrical driven dewatering pumps.

3.06.07 **Dealing with Surface Water**

All working areas shall be kept free of surface water as far as reasonably practicable. Works in the vicinity of cut areas shall be controlled to prevent the ingress of surface water.

Working surfaces shall be formed to such falls to shed water and prevent ponding.

No works shall commence until surface water streams have been properly intercepted, redirected or otherwise dealt with.

Where works are undertaken in the monsoon period, the Successful Bidder may need to construct temporary drainage systems to drain surface water from working areas.

3.07.00 **Treatment of Slips**

The Successful Bidder shall take all precautions to avoid high surcharges and provide proper surface drainage to prevent flow of water over the sides. These precautions along with proper slopes, berms, and control of ground water shall cause no slips to occur. If however slips do occur due to causes beyond control of the Successful Bidder, the same shall be removed by him.

3.08.00 **Earthwork in Filling**

3.08.01 Area Filling for Grading

The material to be used for area filling shall be selected material capable of being compacted to the requirements stated herein below and approved by the Owner, obtained directly from excavation for area grading, from nearby areas where excavation work by the same agency is in progress, from temporary stacks of excavated soils or from borrow pits in selected areas designated/approved by the Owner. The quality of the material shall conform to that mentioned in clause 2.05.2 of this specification.

Where excavated material is mostly rock, the boulders shall be broken into pieces not longer than 150 mm size, mixed with properly graded fine material consisting of murmur or earth to fill up the voids and the mixtures used for filling.

If any material is rejected by the Owner, Successful Bidder shall remove the same forthwith from the site. Surplus fill material shall be deposited / disposed of as directed by the Owner within a lead of 5 KM after the fill work is completed.

No earth fill shall commence until surface water discharges and streams have been properly intercepted or otherwise dealt with as directed by the Owner.

Before commencement of area filling the existing top soil shall be removed up to a minimum depth of 150 mm, or more, as directed by the Owner in order to clear the surface of undesirable materials. After this the filling operation shall be performed with earth in layers not exceeding 300 mm, loose thickness. Successive layers shall not be placed until the layer under construction has been thoroughly compacted to the specified requirements as given below and got approved by the Owner.

a) Each layer of earth of cohesive in nature shall be compacted to 90% of proctor's dry density unless otherwise permitted /directed by the Owner.

b) Each layer of earth of non-cohesive in nature shall be compacted to minimum 75% relative density unless otherwise permitted/directed by

the Owner. Each shall be compacted with approved machine (mechanical plant) and usually manual compaction shall not be allowed unless specifically permitted by the Owner.

The original ground formation and each fill layer shall be compacted by rollers as described below with a maximum of six possess of 8/10 tons roller.

i) When the optimum moisture content of soil is relatively high, a pneumatic tyred roller (type pressure 3.0 - 3.5 kg/sq.cm) shall be considered to give better performance for mechanical compaction.

ii) When the optimum moisture content of soil is relatively low, a vibrating roller shall be considered to give better performance for mechanical compaction.

Since the degree of compaction depends on the moisture content of the soil, a close watch shall be kept on this aspect and corrections done to optimize the moisture content. The adequacy of the compaction and moisture content of the soil shall be determined by performing field density tests and other tests as and when directed by the Owner and shall conform to the stipulations laid down in IS:4701.

The cohesion-less soil to be used for area filling, shall be placed in fully saturated condition to obtain the maximum possible density. The saturation moisture content shall be determined by laboratory tests prior to commencement of work.

Field compaction test shall be carried out at different stages of filling and also after the fill to the entire height has been completed.

When density measurements reveal soft areas in the construction, further compaction shall be undertaken at the Successful Bidder's cost as directed by the Owner. If the required compaction is then not achieved the material in the soft area shall be removed and replaced by approved material and compacted in accordance with this specification all to the Successful Bidder's account.

The fill shall be carried out to such dimensions and levels as indicated on the drawings after the stipulated compaction. The fill shall be considered as incomplete if the desired compaction has not been obtained.

If so specified, the rock as obtained from excavation may be used for filling and leveling to indicate grades without further breaking. In such an event, filling shall be done in layers not exceeding 50 cm approximately. After rock filling to the approximate level, indicated above has been carried out, the void in the rocks shall be filled with finer materials such as earth, broken stone, etc. and the area flooded so that the finer materials fill up the voids. Care shall be taken to ensure that the finer fill material does not get washed out. Over the layer so filled, a 100 mm thick mixed layer of broken material and

earth shall be laid and consolidation carried out by a 12 tonne roller. No less than 12 passes of the roller shall be accepted before subsequent similar operations are taken up.

3.08.02 **Filling in Disposal Areas**

Excavated materials if not used in area filling and any waste material, shall be disposed of in designated disposal areas within a lead of 5KM as directed by the Engineer-in-charge The earth shall not be dumped haphazardly but shall be spread in horizontal layers not exceeding 300mm in thickness and nominal compaction done upto 85% Proctor density to the satisfaction of the Owner.

All clods shall be broken before placing the fill. Earthmoving machinery including dumpers, dozers, rollers and trucks shall be allowed to ply over the fill to permit compaction to take place.

3.09.00 **Compaction Control**

The density of each layer of compacted soil shall be ascertained by testing a number of samples. For this purpose the necessary arrangements for soil testing at the site shall be made by the Successful Bidder in accordance with these specifications and as directed by the Owner.

The Successful Bidder shall arrange the provision of the field laboratory including the testing equipment and a suitable motor vehicle.

All soil testing is to be carried out by a competent and suitable qualified engineering testing firm. The Successful Bidder is to obtain the Owner's approval for the firm to be used. The Successful Bidder may undertake this work with the Owner's approval.

All density testing shall be carried out on a lot by lot basis. A lot shall be considered to be a portion of work which is essentially homogeneous with respect to material type general appearance response during compaction, moisture condition during compaction, compaction process and state of underlying material.

All fill testing shall be carried out in accordance with the recent editions of relevant Indian Standards. The chainage and the off-set from the centre line of the fill of each test sample shall be recorded and presented along with the test results.

Each test lot shall be classified as cohesionless or cohesive. The classification shall be determined by the Owner based upon particle size distribution. Cohesionless fill shall have 10% or less by mass of particles finer than 0.075 mm. Otherwise fill shall be treated cohesive.

For cohesionless fill material, a representative laboratory sample obtained from three field samples from each test lot shall be tested to determine its maximum and minimum dry density. These reference values of dry density

shall be used to compute the density index (relative density) of each of the field density test samples taken from the test lot.

For cohesive fill material, a representative laboratory sample obtained from three field samples from each test lot shall be tested to determine its maximum dry density and optimum moisture content (OMC). These reference values of dry density and moisture content shall be used to compute the dry density ratio of each of the field density test samples taken from that test lot.

The degree of compaction shall be determined by considering the mean density of the samples in each test lot. The mean dry density shall be equal to or exceed the minimum specified density. In no individual case shall density be less than the minimum value specified by more than 2 percent, otherwise further rolling shall be done at the appropriate locations.

The Successful Bidder shall lay a further layer or fill only after compaction or a particular layer has been found and approved by the Owner.

4.00.00 TESTING AND ACCEPTANCE CRITERIA

4.01.00 Soil Testing

Tests shall be undertaken by the Successful Bidder as per IS 2720 and as required by the owner. The results and reports shall be submitted to the Owner/consultant for approval. Test failures are to be immediately notified to the Owner/consultant, otherwise results to be submitted within 24 hours of testing. Each layer of material shall be tested for compaction.

Each layer is to be tested in a manner that is representative of its full depth. The Owner/consultant may at his discretion instruct the Successful Bidder to increase or decrease the frequency of testing.

4.02.00 **Acceptance Criteria**

4.02.01 Excavation

On completion of excavation, the dimensions of the area shall be checked as per the drawings after the area is completely dewatered. The work shall be accepted after all undercuts have been set right and all over excavations filled back to required lines, levels and grades by selective materials. Over excavation of the sides shall be made good by the Successful Bidder. The excavation work shall be accepted after the above requirements are fulfilled & all temporary approaches encroaching inside the required dimension of the excavation have been removed

.

4.02.02 Area-filling

The degree of compaction required shall be as per the stipulations laid down in appropriate sections of this specification. The actual method for measuring

the compaction achieved shall be as decided by the Owner. The work of area filling shall be accepted after the Owner is satisfied with the degree of compaction achieved.

5.00.00 INFORMATION TO BE SUBMITTED

5.01.00 After Award

Following details of Machineries, transport vehicles, equipment proposed to be used for excavation, area-filling and compaction have to be submitted before starting the work.

i) Equipment, machinery & earthmoving vehicles, available with the Successful bidder and proposed to be used for excavation and haulage giving details regarding make, model, capacity, year of manufacture, numbers available for this contract and general condition.

ii) Equipment proposed to be used for area filling and compaction giving similar details as in item 5.1.0 (i) above.

iii) Method of transportation.

After award of contract the Successful Bidder shall submit the following for approval and adoption :

a) The Successful Bidder shall submit a detailed programme of work as proposed to be executed giving completion dates of excavation of the various areas and the time required for area-filling and compaction. The programme shall also show how the excavation and area-filling quantities shall be balanced, minimising temporary stacking of spoils.

It is to be noted that the Owner even after initial approval of the programme, may instruct to enhance or retard the progress of work during the actual execution, in order to match with overall construction schedule without attracting any claims from the Successful Bidder. The initial programme being submitted by the Successful Bidder shall have sufficient flexibility to take care of such reasonable variations.

b) The Successful Bidder shall submit drawings showing details of slopes, approaches, sump pits, dewatering lines, borrow pits, if any, fencing etc. for approval of the Owner/Consultant for adoption.

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SECTION-IV

GUIDELINE
FOR
EARTHWORK IN EXCAVATION AND BACKFILLING

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SECTION - IV

GUIDELINE
FOR
EARTHWORK IN EXCAVATION AND BACKFILLING

1.00.00 SCOPE

This specification covers excavation in all types of soil, soft and decomposed rock not requiring blasting and rocks requiring shoring, dewatering, filling around foundations and to grade, compaction of fills and approaches, protective fencing, lighting, etc. relevant to structures and locations covered under the scope of this contract.

2.00.00 GENERAL

2.01.00 Work to be provided for by the Successful Bidder

The work to be provided for by the Successful Bidder of EPC Package, unless specified otherwise, shall include but not be limited to the following :

a) Furnish all labour, supervision, services including facilities as required under statutory labour regulations, materials, scaffolds, equipment, tools and plants, transportation, etc. required for the work.

b) Prepare and submit working drawings showing the approaches, slopes, berms, shoring, sumps for dewatering, including drains and outfall for drainage, space for temporary stacking of spoils, disposal area, fencing, etc. and all other details as may be required by the Owner.

c) To carry out sampling and testing and submit to the Owner, results of soil compaction tests whenever required by the Owner to assess the degree of compaction.

2.02.00 Work to be provided for by others

No work under this specification shall be provided by any agency other than the Successful Bidder of EPC Package unless specifically mentioned elsewhere in the Contract.

2.03.00 **Codes and Standards**

All works under this specification, unless specified otherwise, shall conform to the latest revision (as on the original scheduled date of Bid opening) and/or replacement of the following or any other Indian Standard Specifications and Codes of Practice. In case any particular aspect of work is not covered specifically by Indian Standard Specification any other standard practice as may be specified by the Owner /Consultant shall be followed :-

IS:2720 (Part-II)	Determination of Moisture Content
IS:2720 (Part-VII)	Determination of Moisture content / Dry Relation using Light Compaction.
IS:2720 (Part-xiv)	Determination of Density Index (Relative Density) of cohesionless soils.
IS:2720 (Part-xxix)	Determination of Dry Density , in place, by core cutter method.
IS:2720 (Part- xxviii)	Determination of Dry Density of soils, in place, by sand replacement methods.
IS:3764	Safety code for Excavation work.
IS:4701	Earthwork on canals

2.04.00 **Conformity with Designs**

Successful Bidder of EPC Package is to carry out the work as per the drawings which are approved by the Consultant and/or the Owner's instructions.

2.05.00 **Materials to be used**

2.05.01 **General**

All materials required for the work shall be of best commercial variety and approved by the Owner.

2.05.02 **Borrow Material**

Borrow material if required for back-filling shall be excavated from approved locations and levels (within a lead of 20KM), and shall consist of material, approved by the Owner, free from roots, vegetation, decayed organic matter, harmful salts and chemicals, free from lumps and clods. If specified, clean graded sand free from harmful and deleterious material from approved quarries shall be used as fill material without any additional cost to owner.

2.06.00 **Quality Control**

The Successful Bidder shall establish and maintain quality control for the various aspects of the work, method, materials and equipment used. The quality control operation shall include but not be limited to the following items of work:

a) Lines, Levels and Grades:	i) Periodic surveys
	ii) Establishment of markers, boards etc.
b) Back-filling :	i) Checking the quality of fill material
	ii) Checking moisture content of the backfill
	iii) Checking the degree of compaction

2.07.00 **Information regarding site conditions**

Surface and Sub-surface data regarding the nature of soil, rock, sub-soil water etc. shown on drawing or otherwise furnished to the Successful bidder shall be taken as a guidance only and variation therefrom shall not affect the terms of the contract. The Successful bidder must satisfy himself regarding the character and volume of all work under this contract and expected surface, sub-surface and / or sub-soil water to be encountered by visiting site before bid submission and doing soil testing if necessary.. He must also satisfy himself about the general conditions of site and ascertain the existing and future construction likely to come up during the execution of the contract so that he may evolve a realistic programme of execution

3.00.00 EXECUTION

3.01.00 **Setting Out**

Successful Bidder shall prepare and submit to the Owner / Consultant, detailed drawings of the excavation work as proposed to be executed by him showing the dimensions as per drawings and specification adding his Proposals of slopes, shorings, approaches, dewatering sumps, berms, etc. On receiving the approval from the Owner/Consultant with modifications and corrections, if necessary, the Successful Bidder shall set out the work from the control points furnished by the Owner and fix permanent points and markers for ease of future checking.

These permanent points and markers shall be fixed at intervals prescribed by the Owner and checked by the Owner and certified by him after which the Successful Bidder shall proceed with the work. It shall be noted that this checking by the Owner prior to start of the work shall in no way absolve the Successful Bidder of his responsibility of carrying out the work to true lines and levels and grades as per drawing and subsequent corrections, if

necessary, in case any errors are noticed in the Successful Bidder's work at any stage.

3.02.00 **Initial Levels**

Initial levels either in a definite grid pattern or as directed by the Owner will be taken by the Successful Bidder jointly with the Owner over the original ground prior to starting actual excavation work and after setting out. These initial levels and cross-sections shall be jointly signed by the Successful Bidder and the Owner before commencement of work.

3.03.00 **Clearing and Grubbing, etc.**

The area to be excavated or filled shall be cleared out of fences, trees, logs, stumps, bush, vegetation, rubbish, slush, etc. and levelled up.

Before earthwork is started, all the spoils and unserviceable materials and rubbish shall be removed from the site to approved disposal areas within a lead of 5KM as may be specified. Useful materials, saleable timber, firewood, etc. shall be the property of the Owner and shall be stacked properly at the worksite in a manner as directed by the Owner. Disposal of waste/surplus material shall be carried out as per cl 3.05.06 of this volume

3.04.00 **Classification**

All earthwork shall be classified under the following categories:

No distinction will be made whether the material is dry or wet.

a) **Ordinary Soil**

This shall comprise vegetable or organic soil, turf, sand, silt, loam, clay, mud, peat, black cotton soil, soft shale or loose moorum, a mixture of these and similar material which yields to the ordinary application of pick and shovel, rake or other ordinary digging implement. Removal of gravel or any other nodular material having diameter in any one direction not exceeding 75 mm occurring in such strata shall be deemed to be covered under this category.

b) **Hard Soil**

This shall include:

i) stiff heavy clay, hard shale, or compact moorum requiring grafting tool or pick or both and shovel, closely applied ;

ii) gravel and cobble stone having maximum diameter in any one direction between 75 and 300 mm ;

iii) soling of roads, paths, etc., and hard core ;

iv) macadam surfaces such as water bound, and bitumen/tar bound;

v) lime concrete, stone masonry in lime mortar and brick work in lime/cement mortar, below ground level ;

vi) soft conglomerate, where the stones may be detached from the matrix with picks ; and

vii) generally any material which requires the close application of picks, or scarifies to loosen and not affording resistance to digging greater than the hardest of any soil mentioned in (i) and (vi) above.

c) **Soft and Decomposed Rock**

This shall include:

i) limestone, sandstone, laterite, hard conglomerate or other soft or disintegrated rock which may be quarried or split with crowbars ;

ii) unreinforced cement concrete which may be broken up with crowbars or picks and stone masonry in cement mortar below ground level ;

iii) boulders which do not require blasting having maximum diameter in any direction of more than 300 mm, found lying loose on the surface or embedded in river bed, soil, talus, slope wash and terrace material of dissimilar origin ; and

iv) any rock which in dry state may be hard, requiring blasting, but which when wet becomes soft and manageable by means other than blasting.

d) **Hard Rock (blasting prohibited)**

This shall include:

i) any rock or cement concrete for the excavation of which the use of mechanical plant or blasting is required;

ii) reinforced cement concrete (reinforcement cut through but not separated from the concrete) below ground level; and

iii) boulders requiring blasting.

Hard rock as described above the excavation has to be carried out by chiseling, wedging or any other agreed method.

In case of any dispute regarding classification, the decision of the Engineer shall be final.

3.05.00 **Excavation for Foundations and Trenches**

3.05.01 **General**

All excavations shall be done to the minimum dimensions as required for safety and working facility. Prior approval of the Owner shall be obtained by the Successful Bidder, in each individual case, for the method he proposes to adopt for the excavations including dimension, side slopes, shoring, dewatering, disposal, etc. This approval, however, shall not in any way make the Owner responsible for any consequent loss or damage. The excavation must be carried out in the most expeditious and efficient manner.

All excavation in open cuts shall be made true to line, slopes and grades shown on the drawing or directed by the Owner. The vertical faces of excavation shall not be undercut for extended footings / foundations. No material shall project within the dimension of minimum excavation lines marked. Boulders projecting out of the excavated surfaces shall be removed, if in the opinion of the Owner they are likely to be a hindrance to the workers.

Method of excavation shall be in every case subject to the approval of the Owner /Consultant and the Successful Bidder shall ensure the stability and safety of the excavation, adjacent structures, services and works.

The Successful Bidder shall have full responsibility of the stability of the excavation and safety of the workmen. If any slip occurs, the Successful Bidder shall remove all slipped material from the excavated pit.

All loose boulders, semi-detached rocks, not directly in excavation but so close to the area to be excavated as to be liable, in the opinion of the Owner, to fall or otherwise endanger the workmen, equipment of the work, etc., shall be stripped off and removed away from the areas of excavation. The method used shall be such as not to shatter or render unstable or unsafe the portion which was originally sound and safe. Any materials not requiring removal as contemplated in the work, but which, in the opinion of the Owner, is later to become loose or unstable shall also be promptly and satisfactorily removed as directed by the Owner.

Prior to starting the excavation, the ground level at the location shall be checked jointly with the Owner.

The rough excavation may be carried up to a maximum depth of 150 mm above the final level. The balance shall be excavated with special care. If directed by the Owner, soft and undesirable spots shall be removed even below the final level. The extra excavation shall be filled up as instructed by the Owner (with lean PCC M10).

If the excavation is done to a depth greater than that shown on the drawing, or directed by the Owner, due to the Successful Bidder's fault, the excess depth shall be filled up to the required level (with cement concrete not leaner than M10 concrete or richer) as directed by the Owner in each individual case.

If the bottom of any excavation at design depth appears to be soft, unsound or unstable, the Successful Bidder shall report the matter to the Owner and if the Owner so directs, shall excavate the same to indicated depths. The extra depth shall be filled up with concrete M10 or such other material as the Owner shall direct.

In formation of rock requiring blasting, those overcuts which are unavoidable shall be made up by ordinary cement concrete 1:2:4. All excavated materials such as hard rock, boulders, bricks, dismantled concrete blocks, etc. shall be stacked separately as directed by the Owner and shall be the property of the Owner.

3.05.02 Excavation in Ordinary Soil, Hard Soil and Soft and Decomposed Rock

The excavation in ordinary soil, hard soil, soft and decomposed rock shall be carried out as per the approved proposal, modified and corrected where necessary by the Owner. The work shall be carried out in a workman like manner without endangering the safety of nearby structures/services or works and without causing hindrance to other activities in the area. As the excavation reaches the required dimensions, lines, levels and grades, the work shall be checked by the Owner thoroughly and the balance work shall be carried out carefully to avoid any over-excavation. On completion, the work shall be finally checked and approved by the Owner. In certain cases, where deterioration of the ground, upheaval, slips, etc. are expected, the Owner may order to suspend the work at any stage and instruct the Successful Bidder to carry out the balance work just before the foundation work of the structure can be started.

3.05.03 Excavation in Hard Rock

In case where excavation, both in ordinary soil and hard rock, are involved, the ordinary soil comprising of soft, hard and dense soils (including laterite formations) and rock including weathered rocks, lateritic rocks, etc. which can be excavated without blasting, shall be completely stripped off. Further work in hard rock shall be resumed after clearance from the Owner.

Personnel deployed for rock excavations shall be protected from all hazards such as loose rock/boulder rolling down and from general slips of excavated surfaces. Where the excavated surface is such that it is not stable against sliding, necessary supports, props, bracings or bulkheads shall be provided and maintained during the period of construction. Where danger exists of loose rock/boulder falling from the excavated surfaces deeper than 2 metres, steel mesh anchored to the lower edge of excavation and extending over and

above the rock face, adequate to retain the dislodged material shall be provided and maintained.

For Hard rock, the excavation shall be carried out by chiseling, wedging or any other approved method.

Note: Extra claim shall not be permitted for difficulties facing in any type of earthwork

3.05.04 NOT USED

3.05.05 **Disposal**

The excavated spoils shall be disposed of in any or all the following manners:

a) By using it for backfilling straightway.

b) By stacking it temporarily for use in backfilling at a later date during execution of the Contract.

c) i) By either spreading or

ii) Spreading and compacting at designated filling areas and / or disposal areas.

d) By selecting the useful material and stacking it neatly in areas designated by the Owner.

3.05.06 **Disposal of Surplus**

All surplus material from excavation shall be carried away from the excavation site to designated disposal area within a lead of 5KM selected by the Owner. The earth shall not be dumped haphazardly but shall be spread in horizontal layers not exceeding 300mm in thickness and nominal compaction done upto 85% Proctor dry density to the satisfaction of the Owner

All clods shall be broken before placing the fill. Earthmoving machinery including dumpers, dozers , rollers and trucks shall be allowed to ply over the fill to permit compaction to take place

All good and sound rock excavated from the pits and all assorted materials of dismantled structures shall be the property of the Owner.

3.05.07 **Protection**

The Owner shall be notified by the Successful Bidder as soon as the excavation is expected to be completed within a day so that it may be inspected by him at the earliest. Immediately after approval of the Owner, the excavation must be covered up in the shortest possible time. But, in no case the excavation shall be covered up or worked on before approval by the

Owner. Excavated material shall be placed beyond 1.5 metres from the edge of the pit or trench or half the depth of the pit or trench whichever is more or further away if directed by the Owner.

Excavation shall not be carried out below the foundation level of structure close by until required precautions have been taken.

Adequate fencing is to be made enclosing the excavation.

The Successful Bidder shall protect all under-ground services exposed by excavation. The Successful Bidder shall also divert all surface drains, etc. affected by the excavation to maintain the working area neat and clean. The use of mechanical equipment shall not be permitted in locations where its operation would cause damage to trees, buildings, culverts, or other existing property, utilities, or structures above or below ground. The existing facilities shall be retained either by modifying or relocating as the case may be without any additional cost to owner.

3.05.08 **Dealing with Surface Water**

All working areas shall be kept free of surface water as far as reasonably practicable. Works in the vicinity of cut areas shall be controlled to prevent the ingress of surface water.

No works shall commence until surface water streams have been properly intercepted, redirected or otherwise dealt with.

Where works are undertaken in the monsoon period, the Successful Bidder may need to construct temporary drainage systems to drain surface water from working areas.

3.05.09 **Dewatering**

All excavations shall be kept free of water and slush. Grading in the vicinity of excavations shall be controlled to prevent surface water running into excavated areas. The Successful Bidder shall remove by pumping or other means approved by the Owner any water inclusive of rain water and subsoil water accumulated in excavation and keep the trench dewatered until the construction of foundation structure and backfilling are complete in all respects. Sumps made for dewatering must be kept clear of the foundations. Method of pumping shall be approved by the Owner but in any case, the pumping arrangement shall be such that there shall be no movement of subsoil or blowing in due to differential head of water during pumping.

Any special dewatering system like well point dewatering required for lowering the ground water table to facilitate construction work of sub-structure / super structure in a water free condition is in the scope of contractor. Dewatering will be planned and continued till backfilling is completed. For discharge of sub-soil water / rain water, a suitable piping system with pumping arrangement will be provided by the contractor with prior approval of

purchaser to the nearby sump/drain. Contractor has to deploy dewatering diesel driven pumps/ DG sets of suitable capacity to take care of any exigencies in case of power disruption to the electrical driven dewatering pumps.

3.05.10 Timber Shoring

Timber Shoring made out of approved quality of timber shall be 'close' or 'open' type, depending on the nature of soil and the depth of pit or trench and the type of timbering shall be determined by the Owner. It shall be the responsibility of the Successful Bidder to take all necessary steps to prevent the sides of trenches and pits from collapsing.

3.05.10.1 Close Timbering

Close timbering shall be done by completely covering the sides of the trenches and pits generally with short, upright members called 'polling boards'. These shall be of minimum 250 x 40 mm sections as directed by the Owner. The boards shall generally be placed in position vertically in pairs, one board on each side of cutting, and shall be kept apart by horizontal walers of strong wood at maximum 1.2 metres spacing, cross strutted with ballies or as directed by the Owner. The length of the bally struts shall depend on the width of the trench or pit.

In case where the soil is very soft and loose, the boards shall be placed horizontally against the sides of the excavation and supported by vertical walers, which shall be strutted to similar timber pieces on the opposite face of the trench or pit. The lowest board supporting the sides shall be taken into the ground. No portion of the vertical side of the trench or pit shall remain exposed, so that the earth is not liable to slip out.

The withdrawal of the timber shall be done very carefully to prevent the collapse of the pit or trench. It shall be started at one end and shall proceed systematically to the other end. Concrete or masonry shall not be damaged during the removal of the timber. No claim shall be entertained for any timber which cannot be withdrawn and is lost or buried.

3.05.10.2 Open Timbering

In the case of open timbering, the entire surface of the side of trench pit is not required to be covered. The vertical board of minimum 250 mm width and minimum 40 mm depth shall be spaced sufficiently apart to leave unsupported strips of maximum 500 mm average width. The detailed arrangement, sizes of the timber and the distances apart shall be subject to the approval of the Owner. In all other respects, specification for close timbering shall apply to open timbering.

3.06.00 **Treatment of Slips**

The Successful Bidder shall take all precaution to avoid high surcharges and provide proper surface drainage to prevent flow of water over the sides. These precautions along with proper slopes, berms, shoring and control of ground water shall cause no slips to occur. If however slips do occur due to causes beyond the control of the Successful Bidder, the same shall be removed and back-filled later by him without any additional cost to the Owner.

3.07.00 **Back-filling**

3.07.01 **General**

The material used for backfilling shall consist of material, approved by the Owner obtained directly from areas where excavation work by the same agency is in progress, from temporary stacks of excavated spoils or from borrow pits from selected areas designated by the Owner. The material shall be free from lumps and clods, roots and vegetations, harmful salts and chemicals, organic materials, etc.

In certain locations, the Owner may direct sand fillings if required. The sand shall be clean, well graded and be of quality normally acceptable for use in concrete. No extra cost shall be claimed by the bidder on account of this.

3.07.02 **Filling and Compaction in Pits and Trenches around Structures**

As soon as the work in foundations has been accepted, the spaces around the foundation structures in pits and trenches shall be cleared of all debris, brick bats, mortar droppings, etc., and filled with earth in layers not exceeding 250 mm in loose thickness each layer being watered, rammed and properly compacted to achieve a dry density of not less that 90% of proctor's dry density at optimum moisture content as per IS-2720 (Part-VII) where backfilling with cohesive soil and sandy silt containing high percentage of silt. For back filling with sand having little or no silt, each layer shall be compacted to a relative density of 75% as per IS-2720 part XIV. Earth shall be rammed with approved mechanized compaction machine. Usually, no manual compaction shall be allowed unless specifically permitted by the Owner. Compaction of the structure backfill by inundation with water shall not be permitted. The final surface shall be trimmed and leveled to proper profile as shown in the drawing and as desired by the Owner.

Since the degree of compaction depends on the moisture content of the soil, a close watch shall be kept on it and corrections done to optimize the moisture content.

3.07.03 **Plinth Filling**

The plinth shall be filled with earth in layers not exceeding 250 mm in loose thickness, watered and compacted as stated under clause no. 3.7.2 with approved compaction machine or manually, if specifically permitted by the

Owner. When the filling reaches the finished level, the surface shall be flooded with water for at least 24 hours, allowed to dry and then rammed and compacted, in order to avoid any settlement at a later stage. The finished level of the filling shall be trimmed to the slope intended to be given to the floor.

3.07.04 Filling in Trenches for Water Pipes and Drains

Earth used for filling shall be free from salts, organic or other foreign matter. All clods of earth shall be broken or removed. Where excavated material is mostly rock, the boulders shall be broken into pieces not bigger than 150 mm size in any direction, mixed with fine material consisting of disintegrated rock, moorum or earth as available, so as to fill up the voids as far as possible and then the mixture used for filling. The types of bedding & pipe surround material shall be as specified in the drawings or as specified elsewhere in the specification.

Filling in trenches for pipes and drains shall be commenced as soon as the joints of pipes and drains have been tested and passed.

Where the trenches are excavated in soil, the filling shall be done with earth on the sides and top of pipes in layers not exceeding 150 mm, watered, rammed and compacted taking care that no damage is caused to the pipe below. Filling of trenches shall be carried out simultaneously on both sides of the pipe in such a manner that unequal pressures do not occur.

In case of excavation of trenches in rock, the filling up to a depth of 300 mm or the diameter of the pipe whichever is more, above the crown of pipe or barrel shall be done with fine material such as earth, moorum, disintegrated rock or ash according to the availability at site. The remaining filling shall be done with rock filling of boulders of size not exceeding 150 mm mixed with fine material as available to fill up the voids, watered, rammed and compacted.

3.07.05 Filling in Disposal Area

Surplus material from excavation which is not required for backfilling shall be disposed of in designated disposal areas within a lead of 5KM. The spoils shall not be dumped haphazardly but shall be spread in layers approximately 300mm thick when loose and compacted with the help of compacting equipment upto 85% Procter's dry density and compaction done to the satisfaction of the Owner at the optimum moisture content which shall be checked and controlled by the Successful Bidder.

In certain cases the Owner may direct disposal without compaction which can be done by tipping the spoils from a high bench neatly maintaining always a proper level and grade of the bench.

3.08.00 **Approaches and Fencing**

The Successful Bidder shall provide and maintain proper approaches for workmen and for inspection. The roads and approaches around the excavated pits shall be kept clear at all times so that there is no hindrance to the movement of men, material and equipment of various agencies connected with the Project. Sturdy and elegant fencing is to be provided around the top edge of the excavation as well as the bottom of the fill at the surplus disposal area where dumping from a high bench is in progress.

3.09.00 **Lighting**

Full scale area lighting is to be provided by the bidder if night work is permitted or directed by the Owner. If no night work is in progress, red warning lights shall be provided by the bidder at the corners of the excavated pit and the edges of the fill.

4.00.00 TESTING AND ACCEPTANCE CRITERIA

4.01.00 **Excavation**

On completion of excavation, the dimensions of the pits shall be checked as per the drawings after the pits are completely dewatered the work shall be accepted after all undercuts have been set right and all over excavations filled back to required lines, levels and grades by placing ordinary concrete of M10 proportion and/or richer, as directed by the Owner / Consultant.

Over excavation of the sides shall be made good by the Successful Bidder while carrying out the back-filling.

The excavation work shall be accepted after the above requirements are fulfilled and all temporary approaches encroaching inside the required dimension of the excavation have been removed.

4.02.00 **Back-filling**

The degree of compaction shall be sufficient to achieve a dry density of not less than 90% of proctor's dry density at optimum moisture content as per IS-2720 (Part - VII) or a relative density of 75% as per IS-2720 (Part-XIV) as applicable depending on the nature of back filling material as stated in clause no. 3.7.2 of this specification. The work of back-filling shall be accepted after the Owner is satisfied with the degree of compaction achieved. Owner may direct for sand filling if compaction not achievable in some cases based on detailed engineering requirement

5.00.00 INFORMATION TO BE SUBMITTED

5.01.00 Details of Equipment proposed to be used for excavation, back-filling and compaction have to be submitted to the Owner before commencing the work.

5.02.00 **After Award of Contract**

After award of the Contract the Successful Bidder shall submit the following for approval and adoption:

a) Successful Bidder shall submit a detailed programme of the work as proposed to be executed giving completion dates of excavation of the various foundations and the time required for back-filling and compaction after completing the foundation for structures.

The programme shall show how the excavation and back-filling quantities shall be balanced, minimising temporary stacking of soils. It is to be noted that the Owner even after initial approval of the programme, may instruct to enhance or retard the progress of work during the actual execution, in order to match with the progress of foundations without attracting any claims from the Successful Bidder. The initial programme being submitted by the Successful Bidder shall have sufficient flexibility to take care of such reasonable variations.

b) The Successful Bidder shall submit drawings showing details of slopes, shorings, approaches, sump pits, dewatering lines, fencing etc. for approval of the Owner /Consultant for adoption.

VOLUME: II-G/2
PART-A

SECTION-V

GUIDELINE
FOR
BORED CAST IN SITU CONCRETE PILE

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SUB SECTION: V

GUIDELINE
FOR
BORED CAST IN SITU CONCRETE PILE

1.00.00 SCOPE

This specification deals with the requirements regarding materials, workmanship and installation of bored cast- in-situ reinforced concrete piles and all related items of work like sand filling in the holes after casting the piles, testing the load bearing capacity of individual piles and group of piles, etc. The relevant clauses of the "Technical Specification for Concrete Work", appearing elsewhere in this document, fall within the scope of this specification.

IS:2911 (Part-I/Sec-2), Latest Revision shall form a part of this specification and shall be complied with unless they are at variance with the specification where the latter shall prevail.

Bored Cast-in-situ RCC pile passing through top soil overburden and highly weathered rock layer and terminating in the underlying sand stone layer with a socket length not less than 3D, (where D is the diameter of the pile) within such layer, will be considered. The capacity of the pile will be confirmed by the successful bidder by necessary load testing as per BIS and by design calculations.

To get generalized & tentative idea of sub-surface stratification as a whole, the soil report available with purchaser may be studied. However a confirmatory soil investigation will be done by the contractor before award of contract if required and after award of work to ascertain the top level of rock layer for their internal assessment of Pile length only. This will in no way affect the pile parameters stipulated in this specification.

2.00.00 GENERAL

2.01.00 Work to be provided by the successful bidder

The work to be provided for by the successful bidder, unless otherwise specified, shall include but not be limited to the following :

a) Furnish all labour, supervision, services, materials, equipment and accessories, tools, plants transportation including consumables and

temporary works required for the supply and installation of piles of desired capacity.

b) Mark the proposed sequence of installation on six (6) copies of identification plan. The identification plan will be prepared by the successful bidder as per the basic plan furnished by the Engineer, if so desired by him.

c) Furnish full details of the proposed piling equipment, accessories, temporary works and method of pile construction for approval of the engineer.

d) Submit detailed daily report of boring and pile casting incorporating information as required by the Engineer.

e) Carryout load tests to the satisfaction of the engineer including casting and dismantling of test caps if necessary and submit the test results in approved proforma.

f) Make necessary earthwork and approaches for movement of pile installation equipment.

g) Provide all necessary work mentioned under "Technical Specification for Cement Concrete (Plain and Reinforced)", as may be applicable.

2.02.00 Work to be provided by others

No work under this specification will be provided by any agency other than the successful bidder unless specified elsewhere in the Contract.

2.03.00 Codes and Standards

All work under this specification shall, unless specified otherwise, conform to the latest revisions and/or replacements/amendments of the following or any other Indian Standard Specifications and Code of Practice.

IS : 8112 - Indian Standard Specifications for 43 Grade Ordinary Portland Cement.

IS : 12269 - Indian Standard Specifications for 53 Grade Ordinary Portland Cement.

IS : 383 - Indian Standard Specifications for Natural Sources for Concrete.

IS : 432 - Indian Standard Specification for (Part - I)Mild Steel & Medium Tensile Steel Bars and Hard drawn Steel Wire for Concrete Reinforcement : Part I Mild Steel and Medium Tensile Steel Bars.

IS : 455 - Indian Standard Specifications for Portland Slag

Cement.

IS : 456	-	Indian Standard Code of Practice for Plain and Reinforced Concrete.
IS : 516	-	Indian Standard Specifications for Methods of Test for Strength of Concrete.
IS : 1199	-	Indian Standard Specifications for Methods of Sampling and Analysis of Concrete.
IS : 1786	-	Indian Standard Specifications for high strength deformed steel bars and wires for concrete reinforcement.
IS : 2062	-	Steel for General Structural Purposes
IS : 2386	-	Indian Standard Specification for Methods of Test for Aggregates for Concrete Part - I to VIII.
IS : 2502	-	Code of Practice for Bending & Fixing of Bars for Concrete Reinforcement.
IS : 2722	-	Indian Standard Specifications for Portable Swing Weight Batches for Concrete (Single and Double Bucket Type).
IS : 2751	-	Code of Practice for Welding of Mild Steel Bars used for Reinforced Concrete Construction.
IS : 2911	-	Code of Practice for Design and Cons-truction of Pile Foundations - Bored Cast-in-situ piles. (Part-I/Sec.2)
IS : 2911	-	Code of Practice for Design and (Part - IV)Construction of Pile Foundations - Load Test on Piles.
IS : 4926	-	Indian Standard Specifications for Ready Mixed Concrete.
IS : 9716	-	Guide for Lateral Dynamic Load Test on Piles.

2.04.00 Conformity with design

The successful bidder will prepare check lists in approved proforma which will be called "Pile Installation Cards". At each important stage of the work as decided by the engineer, the work will be checked and approved by the engineer for correctness and conformity with the design, specification and drawings, before allowing the next phase of work to commence. The intermediate checks and approvals by the engineer will not, however, absolve the successful bidder from his total responsibility to execute the work as per the

specification and drawings and to remove and/or rectify all work which is defective or inaccurate.

2.05.00 Materials

2.05.01 General

All materials whether incorporated in the works or used temporarily as aids or for executing enabling works will be of best approved quality conforming to the latest Indian Standard specification.

2.05.02 Casing

Casing in boreholes where used, should be manufactured out of best quality mild steel with proper treatment, the composition and thickness of the materials being of special importance where they are likely to be in contact with harmful chemicals and organic materials causing deterioration in service. Casing to be left in place like in offshore piling should also receive similar consideration in selection. They shall have sufficient strength and rigidity to permit their being driven and not to be distorted by soil pressure or driving of adjacent tubes. They shall be sufficiently water-tight to exclude water during placing of concrete.

2.05.03 Concrete

Concrete type M30 min grade shall be used for piles. Materials and method of manufacture for cement concrete shall in general be in accordance with IS: 456. The concrete cube strength on 15 cm. cubes at 28 days shall satisfy the acceptance criteria as per IS: 456. Concrete cubes will be cast as per instruction of the Engineer. These will be cast and cured by the Successful bidder at site for testing. The concrete shall be of such consistency as to give a slump of 100 to 150 mm. The water-cement ratio shall not exceed 0.5. To achieve the specified slump using specified water cement ratio without compromising with strength, suitable plasticiser, if required, may be used at no extra cost, subject to approval of OWNER. If concentration of Sulphate (measured as SO_3) exceeds 0.5% in soil or 1200 ppm in ground water, sulphate resisting cement shall be used. The minimum cement content should be 400 for M30 grade concrete respectively based on subsoil condition requirement besides that required from strength and other considerations.

The physical properties, mechanical properties & gradation of coarse & fine aggregate shall follow IS:383. Testing of aggregate properties (if desired by purchaser) shall follow relevant parts of IS:2386.

Refer General Specification for civil work for construction water.

Preliminary mix design shall be done in accordance withIS:10262 & SP:23 subject to approval of OWNER. Cube tests, slump test & other relevant

tests for preliminary mix design and Routine cube test, slump test for regular concreting shall be carried out at site / site laboratory at contractor's own cost. Concrete cube tests shall be done as per IS : 516. The calibration certificate (not older than one year) of the testing machine.

The calibration certificate (not older than one year) of the testing machine shall be available at site. If purchaser feels any doubt about the calibration, the contractor shall get it checked at an approved laboratory at his own cost. All such tests shall be conducted in presence of purchaser. At least one set (3 cubes for 7 days & 3 for 28 days strength) of cube shall be tested for every 10 piles or at any deterioration in concrete quality if felt purchaser, whichever occurs earlier. Slump tests (apparatus conforming to IS:IS:7320) shall be carried out at least once for each pile or more frequently, if desired by purchaser.

2.05.04 Reinforcement

Reinforcement shall be mild steel bars conforming to IS: 432. If instead of mild steel, Tor steel bars are used, they shall conform to IS : 1786. All bars shall be Corrosion Resistant Steel(CRS). Test certificate for reinforcement steel shall be obtained from recognised agency, before using. The purchaser may desire to check the testing of the same and the contractor shall arrange it in an approved laboratory at his own cost.

2.06.00 Storage of Materials

2.06.01 General

All materials shall be stored so as to prevent deterioration or intrusion of foreign matter and to ensure the preservation of their quality and fitness for the work. Any material which has deteriorated or has been damaged or is otherwise considered defective by the engineer shall not be used, failing which, the engineer shall be at liberty to get the materials removed and the cost incurred thereof shall be realized from the successful bidder's dues. The relevant clauses pertaining to storage of material under "Technical Specification for Cement Concrete (Plain and Reinforced)" will apply.

2.06.02 Casing

Mild steel casing will be painted outside with two coats of anticorrosive paint or smeared with protective layer of grease and kept stored in weather proof sheds, off the ground, on sturdy racks in such a manner as to enable quick and easy in spectrum. Epoxy painting on outside surface shall be provided if so specified in the drawing.

2.07.00 Quality Control

The successful bidder shall establish and maintain quality control for different items of work and materials as may be directed by the engineer to assure compliance with contract requirements and maintain and submit to the engineer records of the same. The quality control requirements stipulated under the "Technical Specification for Cement Concrete (Plain and Reinforced)" will apply wherever relevant. In addition, the requirement will include but not be limited to the following.

a) Location and plumb : Control survey for accuracy in plan and check for verticality.

b) Driving of casing : Correction of weight of hammer, length of fall, number of strokes per minute and rate of penetration.

c) Boring : Boring method to suit soil profile.

d) Casting of piles : Check inside casing, reinforcement cage, concrete mix, placing, consolidation and curing.

e) Inspection of pile

f) Load tests

2.07.01 Any work which fails to conform to the specification will be subject to the issue of a `non-conformance report' in line with the quality control procedures to be implemented at site. Corrective or remedial action, design modification or product rejection will be reviewed in accordance with site quality plan.

3.00.00 INSTALLATION

All installation requirements shall be in accordance with IS : 2911 (Part - I/ Sec.2) and as supplemented or modified herein or by other best possible standards where the specific requirements mentioned in this section of the specification might not have covered all the aspects to the full satisfaction of the engineer.

3.01.00 General

The successful bidder shall furnish complete information about the type of piles offered with sketches of pile sections showing reinforcement, method of boring, details and availability of equipment and accessories formula or data curve on which the bidder bases the load carrying capacity of piles as well as the criteria for determining suitable and sufficient founding of individual piles and any other relevant details.

The bidder will be supplied with bore hole logs or any other data indicating the nature of the soil expected to be encountered. The information furnished to the successful bidder shall be taken as a guidance only and variation therefrom shall not affect the terms of the contract. Piles should be founded on suitable continuous hard strata based on approved soil data. In case the successful bidder is required to drive piles to greater or shallower depths than that is envisaged, no other extra claims will be entertained. The tenderer should, in his own interest, investigate the site thoroughly and take additional bores if he feels it necessary to assess the type of boring equipment to be used and the depth to suitable founding strata.

3.02.00 Design of Pile

IS:2911 (Part 1/Section 2) : 'Code of practice for design & construction of Bored Cast- in- Situ concrete piles', IS : 2911 (part 4) 'Load Test on Piles & IS : 14593 : 'Design And Construction of Bored Cast-in-situ Piles founded on Rocks – Guidelines' will be referred to in conjunction with this specification during the entire design, construction & Load Testing work. These code form the integral part of this specification.

The piles will be bored cast-in-situ cylindrical type RCC piles of 450 mm &/or 550 mm &/or 750 mm &/or 1000 mm dia terminated within underlying sand stone layer with a rock- socket length not less than 3D (where D is the diameter of the pile) , to achieve the design capacity. Minimum center to center spacing between adjacent piles will be 2.5 D.

Sub-surface profile & Level of weathered Rock layer in different locations of the site are furnished in the Soil Investigation report available with purchaser .

The contractor will submit the structural design of pile for approval of purchaser/consultant . The contractor will guarantee the minimum safe vertical compressive design load capacities for piles

Capacity of Single Pile

A) Vertical Compressive capacity

The contractor will submit capacity of piles diameter wise along with design requirement .

B) Uplift Capacity

The Uplift capacity (for tension pile only) of single pile (with 3D rock socket), at this site, will be considered as 25 % of their respective Compressive capacity plus buoyant weight of pile. However, the same has to be confirmed by the successful contractor, by field load test on Trial pile before taking up the working piles.

C) Lateral Capacity

The Lateral capacity of single pile, at this site, will be considered as the minimum of the following:-

i) 5 % of their respective compressive capacity of pile.

ii) Lateral pile capacity assessed by the successful contractor by initial Pile Load Test on Trial Pile at selected representative locations, before taking up working piles. At least 3 Nos. of such tests is necessary, locations for which will be mutually decided by the contractor & purchaser.

The successful bidder shall satisfy the engineer as to the boring procedure and equipment which he proposes to use for the particular conditions of the site. If the engineer desires, sufficient test piles shall be installed to prove the adequacy of the pile, at the places indicated by the engineer and a load test shall be performed on each pile.

Piles have to be reinforced throughout their length. Main longitudinal reinforcement in the length of the piles as well as links or spirals shall be provided as shown in the drawings. Longitudinal bars shall preferably be in one length. Reinforced cage shall be handled and installed carefully without damaging its shape. All other requirements of reinforcement bars i.e., qualilty, workmanship, etc. shall be as specified for reinforced concrete work in Technical Specification for Concrete work.

The average basic length of the piles shown in the drawing/schedule of items is tentative and is to be assumed from cut-off level to the tip of the pile, but the final length will be decided by the Successful bidder with approval of the Engineer on the basis of boring resistance actually observed at site at the particular location. It will be the responsibility of the Successful bidder to prove by subsequent load tests/pull-out tests that the adopted length of the pile shall carry the safe loads, in compression and tension with the resulting deflections being within permissible limits. To ensure this, the length of the pile actually installed will be subject to change if considered necessary from the above mentioned basic length with no extra cost to Owner for deviation in length above or below the stipulated basic length.

The load test must be satisfactory and accepted by the Engineer. If the piles by reasons of defective workmanship or failure of one or more load tests, are found to be unsatisfactory, the test shall be repeated to the satisfaction of the engineer without any extra cost.

3.03.00 Identification of Piles

A plan in triplicate, showing clearly the designation of all piles by an identifying system shall be filed with the engineer before installation of piles is started if so desired by the engineer.

3.04.00 Sequence of Piling

Individual piles and pile groups shall be constructed in such a sequence that the adjacent piles already installed are not disturbed, nor their carrying capacity reduced by subsequent boring/driving operation. The Successful bidder shall submit the sequence order and programme chart to the Engineer and get his confirmation before starting the work.

3.05.00 Boring

3.05.01 With Casing

Boring equipment and accessories shall generally conform to IS:2911 - relevant section. Boring may be done by either rotary or percussion equipment or grabbing equipment using reversed or direct mud circulation method. In case of unstable soils the boring tools used should be such that suction effects are minimised. Stabilisation of the sides of bore hole shall be done by use of casing. The size of cutting tools shall not be less than the diameter of the pile by more than 75 mm.

The casing should be used from the ground level and shall be kept ahead of boring in case where there is danger of caving-in due to subsoil water entering into the bore hole or where the soil is loose. While boring below subsoil water level, precaution shall be taken so that no boiling of the bottom of the hole occurs due to difference in hydrostatic head.

Boring shall proceed by alternatively driving the casing and extracting the bored material with the boring tools. While boring in soft material liable to cavitation boring tools shall not be operated at a level below the toe of the casing. Care shall be taken to ensure that the volume of water added to the bore shall be not more than the minimum necessary for the operation of the boring tools. The casing shall be driven down through the soft material to penetrate a hard stratum not subjected to cavitation and shall be sealed in this material as far as possible. Thereafter the boring shall be continued by means of the boring tools until the approved bearing layer is reached.

Criteria for approval of the bearing layer will be agreed between the Engineer and the Successful bidder based on visual inspection of recognizable samples, recovered from the pile bore in the upper levels of the compact layer. The approved samples shall consist of sound material shall be consistent in quality for a depth of 300 mm in the pile bore. A sample of this material shall be supplied by the Successful bidder to the Engineer duly labelled for maintaining records of the founding strata.

The piles shall be installed with due consideration for safety of adjacent structures by a method which leaves their strength unimpaired and which develops and retains the required bearing resistance.

Where the soil is such that driving of a pile causes previously installed piles to heave, load test shall be conducted at the expense of the Successful bidder on

such pro- portion of the heaved piles which shall be ordered by the Engineer.

3.05.02 With Drilling Fluid

Alternate to the boring with casing, stabilisation of the sides of bore hole can be effected by the use of drilling fluids.

In such cases the drilling fluid must be used at least from the level of subsoil water, as the hole, should then be always kept almost full with the fluid. The density and composition of the fluid shall be such as to suit the requirements of ground conditions and to maintain the fine materials from the boring in suspension. At the last stage of boring or in inter- mediate hard layers chisel or a chopper may be used. The rate for piling work should be inclusive of any chiselling, chopping of hard strata, clearing of bottom of pile borehole etc. complete as per specifications and necessary penetration test as may be required to prove the soundness of the founding strata. A five per cent bentonite suspension would be generally suitable and its quality shall conform to specification given in Appendix 'A' of IS : 2911 (Part-I/Sec.2).

3.06.00 Spacing of Piles

In general, all piles shall have a minimum spacing on centres of 2.5d (where 'd' is the diameter of the pile) unless shown otherwise in the drawings.

3.07.00 Placing of Reinforcement

Reinforcement as required shall be made into stiff cages sufficiently wired or welded to withstand handling without any damage or distortion. Reinforcement shall be placed immediately after cleaning and inspection of the bottom of bore holes. The reinforcement should be supported away from the sides of the shaft by means of suitable space block to ensure concentric alignment in the shaft. Steps shall be taken to ensure correct positioning during concreting of reinforcement in the piles without any distortion.

Nominal lap between reinforcement cages shall be 60 cm and the main reinforcing steel shall project for a length sufficient to develop bond (45 times the diameter of reinforcing bar) above the level of the underside of the pile cap.

The concrete cover to main reinforcement shall not be less than 5 cm and suitable spacer blocks shall be provided at intervals not exceeding 2 metres and wired to the main reinforcement.

3.08.00 Concreting

Immediately before concreting the bottom of the hole shall be cleaned very carefully. The cleaning of the hole shall be ensured by careful operation by air lifting process unless otherwise allowed by the Engineer. To lift the spoil at founding level before concreting, borehole shall be agitated by jetting with fresh

drilling mud with relatively higher pressure than that used during boring or air through tremie pipe. While boring by use of drilling mud, the specific gravity of the mud suspension in the vicinity of the bottom of the borehole shall be determined by suitable slurry sampler in a first few piles and at suitable interval of the piles and recorded. Consistency of the drilled mud suspension shall be controlled throughout the boring as well as concreting operation in order to keep the hole stabilized and to avoid concrete mixed up with the thicker suspension of the mud.

Concreting of boreholes shall start as soon as possible after the completion of boring. If a borehole, be left unconcreted for more than two hours, it shall be cleaned thoroughly as directed by the Engineer before concreting. Concrete shall be so placed as to fill the entire volume of the tube or bore without the formation of voids caused by faulty consolidation or entrapped air. Great care shall be taken to ensure that the fluid alluvial soil does not penetrate between batches of the concrete. Concreting under water shall be done in one operation. Concrete shall be placed by means of a tremie pipe. It shall, however, be ensured that concrete entering the tremie pipe does not get mixed up with the slurry and 1/4 kg of granulated vermiculite shall be poured in the tremie pipe before pouring concrete as directed by the Engineer.

3.08.01 Tremie Method of Concreting

The tremie pipes and funnel shall be filled and lifted just 15 cm above bottom before releasing the concrete column to facilitate flushing out the bottom. The concrete levels in the tremie shall be checked every few centimeters in order to note the difference, if any, between the theoretical quantity that should have been placed and actual quantity that has gone in. This is to locate the position of over cut during boring.

In addition to the normal precautions to be taken in tremie concreting as per relevant section of IS:2911 the following specifications shall be particularly applicable for the use of tremie concrete in pipes :

a) The concrete shall be coherent, rich in cement (not less than 400 kg/m3) and of slump not less than 100 mm.

b) The hopper and tremie shall be closed system embedded in the placed concrete, through which water cannot pass.

c) The tremie shall be large enough with due regard to the size of the aggregate. For 20 mm aggregate the tremie pipe shall be of diameter not less than 200 mm, aggregates more than 20 mm shall not be used.

d) The first charge of concrete shall be placed with a sliding plug pushed down the tube ahead of it or with a steel plate of adequate charge to prevent mixing to concrete and water. However, the plug shall not be left in the concrete as a lump.

e) The tremie pipe shall always penetrate well into the concrete with an

adequate margin if safety against withdrawal of the pipe is required while discharging the concrete.

f) The pile shall be concreted wholly by tremie and the method of deposition shall not be changed part way up the pile, to prevent the laittance from being entrapped within the pile.

g) All tremie tubes shall be scrupulously cleaned after use.

Normally concreting of the piles shall be uninterrupted. In exceptional cases interruption of concreting may be allowed but it will be resumed within 1 or 2 hours. The tremie shall not be taken out of the concrete, instead it shall be raised and lowered slowly, from time to time to prevent the concrete around the tremie from setting. Concreting should be resumed by introducing a little richer concrete with a higher slump for taking care of the partly set concrete in the bore.

If the concreting cannot be resumed before final setting of concrete already placed, the pile so cast may be rejected.

In case of withdrawal of tremie out of the concrete, either accidentally or to remove a choke in the tremie, the tremie may be reintroduced in the following manner to prevent impregnation of laittance or scum lying on the top of the concrete already deposited in the bore.

The tremie shall be gently lowered on to the old concrete with very little penetration initially. A ver- miculite plug shall be introduced in the tremie. Fresh concrete of slump between 150 mm and 175 mm shall be filled in the tremie which will push the plug forward and will emerge out of the tremie displacing laitance/scum. The tremie will be pushed further in steps making fresh concrete sweep away laitance/scum in its way. When tremie is buried by about 60 to 100 cm, concreting may be resumed.

3.08.02 Concreting in Cased Holes

In case of cased holes, after the required founding level is encountered, the bottom shall be sealed with concrete and the reinforcement cage shall be lowered. If the borehole is dry, concrete shall be deposited by direct pour from the top followed by gradual withdrawal of casings. If water is present in the borehole, it shall be bailed out by bailer.

If it is difficult to dewater by the bailer, concrete shall be placed under water by means of a placer. After the head of water has been neutralised by the head of the concrete, excess water shall be bailed out and concrete shall then be deposited by direct pouring from the top, as is done, if the borehole is dry.

Extraction of casing shall be done in such a way that no necking or shearing of the concrete in the shaft takes place.

During the extraction of casing, slumping of concrete shall be observed and when required, additional quantity of concrete shall be poured so that the pile is

formed above the cut-off level as per the requirements indicated below.

3.08.03 Cut-off Level

The top of concrete in a pile shall be brought above the cut-off level to permit removal of all laitance and weak concrete before capping and to ensure good concrete at the cut-off level for proper embedment into the pile cap.

Where cut-off level is less than 1.5 m below the working level concrete shall be cast to a minimum of 600 mm above cut-off level. For each additional 0.3 m increase in cut-off level below the working level additional coverage of 50 mm minimum shall be allowed. Higher allowance may be necessary depending on the length of the pile as directed by the Engineer. When concrete is placed by tremie method, concrete shall be cast to the piling platform level to permit overflow of concrete for visual inspection or to a minimum of one metre above cut-off level. In the circumstances where cut-off level is below ground water level, the need to maintain a pressure on the unset concrete equal to or greater than water pressure shall be observed and accordingly length of extra concrete above cut-off level shall be determined and allowed in Works.

3.09.00 Steel Pipe or Casing tube

This item shall be fabricated with mild steel plates conforming to IS : 2062 and/or steel tubes for structural purpose conforming to IS : 1161 & IS : 1239 as shown on drawings.

Fabrication work and welding of steel shall be done in accordance with IS : 800 and IS : 9595. Welding of pipes shall be done by experienced and good welder who have been qualified by tests in accordance with IS : 817.

3.10.00 Trimming of Pile Heads

Completed piles shall be trimmed to the cut-off levels shown on the drawings or until sound concrete is found to the satisfaction of the Engineer. In the event of trimming being carried below the cut-off level, the pile shall be made upto the correct cut-off level, with concrete of the same quality as used in the piles at the Successful bidder's expense. Reinforcement shall be exposed for the full bond length appropriate to the diameter of the bar and projected in the pile cap. The minimum distance of keying of pile into pile cap shall be 75 mm unless noted otherwise. All concrete and cement shall be removed from the bars, which shall also be wire-brushed to remove any loose, rust, dirt and scale.

Manual chipping shall be permitted after three (3) days of pile casting. Pneumatic chipping, if permitted by the Engineer, shall not be started before seven (7) days.

The concreted length of piles shall be measured from the toe of pile to cutoff level of pile.

Boring of any pile shall not be carried out within a clear distance of three times of the pile diameter from the adjacent pile which has been freshly concreted within past 24 hours.

The contractor shall take all necessary actions to prevent side collapse (if any) of pile bore at his own cost.

The contractor shall be responsible for the prompt removal from the site of all spoil due to the boring to places as indicated by purchaser. The cost of such disposal shall be deemed to have been included in the rate of piling.

Founding Strata

All the piles shall be founded on approved bearing strata or upto specified depth as per design requirement & as mentioned in the drawing.

In general, criteria for approval of founding strata shall be agreed between purchaser & contractor based on visual identification of recognisable samples recovered from pile borehole & specified SPT criteria.

In case, pile is socketted in rock strata, a minimum socketted length of Thrice the pile diameter (3D) shall be provided. The founding rock strata shall be identified by recognisable rock piece sample obtained by boring tool from pile bore &/or wash of rock powder in return water, SPT N > 100 at termination level and as decided by purchaser.

Termination criteria may be standardised / modified at site by purchaser depending on actual sub-surface material encountered and rate of penetration through such strata with the available equipment & accessories.

3.11.00 Lengthening of Piles

Where it is necessary to increase the length of any pile after it has been driven, the head of the pile shall be cut-off to expose the reinforcement for a full bond length of the bars to lap with the new bars. The exposed surface of the concrete shall be hacked to form a key, brushed to remove loose material and covered with 25 mm thick cement mortar (1:2 mix) immediately before the new concrete is placed.

3.12.00 Removal of Spoil

The Successful bidder shall be responsible for the prompt removal from the site of all spoil due to the boring to places indicated by the Engineer. The cost of such disposal shall be deemed to have been included in the Scope.

3.13.00 Back-Filling of Abandoned Borings

The Successful bidder shall backfill all the abandoned borings between the concrete pile and the surface level after setting of concrete of the piles, by sand or by other materials as directed by the Engineer.

All permanently abandoned boreholes generally shall be backfilled with selected materials and for a depth of 5 M below cut-off level with plain concrete of mix M10 so that resistance to lateral forces on neighbouring piles are developed.

3.14.00 Record for Installation of Piles

The Engineer and the Successful bidder shall maintain separate registers, signed jointly by both the parties, giving the following information for each pile or any other proforma as agreed between Engineer and Successful bidder. These data shall be submitted to the Engineer, in triplicate, on completion of installation of each pile.

a) Date of completion, pile number & sequence of installation of piles in a group.

b) Bored depth, concreted depth, empty boring and nature of stratum at founding level.

c) Pile diameter, details of reinforcement and details of mild steel liner where provided along with stiffener.

d) Volume of concrete poured, time taken, cement bag consumption, slump of concrete and RL of top of concrete.

e) Time taken for penetration of every 15 cm during last 2 M depth before founding level.

f) Method of cleaning bottom of hole at founding level before concreting.

g) Records of additional borings or other subsurface information obtained during the process of boring.

h) Any other relevant important information.

Any sudden change in the rate of boring which cannot be ascribed to the nature of the ground or any deviation from the designed location, alignment or load carrying capacity of any pile or any upheaval or subsidence noticed on any pile shall be promptly reported to the engineer and adequate corrective measures shall be taken free of any charge as decided by the engineer.

The data for pile load test (load, displacement, time, etc.) are to be recorded sequentially for the test under consideration in a suitable proforma as agreed between Engineer and Successful bidder. These data along with the load-

displacement curve shall be submitted to the Engineer, in triplicate, on completion of each load test.

3.15.00 Defective Piles

Any pile which is shown to be defective under load test shall not be accepted and the Engineer will relate such failure to the acceptance of other piles in the area.

If an individual pile should fail to meet the requirements specified, such piles may be deemed to be defective and the Engineer may order such investigation to be made as he considers appropriate.

When any pile is found defective, the Successful bidder shall perform at his own expense one or more of the following remedial measures as directed by the Engineer.

i) Replacement of defective piles.

ii) Providing additional piles.

iii) Alteration in design of pile caps.

3.16.00 Idle Period

The phasing of construction and movement of plant shall be done as desired by the engineer. The phasing may involve some extra movement of the plant or some idle period, but the successful bidder will not be entitled to any claim due to this reason.

3.17.00 Test Pile

The successful bidder may have to construct test piles, if desired by the engineer, before he starts systematic piling operation at locations indicated. For this purpose, the pile construction process shall be the same as in usual piling process to be followed on this job. Load test on such piles shall be as per the provisions under "Procedure for Initial Load Test" in IS : 2911 (Part - IV) or as directed by the engineer.

4.00.00 TESTING AND ACCEPTANCE CRITERIA

4.01.00 General

The successful bidder shall carry out all sampling and testing in accordance with the relevant Indian Standards and as supplemented herein for the following items at his own cost unless otherwise specified in the contract. Whenever directed, the successful bidder shall get the specimens tested in a laboratory approved by the engineer and submit to the engineer test results in

triplicate within three (3) days of completion of the test.

4.02.00 Components of RCC

The testing and acceptance criteria for components of reinforced cement concrete shall be as stipulated in the relevant clauses of the Technical Specification for Cement Concrete (Plain and Reinforced).

4.03.00 Components of Steel

Testing and acceptance criteria for the component of steel pipe material and fabrication work shall be as stipulated in relevant clauses of IS : 800 and IS : 9595.

4.04.00 Load Tests

4.04.01 General

Initial tests and/or routine tests as indicated in the FQP or as directed by the engineer shall be carried out on single pile or pile groups to ascertain the capacities of the piles and their behaviour.

Any or all of the tests described below shall be carried out as indicated in the FQP or as directed by the engineer. The tests shall be performed as per requirements of the relevant Indian Standards and as supplemented herein.

4.04.02 Vertical Load Test [as per IS : 2911 (Part-IV)]

Load tests shall be carried out on single piles to check the bearing capacity or the quality of piles in the manner specified below :

From among the completed piles the Engineer at his discretion shall select piles for the purpose of testing.

At least 1% of the piles driven shall be tested to an overload of 50% above the working load of the pile and 0.1% of the piles driven shall be tested to an over load of 100% above the working load of the pile.

Load shall be applied in increments of about one-fifth of the design load till the design load is reached and thereafter in increment of 10 tonnes till the test load is reached.

Each increment of load shall be maintained for minimum of half an hour upto design load and thereafter for one hour till the test load is reached. Test load shall be maintained for 24 hours.

For each increment of load, readings of settlement at every ten minutes shall be taken. The next increment of load shall be applied only when the difference

in settlement of readings between the last two readings does not exceed 0.02 mm. On application of test load, readings shall be taken at every hour.

Unloading will be done in following decrements of load :

i) Test load to design load

ii) Design load to 50% of design load

iii) 50% of design load to 25% of design load

iv) 25% of design load to complete unloading

Each decreased load shall be kept for a minimum of half an hour and readings of rebound taken every ten minutes. The next decrement shall be applied only when the difference in readings between the last two readings is less than 0.02 mm.

The observation and recording of settlement and rebound shall be done simultaneously by the Successful bidder and the Engineer's representative. Three copies of all the readings for the test shall be supplied by the Successful bidder to the Engineer-in-charge. Actual proforma for recording the results shall be proposed by the Successful bidder and approved by the Engineer-in-charge before the start of the load test.

The pile shall be deemed to be acceptable if the gross settlement at the test load of one and a half times the designed load does not exceed 0.01" per tonne of test load or 1/2" (12 mm) whichever is less.

In case a pile fails under or during the load test, the Engineer shall select two additional piles in lieu of each of such piles failed and the Successful bidder shall carry out load tests on these piles in the same way as the load tests on the original piles at his own cost. This procedure will be repeated in the case of each failure of pile under/during load test.

The Successful bidder shall arrange at his own expense sufficient amount of knowledge for loading well in advance of the commencement of the load test.

Detailed proposal together with a sketch for the load test arrangement shall be furnished by the Successful bidder to the Engineer-in-charge for checking and approval.

The pile head shall be chipped off to natural horizontal plane till sound concrete is met. The projecting reinforcement shall be cut-off or bent suitably and the top finished smooth and level. A bearing plate with a hole at the centre shall be placed on the head of the pile for the jacks to rest.

Jacks used in any particular load test should be of the same capacity and their number shall be limited to two only. They should preferably be connected and operated by one pump. The Successful bidder shall submit certificates

certifying the correctness of the calibrations of the pressure gauges and jacks before use. All jacks should be fitted with locking devices. Settlement and rebound shall be recorded by minimum two (2) deflectometers of 0.01 mm sensitivity and also by other independent means of direct measurement. Deflectometers shall be supported independently and in such a way as to be not affected by the settlement of the piles.

4.04.03 Lateral Load Test

The test shall be carried out by introducing hydraulic jack with gauge between two piles under test or the reaction shall be suitably obtained otherwise. When the test is conducted by jack located between two piles, the full load imposed by the jack shall be taken as the lateral resistance of each pile.

Load shall be applied in increments of about one-fifth of the design load. The next increment shall be applied after the rate of displacement is nearer to 0.1 mm per 30 minutes. Displacement shall be read by using at least two (2) deflectometer of 0.01 mm sensitivity spaced by 30 cm and kept horizontally one above the other or by any means as per IS-2911 (Part-4) or as approved by the Engineer. The safe lateral load on pile shall be taken as the least of the followings :

a) Fifty percent (50%) of the final load at which displacement increases to 12 mm.

b) Final load at which the total displacement corresponds to 5 mm.

4.04.04 Pull-out Test

The test shall be carried out to an overload of fifty percent (50%) of the estimated safe load or a displacement of 12 mm total whichever is earlier.

Uplift force may preferably be applied by means of hydraulic jack(s) with gauge using a suitable pull-out set up as per IS-2911 (Part-4) or as approved by the Engineer.

The pull-out load increments and consequent displacement readings shall be same as in the case of Vertical Load Test.

The safe load shall be taken as the least of the followings :

a) Two-thirds of the total load at which the load-displacement is 12 mm.

b) Half the load at which the load-displacement curve shows a clear break (downward trend).

4.05.00 Non-destructive Dynamic Test on Working Piles

4.05.01 "Low Strain" Method for Integrity Investigation of Concrete Piles :

The method of testing shall conform to ASTM D 4945.or equivalent Indian Standards.

All equipments e.g., small impact device 16 lbs. nylon tipped hand held hammer, accelerometer, pile integrity tester & pile driving analyser shall be arranged by the Successful bidder. Analysis shall be carried out by exponential amplification of the signal with time and the average velocity curve obtained by numerically integrating the acceleration record to be submitted. From analysis of the results any defect like necking, honey-combing, segregation or weakness in concrete, when detected shall be reported in detail.

4.05.02 "High Strain" Method for Determining of Pile Capacity

The method of testing shall conform to ASTM D 4945 or equivalent Indian Standards.

All equipment including piezoelectric transducers, strain gauges, pile driving analyser, two track oscilloscope for displaying data and analog tape recorders for recording data shall be arranged by the successful bidder. For every hammer below, the analyser shall determine the following data :

i) Pile bearing capacity

ii) Transferred energy

iii) Maximum compression force

iv) Maximum tension force

v) Maximum impact velocity

vi) Maximum acceleration

vii) Maximum displacement

which are to be properly recorded and analysed and submitted in a detailed report form.

4.06.00 Acceptance Criteria

The piles shall be accepted as satisfactory only when the work has been executed in accordance with this specification to the satisfaction of the Engineer and the standards stated hereinafter.

a) The head of the pile shall be within 75 mm of the specified position on the drawings.

b) The pile shall not be out of plumb by more than two percent.

c) The toe of the pile shall be at the approved bearing level in each case.

d) The total volume of concrete shall not be less than 20% and not more than 50% greater than the calculated volume. The calculated volume for this purpose shall be the cross-sectional area inside the casing multiplied by the length of the shaft. The concrete shall show the specified strength as indicated by the cube test results.

e) The results of the load tests incl. non- destructive dynamic test carried out in accordance with the contract and with the specifications shall be satisfactory.

f) In case of single pile the positional tolerance shall not be more than 50 mm.

4.07.00 Lateral Dynamic Load Test on Piles

Two types of tests, namely, free and forced vibration lateral tests shall be carried out to observe response of soil-pile system under horizontal dynamic loads and for the evaluation of soil-pile stiffness, soil modulus, natural frequency, time period and damping characteristics of soil-pile system.

A minimum of three representative piles of same type in almost similar soil conditions shall be tested. Two adjacent piles shall be subjected first to free vibrations and then to forced vibrations, the third pile shall only be tested under forced vibrations.

The equipment and accessories for the test, setting up and test procedure and recording of observations shall be as described in relevant sections of IS : 9716 (Guide for Lateral Dynamic Load Test on Piles). The tests shall normally be carried out without sustained vertical load other than that of the oscillator assembly. However, sustained weight can be used to increase dynamic force to obtain resonance or nearly resonance condition.

From analysis of test data, the following parameters shall be determined:

i) Frequency of vibrations

ii) Amplitude of vibrations

iii) Imparted dynamic force

iv) Natural frequency

v) Damping coefficient

vi) Soil-pile stiffness

vii) Coefficient of horizontal soil modulus variation

5.00.00 INFORMATION TO BE SUBMITTED

5.01.01 Design Data

The successful bidder shall submit full details of the method of construction, design data and drawings for the type of piles he wishes to adopt.

5.01.02 Programme of Construction

The successful bidder will also submit the details of the construction equipment that he will employ. A proposed construction programme, matching with the capacity of the equipment and taking into consideration the various idle and non production periods on account of shifting of equipment, testing and possible delays due to modifications of design should be drawn up, keeping in view the completion dates stipulated in the tender.

5.02.00 After Award

After award of the contract, the successful bidder is to submit the following details :

5.02.01 Execution Plan

The successful bidder will submit six (6) copies of drawings showing the sequence of piling. The drawings will be prepared on the basis of a master plan giving identification number of the piles, which will be furnished by the engineer.

5.02.02 Detailed Construction Programme

A detailed construction programme for completion of the work is to be submitted. This master programme will be reviewed and updated every month or at more frequent intervals as directed by the engineer, incorporating the various factors that have caused or are likely to cause changes in the programme.

5.02.03 Requirement of Materials, Tools and Plants and Equipment

In accordance with the master programme, a detailed material, tools and plants and equipment requirement schedule, particularly for those items which the bidder is to supply as per the terms and conditions of contract is to be submitted.

5.02.04 Test Results

The test data and results for the various items like welding of pipes, ingredients of RCC, concrete cubes and cylinders, driving of the shell, static load tests on single piles and pile groups and dynamic tests on working pile will be submitted regularly and as and when directed by the engineer.

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SECTION-VI

GUIDELINE
FOR
CEMENT CONCRETE (PLAIN & REINFORCED)

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SECTION-VI

GUIDELINE
FOR
CEMENT CONCRETE (PLAIN & REINFORCED)

1.00.00 SCOPE

1.01.00 General

This specification covers all the requirements, described hereinafter for general use of Plain and Reinforced Cement Concrete work in Structures and locations, cast-in-situ or pre-cast, and shall include all incidental items of work not shown or specified but reasonably implied or necessary for the completion of the work.

1.02.00 This specification shall also apply to the extent it has been referred to or applicable with the special requirements of structures covered in IS:456.

1.03.00 IS:456 shall form a part of this specification and shall be complied with unless permitted otherwise. For any particular aspect not covered by this Code, appropriate IS Code, specifications and/or replacement by any International Code of practice as may be specified by the Consultant shall be followed. All codes and Standards shall conform to its latest revisions as on the original scheduled date of Tender opening. A list of IS codes and Standards is enclosed hereinafter for reference.

2.00.00 GENERAL

2.01.00 Work to be provided for by the Successful Bidder.

The work to be provided for by the Successful Bidder, unless otherwise specified shall include but not be limited to the following :-

a) Furnish all labour, supervision, services including facilities as may be required under statutory labour regulations, materials, forms, templates, supports, scaffolds, approaches, aids, construction equipment, tools and plants, transportations, etc. required for the work.

b) Design and prepare working drawings of formworks, scaffolds, supports, etc. and submit for approval.

c) Submit for approval shop drawings for various inserts, anchors, anchor bolts, pipe sleeves, embedments, hangers, openings, frames etc.

d) Submit for approval detailed drawings of supports, templates, hangers, etc. required for installation of various embedments like inserts, anchor bolts, pipe sleeves, frames, joint seals, frames, openings etc.

e) Submit for approval detailed schemes of all operations required for executing the work, e.g. Material handling, Concrete mixing, Placement of concrete, Compaction, curing, services, Approaches, etc.

f) Design and submit for approval concrete mix designs required to be adopted on the job.

g) Furnish samples and submit for approval results of tests of various properties of the following :

i) The various ingredients of concrete

ii) Concrete

iii) Embedments

iv) Joint seals

h) Provide all incidental items not shown or specified in particular but reasonably implied or necessary for successful completion of the work in accordance with the drawings and specifications.

2.02.00 **Work by Others**

No work under this specification shall be provided by any agency other than the Successful Bidder unless specifically mentioned elsewhere in the contract.

2.03.00 **Information to be submitted by the Tenderer**

2.03.01 After Award of the Contract

The following technical information shall be furnished after award :

a) Source and arrangement of processing of aggregates proposed to be adopted.

b) Type of plant and equipment proposed to be used.

c) Names of firms, if any, with which association is sought for to execute the special items of work in the contract.

d) Types of formwork proposed to be used.

2.03.02 The following information and data including samples where necessary shall be submitted by the Successful Bidder progressively during the execution of the contract.

a) Programme of Execution and Requirement of Materials

This Master Programme may have to be reviewed and updated by the Successful Bidder, quarterly or at more frequent intervals as may be directed by the Owner/Owner's Consultant depending on the exigencies of the work.

Detailed day to day programme of every month shall be submitted by the Successful Bidder before the end of the previous month.

b) Samples

Samples of the following materials and any other materials proposed to be used, shall be submitted as directed by the Owner, in sufficient quantities for approval. Approved samples shall be preserved by the Owner for future reference. The approval of the Owner shall not, in any way, relieve the Successful Bidder of his responsibility of supplying materials of specified qualities :

i) Coarse and fine aggregates

ii) Admixtures

iii) Plywood for Formwork

iv) Embedded and anchorage materials as may be desired by the Owner /Consultant.

v) Joint sealing strips and other waterproofing materials.

vi) Joint filling compounds

vii) Foundation quality Rubber Pads

c) Design Mix

Design mix as per Clauses 2.01 (f) & 3.04 of this specification giving proportions of the ingredients, sources of aggregates and cement, along with accompanying test results of trial mixes as per relevant I.S., shall be submitted to the Owner/Consultant for his approval before it can be used on the works.

d) Detail Drawings and Bar Bending Schedules

Detailed working drawings and Bar Bending Schedules in accordance with Clause 2.01(b).

e) Detailed Drawings and Designs of Formworks to be used

Detailed design data and drawings of standard formworks to be used as per clause 2.01 (b).

f) Detailed Drawings for Templates & Temporary Supports for Embedments

As per Clause 2.01 (d).

g) Mill Test Reports for Cement & Reinforcing Steel

h) Inspection Reports

Inspection Reports in respect of Formwork and Reinforcement and any other item of work as may be desired by the Owner /Consultant in accordance with Clause 2.04 of this specification.

i) Test Reports

Reports of tests of various materials and concrete as required under Clause 4.0 : SAMPLING & TESTING of this specification.

j) Any other data which may be required as per this specification.

2.04.00 Conformity with Design

The Successful Bidder shall prepare check lists in approved proforma which shall be called 'Pour Cards'. These Pour Cards shall list out all items of work involved. The Successful Bidder shall inform the Owner/Consultant, sufficiently in advance, whenever any particular pour is ready for concreting. He shall accord all necessary help and assistance to the Owner/ Consultant for all checking required in the pour. On satisfying himself that all details are in accordance to the drawings and specifications, the Owner /Consultant shall give written permission on the same 'Pour Card' allowing the Successful Bidder to commence placement of concrete. Details of all instructions issued by the Owner /Consultant and the records of compliance by the Successful Bidder, deviations allowed by the Owner /Consultant and any other relevant information shall be written on accompanying sheets attached to the Pour Cards. These sheets, termed as 'Progress Cards', shall be prepared by the Successful Bidder on approved proforma. The Pour Cards along with accompaniments shall be handed over to the Owner/Consultant before starting placement of concrete.

One of the mix designs developed by the Successful Bidder as per the I.S. Specifications and established to the satisfaction of the Owner /Consultant by trial mixes shall be permitted to be used by the Owner /Consultant, the choice being dictated by the requirements of designs and workability.

The methods of mixing, conveyance, placement, vibration, finishing, curing, protection and testing of concrete shall be as approved or directed by the Owner /Consultant.

2.05.00 Materials to be used

2.05.01 General Requirement

All materials for the construction shall conform to the relevant IS Code unless stated otherwise and be of best approved quality.

2.05.02 Cement

Generally cement shall be 43 grade ordinary Portland / slag Cement conforming to IS-269 . In special cases any of the following type of cement may be permitted or directed to be used with prior approval by the Owner /Consultant :

a) 53 Grade ordinary Portland Cement conforming to IS-269

b) Rapid hardening Portland Cement conforming to IS-8041

c) Portland slag cement conforming to IS-455

d) Hydrophobic Cement conforming to IS-8043

e) Low heat Portland Cement conforming to IS : 12600

f) Sulphate Resisting Portland Cement conforming to IS-12330

2.05.03 Aggregates

Aggregates shall be natural or crushed stone or crushed rock and free from deleterious material. It shall comply with the requirements of IS-383. All fine and coarse aggregate shall be tested for susceptibility to Alkali Silicate reaction in a laboratory approved by the Owner /Consultant.

a) Coarse Aggregate

Aggregate of sizes ranging between 4.75 mm and 150 mm shall be termed as Coarse Aggregate. Only Coarse Aggregate from approved quarries and conforming to IS:383 shall be allowed to be used on the works. Aggregates shall be washed to make it free from deleterious materials, if necessary.

The grading of coarse aggregates by sieve analysis shall be as per IS:383. If by the analysis the deficiency of a particular grain size is found, which could affect the density of the concrete, the Owner /Consultant may ask the Successful Bidder to avoid such quantities of

aggregate of the particular size or and such quantity of aggregate of any particular size to achieve the required grading as per IS:383.

b) Fine Aggregate

Aggregate smaller than 4.75 mm and within the grading limits and other requirements set in IS:383 (latest revision) is termed as Fine Aggregate or Sand. Only Fine Aggregate from approved sources and conforming to the above IS Specification shall be allowed to be used on works. Normally river sand shall be used as fine aggregates.

In case of unavailability of normal specified river sand, the M sand (Crushed stone sand) shall be used with the approval of the Owner /Consultant as per given criteria/specifications below.

i) As per Cl. 3.1.4 , of IS-383 (latest revision) the terminology of M-sand (manufactured sand) as defined as fine aggregate manufactured from other than natural sources , by processing materials using thermal or other processes such as separation, washing, crushing and scrubbing. Generally the M sand or Crushed stone sand for the fine aggregate are produced by crushing the hard stone.

The Crushed stone sand or M sand conforming to the following shall only be used as fine aggregate in making concrete for sub and superstructures.

The Crushed stone sand is to be manufactured using VSI crushers only and not with HSI crushers. In order to remove the fines , Crushed stone sand manufacturer shall have mechanized washing facility unit. Crushed sand stone conforming to Grading zone –II as per IS-383 (latest rev.) shall only be used. The M sand shall comply all the parameters and recommendations of IS: 383 (latest rev.)

ii) The M sand shall be used only after the following tests are to be conducted by the bidders at the NABL accredited laboratories with proven track records of performing such type of tests by sending sealed samples of the materials –

a) Gradation Test.

b) Petrography.

c) Silt content.

d) Permeability test.

e) Adulteration test.

f) Design Mix Report.

g) Chemical Analysis Report

Using of M-Sand/Crushed Stone Sand based on the Test reports shall only be done after written approval of Engineer–In-Charge.

iii) The Crushed stone sand in general shall not be used for the following structures/facilities :-

a) Chimney and Silos (structures constructed using slip form technology)

b) IDCT

c) All internal & external plastering works.

The structures where the slip form construction is envisaged the M sand or Crushed stone sand may be used for casting its foundations only as they are not constructed using slip form Technology.

iv) Special care for design mix, cement content and necessary curing in the initial stage shall be taken care of while using M sand /Crushed stone sand. However if the results are not satisfactory , the use of crushed stone sand shall not be allowed for all RCC floor slab upto and including 150 mm thickness, which are directly exposed to the atmosphere immediately after casting. In such cases the ordinary river sand shall be used.

v) The M sand/Crushed stone sand manufacturing locations shall be inspected by the Owner before giving approval for supply. The bidder shall ensure that the manufacturing process is done using only VSI crushers & shall have mechanized water washing unit for removal of fines in the Crushed stone sand manufactured.

Aggregates smaller than 4.75 mm and within the grading limits and other requirements set in IS-383 (latest rev.) termed as fine aggregate. Only fine aggregate from approved sources and conforming to IS- 383 (latest rev.) shall be used for execution. The bidder shall have well developed site laboratory and quality control team to take extra care while manufacturing and casting concrete using M sand/ Crushed stone sand.

Normally, any particular structure shall be constructed by using any one type of sand (fine aggregate) only as per the direction / approval of engineer-in-charge. In general, it is not permitted to use different types of sand in any particular structure. However, type of Sand in foundation may be different from the type of sand for the rest of the structure.

2.05.04 Water

Water for use in Concrete shall be clear and free from injurious oils, acids, alkalis, organic matter, salt, silts or other impurities. Normally potable water is found to be suitable. Generally, IS:3550 shall be followed for routine tests. Acceptance test for water shall be as per IS:3025, and Table-1 of IS:456.

In case of doubt regarding development of strength , the suitability of water for making concrete shall be ascertained by compressive strength and initial setting time tests as per method of tests in accordance with the requirements of IS-516 & IS- 4031 respectively. The PH value of water shall generally be not less than 6.

2.05.05 Admixture

Only admixture of approved quality shall be used when directed or permitted by the Owner /Consultant. The different types of admixtures which may be necessary to satisfy the concrete mix and the design requirement shall be as per the following I.S. Standards:

IS : 2645 - Integral cement water proofing compound

IS : 9103 - Indian standard specification for Admixtures for Concrete or equivalent American Codes (ASTM C494 and ASTM C260) or British Codes (BS 5075 , Part 1 to 3) and may be one of the following :

a) Accelerating admixtures :

- Set accelerating admixtures like "Sigunit Powder" or "Sigunit LN10" or equivalent.

b) Retarding admixtures :

- Modified ligno sulphonate based set retarding concrete admixture like , "Plastiment R" or equivalent.

c) Water reducing admixtures :

- Modified sulphonated melamine formaldehyde based water reducing concrete admixture like, "Sikament" or equivalent.

d) Air entraining admixtures :

- Modified ligno sulphonate based air entraining concrete admixture like "FLOMO AEP " or surface - active agents like "Sika AER" or equivalent.

e) Water proofing admixtures

All water retaining structures shall be provided with water proofing admixtures

- Modified ligno-sulphonate based waterproofing admixture like "Plastocrete Super" or equivalent.

However, the Successful Bidder shall furnish following technical information about the admixtures (along with the manufacturer's Catalogue) which he is planning to use in different areas within the scope of work for the approval of the Owner/Consultant :

i) Type of admixture

ii) Mix proportion & mode of application in concrete/mortar

iii) Manufacturer's specification & necessary quality assurance certificates (mainly on chloride & sulphate content , PH value infra-red analysis & solid content.)

2.05.06 Reinforcement

Reinforcement shall be Corrosion Resistant Steel (CRS) of Fe 500/500D/550 grade and as per relevant IS Specification as mentioned in the Contract/Drawing/Instructions. Higher grade steel may also be used; however the design shall be restricted to Fe500 for Flexural Design and Fe415 for Shear design. All bars shall be of tested quality.

2.06.00 Storage of Materials

2.06.01 General

All materials shall be so stored as to prevent deterioration or intrusion of foreign matter and to ensure the preservation of their quality and fitness for the work.

Any material, which has deteriorated or has been damaged or is otherwise considered defective by the Owner /Consultant, shall not be used for concrete and shall be removed from site immediately, failing which, the Owner /Consultant shall be at liberty to get the materials removed and Storage of materials shall conform to IS:4082.

2.06.02 Cement

Sufficient space for storage, with open passages between stacks, shall be arranged by the Successful Bidder to the satisfaction of the Owner/Consultant.

Cement shall be stored off the ground in dry, leak proof, well-ventilated ware-houses at the works in such a manner as to prevent deterioration due to moisture or intrusion of foreign matter.

Cement shall be stored in easily countable stacks with consignment identification marks. Consignments shall be used in the order of their receipts at site. Sub-standard or partly set cement shall not be used and shall be removed from the site, with the knowledge of the Owner /Consultant, as soon as it is detected.

Different types of cement shall be clearly marked with the Type and different types of cement shall not be intermixed.

2.06.03 Aggregates

Aggregates shall be stored on planks or steel plates or on concrete or masonry surface. Each size shall be kept separated with wooden or steel or concrete or masonry bulk-heads or in separate stacks and sufficient care shall be taken to prevent the material at the edges of the stock piles from getting intermixed. Stacks of fine and coarse aggregates shall be kept sufficiently apart with proper arrangement of drainage. The aggregates shall be stored in easily measurable stacks of suitable depths as may be directed by the Owner.

2.06.04 Reinforcement

Reinforcing steel shall be stored consignment-wise and size-wise off the ground and under cover, if desired by the Owner. It shall be protected from rusting, oil, grease and distortions. If necessary, the reinforcing steel may be coated with cement wash before stacking to prevent scale and rust. The stacks shall be easily measurable. Steel needed for immediate use shall only be removed from storage.

2.07.00 Quality Control

Successful Bidder shall establish and maintain quality control for different items of work and materials as may be directed by the Owner/Consultant to assure compliance with contract requirements and maintain and submit to the Owner/Consultant records of the same.

The quality control operation shall include but not be limited to the following items of work :

a)	Admixture	:	Type, quantity, physical and chemical properties that affect strength, workability and durability of concrete. For air entraining admixtures, dosage to be adjusted to maintain air contents within desirable limits
b)	Aggregate	:	Physical, chemical and mineralogical qualities. Grading, moisture content and impurities.
c)	Water	:	Impurities tests.

d)	Cement	:	Tests to satisfy relevant IS Specifications
e)	Formwork	:	Material, shapes, dimensions, lines, elevations, surface finish, adequacy of form, ties, bracing and shoring and coating.
f)	Reinforcement	:	Shapes, dimensions, length of splices, clearances, ties and supports. Quality and requirement of welded splices. Material tests or certificates to satisfy relevant IS Specification
g)	Grades of concrete	:	Usage and mix design, testing of all properties.
h)	Batching & Mixing	:	Types and capacity of plant, concrete mixers and transportation equipment.
i)	Joints	:	Locations of joints, water stops and filler materials. Dimension of joints, quality and shape of joint material and splices.
j)	Embedded and Anchorage Items	:	Material, shape, location, setting.
k)	Placing	:	Preparation, rate of pouring, weather limitations, time intervals between mixing and placing and between two successive lifts, covering over dry or wet surfaces, cleaning and preparation of surfaces on which concrete is to be placed, application of mortar/slurry for proper bond, prevention of cold joint, types of chutes or conveyors.
l)	Compaction	:	Number of vibrators, their prime mover, frequency and amplitude of vibration, diameter and weight of vibrators, duration of vibration, hand-spreading, rodding and tamping.
m)	Setting of base & Beaming Plates	:	Lines, elevations and bedding mortar.
n)	Concrete Finishes	:	Repairs of surface defects, screening, floating, steel trowelling and brooming, special finishes.
o)	Curing	:	Methods and length of time.

Copies of records and tests for the items noted above, as well as, records of corrective action taken shall be submitted to the Consultant for approval as may be desired.

3.00.00 INSTALLATION

All installation requirements shall be in accordance with IS:456 and as supplemented or modified herein or by other best possible standards where the specific requirements mentioned in this section of the specification do not cover all the aspects to the full satisfaction of the Owner /Consultant.

3.01.00 Washing and Screening of Aggregates

Washing and Screening of coarse aggregate shall be carried out to remove fines , dirt or other deleterious materials.

Washing of fine aggregate shall not be allowed, Fine aggregates shall be screened only to remove dirt or other deleterious materials.

However, all washing & screening of aggregates shall be carried out by approved means to ensure compliance with the aggregate specification.

3.02.00 Admixture

All concrete shall be designed for normal rate of setting and hardening at normal temperature. Variations in temperature and humidity under different climatic conditions will affect the rate of setting and hardening, which will, in turn, affect the workability and quality of the concrete.

Admixtures may be permitted to be used in accordance with IS:456 to modify the rate of hardening, to improve workability or as an aid to control concrete quality. The Owner /Consultant reserves the right to require laboratory test or use test data, or other satisfactory reference before granting approval. The admixture shall be used strictly in accordance with the manufacturer's directions and/or as directed by the Owner/Consultant.

3.03.00 Grades of Concrete

Structural concrete grade shall be as per clause 4.00.00 Design of Reinforced Concrete Structures of volume: II-G/1 section-II or specified elsewhere and for other part of the work, shall be as shown on the drawing as per grade classification of IS-456. In case of liquid retaining structures, IS: 3370 shall be followed.

3.04.00 Proportioning and Works Control

3.04.01 General

Proportioning of ingredients of concrete shall be made by any of the two following methods as directed by the Owner /Consultant.

a) With preliminary tests by designing the concrete mix. Such concrete shall be called 'Design Mix Concrete'.

b) without preliminary tests adopting nominal concrete mix. Such concrete shall be called 'Nominal Mix Concrete'.

As far as possible, design mix concrete shall be used on all concrete works. Nominal mix concrete, in grades permitted in accordance with IS:456, may be used if shown on drawings or approved by the Owner /Consultant. In all cases the proportioning of ingredients and works control shall be in accordance with IS:456 and shall be adopted for use after the Owner/ Consultant is satisfied regarding its adequacy and after obtaining his approval in writing.

3.04.02 Mix Design Criteria

Concrete mixes shall be designed by the Successful Bidder to achieve the strength, durability and workability necessary for the job, by the most economical use of the various ingredients. In general, the design shall keep in view the following considerations:

a) Consistent with the various other requirements of the mix, the quantity of water shall be kept at the lowest possible level.

b) The nominal maximum size of coarse aggregate shall be as large as possible within the limits specified.

c) The various fractions of coarse and fine aggregates shall be mixed in such a proportion as to produce the best possible combined internal grading giving the densest and most workable mix.

d) Chemical admixtures may be used to modify the rate of hardening, to improve workability (maintaining low water - cement ratio) or as an aid to control concrete quality.

e) The finished concrete shall have adequate durability in all conditions, to withstand satisfactorily the weather and other destructive agencies which it is expected to be subjected to in actual service.

The requirement of adequate structural strength is catered for by the choice of proper grade of concrete by the Owner/Consultant. The Successful Bidder shall strictly abide by the same in his design of concrete mix installation. Notwithstanding anything mentioned in various tables given in IS:456 giving specific values and degrees of workability for different condition of concrete placing, minimum cement content and maximum water-cement ratio for concrete exposed to sulphate attack and for concrete to ensure durability under different condition of exposure, strength requirement for different grades of concrete, proportion for nominal mix concrete, values given in the tables in IS:456, shall be followed.

Various trials shall be given by the Successful Bidder with specific cement content on each trial . In some cases, plasticizers and other admixtures may be necessary to achieve the desired results.

TABLE – I

STRENGTH REQUIREMENT OF CONCRETE

	Specified Characteristic Compressive Grade of concrete strength of 15 cm Cubes at 28 days conducted in accordance with IS:516 (All values in N/Sq.mm)
M - 15	15
M - 20	20
M - 25	25
M - 30	30
M - 35	35
M - 40	40

NOTE : 1 - Concrete Grade M-15 shall be used as lean concrete for simple foundations for masonry walls..Grades of concrete lower than M-20 shall not be used in reinforced concrete. These mixes need not be designed.

TABLE - II

MIX PROPORTIONS (BY WEIGHT) EXPECTED TO GIVE DIFFERENT DEGREES OF WORKABILITY WITH DIFFERENT VALUES OF WATER - CEMENT RATIO

(FOR GUIDANCE)

CEMENT/TOTAL AGGREGATE RATIOS

WORKABILITY	WATER/CEMENT/RATIO	RATIO BY WEIGHT OF CEMENT OF GRAVEL AGGREGATE		RATIO BY WEIGHT OF CEMENT OF CRUSHED STONE AGGREGATE	
		20 mm	38 mm	20 mm	38 mm
		Size	size	size	size
Very low	0.4	01:04.8	01:05.3	01:04.5	01:05.0
Slump	0.5	01:07.2	01:07.7	01:06.5	01:07.4
0-25 mm	0.6	01:09.4	1:10	01:07.8	01:09.6
	0.7	1:10	1:12	01:08.7	01:10.6
Low	0.4	01:03.9	01:04.5	01:03.5	01:04.0
Slump	0.5	01:05.5	01:06.7	01:05.0	01:05.5
25-50 mm	0.6	01:06.8	01:07.4	01:06.3	01:07.0

	0.7	01:08.0	01:08.5	01:07.4	01:08.0
Medium	0.4	01:03.5	01:03.8	01:03.1	01:03.6
Slump	0.5	01:04.8	01:05.7	01:04.2	01:05.0
50-100 mm	0.6	01:06.0	01:07.3	01:05.2	01:06.2
High	0.4	01:03.2	01:03.5	01:02.9	01:03.3
Slump	0.5	01:04.4	01:05.2	01:03.9	01:04.6
100-175 mm	0.6	01:05.4	01:06.7	01:04.7	01:05.7
	0.7	01:06.2	01:07.4	01:05.5	01:06.5

NOTE : 1 - Notwithstanding anything mentioned above, the cement/Total aggregate ratio is not to be increased beyond 1:9.0 without specific permission of the Owner /Consultant.

NOTE : 2 - It shall be noted that such high aggregate cement ratios will be required for concretes of very low slump and high water- cement ratios which may be required to be used in mass concrete work only.

NOTE : 3 - The above figures are for guidance only, the actual cement/aggregate ratios are to be worked out from the specific gravities of coarse aggregates and sand being used and from trial mixes.

3.05.00 Strength Requirements

The strength requirements of both design mix and nominal mix concrete where ordinary Portland Cement or Portland slag cement is used, shall be as per Table-2 of IS:456. All other relevant clauses of IS:456 shall also apply.

3.06.00 Minimum Cement Content

The minimum cement content for each grade of concrete shall be as per IS-456 or as per cl.4.00.00 of Vol G1/sec II whichever is higher.

3.07.00 Water-Cement Ratio

The choice of water-cement ratio in designing a concrete mix will depend on -

a) The requirement of strength.

b) The requirement of durability.

3.07.01 Strength Requirement

In case of 'Design Mix Concrete', the water-cement ratio of such value as to give acceptable test results as per IS: 456, shall be selected by trial and error. The values of water-cement ratios for different grade and mix designs shall have to be established after conducting sufficiently large number of

preliminary tests in the laboratory to the satisfaction of the Owner /Consultant. Frequent checks on test shall have to be carried out and the water-cement ratios shall be revised if the tests produce unsatisfactory results. Notwithstanding anything stated above the Successful Bidder's responsibility to produce satisfactory test results and to bear all the consequences in case of default remains unaltered.

In case of nominal mix concrete, proportions for different grades of concrete is specified in Table-9 of IS:456 and no tests are necessary. The acceptance test criteria for nominal mix concrete shall be as per IS:456.

3.07.02 Durability Requirement

Table-5 of IS:456 gives the maximum water-cement ratio permissible from the point of view of durability of concrete subjected to adverse exposure to weather, sulphate attacks, and contact with harmful chemicals. Impermeability may also be an important consideration.

Whenever the water-cement ratio dictated by durability consideration is lower than that required from strength criterion, the former shall be adopted.

In general the water cement ratio between 0.4 and 0.45 shall be desirable to satisfy the durability requirement and from the consideration of impermeability of concrete.

The Successful Bidder may propose lower water cement ratio as mentioned above by addition of a suitable plasticizer / super-plasticizer. However the Successful Bidder has to propose specifically along with field trials in the event of lower cement content if found suitable along with a plasticizer. It shall be preferable to use Melamine based plasticizer.

3.08.00 Workability

The degree of workability necessary to allow the concrete to be well consolidated and to be worked into the corners of formwork and around the reinforcement and embedments and to give the required surface finish shall depend on the type and nature of structure and shall be based on experience and tests. The usual limits of consistency for various types of structures are given below :

TABLE - III

LIMITS OF CONSISTENCY

Degree of workability	Slump in mm with Standard Cone as per IS:1199		Use for which concrete is suitable.
	Min.	Max.	
Very low	0	25	Large Mass concrete structure with heavy compaction equipment, roads and like.
Low	25	50	Uncongested wide and shallow R.C.C. structures.
Medium	50	100	Deep but wide R.C.C. structures with congestion or reinforcement and inserts.
High	100	150	Very narrow and deep R.C.C. structures with congestion due to reinforcement and inserts.

(**NOTE** : Notwithstanding anything mentioned above, the slump to be obtained for work in progress shall be as per direction of the Owner/Consultant)

With the permission of the Owner /Consultant, for any grade of concrete, if the water has to be increased in special cases, cement shall also be increased proportionately to keep the ratio of water to cement same as adopted in trial mix design for each grade of concrete. The workability of concrete shall be checked at frequent intervals by slump tests. Alternatively where facilities exist or if required by the Owner /Consultant, the compacting factor test in accordance with IS:1199.

3.09.00 Size of Coarse Aggregates

The maximum size of coarse aggregates for different locations shall be as follows unless otherwise directed by the Owner /Consultant:-

Very narrow space - 12 mm

Reinforced concrete including foundation - 20 mm

Ordinary Plain concrete M10 and below - 40 mm / 20 mm

Ordinary Plain Concrete M15 - 20 mm

Grading of coarse aggregates for a particular size shall conform to relevant I.S. Codes and shall also be such as to produce a dense concrete of the

specified proportions, strength and consistency that shall work readily into position without segregation.

Coarse aggregate shall normally be separated into the following sizes and stacked separately in properly designed stockpiles :

40 mm to 20 mm and 20 mm to 5 mm. In certain cases it may be necessary to further split the 20 mm to 5 mm fraction into 20 mm to 10 mm and 10 mm to 5 mm fractions. Coarse aggregates more than 40mm size shall not be used in concrete.

This separation of aggregates in different size fractions is necessary so that they may be remixed in the desired proportion to arrive at a correct internal grading to produce the best mix.

3.10.00 Mixing of Concrete

Concrete shall always be mixed in mechanical mixer unless specifically approved by the Owner /Consultant for concrete to be used in unimportant out of the way locations in small quantities. Water shall not normally be charged into the drum of the mixer until all the cement and aggregates constituting the batch are already in the drum and mixed for at least one minute. Mixing of each batch shall be continued until there is a uniform distribution of the materials and the mass is uniform in colour and consistency, but in no case shall mixing be done for less than 2 (two) minutes and at least 40 (forty) revolutions after all the materials and water are in the drum.

When absorbent aggregates are used or when the mix is very dry, the mixing time shall be extended as may be directed by the Owner/Consultant. Mixers shall not be loaded above their rated capacity as this prevents thorough mixing.

The entire contents of the drum shall be discharged before the ingredients for the next batch are fed into the drum. No partly set or remixed or excessively wet concrete shall be used. Such concrete shall be immediately removed from site. Each time the work stops, the mixer shall be thoroughly cleaned & when the next mixing commences, the first batch shall have 10% additional cement to allow for loss in the drum.

Regular checks on mixer efficiency shall be carried out as directed by the Owner/Consultant as per IS:4634 on all mixers employed at site. Only those mixers whose efficiencies are within the tolerances specified in IS:1791 shall be allowed to be employed.

Ingredients for design mix concrete shall be measured by weight. For small jobs portable swing weigh Batchers conforming to IS:2722 may be used.

Batching plant conforming to IS:4925 shall be used for large jobs. The accuracy of the measuring equipment shall be within + 2% of the quantity of

Cement , water or total aggregates being measured and within + 5% of the quantity of any admixture being used . The batching equipment shall be fitted with an accurate mechanism for weighing separately the cement, fine aggregate and coarse aggregate. Water may be measured by volume or by weight. All measuring equipment shall be maintained in a clean serviceable condition, and their accuracy shall be checked periodically.

Mechanical / electrical control shall be provided on the mixing equipment to ensure the batch cannot be discharged until approved mixing time has elapsed and the entire batch shall be discharged before the mixer is recharged.

Where admixtures are employed, separate containers & measuring devices shall be used.

For minor concreting works, batching by volume according to specific weight may be permitted by the Owner /Consultant. In that case the whole bags of cement shall be used and gauge boxes used for measuring aggregates.

When hand mixing is permitted by the Owner/Consultant, it shall be carried out on a water-tight platform and care shall be taken to ensure that mixing is continued until the mass is uniform in colour and consistency. In case of hand-mixing, 10% extra cement shall be added to each batch.

3.11.00 Conveying Concrete

Concrete shall be handled and conveyed from the place of mixing to the place of laying as rapidly as practicable by approved means and placed and compacted in the final position before the initial setting of the cement starts. Concrete shall be conveyed in such a way as shall prevent segregation or loss of any of the ingredients. For long distance haulage, agitator cars of approved design shall be used. If, in spite of all precautions, segregation does occur during transport, the concrete shall be properly re-mixed before placement. During very hot or cold weather, if directed by the Owner /Consultant, concrete shall be transported in deep containers which will reduce the rate of loss of water by evaporation or loss of heat. If necessary, the container may have to be covered and insulated. Conveying equipments for concrete shall be well maintained and thoroughly cleaned before commencement of concrete mixing. Such equipments shall be kept free from set concrete.

3.12.00 Placing and Compacting Concrete

Where specifically covered, the relevant I.S. Code shall be followed for the procedure of surface preparation, placement, consolidation, curing, finishes, repairs and maintenance of concrete. If, however, there is no specific provision in the relevant I.S. Code for any particular aspect of work, any other standard Code of practice, as may be specified by the Consultant, shall be adopted. Concrete may have to be placed against the following types of surfaces :

a) Earth foundation

b) Rock foundation

c) Formwork

d) Construction joint in concrete or masonry

The surface on or against which concrete is to be placed has to be cleaned thoroughly. Rock or old construction joint has to be roughened by wire brushing, chipping, sand blasting or any other approved means for proper bond. All cuttings, dirt, oil, foreign and deleterious material, laitance, etc. are to be removed by air water jetting or water at high pressure. All excavated areas for foundations, ring beams, plinths, pile caps etc. shall be rammed & consolidated properly before blinding with nominal mix plain concrete, as per drawing and / or direction of the Owner /Consultant and shall be allowed to cure prior to setting out steel fixing, shuttering and concrete pouring for the main structural element.

Formwork, reinforcement, preparation of surface, embedments, joint seals etc., shall be approved in writing by the Owner/Consultant before concrete is placed. As far as possible, concrete shall be placed in the formwork by means approved by the Owner /Consultant and shall not be dropped from a height or handled in a manner which may cause segregation. Any drop over 1500 mm shall have to be approved by the Owner/Consultant.

Rock foundation or construction joint shall be kept moist for at least 72 hours prior to placement. Concrete shall be placed always against moist surface but never on pools of water. In case the foundation cannot be dewatered completely, special procedure and precaution, as directed by the Owner Engineer/ Consultant shall have to be adopted.

Formwork shall be cleaned thoroughly and smeared lightly with form oil or grease of approved quality just prior to placement.

A layer of mortar of thickness 12 mm of the same or less w/c ratio and the same proportion as that of the concrete being placed and cement slurry shall be spread thoroughly on the rock foundation or construction joint just prior to placement of concrete. The cost of application of such cement slurry and mortar shall be deemed to be included.

After concrete has been placed, it shall be spread, if necessary and thoroughly compacted by approved mechanical vibration to maximum subsidence without segregation and thoroughly worked around shape. Vibrators shall not be used for pushing concrete into adjoining areas. Vibrators must be operated by experienced workmen and the work carried out as per relevant IS Code of Practice. In thin members with heavy congestion of reinforcement or other embedments, where effective use of internal vibrator is, in the opinion of the Owner /Consultant, doubtful, in addition to immersion

vibrators the Successful Bidder may have to employ form vibrators conforming to IS:4656. For slabs and other similar structures, the Successful Bidder shall additionally employ screed vibrator as per IS:2506. Hand tamping may be allowed in rare cases, subject to the approval of the Owner /Consultant. Care must be taken to ensure that the inserts, fixtures, reinforcement and formwork are not displaced or distorted during placing and consolidation of concrete.

The rate of placement of concrete shall be such that no cold joint is formed and fresh concrete is placed always against green concrete which is still plastic and workable. No concrete shall be placed in open, during rains. During rainy season, no placement in the open is to be attempted unless sufficient tarpaulins or other similar protective arrangement for completely covering the still green concrete from rain is kept at the site of placement. If there has been any sign of washing of cement and sand, the entire affected concrete shall be removed immediately. Suitable precautions shall be taken in advance to guard against rains before leaving the fresh concrete unattended. No accumulation of water shall be permitted on or around freshly laid concrete.

The size of the concrete pours must be carefully considered prior to commencement to ensure the structural elements are poured in on continuous shift to avoid cold joints.

Slabs, beams and similar members shall be poured in one operation, unless otherwise instructed by the Owner /Consultant. Moulding, throating, drip course, etc., shall be poured as shown on the drawings or as directed by the Owner /Consultant. Holes shall be provided and bolts, sleeves, anchors, fastenings or other fixtures shall be embedded in concrete as shown on the drawings or as directed by the Owner /Consultant. Any deviation therefrom shall be set right by the Successful Bidder as instructed by the Owner /Consultant.

In case the forms or supports get displaced during or immediately after the placement and bring the concrete surface out of alignment beyond tolerance limits, the Owner /Consultant may direct to remove the portion and reconstruct or repair the same.

The Owner /Consultant shall decide upon the time interval between two placements of concrete of different ages coming in contact with each other, taking in consideration the degree of maturity of the older concrete, shrinkage, heat dissipation and the ability of the older concrete to withstand the load imposed upon it by the fresh placement.

Once the concrete is deposited, consolidated and finished in its final position, it shall not be distributed.

3.13.00 Construction Joints and Cold Joints

3.13.01 Construction Joints

It is always desirable to complete any concrete structure by continuous pouring in one operation. However, due to practical limitation of methods and equipment and certain design considerations, construction joints are formed by discontinuing concrete at certain predetermined stages. These joints shall be formed in a manner specified in the drawings/ Instruction. Vertical construction joints shall be made with rigid stop-board forms having slots for allowing passage of reinforcement rods and any other embedments and fixtures that may be shown. Next stage concrete shall be placed against construction joint. For water retaining structures and leak-proof buildings suitable approved water bars shall be installed at the construction joints.

Where the location of the joints are not specified, it shall be in accordance with the following :

a) In a column, the joint shall be formed 75 mm below the lowest soffit of the beam framing into it.

b) Concrete in a beam shall preferably be placed without a joint, but if provision of a joint is unavoidable, the joint shall be vertical and within the middle third of the span.

c) A joint in a suspended floor slab shall be vertical and within the middle third of the span and at right angles to the principal reinforcement.

d) Feather-edges in concrete shall be avoided while forming a joint.

e) A construction joint shall preferably be placed in a low-stress zone and at right angles to the direction of the principal stress.

f) In case the Successful Bidder proposes to have a construction joint anywhere to facilitate his work, the proposal shall be submitted well in advance to the Owner /Consultant for study and approval without which no construction joint shall be allowed.

3.13.02 Cold Joint

An advancing face of a concrete pour, which could not be covered by fresh concrete before expiry of initial setting time (due to an unscheduled stoppage or delay on account of breakdown in plant, inclement weather, low rate of placement or any other reason), is called a cold joint. The Successful Bidder shall always remain vigilant to avoid cold joints.

If, however, a cold joint is formed due to unavoidable reasons, the following procedure shall be adopted for treating it:

a) If the concrete is so green that it can be removed manually and if vibrators can penetrate the surface without much effort, fresh concrete can be placed directly against the old surface. The old concrete shall be covered by fresh concrete as quickly as possible and the joint thoroughly and systematically vibrated.

b) In case concrete has hardened a bit more than (a) but can still be easily removed by a light hand pick, the surface shall be raked thoroughly and the loose concrete removed completely without disturbing the rest of the concrete in depth. A rich mortar layer 12 mm in thickness with same or richer grade than the concrete under consideration), shall be placed on the cold joint fresh concrete shall be placed on the mortar layer and the joint shall be thoroughly and systematically vibrated penetrating the vibrator deep into the old layer of concrete.

c) In case the concrete at the joint has become so stiff that it cannot be remoulded and mortar or slurry does not rise in spite of extensive vibration, the joint shall be left to harden for at least 12 - 24 hrs. It shall then be treated as a regular construction joint, after cutting the concrete to required shape and preparing the surface as described under Clause 3.12.

3.14.00 Repairs, Finishes and Treatment of Concrete surfaces

3.14.01 Adequate and sound concrete surfaces, whether formed or unformed, can be obtained by employing a concrete mix of proper design, competent formwork, appropriate methods of handling, placing and consolidation by experienced workmen.

Unsound concrete resulting from improper mix design, incompetent methods, equipment and formwork, poor workmanship and protection shall not be accepted and, shall have to be dismantled, removed and replaced by sound concrete without any additional cost and time to Owner. The Owner /Consultant may, at his sole discretion, allow to retain concrete with minor defects provided the Successful Bidder is able to repair it by approved methods. All concrete work shall be inspected by the Successful Bidder immediately after the forms are removed and he shall promptly report occurrence of any defects to the Owner /Consultant. All repair works shall be carried out as per the instructions and in the presence of the Owner /Consultant or his representative at successful bidder's own cost and risk. Generally, repair work shall consist of any or all of the following operations :

a) Sack rubbing with mortar and stoning with carborundum stone.

b) Cutting away the defective concrete to the required depth and shape.

c) Cleaning of reinforcement and embedments. It may be necessary to provide an anti-corrosive coating on the reinforcement.

d) Roughening by sand blasting or chipping.

e) Installing additional reinforcement/welded mesh fabric.

f) Dry packing with stiff mortar.

g) Plastering, guniting, shotcreting etc.

h) Placing and compacting concrete in the void left by cutting out defective concrete.

i) Grouting with a cement sand slurry of 1:1 mix.

j) Repairing with a suitable mortar either cement or resin modified mortar.

k) Polymer modified patching and adhesive repair mortar for beams & columns.

Based on the nature of defects, any proven method of repair works suggested by owner/consultant shall be followed by the successful bidder without any additional cost and time to the owner.

3.14.02 Finishing Unformed Surface

A few typical and common cases of treatment of concrete surface are cited below :

a) Floor

Whenever a non-integral floor finish is indicated, the surface of reinforcement concrete slab shall be struck off at the specified levels and slopes and shall be finished with a wooden float fairly smooth removing all laitance.
No over trowelling, to obtain a very smooth surface, shall be done as it will prevent adequate bond with the subsequent finish. If desired by the Owner /Consultant, the surface shall be scored and marked to provide better bond.

Where monolithic finish is specified or required, concrete shall be compacted and struck off at the specified levels and slopes with a screed, preferably a vibrating type and then floated with a wooden float. Steel trowelling by hand or by rotary power float is then started after the moisture film and shine have disappeared from the surface and after the concrete has hardened enough to prevent excess of fines and water to rise to the surface but not hard enough to prevent proper finishing of aberrations. Steel trowelling properly done will flatten and smoothen sandy surface left by wooden floats and produce a dense surface free from blemishes, ripples and trowel marks. A fine textured surface that is not slick and can be used where there is likelihood of spillage of oil or water can be obtained by trowelling the surface lightly with a circular motion after initial trowelling keeping the steel trowel flat on the surface.

To provide a better grip the Owner /Consultant may instruct marking the floor in a regular geometric pattern after initial trowelling.

b) Beams, Columns & Walls

If on such or any other concrete structure it is intended to apply plaster or such concrete surfaces against which brickwork or other allied works are to be built, the Successful Bidder shall hack the surface adequately as soon as the form is stripped off so that proper bond can develop. Pattern, adequacy and details of such hacking shall meet with the approval of the Owner /Consultant, who shall be informed to inspect such surfaces before they are covered up.

3.15.00 Protection and Curing of concrete

Newly placed concrete shall be protected by approved means from rain, sun and wind. Concrete placed below the ground level shall be protected against contamination from falling earth during and after placing.

Concrete placed in ground containing deleterious substances, shall be protected from contact with such ground, or with water draining from such ground, during placing of concrete and for a period of at least three days or as otherwise instructed by the Owner /Consultant. The ground water around newly poured concrete shall be kept to an approved level by pumping out or other adequate means of drainage to prevent floatation or flooding.

Steps, as approved by the Owner /Consultant, shall be taken to protect immature concrete from damage by debris, excessive loadings, vibration, abrasion, mixing with earth or other deleterious materials, etc. that may impair the strength and durability of the concrete.

As soon as the concrete has hardened sufficiently, it shall be covered either with sand, polythene sheet, hessian, canvas or similar materials and kept continuously wet for at least 14 (fourteen) days after final setting. Curing by continuous sprinkling of water shall be allowed if the Owner /Consultant is satisfied with the adequacy of the arrangements made by the Successful Bidder.

If permitted by the Owner /Consultant, curing compound like "ANTISOLE (WP)" may be used for prevention of premature water loss in concrete and thereby effecting curing of concrete . This type of curing compound shall be sprayed on newly laid concrete surfaces to form thin film barrier against premature water loss without disturbances to normal setting action. The curing compound shall comply with ASTM requirements for acceptance.

The curing compound shall be applied following the final finishing operation and immediately after disappearance of water sheen from concrete surface.

It is important not to apply the curing compound when standing water is still present on concrete.

The Successful Bidder shall arrange for the manufacturer's supervision.

The Successful Bidder shall remain extremely vigilant and employ proper equipment and workmen under able supervision for curing. The Owner's Consultant's decision regarding the adequacy of curing is final.

In case any lapse on the part of the Successful Bidder is noticed by the Owner /Consultant, he shall inform the Successful Bidder or his supervisor verbally or in writing to correct the deficiency in curing. If no satisfactory action is taken by the Successful Bidder within 3 (three) hours of issuance of such instruction, the Consultant shall be at liberty either to employ sufficient means through any agency to make good the deficiency and entirely at the discretion of the Owner and at bidder's cost.

3.16.00 Reinforcement

Mild steel round bars, high yield strength steel, etc., shall be used as reinforcement as per drawings and directions. All reinforcement shall be Corrosion Resistant Steel.

3.16.01 Bar Bending Schedules

The Successful bidder shall submit to the site Engineer-in-charge. Bar Bending Schedules under Information category, with working drawings in triplicate, showing clearly the arrangements proposed by the Successful bidder to match available stock of reinforcing steel, within one month of receipt of the Letter of Intent or of the receipt of the relevant design drawings, whichever is later. Upon receipt of the Engineer's final review of the Bar Bending Schedule and drawings, the Successful bidder shall submit 6 (six) prints of the final drawings with one reproducible print after incorporating necessary modifications or corrections, for final record and distribution. Approval of such working drawings by the site Engineer shall not relieve the Successful bidder of his responsibility for correctness nor of any of his obligations to meet the other requirements of the Contract.

3.16.02 Cleaning

All steel for reinforcement shall be free from loose scales, oil, grease, paint or other harmful matters immediately before placing the concrete.

3.16.03 Cutting & Bending of Reinforcement

Unless otherwise specified, reinforcing steel shall be bent in accordance with the procedure specified in IS:2502 Bends and shapes shall comply strictly with the dimensions corresponding to the approved Bar Bending Schedules. Bar Bending Schedules shall be rechecked by the Successful Bidder before any bending is done.

No reinforcement shall be bent when already in position in the work, , whether or not it is partially embedded in concrete. Bars shall not be straightened in a manner that shall injure the material. Re-bending can be

done only if approved by the Site Engineer-incharge /Consultant. Reinforcing bars above 16 mm diameter shall be bent by machine producing a gradual and even motion. Bars of 16 mm or below may be bent by hand. All the bars shall be cold bent unless otherwise approved. Bending hot at a cherry-red heat (not exceeding 845°C) may be allowed under very exceptional circumstances except for bars whose strength depends on cold working. Bars bent hot shall not be cooled by quenching.

Reinforcing bars, whether high yield or mild steel shall be cut using either hand held shears, guillotines or foot operated pneumatic cutters. Cutting bars using cold chisels may be allowed by the Owner /Consultant at exceptional cases.

3.16.04 Placing in Position

All reinforcements shall be accurately fixed and maintained in position as shown on the drawings by such approved and adequate means like mild steel chairs and/or concrete spacer blocks irrespective of whether such supports are payable or not. Bars intended to be in contact at crossing points, shall be securely tied together at all such points by No. 18 SWG/annealed soft iron wire in two strands. Tack welding of bars shall not be done unless permitted by the Owner /Consultant. Binders shall tightly embrace the bars with which they are intended to be in contact and shall be securely held.

The vertical distance between successive layers of bars shall be maintained by provision of mild steel spacer bars. They shall be spaced such that the main bars do not sag perceptibly between adjacent spacers. Before actual placing, the Successful Bidder shall study the drawings thoroughly and inform the Owner/ Consultant in case he feels that placement of certain bars is not possible due to congestion. In such cases he shall not start placing any bar before obtaining clearance from the Owner /Consultant.

3.16.05 Welding

Normal bond laps in reinforcement may be placed by lap or butt welding reinforcement bars, if asked by the Owner /Consultant, under certain conditions. The work shall be done with suitable safeguards in accordance with relevant Indian Standards for welding of mild steel bars used in reinforced concrete construction as per IS:2751 and IS:456. Welded mesh fabrics conforming to IS:1566 may also be used if specified and in the Drawings.

3.16.06 Control

The placing of reinforcements shall be completed well in advance of concrete pouring. Immediately before pouring, the reinforcement shall be examined by the Owner/ Consultant for accuracy of placement and cleanliness. Necessary corrections as directed by him shall be carried out.

Laps and anchorage lengths of reinforcing bars shall be in accordance with IS:456, unless otherwise specified. If the bars in a lap are not of the same diameter, the smaller will guide the lap length. The laps shall be staggered as far as practicable and as directed by the Owner /Consultant. Arrangements for placing concrete shall be such that reinforcement in position do not have to bear extra load and get disturbed.

The cover for concrete over the reinforcements shall be as shown on the approved drawings unless otherwise directed by the Owner /Consultant. Where concrete blocks are used for ensuring the cover and positioning reinforcement, they shall be made of mortar not leaner than 1 (one) part cement to 2 (two) parts sand by volume and cured in a pond for at least 14 (fourteen) days. The type, shape, size and location of the concrete blocks shall be as approved by the Owner /Consultant.

3.17.00 Cold Weather Concreting

When conditions are such that any operation of concreting may be expected to be done at 5ºC atmospheric temperature or below the work shall conform to the requirement of Clause 14 of IS:456 and IS:7861. (Part. II).

3.18.00 Hot Weather Concreting

When depositing concrete in very hot weather, the Successful Bidder shall take all precautions as per IS:7861 (Part-I) and stagger the work to the cooler parts of the day to ensure that the temperature of wet concrete used in massive structures does not exceed 40ºC while placing. Positive temperature control by precooling, post-cooling or any other method, if required, shall be specified.

3.19.00 Concreting under water

When it is necessary to deposit concrete under water it shall be done in accordance with the requirements of clause 14 of IS:456.

3.20.00 Form Work

3.20.01 General

Formwork shall conform to the shape, grade, lines, levels and dimension as shown on the drawings. The Successful Bidder shall prepare design & working drawings for formwork & temporary support system for important structures and get them approved by the Owner /Consultant prior to commencement of actual work.

Materials used for the formwork inclusive of the supports and centering shall be capable of withstanding the working load and remain undistorted throughout the period it is left in service. All supports and scaffolds shall be manufactured from structural or tubular steel except when specifically permitted otherwise by the Owner /Consultant.

The centering shall be true to vertical, rigid and thoroughly braced both horizontally and diagonally. Rekers are to be used where forms are to support inclined members. The forms shall be sufficiently strong to carry without undue deformation, the dead weight of the concrete as a liquid as well as the working load, in case the Successful Bidder wishes to adopt any other design criteria, he has to convince the Owner /Consultant about its acceptability before adopting it. Where the concrete is vibrated, the formwork shall be strong enough to withstand the effects of vibration without appreciable deflection, bulging, distortion or loosening of its components. The joints in the formwork shall be sufficiently tight to prevent any leakage of slurry or mortar.

To achieve the desired rigidity, tie bolts, spacer blocks, tie wires and clamps as approved by the Owner /Consultant shall be used but they must in no way impair the strength of concrete or cause stains or marks on the finished surface. Where there are chances of these fixtures being embedded, only mild steel or concrete of adequate strength shall be used.

Alternatively, except in case of water retaining structures through rods and the tie bolts shall be sleeved with PVC conduits to allow retraction of the ties on removal of the shutters. Where required, the annulus of the conduits shall be filled with expanding mortar to seal the void. Bolts passing completely through liquid retaining walls/slabs for the purpose of securing and aligning the formwork shall not be used.

The formwork shall be such as to ensure a smooth uniform surface free from honeycombs, air bubbles, bulges, fins and other blemishes. Any blemish or defect found on the surface of the concrete must be brought to the notice of the Owner/Consultant immediately and rectified as directed by him.

For exposed interior and exterior concrete surfaces of beams, columns and wall, plywood or other approved form shall be thoroughly cleaned and tied together with approved corrosion- resistant devices. Rigid care shall be exercised in ensuring that all column forms are plumb and true and thoroughly cross braced to keep them so. All floor and beam centering shall be crowned not less than 8 mm in all directions for every 5 metres span. Unless specifically described on the drawings or elsewhere to the contrary, bevelled forms 25 mm by 25 mm shall be fixed in the form-work at all corners to provide chamfering of the finished concrete edges. The formwork shall lap and be secured sufficiently at the lift joints to prevent bulges and offsets.

Temporary openings for cleaning, inspection and for pouring concrete shall be provided at the base of vertical forms and at other places, where they are necessary and as may be directed by the Owner /Consultant. The temporary openings shall be so formed that they can be conveniently closed when required, during pouring operations without leaving any mark on the concrete.

3.20.02 Cleaning and Treatment of Forms

All parts of the forms shall be thoroughly cleaned of old concrete, wood shavings , saw dust, dirt and dust sticking to them before they are fixed in position. All rubbish, loose concrete, chippings, shavings, saw dust etc. shall be scrupulously removed from the interior of the forms before concrete is poured. Compressed air jet and/or water jet along with wire brushes, brooms etc. shall be used for cleaning. The inside surface of the formwork shall be treated with approved non-staining oil based shutter release agent like "Separol/Sika form oil/ Siparol Concentrate" before it is placed in position. Care shall be taken that oil or other compound does not come in contact with reinforcing steel or construction joint surfaces. They shall not be allowed to accumulate at the bottom of the formwork.

The oiling of the formwork shall be inspected just prior to placement of concrete and redone wherever necessary.

3.20.02.01 Design

The formwork shall be so designed and erected that the forms for slabs and the sides of beams, columns and walls are independent of the soffits of beams and can be removed without any strain to the concrete already placed or affecting the remaining formwork. Removing any props or repropping shall not be done except with the specific approval of the Owner /Consultant. If formwork for column is erected for the full height of the column, one side shall be left open and built up in sections, as placing of concrete progress. Wedges, spacer bolts, clamps or other suitable means shall be provided to allow accurate adjustment and alignment of the formwork and to allow it to be removed gradually without jarring the concrete.

The design of formwork shall take into account all vertical and lateral loads that the forms shall carry or be subjected to during the construction process. Besides weight and pressures of reinforced concrete and weight of the forms themselves, the design shall consider loading due to unsymmetrical placement of concrete ; impact from dumping of concrete ; movement of men and construction equipment ; wind action and any other imposed load during construction. The Successful Bidder shall assess the magnitude of vertical live load to be taken for design of formwork duly considering his method, sequence and rate of pour of concrete. However, minimum design vertical live load to be considered shall be 750 kg/sqm excluding weight of concrete.

3.20.03 Inspection of Forms

Casting of Concrete shall start only after the formwork has been inspected and approved by the Owner /Consultant. The concreting shall start as early as possible within 3 (three) days after the approval of the formwork and during this period the formwork shall be kept under constant vigilance against any interference. In case of delay beyond three days, a fresh approval from the Owner /Consultant shall be obtained.

3.20.04 Removal of Forms

Before removing any formwork, the Successful Bidder must notify the Owner /Consultant well in advance to enable him to inspect the concrete if he so desires. The Successful Bidder shall record on the drawing or in any other approved manner, the date on which concrete is placed in each part of the work and the date on which the formwork is removed therefrom and have this record checked and countersigned by the Owner regularly.

The Successful Bidder shall be responsible for the safe removal of the formwork and any work showing signs of damage through premature removal of formwork or loading shall be rejected and entirely reconstructed by him. The Owner may, however, instruct to postpone the removal of formwork if he considers it necessary.

Forms for various types of structural components shall not be removed before the minimum periods specified herein and the removal after the minimum periods shall also be subject to the approval of the Owner /Consultant in each case.

TABLE - IV

SCHEDULE OF REMOVAL OF FORM

Part of Structure	Ordinary Portland Cement Concrete Temperature °C				Rapid Hardening Portland Cement Concrete Temperature °C			
	Above 40°C	40°C - 20°C	20°C - 5°C	Below 5°C.	Above 40°C	40°C - 20°C	20°C - 5°C	Below 5°C
	Days	Days	Days	Days	Days	Days	Days	Days
a) Columns & Walls	2	1	1	Do not remove forms until site cured test speci-	1	1	1	Do not remove forms until site cured test specim-
b) Beam sides	3	2	3		2	1	1	
c) Slabs, 125 mm	10	7	8	men develop at least 50% of the	7	4	5	
d) Slabs over 125 mm				specified 28 days				en dev- elop at

	thick and soffit of minor beams	18	14	16	strength	12	8	9	least 50% of the specified 28
e)	Soffit of main beams	24	21	22		14	10	12	days strength

Wherever exposed surfaces of concrete can be effectively sealed to prevent loss of water, the periods specified for temperature above 40ºC can be reduced to those of the temperature range of 20ºC to 40ºC subject to approval of the Owner.

Construction joints in beams, if required to be provided, shall be located within the middle third of span according to clause 3.13.1(b) of this specification. In such cases, however, entire span of beam shall have to be kept supported by formwork till its removal for the portion of beam, cast at a later date, is due and so approved by the Owner /Consultant.

If any type of cement other than ordinary portland cement and Rapid hardening portland cement is used the time of removal or forms shall be revised as approved by the Owner /Consultant such that the strength of this cement at the time of removal of forms match with strength of portland cement at the time of removal of form as mentioned above . This has to be supported by regular tests.

3.20.05 Tolerance

The formwork shall be so made as to produce a finished concrete, true to shape, lines, levels, plumb and dimensions as shown on the drawings subject to the following tolerances unless otherwise specified in this Specification or drawings or directed by the Owner /Consultant :

For

a) Sectional dimension - $\pm$ 5 mm

b) Plumb - 1 in 1000 of height

c) Levels - $\pm$ 3 mm before any deflection has taken place

The tolerance given above are specified for local aberrations in the finished concrete surface and shall not be taken as tolerances for the entire structure taken as a whole or for the setting and alignment of formwork, which shall be as accurate as possible to the entire satisfaction of the Owner /Consultant. Any error, within the above tolerance limits or any other as may be specially set up by the Owner /Consultant, if noticed in any lift of the structure after stripping of forms, shall be corrected in the subsequent work to bring back the surface of the structure to its true alignment.

3.20.06 Re-use of Forms

Before re-use, all forms shall be thoroughly scraped, cleaned, joints and planes examined and when necessary repaired, and inside surface treated as specified hereinbefore. Formwork shall not be used/re-used if declared unfit or unserviceable by the Owner.

3.20.07 Classification

Generally, the 'ordinary' class formwork shall be used unless otherwise directed by the Owner :

a) Ordinary : These shall be used in places where ordinary surface finish is required and shall be composed of steel and/or approved good quality partially seasoned timber.

b) Plywood : These shall be used in exposed surfaces, where a specially good finish is required and shall be made of approved brand of heavy quality plywood to produce a perfectly uniform and smooth surface conforming to the shape described in the drawing with required grain texture on the concrete. Re-use may only be permitted after special inspection and approval by the Owner /Consultant. He may also permit utilisation of used plywood for the 'ordinary' class, if it is still in good condition.

c) Ornamental: These shall be used where ornamental and curved surface are required and shall be made of selected best quality well seasoned timbers or of plywood, which can be shaped correctly.

3.21.00 Opening, Chases, Grooves, Rebates, Blockouts etc.

The Successful Bidder shall leave all openings, grooves, chases, etc. in concrete work as shown on the drawings or as specified by the Owner /Consultant.

3.22.00 Anchor Bolts, Anchors, Sleeves, Inserts, Hangers/Conduits/Pipe and Other misc. Embedded Fixtures. The Successful Bidder shall build into concrete work all the items noted below and shall embed them partly or fully as directed and secure the same as may be required. The materials, if required to be supplied by the Successful Bidder, shall be as specified and be of best quality available according to relevant Indian Standards of approved manufacture and to the satisfaction of the Owner. Exposed surfaces of embedded materials are to be painted with one coat of approved anti-corrosive paint and/or bituminous paint. If welding is to be done subsequently on the exposed surface of embedded material the paint shall be cleaned off the member to a minimum length of 50 mm beyond each side of the weld line.

Necessary templates, jigs, fixtures, supports etc. shall be used as may be required or directed by the Owner /Consultant. Items to be embedded.

a) Inserts, hangers, anchors, frames around openings, manhole covers, frames, floor clips, sleeves conduits and pipes.

b) Anchor bolts and plates for machinery, equipment and for structural steel work.

c) Steel structural to be left embedded for future extension, special connection etc.

d) Lugs or plugs for door and window frames occurring in concrete work.

e) Flashing and jointing in concrete work.

f) Any miscellaneous embedments and fixture as may be required.

Correct location and alignment, as per drawings/instruction of all these embedded items shall be entirely the responsibility of the Successful Bidder.

3.23.00 Expansion and Isolation Joints

3.23.01 General

Expansion and isolation joints in concrete structures shall be provided at specific places as per details indicated on the drawings. The materials and types of joints shall be as specified hereinafter.

In case of liquid retaining structures, additional precautions shall be taken to prevent leakage of liquids by using water proofing admixtures and water stoppers as specified on the drawings/specifications or as directed by the Owner /Consultant. All materials are to be procured from reliable manufacturers and must have the approval of the Owner /Consultant. Where it is the responsibility of the Successful Bidder to supply the material, the Owner /Consultant may demand test certificates for the materials and/or instruct the Successful Bidder to get them tested in an approved laboratory. Joints shall be formed true to line, level, shape, dimension and quality as per drawings and specifications. Prior approval of the method of forming the joints shall be obtained from the Owner/ Consultant before starting the work.

3.23.02 Bitumen Board/Expanded Polystyrene Board

a) Bitumen Board

Bitumen impregnated fibre board of approved manufacturer as per IS:1838 may be used as fillers for expansion joints. It must be durable and waterproof. It shall be compressible and possess a high degree of rebound. The dimensions of the board shall be equal to that of the joint being formed. It shall, preferably be manufactured in one

piece, matching the dimension of the joint and not prepared by cutting to size smaller pieces from larger boards at site. On already concreted surface a coat of hot bitumen shall be applied and the board shall be pasted over it. After placing the board a coat of Bitumen paint may have to be applied on the board against which concrete shall be placed.

At the exposed end, the joint shall be sealed with approved sealing compound to a depth of at least 25 mm after application of an approved primer. The sealing compound and the primer shall be applied as specified by the manufacturer.

b) Expanded Polystyrene Boards

If required, commercial quality\of expanded polystyrene products commonly used for thermal insulations may also be used as filler material in expansion joints. The thickness may vary from 12 mm to 50 mm. The material shall have to be procured from reliable manufacturers as approved by the Owner /Consultant. The method of installations shall be similar to that recommended by the manufacturers for fixing on cold storage walls. On already concreted surface a coat of hot bitumen shall be applied and the board shall be pasted over it. After placing the board a coat of Bitumen paint may have to be applied on the board against which concrete shall be placed. At the exposed end, the joint shall be sealed with approved sealing compound to a depth of at least 25 mm after application of an approved primer. The sealing compound and the primer shall be applied as specified by the manufacturer.

3.23.03 Joint Sealing Strips

Joint sealing strips may be provided at the construction, expansion and isolation joints as a continuous diaphragm to contain the filler material and/or to exclude passage of water or any other material into or out of the structure.

The sealing strips shall be non-metallic like rubber or P.V.C.

Sealing strips shall not have any longitudinal joint and shall be procured and installed in largest practicable lengths having a minimum number of transverse joints. The material is to be procured from reputed manufacturers having proven records of satisfactory supply of joint strips of similar make and shape for other jobs.

The jointing procedure shall be as per the manufacturer's recommendations, revised if necessary, by the Owner /Consultant. The Successful Bidder is to supply all labour and material for installation including the material and tools required for jointing, testing, protection, etc. If desired by the Owner /Consultant, joints in rubber seals may have to be vulcanised.

Non-metallic sealing strips shall be normally in Rubber or P.V.C. Rubber or P.V.C. joint seals can be of shape having any combination of the following features :

i) Plain

ii) Central bulb

iii) Dumb-bell or flattened ends

iv) Ribbed and Corrugated Wings

v) V shaped

As these types of seals can be easily handled in very large lengths, transverse joints shall be allowed only under unavoidable circumstances and with the specific approval of the Owner /Consultant.

The method of forming these joints, laps etc. shall be as specified by the Manufacturer and/or as approved by the Owner /Consultant taking particular care to match the central bulbs and the edges accurately.

a) Rubber Sealing Strips

The minimum thickness of Rubber sealing strips shall be 6 mm and the minimum width 230 mm unless otherwise stated. The actual size and shape shall be as shown in drawings or as specified elsewhere in the specification or as directed by the Owner /Consultant. The material shall be natural rubber and be resistant to corrosion, abrasion and tear and also to attacks from the acids, alkalis and chemicals normally encountered in service. The physical properties shall be generally as follows. The actual requirements may be slightly different as decided by the Owner /Consultant :

Specific Gravity	:	1.1 to 1.15
Shore Hardness	:	65A to 75A
Tensile Strength	:	25 - 30 N/Sq.mm
Maximum Safe Continuous Temperature	:	75ºC
Ultimate Elongation	:	Not less than 350%

b) P.V.C. Sealing Strips

The minimum thickness of P.V.C. sealing strips shall be 6 mm and the minimum width 230 mm unless otherwise stated. The actual size and

shape shall be as shown in drawings/ specified elsewhere in the specification or as directed by the Owner /Consultant. The material shall be of good quality Polyvinyl Chloride highly resistant to tearing, abrasion and corrosion as well as to chemicals likely to come in contact with during use. The physical properties shall generally be as follows. The actual requirements, which shall be directed by the Owner /Consultant, may vary slightly :

Specific Gravity	:	1.3 to 1.35
Shore Hardness	:	60A to 80A
Tensile Strength	:	10 - 15 N/Sq.mm
Maximum Safe Continuous Temperature	:	70ºC
Ultimate Elongation	:	Not less than 275%

3.23.04 Joint Sealing Compound

When directed, the gap in expansion joints shall be thoroughly cleaned and bitumen compound laid as per manufacturer's specifications. The compound to be used shall be of approved manufacture and shall conform to the requirements of IS:1834.

Alternatively, when directed , the expansion Joints may be filled with joint sealing compound like "Sikalastic" or approved equivalent and shall be applied as per manufacturer's specification.

3.23.05 Isolation Joints

Strong and tough alkathene or PVC sheet about 1 mm in thickness and as approved by the Owner /Consultant shall be used in isolation joints. It shall be fixed by an approved adhesive compound on the cleaned surface of the already set concrete, to cover it fully. Fresh concrete shall be laid against the sheet, care being taken not to damage the sheet in any way.

3.23.06 Rubber Pad

Hard foundation quality rubber pads of required thickness and shapes shall be put below machine or other foundations as shown on the drawings or as directed by the Owner /Consultant. The rubber shall have a unit weight of 1500 Kg/Cu.m, a shore hardness - 65A to 70A and be of best quality of approved manufacture, durable, capable of absorbing vibration and must be chemically inert in contact with moist or dry earth or any other deleterious material expected under normal conditions.

3.24.00 Grouting under Machinery or Structural Steel Bases

If required, grouting under base plates of machines or structural steel etc. shall be carried out by the Successful Bidder. In general , the mix shall be 1 (one) part cement and 1 (one) part sand and just enough water to make it flow as required. The areas to be grouted shall be cleaned thoroughly with compressed air jet and/or with water in locations where accumulated surplus water can be removed. Where directed by the Owner /Consultant, 6 mm down stone chips may have to be used in the mix if the thickness of the grout is 25mm or more. Surface to be grouted shall be kept moist for at least 24 hours in advance. The grout shall be placed under expert supervision, so that there is no locked up air. Edges shall be finished properly. If desired by the Owner /Consultant, admixtures like Aluminium powder, 'Ironite' etc. may have to be added with the grout in proportions to be decided by the Owner /Consultant. Admixture, if directed to be added.

Alternatively non-shink , free flow, cementious grout like "Sikagrout 214/ Anchor NSG" or approved equivalent specifically selected for the type of equipment to be located (vibrating, static etc.) may also be used for grouting as per manufacturer's specification with necessary approval of the Owner /Consultant.

3.25.00 Precast Concrete

The Specification for precast concrete shall be similar as for the cast-in-place concrete described herein and as supplemented in this section. All precast work shall be carried out in a yard made for the purpose.

This yard shall be dry, properly levelled and having a hard and even as well as well drained surface to prevent excessive uneven settlement due to softening of soil during casting & curing. If the ground is to be used as a soffit former of the units, it shall be paved with concrete or masonry and provided with a layer of plaster (1:2 proportion) with smooth neat cement finish or a layer of M.S. sheeting. Where directed by the Owner /Consultant, casting shall have to be done on suitable vibrating table. The yard, lifting equipment, curing tank, finished material storage space etc. shall be designed such that the units are not lifted from the mould before 10 (Ten) days of curing and can be removed for erection after 28 (twenty eight) days of curing. The moulds shall preferably be of steel or of timber lined with G.I. sheet metal and must be rigid enough to prevent distortion during placing and compaction of the concrete.

Other than normal curing by applying water through spray nozzles or perforated hose curing by high pressure steam, steam vapour or other accepted processes may also be employed to accelerate the hardening of the concrete and to reduce the curing time.

Lifting hooks, where necessary or as directed by the Owner/ Consultant, shall be embedded in correct position of the units to facilitate erection, even though they may not be shown on the drawings, and shall be burnt off and finished after erection.

All members shall be indelibly marked with a unique identification mark on a surface which shall not be permanently exposed to show on which production line they were manufactured , their type , the class of concrete, the data of casting and if they are of a symmetrical section the face which shall be uppermost when the member is in its correct position after erection.

Precast concrete units, when ready, shall be transported to site by suitable means approved by the Owner /Consultant. Care shall be taken to ensure that no damage occurs during transportation. All adjustments, levelling and plumbing shall be done as per instructions of the Owner /Consultant. The Successful Bidder shall render all help with instruments, materials and men to the Owner /Consultant for checking the proper erection of the precast units.

After erection and alignment, the joints shall be filled with grout or concrete as directed by the Owner /Consultant. If centerings have to be used for supporting the precast units, they shall not be removed until the joints have attained sufficient strength and in no case before 14 (fourteen) days. The joint between precast roof planks shall be pointed with 1:2 cement : sand mortar where called for in the drawings.

3.26.00 Waterproofing of Concrete Structure (Liquid Retaining Structure)

3.26.01 General

Waterproofing of concrete structures shall be done by either suitable extraneous treatments like applying waterproofing paints like "Sikatop Seal" fixing bitumen felts etc. or internally by suitable design of the concrete mix, addition of suitable admixtures conforming to IS:2645 and equivalent American or British codes in the concrete or mortar at the time of mixing and/or installing water bars at the joints. Refer cl 3.26.04, cl 3.26.05 and 3.026.07 .

The design, material and workmanship shall conform to the relevant I.S. Codes where applicable. The Owner’s /Consultant's approval of the materials shall be obtained by the Successful Bidder before procurement. If desired by the Owner /Consultant, test certificates for the materials and samples shall be submitted by the Successful Bidder. The materials shall be of best quality available indigenously, fresh clean and suitable for the duties called upon.

3.26.02 Water Bar/Seal/Special Treatment of Construction Joint for water beating structures and underground structures.

Water bearing structures and underground structures may have water bar/seals installed at the joints. They may be rubber or P.V.C. The materials and installation shall be as described under Clause 3.23.3. Construction joint shall be provided as per clause 3.13.1 with or without water bar / Seal as shown on the drawing. In case of water bars being used at the construction Joint, fixing of the same has to be done carefully so that the water bar is not disturbed during concreting. The construction joint shall also be treated by any one of the following methods :

Method 1 : A surface retarder in the form of a thixotropic gel shall be applied on the joint surface of the previous pour in case of joint on the wall and in case of floor the same shall be applied on the formwork against which previous pour of concreting shall be done. The retarder may be liquid or paste form depending on the type of formwork. The formwork shall be removed within 24 hours after concreting. Within 2 hours of striking of the formwork the retarder shall be washed off with strong water jet to make surface rough and clean. Then a rich cement mortar using cement, sand and aggregates (maximum size 8 mm) along with synthetic rubber emulsion type water resistant bonding agent shall be applied for a depth of 50 mm just before pouring the next stage of concreting in case of walls. The above bonding agent shall be mixed with water which shall be used for making the cement mortar. The proportion of mixing of this bonding agent with water shall be as per manufacturer's specification. In case of floor joint, however, after washing of retarder a solvent free two component epoxy resin bonding agent shall be used at the joint before the next pour of concrete. The above bonding agent shall have the following properties after 28 days :

Compressive strength	-	55 to 60 N /Sq. mm
Flexural Strength	-	25 to 30 N /Sq. mm.
Tensile strength	-	15 N Sq. mm (approx)
Bonding strength to concrete	-	3 N / Sq. mm (approx)
Bonding strength to steel	-	20 N / Sq. mm (approx)

The whole operation shall be done as per manufacturer's specification.

Method 2 : One row of threaded nozzles at regular intervals not exceeding 1.5 m centre to centre shall be placed in concrete along the construction joint during casting. Injection of cement water together with a suitable waterproof expanding grouting admixture of approved quality shall be done through the nozzles after the construction joint in walls and slabs. The injection shall be done under pressure of approximately 2 to 4 Kg/Sq cm . The nozzles shall be sealed off with suitable admixture after the injection is over. The whole operation shall be carried out as per manufacturer's specification and supervision.

3.26.03 Waterproofing Admixtures

The waterproofing admixture for concrete and cement mortar / plaster shall conform to relevant IS code. The admixture shall not cause decrease of strength of concrete / plaster at any stage and it is free from chlorides and sulphates. The admixture shall not affect the setting time by more than 5 %

The maximum permissible dosage of admixture shall be 2% (two percent) by weight of cement.

The product shall be stored in strong moisture proof packings.

However, in case of important structures where M25 or higher grade concrete is specified, the use of melamine based, high range water resistant concrete admixture shall be used to provide a waterproof concrete around 410 Kg/ Cu.m a melamine based super plasiticizer shall be preferable.

a) In concrete : The approved admixture shall be based on modified lignosulphonate like "Plastocrete - N/Super" or approved equivalent. The method of application and other details shall conform to the manufacturer's specification and/or as instructed by the Owner /Consultant. The Successful Bidder shall have the services of the manufacturer's supervisor to supervise the work, if desired by the Owner /Consultant.

b) In Plaster : The concrete surface, to be plastered, shall be hacked to Owner's /Consultant's satisfaction, cleaned thoroughly and kept wetted for 24 hours. The plaster shall be in cement sand mortar mixed in proportion varying from 1:1 to 1:4 by volume along with the approved waterproofing admixture like "Noleak CP/Sika Latex" or approved equivalent and laid in appropriate thickness and in layers not exceeding 15 mm/layer or as per manufacturer's specification. The additive shall be of quality and type approved by the Owner /Consultant. If desired by the Owner /Consultant, the Successful Bidder shall have the work supervised by the manufacturer's supervisor. On completion, the plastered surface shall be cured continuously for a minimum period of 14 days like concrete.

3.26.04 Bituminous or Tar Coating on External Surface

The surface to be waterproofed shall be rendered absolutely dry, clean and dust free. The surface shall be sand papered, cleaned and completely coated with hot coal tar pitch of approved manufacturer and quality as per IS:216 (not heated above 375ºF) using not less than 2 Kg. per Sq.M. or with hot asphalt i.e., bitumen according to IS:73 (not heated above 400ºF) using not less than 1.5 kg. per Sq.M. When the first coat has completely dried up and approved by the Owner/Consultant, the second coat shall be applied in the same manner using not less than 1.25 Kg. per Sq.M. in case of coal tar and 1 Kg. per Sq.M. in case of asphalt. Immediately after application of the second coat and before it is dried up, sand shall be spread on the surface to cover it completely. Sufficient time shall be allowed after spreading of sand before backfilling is done in order to allow the final coat to dry up completely.

3.26.05 Protective Coating on Inside Surface

Unless otherwise stated, Two coats cement based two components polymer modified flexible protective and waterproofing slurry having 1 mm thick for each coat shall be applied on the walls/ floor after proper surface preparation as mentioned above. The slurry shall be applied by brush.

3.26.06 NOT USED

3.26.07 Polyethylene Films : Application in Walls or base of Structures

Waterproof treatment shall be applied as outlined and as per sequence given hereunder :

i) the concrete surface shall be made smooth with 12 mm cement plaster 1:6

ii) apply hot bitumen 80/100 grade (IS:73-1961) at the rate of 1.0 Kg/Sq.m minimum

iii) lay black polyethylene film 250 micron (IS:2508-1977) with cut back bitumen adhesive in overlaps over hot bitumen surface, gently pressed, taking care not to puncture the film.

Alternatively, the overlaps shall be heat sealed by an electric iron having three parallel sealing bars. A long piece of plywood is to be placed below the polyethylene film to be heat sealed.

On the plywood a rubber gasket is to be laid to provide a cushion for better welding of the film. On the rubber padding, a cellophane tape is to be spread and on this the LDPE film, with 100 mm overlap, is to be stretched. On the overlapped film another cellophane tape is to be placed to prevent the heat sealer from sticking to the LDPE film. After this, the electric iron is to be pressed on the overlap joint for sufficient time so as to allow perfect welding. The operation is to be repeated for subsequent lengths of joints. After heat sealing, the cellophane tape is to be removed and the joints are to be tested for leaks.

iv) Lay 100 gm brown craft paper laminated with a layer of straight run bitumen.

v) Lay hot bitumen 80/100 grade (IS:73-1961) at 1.0 Kg/Sq.m minimum.

vi) Lay 250 micron polyethylene film as second layer similar to (iii) above.

vii) Lay second layer of 100 gm. brown craft paper laminated similar to (iv) above.

viii) Apply hot bitumen (straight run grade) to IS:73-1961 at 1.0 Kg/Sq.m dusted with fine sand.

ix) Protecting with a layer of 75 mm plain cement concrete M10, or a layer of brick laid in cement mortar 1:6. In case of wall apply a 12 mm thick plaster as shown on the drawing or a protective brick wall in 1:6 cement mortar as shown on the drawing.

3.27.00 Protective coating on Concrete Surface

3.27.01 On Foundation

The outside faces of foundation of important structures shall be protected from adverse effect of soil/ underground water, if shown on drawing or instructed by the Owner /Consultant, by using bitumen emulsion protective coating of approved manufacturer applied with two coats of Hot bituminous painting of grade 85/25 over a coat of Bitumen Primer except where special water proofing is specified for specific structures mentioned elsewhere.

3.28.00 Waterproofing by Pressure /Chemical Grouting

Where required, waterproofing for underground concrete structure shall be done by injecting high polymer based non-shrink waterproof grouting compound through nozzle under pressure as per manufacturer's recommendation. The pressure during injection shall not be less than 2.5 kg/Sq.cum and the thickness of epoxy resinous emulsion waterproof paint (to be applied on the external surface of walls/slabs) shall not be less than 700 microns.

4.00.00 SAMPLING AND TESTING

4.01.00 General

The Successful Bidder shall carry out all sampling and testing in accordance with the relevant Indian Standards and as supplemented herein for the following items at his own cost unless otherwise specified in this specification. The Successful Bidder shall get the specimens tested in a laboratory approved by the Owner /Consultant and submit to the Owner /Consultant the test results in triplicate within 3 (three) days after completion of the test.

4.02.00 Cement

Representative samples shall be taken from each consignment of cement received from the manufacturer/supplier for carrying out the tests for fineness (by hand sieving), setting time and compressive strengths. Soundness Tests may also be required to be carried out if required by the Owner /Consultant.

4.03.00 Aggregates

The Successful Bidder shall carry out any or all the tests aggregates as may be required by the Owner /Consultant in accordance with IS:2386 PARTS-I to VIII. The acceptance criteria of the samples tested shall be in accordance with the requirements of the relevant Indian Standards.

4.04.00 Water

Sampling and Testing of water being used for concrete works as per IS:3550 shall be carried out by the Successful Bidder at regular intervals and whenever directed by the Owner /Consultant. The final acceptance criteria in case of doubt shall be as per IS:3025 & IS:456.

4.05.00 Admixture

4.05.01 Air Entraining Agents (A.E.A)

Initially, before starting to use A.E.A., relationship between the percentage of air entrained and the cube crushing strength vis-a-vis quantity of A.E.A. used for all types of concrete shall be established by the Successful Bidder by carrying out sufficiently large number of tests. After then, at regular intervals and whenever directed by the Owner /Consultant, the Successful Bidder shall check-up the actual percentages of air entrained and corresponding crushing strengths to correlate with the earlier test results.

4.05.02 Other Admixtures

Tests for establishing the various properties of any other admixtures which may be required to be added shall be carried out by the Successful Bidder.

4.06.00 Concrete

The sampling of concrete, making the test specimens, curing and testing procedure etc. shall be in accordance with IS:516 and IS:1199 the size of specimen being 15 cm cubes. Normally, only compression tests shall be performed but under special circumstances the Owner /Consultant may require other tests to be performed in accordance with IS:516.

Sampling procedure, frequency of sampling and test specimen shall conform to Clause 14 of IS:456.

To control the consistency of concrete from every mixing plant, slump tests and/or compacting factor tests in accordance with IS:1199 and as mentioned in Clause 3.6 of this Specification shall be carried out by the Successful Bidder every two hours or as directed by the Owner /Consultant. Slumps corresponding to the test specimens shall be recorded for reference.

The acceptance criteria of concrete shall be in accordance with Clause 15 of IS:456.

Concrete work found unsuitable for acceptance shall have to be dismantled and replacement is to be done as per specification by the Successful Bidder. No payment for the dismantled concrete, the relevant formwork and reinforcement, embedded fixtures, etc. wasted in the dismantled portion shall be made. In the course of dismantling, if any damage is done to the

embedded items or adjacent structures, the same shall be made good to the satisfaction of the Owner /Consultant.

5.00.00 ACCEPTANCE CRITERIA

5.01.00 Standard Deviation

Standard deviation shall be based on test results and determination of Standard deviation shall conform to clause 16 of IS:456.

5.02.00 Acceptance Criteria

The strength requirements and acceptance criteria shall conform to Clause 16 of IS:456.

5.03.00 Inspection and Core Tests

Inspection of concrete work immediately after stripping the formwork and core test of structures shall conform to Clause 17 of IS:456.

5.04.00 Load Test (If Required)

Load tests of structural members may be required by the Owner /Consultant, when the strength of test specimen results fall below the required strength, as per 'Load Test on Parts of Structures', Clause 17.6 of IS:456.

If load testing is decided by the Owner /Consultant, the member under consideration shall be subjected to a test load equal to 1.25 (one and a quarter) times the specified live load used for design and this load shall be maintained for a period of 24 (twenty four) hours before removal. The detailed procedure of the test is to be decided by the Owner /Consultant. Load tests shall not be made until the structure is at least 56 days old.

If the member shows evident failure, such changes as are necessary to make the structure adequately strong shall be made by the Successful Bidder. Alternatively, if permitted under Statutory Regulations and at the discretion of the Owner /Consultant, the structure under test or a portion thereof may be retained as such without any modification by derating its load bearing capacity, provided the design criteria allows such derating.

A reinforced concrete beam, floor or roof shall be deemed to have passed the test if the maximum deflection at the end of 24 hours does not exceed the deflection given in Clause 17.6 of IS:456.

The entire cost of load testing shall be borne by the Successful Bidder. If a portion of the structure is found to be unacceptable, it shall be dismantled and replaced by a new structure as per specification at the successful bidder's own cost and risk.

If, in the course of dismantling, any damage is done to the embedded items and or other adjacent structures, the same shall be made good by the Successful Bidder to the satisfaction of the Owner / Consultant without any extra cost to Owner.

6.00.00 LIST OF I.S. CODES AND STANDARDS FOR REFERENCE

All work under this specification shall, unless specified otherwise, conform to the latest revisions as on the original scheduled date of tender opening and/or replacements of the following or any other Indian Standard Specifications and Codes of Practice. In case any particular aspect of work is not specifically covered by Indian Standard Specifications, any other standard practice, as may be specified by the Consultant, shall be followed :-

IS : 73	-	Indian Standard Specification for Paving Bitumen
IS : 216	-	Indian Standard Specification for Coal Tar Pitch
IS : 269	-	Indian Standard Specification for 33 grade Ordinary Portland Cement
IS : 383	-	Indian Standard Specification for Coarse and Fine Aggregates from Natural Sources for Concrete
IS : 432	-	Indian Standard Specification for Mild Steel and Medium Tensile Steel Bars and Hard Drawn Steel Wire for concrete Reinforcement - Part 1 & 2
IS : 455	-	Indian Standard Specification for Portland Slag Cement
IS : 456	-	Indian Standard Code of Practice for Plain and Reinforced Concrete
IS : 457	-	Indian Standard Code of Practice for General Construction of Plain and Reinforced Concrete for Dams and other Massive Structures
IS : 516	-	Indian Standard Specification for Methods of Test for Strength of Concrete
IS : 737	-	Indian standard specification for wrought Aluminium and Aluminium Alloy sheet and strip for general Engineering purpose. IS : 1199 - Indian Standard Specification for Methods of Sampling and Analysis of Concrete
IS : 1200	-	Indian Standard Specification for Method of (Part-II) Measurement Cement Concrete Works.

IS : 1200	-	Indian Standard Specification for Method of (Part-V) Measurement of Formwork
IS : 1322	-	Indian Standard Specification for Bitumen Felts for Waterproofing and Damp-proofing
IS : 1489	-	Indian Standard Specification for Portland - Pozzolona Cement - Part 1 & 2
IS : 1566	-	Indian Standard Specification for hard drawn steel wire fabric for concrete reinforcement.
IS : 1609	-	Code of Practice for Laying Damp-proof Treatment using Bitumen Felts
IS : 1786	-	Indian Standard Specification for high strength deformed Bars & wires for Concrete Reinforcement
IS : 1791	-	Indian Standard Specification for Batch Type Concrete Mixers
IS : 1834	-	Indian standard specification for hot applied sealing compound for joint in concrete.
IS : 2062	-	Steel for general structural purpose.
IS : 2185	-	Indian Standard Specification for Hollow and solid / solid light wt. Cement Concrete Blocks - Part - 1 & 2
IS : 2210	-	Indian Standard Specification for Design of Reinforced Concrete Shell Structures and Folded Plates
IS : 2386	-	Indian Standard Specification for Methods of Test for Aggregates for Concrete - Part-I to VIII
IS : 2430	-	Indian standard specification for method of sampling of Aggregate for concrete.
IS : 2502	-	Indian Standard Code of Practice for Bending and Fixing of Bars for Concrete Reinforcement
IS : 2505	-	Indian Standard Specification for Concrete Vibrators Immersion Type
IS : 2506	-	Indian Standard Specification for Screed Board Concrete Vibrators
IS : 2514	-	Indian Standard Specification for Concrete Vibrating Tables

IS : 2645	-	Integral Cement water proofing compound
IS : 2722	-	Indian Standard Specification for Portable Swing Weigh Batchers for Concrete (Single and Double Bucket type)
IS : 2751	-	Code of Practice for Welding of Mild Steel Bars used for Reinforced Concrete Construction
IS : 2770	-	Indian Standard Specification for Method of Testing Bond in Reinforced Concrete. Part - 1 : Pull out Test
IS : 3025	-	Indian Standard Specification for Methods of Sampling and Test (Physical and Chemical) for Water & waste water - art - 1 to 37
IS : 3201	-	Indian Standard Specification for Design and Construction of Precast Concrete Trusses and purlins.
IS : 3370	-	Indian Standard Specification for Code of Practice for Concrete Structures for Storage of Liquids Part 1 to 4
IS : 3384	-	Indian standard specification for / Bitumen primer for use in waterproofing and Damp proofing
IS : 3414	-	Code of practice for Design and Installation of joints in Buildings
IS : 3550	-	Indian Standard Specification for Method of Test for Routine Control for Water used in Industry
IS : 3558	-	Code of Practice for use of Immersion Vibrators for Consolidating Concrete
IS : 3696	-	Safety Code for Part-1 : Scaffolding and Part 2: Ladders
IS : 3812	-	Indian Standard Specification for Fly Ash for Use as Pozzolona & Admixture
IS : 4031	-	Indian Standard Specification for Method of Tests for Hydraulic Cement - Part - 1 to 14
IS : 4082	-	Indian Standard Specification for Recommendation on Stacking and Storage of Construction Materials at site
IS : 4090	-	Indian Standard Specification for Design of Reinforced Concrete Archs
IS : 4634	-	Indian Standard Specification for Method of Testing Performance of Batch-type Concrete Mixers

IS : 4656	-	Indian Standard Specification for Form Vibrators for Concrete
IS : 4925	-	Indian Standard Specification for Concrete Batching and Mixing Plant
IS : 4926	-	Indian Standard Specification for Ready Mixed Concrete
IS : 4990	-	Indian Standard Specification for Plywood for Concrete Shuttering work
IS : 4991	-	Indian Standard Specification for Blast Resistant Design of Structure for Explosion above ground
IS : 4995	-	Indian Standard Specification for Design (Part-I of Reinforced Concrete Bins for the Storage & II) of Granular and Powdery Materials
IS : 4998	-	Indian Standard Specification for Design of Reinforced Concrete Chimneys
IS : 5512	-	Indian Standard Specification for Flow Table for use in Tests of Hydraulic Cement and Pozzolanic Materials
IS : 5513	-	Indian Standard Specification for Vicat Apparatus
IS : 5515	-	Indian Standard Specification for Compaction Factor Apparatus
IS : 5751	-	Indian Standard Specification for Precast Concrete Coping Blocks
IS : 5816	-	Indian Standard Specification for Method of Test for Splitting Tensile Strength of Concrete Cylinders
IS : 5891	-	Indian Standard Specification for Hand Operated Concrete Mixers
IS : 6452	-	Indian Standard Specification for High Alumina Cement for Structural Use
IS : 6909	-	Indian Standard Specification for Super-sulphated Cement
IS : 6923	-	Indian Standard Specification for Method of Test for performance of Screed Board Concrete Vibrators

IS : 6925	-	Indian Standard Specification for Method of Test for Determination of Water Soluble Chloride in Concrete Admixtures
IS : 7242	-	Indian Standard Specification for Concrete Spreaders
IS : 7246	-	Indian Standard Specification for Table Vibrators for Consolidating Concrete
IS : 7251	-	Indian Standard Specification for Concrete Finishers
IS : 7320	-	Indian Standard Specification for Concrete Slump Test Apparatus
IS : 7861	-	Indian Standard Specification for (Part-I Recommended Practice for hot and cold & II) Weather Concreting
IS : 7969	-	Safety Code for Storage and Handling of Building Materials
IS : 8041	-	Indian Standard Specification for Rapid Hardening Portland cement
IS : 8043	-	Indian standard specification for hydrophobic cement
IS : 8112	-	Indian Standard Specification for 43 grade Ordinary Portland Cement
IS : 8142	-	Indian Standard Specification for Determining Setting time of Concrete by Penetration Resistance
IS : 8989	-	Safety Code for Erection of Concrete Framed Structures
IS : 9013	-	Indian Standard Specification for Method of Making, Curing and Determining Compressive Strength of Accelerated - cured Concrete Test Specimens
IS : 9077	-	Code of Practice for Corrosion Protection of Steel Rails in RB and RCC Construction
IS : 9103	-	Indian Standard Specification for Admixtures for Concrete.
IS : 9417	-	Recommendation for welding cold worked bars for reinforced concrete construction
IS : 10262	-	Recommended Guideline for concrete Mix Design

IS : 12269	-	Indian standard specification for 53 grade ordinary portland cement
IS : 12330	-	Indian standard specification for sulphate resting portland cement
IS : 12600	-	Indian standard specification for low heat portland cement

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SECTION-VIII

GUIDELINE
FOR
FABRICATION OF STRUCTURAL STEELWORK

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SECTION-VIII

GUIDELINE
FOR
FABRICATION OF STRUCTURAL STEELWORK

1.00.00 SCOPE

This specification covers supply of all raw steel materials, fabrication, testing, painting and delivery to site of structural steelwork including supply of all consumable stores and bolts, nuts, washers, electrodes and other materials required for fabrication and field connections of all structural steelwork in general covered under the scope of the contract. However, for any special structures such as rail & road bridges, steel chimney, tanks, transmission towers, furnace structures, etc., the relevant Indian Standard or IRC specification and Codes of Practices shall be given due consideration over and above this specification.

The Steel structure may either be Site fabricated or by Shop fabricated

2.00.00 GENERAL

2.01.00 Work to be provided for by the Successful Bidder

The work to be provided for by the Successful Bidder, unless otherwise specified elsewhere in the contract, shall include, but not be limited to the following :

a) Preparation of complete detailed fabrication drawings and erection marking drawings required for all the structures covered under the scope of the contract based on Successful Bidder's design drawings approved by the Consultants.

b) To submit revised design with calculations and detailed fabrication drawings in case any substitution of the designed sections are to be made.

c) To submit design calculations for joints and connections developed by the Successful Bidder along with detailed fabrication drawings.

d) Furnish all materials, labour, tools and plant and all consumables required for fabrication and supply, all necessary bolts, nuts, washers, tie rods and welding electrodes for field connections. The field connection materials supplied by the Successful Bidder shall be in adequate quantity to avoid delay in erection.

e) Furnish details of structures if shop fabricated with shop painting as per requirements of this Specification.

f) Suitably mark, bundle and pack for transport all fabricated materials.

g) Prepare and furnish Drawing Office Despatch lists, Bolt List and any other list of bought out items required in connection with the fabrication and erection of the structural steelwork.

h) Insure, load and transport all fabricated steelwork field connection materials to site.

2.02.00 **Work by others**

No work under this specification shall be provided for by any agency other than the Successful Bidder, unless specifically mentioned otherwise elsewhere in the contract.

2.03.00 **Codes and standards**

All work under this specification shall, unless otherwise specified in the contract, conform to the requirements of the latest revision as on the original scheduled date of tender opening and/or replacements of the following or any other relevant Indian Standard specifications and codes of practice. In case any particular aspect of the work is not specifically covered by any Indian Standard Specification, any other standard practice, as may be specified by the Engineer shall be followed:-

LIST OF I.S. CODES - RELEVANT TO FABRICATION OF STRUCTURAL STEEL WORK

IS Codes	Description
IS : 800 -	Code of practice for general construction in steel.
IS : 801 -	Code of practice for use of cold formed light gauge steel structural members in general building construction.
IS : 806 -	Code of practice for use of steel tubes in general building construction.
IS : 808 -	Dimensions for rolled steel beams, channels and angle sections.
IS : 812 -	Glossary of terms relating to welding & cutting of metals.
IS : 813 -	Scheme of symbols for welding.
IS : 814 -	Covered electrodes for metal arc welding of carbon and carbon manganese steel.
IS : 815 -	Classification coding of covered electrodes for metal arc welding of mild steel and low alloy high tensile steel.

IS : 816 -	Code of practice for use of metal arc welding for general construction in mild steel.
IS : 817 -	Code of practice for training & testing metal arc welders.
IS : 818 -	Code of practice for safety and health requirements in electric and gas welding and cutting operations.
IS : 819 -	Code of practice for resistance spot welding for light assemblies in mild steel.
IS : 822 -	Code of practice for inspection of welds.
IS : 919 - (Part - 1&2)	Recommendations for limits and fits for engineering.
IS : 1161 -	Steel Tubes for structural purposes.
IS : 1182 -	Recommended practice for Radiographic Examination of fusion welded butt joints in steel plates.
IS : 1200 - (Part - 8)	Method of measurement of steel work and iron work
IS : 1239 - (Part - 1&2)	Mild steel tubes, tubulars and other wrought steel fittings
IS : 1363 - (Part - 1 to 3)	Hexagon head bolts, screws and nuts of product grade C.
IS : 1364 - (Part - 1 to 5)	Hexagon head bolts, screws and nuts of product grade A & B.
IS : 1365 -	Slotted counter sunk head screws (dia. 1.6 to 20 mm)
IS : 1367 - (Part - 1 to 18)	Technical supply conditions for threaded steel fasteners.
IS : 1608 -	Method for tensile testing of steel products.
IS : 1730 -	Dimensions for steel plate, sheet and strip for structural and general engineering purposes.
IS : 1852 -	Rolling and cutting tolerances for hot-rolled steel product.
IS : 1977 -	Structural steel (Ordinary quality)
IS : 2016 -	Plain washer
IS : 2062 -	Steel for general structural purposes.
IS : 2629 -	Recommended practice for hot-dip galvanising of iron and steel.

IS : 2633 -	Method for testing uniformity of coating on zinc coated articles.
IS : 3644 -	Code of practice for ultrasonic pulse echo testing by contact and immersion method.
IS : 3757 -	High Strength Structural Bolt
IS : 4000 -	High strength bolts in steel structure
IS : 4759 -	Specifications for hot-dip zinc coatings on structural steel and other allied products.
IS : 4923 -	Hollow steel sections for structural use.
IS : 5334 -	Code of practice for magnetic particle flaw detection of weld.
IS : 5369 -	General requirements for plain washers and lock washer.
IS : 6005 -	Code of practice for phosphating of iron and steel.
IS : 6649 -	Specification for hardened and tempered washers for high strength structural bolts and nuts.
IS : 6623 -	Specification for high strength structural nuts.
IS : 7215 -	Tolerances for fabrication of steel structures.
IS : 7280 -	Bare wire electrode for submerged arc welding.
IS : 8500 -	Structural steel micro alloyed (medium & high strength quality).
IS : 8629 -	Code of practice for protection of iron and (Part - I to III) steel structures from atmospheric corrosion.
IS : 9595 -	Recommendation for metal arc welding of carbon manganese steels.

PAINTING

IS : 117 -	Specification for ready mixed paint, brushing, finishing, exterior, semi-gloss, for general purposes.
IS : 128 -	Specification for ready mixed paint, brushing, finishing, semi-gloss for general purposes, black.
IS : 1477 - (Part - I & II)	Code of practice for painting of ferrous metal in building.
IS : 2074 -	Ready mixed paint, air-drying red-oxide zinc chrome priming.

IS : 2339 - Specification for aluminium paints for general purposes in dual container.

IS : 2932 - Specification for enamel, synthetic exterior type - I.

IS : 2933 - Specification for enamel, synthetic exterior type - II.

2.04.00 **Conformity with Designs**

The Seller shall design all connections and all steelwork and furnish all connection materials in accordance with the approved drawings and/or as instructed by the Consultant keeping in view the maximum utilization of the available sizes and sections of steel materials. The methods of painting, of all fabricated materials shall be in accordance with the provisions of the contract and/or as approved by the Consultant.

Provision of all relevant Indian Standard Specifications and Codes of Practice shall be followed unless otherwise specified in the contract.

2.05.00 **Materials to be used**

2.05.01 **General**

All steel materials shall be free from all imperfections, mill scales, slag intrusions, laminations, pittings, rusts etc. that may impair their strength, durability and appearance. All materials shall be of tested quality only unless otherwise permitted by the Owner/Consultant. If desired by the Owner / Consultant, Test Certificates of materials shall be submitted in triplicate. Whenever the materials are required to be used from unidentified stocks, if permitted by the Owner / Consultant, a random sample shall be tested at an approved laboratory from each lot of 50 tonnes or less of any particular section.

The arc welding electrodes shall conform to the relevant Indian Standard Codes of Practice and Specifications and shall be of heavily coated type and the thickness of the coating shall be uniform and concentric. With each container of electrodes, the manufacturer shall furnish instructions giving recommended voltage and amperage (Polarity in case of D.C. supply) for which the electrodes are suitable.

2.05.02 **Steel**

All steel materials to be used in construction within the purview of this specification shall comply with any of the following Indian Standard Specifications as may be applicable:

1) IS : 801 - Cold formed light gauge steel structural member.

2) IS : 806 - Steel tubes in general building construction.

3) IS : 1161 - Steel tubes for structural purpose.

4) IS : 2062 - Steel for general structural purpose

5) IS : 8500 - Structural steel-micro alloyed (Ordinary & high strength quality)

In case of imported steel materials being used, these shall conform to specifications equivalent to any of the above as may be applicable.

2.05.03 **Electrodes**

All electrodes to be used under the Contract shall comply with any of the following Indian Standard Specifications as may be applicable:

1) IS : 814 - Covered electrodes for metal arc welding structural steel

2) IS : 815 - Classification and coding of covered electrodes for metal arc welding of mild steel and low alloy high tensile steel.

3) IS : 7280 - Base wire electrode for submerged arc welding.

2.05.04 **Bolts and Nuts**

All bolts and nuts shall conform to the requirements of Indian Standard Specification IS:1367 - Technical Supply Conditions for Threaded Fasteners.

Materials for Bolts and nuts under the purview of this contract shall comply with any of the following Indian Standard Specifications as may be applicable.

a) Mild Steel : All mild steel for bolts and nuts when tested in accordance with the following Indian Standard Specification shall have a tensile strength of not less than 44 Kg/mm^2 and a minimum elongation of 23 per cent on a gauge length of 5.6 /A, where 'A' is the cross sectional area of the test specimen : -

1) IS:1367 - Technical supply conditions for threaded fasteners.

2) IS:1608 - Method for tensile testing of steel other than sheet, strip, wire and tube.

b) High Tensile Steel : The material used for the manufacture of high tensile steel bolts and nuts shall have the mechanical properties appropriate to the particular class of steel as set out in IS:1367 or as approved by the Consultant.

c) High Strength Friction Grip Bolt : HSFG Bolts shall be high tensile of 20 mm dia or higher diameter and of property class 8.8 (minimum) as per IS – 1367 (Latest) for all major connection. All bolts, nuts and washers shall be procured from the approved manufacturers. The bolted joints shall be designed for friction type connection and the HT bolts shall be tightened to develop the required pretension during their installation.

2.05.05 **Washers**

Washers shall be made of steel conforming to any of the following Indian Standard Specifications as may be applicable under the provisions of the Contract :

1) IS : 2062 - Steel for general structural purpose

2) IS : 8500 - Structural steel - micro alloyed (medium & high strength quality)

3) IS : 6623 - High Strength Structural Nuts

4) IS : 6649 - Hardened and tampered washers for high strength structural bolts & nuts.

2.05.06 **Paints**

Paints to be used for fabricated steel under the purview of this contract shall conform to the Indian Standard Specification- Ready mixed Paint, Air Drying, Inorganic Zinc Ethyl Silicate Priming Refer Section III/volume IIG1

2.06.00 **Storage of Material**

2.06.01 **General**

All materials shall be so stored as to prevent deterioration and to ensure the preservation of their quality and fitness for the work. Any material which has deteriorated or has been damaged shall be removed from the Successful Bidder's yard immediately, failing which, the Consultant shall be at liberty to get the material removed. The Successful Bidder shall maintain upto date

accounts in respect of receipt, use and balance of all sizes and sections of steel and other materials. In case the fabrication is carried out in Successful Bidder's fabrication shop outside the plant site where other fabrication works are also carried out, all materials meant for use in this contract shall be stacked separately with easily identifiable marks.

2.06.02 **Steel**

The steel to be used in fabrication and the resulting cut-pieces shall be stored in separate stacks off the ground section-wise and lengthwise so that they can be easily inspected, measured and accounted for at any time. If required by the Owner / Consultant, the materials may have to be stored under cover and suitably painted for protection against weather.

2.06.03 **Electrodes**

The electrodes for electric are welding shall be stored in properly designed racks, separating different types of electrodes in distinctly marked compartments. The electrodes shall be kept in a dry and warm condition if necessary by resorting to heating.

2.06.04 **Bolts, Nuts and Washers**

Bolts, nuts and washers and other fastening materials shall be stored on racks off the ground with a coating of suitable protective oil. These shall be stored in separate gunny bags or compartments according to diameter, length and quality.

2.06.05 **Paints**

Paints shall be stored under cover in air tight containers. Paints supplied in sealed containers shall be used up as soon as possible once the container is opened.

2.07.00 **Quality Control**

The Successful Bidder shall establish and maintain quality control procedures for different items of work and materials to the extent he deems necessary to ensure that all work is performed in accordance with QA/QC plan included as Appendix H. In addition to the Successful Bidder's quality control procedures, materials and workmanship at all times shall be subjected to inspection by the Owner / Consultant. As far as possible, all inspection by the Owner/Consultant shall be made at the Successful Bidder's fabrication shop whether located at Site or elsewhere. The Successful Bidder shall co-operate with the Owner / Consultant in permitting access for inspection to all places where work is being done and in providing all necessary help in respect of tools and plants, instrument, labour and materials required to carry out the inspection. The inspection shall be so scheduled as to provide the minimum interruption to the work of the Successful Bidder.

Materials or workmanship not in reasonable conformance with the provisions of this Specification may be rejected at any time during the progress of the work.

The quality control procedure shall cover but not be limited to the following items of work:

a) Steel :	Quality, manufacturer's test certificates, test reports of representative samples of materials from unidentified stocks if permitted to be used.
b) Bolts, Nuts : & Washers	Manufacturer's certificate, dimension checks, material testing.
c) Electrodes :	Manufacturer's certificate, thickness and quality of flux coating.
d) Welders :	Qualifying Tests
e) Welding sets :	Performance Tests
f) Welds :	Inspection, X-ray, Ultrasonic tests
g) Paints :	Manufacturer's certificate, physical inspection reports
h) Galvanizing :	Tests in accordance with IS : 2633 - Method for testing uniformity of coating on Zinc Coated Articles and IS : 4759 - Specification for Hot-Dip Zinc coatings on Structural Steel and other allied products.

2.08.00 Standard dimensions, forms and weights

The dimensions, forms, weights and tolerances of all rolled shapes bolts, nuts, studs, washers etc. and other members used in the fabrication of any structure shall, wherever applicable, conform to the requirements of the latest relevant Indian Standards, wherever they exist, or, in the absence of Indian Standards, to other equivalent standards.

2.09.00 Shop Drawings

The Successful Bidder shall submit to the site incharge the Schedule of Fabrication and delivery of structural steelwork. He shall start to submit progressively for information and the shop drawings based on the approved Design Drawings and before proceeding with the fabrication work..

The sequence of submission of shop drawings shall match with the fabrication and delivery schedule. The shop drawings shall conform with the design requirements as well as specification and shall ensure the correctness

of general arrangement for centre line dimensions and levels, Section sizes, and adequacy of connections including splice joints as to the no. of bolts, weld length, size of gusset/end plates.

The correctness of all other details like cutting lengths, matching of holes, notch dimensions, match markings, bill of materials, bolt list etc. shall be entirely the Successful Bidder's responsibility.

The approval of the drawing however shall not relieve the Successful Bidder of his sole responsibility in carrying out the work correctly and fulfilling the complete requirements of contract documents.

The shop drawings shall include but not be limited to the following : -

a) Assembly drawings giving exact sizes of the sections to be used and identification marks of the various sections.

b) Dimensional drawings of base plates, foundation bolt location etc.

c) Details of all connections with supporting calculations.

d) Comparison sheets to show that the proposed alternative sections, if any, are as strong as the original sections shown on the Design Drawings.

e) Complete Bill of Materials and detailed drawings of all sections as also their billing weights.

f) Any other drawings or calculations that may be required for the clarification of the works or substituted parts thereof.

The shop drawings shall give all the necessary information for the fabrication, erection and painting of the steelwork in accordance with the provisions of this Specification. Shop drawings shall be made in accordance with the best modern practice and with due regard to sequence, speed and economy in fabrication and erection. Shop drawings shall give complete information necessary for fabrication of various components of the steelwork, including the location, type, size and extent of welds. These shall also clearly distinguish between shop and field bolts and welds and specify the class of bolts and nuts. The drawings shall be drawn to a scale large enough to convey all the necessary information adequately. Notes on the shop drawings shall indicate those joints or groups of joints in which it is particularly important that the welding sequence and technique of welding shall be carefully controlled to minimize the locked -up stresses and distortion.

Welding symbols used shall be in accordance with the requirements of the Indian Standard Specification --IS:813 - Scheme of symbols for Welding, and shall be consistent throughout. Weld lengths called for on the drawings shall mean the net effective length.

The Successful Bidder shall be responsible and shall pay the Owner for any alterations of the work due to any discrepancies, errors or omissions on the drawings or other particulars supplied by him, whether such drawings or other particulars have been duly approved or not in accordance with the Contract.

3.00.00 WORKMANSHIP

3.01.00 **Fabrication:** Fabrication may be either shop fabricated or Site fabricated.

3.01.01 **General**

All workmanship shall be equal to the best practice in modern structural shops, and shall conform to the provisions of the Indian Standard IS:800 - Code of Practice for use of Structural Steel in General Building Construction and other relevant Indian Standards.

3.01.02 **Straightening Material**

Rolled materials before being laid off or worked, must be clean, free from sharp kinks, bends or twists and straight within the tolerances allowed by the Indian Standard Specification IS:1852 - Specification for rolling and cutting tolerance for hot-rolled steel products. If straightening is necessary, it may be done by mechanical means or by the application of a limited amount of localized heat. The temperature of heated areas, as measured by approved methods, shall not exceed 600ºC.

3.01.03 **Cutting**

Cutting shall be affected by shearing, cropping or sawing. Use of a mechanically controlled gas cutting torch may be permitted for mild steel only. Gas cutting of high tensile steel may also be permitted provided special care is taken to leave sufficient metal to be removed by machining, so that all metal that has been hardened by flame is removed. Gas cutting without a mechanically controlled torch may be permitted if special care is taken and done under expert hand, subject to the approval of the Owner / Consultant.

To determine the effective size of members cut by gas, 3 mm shall be deducted from each cut edge. Gas cut edges, which shall be subjected to substantial stress or which are to have weld metal deposited on them, shall be reasonably free from gouges. Occasional notches or gauges not more than 4 mm deep shall be permitted. Gouges greater than 4 mm, which remain from cutting, shall be removed by grinding. All re-entrant corners shall be shaped notch-free to a radius of at least 12 mm. Shearing, cropping and gas cutting shall be clean, reasonably square and free from any distortion.

3.01.04 **Planning of edges**

Planning or finishing of sheared or cropped edges of plates or shapes or of edges gas-cut with a mechanically controlled torch shall not be required, unless specifically required by design and called for on the drawings, included in a stipulation for edge preparation for welding or as may be required after the inspection of the cut surface. Surface cut with hand-flame shall generally be ground, unless specifically instructed otherwise by the Owner / Consultant.

3.01.05 **Clearances**

The erection clearance for cleated ends of members connecting steel to steel shall preferably be not greater than 2 mm at each end. The erection clearance at ends of beams without web cleats shall be not more than 3 mm at each end, but where, for practical reasons, greater clearance is necessary, suitably designed cleatings shall be provided.

3.02.00 **Bolted construction**

All bolted connections shall have a minimum of 2 bolts with c/c distance limited to minimum spacing as per IS: 800.

3.02.01 **Holes**

Holes through more than one thickness of material for members, such as compound stanchions and girder flanges, shall be drilled after the members are assembled and tightly clamped or bolted together. Punching may be permitted before assembly, if the thickness of the material is not greater than the nominal diameter of bolt plus 3 mm subject to a maximum thickness of 16 mm provided that the holes are punched 3 mm less in diameter than the required size and reamed after assembly to the full diameter.

Holes for rivets or black bolts shall be not more than 1.5 mm or 2.0 mm (depending on whether the diameter of the bolt is less or more than or equal to 25 mm) larger in diameter than the nominal diameter of the black bolt passing through them.

Holes for turned and fitted bolts shall be drilled to a diameter equal to the nominal diameter of the shank or barrel subject to a tolerance grade of H8 as specified in IS:919. Parts to be connected shall be firmly held together by tacking welds or clamps and the holes drilled through all the thicknesses in one operation and subsequently reamed to size. Holes not drilled through all thickness in one operation shall be drilled to a smaller size and reamed out after assembly.

Holes for bolts shall not be formed by gas cutting process.

3.02.02 **Assembly**

Drifting to enlarge unmatching holes shall not generally be permitted. In case drifting is permitted to a slight extent during assembly, it shall not distort the metal or enlarge the holes. Holes that must be enlarged to admit the bolts shall be reamed. Poor matching of holes shall be cause for rejection. The component parts shall be so assembled that they are neither twisted not otherwise damaged, and shall be so prepared that the specified cambers, if any, are maintained.

Bolted construction shall be permitted only in case of field connections if called for on the Drawings and is subjected to the limitation of particular connections as may be specified

Washers shall be tapered or otherwise suitably shaped, where necessary, to give the heads and nuts of bolts a satisfactory bearing. The threaded portion of each bolt shall project out through the nut at least one thread. In all cases the bolt shall be provided with a washer of sufficient thickness under the nut to avoid any threaded portion of the bolt being within the thickness of the parts bolted together. In addition to the normal washer, one spring washer or lock-nut shall be provided for each bolt for connections subjected to vibrating forces or otherwise as may be specified on the Drawings. For base plates at any level, the minimum thickness of the washer plate shall be 0.8 times of base plate thickness.

3.03.00 **Welded Construction**

3.03.01 **General**

Welding shall be in accordance with relevant Indian Standards and as supplemented in the Specification. Welding shall be done by experienced and good welders who have been qualified by tests in accordance with IS:817.

3.03.02 **Preparation of Material**

Surface to be welded shall be free from loose scale, slag, rust, grease, paint and any other foreign material except that mill scale which withstands vigorous wire brushing may remain. Joint surfaces shall be free from fins and tears. Preparation of edges by gas-cutting shall, wherever practicable, be done by a mechanically guided torch.

3.03.03 **Assembling**

Parts to be fillet welded shall be brought in as close contact as practicable and in no event shall be separated by more than 4 mm. If the separation is 1.5 mm or greater, the size of the fillet welds shall be increased by the amount of the separation. The fit of joints at contact surfaces which are not completely sealed by welds, shall be close enough to exclude water after painting. Abutting parts to be butt-welded shall be carefully aligned.

Misalignments greater than 3 mm shall be corrected and in making the correction the parts shall not be drawn into a sharper slope than two degrees (2 Deg.).

The work shall be positioned for flat welding whenever practicable.

3.03.04 **Welding Sequence**

In assembling and joining parts of a structure or of built-up members, the procedure and sequence of welding shall be such as shall avoid needless distortion and minimize shrinkage stresses. Where it is impossible to avoid high residual stresses in the closing welds of a rigid assembly, such closing welds shall be made in compression elements.

In the fabrication of cover-plated beams and built-up members, all shop splices in each component part shall be made before such component part is welded to other parts of the member. Long girders or girder sections may be made by shop splicing not more than three sub-sections, each made in accordance with this paragraph. When required by the Owner /Consultant, welded assemblies shall be stress relieved by heat treating in accordance with the provisions of the relevant Indian Standard or any other Standard approved by the Consultant.

3.03.05 **Welding technique**

All complete penetration groove welds made by manual welding, except when produced with the aid of backing material not more than 8 mm thick with root opening not less than one-half the thickness of the thinner part joined, shall have the root of the initial layer gouged out on the back side before welding is started from that side, and shall be so welded as to secure sound metal and complete fusion throughout the entire cross-section. Groove welds made with the use of the backing of the same material as the base metal shall have the weld metal thoroughly fused with the backing material. Backing strips need not be removed. If required, they may be removed by gouging or gas cutting after welding is completed, provided no injury is done to the base metal and weld metal and the weld metal surface is left flush or slightly convex with full throat thickness.

Groove welds shall be terminated at the ends of a joint in a manner that shall ensure their soundness. Where possible, this should be done by use of extension bars or run-off plates. Extension bars or run-off plates need not be removed upon completion of the weld unless otherwise specified elsewhere in the Contract.

Minimum size of fillet weld based on thickness of thicker element connected shall be

(a) 6 mm for plate up to 20mm thick

(b) 8 mm for 21 to 30 mm thick

(c) 10 mm for 31 to 50 mm thick

(d) 12 mm for 51mm & above

All members shall be welded to the gusset for full contact length available.

Minimum fillet weld thickness for site welds shall be 8 mm with plates of thickness more than 8 mm.

Spacer plates for double and starred angle members shall be provided at a spacing of not more than 40 r (min) for compression elements and 80 r(min) for tension elements, where r (min) is rxx and ryy of the single angle respectively.

All gussets shall be of minimum 8mm thick. In the drawings thickness of gusset plate corresponding to forces in members shall be

(a) 8 mm gusset plate for forces up to 15 tonnes.

(b) 10 mm gusset plate for forces 16 – 25 tonnes.

(c) 12 mm gusset plate for forces 26 – 40 tonnes.

(d) 14 mm gusset plate for forces 41 - 60 tonnes.

(e) 16 mm gusset plate for forces 61 - 80 tonnes.

(f) 18 mm gusset plate for forces 81 - 100 tonnes.

(g) 20 mm gusset plate for forces 101 ton and above.

To get the best and consistent quality of welding, automatic submerged arc process shall be preferred. The technique of welding employed, the appearance and quality of welds made, and the methods of correcting defective work shall all conform to the relevant Indian Standards.

3.03.06 **Temperature**

No welding shall normally be done on parent material at a temperature below (-) 5 Deg. C. However, if welding is to be undertaken at low temperature, adequate precautions as recommended in relevant Indian Standard shall be taken. When the parent material is less than 40 mm thick and the temperature is between (-) 5 Deg. C and 0 Deg. C, the surface around the joint to a distance of 100 mm or 4 times the thickness of the material, whichever is greater, shall be preheated till it is handwarm. When the parent material is more than 40 mm thick, the temperature of the area mentioned above shall be in no case be less than 20 Deg. C. All requirements regarding preheating of the parent material shall be in accordance with the relevant Indian Standard.

3.03.07 **Peening**

Where required, intermediate layers of multiple-layer welds may be peened with light blows from a power hammer, using a round-nose tool. Peening shall be done after the weld has cooled to a temperature warm to the hand. Care shall be exercised to prevent scaling or flaking of weld and base metal from over peening.

3.03.08 **Equipment**

These shall be capable of producing proper current so that the operator may produce satisfactory welds. The welding machine shall be of a type and capacity as recommended by the manufacturers of electrodes or as may be accepted by the Owner.

3.04.00 **Finish**

Column splices and butt joints of compression members depending on contact for stress transmission shall be accurately machined and close-butted over the whole section with a clearance not exceeding 0.2 mm locally at any place. In column caps and bases, the ends of shafts together with the attached gussets, angles, channels etc., after welding together, should be accurately machined so that the parts connected butt over the entire surfaces of contact. Care should be taken that those connecting angles or channels are fixed with such accuracy that they are not reduced in thickness by machining by more than 2.0 mm.

3.05.00 **Slab bases and caps**

Bases and caps fabricated out of steel slabs, except when cut from material with true surface, shall be accurately machined over the bearing surface and shall be in effective contact with the end of the stanchion. A bearing face which is to be grouted direct to a foundation need not be machined if such face is true and parallel to the upper face. To facilitate grouting, holes shall be provided, where necessary, in stanchion bases for the escape of air.

3.06.00 **Lacing bars**

The ends of lacing bars shall be neat and free from burrs.

3.07.00 **Separators**

Rolled section or built-up steel separators or diaphragms shall be required for all double beams except where encased in concrete, in which case, pipe separators shall be used.

3.08.00 **Bearing Plates**

Provision shall be made for all necessary steel bearing plates to take up reaction of beams and columns and the required stiffeners and gussets whether or not specified in Drawings.

3.09.00 **Architectural Clearances**

Bearing plates and stiffener connections shall not be permitted to encroach on the designed architectural clearances.

3.10.00 **Shop connections**

a) All shop connections shall be welded as specified on the Drawings.

b) Certain connections, specified to be shop connections, may be changed to field connections if desired by the Engineer for convenience of erection and the Successful bidder will have to make the desired changes.

3.11.00 **Castings**

Steel castings shall be annealed

3.12.00 **Shop erection**

The steelwork shall be checked for accuracy of fit before despatch.

3.13.00 **Shop painting**

3.13.01 **General**

Unless otherwise specified, steelwork which shall be concealed by interior building finish need not be painted; steelwork to be encased in concrete shall not be painted. Unless specifically exempted, all other steelwork shall be given final coat of shop paint, applied thoroughly and evenly to dry surfaces which have been cleaned, in accordance with the following paragraph, by brush, spray, roller coating, flow-coating or dipping as may be approved by the Consultant.

After inspection and approval and before leaving the shop, all steelwork specified to be painted shall be cleaned by hand-wire brushing or by other mechanical cleaning methods to remove loose mill scale, loose rust, weld slag or flux deposit, dirt and other foreign matter. Oil and grease deposits shall be removed by solvent. Steelwork specified to have no shop paint shall, after fabrication, be cleaned of oil or grease by solvent cleaners and be cleaned of dirt and other foreign material by through sweeping with a fibre brush.

After completion of the pre-cleaning, the metal surface shall immediately painted with zinc ethyl silicate primer conforming to IS-14946..

All steelwork shall be given a coat of shop paint, applied thoroughly and evenly to dry surfaces which have been cleaned by sand blasting to SA 2/1/2 grade minimum.

3.13.02 **Inaccessible parts**

Surfaces not in contact, but inaccessible after assembly, shall receive two coats of shop paint, positively of different colours to prove application of two coats before assembly. This does not apply to the interior of sealed hollow sections.

3.13.03 **Contact surfaces**

Contact surface shall be cleaned in accordance with Sub-clause 3.13.1 before assembly.

3.13.04 **Finished surfaces**

Machine finished surfaces shall be protected against corrosion by a rust inhibiting coating that can be easily removed prior to erection or which has characteristics that make removal unnecessary prior to erection.

3.13.05 **Surfaces adjacent to field welds**

Unless otherwise provided for, surfaces within 50 mm of any field weld location shall be free of materials that would prevent proper welding or produce objectionable fumes while welding is being done.

3.14.00 **Galvanizing**

3.14.01 **General**

Structural steelwork for switchyard or other structures as may be specified in the Contract shall be hot dip galvanized in accordance with the American Society for Testing and Materials Specification ASTM-A 123 or IS : 2629 - Recommended practice for Hot-Dip Galvanising of Iron and steel. Where the steel structures are required to be galvanized the field connection materials like bolts, nuts and washers shall also be galvanized.

3.14.02 **Surface Preparation**

Members to be galvanized shall be cleaned, by the process of pickling of rust, loose scale, dirt, oil, grease, slag and spatter of welded areas and other foreign substances prior to galvanizing. Pickling shall be carried out by immersing the steel in an acid bath containing either sulphuric or hydrochloric acid at a suitable concentration and temperature. The concentration of the

acid and the temperature of the bath can be varied, provided that the pickling time is adjusted accordingly.

The pickling process shall be completed by thoroughly rinsing with water, which should preferably be warm, so as to remove the residual acid.

3.14.03 **Procedure**

Galvanizing shall be carried out by hot dip process in a proper and uniformly heated bath. It shall meet all the requirements when tested in accordance with IS:2633 - Method for testing uniformity of coating on Zinc Coated Articles and IS:4759 - Specification for Hot-dip zinc coatings on Structural Steel & other allied products.

After finishing the threads of bolts, galvanizing shall be applied over the entire surface uniformly. The threads of bolts shall not be machined after galvanizing and shall not be clogged with zinc. The threads of nuts may be tapped after galvanizing but care shall be taken to use oil in the threads of nuts during erection.

The surface preparation for galvanizing and the process of galvanizing itself, shall not adversely affect the mechanical properties of the materials to be galvanized. Where members are of such lengths as to prevent complete dipping in one operation, great care shall be taken to prevent warping.

Materials on which galvanizing has been damaged shall be acid stripped and re-galvanized unless otherwise directed, but if any member becomes damaged after having been dipped twice, it shall be rejected. Special care shall be taken not to injure the skin on galvanized surfaces during transport and handling. Damages, if occur, shall be made good in accordance with the provisions of this Specification or as directed by the Owner /Consultant.

4.00.00 INSPECTION, TESTING, ACCEPTANCE CRITERIA AND DELIVERY

4.01.00 **Inspection**

Unless specified otherwise, inspection to all work shall be made by the Owner /Consultant at the place of manufacture prior to delivery. The Owner /Consultant shall have free access at all reasonable times to those parts of the manufacturer's works which are concerned with the fabrication of the steelwork under this Contract and he shall be afforded all reasonable facilities for satisfying himself that the fabrication is being done in accordance with the provisions of this Specification.

The Successful Bidder shall provide such labour, materials, electricity, fuel, water, stores, tools and plant, apparatus and instruments as may be required by the Owner/Consultant to carry out inspection and/or tests in accordance with the Contract.

The Successful Bidder shall guarantee compliance with the provisions of this Specification.

4.02.00 **Testing and Acceptance Criteria**

4.02.01 **General**

The Successful Bidder shall carry out sampling and testing in accordance with the relevant Indian Standards and as supplemented herein for the following items

The Successful Bidder shall get the specimens tested in a laboratory approved by the Owner /Consultant and submit to the Consultant the test results in triplicate within 3 (three) days after completion of the test.

4.02.02 **Steel**

All steel supplied by the Seller shall conform to the relevant Indian Standards. Except otherwise mentioned in the Contract, only tested quality steel having mill test reports shall be used.

All material shall be free from all imperfections, mill scales, slag intrusions, laminations, pittings, rusts etc. that may impair their strength, durability and appearance.

Steel shall conform to IS : 2062 (latest) for rolled structural steel members.

4.02.03 **Testing Criteria for checking Lamination in raw steel plates**

All raw steel plate of thickness more than 20 mm supplied by the Seller shall be checked against lamination before procurement & prior to commencement of fabrication work in the following ways as directed by the Owner /Consultant.

a) Ultrasonic testing along the edge of specified points of the plates shall be carried out to delete lamination in the plates, if any.

b) If the results of the tests in (a) are not satisfactory, the whole area of the plates shall be checked by ultrasonic testing at specified nodal points formed at equidistant grid locations. The spacing of the grids shall be determined from tests in (a) or as directed by the Consultant.

If the results of the above tests are not satisfactory, the plates shall not be taken up for fabrication work. Even after fabrication at shop/site, if the Consultant requires any ultrasonic testing to detect lamination of plates, the same shall be carried out by the Successful Bidder. If the plates in the fabricated item are found to be laminated, the component shall be rejected.

4.02.04 **Welding**

All electrodes shall be procured from reliable manufacturers with test certificates. The correct grade and size of electrode which has not deteriorated in storage shall be used. The inspection and testing of welding shall be performed in accordance with the provisions of the relevant Indian Standards or other equivalents. For every 50 tonnes of welded fabrication, the Owner/Consultant may ask for at least 1 (one) test-destructive or non-destructive including X-ray, ultrasonic test or similar. In the event of further tests as may be desired by the Owner /Consultant, if the results are found to be unsatisfactory; and if the test shows no defect. In cases of the test results showing deficiency, the Owner /Consultant shall have option to reject or instruct any remedial measures to be taken.

4.02.05 **Bolts, nuts and washers**

All bolts, nuts and washers shall be procured from reputed manufacturer accepted by the Owner and shall conform to the relevant Indian Standards. If desired by the Owner, representative samples of these materials may have to be tested in an approved laboratory and in accordance with the procedures described in relevant Indian Standards.

4.02.06 **Shop painting**

All paints and primers shall be of standard quality and procured from approved manufacturers and shall conform to the provisions of the relevant Indian Standards.

4.02.07 **Galvanizing**

All galvanizing shall be uniform and of standard quality when tested in accordance with IS:2633 - Method for testing uniformity of coating on Zinc Coated Articles and IS:4759 - specification for Hot-Dip Zinc Coatings on Structural Steel & other allied products.

4.03.00 **Tolerance**

The tolerances on the dimensions of individual rolled steel components shall be as specified in IS:1852 - specification for rolling and Cutting Tolerances for Hot-rolled Steel Products. The tolerances on straightness, length etc. of various fabricated components (such as beams and girders, columns, crane gantry girder etc.) of the steel structures other than steel railway & road bridges, structures subjected to dynamic loading (like wind, seismic etc.) and thin walled construction (like box girders) shall be as specified in IS:7215 - Tolerances for Fabrication of Steel Structures.

4.04.00 **Acceptance**

Should any structure or part of a structure be found not to comply with any of the provisions of this Specification, the same shall be liable to rejection. No structure or part of the structure, once rejected, shall be offered again for test, except in cases where the Owner /Consultant considers the defects rectifiable. The Owner /Consultant may, at his discretion, check the test results obtained at the Successful Bidder's works by independent tests at an approved laboratory and should the items, so tested, be found to be unsatisfactory.

When all tests to be performed in the Successful Bidder's shop/site under the terms of this contract have been successfully carried out, the steelwork shall be accepted forthwith and the Owner /Consultant shall issue an acceptance certificate, upon receipt of which, the items shall be shop painted, packed and despatched/cleared for erection if site fabricated. No item to be delivered unless an acceptance certificate for the same has been issued. The satisfactory completion of these tests or the issue of the certificates shall not bind the Owner to accept the work, should it, on further tests before or after erection, be found not in compliance with the Contract.

4.05.00 **Delivery of materials**

4.05.01 **General**

The Successful Bidder shall deliver the fabricated structural steel materials to site with all necessary field connection materials in such sequence as shall permit the most efficient and economical performance of the erection work. the Owner may prescribe or control the sequence of delivery of materials, at his own discretion.

4.05.02 **Marking**

Each separate piece of fabricated steelwork shall be distinctly marked on all surfaces before delivery in accordance with the markings shown on approved erection drawings and shall bear such other marks as shall further facilitate identification and erection.

4.05.03 **Packing and Shipping**

All projecting plates or edges and all ends of members of joints shall be stiffened, all straight members and plates, shall be bundled, all screwed ends and machined surfaces shall be suitably packed and all bolts, nuts, washers, and small loose parts shall be packed separately in order to prevent damage or distortion during shipping.

Shipping shall be strictly in accordance with the sequence stipulated in the agreed programme. All packings shall allow for easy removal and checking at site. Special precautions shall be taken against rusting, corrosion, breakage

or damage otherwise of the materials. All parts shall be adequately braced to prevent damage in transit.

The Successful bidder shall submit periodic test reports of all materials procured and used such as raw steel, paints, electrodes, colour coated sheets, poly carbonate sheets, sheeting fixtures, bolts, nuts & washers etc. The test reports shall indicate conformance to specifications / IS codes etc.

The Successful bidder shall submit test reports for all welds carried out at shop such as UT and RT reports, shall also be submitted along with each inspection call, covering structures offered for inspection.

DFT record of paint applied measured at random covering structures offered for inspection.

5.00.00 INFORMATION TO BE SUBMITTED

5.01.00 After Award of Contract

After award of the Contract the Successful Bidder is to submit the following:

a) Complete fabrication drawings, material lists, cutting lists, bolt lists, field welding schedules based on the design drawings in accordance with the approved schedule.

b) Monthly Progress Report with necessary photographs in six (6) copies to reach the Owner /Consultant on or before the 7th day of each month, giving the up to date status of preparation of detailed shop drawings, bill of materials, procurement of materials, actual fabrication done, shipping and all other relevant information.

c) Results of any test as and when conducted and as required by the Owner /Consultant.

d) Manufacturer's mill test report in respect of steel materials, bolts, nuts and electrodes as may be applicable.

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SECTION-IX

GUIDELINE
FOR
ERECTION OF STRUCTURAL STEELWORK

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SECTION-IX

GUIDELINE
FOR
ERECTION OF STRUCTURAL STEELWORK

1.00.00 SCOPE

This specification covers the erection of structural steelwork including receiving and taking delivery of fabricated structural steel materials fabricated/arriving at Site and installing the same in position, painting and grouting the stanchion bases all complete as per Drawings, this Specification and other provision of the Contract.

2.00.00 GENERAL

2.01.00 Work to be provided for by the Successful Bidder

The work to be provided for by the Successful Bidder, unless otherwise specified in the Contract, shall include but not be limited to the following:-

a) The Bidder shall provide all construction materials and the Successful Bidder shall provide all transport equipment, tools, tackle, consumables, materials, labour and supervision required for the erection of the structural steelwork.

b) Receiving, unloading, checking and moving to storage yard at Site including prompt attendance to all insurance matters as necessary for all fabricated steel materials arriving at Site.

c) Transportation of all fabricated structural steel materials from Site storage yard, handling, rigging, assembling, bolting, welding and satisfactory installation of all fabricated structural steel materials in proper location according to approved erection drawings and/or as directed by the Owner/Consultant. If necessary suitable temporary approach roads to be built for transportation of fabricated steel structures by the successful bidder.

d) Checking center lines, levels of all foundation blocks including checking line, level, position and plumb of all bolts and pockets. any defect observed in the foundation shall be brought to the notice of the Owner/Consultant. The Successful Bidder shall fully satisfy himself regarding the correctness of the foundations before installing the fabricated steel structures on the foundation blocks.

e) Aligning, plumbing, levelling, bolting, welding and securely fixing the fabricated steel structures in accordance with the Drawings or as directed by the Owner /Consultant.

f) Final coat of Painting of the erected steel structures by the successful bidder. For painting of structural steel members: shall be applied with primer paint shall be single coat of zinc ethyl silicate primer of 75micron thick and conform to IS: 2074 (Latest Revision). The surface preparation shall be done in accordance with IS: 1477 (Part I & II) (Latest Revision) – Code of Practice for Finishing of Ferrous Metals in Buildings. Two coats of synthetic enamel paint conforming to IS: 2932 (Latest Revision) of approved shade and quality and not less than 50 microns each coat shall also be applied. Total Dry film thickness of the finished paint shall not be less than 175 microns. For structures fabricated in shop, one additional coat of primer shall be given at the shop of 75 micron thick.

g) All minor modifications of the fabricated steel structures as directed by the Owner /Consultant including but not limited to the followings:

i) Removal of bends, kinks, twists etc. for parts damaged during transport and handling.

ii) Cutting, chipping, filling, grinding etc. if required for preparation and finishing of site connections.

iii) Reaming of holes for use of higher size bolt if required.

iv) Welding of connections in place of bolting for which holes are either not drilled at all or wrongly drilled during fabrication. Welding in place of bolting shall be permitted only at the discretion of the Owner /Consultant.

v) Refabrication of parts damaged beyond repair during transport and handling or Refabrication of parts which are incorrectly fabricated.

vi) Fabrication of parts omitted during fabrication by error, or subsequently found necessary.

vii) Drilling of holes which are either not drilled at all or are drilled in incorrect location during fabrication.

viii) Carry out tests in accordance with this Specification if directed.

The above are to be followed for the site fabricated structures also.

2.02.00 **Work by others**

No work under this Specification shall be provided for by any agency other than the Successful Bidder unless specifically mentioned elsewhere in the Contract.

2.03.00 **Codes and Standards**

All work under this Specification shall, unless specified otherwise, conform to the latest revisions as on the original scheduled date of tender opening and/or replacements of the following or any other Indian Standard Specification and codes of Practice of equivalent:-

IS-800 : Code of Practice for general construction in steel

IS-456 : Code of Practice for plain or reinforced concrete

IS-7205 : Safety Code for erection of Structural Steel work

IS-12843 : Tolerance for erection of Steel Structures

2.04.00 **Conformity with designs**

The Successful Bidder shall erect the entire fabricated steel structure, align all the members, complete all field connections and grout the foundations all as per the provisions of this specification and the design criteria detailed in the approved erection drawings and/or other stated document. All work shall conform to the provisions of the relevant Indian Standard Specifications and/or the instructions of the Owner /Consultant. The testing and acceptance of the erected structures shall be in accordance with the provisions of this Specification and/or the instructions of the Owner /Consultant.

2.05.00 **Material**

2.05.01 **General**

The Successful Bidder shall check the quantity, quality and the sizes of the fabricated materials and verify the adequacy of the same in accordance with the Drawings and Specifications. The Successful Bidder shall make good any deficiency, if detected, either by repair or with fresh material as may be directed by the Owner /Consultant.

All consumables like oxygen and acetylene gas, paints, fuels, lubricants, oil, grease, cement, sand, aggregates and any other material that may be required for the execution of the works in accordance with the contract shall be supplied by the Successful Bidder for erection work and shall be deemed to have been included in this rates.

2.05.02 **Materials to conform to Indian Standards**

All materials required to be supplied by the Seller under this Contract shall conform to the relevant Indian Standard Specifications.

2.06.00 **Storage of materials**

2.06.01 **General**

All material shall be so stored as to prevent deterioration and to ensure the preservation of their quality and fitness for use in the works. Any material which has been deteriorated or damaged beyond repairs and has become unfit for use shall be removed immediately from the site, failing which, the Owner /Consultant shall be at liberty to get the materials removed by agency.

2.06.02 **Yard**

The Successful Bidder shall have to establish a suitable yard in an approved location at site for storing the fabricated steel structures and other materials which shall be delivered to him by the Owner according to the Contract. The yard shall have proper facilities like, drainage, lighting, suitable access for large cranes, trailers and other heavy equipments.

The yard shall be fenced all around with security arrangement and shall be of sufficiently large area to permit systematic storage of the fabricated steel structures without overcrowding and with suitable access for cranes, trailers and other equipment for use in erection work in proper sequence in accordance with the approved programme of work.

2.06.03 **Covered Store**

All field connection materials, paints, cement etc. shall be stored on well-designed racks and platforms off the ground in a properly covered store building to be built.

2.07.00 **Quality Control**

The Successful Bidder shall establish and maintain quality control procedures for different items of work and materials as may be directed by the Owner/Consultant to assure compliance with the provisions of the Contract and shall submit the records of the same to the Owner /Consultant. The quality control operation shall include but not be limited to the following items of work:-

1) Erection: Lines, levels, grades, plumbs, joint characteristics including tightness of bolts.

2) Grouting: Cleaning and roughness of foundation, quality of materials used for grouting, admixtures, consistency and strength of grout.

3) Painting: Preparation of surface for painting, quality of primers and paints, thinners, application and uniformity of coats.

The Successful Bidder shall salvage, collect and deliver all the packing materials to the Owner.

3.00.00 WORKMANSHIP

3.01.00 Erection

3.01.01 Plant and equipment

The suitability and adequacy of all erection tools and plant and equipment proposed to be used shall be efficient, dependable, in good working condition and shall have the approval of the Owner /Consultant.

3.01.02 Method and sequence of erection

The method and sequence of erection shall have the prior approval of the Engineer. The Erection shall arrange for most economical method and sequence available to him consistent with the Drawings and Specifications and such information as may be furnished to him prior to the execution of the Contract.

3.01.03 Temporary bracing

Unless adequate bracing is included as a part of the permanent framing, the erector during erection shall install temporary guys and bracings where needed to secure the framing against loads such as wind or seismic forces comparable in intensity to that for which the structure has been designed, acting upon exposed framing as well as loads due to erection equipment and erection operations.

The responsibility of the Successful Bidder in respect of temporary bracings and guys shall cease when the structural steel is once located, plumbed, levelled, aligned and grouted within the tolerances permitted under the specification and guyed and braced to the satisfaction of the Owner /Consultant.

3.01.04 Temporary floors for buildings

It shall be the responsibility of the successful bidder to provide free of cost planking and to cover such floors during the work in progress as may be required by any Act of Parliament and/or by-laws of state, Municipal or other local authorities.

3.01.05 Setting out

Positioning and levelling of all steelwork, plumbing of stanchions and placing of every part of the structure with accuracy shall be in accordance with the

approved Drawings and to the satisfaction of the Owner /Consultant. Anchor bolts and other anchor steel shall be embedded in position. The Successful Bidder shall check the positions and levels of the anchor bolts, etc. before concreting and get them properly secured against disturbance during pouring operations. He shall remain responsible for correct positioning. For heavy columns, etc. the Successful Bidder shall set proper screed bars if desired by the Owner /Consultant, to maintain proper level.

Each tier of column shall be plumbed and maintained in a true vertical position subject to the limits of tolerance allowable under this Specification.

No permanent field connections by bolting or welding shall be carried out until proper alignment and plumbing has been attained.

3.01.06 Field bolting

All relevant portions in respect of bolted construction of the Specification for Fabrication of Structural Steelwork applicable to the Project shall also be applicable for field bolting in addition to the following:

Bolts shall be inserted in such a way so that they may remain in position under gravity even before fixing the nut. Bolted parts shall fit solidly together when assembled and shall not be separated by gaskets or any other interposed compressible materials. When assembled, all joint surfaces, including those adjacent to the washers shall be free of scales except tight mill scales. They shall be free of dirt, loose scales, burns, and other defects that would prevent solid seating of the parts. Contact surfaces within friction-type joints shall be free of oil, paint, lacquer, or galvanizing.

All high tensile bolts shall be tightened to provide, when all fasteners in the joint are tight, the required minimum bolt tension by any of the following methods.

a) Turn-of-nut method

When the turn-of-nut method is used to provide the bolt tension, there shall first be enough bolts brought to a "snug tight" condition to ensure that the parts of the joint are brought into good contact with each other. "Snug tight" is defined as the tightness attained by a few impacts of an impact wrench or the full effort of a man using an ordinary spud wrench. Following this initial operation, bolts shall be placed in any remaining holes in the connection and brought to snug tightness. All bolts in the joint shall then be tightened additionally by the applicable amount of nut rotation specified in Table-1 with tightening progressing systematically from the most rigid part of the joint to its free edges. During this operation there shall be no rotation of the part not turned by the wrench.

TABLE - I

Bolts length not exceeding 8 x dia. or 200 mm	Bolt length exceeding 8xdia. or 200 mm	Remarks
1/2 turn	2/3 turn	Nut rotation is relative to bolt regardless of the element (nut or bolt) being turned. Tolerance on rotation - 30 over or under.

Bolts may be installed without hardened washers when tightening is done by the turn-of-nut method. However, normal washers shall be used.

Bolts tightened by the turn-of-nut method may have the outer face of the nut match-marked with the protruding bolt point before final tightening, thus affording the inspector visual means of noting the actual nut rotation. Such marks can be made by the wrench operator by suitable means after the bolts have been brought up snug tight.

b) Torque Wrench tightening

When torque wrenches are used to provide the bolt tensions, the bolts shall be tightened to the torques specified in TABLE - II. Nuts shall be in tightening motion when torque is measured. When using torque wrenches to install several bolts in a single joint, the wrench shall be returned to touch up bolts previously tightened, which may have been loosened by the tightening of subsequent bolts, until all are tightened to the required tension.

TABLE - II

Nominal Bolt Diameter (mm)	Torque to be applied (Kg.M) for bolt class 8.8 of IS : 1367
20	59.94
22	81.63
24	103.73

NOTE :

The above torque values are approximate for providing tensions of 14.7 MT for 20 mm dia., 18.2 MT for 22 mm dia; and 21.2 MT for 24 mm dia. bolts under moderately lubricated condition. The torque wrench shall be calibrated at least once daily to find out the actual torque required to produce the above required tension in the bolt by placing it in a tension indicating device. These torques shall be applied for tightening the bolts on that day with the particular torque wrench.

In either of the above two methods, if required, for bolt entering and wrench operation clearances, tightening may be done by turning the bolt while the nut is prevented from rotating.

Impact wrenches if used shall be of adequate capacity and sufficiently supplied with air to perform the required tightening of each bolt in approximately ten seconds.

Holes for turned bolts to be inserted in the field shall be reamed in the field. All drilling and reaming for turned bolts shall be done only after the parts to be connected are assembled. Tolerances applicable in the fit of the bolts shall be in accordance with relevant Indian Standard Specifications. All other requirements regarding assembly and bolt tightening shall be in accordance with this sub clause.

3.01.07 **Field Welding**

All field assembly and welding shall be carried out in accordance with the requirements of the specification for fabrication work applicable to the project, excepting such provisions therein which manifestly apply to shop conditions only. Where the fabricated structural steel members have been delivered painted, the paint shall be removed before field welding for a distance of at least 50 mm on either side of the joints.

3.01.08 **Holes, cutting and fitting**

No cutting of sections, flanges, webs, cleats, bolts, welds etc. shall be done unless specifically approved and/or instructed by the Owner /Consultant.

The Successful Bidder shall not cut, drill or otherwise alter the work of other trades, or his own work to accommodate other trades, unless such work is clearly specified in the Contract or directed by the Owner /Consultant. Wherever such work is specified the Successful Bidder shall obtain complete information as to size, location and number of alterations prior to carrying out any work.

3.02.00 **Drifting**

Correction of minor misfits and reasonable amount of reaming and cutting of excess stock from rivets shall be considered as permissible. For this, light

drifting may be used to draw holes together and drills shall be used to enlarge holes as necessary to make connections. Reaming, that weakens the member or makes it impossible to fill the holes properly or to adjust accurately after reaming shall not be allowed.

Any error in fabrication work which prevents the proper assembling and fitting of parts by moderate use of drift pins and reamers shall immediately be called to the attention of the Owner /Consultant and approval of the method of correction obtained. The use of gas cutting torches at erection site is prohibited.

3.03.00 **Grouting of stanchion bases and bearings of beams and girders on concrete (Plain or reinforced)**

Grouting shall be carried out with Ordinary Cement grout as described below :

The mix shall be one (1) part cement and one (1) part sand and just enough water to make it workable. The positions to be grouted shall be cleaned thoroughly with compressed air jet and wetted with water and any accumulated water shall be removed. These shall be placed under expert supervision, taking care to avoid air-locks. Edges shall be finished properly. If the thickness of grout is 25 mm or more, two (2) parts of 6 mm downgraded stone chips may be added to the above noted cement-sand grout mix, if required, by the Owner /Consultant or shown on the drawings.

Admixtures like aluminium powder, "ironite" may be required to be added to the grout to enhance certain desirable properties of the grout.

Alternatively, the grouting may be done with non-shrink high strength free flow cementious grout (ready mixed) like “Sika grout - 214", or "Anchor NSG" or approved equivalent.

No grouting shall be carried out until a sufficient number of bottom lengths of stanchions have been properly lined, levelled and plumbed and sufficient floor beams are tied in position.

Whatever method of grouting is employed, the operation shall not be carried out until the steelwork has been finally levelled and plumbed, the stanchion bases being supported meanwhile by steel wedges, and immediately before grouting, the space under steel shall be thoroughly cleaned.

3.04.00 **Painting after erection**

Field painting, shall only be done after the structure is erected, levelled, plumbed, aligned and grouted in its final position, tested and accepted by the Owner /Consultant. However, touch up paintings, making good any damaged shop painting and completing any unfinished portion of the shop coat shall be carried out by the Successful Bidder. The materials and specification for such painting in the field shall be in accordance with the requirements of the specification for fabrication of structural steelwork applicable for the project.

Painting shall not be done in rainy or foggy weather or when humidity is such as to cause condensation on the surfaces to be painted. Before painting of steel, which is delivered unpainted, is commenced, all surfaces to be painted shall be dried and thoroughly cleaned from all loose scale and rust.

All field bolts, welds and abrasions to the shop coat shall be spot painted with the same paint used for the shop coat. Where specified, surfaces which shall be in contact after site assembling shall receive a coat of paint (in addition to the shop coat, if any) and shall be brought together while the paint is still wet.

Surface which will be inaccessible after field assembly shall receive the full specified protective treatment before assembly. Bolts and fabricated steel members which are galvanized or otherwise treated and steel members to be encased in concrete shall not be painted.

The specification for paint and workmanship shall be in accordance with the requirements of the specification for fabrication of structural steelwork applicable to the project.

The number of coats and the shades to be used shall be as specified or as directed by the Owner /Consultant.

3.05.00 Not used

3.06.00 **Final cleaning up**

Upon completion of erection and before final acceptance of the work by the Owner /Consultant, the Successful Bidder shall remove all falsework, rubbish and all Temporary Works resulting in connection with the performance of his work.

3.07.00 **Safety Measures during Erection**

The safety measures to workmen and supervisors during all types of erection work (e.g., use of lifting appliances, slinging, welding, gas cutting, etc.) should be taken as per IS : 7205. When any statutory provisions exist, the same shall be complied with in addition to the provisions contained in the above code.

4.00.00 TESTING AND ACCEPTANCE CRITERIA

4.01.00 **General**

Loading tests shall be carried out on erected structures, if required by the Owner /Consultant, to check adequacy of fabrication and/or erection. Any structure or a part thereof found to be unsuitable for acceptance as a result of the test shall have to be dismantled and replaced with suitable member. In course of dismantling, if any damage is done to any other parts of the structure or to any fixtures, the same shall be made good by the Successful Bidder responsible, to the satisfaction of the Owner /Consultant.

The structure or structural member under consideration shall be loaded with its actual dead load for as long a time as possible before testing and the tests shall be conducted as indicated in the following Sub-clauses 4.1.1, 4.1.2 and 4.1.3. The method of testing and application of loading shall be as approved by the Owner /Consultant.

4.01.01 **Stiffness Test**

In this test, the structure or member shall be subjected, in addition to its actual dead load, to a test load equal to1.5 times the specified superimposed load, and this loading shall be maintained for 24 hours. The maximum deflection attained during the test shall be within the permissible limit. If, after removal of the test load, the member or structure does not show a recovery of at least 80 per cent of the maximum strain or deflection shown during 24 hours under load, the test shall be repeated. The structure or member shall be considered to have sufficient stiffness, provided that the recovery after this second test is not less than 90 percent of the maximum increase in strain or deflection recorded during the second test.

4.01.02 **Strength Test**

The structure or structural member under consideration shall be subjected, in addition to its actual dead load, to a test load equal to the sum of the dead load and twice the specified superimposed load, and this load shall be maintained for 24 hours.

In the case of wind load, a load corresponding to twice the specified wind load shall be applied and maintained for 24 hours, either with or without the vertical test load for more severe condition in the member under consideration or the structure as a whole.

Complete tests under both conditions may be necessary to verify the strength of the structure. The structure shall be deemed to have adequate strength if, during the test, no part fails and if on removal of the test load, the structure shows a recovery of at least 20 per cent of the maximum deflection or strain recorded during the 24 hours under load.

4.01.03 **Structure of same design**

Where several structures are built to the same design and it is considered unnecessary to test all of them, one structure, as a prototype, shall be fully tested, as described in previous Sub-clauses, but in addition, during the first application of the test load, particular note shall be taken of the strain or deflection when the test load 1.5 times the specified superimposed load has been maintained for 24 hours. This information is required as a basis of comparison in any check test carried out on samples of the structure.

When a structure of the same type is selected for a check test, it shall be subjected, in addition to its actual dead load, to a superimposed test load,

equal to 1.5 time the specified live load, in a manner and to an extent prescribed by the Owner /Consultant. This load shall be maintained for 24 hours, during which time, the maximum deflection shall be recorded. The check test shall be considered satisfactory, provided that the maximum strain or deflection recorded in the check test does not exceed by more than 20% of the maximum strain or deflection recorded at similar load in the test on the prototype.

4.01.04 **Repair for subsequent test and use after strength tests**

An actual structure which has passed the "Strength Test" as specified in Sub-clause 4.1.2 hereinbefore and is subsequently to be erected for use, shall be considered satisfactory for use after it has been strengthened by replacing any distorted members and has subsequently satisfied the 'Stiffness Test' as specified in Sub-clause 4.1.1. herein before.

4.02.00 **Tolerances**

Some variation is to be expected in the finished dimensions of structural steel frames. Unless otherwise specified, such variations are deemed to be within the limits of good practice when they are not in excess of the cumulative effect of detailed erection clearances, fabricating tolerances for the finished parts and the rolling tolerances for the profile dimensions permitted under the Specifications for fabrication of structural steelwork applicable to this Project and as specified below :

Component	Description	Variation Allowed
I. For Buildings Containing Cranes		
Main columns	a) Shifting of column axis at foundation level with respect to building line	
	i) In longitudinal direction	i) ± 3.0 mm
	ii) In lateral direction	ii) ± 3.0 mm
	b) Deviation of both major column axis from vertical between foundation and other member connection levels :	
	i) For a column upto and	i) ± 3.5 mm from

Component	Description	Variation Allowed
	including 10M height	true vertical
	ii) For a column greater than 10M but less than 40M height	ii) ± 3.5 mm from true vertical for any 10M length measured between connection levels, but not more than± 7.0 mm per 30 m length
	c) For adjacent pairs of columns across the width of the building prior to placing of truss.	± 9 mm on true span.
	d) For any individual column deviation of any bearing or resting level from levels shown on drawings	. ± 3.0 mm
	e) For adjacent pairs of columns either across the width of building or longitudinally level difference allowed between bearing or seating level supposed to be at the same level.	3 mm
Trusses	a) Deviation at centre of span of upper chord member from vertical plane running through centre of bottom chord.	1/1500 of the span or not greater than 10 mm whichever is the. least.

Component	Description	Variation Allowed
	b) Lateral displacement of top chord at centre of span from vertical plane running through centre of supports	1/250 of depth of truss or 20 mm whichever is the least.
Crane Girders & Tracks	a) Difference in levels of crane rail measured between adjacent columns	2.0 mm
	b) Deviation to crane rail gauge	± 3.0 mm
	c) Relative shifting of ends of adjacent crane rail in plan and elevation after thermit welding.	1.0 mm
	d) Deviation of crane rail axis from centre line of web.	± 3.5 mm
Setting of Expansion gaps	At the time of setting of the expansion gaps, due regard shall be taken of the ambient temperature above or below 30°C. The coefficient of expansion or contraction shall be taken as 0.000012 per °C per unit length.	

II. For Building without Cranes

The maximum tolerances for line and level of the steel work shall be ± 3.0 mm on any part of the structure. The structure shall not be out of plumb more than 3.5 mm on each 10M section of height and not more than 7.0 mm per 30 M section.

These tolerances shall apply to all parts of the structure unless the drawings issued for erection purposes state otherwise.

4.03.00 **Acceptance**

Structures and members which have passed the tests and conform to all requirements specified in the foregoing Sub-clause 4.1.0, 4.1.1, 4.1.2, 4.1.3 and 4.1.4 and other applicable provisions of this Specification and are within the limits of tolerances specified in Sub-clause 4.2.0 and/or otherwise approved by the Consultant shall be treated as approved and accepted for the purpose of fulfillment of the provisions of this Contract. Acceptance of erected steel structures shall be either after completion of erection of the whole building or in blocks.

5.00.00 INFORMATION TO BE SUBMITTED

5.01.00 **After Award**

After award of the work, the successful bidder will be required to submit the following information

5.01.01 **Tentative Programme**

The successful bidder shall submit a tentative programme based on the information available in the Tender Document and visit to Site indicating the structure-wise erection schedule proposed to be maintained by the successful bidder to complete the job in time in accordance with the Contract.

5.01.02 **Constructional Plant and Equipment, Tools, Temporary Works & Manpower (After Award of contract)**

A detailed list of all Constructional Plant & Equipment like cranes, derricks, winches, welding sets, erection tools etc. along with their make, model, present condition and location available with the successful bidder which he will be able to employ on the job to maintain the progress of work in accordance with the Contract shall be submitted before starting the work. The total number of each category of experienced personnel like fitters, welders, riggers etc. that he will be able to employ on the job shall also be indicated.

5.01.03 **Erection yard (After award of contract)**

A site plan showing the layout and location of the erection yard proposed to be established by the successful bidder shall be furnished indicating the storage space for fabricated steel materials, site-fabrication and repair shop, covered stores, offices, locations of erection equipments and other facilities. The Engineer shall have the right to modify the arrangement and location of the proposed yard to suit site conditions and the successful bidder shall comply with the same without any claim whatsoever.

5.01.04 **Detailed Programme**

The successful bidder shall submit a detailed erection programme for completion of the work in time in accordance with the Contract. This will show the target programme, with details of erection proposed to be carried out in each fortnight, details of major equipment required and an assessment of required strength of various categories of workers in a proforma approved by the Engineer.

5.01.05 **Fortnightly Progress Report**

The successful bidder shall submit fortnightly progress reports in triplicate to the Engineer showing along with necessary photographs, 125 mm x 90 mm size, and all details of actual achievements against the target programme specified in Sub-clause 5.2.1 above. Any shortfall in the achievement in a particular fortnight must be made up within the next fortnight. Along with this report, the successful bidder shall also furnish details of fabricated materials in hand at site and the strength of his workers.

6.00.00 MISCELLANEOUS GUIDELINES

ERECTION PRACTICE

(a) DO'S

(1) Carry out erection only after structures are thoroughly inspected and cleared.

(2) Start erection from braced bay.

(3) Ensure proper packing below the columns to have correct levels (to be checked by survey schemes)

(4) Ensure proper anchoring of column base by tightening of all anchor bolts.

(5) Ensure that guying is done at 2/3rd height in 3 directions 120 degree apart.

(6) Ensure that guy ropes are fully tight and anchored .Size of the guy rope should be adequate to take loads

(7) Provide temporary bracing wherever needed.

(8) Outstanding of flanges of beams /columns are to be protected against local bending at location of slinging during erection.

(9) Ensure that cross beam/bracings are erected only after the cleats/gussets are fully welded.

(10) Do the welding of cross beams with cleats, only after ensuring all bolts are in position and are tightened fully.

(b) DON'TS

(1) Don't leave the structures without proper guying in all directions till they are braced.

(2) Don't miss to anchor properly at the base of columns with anchor nuts fully tightened.

(3) Don't use manila ropes in place of steel ropes for guying.

(4) Don't support the cross beams with temporary jigs. Ensure all the bolts are provided and tightened.

(5) Don't use bracings/tie members for fixing lifting tackles/diversion pulleys/cable trays to avoid damages due to erection loads.

(6) Avoid indiscriminate cutting/notching of erected and loaded structures.

(7) Don't use column bases for anchoring guy ropes of structures.

GENERAL INSTRUCTION FOR WELDING

The Contractor shall work out welding procedure for the structures at his own responsibility and submit for Owner's/ consultant's information, considering the following factors.

a) Specification and thickness of steel.

b) Specification of electrode or/and base wire.

c) Welding process (manual arc welding, submerged arc welding).

d) Type of structures to be welded (thickness of components meeting at a joint).

e) Pre and post heating requirement.

f) Preparation of fusion faces.

g) Sequence of welding.

h) Weather condition.

i) Use of jigs and fixtures etc.

j) Type of non-destructive testing to be carried out.

k) Inspection procedure to be followed.

l) Design requirements of the joints.

Welding of any load bearing structure shall be carried out only by the person who has passed welder's qualification as per IS: 7318 (Part-I).

Contractor shall employ competent supervisors, exclusively for welding works, to ensure that the standard of workmanship and quality of materials comply with requirements of this specification.

All metal arc welding shall be carried out as per IS:9595-1996

Submerged arc welding of mild steel and low alloy steel shall be as per IS:4353-1995

Purchaser may at his own discretion order periodic tests of the Welders and/or of welds produced by them. Such tests shall be at the expense of the Contractor.

Electrodes shall be stored in a dry place. Electrodes whose coatings are damaged due to absorption of moisture or due any other reason shall not be used.

Low Hydrogen electrodes and flux for submerged welding shall be dried at 250°-300° C for one hour in drying even before use.

For suitability of wire flux combination, procedure test shall be carried out as per IS: 15977-2013 if so required.

Welding shall be done by electric arc process. Generally submerged arc, automatic & Semi-automatic welding shall be employed. Only where it is not practicable, manual arc welding may be resorted to. In case of manual arc welding, recommendations of electrode manufacturer are to be strictly followed.

After completing each run of weld, all slag should be thoroughly removed and surface cleaned before starting the next run of weld. The weld metal as deposited (including tack welds if to be incorporated) shall be free from cracks, slag, inclusions, gross porosity, cavities and other deposition faults. The weld metal shall be properly fused with the parent metal without serious undercutting or overlapping at the toes of the weld. The surfaces of the weld shall have a uniform and consistent contour and uniform appearance.

Fillet weld shall have the correct profile with smooth transition into parent metal. Dressing of welds, if specified, shall be done by such method, which does not cause grooving and other surface defects on the weld or on the parent metal.

All butt welds shall start and end with run-on and run-off plates. All such plates shall be carefully trimmed off by gas cutting after welding is over.

Fillet welds shall not be stopped at corners but shall be returned round them.

If butt weld is to be ground flush with the surface of the member as per drawing. Adequate reinforcement shall be built up and then the same shall be chipped off and ground flush. The grinding is to done in the direction of stress flow till the transverse marks are eliminated.

Welding shall not be done under such weather conditions, which might adversely affect the efficiency of the welding and arc-strikes on parent surfaces of structures shall be strictly avoided.

Manipulators shall be used wherever necessary and shall be designed to facilitate welding and ensure that all welds are easily accessible to the operators.

Stress relieving after welding shall be done if especially called for in the drawing or specification. Ends of structural members and portions of gussets receiving welding at site shall be left unpainted.

CONTROLS IN WELDING

The extent of quality control in respect of welds for structural elements for both statically and dynamically loaded structures shall be as follows and shall be conducted by the contractor at his own cost. Before inspection, the surface of weld metal shall be cleaned of all slag, spatter matter; scales etc. by using wire brush or chisel.

a) Visual Examination

All welds shall be 100% visually inspected to eliminate the following defects like Presence of undercuts, Visually identifiable surface cracks in both welds and base metals, Unfilled craters, Improper weld profile and size, excessive reinforcement in weld, Surface porosity etc.

b) Dye Penetration Test (DPT)

This shall be carried out in accordance with IS: 11732 – 1995, used for steel castings, for all important fillet welds and groove welds for both statically and dynamically loaded structures to check the following like Surface cracks, Surface porosity. Severity Level 3 shall be considered for acceptance.

c) Ultrasonic testing

Ultrasonic test shall be conducted for all groove welds and heat affected zone in dynamically loaded structures and for other important load bearing butt welds in statically loaded structures as desired by

purchaser, to detect the following like Cracks, Lack of fusion, Slag inclusions, Gas porosity.

All butt welds shall be tested for 100 % length by Ultrasonic tests and report shall be submitted.

Ultrasonic testing shall be carried out in accordance with American National Standard ANSI/AWS D1.1-96 Chapter -6: Part F.

Before ultrasonic test is carried out, any surface irregularity like undercuts, sharp ridges etc. shall be rectified. Material surface to be used for scanning by probes must allow free movement of probes. For this purpose, surface shall be prepared to make it suitable for carrying out ultrasonic examination.

d) Radiographic Testing (X-ray and Gamma-Ray Examination)

This test shall be conducted to a minimum of 2% of length of welds of each element of each butt joint for welds made by manual or semi-automatic welding and 1 % of length of weld if made by automatic welding machines. The location and extent of weld to be tested by this method shall be decided by purchaser to detect the following defects like gas porosity, slag inclusions, lack of penetration, lack of fusion, cracks.

Radiographic testing shall be conducted in accordance with American National Standard ANSI/AWS D1.1-96 Part E.

Any surface irregularity like undercuts, craters, pits etc. shall be removed before conducting radiographic test. The length of weld to be tested shall not be more than 0.75 x focal distance. The width of the radiographic film shall be width of the welded joint plus 20 mm on either side of the weld.

Before inspection, the surface of weld metal shall be cleaned of all slag, spatter matter; scales etc. by using wire brush or chisel.

ACCEPTABLE LIMITS OF DEFECTS IN WELD

Limits of Acceptability of welding defects shall be as follows.

a) Visual inspection & Dye Penetration Test –

The limits of acceptability of defects detected during visual inspection and Dye Penetration Test shall be in accordance with clauses 6.9 & clause 6.10 of American National Standard ANSI/AWS D1.1-96 or equivalent Indian Standards for statically as well as dynamically loaded structures respectively.

b) Ultrasonic Testing –

The limits of acceptability of defects detected during ultrasonic testing shall be in accordance with clause 6.13.1 & clause 6.13.2 of American National Standard ANSI/AWS D1.1-96 Chapter 6: Part C or equivalent Indian Standards for statically and dynamically loaded structures respectively.

c) Radiographic testing –

The limits of acceptability of defects detected during Radiographic testing shall be in accordance with clauses 6.12.1 & 6.12.2 of American National Standard ANSI/AWS D1.1-96 Chapter 6: Part C or equivalent Indian Standards for statically and dynamically loaded structures respectively.

RECTIFICATION OF DEFECTS IN WELDS

In case of detection of defects in welds, the rectification of the same shall be done as follows.

a) All craters in the weld and breaks in the weld run shall be thoroughly filled with weld.

b) Undercuts, beyond acceptable limits, shall be repaired with dressing so as to provide smooth transition of weld to parent metal.

c) Welds with cracks and also welds with incomplete penetration, porosity, slag inclusion etc. exceeding permissible limits shall be rectified by removing the length of weld at the location of such defects plus 10 mm from both ends of defective weld, and shall be re-welded. Defective weld shall be removed by chipping hammer, gouging torch or grinding wheel. Care shall be taken not to damage the adjacent material.

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SECTION-X

GUIDELINE
FOR
ROADS AND DRAINAGE

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SECTION-X

GUIDELINE
FOR
ROADS AND DRAINAGE

1.00.00 SCOPE

This specification covers all work required for the construction of R.C.C road including box-cutting, edging, Subgrade, sub-bases preparation, RC pavement slab etc. and shall include all incidental items of work not shown or specified but reasonably implied or necessary for the completion of the work.

This specification also includes all work required for drainage including roadside drain, R.C.C. culverts, drainage pipes, manholes etc. and all other incidental items.

2.00.00 GENERAL

2.01.00 EPC package bidder shall built up the entire plant road as per the cross section of the road specified elsewhere in the spec or as per the roads drawing.

Necessary temporary approach roads to the Lay down areas shall be laid by the successful bidder at their own cost

.

All the other roads within the plant area shall be under the scope of the bidder including formation of sub-grade, sub-base and laying of RCC.

All the roads in the entire plant area within the EPC package scope will be executed by successful bidder. All roads included in EPC Package as shown in Plot Plan shall be constructed by the successful bidder as per the basic design and layout.

Work to be provided for by the Successful Bidder:

The work to be provided for by the Successful Bidder, unless specified otherwise, shall include but not be limited to the followings:

a) Furnish all labour, supervision, services, tools and plants, transportation etc. required for the work. All materials and equipment shall be supplied by Bidder.

b) Submit for approval detailed schemes of all operations required for executing the work e.g. material handling, placement, services, approaches etc.

c) To carry out and submit to the Owner/Consultant results of tests whenever required by the Owner /Consultant to assess the quality of work.

2.02.00 **Work to be provided for by Others**

No work under this specification shall be provided for by any agency other than the Successful Bidder unless specifically mentioned elsewhere in the Contract.

2.03.00 **Codes and Standards**

All work under this specification, unless specified otherwise, shall conform to the latest revision as on the original scheduled date of tender opening and/or replacements of the following or any other relevant I.S. Specifications and Codes of Practice.

1. Specification for road and bridge works of Ministry of shipping & Transport (Roads wing) Published by the IRC.
2. IRC:19 Standard specifications and Code of Practice for Water Bound Macadam.
3. IRC:SP-11 Hand Book of Quality Control for Construction of Roads and Runways.
4. IS:456 Indian Standard Code of Practice for Plain and Reinforced Concrete.
5. IS:2212 Code of Practice for Brickwork.
6. IS:783 Code of Practice for Laying of Concrete Pipes.
7. IRC:15 Code of practice for construction of Concrete Pavement.
8. IRC:58 Guidelines for the Design of plain jointed Rigid Pavement.
9. Other specifications mentioned elsewhere in this specification.

In case any particular aspect of work is not covered specifically by Indian Standard Specification, any other standard practice as may be specified by the Owner/Consultant shall be followed.

2.04.00 **Conformity with Designs**

The Successful Bidder shall carryout the work as per the Bidder's drawings which are approved by the Consultant and/or the Consultant's instructions.

2.05.00 **Materials to be Used**

2.05.01 **General**

All materials required for the work shall be of best commercial variety and as approved by the Owner/Consultant.

2.06.00 **Quality Control**

The Successful Bidder shall establish and maintain quality control for the various aspects of the work, method, materials and equipment used. All works performed shall conform to the lines, grades, cross-sections and dimensions shown on the drawings or as directed by the Owner/Consultant. Permitted tolerances for road works are described hereinafter.

2.07.00 **Concrete Road and Rigid Pavement**.

Plant Roads:

Access within the plant site shall be provided by a system of roadways.

All roads& approach roads to the buildings / structures shall be of RCC roads and inspection road for both Ash Pond and Raw Water Reservoir, inspection road upto Raw water intake pump house, Patrol road (as shown in plot plan) inside boundary of Plant compound wall are BT roads. Bund top roads of Raw water reservoir and ash ponds shall be WBM Road. Ramp of Ash pond and Raw water reservoir shall be of RCC.

.

All building and facilities shall be approached by access road from the main roads, which shall either be 7.5m carriage width only.

The sub base over the well compacted subgrade of all plant service roads within plant area will initially be made of well graded granular material like locally available laterite (63mm down-graded) / stone boulders as per IRC-63 and 100mm DLC with hard shoulder on either side of carriage width. After major construction activities are completed the road shall be surfaced with RC concrete slab as per proper design requirement after attending all pot holes, damages, undulations etc

All main plant (RCC) roads within plant area shall have rectangular RCC side drain along both sides.

All RCC Roads and parking area shall be designed in accordance with the provision of the latest edition of the relevant I.R.C. codes of practice and MOST specification (MORT&H) for movement of heavy equipment.

The sub-grade whether in cut or fill shall be well compacted to utilize its full strength. The R.C.C roads of required thickness as per design or 250mm thick whichever is higher shall be laid over 100mm PCC M10 and 100mm DLC on a

laterite / stone boulder sub-base of 230 mm consolidated thickness with 63 mm downgraded aggregate size.

All the roads shall be of width as specified in Overall plot plan & Roads and drains layout tender drawings. Shoulder width shall be 1500 mm on both sides for all type of roads.

All the roads inside the plant area shall be of reinforced cement concrete of minimum 250 mm thick.

.

All type of roads shall have a minimum turning radius as per relevant IRC codes (IRC-38).

Kerbs stones shall be provided alongside of all RCC roads. Spare duct bank shall be provided under all type roads spaced at 100m intervals or wherever required as decided by the Owner/Consultant.

Sign boards shall be provided for vehicle management and shall meet the Indian standards. All signs shall be dual worded in both English and the local Indian language. Finished top (crest) of roads shall be 250mm min above the adjoining FGL. Geometric design of road shall be in accordance with IRC: 73. The ruling gradient for roads in longitudinal direction shall not exceed 1 in 25.

The shoulder shall be laid with slope of 1 in 30.

Top level of parking area shall be flushed with crown connecting roads with cross slope. Parking area shall be provided rigid pavements & shall be provided with anti-skid interlocking concrete paver blocks.

On either side of roads, open RCC drains shall be provided. Minimum clear width of drains shall be 600mm.The drains shall be designed and built using RCC. Drainage lines and other underground services shall be located at least 1m clear from the edge of the roads. Only RCC box culverts shall be provided for drainage and for all the underground conduits at road crossings. All culverts carrying storm water shall be cast in place RCC box culverts. The RCC drains in Boiler area, Transformer Yard area and Switch Yard area shall be with RCC perforated cover slabs with GI gratings at a regular interval of 4m.

No underground service piping except for drainage and sewage system shall run directly below the road (including upto 1 m. from edge of road) along its longitudinal direction.

Surface drainage of roads shall be provided by giving proper longitudinal slopes and cross falls.

The roads must be designed for the heaviest equipment of the plant and before designing the CBR test to be carried out. Road shall be designed as per IRC & MOST standards. (MORT&H).

The Cross section for Reinforced Concrete road shall be as follows:

i) The Sub-grade, whether in cut or fill shall be well compacted to utilize its full strength. The Sub-grade shall have no soft spots or voids and undulations and shall be well compacted to achieve a minimum 95% dry density.

ii) Laterite / Stone Boulders sub-base of 230 mm consolidated thickness with 63 mm downgraded aggregate size. This shall be laid in two layers of 115mm consolidated thickness. The voids shall be filled completely with gravel/sand.

iii) 100mm thick dry lean concrete (DLC).

iv) 100mm thick M10 grade PCC.

v) Toping with RCC Pavement of 250mm thick M30 mix, with double mat reinforcement of 10tor @ 200 c/c both ways or as per the design whichever is higher.

vi) The drainage system shall be designed for precipitation intensity of 100mm per hour.

The above specified description is minimum and indicative and the successful bidder has to design and provide roads as per actual functional requirements and design criteria stipulated in relevant codes.

The detailed methodology for construction of concrete /rigid pavement including construction and expansion joint shall be prepared by the successful bidder for approval of Owner.

BT Roads and WBM Roads

BT roads (flexible pavement) shall be designed in accordance with the provision of the relevant IRC Codes of Practices.

Road shall be designed as per IRC-37: 1984 “Guidelines for the design of flexible pavements”. California Bearing Ratio (CBR) method shall be adopted for the design of roads. Sub-base shall be of granular material with laterite/Broken stone (63mm downgraded) filled with 1/3 volume of gravel/sand in the interstices. This shall be of 230mm consolidated thick laid in two layers of 115mm consolidated thick. Over this 150mm thick water bound macadam course (WBM) construction with 40mm downgraded Blue Granite Metal laid in two layers of 75mm consolidated thick.

. The wearing course shall be of 40mm thick bituminous macadam binder course with 12mm downgraded BG metal with 12mm thick seal coat laid over it. Shoulder and Kerb shall be as specified elsewhere in this specification.

2.08.00 **Road Side Drains**

2.08.01 **Formation of Drains**

Generally Open RCC rectangular drains shall be provided for storm water. The thickness of sides & bottom shall be minimum 125 mm upto 0.5m depth and 150mm thick with double reinforcement for more than 0.5m depth or as per design considerations whichever is higher. RCC box culverts shall be provided for road and rail crossing. Drains shall be provided on both sides of the roads.

Inside surface of the drain shall have screed concrete with 12mm blue metal chips in M20 and smooth neat cement finish over screed concrete. Invert of the drain shall be decided in such a way that the water can easily be discharged to the recommended nearest outfall outside the plant boundary. The slope of the drain shall be 1:1000 longitudinally in general. However, discharge velocity shall be within non-silting & non-scouring condition.

2.09.00 **Culverts (RCC)**

Excavation in trenches for foundation of culverts and wing walls shall be done with side slopes as per the instructions of Owner/Consultant after clearing the site, etc. as per specifications of earthwork. Backfilling with ramming and watering shall be done after construction of the foundations.

The construction of culverts shall be done true to lines and levels and as shown on the drawing. The specification for Reinforced Cement concrete shall be followed. The top level of the Culverts shall match with the top level of road.

2.10.00 **Shoulders**

The sub grade shall be compacted well and the sub base shall be 230mm consolidated thickness of stone boulders/laterite soling as per specification over which P.C.C (M20) shall be laid to required thickness. The level of the shoulder shall be in line with the road top level or at higher level based on the location which will be decided during detailed engineering. Necessary chutes to the adjoining drain shall be provided.

2.11.00 **Kerbs**

Pre cast P.C.C (M20) continuous Kerb stone 650mm (D) x 500mm (W) X100 (T) mm thick for the pavement shall be provided on both sides of carriage way of concrete roads and every 10 kerb shall be flushed to road level. Kerbs shall be laid and set in place before completing the concrete wearing surface as well as the concrete wearing surface of shoulder. Setting shall be done in mortar where so specified. They shall be laid and set in such a way as to obtain straight lines in the finished work, the top surface matching with the

finished surface of shoulder if the shoulder is at higher level of the road. Where the road edge forms a curve, the kerbs shall follow such curve. Gaps may be left as shown in drawings or as may be required to provide for drainage. They shall be fixed true to line and level and secured in position by approved means.

The Kerbs shall be painted as per IRC- 35 (latest edition).

3.00.00 MANHOLES AND INSPECTION CHAMBERS

The channel or drain at the bottom of chamber shall be plastered with 1:2 cement sand mortar and finished smooth to the grade. The channels and drains shall be shaped and laid to provide smooth flow. All manholes and chambers are RCC grade M30.

Cement Concrete (Plain and Reinforced)

This Shall be as laid down in “Guideline for Cement Concrete (Plain and Reinforced)” Part – A Section - VI.

4.00.00 TESTING AND ACCEPTANCE CRITERIA

4.01.00 Roads

All testing, as mentioned in the body of the specification and as mentioned in Clause No. 900 of Specification for Roads and Bridge Works, 1983 published by IRC on behalf of Ministry of Shipping and Transport(Roads Wing) shall be carried out by the Successful Bidder as per direction of the Consultant. No extra payment shall be made for such tests.

4.02.00 NOT USED

4.03.00 Cement Concrete

The strength requirements and acceptance criteria shall conform to the relevant clauses of IS:456.

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NOT USED

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PART-B

GUIDELINE
FOR
ARCHITECTURAL WORKCONTENTS

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SECTION-I

GUIDELINE
FOR
PROPERTIES, STORAGE AND HANDLING OF COMMON BUILDING MATERIALS

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SECTION-I

GUIDELINE
FOR
PROPERTIES, STORAGE AND HANDLING OF
COMMON BUILDING MATERIALS

1.00.00 SCOPE

The scope of this Section is to specify the properties, storage and handling of common building materials unless otherwise mentioned in drawings or specification.

2.00.00 MATERIALS

a) **Bricks**

i) Common Burnt Clay Bricks:Bricks for general masonry work shall conform to IS: 1077-1970 and for face brick work shall conform to the specifications in IS: 2691-1972.

Bricks for general masonry work shall be of first class (Class-A) quality, well burnt, of uniform size, shape and colour free from cracks, flaws warpage or nodules or free lime, having a frog 100mm in length 40 mm in width and 10mm to 20mm deep on one of its flat sides and emit clear ringing sound when struck. Fractured surface shall show uniform texture free from grits, lumps boles etc.

Compressive strength shall be as per table-1below.The bricks, when tested, shall have a minimum average compressive strength for various classes as given in Table-1below. The compressive strength of any individual brick tested shall not fall below the min. average compressive strength specified for the corresponding class of brick by more than 20%. In case compressive strength of any brick tested exceeds the upper limit for the corresponding class of bricks, the same shall be limited to upper limit of the class as specified in Table-1 for the purpose of calculating the average compressive strength. The minimum class requirement is class 5 of compressive strength of 50 kg/sqm.

The average value of water absorption of bricks when tested shall not be more than 20% by weight.The dimensions of the Bricks shall be 230x110x70mm.

All bricks shall have rectangular faces and sharp straight edges. Maximum permissible chippage for face bricks shall be 6 mm at the edges and 10 mm for corners. The rating of efflorescence shall not be more than 'moderate'.

Each brick shall have the manufacturer's identification marks clearly marked on the frog. Representative samples shall be submitted and approved sample shall be retained by the Engineer for future comparison and reference. The colour and texture of face bricks shall be up to the specification and defective bricks shall be removed immediately from site at the Bidder's own cost.

TABLE-1

Class Designation	Average compressive strength			
	Not less than			
	N/mm^2	(kg/cm^2)		
12.5(125)	12.5	(125)		
10 (100)	10	(100)		
7.5 (75)	7.5	(75)		
5 (50)	5	(50)		
3.5 (35)	3.5	(35)		

ii) Fly Ash Lime Bricks (FLAG Bricks):The Fly Ash Lime Bricks (flag Bricks) shall conform to IS 12894. The dimensions of the Fly ash bricks shall be 230x110x70mm.Visually the bricks shall be sound, compact and uniform in shape free from visible cracks, warpage, flaws and organic matter. The bricks shall be solid and with frog on one flat side and without frog on other flat side. Fly ash shall confirm to IS 3812.The average compressive strength shall conform to Class 5 as given in the Table above.

Note: Fly ash bricks will be operated only for non-load bearing walls and above ground level.

Sand: Deleterious materials, such as clay and silt in the sand shall preferably be less than 5%.

Lime: Lime shall confirm to class 'C' hydrated lime of IS 712

Additives: Any suitable additive considered not detrimental to the durability of bricks may be used.

Alternatively Lime may be replaced by cement in manufacturing of Flyash bricks. The cement shall be blended at the rate of 8 to 12%

iii) **Mechanised Autoclave Fly Ash Lime Brick:** These bricks shall be machine moulded and prepared in plat by appropriate proportion of fly ash and lime/cement. The autoclave fly ash bricks shall conform to IS 12894. Visually, the bricks shall be sound, compact and uniform shape, free from visible cracks, warpage and organic matters. The brick shall be solid with or without frog, and the frog shall be of 100/80 mm in length, 40 mm width and 10 to 20 mm deep on one of its flat sides as per IS 12894. The brick shall have smooth rectangular faces with sharp corners and shall be uniform in shape and colour. Fly ash shall conform to IS 3812 and lime shall conform to class 'C' hydrated lime of IS 712.

b) **Stone**

For all concrete works Blue Granite Metal shall only be used.

All stones shall be from approved quarries, hard, tough, durable compact grained, uniform in texture and colour and free from decay, flaws, veins, cracks and sand holes. The surface of a freshly broken stone shall be bright, clean and sharp and shall show uniformity of texture, without loose grains and free from any dull, chalky or earthy appearance. Stone showing mottled colours shall not be used for face work. A stone shall not absorb more than 5 per cent of its weight of water after 24 hours immersion and for laterite this percentage is 12%. The type of stone shall be as specified on drawings and/or instructed by the Engineer. Samples shall be submitted by the Bidder and approved samples shall be retained by the Engineer for comparison of bulk supply. The compressive strength of common types of stones shall be as per Table below.

TABLE-2

Type of stone	Maximum Water Absorption Percentage by weight	Minimum Compressive Strength kg/sq.cm
Granite	0.5	1000
Basalt	0.5	400
Lime stone(Slab & Tiles)	0.15	200
Sand stone (Slab & Tiles)	2.5	300
Marble	0.40	500
Quartzite	0.40	800
Laterite(Block)	12	35

c) **Lime**

Lime shall be stone lime and conform to the specification Building Limes - IS: 712. Lime putty may be prepared from hydrant lime or quick lime. Hydrated lime shall be mixed with water to form putty and stored with reasonable care to prevent evaporation for at least 24 hours before use. Quick lime shall be shaked with enough water to make a cream, passed through a No. 0 Sieve and then stored with reasonable care to prevent evaporation for at least 7 days before use.

d) **Cement**

Cement (OPC grade 43) used shall be ordinarily Portland cement conforming to Code for ordinary cement in IS: 269 and shall be fresh when delivered. The Bidder shall submit the manufacturer's test certificate for each consignment of cement procured to the Engineer If at any time, the Engineer feels that the cement being used by the Bidder is not up to specification, he may stop the work and send the samples of the cement to a testing laboratory for standard tests and all expenses incurred thus shall be borne by the Bidder. The Bidder shall also have no claim for this type of suspension of work.

e) **Coarse Aggregates**

Coarse aggregates shall be as per IS:383 latest edition, consisting of hard, strong and durable pieces of crushed stone and shall be free from organic or clay coatings and other impurities like disintegrated stones, soft flaky particles etc. and any other material liable to affect the strength, durability or appearance of concrete.
Aggregates other than crushed stone conforming to the provisions of specification may be used if permitted by the Engineer.

Washing of aggregates by approved means shall be carried out, if desired by the Engineer.

Grading of coarse aggregates shall generally conform to IS:383 and shall be such as to produce a dense concrete of the specified proportions and strength and of consistency that will work readily into position without segregation.

f) **Sand**

Sand shall be hard, durables, clean and free from adherent coatings or organic matter and shall not contain clay balls or pellets. The sand shall be free from impurities such as iron pyrities, alkalis, salts, coal, mica or other laminated materials in such forms or quantities as to affect adversely the hardening, strength, durability or appearance of mortar, plaster or concrete or to cause corrosions to any metal in contact with such mortar, plaster or concrete. All sand shall be properly graded. Unless otherwise directed by the Engineer all sand

shall pass through IS Sieve No. 240 and 15 to 35% for masonry mortar and 5 to 50% of sand for plaster shall pass through IS Sieve No. 30. Sand for concrete shall conform to IS: 383.

Generally River sand shall be used for all the works.In case of scarcity/non-availability of River sand,M-Sand may be used at the discretion of the Engineer-in-charge at site as specified elsewhere.

g) **Water**

Water shall be clean, fresh and free from organic matters, acids or soluble salts and other deleterious substances which may cause corrosion, discolouration, efflorescence etc.

h) **Reinforcement**

Reinforcement steel shall be clean and free from loose mill scales, dust, loose rust, oil and grease or other coatings which may impair proper bond. Structural steel shall conform to IS: 2062. Mild steel and medium tensile steel bars and hard-drawn steel wire for concrete reinforcement shall conform to IS: 432. HoweverCold twisted steel bars conforming to IS: 1786shall be used in this package. Hexagonal wire netting shall conform to IS: 3150. All steel bars shall be of tested quality. All wire netting shall be galvanised.. All reinforcements shall be Corrosion Resistant Steel (CRS).

3.00.00 STORAGE AND HANDLING OF MATERIALS

a) **Bricks**

Bricks shall not be dumped at site. They shall be stacked in regular tiers, even as they are unloaded, to minimise breakage and defacement of bricks. Bricks selected for different situation of use in the work shall be stacked separately.

b) **Stones**

Stones shall be stored at site in manner approved by the Engineer. Dressed stone for wall facing, paving etc. shall be stored with special care to avoid defacement of faces and edges or damp and rust stains.

c) **Lime**

Lime shall be stored in weatherproof sheds.

d) **Cement**

The cement shall be stored above the ground level in perfectly dry and watertight sheds. The bags shall be stacked in a manner so as to facilitate removal or first in first out basis. Any material considered

defective by the Engineer shall not be used by the Bidder and shall be removed from the site immediately.

e) **Coarse and Fine Aggregates**

Aggregates shall be stored on brick soling or an equivalent platform so that they do not come in contact with dirt, clay, grass or any other injurious substances at any stage. Aggregate of different size shall be kept in separate stacks. If so desired by the Engineer aggregate from different sources shall be stacked separately with proper care to prevent intermixing.

f) **Reinforcement**

Reinforcement(CRS) bars shall be stored off the ground and under cover if so desired by the Engineer. If necessary, a coat of cement wash shall be given to the bars to guard against rusting.

4.00.00 I. S. CODES

Following are some of the important I.S. Codes and standards relevant to this Section:

IS: 1077-1970	:	Common Burnt Clay Building Bricks –Specification
IS: 2691-1972	:	Burnt clay facing bricks-Specification
IS 12894: 2002	:	Pulverized Fuel Ash-Lime bricks - Specification
IS 712: 1984	:	Specification for building limes
IS 383:2016	:	Course and fine aggregate for concrete-specification
IS 1727: 1967	:	Methods of test for pozzolanic materials
IS-269-1989	:	Ordinary Portland cement 33 grade Specification
IS-8112-1989	:	Ordinary Portland cement 43 grade specification
IS-12269-1987	:	Ordinary Portland cement 53 grade specification
IS: 3812-2003(PART1):		Pulverized fuel ash specifications for use of pozzolona in cement, cement mortar and concrete
IS-3812-2003(PART 2):		Pulverized fuel ash specifications for use as admixture in cement mortar and concrete
IS 3495(Part1): 1992	:	Determination of compressive strength of burnt clay building bricks
IS 3495(Part 2)1992	:	Determination of water absorption of burnt clay building bricks
IS 3495(Part 2)1992	:	Determination of efflorescence of burnt clay building bricks
IS 3812: 1981	:	Specification for fly ash for use as pozzolana and admixture
IS 4082: 1996	:	Recommendations on stacking and storage of Construction materials and components at site
SP 27: 1987	:	Handbook of Method of Measurement of Buildings Works

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SECTION-II

GUIDELINE
FOR
ANTI-TERMITE TREATMENT

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SECTION-II

GUIDELINE
FOR
ANTI-TERMITE TREATMENT

1.00.00 SCOPE

The scope of work is to prevent the subterranean termites from reaching the super-structure of the building and its contents can be achieved by creating a chemical barrier between the ground, from where the termites come and other contents of the building which may form food for the termites while the building is under construction. This is achieved by treating the soil beneath the building and around the foundation with a suitable insecticide.

2.00.00 EXECUTION

2.01.00 General

All work shall in general be executed as specified in IS: 6313 Part II-2013 and as per approved specification of the agency having special know-how for the job.

All necessary work to ensure uniform distribution and proper penetration of treatment of treating solution shall be done according to the instruction of the Engineer.

Soil treatment shall not be done when it is raining or when the soil is wet with rain or subsoil water. Once formed, the treated soil barrier shall not be disturbed.

Anti-termite treatment chemical is available in concentrated form in the market and concentration is indicated on the sealed containers. To achieve the specified percentage of concentration, chemical shall be diluted with water in required quantity before it is used. Graduated containers shall be used for dilution of chemical with water in the required proportion to achieve the desired percentage of concentration as per Manufacturer recommendation.

2.02.00 Safety Precautions

Chemical used for anti-termite treatment are insecticides with a persistent action and are highly poisonous. This chemical can have an adverse effect upon health when absorbed through the skin, inhaled as vapours or spray mists or swallowed.

The containers having emulsifiable concentrates shall be clearly labeled and kept securely closed in stores so that children or pet cannot get at them. Storage and mixing of concentrates shall not be done near any fire source or flame. Persons using these chemical shall be warned that absorption though skin is the most likely source of accidental poisoning. Particular care shall be taken to prevent skin contract with concentrates and prolonged exposure to dilute emulsion shall also be avoided. After handling the concentrates or dilute emulsion, workers shall wash themselves with soap and water and wear clean clothing, especially before eating. In the event of severe contamination, clothing shall be removed at once and skin washed with soap and water. If chemical has splashed into the eyes, they shall be flushed with plenty of soap and water and immediate medical attention shall be sought.

Care shall be taken in the application of chemicals to see they are not allowed to contaminate wells or springs which serve as source of drinking water.

2.03.00 **Chemicals and Rate of Application**

Any of the following chemicals (conforming to relevant Indian Standards) in water emulsion shall be applied by pressure pumps, uniformly over the area treated.

Chemicals		**Concentration by Weight, Percentage**
ChlorpyrifosEmulsifiable (20EC) (IS 8944 - 1978)	:	1.0
Heptachlor Emulsifiable (20EC) Concentrate (IS: 6439 - 1978)	:	0.5
Chlordane Emulsifiable (20EC) Concentrate (IS: 2682 - 1984)	:	1.0
Lindane (20 EC) (IS: 632)	:	1.0

2.03.01 **Treatment**

To facilitate proper penetrations of chemical in to the surface to be treated, hand operated pressure pump shall be used. To have proper check for uniform penetration of chemical, graduated containers shall be used. Proper check shall be kept so that the specified quantity of chemical is used for the required area during the operation. Chemical treatment for the eradication and control of sub-terraneantermites shall be done as per IS 6313 (Part III).

2.03.02 **Treatment of Column Pits, Wall Trenches and Basement Excavations**

Foundations, basements etc. may either be fully enveloped by the chemical barrier or the treatment may start from finished 500 mm to the bottom of foundation. The bottom surface and sides of excavation (up to a height of about 300 mm) for column pits, walls trenches and basements shall be

treated with chemicals at the rate of 5 litres / M^2 of surface area and for balance height upto FGL shall be at the rate of 7.5 lit/sqm.. Backfills around columns, walls etc. shall be treated at the rate of 7.5 litres / M^2 of the vertical surface. Chemical treatment shall be done in stages following the compaction of earth in layers. The treatment shall be carried out after the ramming operation is done by rodding the earth at 150 mm centres close to the wall surface and spraying the chemicals in the specified dose.

If there is a concrete or masonry apron around the building, approximately 12mm diameter holes shall be drilled as close as possible to the plinth wall about 300mm apart, deep enough to reach the soil below and the chemical emulsion pumped into these holes to sock the soil below at the rate of 2.25 litres per linear metre.

2.03.03 **Treatment of Top Surface of Plinth Filling**

Holes 50 cm to 75 cm deep at 100 cm centres both ways shall be made with crowbars on the surface of compacted plinth fill. Chemical emulsion at the rate of 5 litres / $M^2$of surface shall be applied prior to laying soling or sub-grade. Special care shall be taken to maintain continuity of the chemical barrier at the junction of vertical and horizontal surfaces.

2.03.04 **Treatment of Soil Surrounding Pipes, Wastes and Conduits**

Special care shall be taken at the points where pipes and conduits enter the building and the soil shall be treated for a distance of 150 cm and a depth of 75 cm at the point where they enter the building.

2.03.05 **Treatment of Expansion Joints**

These shall receive special attention and shall be treated in a manner approved by the Engineer.

2.03.06 **Treatment at Junction of the Wall and the Floor**

Special care shall be taken to establish continuity of the vertical chemical barrier on inner wall surfaces from ground level up to the level of the filled earth surface.

A small channel 30 x 30 mm shall be made at all the junctions of wall and columns with the floor. Rod holes made in the channel up to the ground level 300 mm apart and the chemical emulsion poured along the channel at the rate of 7.5 litres per square meter of the vertical wall or column surface. The soil shall be tamped back into place after this operation.

3.00.00 I.S. CODE

Relevant code applicable for this Specification.

IS: 6313 (Part-II) 2013 : Code of Practice of Anti-Termite Measures in Buildings (pre-constructional)

IS: 632	:	Gamma-BHC (Lindane) emulsifiable Concentrates
IS: 8944 – 1978	:	Chlorpyrifosemulsifiable concentrates
IS: 8963	:	Chlorpyrifos- Technical specifications
IS: 6439 – 1978	:	Heptachlor Emulsifiable
IS: 2682 – 1984	:	Chlordane Emulsifiable
		Pre-constructional chemical treatment measures.

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SECTION-III

GUIDELINE
FOR
MASONRY AND ALLIED WORK

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SECTION-III

GUIDELINE
FOR
MASONRY AND ALLIED WORK

1.00.00 SCOPE

This specification covers furnishing, providing, installation, repairing, finishing, curing, protection, maintenance and handing over of masonry and allied works for use in structures and locations covered under the scope of the Contract.

2.00.00 INSTALLATION

2.01.00 Masonry

2.01.01 General

All masonry work shall be true to lines and levels as shown on drawings. All masonry shall be tightly built against structural members and bonded with dowels, inserts etc. as shown on drawings.

2.01.02 Mortar

Mix for mortar shall be specified..

For cement sand mortar cement and sand in requisite proportions shall be mixed dry in a mechanical mixer and then water added and mixed further. Minimum quantity of water shall be added to achieve working consistency.

Surplus mortar droppings from masonry, if received on surface free from dirt may be mixed with fresh mortar if permitted by the Engineer who may direct addition of additional cement without any extra payment. No mortar, which has stood for more than half an hour, shall be used.

2.01.03 Brick Masonry

Bricks shall be soaked in water before use for a period for the water to just penetrate the whole depth of the bricks. Alternatively bricks may be adequately soaked in stacks by profusely spraying with clean water at regular intervals for a period not less than six hours. When the bricks are soaked they shall be removed from the tank sufficiently early so that at the time of laying they are skin-dry. Such soaked bricks shall be stacked on a clean place where they are not again spoiled by dirt earth etc.

Bricks shall be laid in English bond unless specified otherwise. Broken bricks shall not be used. Cut bricks shall be used if necessary to complete bond or as closers. For brick work in half brick wall, bricks shall be laid in stretcher bond. Header bond shall be used preferably in all courses in curved plan for ensuring better alignment. Bricks shall be laid with frogs upwards over full mortar beds. Bricks shall be pressed into mortar and tapped into final position so as to embed fully in mortar. Inside faces shall be buttered with mortar before the next bricks is placed and pressed against it. Thus all joints between bricks shall be fully filled with mortar. At the joint of brick masonry with RCC column/beam/wall, the mortar shall be with rich grade to avoid shear cracks.

Mortar joints shall be kept uniformly 10 mm thick. All joints on face shall be raked to minimum 10 mm depth using raking tool while the mortar is still green to provide bond for plaster or pointing. The inside face of the brick work shall be buttered with mortar before the next brick is laid and pressed against it. Joints shall be fully filled and packed with mortar such that no hollow spaces are left inside the joints. Where plaster or pointing is not provided, the joints shall be struck flush and finished immediately. Brickworks two bricks thick or more shall have both faces in true plane. Brickwork of lesser thickness shall have one selected face in true plane.

2.01.04 Reinforced Brickworks

Reinforcements shall be as specified. All reinforcements shall be thoroughly cleaned and fully embedded in mortar. Where M.S. bars are used as reinforcement, these shall be lapped with dowels if left in R.C. Columns or welded to steel stanchions.

2.01.05 Expansion & Separation Joints

Location of joints shall strictly be as shown on drawings or as instructed by the Engineer. Expansion joints shall be as shown on drawings and as specified. Expansion joint filler boards and sealing strips shall have minimum transverse joints. Transverse joints shall meet the approval of the Engineer.

Separation joints shall be with standard waterproof paper or with alkathene sheets about 1 mm in thickness. Length and sealing of laps shall be to the satisfaction of the Engineer.

2.01.06 Moldings, Cornices, Drip Course

These shall be made as shown in drawings. Bricks shall be cut and dressed as required. If no subsequent finish is envisaged, these shall be rubbed to correct profile with carborandum stone.

2.01.07 Curing

Masonry shall be cured by keeping it wet for seven days from the date of laying. In dry weather at the end of days work top surface of masonry shall be kept wet by ponding.

2.01.08 **Embedding of fixtures**

All fixtures shall generally be embedded in mortar and masonry units shall be cut as required.

2.01.09 **Encasing of Structural Steel**

This shall be done by building masonry work, around flanges, webs etc. of steel members and filling the gap between steel and masonry by minimum 12 mm thick rich mortar. Encased members shall be wrapped with minimum 18G chicken wire mesh when shown on drawings or instructed by the Engineer, before plastering work.

The minimum lap in chicken wire mesh shall be 50 mm.

2.02.00 **Damp Proof Course**

Unless otherwise specified Damp-proof course shall be 40 mm thick 'artificial stone' in proportion 1:1-1/2:3 cement sand stone-chips (10 mm down) with admixture of a waterproofing compound as approved by the Engineer. The percentage of admixture shall be as per manufacturer's specifications but not less than 2% by weight of cement. The top surface shall be double chequered and cured by ponding for seven days.

2.03.00 **Damp Proof Membrane**

Damp proof treatment using fiber base bitumen felt shall be 6, 8 or 10 course treatments as specified in IS: 1609. The number of courses shall be as mentioned elsewhere in the specification. Sequence or work shall be as directed by the Engineer. Extreme care shall be taken to prevent damage to felt during and after lying. The Bidder shall be obliged, at his own expense, to rectify any leakage appearing within 5 years of installation by removing and renewing the coats at the point of leakage.

Where shown on drawing, damp proof membrane with one layer bitumen paper or one layer alkathene sheet shall be laid with minimum 150mm lap under slabs on grade.

3.00.00 I.S. CODES

Some of the important relevant codes for this section are: -

IS: 1127	:	Recommendations for dimensions and workmanship of natural building stones for masonry work.
IS : 2185	:	Code Practice for hollow concrete block.
IS: 1597	:	Code of Practice for Construction of stone Masonry.

IS: 1609	:	Code of Practice for laying Damp-proof treatment Using bitumen felts.
IS: 2212	:	Code of Practice for Brickwork.
IS: 2250	:	Code of Practice for preparation and use of Masonry Mortar.
IS: 5134	:	Bitumen Impregnated Paper & Board.
SP 27: 1987	:	Handbook of Method of Measurement of Buildings Works

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SECTION-IV

GUIDELINE
FOR
FINISH TO MASONRY AND CONCRETE

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SECTION-IV

GUIDELINE
FOR
FINISH TO MASONRY AND CONCRETE

1.00.00 SCOPE

This Specification covers furnishing, installation, repairing, finishing, curing, testing, protection, maintenance till handing over of finishing items for masonry and concrete. This shall also include the work to be done to make the surface suitable for receiving the finishing treatment.

Before commencing finishing items the Bidder shall obtain the approval of the Engineer regarding the scheduling of work to minimize damage by other trades. He shall also undertake normal precaution to prevent damage or disfiguration to work of other trades or other installation.

2.00.00 INSTALLATION

2.01.00 Scaffolding

For all exposed brick work or tile work double scaffolding independent of the work having two sets of vertical supports shall be provided. The supports shall be sound and strong, tied together with horizontal pieces over which scaffolding planks shall be fixed.

For all other work in buildings, single scaffolding shall be permitted. In such cases the inner end of the horizontal scaffolding pole shall rest in a hole provided only in the header course for the purpose. Only one header for each pole shall be left out. Such holes for scaffolding shall, however, not are allowed in pillars/columns less than one metre in width or immediately near the skew backs of arches. The holes left in masonry works for scaffolding purpose shall be filled and made good before plastering.

Note: In case of special type of brick work, scaffolding shall be got approved from Engineer-in-Charge in advance.

2.01.01 Preparation of Surface

The cement plaster shall be 10 mm, 12mm, 15mm, 18mm or 20mm as specified.

All joints in masonry walls shall be raked out to a depth of at least 10 mm with a hooked tool made for the purpose while the mortar is still green. Walls shall be brushed down with stiff wire brush to remove all loose dust from joints. Efflorescence if any shall be removed by brushing and scrapping. The surface shall then be thoroughly washed with water, cleaned and kept wet before plastering is commenced. All laitance shall be removed from concrete to be plastered.

For all types of flooring, skirting and dado work, the base cement concrete slab or masonry surface shall be roughened by chipping and cleaned of all dirt, grease or loose particles by hard brush and water. The surface shall be thoroughly moist to prevent absorption of water from the base course. Any excess of water shall be mopped up.

At any point, the level of base shall be lower than the theoretical finished floor level by the thickness of floor finish. Any chipping or filling to be done to bring the base in the required level shall be brought to the notice of the Engineer and his approval shall be taken regarding the method and extent of rectification work required.

Prior to commencement of actual finishing work, the approval of the Engineer shall be taken as to the acceptability of the base.

2.02.00 Plastering

2.02.01 Mortar

Mortar for plastering shall be as specified in the specifications.

For sand cement plaster, sand and cement in the specified proportion shall be mixed dry on a watertight platform and minimum water added to achieve working consistency.

No plaster, which has stood for more than half an hour, shall be used; plaster that shows tendency to become dry before this time shall have water added to it.

2.02.02 Application of Plaster

Ceiling plaster shall be completed before commencement of wall plaster.

Plastering shall be started from the top and worked down towards the floor. All putlog holes shall be properly filled in advance of the plastering as the scaffolding is being taken down. To ensure even thickness and a true surface, plaster about 15 x 15 cm shall be first applied, horizontally and vertically, at not more than 2 metre intervals over the entire surface to serve as gauges. The surface of these gauged areas shall be truly in the plane of the finished plaster surface.

The mortar shall then be laid on the wall, between the gauges with trowel. The mortar shall be applied in a uniform surface slightly more than the specified thickness. This shall be brought to a true surface, by working a wooden straight edge reaching across the gauges, with small upward and sideways movements at a time. Finally the surface shall be finished off true with trowel or wooden float according as a smooth or a sandy granular texture is required. Excessive troweling or over working the float shall be avoided.

All corners, arises, angles and junctions shall be truly vertical or horizontal as the case may be and shall be carefully finished. Rounding or chamfering corners, arises, provision of grooves at junctions etc. where required shall be done. Such rounding, chamfering or grooving shall be carried out with proper templates or battens to the sizes required.

When suspending work at the end of the day, the plaster shall be left, cut clean to line both horizontally and vertically. When recommencing the plastering, the edge of the old work shall be scrapped cleaned and wetted with cement slurry before plaster is applied to the adjacent areas, to enable the two to properly join together. Plastering work shall be closed at the end of the day on the body of wall and not to nearer than 15 cm to any corners or arrises. It shall not be closed on the body of the features such as plasters, bands and cornices, nor at the corners of arrises. Horizontal joints in the plaster work shall not also occur on parapet tops and copings as these invariably lead to leakages. The plastering and finishing shall be completed within half an hour of adding water to the dry mortar.

No portion of the surface shall be left out initially to be patched up later on. The plastering and finishing shall be completed within half an hour of adding water to the dry mortar.

Thickness

Where the thickness required as per specification is 20mm the average thickness of the plaster shall not be less than 20mm weather the wall treated is of brick or stone.But, In case of brick work, the minimum thickness over any portion of the surface shall be not less than 15mm.

Curing

Curing shall be started as soon as the plaster has hardened sufficiently not to be damaged when watered.

The plaster shall be kept wet for a period of at least 7 days. During this period, it shall be suitably protected from all damages at the Bidder’s expense by such means as the Engineer-in-Charge may approve. The dates on which the plastering is done legibly marked on the various sections plastered so that curing for the specified period thereafter can be watched.

2.02.03 **Finish**

The plaster shall be finished to a true and to the proper degree of smoothness as required. The work shall be tested frequently as the work proceeds with true straight edge not less than 2.5 m long and with plumb bobs. All horizontal lines and surface shall be tested with a level and all jambs and corners with a plumb bob as the work proceeds.

Precaution

Any cracks which appear in the surface and all portions which sounds hollow when tapped, or are found to be soft or otherwise defective, shall be cut out in rectangular shape and redone as directed by the Engineer-in-Charge.

i) When ceiling plaster is done, it shall be finished to chamfered edge at an angle at its junction with a suitable tool when plaster is being done. Similarly when the wall plaster is being done, it shall be kept separate from the ceiling plaster by a thin straight groove not deeper than 6mm drawn with any suitable method with the wall while the plaster is green.

ii) To prevent surface cracks appearing between junctions of column/beam and walls, 150mm wide chicken wire mesh shall be fixed with U nails 150mm centre to centre before plastering the junction. The plastering of walls and beam/column in one vertical plane shall be carried out in one go.

iii) Due to faulty construction, if the plaster thickness increases more than 20 mm, the Bidder shall provide chicken mesh to hold the plaster, at his own cost.

Cement Plaster with a Floating coat of Neat Cement(if applicable)

The cement plaster shall be10, 12, 15, 18 or 20mm thick, finished with a floating coat of neat cement, as described in the specification.

Specifications for this work shall be same as described above except for the additional floating coat which shall be carried out as below.

When plaster has been brought to a true surface with the wooden straight edge, it shall be uniformly treated over its entire area with a pest of neat cement and rubbed smooth, so that the whole surface is covered with neat cement coating. The quality of cement applied for floating coat shall be 1 kg per sqm. Smooth finishing shall be completed with trowel immediately and in

no case later than half an hour of adding water to the plaster mix. The rest of the specifications described in above shall apply.

18mm/20 mm Cement Plaster (Two Coat Work)

The specification for scaffolding and preparation of surface shall be as described above.

Mortar

The mix and type of the aggregate specified shall be used for the respective coats. Generally the mix of the finishing coat unless otherwise described in the specification.

Generally coarse sand shall be used for the under coat and fine sand for the finishing coat, unless otherwise specified for external work and under coat work, the fine aggregate shall conform to grading zone IV. For finishing coat work the fine aggregate conforming to grading zone V shall be used.

Application

The plaster shall be applied in two coats i.e. 12 mm under coat and then 6/8mm finishing coat and shall have an average total thickness of not less than 18/20mm.

12mm under coat

This shall be applied as specified earlier except that when the plaster has been brought to a true surface a wooden straight edge and the surface shall be left rough and furrowed 2 mm deep with a scratching tool diagonally both ways, to form key for the finishing coat. The surface shall be kept wet till the finishing coat is applied.

6/8 mm finishing coat

The finishing coat shall be applied after the under coat has sufficiently set but not dried and in any case within 48 hours and finished in the manner specified earlier.

Specifications for curing, Finishing and Precautions shall be as describe earlier.

10 mm Cement Plaster on Cement Concrete and Reinforced Cement Concrete Work

Scaffolding

Stage scaffolding shall be provided for the work. This shall be independent of the walls.

Preparation of Surface

Projecting burrs of mortar formed due to the gaps at joints in shuttering shall be removed. The surface shall be scrubbed with wire brushes. In addition concrete surfaces to be plastered shall be pock marked with a pointed tool, at spacing of not more than 5 cm. Centers, the pock being made not less than 3mm deep. This is to ensure a proper key for the plaster. The mortar shall be washed off and surface, cleaned off all oil, grease etc. and well wetted before the plaster is applied.

Mortars

Mortar of the specified mix using the types of sand described in the specification shall be used.

Application

To ensure even thickness and true surface, gauges of plaster 15 x 15 cm. shall be first applied at more than 1.5m intervals in both directions to serve as guides for the plastering. Surface of these gauged areas shall be truly in the plane of the finished plaster surface. The plaster shall be then be applied in a uniform surface to a thickness slightly more than the specified thickness and shall then be brought to true and even surface by working a wooden straight edge reaching across the gauges. Finally the surface shall be finished true with a trowel or with wooden float to give a smooth or sandy granular texture as required. Excess troweling or over working of the floats shall be avoided. The plastering and finishing shall be completed within half an hour of adding water to the dry mortar.

Plastering of ceiling shall not be commenced until the slab above has been finished and centering has been removed. In the case of ceiling of roof slabs, plaster shall be commenced until the terrace work has been completed. These precautions are necessary in order that the ceiling plaster is not disturbed by the vibrations set up in the above operations.

Finish

The plaster shall be finished to a true and plumb surface and to the proper degree of smoothness as required. The work shall be tested frequently as the work precedes with a true straight edge not less than 2.5m long and with plumb bobs. All horizontal lines and surfaces shall be tested with a level and all jambs and corners with a plumb bob as the work proceeds.

Thickness

The average thickness of plaster shall not be less than /10 mm. The minimum thickness over any portion of the surface shall not be less than 9mm.

Curing

The specification as stated earlier

Precautions

The specification as stated earlier

2.02.04 **Other Finish**

Generally, the standard finish shall be used unless otherwise shown on drawing or directed by the Engineer. Wherever any special treatment to the plastered surface is indicated, the work shall be done exactly as shown on the

drawings, to the entire satisfaction of the Engineer regarding the texture, colour and finish.

a) **Standard Finish**

Wherever punning is indicated, the interior plaster shall be finished rough. Otherwise the interior plaster shall generally be finished to a smooth surface. The exterior surface shall generally be finished with a wooden float.

b) **Neat Cement Finish**

Immediately after achieving a true plastered surface with the help of a wooden straight edge, the entire area shall be uniformly treated with a paste of neat cement at the rate of one (1) kg. Per Sq.M. and rubbed smooth with a trowel.

2.03.00 **Pointing to Masonry**

All joints of brickwork shall be raked out to a depth of 10 mm with a hooked tool made for the purpose while the mortar is still green. The brickwork shall then be brushed down with a stiff wire brush, so as to remove all loose dust from the joints and thoroughly washed with water. Mortar consisting of 1 part cement and 3 parts clean, sharp, well graded sand by volume shall be pressed carefully into the joints and finishes with suitably tools to shape as shown on the drawings. Any surplus mortar shall be scraped off the wall face leaving the surface clean.

The pointed surface shall be kept wet for at least three days for curing.

2.04.00 NOT USED

2.05.00 **Plaster of Paris Punning**

Plastered surfaces, where specified shall be finished with Plaster-of-Paris punning. The material shall be from approved manufacturers and approved by the Engineer. The thickness of the punning shall be 3mm and shall be applied by skilled workmen. The finish shall be smooth, even and free from undulation, cracks etc.

2.06.00 NOT USED

2.07.00 **White Cement Putty Punning**

Plastered surfaces, where specified shall be finished with White Cement Putty punning. The material shall be from approved manufacturers and approved by the Engineer. The finish shall be smooth, even and free from undulation, cracks etc.

Before bulk work is taken in hand, a sample of punning shall be done on roughly 10 sq.m. area and approval of the Engineer taken. The work shall then be taken in hand as per approved sample.

	PROPERTY	
1.	Tensile Adhesion Strength (N/MM^2) @ 28 Days	> 1.0
2.	Compressive Strength (N/MM^2) @ 28 Days	> 9.0
3.	Setting Time (Minutes) - Initial Final	=> 100 =< 500
4.	Water Absorption Coefficient - $Kg/M^2.H^{1/2}$	< 1.0
5.	Water Capillary Absorption (ML) @ 24 Hrs.	0.8
6.	Water Retentivity %	> 98

Surface Preparation

All loosely adhering materials on the plastered wall surface is to be removed with the help of emery stone, putty blade or wire brush and clean water. The substrate shall be cleaned, free from dust, grease and loose materials. Dry

and absorbent surface shall be moistened with sufficient quantity of clean water.

Mixing

White cement putty shall be mixed slowly with 30-35% of clean water to form a paste. Mixing is to be continued for 10-15 minutes to form a uniform paste.

Application method

First coat shall be applied on well moistened plastered wall surface from bottom to upward direction uniformly with putty blade. After drying of first coat the surface shall be rubbed gently with wet sponge or putty blade to remove loose particles. Surface shall be allowed 3 hours to dry before applying the second coat. After complete drying of second coat, loose particles shall be removed by gently rubbing the surface with wet sponge or putty blade. After mixing the putty shall be utilized within 2 hours.

2.08.00 **Cement Water Proofing Compound**

It shall be used for cement mortar for plastering or concrete work.

Water Proofing Compound

Integral cement water proofing compound conforming to IS 2645 and of approved brand and manufacturer, enlisted by the Engineer-in-Charge from time to time shall be used.

The Bidder shall bring the materials to the site in their original packing. The containers will be opened and the material mixed with dry cement in the proportion by weight, recommended by the manufacturers or as specifically described in the Specification. Care shall be taken in mixing, to see that the water proofing material gets well and integrally mixed with the cement and does not run out separately when water is added.

It shall be measured by weight.

The scope shall include all labour and materials involved in all the operations described above.

3.00.00 ACCEPTANCE CRITERIA

Finish to masonry and concrete shall fully comply with the Specifications, approved samples and instructions of the Engineer with respect to lines, levels, thickness, colour, texture, pattern and any other special criteria as mentioned in the body of the specification or as shown on drawings.

4.00.00 I. S. CODE

Important relevant code for this Section:

a)	IS: 1661	:	Code of practice for cement and cement-lime plaster finish on walls and ceilings.
b)	IS: 4101	:	Code of practice for external facings and veneers.
c)	IS: 1200	:	Method of Measurements of Building and Civil (Pt-XII) Engineering Works: Part: XII- Plastering and pointing
d)	SP 27	:	Handbook of Method of Measurement of Buildings Works

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SECTION-V

GUIDELINE
FOR
SINGLE AND DOUBLE SKINSANDWICH METAL CLADDING

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SECTION-V

GUIDELINE
FOR
SINGLE AND SANDWICH METAL CLADDING

1.00.00 GENERAL

1.01.00 Description

1.01.01 This section covers, providing, furnishing and installation of sandwich/double skin / Single skin metal cladding with insulation for wall/roof as shown in contract drawings including making cut outs for various openings for doors, windows, ducts, pipes, conductors etc. and fixing of such components with the cladding arrangement with necessary flashing, sealant as required as per contract drawings. The Bidder shall furnish all labour, materials, tools and equipment required to complete the work.

1.02.00 Applicable Codes and Standards

1.02.01 The following codes and standards are intended to provide an acceptable level of quality for materials and products. The Bidder may propose alternative codes and standards provided they give an equivalent degree of quality as the referred codes and standards and are submitted for consultants/owner's approval.

1.02.02 ASTM - American Society for Testing Materials.

1.02.02.1 A446 - Zinc-coated (Galvanized) steel sheets of structural quality. Coils and cut lengths.

1.02.02.2 A611 - Steel, cold rolled sheet. (IS 277)

1.03.00 Submittals

The Bidder shall submit to the owner the following items for review before commencing work.

1.03.01 Samples

a) Three pieces of one full sheet of standard size as recommended by the manufacturer of each type of pre-coated and preformed metal sheet for top skin and bottom skin and for single skin.

b) Type of insulation proposed for use and its thickness and density.

c) Fabricated sandwich metal cladding- Sample size shall be of one full sheet of standard size as recommended by the manufacturer -three nos.

d) Edge sealing and flashing.

1.03.02 Manufacturer's literature indicating the nature of preformed profiled, colour coating, manufacturer's recommended installation, instructions and maintenance procedure.

1.03.03 Manufacturer's certification of compliance with each delivery.

1.03.04 **Shop Drawings**

Showing fabrication details of sandwich/double/single skin metal cladding with or without Insulation, preformed sheet profile and total colour thickness for profiled top skin and slightly ribbed bottom skin, thickness and nature of insulation, installation and erection, anchorage, fasteners and details of accessories, metal flashing and its fixing including various openings for doors, windows, louvres, pipes etc.

1.03.05 **Test Reports**

Two copies of Test Reports and Source of Quality Control Tests.

1.03.06 **Supplier Certificates**

Two copies of technical data showing that the proposed finish product is suitable for the environmental conditions of the job site and that the materials meet specification requirements.

1.04.00 **Product Handling**

1.04.01 Delivery of Materials to job site in manufacturer's original unopened packaging.

1.04.02 Identify contents with name of manufacturer, brand name, thermal value and applicable standard.

1.04.03 Store materials in an area protected from adverse climatic conditions, moisture and open flame or spark and shall be stored off the ground with one end elevated for drainage. The sheets shall be protected from inclement weather with a waterproof covering with ventilation to avoid condensation.

2.00.00 PRODUCTS

2.01.00 **General**

2.01.01 All goods and products covered by these specifications shall be procured from manufacturer duly approved by the owner

2.01.02 Roof insulation shall have a minimum R-value of 2.083 M^2 ^oK/Watt. Thickness of sandwich cladding shall be as required to meet the specified "R" values.

2.01.03 Sandwich material shall be of "Rib and Flute" design to ensure wide spanning and quick recovery after being subjected to excessive load. Double skin materials shall be interlocking type 150mm wide strip and inner sheet shall be mild rib & flute type profile to ensure quick recovery after being subjected to excessive load.

2.01.04 **Material**

2.01.04.1	Base Material	High tensile steel
2.01.04.2	Metal protection	Zincalume
2.01.04.3	Organic coating	Silicon Modified Polyester (SMP) Polyvinylidene Difluoride (PVF2) and plastisol to resist aggressive climate of the jobsite

2.01.05 Material shall be prefabricated sandwich panel with polystyrene insulation/high density rock wool slab insulation shall be conformed to relevant ASTM or alternative codes and standard. Insulation shall be bonded to steel sheet with industrial grade adhesive. Sheeting material shall be preformed and percolated profile sheeting of thickness 0.60 mm to resist the climate of the jobsite for Top skin (Weather side) and Bottom skin or inner side slightly ribbed type and minimum 0.5 mm thick of similar pre coated panel. Wherever single sheets are used for roofing and cladding the thickness of the Zincalume sheets shall be 0.8mm minimum.

2.01.06 Insulating core shall be average 50mm thick according to the climatic requirement of the site and shall be either polystyrene block or rock wool slab made to profile of the sheet. The maximum density shall be 32.35 Kg / M^3 for polystyrene and shall have minimum R-value 2.083 M^2 ^oK/Watt.

2.01.07 Panel size shall be largest available size.

2.01. 08 **Sealants**

Penetration and end laps in sheeting shall be sealed with a non-hardening approved sealant as recommended by the manufacturer.

2.01. 09 Profile HDPE Filler

2.01. 09.1 Profile HDPE Filler shall be die cut in profile to match the profile of the sheet.

2.01.09.2 Metal flashing shall be of similar material and colour of top skin.

3.00.00 DOUBLE SKIN INSULATED METAL CLADDING

3.01.00 General

3.01.01 Wherever specified, Metal cladding may be of double skin on the side of side runner (purlins). External sheet shall be of interlocking type.

3.01.02 Providing, erecting, fitting & fixing at all elevations double skin insulated roofing / wall cladding with zincalume and profiled steel sheets made out of 0.6 mm for external and 0.5 mm thick internal sheets (TCT) permanently colour-coated zincalume steel (150gsm Zinc Aluminium alloy coating total of both as per AS 1397:1993) having 550 MPa yield strength. Colour coating shall comprise of Polyester coating of approved colour as per Vol. II-G1-Sec. IV of specific design requirement

The external sheet shall be zincalume fixed on to the hat sections with the help of specially designed carriers to hold the external zincalume cladding. The inner sheet shall have 980mm cover width, with special male / female side-laps and anti-siphoning features to prevent leakage. Two small ribs are there in between the two profiles. The inner sheet along with sub-girths of size 50mm x 50mm x 50mm manufactured out of 1.6mm GI sheet in 'C' / 'Z' shape would be fixed to the purlin by means of self-drilling fasteners (12G - 14TPI x required length). Outer sheeting shall be fixed with the help of concealed compatible interlocking clips and wafer-head Zinc-coated self-drilling fasteners / screws on to the sub-girths. The clips shall be concealed and no fasteners are to penetrate the external sheeting.

3.01.03 The colour coating shall comprise of SMP / super polyester PVF2. The inner sheeting shall be 0.50mm/0.6mm TCT of SMP / super polyester PVF2 coated zincalume steel 150 gsm. (Zinc – aluminium alloy coating mass total of both sides as per AS 1397:1993) having 550 Mpa yield strength or 180gsm galvanised of 240 mpa. The colour coating shall comprise of 20 microns finish coat over a 5-micron primer coat on the exposed side and a back coat of 5 microns over a primer coat of 5 micron on the reverse side. The external sheet shall have special male / female side laps and anti-siphoning feature to prevent leakage. The inner sheet shall have 980mm cover with special male / female side laps and anti-siphoning features to prevent leakages.

The clips shall be concealed and no fasteners are to penetrate the external sheeting. Insulation of density 100 Kg/m3 and average thickness 50 mm. conforming to IS 8183 having a thermal conductivity value of 0.034 W/mk at 50 degree C mean temperature.

Wherever single skin metal cladding shall be used over brickwork, the material shall be same as the outer skin of insulated metal cladding system and the thickness shall be 0.8mm minimum.

4.00.00 EXECUTION

4.01.00 Inspection

4.01.01 the Bidder shall examine the area, which will be covered, and the masonry wall where the edge of the sandwich/double/single skin cladding will be fixed and the structural alignments.

4.01.02 Bidder shall correct any unsatisfactory conditions prior to start of work.

4.02.00 Installation

4.02.01 Sandwich panel shall be fixed over structural members with joints overlapped and fastened using stainless steel fasteners self-drilling type or as recommended by the manufacturer.

4.02.02 Double/single skin wall cladding with / without insulation shall be installed strictly as per manufacturer specification and details.

4.02.03 All end laps of profiled sheeting and joints of flashing shall be sealed properly with non-hardening natural cure silicon sealant or as recommended by the manufacturer.

4.02.04 Accessories like fasteners, tape, and foam fillers, flashing etc. as required shall be provided as per recommendation of manufacturer.

4.03.00 Clean-Up

Remove sealant splatters and smears remove steel particles generated by drilling to avoid damage.

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SECTION-VI

GUIDELINE
FOR
CARPENTRY AND JOINERY

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SECTION-VI

GUIDELINE
FOR
CARPENTRY AND JOINERY

1.00.00 SCOPE

This shall include supply, fitting and fixing of timber frames to doors and windows with M S holdfasts, paneled or flush doors, windows, shutters, partitions, wall paneling, pelmets, shelves, furniture, etc. as shown in drawings, including a prime coat of approved paint, varnish, or fixing of decorative plastic laminate where called for in the specification. This shall also include the supply and fixing of all hardware and fixtures shown in drawing or specified in the “Schedule of Fixtures”.

2.00.00 INSTALLATION

2.01.00 **Materials**

a) **Timber**

Unless otherwise specified, all timber shall be best quality well-seasoned C P teakwood free from decay, fungal growth, boxed heart, pitch pockets or steaks on the exposed edges, splits, large or loose, knots cracks or other defects. Where specified, timber shall be treated with approved wood preservative before use. Before starting the carpenter’s work, the successful bidder shall have the rough timber approved by the Engineer.

b) **Plywood**

Plywood boards are formed by gluing and pressing three or more layers of veneers with the grains of adjacent veneers running at right angles to each other. The veneers shall be either rotary cut or sliced and shall be sufficiently smooth to permit an even spread of glue. Face veneers may be either decorative on both sides or one side commercial and the other decorative. Ply wood shall be BWP grade or BWR grade as per IS 303.

Plywood shall be commercial quality or with decorative surface veneer. Unless specifically permitted otherwise, the adhesive used in plywood shall be phenol formaldehyde resin of B W R grade conforming to IS: 848.

c) **Decorative Laminated Plastic Sheets**

The colour, pattern, finish and texture shall be approved by the Engineer and the bulk supply procured in sheet sizes which will ensure the least number or joints in one surface.

d) **Flush Doors**

Flush door shutters shall have a solid core with commercial or decorative or non-decorative (Paintable type as per IS 2202 Part I) faces and hardwood edges. The core for solid core doors shall be of block board or wood particleboard. Manufacturer's literature and test certificates shall be submitted for the approval of the Engineer. The Bidder shall ensure that the adhesive used is phenol formaldehyde of BWR grade, conforming to IS: 848. The thickness shall be as specified elsewhere in drawing/specification The moisture content in timbers used in the manufacture of flush door shutters shall be not more than 12 percent when tested according to IS 1708.

Face Panel

The face panel shall be formed by gluing, by the hot-press process on both faces of the core, either plywood or cross-bands and face veneers. The thickness of the cross bands as such or in the plywood shall be between 1.0mm and 3.0mm. The thickness of the face veneers as such or in the plywood shall be between 0.5 mm and 1.5mm for commercial veneers and between 0.4 mm and 1.0mm for decorative veneers, provided that the combined thickness of both is not less than 2.2mm. The direction of the veneers adjacent to the core shall be at right angles to the direction of the wooden strips. Finished faces shall be sanded to smooth even texture. Commercial face veneers shall conform to marine grade plywood and decorative face veneers shall conform to type I decorative plywood in IS 1328.

Lipping

Lipping, where specified, shall be provided internally on all edges of the shutters. Lipping shall be done with battens of first class hardwood or as specified of depth not less than 25mm. For double leaved shutters, depth of the lipping at meeting of stiles shall be not less than 35 mm. Joints shall not be permitted in the lipping.

Rebating

In the case of double leaves shutters the meeting of stiles shall be rebated by 8mm to 10mm. The rebating shall be either splayed or square type as shown in the drawing where lipping is provided. The depth of lipping at the meeting of stiles shall not be less than 30 mm.

Opening for glazing

When required, glazing shall be provided and unless otherwise specified the opening for glazing shall be 250mm in height and 150mm or 200mm in width unless directed otherwise. The bottom of the opening shall be at a height of 1.4 m from the bottom of the shutter. Opening for glazing shall be lipped internally with wooden batten of width not less than 25mm. Opening for glazing shall be provided where specified or shown in the drawing.

Tolerance

Tolerance on the width and height shall be +3 mm and tolerance on nominal thickness shall be ± 1.2mm. The thickness of the door shutter shall be uniform throughout with a permissible variation of not more than 0.8 mm when measured at any two points.

Adhesive

Adhesive used for bonding various components of flush door shutters namely, core, core frame, lipping, cross-bands, face veneers, plywood etc. and for bonding plywood shall conform to BWP type, phenol formaldehyde synthetic resin adhesive conforming to IS 848.

e) **Panelled Glazed or Panelled and Glazed Shutters**

Panel door shall be of teakwood shutter frame unless otherwise noted and panels with teakwood/commercial ply/teakwood particleboard as per drawing or as recommended and approved by Engineer in charge.

Panelled or glazed shutters for doors, windows, ventilators and cupboards shall be constructed in the form of timber frame work of stiles and rails with panel inserts of timber, plywood, block board, veneered particle board, fiber board wire gauze or float glass. The shutters may be single or multi-paneled, as shown in the drawings or as directed by the Engineer-in-Charge. Timber for frame work, material for panel inserts and thickness of shutters shall be as specified. All members of the shutters shall be straight without any wrap or bow and shall have smooth well planed face at right angles to each other.

Other considerations shall be as mentioned in item (d) above.

Window and Ventilator Shutters

Window and Ventilator shutters shall conform to IS 1003 (Part 2)

f) **Laminated Veneer Lumber (LVL)**

Laminated Veneer Lumber door frames and shutters shall conform to IS 14616

Material

i) **Laminated Veneer Lumber (LVL)**

Laminated Veneer Lumber is made of rubber wood silver oak, eucalyptus, Poplars, acacias etc. veneers glued tighter having grains of all the veneers in one direction under high temperature and pressure to develop high Modulus of Rapture& Modulus of elasticity. Veneers for LVL shall be of thickness between 1.5 to 2.5mm.

ii) Veneers shall be free from knot holes, decayed knots except pin knots, unfilled splits wider than 3 mm, concentrated borer holes, shakes, objectionable decay or termite attack, except that for the face veneers none of these defects or cross grain exceeding 1 in 10 shall be permitted. The nominal thickness of all the veneers used shall be identical and uniform within a tolerance of ± 5 percent.

iii) **Adhesives:**Only BWP grade adhesive conforming to IS 848 shall be used for making LVL.

iv) **Preservatives:** Veneers used for LVL shall be given preservative treatment before lamination, with a preservative that is compatible with the adhesive to be used. Only fixed type of water soluble preservatives, CCA or CCB, or non-leachable, solvent soluble preservatives as per IS 401 shall be used for treating the veneers. Retentions of preservatives shall be as per IS 401 depending upon the proposed end use.

All the Veneers shall be given preservative treatment by one of the water soluble fixed type treatment, Copper Chrome-Boron Composition. (CCB) as per IS 401. The treated Veneers shall than be dried having moisture content less than 6%. The Veneers shall be glued together, by keeping all the grains in one direction, with BWP grade synthetic resin adhesive conforming to IS 848. The Veneers having moisture content less than 6% so glued, shall be pressed in hot press at high temperature of 140 degree C to 180 degree C. and pressure 1.4 to 1.8 MPa. The net absorption of preservative in LVL when tested as per IS 2753 shall not be less than 8.0 kg/m^3 Veneers shall be scarf joined only length wise and not in the direction of width with EWP type synthetic resin adhesive. However, the length of individual Veneer shall not be less than 600mm.

Moisture Content

The average moisture content of three test specimens, when determined in accordance with IS 1734 (Part 1) shall be between 5 to 15%.

g) **Laminated Veneer Lumber (LVL) Door Shutters**

This specification lays down requirements regarding types, sizes, material, construction, workmanship and finish, performance evaluation, sampling, and testing of Laminated Veneer Lumber (LVL) door shutter for use in domestic buildings, offices, schools, hospitals, etc. This specification does not cover large size door shutters for industrial and special buildings such as workshops, garages, godowns etc.

The material of each lot shall be supported by a certificate to that effect:

Each lot of LVL materials shall be accompanied by the test reports. Fabricated shall take up manufacturing of shutters only if provisions of clause mentioned above fulfilled, failing which, shutters so manufactured are liable for rejection.

Panelling Materials

Plain Particle Board: Plain particle boards used for panels shall be FPT-1 conforming to IS 3087 and shall have been bonded with BWP type of synthetic resin adhesive as per IS 848.

Pre-laminated Particle Board: Pre-laminated particle boards used for panels shall conform to IS 12823. The plain particle boards used in pre-laminated particle boards shall be as per stated above.

Medium Density Fiber Board: Medium density fibre board used for panels shall confirm to exterior grade as per IS 12406 made from agro-forest products or agricultural wastes or natural fibers.

Pre-laminated Medium Density Fiber Board: Pre-lamination in pre-laminate medium density fiber board shall confirm to the requirements such as Abrasion Resistance, Resistance to Steam, Crack Resistance, Resistance to Cigarette Burn and Resistance to Stain as specified in IS 12823. The medium density fiber board used in pre-laminated medium density fiber board shall be as per stated above.

Glass: Glass for glazing shall confirm to IS 2835 or IS 2553. The use of other types of glass, such as frosted glass, wired glass may also be specified by the Engineer-in-Charge.

Wire Gauze: Wire gauze shall generally confirm to IS 1568 and shall be regularly woven with equally spaced galvanized mild steel wires of 0.63 mm nominal diameter in both warp and weft directions to form aperture of average width 1.40 mm.

h) **Construction and Workmanship**

Laminated Veneer Lumber (LVL) paneled, glazed and panelled and glazed shutter shall be constructed in he form of LVL framework of stiles and rails with panel inserted conforming (as per stated above) of plain or perlaminated particle board, plain or perlaminated medium density fibre board, wire gauze or glass. The panels shall be fixed by either providing grooves in stiles and rails and beading as specified. The stiles top rails, lock rails and bottom rails shall be jointed to each other by mortice and tenon joints. Rails having width of 150 mm or more shall have plain double tenon joints. Other rails shall have single tenon joints. The bottom lock and top rails shall be inserted 25+3 mm short of the width of stiles to form a stub mortice & tenon joint. After assembling shutters complete with panels, Bamboo pins of 6 mm dia shall be fitted on each tenon and mortice joint by drilling suitable size of holes (2 pins per joint for rail width upto 150 mm and 3 pins for rails of greater width). All the four edges of shutter shall be beaded with 12 mm thick rubber wood /plantation wood lipping. Lipping shall be seasoned and chemically treated. Lipping on top and bottom rails shall be of one piece and lipping on stiles may be in two pieces. All lippings shall be glued to shutter with water resisting glue (Synthetic rubber passed adhesive) at the rate of 0.15 kg/m^2.

All members of the shutters shall be straight, smooth and with well planed faces at right angles to each other. Any wrap and bow shall not exceed 1.5 mm. The right angle for the shutters shall be checked by measuring the two diagonals from one extreme corner to the opposite one and the difference between the two diagonals shall not be more than 3 mm.

Beading: All the panels except glass and wire gauze shall be fixed with grooves but additional beading may be provided either on one side or on both the sides, if so specified. In so far as glass and wire gauze panels are concerned, beading shall be provided without grooves.

In such a case where beading is provided without the grooves, the beading shall be only on one side, the other side being supported by rebate from stiles. The beading shall have a size not less than 15 mm x 10 mm. It can be fixed by suitable handless nailing or screwing. The beading shall be of plantation timber section, preservative chemically treated of fixed type as per IS 401–1982.

Stiles, top rails, bottom rails and lock rails of shutters shall each be made in one piece of LVL, only.

Muliions and glazing bars shall be stubtenoned to the maximum depth which the size of the member wood permit or to a depth of 25 mm, whichever is less.

The minimum depth of grooves of stiles and rails shall be 12 mm for all types of panelling. The panels shall be framed into grooves to the full depth of groove leaving an air space of 1.5 mm and the faces shall be closely fitted to the sides of the groove.

LVL shutters shall be manufactured in factories under controlled conditions.

i) **Panelling**

Plain and perlaminated Particle Board Panelling: The panels shall be made of one piece of plain or prelaminated particle board of thickness 12 mm or more.

Wire Gauze Panelling: Wire gauze panel shall be so designed that no single panel shall exceed 0.5 sqm. in area.

j) **Rebating**

In case of double leaved shutters, the meeting of the stiles shall be rebated either splayed or squire type as per IS 1003 (part-1).

k) **Gluing of Joints**

The contact surfaces of tenon and mortice shall be treated before putting together as per IS 1003 (part-1). All the tenon and mortice joints shall be glued together and pinned to full thickness of the door with Bamboo pins.

l) **Tolerances**

Tolerance on the size of door shutter shall be +3 mm and in thickness +1.2 mm.

m) **Location of Fittings and Accessories**

Each door shutter shall be fixed to the frame with four hinges, unless otherwise specified by the Engineer-in-Charge, of the type specified.

The lock rail of door shutters, where provided, shall be so placed that its centre line is at a height 850+5 mm from the bottom of the shutter. Hinges and other fixtures shall be fixed to shutter with full threaded steel screws after coating the screws with adhesive such as fevicol etc. For fixing of hinges, holes of 3.5 mm diameter and 52 mm length shall be bored and No. 10 full threaded parallel shank steel screws, 50 mm long, coated with adhesive shall be used. In no circumstances screws shall be hammered into board.

Cleats and blocks made of LVL wood shall be fixed to door shutter, if required, by the user as per size and shape approved. Pull bolt or sliding door bolt etc. shall be provided in the door shutter at a height of

850 mm from bottom of shutter. These shall be fixed to shutter as per method of fixing described above.

For rescrewing, a plastic sleeve of appropriate diameter shall be inserted into the hole and then fixing with full threaded screws shall be done. Fittings other than hinges shall be provided as per scheduled by the user. The fittings shall conform to specifications as described above.

Panelled shutter may be provided with louvers of vision panels as specified. Where such a provision is made, the position, size and shape of louver or vision panel opening shall be as specified.

n) **Finish**

All the four edges of the shutter shall be squire. The shutter shall be free from twist or warp in its plane. Panels of the door shutters shall be flat and well sanded to a smooth and level surface. All the surfaces shall be delivered without protective coat of wood primer polish or varnish.

o) **Glazing**

Glazing in the shutters of door and window shall be as per in specifying sizes of the openings or panels of glass, the first dimension shall be width. The glass shall be embedded in putty and secured to the rebate by the wooden beading of suitable size and shape.

p) **Fixtures**

Fixtures for doors, windows, furniture, etc. shall be as shown on drawing or specified in the “Schedule of Fixtures”. However minimum number of fixtures shall be as follows:

i) **For external single leaf door :**

- 6Nos hold fast or anchor bolts.
- 4Nos 100mm long SS hinge
- 10mm dia& 300mm long SS tower bolt on inside face.
- Mortise lock & latch either barrel type or rectangular type.
- SS doorknob or handle on both faces.
- SS Door stopper with EPDM stay piece.
- Heavy duty automatic door closer.
- Rain drip

ii) **For external double leaf door:**

- 6Nos hold fast or anchor bolts.
- 4Nos 100mm long SS hinge on both shutters.

- 10mm dia& 300mm long SS tower bolt on inside face on both shutters.
- Mortise lock & latch either barrel type or rectangular type.
- SS doorknob or handle on both faces.
- SS Door stopper with EPDM stay piece.
- Heavy duty automatic door closer on active shutter.
- Rain drip

iii) **For external single leaf window:**

- 6Nos hold fast or anchor bolts.
- 3Nos 100mm long SS hinge
- 10mm dia& 300mm long SS tower bolt on inside face.
- SS pull ring minimum 6mm thick and 50~75mm dia.
- SS window stay piece.

2.02.00 **Partitions**

These shall be conform to drawings with all details. No unsightly nail marks etc. shall be permitted. Plywood grains shall be matched to give a uniform and pleasing appearance.

a) **Materials**

Gypsum Board conforming to IS 2095 (Part-1)

Non asbestos multi-purpose cement board conforming to IS 14862
Tapered edge calcium silicate board

Tapered Edge Calcium Silicate Board is manufactured from Siliceous and Calcareous materials reinforced with fibers. The boards are made in a laminar process and then autoclaved to give a stable crystalline structure. It is lightweight and can be fixed to either side of timber, aluminium or lightweight galvanized metal sections. The partitions are non-load bearing and can easily be assembled at site.

b) **Installation**

The G.I. frame and board partitions shall be fixed as per nomenclature of the item and directions of Engineer-in-Charge.

c) **Jointing & Finishing**

Joints of the boards are finished with specially formulated joining compounding and fiber tape to provide seamless finish. Board surface can be decorated with any type of paint, wall paper, wood veneer & hard laminates. Services shall be incorporated before commencement of board fixing.

d) **Fitting and Fixtures**

It is easy and simple to attach different fittings to wall panelling boards. Inclined nails can be fixed to the boards itself for light materials. For heavier materials the fastening shall be centered on internal stud work or steel or wood frame behind the boards, fixed before boarding. Services shall be incorporated before commencement of board fixing.

e) **Tolerance**

Tolerance in dimensions shall be ± 5 mm.

2.03.00 **Fibre Glass Reinforced Plastic (FRP) Door Frames**

Door frames shall be three legged of cross section 90 mm x 45 mm having single rebate of size 32 mm x 15 mm to receive shutter of 30 mm thickness. The frame shall be made of laminate of thickness of 2 mm and shall be filled with wooden blocks of exterior grade MDF or seasoned and treated hard wood inside the laminate in all the three legs of the frame. The frame to be moulded by either hand lay up to resin transfer moulding process. The process shall consist of laying gelcoat at 1000 gms./sqm. and laid over with layer of FRP Mat (CSM mat) gelcoat and FRP (CSM Mat) are defined in IS 14856. The CSM mat shall be bonded with Isophatholic resin in the ratio not less than 1:2 (One part of Mat to two parts of Isopathlic resin and fillers & additives) by weight. The edge shall be sealed with gelcoat and FRP mat to obtain smooth finish. Sufficient roving shall be laid in the corner to have smooth curve while laying the CSM mat.

a) FRP door shall be manufactured as per specifications laid down in IS 14856, nomenclature of items & direction of Engineer-in-Charge.

b) **Tolerance:** Tolerance of size of frame to be ± 2 mm. and on size of rebate to be +1 mm.

c) **Finish:** The surface of the moulded frame shall be free from any visible defects such as small pores, crazing, blistering, wrinkling, impurities, defective impregration, colour bolts and aggregate defects, as mentioned in IS 14856. Scattered pin holes duly repaired and finished by applying resin and not noticeable shall be acceptable. Frame laminate shall be flat and shall have smooth and level surface. Laminate shall be finished in colour and shade as approved by Engineer-in-Charge.

Fixing of Frame: As described earlier

2.04.00 **Fibre Glass Reinforced Plastic (F.R.P.) Shutters**

a) F.R.P. Shutters shall be manufactured conforming to the specifications as per IS 14856 and nomenclature of item & direction of Engineer-in-Charge.

b) Blocks of any seasoned hard wood of bulk density not less than 450 kg / cum At 12 per cent moisture content or any other material of sufficient thickness and length shall be provided inside the shutter at suitable place to hold fittings and fixtures such as aldrops, tower bolt, handle, sliding door bolt, mortice lock etc. Blocks for hinges shall be provided at three locations, unless otherwise specified by the purchaser. One at the centre and other two at 200 mm from the top and the bottom of the shutter. Blocks shall be provided at predetermined places in the shutter so as to fix hinges mortice locks, tower bolts, aldrops, door closures, etc. The finished surface shall be buffed and polished with wax.

c) **Location of Fittings and Accessories:** The lock rail of door shutters shall be so placed that is centre line is at a height 850 + 5 mm from the bottom of the shutter. Door shutter shall be fixed to the frame with three hinges, unless otherwise specified by the purchaser, of the type specified. These locations shall be, one at centre and other two at 200 mm from the top and the bottom of the shutter, where blocks have already been provided and suitable location by depressing the profile has been made.

Screws for fixing the hinges shall be screwed in with screwdrivers & not hammered. The length of screw shall be 8/30 mm. The hinges used shall be stainless steel or aluminium.

Sampling & Criteria for conformity: As described earlier.

d) **Finish:** Stated earlier

e) **Fixing of Shutter:**As described earlier**.**

Tolerance: As described earlier.

2.05.00 **Workmanship**

2.05.01 **General**

Skilled carpenters as per details shown on drawing or instructed by the Engineer shall do the work.

Framing timber and other work shall be close-fitting with proper wood joinery, accurately set to required lines or levels and rigidly secured in place. The surface of frames etc. that will come in contact with masonry after fixing shall be given two coats of approved paint before fixing (preferably Bitumen Painting).. Mastic caulking shall be done after fixing external door and window frames. Special care shall be taken to match the grain of timber or plywood, which will be subsequently polished. Screwing or nailing will not be permitted to the edge of plywood and particleboard. The edge of all plywood, block board and particle board shall be finished with teakwood lipping unless otherwise shown on drawings.

Fixing for frames and partitions shall generally be with 40 mm x 6 mm x 300 mm long MS holdfasts bifurcated at end and grouted with 1:2:4 cement concrete. The gap between masonry and external door and window frame shall be caulked with polysulphide mastic. Al grills or guard bars shall be provided to windows where called for in the drawings or specification.

2.05.02 **Finish**

All carpentry work after finishing shall be sand papered smooth. Prime coat paint shall be given after inspection of the Engineer to all surfaces other than those, which shall be subsequently polished or covered with laminated plastic sheet.

2.05.03 **Surface Treatment**

When shown on drawings or called for in specification, decorative ply or laminated plastic sheets shall be bonded under pressure to the surface to be finished. The adhesive used shall be of approved brand and brought to site in sealed containers. The rate of application and the length of time for which the pressure is to be applied shall be as per the manufacturer's instructions. The edge of sheets shall be protected by teak lipping or beveled as shown on drawings.

3.00.00 ACCEPTANCE CRITERIA

3.01.00 **Door and Window Frames**

Shall bechecked for dimensions and corner angles. After fixing they shall be on a fine vertical plane. All external door and window frames shall be caulked with mastic.

3.02.00 **Door and Window Shutters**

Shall be of proper size, shape and design and free of warp. When fixed to frames, these shall operate smoothly without jamming and all latching or locking devices shall engage properly without undue pressure.

3.03.00 **Furniture**

3.03.01 **General**

These shall conform to drawings in all details. No unsightly nail marks etc. shall be permitted. Plywood grains shall be matched to give a uniform and pleasing appearance.

3.03.03 **Cupboard Shutters**

Shall operate smoothly without jamming and locks, holding chains, bolts and double ball catches shall engage securely. Single ball catches shall not be used.

3.03.04 **Loose Furniture**

When placed on level surface tables tops etc. shall be horizontal and the pieces stand stably on legs or supports.

4.00.00 IS CODES

Some of the important relevant Codes for the Sections are:

IS: 4021	-	Timber door, window and ventilator frames
IS: 1003	-	Timber paneled and glazed shutters.
IS: 2191	-	Wooden flush door shutter (Cellular and hollow core type)
IS: 2202	-	Wooden flush door shutters (Solid core type)
SP 27	-	Handbook of Method of Measurement of Buildings Works

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SECTION-VII

GUIDELINE
FOR
METAL DOORS, WINDOWS, VENTILATORS, LOUVRES, CURTAIN WALL, STRUCTURAL GLAZING, ETC.

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SECTION-VII

GUIDELINE
FOR
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1.00.00 SCOPE

The work in general shall consist of supplying and erecting and installing of all metal doors, windows, ventilators, louvers, glazed partitions, etc. as shown on drawings with all materials complete including supply of glass and glazing. The scope of work shall also include the assembly at site and supply & erection of all doors, windows, louvers, glazed partitions, etc. for which fabricated materials. Supplying and fixing of all door and window accessories and hardware are also included in the scope.

2.00.00 INSTALLATION

2.01.00 Materials

Steel sections used for fabrication of doors, windows etc. shall be standard rolled steel sections specified in IS: 1038 and IS: 1361 or as specified in drawing.

Steel sheets for frames, shutters, louver blades etc. shall be of gauge mentioned in drawings and specification.

Aluminium sections for fabricating doors, windows, partitions, etc. shall be extruded sections conforming to IS: 733 and 1285 for chemical composition and mechanical properties. The stainless steel screws shall be grade AISI 304.The alloy used shall conform to IS Designation HE 9-WP of IS: 733.

Hardware and fixtures shall be as specified in “Schedule of Fixtures” and the best quality from approved list of manufacturers shall only be used. The successful bidder shall specifically state the list of manufacturer’s materials he proposes to use. “Schedule of Fixtures” is for the purpose of stating the minimum requirement and improper alignment or faulty operation due to inadequate strength of hardware or fixture shall entirely be the Bidder’s responsibility.

All hardware and fixtures shall be able to withstand repeated use. Door closers shall conform to IS: 3564 and shall be suitable for doors weighing 61-80 Kg. unless otherwise stated elsewhere in the specification. Each closer shall be ensured against manufacturing defect throughout the DLP and any

defect found within this period shall be rectified or the closer replaced free of charge. Concealed door closers shall be either floor mounted or transom mounted, suitable for installation with metal doors. It shall conform to the performance requirements & endurance test stated in IS: 3564 Appendix- A.

The Bidder shall submit **three** samples of each type of hardware to the Engineer for approval. The approved samples shall be retained by the Engineer for comparison of bulk supply. The samples shall be returned to the Bidder towards the end for incorporation in the job.

The mastic for caulking shall be of best quality from a manufacturer approved by the Engineer. In general, the mastic for fixing of metal frames shall be as per IS: 1081 and/or as approved by the Engineer.

2.02.00 Fabrication

2.02.01 Steel Doors, Windows, Ventilators, Louvers, etc.

a) Door Frames

Frames shall be fabricated from 16 G sheets. They shall be mortised, reinforced, drilled and tapped for hinges and lock and bolt strikes. Where necessary, frames shall be reinforced for door closers. Welded construction with mitered corners shall be used. Rubber door silencers shall be furnished for the striking jamb. Loose “T” masonry anchors shall be provided. Frames shall finish flush with floor and adjustable floor anchors shall be supplied. Frames shall be brought to site with floor ties/weather bars installed in place.

b) Double Plate Flush Door Shutters

Door shutters shall be 45 mm thick, completely flush design and shall comprised of two outer sheets or 18 G steel sheets, rigidly connected and reinforced inside with continuous vertical 20 G stiffeners, spot welded in position at not more than 150 mm on centres.

Both edges of doors shall be joined and reinforced full height by steel channels placed immediately inside and welded to the door faces. Top and bottom of doors shall be reinforced horizontally as shown on drawing by steel channels running full width of door. Doors shall not have more than 2.5 mm clearance at jambs and heads, shall have proper level on lock stiles and rails to operate without binding, and shall be reinforced at corners to prevent sagging or twisting. Pairs or double doors shall have meeting stile edges beveled or rebated. Where shown on drawing the doors shall be sound deadened by filling the inside voids with mineral wool or other suitable approved materials.

Doors shall be mortised, reinforced, drilled and tapped in shop for hinges, locks and bolts. They shall also be reinforced for closers, push-plates and other surface hardware where necessary. Any

drilling and tapping required for surface hardware shall be done at site. Where shown in drawing, provision shall be made for fixing glazing, vision panels, louvers etc. glazing mouldings shall be of 18 G steel or extruded aluminium sections with profiles shown in drawing and suitable for fixing 6 mm glass. Louvres blades shall be V or Z shaped and made out of 16 G sheets.

c) **Single Sheet Door Shutters**

Single sheet doors shall be made from best quality 18 G mild steel sheets and shall present a flush surface on the outside. The inside shall be stiffened with semi-tubular edge and central stiffening rail, which shall convey the lock and other furniture. The frames shall be made from best quality 16 G mild steel sheets.

Wherever required as shown on drawings, provisions for fixing glass panes, louvers, etc. shall be made.

The manufacturing shall be done as specified in “Double Plate Flush Door Shutters”.

d) **Sliding Doors**

These shall be manufactured as per drawings and specification. These shall be fabricated from mild steel sheet.

The shutter shall be double or single leaf shutter as specified. The shutters shall be fabricated of specified size of M.S. angle iron frame diagonally braced with the same size of M.S. angle riveted/ welded together with 3mm gusset plate at junction to form a rigid frame. Sliding doors shall be either double plate or single plate construction as called for in drawings and made out of 18 gauge steel sheets with adequate stiffeners. The Bidder shall specify the weight of the door in his shop and submit the manufacturer’s catalogue of the sliding gear he proposes to use. Where shown on drawings or call for in them specification, these shall be provided with top and bottom guide rails of specified size angles or T-irons and 25mm diameter pulley or with 25mm diameter ball bearing at the bottom and guide block with steel pulleys at the top. The shutters shall be provided with locking arrangement, handles, stoppers, and holdfasts, other fittings as specified in the description of item. Doors shall close positively to exclude rainwater from seeping in. Sliding doors shall withstand specified wind loads without buckling or jamming. The door shall slide freely under all ambient conditions.

The guide rail shall be sufficiently long and continued along the wall on both ends so that the sliding shutters can against the walls, giving full opening when so required.

FIXING: The guide rail shall be fixed to the floor by means of anchor bolts embedded in the cement concrete floor. The steel section at the

top shall be suitably supported from the walls. Two channel sections shall be suitably fixed vertically below the extreme clamps in the wall and floor to avoid the shutter from going out of the supports at top and bottom. A suitable clamping arrangement will be provided at either end of the opening to avoid the shutters from rolling back into the opening.

The adjoining work damaged in fixing shall be made good to match the existing work.

e) **Door Threshold**

Door threshold shall be provided as shown on drawing. Doors without threshold shall have bottom tie of approved type.

f) **Steel Windows, Sashes, and Ventilators etc.**

These shall conform in all respects to IS: 1038 and IS: 1361 latest editions and as shown on drawings. The details as called for in the above codes shall be applicable for coupling mullions, transoms, weather bars, pivot arrangements for ventilators, etc. or as shown on drawings All welds shall be dressed flush on all exposed and contact surfaces.

Where composite unit openings are shown on drawings, the individual window units shall be joined together with requisite transoms and mullions as shown on drawings. All windows shall be outside glazed fixed with putty or metal glazing beads as shown on the drawings and/or specified. Where aluminium glazing beads are specified they shall be extruded aluminium channel 9.5 mm x 9.5 mm x 1.6 mm (Indal Section No. 2209) unless otherwise shown on drawings. Aluminium beads shall be given one coat of zinc ethyl silicate primer before fixing to windows.

2.02.02 **Aluminium Door, Windows and Frames**

Extruded sections shall have a minimum 3 mm wall thickness. All sections shall be approved by the Engineer before fabrication is taken up. Doors, frames, mullions, transom etc. shall be anodized in a bath of sulphuric acid to provide a clear coating of minimum 25 micron for permanent installationsthickness. The anodized materials shall then be sealed by immersing in boiling water for 15 minutes. A protective transparent coating shall be applied to the sections before shipment from the factory.

Where required factory made evenly baked powder coated coloured aluminium extruded sections shall be used. DFT shall not be less than 0.8 mils. Colour shall be as per instruction of the Engineer-in-Charge.

All work shall be fitted and shop assembled to a first class job and ready for erection. Shop joints shall be made to hairlines and then welded or braced by

such method as will produce a uniform colour throughout the work. Work on the above, other than described, shall be carefully fitted and assembled with

neat joints with concealed fasteners. Wherever possible, joints shall be made in concealed locations and on edges of doors. Field connections of all work may be made with concealed screws or other approved type of fasteners. Glazing beads shall be snap fit type without visible screws and shall be of sizes to accommodate 6 mm thick glazing. All work shall be adequately braced and reinforced as necessary for strength and rigidity.

2.02.03 **Fire Door**

Hollow metal fire rated doors shall be as per IS 3614 Part-1 & Part-2.It shall be made of pressed Galvanised steel conforming to IS 277. It shall be tested at CBRI or ARAI for maximum rating of 2 hrs with vision panel. Test certificates shall be available for vision lites/ panels as part of the fire door assembly. Independent glass test certificates will not be accepted. Manufacturer test certificate shall cover doors both single and double leaf and all doors supplied shall be within the tested specimen, deviation in specification and sheet thickness other than what is mentioned in the test certificates will not be allowed. Proper label conforming the type of door and the hourly rating is mandatory.

Door Frame: Door frame shall be double rebate profile of size 143 x 57 mm made out of 1.60mm (16 gauge) minimum thick G.I. sheet (zinc coating not less than 120gm/sqm) duly filled with vermiculite based concrete mix. Suitable for mounting 120 minutes fire rated door shutters. The frame is fitted with intumuscent fire seal strip of size 10 x 4 mm (minimum) all-round the frame and fixing with dash fastener of approved size and make, including applying a coat of approved brand fire resistant primer. Frames shall be metered and field assembled with self tabs. All provision shall be mortised, drilled and tapped for receiving appropriate hardware. Rubber door silencers shall be provided on the skirting jamb. Frames shall be provided with black plate bracket for installation on a finished plastered masonry wall opening. Once frame installed shall be grouted with cement & sand slurry of approved proportion necessary for fire doors on the clear masonry opening.

Door Shutter: Door shutters will be 50 mm thick (unless otherwise stated in the drawing) of 120 minutes fire rating conforming to IS: 3614(Part-II) tested and certified as per laboratory approved by Engineer-in-Charge with suitable mounting on door frame, consisting of vertical styles, lock rail, top rail 100 mm wide, bottom rail 200 mm wide, shall fully flush double skin door with or without vision lite. Door shall be manufactured from 1.6 mm (16 gauge) minimum thick SWG G.I. sheet (zinc coating not less than 120gm/sqm) duly filled FR insulation material and fixing with necessary stainless steel ball bearing hinges of approved make (if mentioned in the drawing) including applying a coat of approved fire resistant primer. The internal construction of the door shall be rigid reinforcement pads for receiving appropriate hardware.All doors shall be factory prepared for receiving appropriate hardware and provided with necessary reinforcement hinges, locks and door closers. The edges shall be interlocked with a bending radius of 1.4 mm. For

pair of doors astragals has to be provided on the meeting stile for both active and inactive leaf of 200 x 300mm Vision lite wherever applicable shall be provided as per manufacturer's recommendation with a beeding and screws from inside. The glass shall be 6 mm clear borosilicate fire rated glass of relevant rating of the door.

The door leaf and frame shall have passed minimum 250hours of salt spray test.

Paint: All doors and frames shall be finished with paint as per Volume-II-G/1-Sec-IV.

2.03.00 **Structural Glazing**

Aluminium semi unitised vertical Structural glazing system with single glass vision panel and spandrel panel of approved make having main frame of verticals and horizontals made out of specially designed extruded aluminium sections to withstand wind pressure of 175 kg/sq.m at a height of 40m and fabricated, fixed at all levels, elevation and heights to the Masonry / RC walls with necessary clamps, brackets and anchor fasteners. All clamps and brackets shall be Mild Steel Hot dip galvanized minimum 80 microns thick and shall conform to IS: 4759-1996. The extruded aluminium section shall be anodised in approved colour with anodic coating of minimum 25 microns. Extruded section shall be of 6063 T5 or T6 alloy conforming to ASTM B 221. Any other fastening straps, nuts, bolts, rivets, washers, Fire stops at all floor levels etc. shall be in stainless steel SS 304 grade. All tapes shall be of approved make.

The system shall be designed to withstand a wind pressure of 200 kg/Sqm and shall be fixed to the masonry/RC walls with necessary clamps, brackets and anchor fasteners, clamps and brackets shall be Hot dip galvanized minimum 80 microns thick, all complete as per manufacturer's manual and specifications. The spandrel panel shall have 50mm thick fiber glass insulation of 48 kg/cum density of approved make conforming to IS-8183 and 1.0 mm thick Twiga black tissue conforming to BS 476 Part 7. This insulation shall be enclosed in a GI tray fabricated out of 1mm thk. GI sheet and fixed to the glazing framework with stainless steel fasteners.

The gap between the GI framework and the concrete framework shall be sealed with Aluminium flashing fixed with stainless steel fasteners. All gaps shall be sealed with Silicone sealant of approved brand. Insulation shall be provided in between the Structural glazing aluminium frame work (i.e., behind the spandrel glazed panel) and the structure.

Providing 6 mm thick toughened fully tempered hard coated glass(or as per thickness mentioned elsewhere) of blue/green/blue-green or approved colour having VLT = 35 to 50 % ,External reflectance= 6 to 15% ,Internal reflection = 8 to 15%, Solar factor = 0.36 to 0.43, U Factor = 2.8 to 3.0 W/sqm K etc.

2.04.00 Aluminium Curtain Wall System

2.04.01 General

1) Aluminium Curtain Wall System shall be designed for the following effects:

   a) Permanent Deformation, thermal expansion.

   b) Wind and seismic load

   c) Air and water infiltration or leakage.

   d) Lateral deflection per floor height

2) Unless otherwise specified the design of the system shall be prepared by the specialized firm for executing such works and submitted to the EIC / Department for approval after detailed scrutiny and checking design calculations and drawings.

3) It will be obligatory on the part of the Bidder to execute the work systematically and conduct the necessary mock-up unit tests, before taking up the work to the satisfaction of EIC / Department.

2.04.02 Specification for Materials used for Curtain Wall

1	Glazing	Glazing work shall be as specified in the description of the item and / or as described under the chapter Glass & Glazing of this book.
2	Framing system	Aluminium anodized extruded sections manufactured by reputed approved manufacturers, for all types of members like brackets, mullions, transom etc.
3	Sealant	As specified in the item or silicon sealant
4	Insulation	50 mm thick rock wool of minimum density 48 kg/cum sandwiched with black polythene sheet 100 micron on one side and aluminium foil of 100 micron on the other side or as specified by manufacturer at spandrel area. The surface after fixing insulation shall be plain without any distortion
5	Heat Reflective Toughened Glass	As specified elsewhere in the specification. Colour of any shade approved by the Engineer-in-Charge.

2.04.03 Aluminium Alloy Extruded Sections

Extruded sections to be used for fabrication of framing system for curtain walls shall be manufactured and supplied by approved reputed companies. In absence of specific extruded section, sections available conforming to BIS specification, manufactured by approved reputed companies, shall be used in

the works. Dimensions and weights of the sections shall be as per approved drawings.

2.04.04 **Components, General specifications, Glazing, Panelling etc. for Curtain Wall System:**

These shall be generally as per relevant Chapters in this book.

2.04.05 **Scope of Work**

Preliminary Requirements

i) The Bidder shall design, test, fabricate, deliver, install all construction necessary to provide a complete curtain wall system, all in conformity with the drawings and approval of the Engineer-in-Charge.

ii) Specification and all relevant construction regulations including providing any measures that may be required to that end, notwithstanding any omissions or inadequacies of the drawings,

iii) **The curtain wall system shall also include the following activities:**

a) Metal frames, glass glazing, spandrels, ventilators, finish hardware, copings, metal closure, windows etc.

b) All anchors attachments, reinforcement and steel reinforcing for the systems required for the complete installations.

c) All thermal insulation associated with the system. (d) All fire protection associated with the system.

d) All copings and closure and metal cladding to complete the system.

e) All sealing and flushing including sealing at junctions with other trades to achieve complete water tightness in the system.

f) Isolation of dissimilar metals and moving parts,

g) Anticorrosive treatment on all metals used in the system, (i) Polyester powder coating aluminium sections,

iv) **The Bidder shall also be responsible for providing the following:**

a) Engineering proposal, shop drawings, engineering data and structural calculations in connection with the design of the curtain wall system.

b) Mock-ups, samples and test units.

c) Performance testing of the curtain wall framing and glazing assembly. (d) Co-ordination with the work of other trade.

d) Insulation with glass wool 48 kg/cum at spandrels area.

e) All final exterior and interior cleaning and finishing of the curtain wall system.

f) Protection.

g) As built record drawings and photographs.

h) All hoisting, scaffolding, staging and temporary services.

i) Conceptualising and design of a suitable maintenance system for curtain glazing,

v) The water tightness and structural stability of the whole curtain wall system shall be the prime responsibility of the Bidder. Any defect or leakage found within the Defect Liability period (DLP) shall be sealed and made good all at the risk and cost of the Bidder.

vi) The curtain wall system shall be designed to provide for expansion and contraction of components which will be caused by an ambient temperature range without causing buckling, stress on glass, failure of joint sealants, undue stress on structural elements or other detrimental effects, specific details shall be designed to accommodate thermal and building movements.

2.04.06 **Design Requirements**

i) Curtain wall shall comply with all government codes and regulations, building bye-laws, if any.

ii) All curtain walling, individual aluminium and glass components and all completed work shall be designed and erected to comply with the following requirements.

2.04.06.01 **Basic requirement**

The basic design and architectural requirements shall consist of the size of window, net glass area, ventilator, configuration of windows and spandrels to be retained. However the Bidder may propose alternatives on the construction details for approval of the Engineer-in-Charge, provided that all basic functional and architectural requirements are fulfilled.

2.04.06.02 **Quality Consideration and other Activities**

i) The Bidder while submitting the detailed design calculations shall submit the following information on the quality of materials to be used and other aspects as detailed below:

1) Metal quality, finishes and thickness

2) Glass quality, coating and thickness and proposed manufacturer's brand names.

3) Aluminium extruded sections including mullions and transoms together with structural calculations and proposed manufacturer's brand name and also the name of agency proposed for fabrication work.

4) Arrangement and jointing of components.

5) Field connections especially mullion to mullion and transom to mullion.

6) Fixing and anchorage system of typical wall unit together with structural calculations.

7) Drainage system and provision in respect of water leakage in the curtain wall system.

8) Provisions for thermal movements.

9) Sealant and sealing methods.

10) Glazing Method

11) Wind load and seismic load and any other specific load considered in the design

ii) Design concept over lighting protection link-up system of the curtain wall for connection and incorporation into the lighting conductor system of the building (Lighting conductor system of the building shall be done by other approved specialized agency).

iii) The maximum permissible structural tolerances of the building that the system has been designed to accommodate in case these tolerances exceed those specified in the specification.

2.04.06.03 **Tolerances:** Any parts of the curtain wall, when completed, shall be within the following tolerances:

1) Deviation from plumb level or dimensioned angle must not exceed 3 mm per 3.5 m length of any member, or6 mm in any total run in any line.

2) Deviation from theoretical position on plan or elevation, including deviation from plumb, level or dimensioned angle must not exceed 9mm total at any location.

3) Change in deviation must not exceed 3mm for any 3.5 m run in any direction.

2.04.06.04 **Samples :** The Bidder shall also submit samples of aluminium extruded sections; mullion and transom sections in lengths of 300 mm with the same finish and workmanship as per the tender proposals and 300 mm x 300 mm samples of glass for approval of the EIC. (samples to include exposed screws and other exposed securing devices if any).

2.04.06.05 **Ancillary Requirements to be fulfilled by the Bidder**

i) The Bidder / approved specialized agency shall submit a maintenance manual for the curtain wall system inclusive of all metal parts, glass and finish etc.

ii) During detailed design scrutiny and also during the actual execution of the work any additions and extra provisions that will have to be made as per theoretical requirements or site conditions shall be implemented and executed by the Bidder at his own cost, without claiming any thing extra under any circumstances.

2.04.07 **Execution of work**

2.04.07.01 Performance Testing - General Requirements

i) Mock-up units shall be constructed by the Bidder and tested to determine the structural stability as well as air and water infiltration or leakage at glazing beads and all other joints designed into the face of the building.

ii) After the approval of structural calculations and the drawing for construction of the curtain wall, one test unit for performance testing of the curtain wall shall be constructed by the Bidder at an independent laboratory or at a laboratory approved by the Engineer-in-Charge.

iii) Erect mock-up under manufacturer's / Fabricator's direct supervision and employ workmen as they would be employed during the actual erection at the job site.

iv) The Bidder shall submit to the Engineer-in-Charge the test procedures to be adopted, test schedule and location for testing before the work of actual testing is taken up.

v) Prior to the fabrication of test units, the Bidder shall submit shop drawings and design calculations of the test unit for approval of the Engineer-in-Charge.

vi) Bidder shall not start the work of erection of curtain wall on site till the approval for the successful completion of the mock up test and clear

instruction in writing to start the work is received from the Engineer-in-Charge.

vii) The decision of the Engineer-in-charge in respect of the procedure to be adopted, in conducting the mock-up test and the judgment over the net results, shall be final and binding on the Bidder.

2.04.07.02 **Test of Wind Pressure**

i) The equivalent load of wind pressure or wind suction shall be given to the test unit as increasing or decreasing the inside pressure in the "pressure chamber" at which the test unit is fixed.

ii) The static wind pressure shall be applied up to 1.5 kpa at maximum wind pressure.

iii) The variation of dynamic pressure shall be of any approximate sine curve line.

iv) Deflection on each observational points of the test unit shall be observed and recorded under static pressure as described above.

v) Any damage and harmful permanent deformation on any parts except sealing materials shall not be found at maximum wind pressure.

vi) The deflection on the main structural parts in this condition shall not exceed :

1) 1/175 of the span between supports or 20 mm, whichever is less for vertical elements.

2) 1/250 of the span between supports for horizontal elements.

3) The extent of recovery of deformation, 15 minutes after the removal of the test load, is to be at least 95%.

2.04.07.03 **Test of Lateral Deflection per floor height**

i) Lateral deflection per floor height shall occur on the test unit, when the structural frame which fixes the test unit is deflected horizontally.

ii) The deflection of every ± 2.5 mm shall be increased up to ± 13 mm on the test unit (static deflection test)

iii) The dynamic deflection shall be applied up to ± 13 mm.

iv) The variation of dynamic deflection shall be of an approximate sine curve line, one period of 3 seconds.

v) The dimensions of the deflection on each observational point of the test unit shall be measured under the condition as described above and the damage shall be observed.

vi) Any damage and harmful permanent deformation shall not be found in any parts of the curtain wall except the damage to sealant at maximum deflection.

2.04.07.04 **Water-tightness Test**

i) Water shall be sprinkled to the Test Unit' under wind pressure.

ii) Pressure shall not be applied to the test unit.

iii) The volume of the sprinkling water in one minute shall be 5 litres per sqm minimum.

iv) All water leakage and drainage system at the joint and the open able sash of the curtain wall system shall be observed from the outside of the chamber.

v) Hold the test two times, in sequence as described below, conforming to the above mentioned conditions.

vi) Water leakage shall not be observed inside at all parts of the test unit during first water-tightness test.

1) Install the test unit.

2) Hold first water-tightness test.

3) Hold test of wind pressure as described above.

4) Hold second water-tightness test.

5) Lateral deflection test.

2.04.07.05 **Test Report:** The Bidder shall submit five copies of test report to the Engineer-in-charge.

2.04.07.06 **Cost of Performance Test**

i) The Bidder shall allow in his tender for the cost of the performance testing and fabrication, erection, corrections to and demolition of the test units including any special provision required in the testing laboratory for the tests mentioned above.

ii) The Bidder shall allow for amendments and adjustments to the mock-up unit as instructed and required by the Engineer-in-Charge / Architect or the consultant.

iii) If the mock-up test unit fails to pass the initial testing, the Bidder shall make the necessary corrections to the test unit and shall get the test unit retested by the testing laboratory until it passes the test.

iv) Cost of corrections to the test unit and the cost of retesting shall be borne by the Bidder.

v) The Bidder shall be allowed six calendar months time after the work is awarded to set up the test unit and conduct the required test as described above to the satisfaction of the Engineer-in-charge.

vi) In case the Bidder fails to conduct the necessary tests as described above or fails to meet the required test results, without any genuine cause within the allotted period of six months, the Engineer-in-charge shall be free to take necessary action as per the condition of contract.

2.04.07.07 **Record of Test and Drawings**

i) The testing laboratory shall keep the approved copy of the shop drawing and calculations of the test unit at testing laboratory during testing of test unit.

ii) The testing laboratory shall accurately and nearly record on the above mentioned shop drawings all changes, revisions, modifications etc. made to test unit, which shall become the record drawing.

iii) On completion of testing and after approval of the test reports the testing laboratory shall submit the final record drawings to the Engineer-in-charge.

2.04.07.08 **Fabrication and Erection**

i) Frames shall be square and flat, both the fixed and openable frames shall be constructed of sections, which have been cut to length, mitred and mechanically jointed at the corners, Sub-dividing bar of units shall be tenoned and riveted into frames.

All frames shall have corners welded to true right angles. For jointing hollow sections flash butt welding, argon arc welding or mechanical jointing by inserts shall be used. (Gas welding or brazing shall not be done). Concealed screws shall be used for joining the sub-units.

ii) The grid for the curtain wall system shall be fabricated carefully with aluminium extruded sections like mullions and transom in the exactly same pattern as per the final drawings with amendments if any received from the laboratory after conducting the mock-up unit test.

iii) The sizes of different members of the curtain wall system shall be exactly as adopted for the mock-up unit tests and the grid shall be

fixed to the building member as shown in the drawing, received after conducting the mock-up unit test.

iv) Care shall be taken to see that any gap between the frame and support and the frame **itself is sealed with silicon sealant.**

v) Finish of grid frame shall be either anodized, organic coating, backed enamel finish or as specified in the item of work, no visual variation in anodizing / colour shall be accepted.

vi) Care shall be taken to see that the curtain wall system is not deformed, damaged during erection and it shall be protected from direct contact with wet or intermittent wet cement concrete mortar etc.

2.04.08 **Representative of the Bidder**

Full time attendance of a qualified civil engineer with sufficient experience in construction of curtain wall system shall be provided for erection of test unit, all testing and later on actual construction.

3.00.00 ACCEPTANCE CRITERIA

3.01.00 **For Fabricated Items**

a) Overall dimensions shall be within ± 1.5 mm of the size shown on drawings.

b) Mullions, transoms etc. shall be in one length and permissible deviations from straightness shall be limited to ± 1.5 mm from the axis of the member.

c) Door and window shutters shall operate without jamming. The clearance at head and jamb for door shutters shall not exceed 1.5 mm. For double leaf doors, the gap at the meeting stiles shall not be more than 1.5 mm.

d) Door leaves shall be undercut where shown on drawings.

e) Doors, windows, frames, etc. shall be on a true planes, free from warp or buckle.

f) All welds shall be dressed flush on exposed and contact surfaces.

g) Correctness of location and smoothness of operations of all shop installed hardware and fixtures.

h) Provisions for hardware and fixtures to be installed at site.

I) Glazing beads shall be cut with mitered corners.

j) Glazing clips, fixing devices etc. shall be supplied in adequate numbers.

k) Shop coats shall be properly applied.

l) Exposed aluminium surfaces shall be free from scratches, stains and discolouration. Anodised surfaces shall present a uniform and pleasing look.

3.02.00 **For Installed Items**

a) Installations shall be at correct location, elevation and in general on a true vertical plane.

b) Fixing details shall be strictly as shown on drawings.

c) Assembly of composite units shall be strictly as per drawings with mastic caulking of transoms and mullions, gaskets, weather strips etc. complete.

d) All frames on external walls shall be mastic caulked to prevent leakage through joint between frames and masonry.

e) All openable section shall operate smoothly without jamming.

f) Locks, fasteners, etc. shall engage positively. Keys shall be non-interchangeable.

g) Cutting to concrete or masonry shall be made good and all abrasions to shop paint shall be touched up with paint of same quality as shop paint.

h) Aluminium doors, windows, etc. shall be free from scratches stain or discolouration.

4.00.00 INFORMATION TO BE SUBMITTED

4.01.00 After Award

a) Names of manufacturers for doors, windows, etc.

b) Manufacturer's catalogue for all hardware and fixtures proposed to be used.

c) Before starting fabrication of all metal doors, windows, etc. the Bidder shall submit detailed fabrication drawings to the Engineer for approval. The fabrication shall be started only after approval of drawings.

d) He shall submit a programme of work to be done for the approval of the Engineer.

e) Before bulk supply, he shall submit for the approval of the Engineer samples of all bought out items and samples of each type of fabricated items. The samples shall be retained by the Engineer for comparison of bulk supply and returned to the Bidder towards the end for final incorporation in the job.

5.00.00 I.S. CODES

Following are some of the important I.S. Codes as relevant to this section:

Steel doors, windows and ventilators	-	IS: 1038
Steel windows for industrial buildings	-	IS: 1361
Aluminium doors windows and ventilators	-	IS: 1948
Aluminium windows for industrial buildings	-	IS: 1949
Steel doorframes	-	IS: 4351
Code of practice for fixing and glazing of Metal (steel and aluminium) doors, windows, And ventilators.	-	IS: 1081
Wrought Aluminium and Aluminium Alloys, Bars, Rods and Sections (For General Engineer Purposes) – Specification	-	IS: 733
Wrought Aluminium and Aluminium Alloy sheet, and strip for General Engineer Purposes - Specification	-	IS: 737
Wrought Aluminium and Aluminium Alloy, Extruded Round Tube and Hollow sections (For General Engineering Purposes)–Specification	-	IS: 1285
Anodic coating on Aluminium and its Alloys – Specification	-	IS: 1868
Specification for Aluminium equal leg angles	-	IS: 3908
Specification for Aluminium unequal leg angles	-	IS: 3909
Dimensions for wrought Aluminium and Aluminium Alloys bars, rods and sections.	-	IS: 3965
Method of testing anodic coating on aluminium AndIts alloys	-	IS: 5523

Measurement of coating thickness by Eddy Current Method	-	IS: 6012
Floor springs (Hydraulically regulated) for heavy doors Specifications		IS: 6315
Dimensions of extruded hollow section and tolerances	-	IS: 6477
Handbook of Method of Measurement of Buildings Works	-	SP 27: 1987

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SECTION-VIII

GUIDELINE
FOR
ROLLING STEEL SHUTTERS,
AND COLLAPSIBLE GATE

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SECTION-VIII

GUIDELINE FOR ROLLING STEEL SHUTTERS, AND COLLAPSIBLE GATE

1.00.00 SCOPE

This specification covers the design, supply of materials, fabrication, delivery and erection of collapsible doors and Rolling Shutters with motor driven operation including all accessories as hereinafter specified.

2.00.00 INSTALLATION

2.01.00 **Components**

a) Slats for rolling shutters shall be made from tested bright cold rolled, annealed M.S. strips, not less than 0.9 mm thick of CR grade for shutters up to 4.5 M wide and not less than 2.25 mm thick of CR grade for shutters 5.5 M wide and above, machine rolled at 75 mm rolling centers, interlocking with each other. The profile will be such as to prevent excessive deflection under specified wind load.

b) NOT USED

c) End locks shall be heavy type M.C.I./C.I. and shall be provided at each end of alternate slats

d) Bottom bars shall be finished with two angles not less than 6 mm thick for external shutters. When shown on drawings, a flexible weather strip shall be applied to make tight contact with the floor.

e) Guides shall be of such depth as to retain the shutter under a wind pressure of 100 Kg/Sq.M

f) Shafts shall be of steel pipe of sufficient size to carry the torsional load with a maximum deflection of 1/360th of span. Grease packed ball bearings or bushings shall be provided for smooth trouble free operation.

g) Hoods shall be formed of not less than 20 gauge steel, suitable reinforced to prevent sag.

h) Locks shall be slide bolt and hasp, or cylinder lock operable from one or both sides. Provision securing hand chain with pad-lock, provision for removable handle for hand cranks etc. .

i) Power unit shall be suitable for 3 phase, 50 cycle, 400 volt A.C. power supply and shall be either floor or wall mounted unit. The motor shall be of sufficient capacity to move the shutter in either direction at a speed of 0.3 metre per second. In addition to the gear motor each standard power unit shall include a magnetic brake, a reversing starter with built-in overload protection, a geared limit switch and one push button station located inside the building

It is desirable that the bottom bar of motor operated doors shall be provided with a sensitive edge, electrically connected to stop the travel of the door on meeting an obstruction.

j) Operating chains shall be of tested quality, heavily galvanised and with all ends rounded to assure smooth operation and hand protection.

k) Reduction gears shall be high strength gray cast iron, machine moulded from machine out patterns.

2.02.00 NOT USED

2.03.00 **Power Operated Shutters**

These shall be operable from a push button station conveniently located beside the door or as shown on drawings. One emergency hand chain/crank operation shall also be provided for use in case of failure of the electric system. Where called for, externally mounted shutters shall be operated by control mechanism located inside the building.

2.04.00 **Rolling Shutters**

Rolling shutters shall conform to IS 6248. These shall include necessary locking arrangement and handles etc. These shall be suitably fixing in the position as specified i.e. outside or inside on or below lintel or between jambs of the opening. The door shall be either push and pull type/Mechanical and electrically operated

Shutter: The shutter be built up of inter locking lath section formed from cold rolled steel strips. The thickness of the sheets from which the lath sections have been rolled shall be not less than 0.90mm for the shutters up to 3.5m width and not less than 2.25 mm thick of CR grade for shutters 5.5 M wide and above. Shutters above 9 metres width should be divided in 2 parts with provision of one middle fixed or movable guide channel or supported from the back side to resist wind pressure of 100 kg/sq.m. The lath section shall be rolled so as to have interlocking curls at both edges and a deep corrugation at the centre with a bridge depth of not less than 12 mm to provide sufficient curtain of stiffness for resisting manual pressures and normal wind pressure.

Each lath section shall be continuous single piece without any welded joint. When interlocked, the lath sections shall have a distance of 75 mm rolling centers. Each alternate lath section shall be fitted with malleable cast iron or mild steel clips securely riveted at either ends, thus locking in the lath section at both ends preventing lateral movement of the individual lath sections. The clips shall be so designed as to fit the contour of the lath sections.

Spring: The spring shall be coiled type. The spring shall be manufactured from high tensile spring steel wire or strips of adequate strength conforming to IS 4454 - Part I.

Roller and Brackets: The suspension shaft of the roller shall be made of steel pipe conforming to heavy duty as per IS 1161 to carry the tortional load with a maximum deflection of $1/360^{th}$ of span. For shutter up to 6 metre width and height not exceeding 5 metre, steel pipes of 50mm nominal bore shall be used. The shaft shall be supported on mild steel brackets of size 375 x 375 x 3.15 mm for shutters up to clear height of 3.5 metre. The size of mild steel brackets shall be 500 x 500 x 10 mm for shutters of clear height above 3.5m and up to 6.5 m. The suspension shaft clamped to the brackets shall be fitted with rotatable cast iron pulleys to which the shutter is attached. The pulleys and pipe shaft shall connected by means of pre-tensioned helical springs to counter balance the weight of the shutter and to keep the shutter in equilibrium in any partly open position.

When the width of the opening is greater than 3.5 mtr, the cast iron pulleys shall be interconnected with a cage formed out of mild steel flats of at least 32 x 6 mm and mild steel dummy rings made of similar flats to distribute the torque uniformly. Self aligning two row ball bearings with special cast iron casings shall be provided at the extreme pulley and caging rings shall have a minimum spacing of 15 mm and at least 4 number flats running throughout length of roller shall be provided.

In case of shutters of large opening the roller shall be fitted with a purion wheel at one end which in contact with a worm fitted to the bracket plate, caging and pulley with two ball bearing shall be provided.

Guide Channel: The width of guide channel shall be 25mm the minimum depth of guide channels shall be as follows:

Clear width of shutter	Depth of guide channel
Up to 3.5 m	65mm
3.5m up to 8m	75mm
8m and above	100mm

The gap between the two legs of the guide channels shall be sufficient to allow the free movement of the shutter and at the same time close enough to prevent rattling of the shutter due to wind.

Each guide channel shall be provided with a minimum of three fixing cleats or supports for attachment to the wall or column by means of bolts or screws. The spacing of cleats shall not exceed 0.75 m. Alternatively, the guide

channels may also be provided with suitable dowels, hooks or pins for embedding in the walls.

The guide channels shall be attached to the jambs, plumb and true either in the overlapping fashion or embedded in grooves, depending on the method of fixing.

Cover: Top cover shall be mild steel sheets not less than 0.90mm thick and stiffened with angle or flat stiffeners at top and bottom edges to retain shape.

Power unit: Power unit shall be suitable for 3 phases, 50 cycles, 400 volt A.C. power supply and shall be either floor or wall mounted unit. The motor shall be of sufficient capacity to move the shutter in either direction at a speed of 0.3 metres per second. In addition to the gear motor each standard power unit shall include a magnetic brake, a reversing starter with built-in overload protection, a geared limit switch and one push button station located inside the building It is desirable that the bottom bar of motor operated doors shall be provided with a sensitive edge, electrically connected to stop the travel of the door on meeting an obstruction.

Lock plates with sliding bolts, handles and anchoring rods shall be as per IS 6248.

Operating chains shall be of tested quality, heavily galvanised and with all ends rounded to assure smooth operation and hand protection.

Reduction gears shall be high strength gray cast iron, machine moulded from machine out patterns.

Fixing: The arrangement for fixing in different situations in the opening shall be as per IS 6248.

Brackets shall be fixed on the lintel or under the lintel as specified with rawl plugs and screws bolts etc. The shaft along with the spring shall then be fixed on the brackets.

The lath portion (shutter) shall be laid on ground and the side guide channels shall be bound with ropes etc. The shutter shall then be placed in position and top fixed with pipe shaft with bolts and nuts. The side guide channels and cover frames shall then be fixed to the walls through the plate welded to the guides. These plates and brackets shall be fixed by means of steel screws bolts, and rawl plugs concealed in plaster to make their location invisible. Fixing shall be done accurately in workmen like manner that the operation of the shutter is easy and smooth.

2.05.00 **Shop Coat**

Shutters shall be painted with one coat of zincethyl silicate primer. Where specified, doors shall be galvanized and subsequently painted one coat of zinc ethyl silicate for adhesion of field coat.

2.06.00 **Erection**

Door shall be installed by the manufacturer or his authorised representative and all work shall be as per manufacturer's instructions. Any drilling or cutting to concrete, masonry etc. shall be made good after erection of shutters and all abrasion to shop coat shall be touched up. All electrical work shall be in strict accordance with the latest Indian Electricity Rules.

2.07.00 **Collapsible Gate / Door**

2.07.01 These shall be of approved manufacture and shall be fabricated from the mild steel sections.

2.07.02 The gates shall consist of double or single collapsible gate depending on the size of the opening. These shall consist of vertical double channels each 20 x 10 x 2 mm. at 10 cm. centre to centre braced with flat iron diagonals 20 x 5 mm and top and bottom rails of T- iron 40 x 40 x 6 mm @ 3.5 kg/m with 40 mm dia. ball bearings in every fourth double channel, unless otherwise specified. Wherever collapsible gate is not provided within the opening and fixed along the outer wall surface, T- iron at the top may be replaced by flat iron 40 x 10 mm.

The collapsible gate shall be provided with necessary bolts and nuts, locking arrangement, stoppers and handles. Any special fittings like spring, catches and locks, shall be so specified in the description of item where so required. The gate shall open and close smoothly and easily.

2.07.03 **Fixing**

T- iron rails shall be fixed to the floor and to the Lintel at top by means of anchor bolts embedded in cement concrete of floor and lintel. The anchor bolts shall be placed approximately at 45 cm centers alternatively in the two flanges of the T- iron. The bottom runner (T- iron) shall be embedded in the floor and proper groove shall be formed along the runner for the purpose. The collapsible shutter shall be fixed at sides by fixing the end double channel with T-iron rails and also by hold- fasts bolted to the end double channel and fixed in masonry of the side walls on the other side. In case the collapsible shutter is not required to reach the lintel, beam or slab level, a Tee-section suitably designed may be fixed at the top, embedded in masonry and provided with necessary clamps and roller arrangement at the top. All the adjoining work damaged in fixing of gate shall be made good to match the existing work without any extra cost to Owner.

2.07.04 **Painting**

All the members of the collapsible gate including T-iron shall be thoroughly cleaned off rust, scales, dust etc. and given priming cost of zinc ethyl silicate before fixing them in position .Painting shall be the same as specified for Rolling Shutters.

3.00.00 ACCEPTANCE CRITERIA

3.01.00 Shop Inspection

After completing the manufacture of the different components of the rolling shutter, an arrangement for shop inspection by the Engineer shall be made to check the conformity with approved shop drawings.

3.02.00 Field Inspection

After installing the shutters, the Successful Bidder shall test the performance of the shutter in the presence of the Engineer. The doors shall be smoothly operable under all ambient conditions. All control and locking devices shall give fault-free performance.

4.00.00 I.S. CODE

IS: 6248-1979	-	Metal rolling shutters and rolling grills.
IS: 10521-1983	-	Collapsible Gate

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SECTION-IX

GUIDELINE
FOR
MISCELLANEOUS METAL

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SECTION-IX

GUIDELINE
FOR
MISCELLANEOUS METAL

1.00.00 SCOPE

This shall include supply, fabrication and erection of miscellaneous metal items of light nature in gates, grills, balcony and stair handrails particulars, structural mullions and transoms, ladders hangers masonry anchors, shelf angles, anchor bolts, fasteners, etc. as shown on drawing or as instructed by the Engineer. The above items shall be of fabricated or cast M.S/Aluminium/Brass, cast iron, M.S. and galvanised M.S. Sheets, aluminium sheets, expanded metal, wire mesh etc. as shown on drawings and/or described elsewhere in the specification.

2.00.00 INSTALLATION

2.01.00 Fabrication/Casting

2.01.01 General

All work shall be done according to approved shop drawings. All workmanship shall be equal to the best practice in modern structural or foundry shop.

2.01.02 Shop Connections

a) All shop connections shall be riveted or welded except when noted otherwise on drawings.

b) Welding of steel shall be done in accordance with the IS : 816. Use of metal arc welding for general construction in Mild Steel.

c) Welding of aluminium shall be done in accordance with IS: 2812, Arc welding of Aluminium and Alloys, Special care shall be taken to grind smooth all welded surface that shall remain exposed to view. Welds shall be electrically continuous if so required by the Engineer.

2.01.03 Shop Coat

Before leaving the shop, all metal work shall be thoroughly cleaned by effective means of all loose mill/ scale, rust and foreign matter. Except where encased in concrete, all steelwork shall be given one coat of approved metal protective paint, applied by brush thoroughly and evenly, well worked into joints and other open spaces. All paint shall be applied to dry surfaces. When specified ,steel work shall be galvanised or non-galvanized steel work shall be painted with a

coat of zinc ethyl silicate primer. Aluminium surfaces which shall come in contact with masonry shall be given one coat of zinc ethyl silicate primer.

2.02.00 **Erection**

2.02.01 **Bracing**

The Bidder shall provide all necessary temporary guys and braces to ensure alignment and stability of the members and to take care of all loads to which the structure may be subjected including erection of equipment and operation of the same.

2.02.02 **Temporary Bolting-Up**

As erection precedes the Bidder shall plumb up and level all members and shall securely bolt up to take care of all dead load, wind load and erection stresses. Wherever piles of materials, erection equipment or other loads are carried during erection, proper provision shall be made to take care of the stresses resulting from the same.

2.02.03 **Turned Bolt**

For field connections where bolting is specified, holes for the turned bolts may be renamed in the field, if required. All drilling or reaming for turned bolts shall be done after the parts to be connected are assembled.

2.02.04 **Welding**

Where specified on drawings, welding shall be done in accordance with IS : 816 for steel and IS: 2812 for Aluminium and Alloys.

2.02.05 **Cutting and Fitting**

No cutting of sections, flanges, webs of angles shall be done without the approval of the Engineer. Where indicated on the drawings, holes, cuttings, etc. shall be provided as required for installation, to the work by the other Bidders. No additional holes or cuttings, than those shown on drawings, shall be made without the approval of the Engineer.

2.02.06 **Drifting**

Correction of minor misfits and a reasonable amount of reaming and cutting of excess stock from rivets may be permitted. For this, light drifting may be allowed to draw holes together. Twist drills shall be used to enlarge as necessary to make connections. Reaming that weakens the members or make it impossible to fill the holes properly or to adjust accurately after reaming shall not be allowed.

Any error in shop work which prevents the proper assembling and fitting of parts by moderate use of drift pins or a moderate amount or reaming and slight chipping and cutting shall immediately be called to the attention of the Engineer

and approval of the method of correction obtained. The use of cutting torches to enlarge or alter rivet holes shall not be permitted.

2.02.07 **Grouting**

All bearing plates, loose lintels and beams, etc. shall be set to proper grade and level by the Bidder and the Engineer's approval obtained before proceeding with the grouting. Grouting shall be done in 1:1.5:3 or 1:1- 1/2:3 concrete with 6 mm down stone chips or with non-shrink grout. Grouting shall be done as specified in G1/section II.

2.02.08 **Anchor Bolting**

When shown on drawings, the miscellaneous metal items shall be fixed to concrete by case hardened and drawn carbonizing steel expander nut and bolt. The Bidder shall submit the manufacturer's literature showing the average pull out and average shear values for bolts of various sizes. The bolts shall be fixed strictly as per the manufacturer's instructions.

2.02.09 **Pipe Joints**

M.S. Pipes shall be joined by threaded sockets or by welding. Cast iron pipes shall be socket and spigot jointed and caulked with hemp and molten lead.

2.02.10 **Spot Painting**

All field rivets and bolts and also any serious abrasion to shop paint shall be spot painted with the same materials as used for the shop paint or equivalent.

2.02.11 **Making Good**

All cutting to concrete or masonry shall be made good to the satisfaction of the Engineer.

3.00.00 ACCEPTANCE CRITERIA

a) All items shall be of correct shape, size, weight etc. shown on drawings

b) For installed items, the tolerances shall be follows:

i) Permissible deviation from straightness - 1 in 1000.

ii) Seats, stiffener connections etc. shall be as per approved drawings and shall not interfere with architectural clearances.

c) All castings shall be free from blowholes, cracks and other blemishes.

4.00.00 SCOPE

The Bidder's scope shall include for supply of materials, fabrication, shop paint and erection. This shall also include transporting the fabricated materials to the site, unloading storing and erection, including furnishing necessary temporary bracings guys, staging and planking. This shall also include cutting and drilling to steel, concrete or masonry and welding, bolting grouting and making good damages after erection and removing all rubbish and clearing the site upon completion of erection.

5.00.00 I.S. CODES

IS: 226	-	Structural Steel (Standard Quality)
IS: 800	-	Code of practice for use of structural steel in general building construction.
IS: 816	-	Use of metal arc welding for general construction in mild steel.
IS: 2812	-	Arc welding of Aluminium and Alloys
IS: 3150	-	Hexagonal Wire Netting
IS: 4948	-	Welded steel wire fabric for general use.
SP 27: 1987	-	Handbook of Method of Measurement of Buildings Works

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SECTION-X

GUIDELINE
FOR
GLASS AND GLAZING

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SECTION-X

GUIDELINE
FOR
GLASS AND GLAZING

1.00.00 SCOPE

The work in general shall consist of supplying and fixing all glass and glazing including all clips, putty, mastic cement etc. wherever required as shown on drawings and specifications, supply of metal glazing beads and neoprene gaskets shall be included in this scope.

2.00.00 INSTALLATION

2.01.00 General

The Bidder shall supply and install all glass and glazing as required for various doors, windows, sashes, ventilators and fixed louvers, miscellaneous glazing and partitions from approved manufacturer, shall have uniform refractive index and free from flaws, specks and bubbles. The glass shall be brought to site in the original packing from the manufacturer and cut to size at site.

Materials

a) Clear glass shall be float glass/troughed glass and shall be approved by the Engineer-in-Charge and shall be at least 6mm thick for windows and for doors & glazed partitions shall be minimum 8mm thick. . It shall be clear, float transparent, and free from cracks subject to allowable defects. The float glass shall conform to the IS 14900.The thickness of float glass shall be measured with micrometers or a calliper which is graduated to 0.01 mm or with a measuring instrument having an equivalent capacity.Wired glass of 5.5mm thick minimum shall be provided all plant buildings as per the requirement except office rooms, control rooms and A/C rooms.

b) Obscure glass shall have a cast surface in one side.

c) 24mm thick insulated double glazing having 6mm thick tinted heat-reflecting type float glass on outer side and 6mm thick clear float glass on inner side with 12mm air gap & hermetically sealed shall be mounted on 15 micron coloured anodized aluminium frame suitable for structural glazing system.

d) In general, the putty shall conform to IS: 400 and be of best quality from approved manufacturer. It shall be brought to site in the manufacturer's original packing. Quick setting putty glass is used where it shall be non-setting type.

e) The EPDM Gaskets shall be of size and profile as shown in drawings and as called for, to render the glazing, doors, windows, ventilators etc. air and water tight. Samples of gaskets shall be submitted for approval and the EPDM gasket approved by Engineer-in-Charge shall only be used. The Bidder shall submit documentary proof of using the above material in the work to the entire satisfaction of Engineer-in-Charge.

The EPDM gasket shall meet the requirements as given in Table below :

SL. No.	Description	Standard Follow	Specification
1	Tensile strength kgf/cm^2	ASTM-D 412	70 Min.
2	Elongation at break %	ASTM-D 412	250 Min.
3	Modulus 100% Kgf/cm^2	ASTM-D 412	22 Min.
4	Compression set % at 0º CC 22 Hrs.	ASTM-D 395	50 Max.
5	Ozone resistance	ASTM-D 1149	No visible cracks

Quality of glass

a) All glass shall comply with ECBC 2007 requirements.

b) 6mm thick Glass quality shall be toughened hard coated CVD on line process glass with Low –E coated in surface # 2 having (Light Transmission 82%, Visible light Reflectance- 10% & inside – 11%, Total Solar Energy Transmittance – 66% Reflectance–10% UV transmission – 49%, Solar Heat Gain Coefficient – 0.70 Shading Coefficient – 0.81 ,U – Factor Air 2.77 W/m2k , Sound Insulation – 31db outer lite.

c) 6 mm thick toughened Blue low E hard coated CVD on line process glass with Low –E coated in surface # 2 having (Light Transmission 35%, Reflectance 13%outside & inside – 30 %, Total Solar Energy Transmittance – 19%, Reflection – 9%, UV – 9 %, Solar Heat Gain Coefficient – 0.29 Shading Coefficient – 0.33,U –Factor Air – 1.9 W/m2k, Sound Insulation – 33db outer lite (# 2 surface) Glass with a combination of 6 mm thick toughen Opt float clear 6mm glass inner lite (# 3 Surface) Now the two sheets of glass will be separated by an

aluminium spacer leaving an air gap of 12.7 mm thick and sealed with the weather proof sealant.

2.02.00 **Reflective Glass**

Definitions

i) **Shading Coefficient**: The shading coefficient is the ratio of total solar transmittance to the transmittance through 3.2 mm (1/8") clear glass. Windows with low shading coefficient values improve comfort for building, lower the total cooling load of the building and help smooth out of the difference in cooling loads between perimeter & core zones.

ii) **Luminous Efficiency Constant (Key)**indicates a windows relative performance in rejection solar heat-while transmitting day light. It is the ratio of the visible transmittance to the shading coefficient; clear glass which lets in roughly equal amounts of visible light and solar near-infrared energy has a Key close to 1.0. The solar radiation contains about 50% invisible near-infrared & ultra violet light. Therefore, a perfectly selective glazing, which would all allow visible light pass through while blocking all of the invisible near-infrared & ultraviolet light, would have Key of about 2.0.

iii) **Resistance to Heat Conduction (R-valve):**It is a measure of resistance to heat flow that occurs because of temperature difference between the two sides of the windows. The inverse of R-value is termed as U-value.

Reflective Glass

This is an ordinary float glass with a metallic coat to reduce solar heat. Clear glass transmits most of the sunlight that shines upon it, and most of the solar heat as well; the metallic coated glass i.e. reflective glass has better shading coefficients because they reflect rather than absorb infrared energy. However, most of reflective glazing blocks day light more than solar heat.

Types of Coatings: There are two types of reflective glass, Pyrolytic (Hard) coated and vacuum (soft) coated.

i) **Pyroltic:**It is a coating applied during glass manufacture. The coating is fused in to the glass at 1200ºC.

ii) **Vacuum Coated Glass:** It involves the deposition of metal particles on the glass surface by a chain reaction in a vacuum vessel. It is often called a soft coat; because the coating is more susceptible to damage than hard coat glass. Where toughening of product is required, the product must be toughened first & then vacuum coated. Vacuum coated products have better shading coefficient values than Pyroltic products.

Performance of Reflective Glass: The performance of reflective glass 6 mm of nominal thickness is given below:

Sl. No.	Parameter	Threshold Ratio in %age
1.	Visible Light - Transmittance (%) - Reflectance (%)	 15-46 12-24
2.	Total Solar Energy: - Transmittance (%) - Reflectance (%)	 16-24 8-12
3.	Ultra Violet Rays: - Transmittance (%)	 2-10
4.	U-Value - Summer - Winter	 0.58 0.45
5.	Shading Coefficient	0.25-0.35

Testing: The reflective glass shall be tested for the followings:

i) Physical/Field Test: In a true reflective glass, when a pointed pencil is placed, then tip of pencil (physical) & image shall coincide.

ii) Laboratory Test: In the laboratory, the reflective glass shall be tested for the parameter specified in the table above.

2.03.00 **Glazing, Setting and Finish**

All glazing clips, bolts, nuts, putty, mastic cement etc. as required shall be supplied by the Bidder.

All glass shall be thoroughly cleaned before putting in position. Each glass pane shall be held in place by special glazing clips of approved type. As specified in relevant I.S. Codes, four glazing clips shall be provided per glass pan, except for large panes where six or more clips shall be used as per Engineer's instructions. All holes that may be necessary for holding the clips glazing heads and all other attachments shall be drilled by the Bidder.

Glass panes shall be set without springing, and shall be bedded in putty and back puttied, except where moulding or gasket are specified, putty, mastic cement etc. shall be smoothly finished to the even line and figured glass shall be set with smooth side out.

Necessary glazing clips, putty, mastic cement etc. shall be supplied by the Bidder. The Bidder shall be responsible for damage of glass during handling, transportation, fixing etc.
After completion of glazing work, the Bidder shall remove all dirt stains, excess putty etc. clean the glass panes and leave

the work in perfectly acceptable condition. All broken cracked or damaged glass shall be replaced by new ones at the Bidder's own cost.

3.00.00 ACCEPTANCE CRITERIA

a) All installation shall be free from cracked, broken or damaged glass. Edges of large panes of thicker glass and heat absorbing glass shall be inspected carefully for chipped, cracked or underground edges.

b) Glazing shall be carefully done to avoid direct contact with metal frames.

c) All glass shall be embedded in mastic or fixed by EPDM gaskets to give a leak proof installation.

d) At completion, the panes shall be free from dirt, stains, excess putty etc. to the complete satisfaction of the Engineer.

4.00.00 IS CODES

Following are some of the important I.S.Codes relevant to this Section;

IS : 3548	-	Code of practice for glazing in building.
IS : 1083	-	Code of practice for fixing and glazing metal doors, windows and ventilators.
IS : 14900	-	Transparent Float glass- Specifications.
SP 27: 1987	-	Handbook of Method of Measurement of Buildings Works

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SECTION-XI

GUIDELINE
FOR
FLOOR FINISHES AND ALLIED WORKS

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SECTION-XI

GUIDELINE
FOR
FLOOR FINISHES AND ALLIED WORKS

1.00.00 SCOPE

This specification covers furnishing, installation, finishing, curing, testing, protection, maintenance till handing over various types of floor finishes and allied items of work relevant to this package as listed below:

a) **In Situ Finishes**

i) Integral finish to concrete base

ii) Metallic Hardener like “Ironite” or equivalent finish

iii) Mastic Asphalt finish

iv) Chemical Resistant finish

b) **Tiled Finishes**

a) Pressed ceramic Glazed tile

b) Chemical Resistant(Acid or Alkali resistant Tiles Finish)

c) Rubber, Vinyl etc.

d) Stone slab (Marble/Granite/Kota)

e) Vitrified tiles

1.01.00 Base

The base to receive the finish is covered under other relevant specifications.

1.02.00 Sequence

Commencement, scheduling and sequence of the finishing works shall be planned in detail and must be specifically approved by the Engineer in view the activities of other agencies working in that area. However, the Bidder for the finishing items shall remain fully responsible for all normal precautions and vigilance to prevent any damages whatsoever till handing over.

2.00.00 INSTALLATION

2.00.01 Special Materials

Basic materials are covered under Specification "Properties Storage and Handling of Common Building Materials". Special materials required for individual finishing items are specified under respective items. In general, all such materials shall be as per relevant I.S. Codes where available. In all cases these materials shall be of the best quality available indigenously, unless specified otherwise.

The materials for finishing items must be procured from well-reputed specialised manufacturers and on the basis of approval of samples by the Engineer. The materials shall be ordered, procured and stored well in advance to avoid compulsion to use substandard items to maintain in the construction schedule.

2.00.02 Workmanship

Only workers specially experienced in particular items of finishing work shall be engaged, where such workers are not readily available, with the Engineer's permission, experienced supervisors recommended by the manufacturer shall be engaged. In particular cases where the Engineer so desires that the Bidder shall get the finishing items installed by the manufacturer.

2.00.03 Preparation of the Base Surface

The surface to be treated shall be thoroughly examined by the Bidder. Any rectification necessary shall be brought to the notice of the Engineer and his approval shall be taken regarding method and extent of such rectification work.

For all types of flooring, skirting, dado and similar locations, the base to receive the finish shall be adequately roughened by chipping, raking out joints and cleaning thoroughly all dirts, grease etc. with water and hard brush and detergent if required, unless otherwise directed by the manufacturer of any special finishing materials or specifically indicated in this specification under individual item.

To prevent of water from the finishing treatment the base shall be thoroughly soaked with water and all excess water mopped up.

The surface shall be done dry where adhesives are used for fixing the finishes.

Prior to commencement of actual finishing work the approval of the Engineer shall be taken as per the acceptability of the surface.

2.01.00 **In-situ finishes**

2.01.01 NOT USED

2.01.02 NOT USED

2.01.03 Patent Stone NOT USED

2.01.04 **Cement Concrete Flooring with Metallic Hardener Topping**

Wherever floors are required to withstand heavy wear and tear, floor hardener(metallic) shall be used.

This will consist of a topping (incorporating iron particles) to bond with concrete base while the latter is “Green”.

The base concrete shall be provided with the slopes required for the flooring. Floors should be so finished that no water is spread/ stopped in between. Accordingly the slopes shall be designed that all water should go to the drain. Plinth masonry off set shall be depressed so as to allow the base concrete to rest on it. While the surface of the concrete laid as per specification for ‘Cement Concrete has been fully compacted and levelled but the concrete is still green thick slurry made with neat cement shall be applied evenly and worked in with iron floats. When the slurry starts to set it shall be pressed with iron floats to have a firm compact smooth surface without trowel mark or undulations.

a) **Thickness**

The overall thickness of the finishing is 50mm laid in two layers. The bottom layer is 38mm thick in CC 1:2:4 with 12mm downgraded blue metal chips. The top layer is 12mm thick with metallic hardener.

b) **Material**

The hardening compound shall be of approved quality consisting of uniformly graded iron particles free from non-ferrous metal impurities, oil, grease, sand soluble alkaline compounds or other injurious materials. When desired by the engineering charge (Owner), actual samples shall be tested.

c) **Mix**

The top layer shall consist of 12mm thick layer of mix 1: 2 (1 cement: 2 stone aggregate 6mm nominal size) by volume or as otherwise specified with which metallic hardening compound is mixed in the ratio of 1:4 (1 metallic concrete hardener: 4 cement) by weight or as per manufacturer’s specification relevant to medium/heavy duty floor. Metallic hardener shall be dry mixed thoroughly with cement on a clean dry pacca platform. This dry mixture shall be mixed with stone

aggregate 6mm nominal size or as otherwise specified in the ratio of 1:2 (1 cement :2 stone aggregate) and well turned over. Just enough water shall then be added to this dry mix as required for floor concrete.

d) **Laying**

The concrete floor shall be laid as per specification "Cement Concrete" and levelled upto the required grade. The forms, if any shall remain sufficiently projecting to take the finish. The surface shall be roughened by wire brush as soon as possible.

Normally cement concrete flooring shall be laid in one operation using glass/aluminium/PVC/brass strips/stainless steel strips or any other strips as required as per drawing or instructions of the Engineer-in-Charge, at the junction of two panels. This method ensures uniformity in colour of all the panels and straightness at the junction of the panels. 4mm thick glass strips or 2mm PVC strips or 2mm aluminium or brass strips shall be fixed with their tops at proper level, giving required slopes. Use of glass and metallic strips shall be avoided in areas exposed to sun.

The mixture so obtained shall be laid in 12mm thickness, on cement concrete floor while the concrete under bed is still very "green" within 2 to 4 hours of it'slaying.The topping shall be laid true to provide a uniform and even surface without trowel marks, pin holes etc. It shall be firmly pressed into the bottom concrete so as to have good bond with it. Just when the initial set starts the surface shall be finished smoothened with steel trowel.

The finished floor shall be cured for 7 days by keeping it wet.

2.01.05 Not used.

2.01.06 **Acid or Alkali Resistant Tiles finish**

Manufacture and Finish

The tiles shall be of vitreous ware and free from deleterious substances. The iron oxide content allowable in the raw material shall not exceed two percent. The tiles shall be vitrified at the temperature of 1100ºC and above and shall be kept unglazed. The finished, tile, when fractured shall appear fine grained in texture, dense and homogeneous. The tiles shall be sound, true to shape, flat and free from flows and manufacturing defects affecting their utility.

The tiles shall be conforming to IS 4457. The tiles to be tested for water absorption, compressive strength, acid resistance as per IS 4457. Sampling procedure for acceptance tests and criteria for conformity to be as per IS 4457. The tiles shall be of required colour

Dimensions and Tolerances

Ceramic unglazed vitreous acid-resistant tiles shall be made in three sizes namely 98.5 x 98.5 mm, 148.5 x 148.5mm and 198.5 x 198.5mm. They shall be available in the following thickness: 35, 30, 25, 20 and 15 mm. The depth of the grooves on the under side of the tile shall not exceed 3 mm. Tolerance on length, breadth and thickness of tiles shall be ± 2 percent.Minimum 20 mm thick acid and alkali resistant vitrified tile shall be used.

Shape

The tiles shall be square shaped. Half tiles rectangular in shape shall also be available. Half tiles for use with full tiles shall have dimensions which shall be such as to make two half tiles, when joined together, match with the dimension of full tile. The shape of tiles other than square shall be as agreed to between the purchaser and the manufacturer. Tiles shall be checked for square ness and warp as per IS 4457.

Performance Requirements

The tiles when tested in accordance with method given in IS 4457, shall conform to be requirement specified in the code (IS 4457).

Loss in Abrasion

The maximum percentage of loss in abrasion of the ceramic unglazed vitreous acid resistant tiles determined in accordance with the procedure laid down in IS 1237, shall be as mentioned in IS 4457.

Marking

Tiles shall be legibly marked on the back with the name of the manufacturer or his trade mark with Manufacturer's batch number and year of manufacturing.

Each tile may also be marked with the ISI certification mark.

Preparation of Surface and Laying

Base concrete or the RCC slab on which the tiles are to be laid shall be cleaned, wetted and mopped. The average thickness of the bedding shall be 10mm or as specified while the thickness for dado/skirting to be 20mm or specified.(the overall thickness of the Floor Finishing shall be 50mm).

Alkali resistant mortar shall be spread, tamped and corrected to proper levels and allowed to harden sufficiently to offer a fairly rigid cushion for the tiles to be set and to enable the mason to place wooden plank across and squat on it.

Over the mortar bedding neat grey cement slurry of honey like consistency shall be spread at the rate of 3.3 kg of acid alkali resistant cement per square

metre over an area up to one square metre. Tiles shall be socked in water washed clean and shall be fixed in this grout one after another, each tile gently being tapped with a wooden mallet till it is properly bedded and in level with the adjoining tiles. The joints shall be kept as thin as possible and in straight lines or to suit the required pattern.

The surface of the flooring during laying shall be frequently checked with a straight edge about 2 m long, so as to obtain a true surface with the required slope to avoid spread of water. Where full size tiles cannot be fixed these shall be cut (sawn) to the required size, and their edge rubbed smooth to ensure straight and true joints.

Tiles which are fixed in the floor adjoining the wall shall enter not less than 10mm under the plaster, skirting or dado.

After tile has been laid surplus cement slurry shall be cleaned off.

Pointing and finishing

The joints shall be cleaned off the grey cement slurry with wire/coir brush or trowel to a depth of 2 mm to 3mm and all dust and loose mortar removed. Joints shall then be flush pointed with white cement added with pigment if required to match the colour of tiles. Where spacer lug tiles are provided, the half the depth of joint shall be filled with polysulphide or as specified on top with under filling with cement grout the lugs remaining exposed. The floor shall then be kept wet for 7 days. After surface shall be washed and finished clean. The finished floor shall not sound hollow when tapped with a wooden mallet.

2.02.00 Tiled Finish

These shall include finish tiles, stone slabs and similar manufactured or natural items over already laid and matured base of concrete or masonry by means of an under bed or an adhesive layer.

2.02.01 Pressed Ceramic Tile Flooring (Fully Vitrified Tile Flooring)

Tiles shall conform to Table 12 of IS and the joint thickness in flooring shall not be more than 1mm.

a) **Materials : Vitrified Tiles**

The tiles shall be of approved make and shall generally conform to the approved standards. They shall be fully vitrified, flat and true to shape, free from cracks, crazing spots, chipped edges and corners. Unless otherwise specified, the nominal sizes of tiles shall be as under:

The tiles shall be square or rectangular of nominal sizes such as: 600 x 600 mm; 900 x 900 mm or as per drawings or as directed by the Engineer-in-Charge.. However the floor tile thickness shall not be less

than 10mm and the overall thickness of the floor finishing shall be 50mm.

Technical specifications of the tiles shall be generally conforming to the following standards:

Technical Specifications For Vitrified Tiles

No.	Property	Expected Standards
1	Deviation in length	(+/-) 0.6%
2	Straightness of sides	(+/-) 0.5%
3	Rectangularity	(+/-) 0.6%
4	Surface flatness	(+/-) 0.5%
5	Water absorption	< 0.50%
6	Mohs. Hardness	> 6
7	Flexural strength	> 27 N / mm2
8	Abrasion resistance	< 204 mm2
9	Skid resistance (friction coefficient)	> 0.4
10	Glossiness Min.	85% reflection

The tiles shall conform to the relevant standards in all respects. Samples of tiles shall be got approved from the Engineer-in-charge before bulk procurement for incorporation in the work.

b) **Preparation of Surface for Flooring**

Following procedure shall be followed:

- **Sub grade**

  Concrete or RCC slab or side brick wall / or plastered surfaces on which tiles are to be laid shall be cleaned, wetted and mopped as specified.

- **Mortar and bedding**

  Cement mortar for bedding shall be prepared of mix 1:4, to a consistent paste and shall conform to the specification for materials; preparations etc. as specified under cement mortar. The amount of water added while preparing mortar shall be the minimum necessary to give sufficient plasticity for laying. Care

shall be taken in preparation of the mortar to ensure that there are no hard lumps that would interfere with even bedding of the tiles. Before spreading the mortar bed the base shall be cleaned off all dirt, scum or laitance and loose materials and well wetted without forming any pools of water on the surface. The mortar of specified proportion and thickness shall then be evenly and smoothly spread over the base by use of screed battens to proper level or slope.

Once the mix is prepared, no further water be added and the same shall be used within one hour of adding water.

Apply on an average 20 mm thick bedding of mortar over an area of 1 sq.m at a time over surface of the area for laying tiles, in proper level and allowed to harden sufficiently to offer a fairly good cushion for the tiles to set.

c) **Laying Of Tiles for Flooring**

The tiling work shall be done as per the pattern shown in the drawing or as directed by the Engineer-in-Charge. As a general practice laying of tiles shall be commenced from the centre of the area and advanced towards the walls. Cut tiles, if any, shall be laid along wall with necessary border pattern as shown / directed by the Engineer-in-Charge. Tiling work shall be completed by pressing tiles firmly into place along the wall /floor. White cement slurry to the back of the tile to be applied to ensure proper and full bedding. The tiles shall be laid on the bedding mortar when it is still plastic but has become sufficiently stiff to offer a fairly firm cushion for the tiles. Tiles, which are fixed on the flooring adjoining the wall, shall be so arranged that the surface on the round edge tiles shall correspond to the skirting or dado. Press gently the tile with wooden mallet for even adherence at the back of the tile. Do not use an iron hammer or some heavy material to press the tile. The edges of the tiles shall be smeared with neat white cement slurry and fixed in this grout one after the other, each tile being well pressed and gently tapped with a wooden mallet till it is properly bedded and in level with the adjoining tiles.

There shall be no hollows in bed or joints. The joints shall be kept as close as possible and in straight line. Unless otherwise specified, joint-less tiling shall be done butting the tiles with each other. If joint is specified, the same shall not exceed 1.00 mm. in width. The joint shall be grouted with white / matching colour cement slurry. After fixing the tiles, finally in an even plane or slope, the flooring shall be covered with wet sand and allowed undisturbed for 14 days.

d) **Fixing Tiles For Dado & Skirting / Facia**

The fixing of tiles on wall surfaces shall be done only after completing fixing of the tiles on the floor. Following procedure shall be followed:

The back of tiles shall be cleaned off and covered with layer of approved adhesive like BAL-ENDURA or equivalent with proper trowelling as per manufacturers recommendations.

The edges of the tiles shall be smeared with the adhesive and fixed on the wall one after the other, each tile being well pressed and gently tapped with a wooden mallet till it is properly fixed in level with the adjoining tiles. There shall be no hollows on the back or in joints. Unless otherwise specified, joint-less tiling shall be done butting the tiles with each other. If joint is specified, the same shall not exceed 1.00 mm. in width. The joint shall be grouted with approved adhesive. The joints shall be kept in straight line or as per the approved pattern.

While fixing tiles in dado / skirting work, care shall be taken to break the joints vertically. The top line shall be touched up neatly with the rest of the plaster above. If doors, windows or other openings are located within the dado area, the corners, sills, jambs etc. shall be provided with true right angles without any specials.

The fixing shall be done from bottom of wall to upward without any hollows in the bed of joints. Each tile shall be as close as possible to one adjoining. All tiles faces shall be in one vertical plane.

e) **Grouting Of Joints In Floor / Skirting / Dado**

The joints, if specified, shall be cleaned off and all dust and loose particles removed. Joints shall then be filled with approved adhesive like BAL-ENDURA or equivalent grouts.

After finishing the grouting process, after 15 minute, wipe off excess grout with a damp sponge and polish the tiles with a soft & dry cloth for a clean surface. The Finished work shall not sound hollow when tapped with a wooden mallet.

f) **Cleaning**

As directed by the Engineer-in-Charge, the tiles shall be cleaned by mild acid (However, Hydrofluoric acid and its derivatives shall not be used). After the tiles have been laid in a room or the days fixing work is completed, the surplus cement grout / adhesive that may have come out of the joints shall be cleaned off before it sets. The dado / skirting shall be thoroughly cleaned. In the case of flooring, once the floor has set, the floor shall be carefully washed clean and dried. When drying, the floor shall be covered with oil free dry sawdust. It shall be removed only after completion of the construction work and just before the floor is used.

g) **Cleaning Agents for Vitrified Tiles**

Vitrified tiles are resistant to all chemicals (except hydrofluoric acid and its derivatives), hence commercially available detergents and

cleaning agents can also be used for regular maintenance. Any spills and stains must be removed immediately. If left dry they may leave stains, which may be difficult to remove completely.

Cleaning Agents for Vitrified Tiles

Stains	Cleaning Agent
Robin Blue	Household detergent / Warm water
Marker ink	Turpentine / Acetone / Trichloroethylene
Pen ink	Acetone / Isopropyl alcohol
Methylene blue	Isopropyl alcohol / Acetone
Sauce	Ammonia solution
Cement	Turpentine / Acetone / Trichloroethylene / Conc. HCL
Tea	Hydrochloric acid / Bleaching powder
Coffee	Sodium hydroxide / Potassium hydroxide
Beer	Sodium hydroxide / Potassium hydroxide
Diesel	Acetone / Petrol
Lab indicator	Acetone / Isopropyl alcohol
Cement and grouting	Hydrochloric acid
Pencil mark	Benzene or Toluene or Xylene
Plaster of Paris (POP)	Ammonium sulphate solution

Stains	Cleaning Agent
Iodine (Tincture iodine)	Sodium hydroxide / Potassium hydroxide
Hair dye	Per chloric acid
Paan	Lemon juice or citric acid
Marker pen	Acetone

2.02.02 **Pressed Ceramic Tiles In Skirting And Dado**

The tiles shall be approved make and shall generally conform to IS 15622. The tiles shall be pressed ceramic covered by a glaze thoroughly matured and fitted to the body. The tiles shall be sound, true to shape, flat and free from flaws and other manufacturing defects affecting their utility.

The top surface of the tiles shall be glazed. The underside of the tiles shall not have glaze or more than 5% of the area in order that the tile may adhere properly to the base. The edges of the tiles shall be free from glaze; however, any glaze if unavoidable shall be permissible on only up to 50% of the surface area of edges.

The glaze shall be free from welts, chips, craze specks, crawling or other imperfections detracting from the appearance when viewed from a distance of

one metre. The glaze shall be either glossy or matt as specified. The glaze shall be white in colour except in the case of coloured tiles when colours shall be specified by the Engineer-in-Charge. There may be more than one colour on a tile.

Dimensions and Tolerances

Glazed pressed ceramic tiles shall be made square or rectangular in sizes Table 1, 3, 5, & 7 of IS 15622 give the modular sizes and table 2, 4, 6 & 8 of IS 15622 gives the sizes of non modular tiles. The tiles shall conform to IS 15622 for dimensional tolerance, physical and chemical properties.

Half tiles for use as full tiles shall have dimensions which shall be such as to make the half tiles when joined together (with 1mm joint) match with dimensions of full tiles. Tiles may be manufactured in sizes other than those specified above.

The thickness of the tiles shall be minimum 5 mm or as specified.

The dimensions of fittings associated with the glazed tiles namely cover base, round edge tile, angles corner cups, ridge and legs and capping beds shall be of the shape and dimensions as required and thickness of fittings shall be the same as the thickness of tiles given above.

Preparation of Surface

The joints shall be raked out to a depth of at least 15mm in masonry walls.In case of concrete walls, the surface shall be hacked and roughened with wire brushes. The surface shall be cleaned thoroughly, washed with water and kept wet before skirting is commenced.

Laying

12mm thick plaster of cement mortar 1:3 (1 cement: 3 coarse sand) mix of as specified shall be applied and allowed to harden. The plaster shall be roughened with wire brushes or by scratching diagonal at closed intervals.

The tiles shall be soaked in water, washed clean and a coat of cement slurry applied liberally at the back of tiles and set in the bedding mortar. The tiles shall be tamped and corrected to proper plane and lines. The tiles shall be set in the required pattern and joined. The joints shall be as fine as possible. Top of skirting or dado shall be truly horizontal and joints truly vertical except where otherwise indicated. Odd size/cut size of tile shall be adjusted at bottom to take care of slope of the flooring. Skirting and dado shall rest on the top of the flooring. Where full size tiles cannot be fixed these shall be cut (swan) to the required size and their edges rubbed smooth. Skirting/ dado shall not project from the finished “surface of wall” by more than the thickness, undulations if any shall be adjusted in wall.

Curing and Finishing

The joints shall be cleaned off the grey cement grout with wire/coir brush or trowel to a depth of 2 mm to 3 mm and all dust and loose mortar removed. Joints shall then be flush pointed with white cement added with pigments if required to match the colour of tiles. The work shall then be kept wet for 7 days.

After curing, the surface shall be washed and finished clean. The finished work shall not sound hollow when tapped with a wooden mallet.

2.02.03 **Chemical Resistant Tiled Finish**

This shall include all verities of special tiles used for specific chemical resistance function and an under bed over already laid concrete or masonry.

a) **Tiles**

The chemical resistant tiles shall be of the best indigenous manufacture unless otherwise specified and shall be resistant to the chemical The tiles shall have straight edges, uniform thickness, plain surface, uniform non-fading colour and textures.

Usually the chemical resistant tiles shall not absorb water more than 2% by weight. The tiles shall have at least compression strength of 700 Kg/Cm^2. The surface shall be abrasion resistant and durable.

b) **Laying**

The mortar used for setting or for under bed the tiles shall be durable and strong. The grout which shall be to the full depth of tile shall have equal chemical resistant properties. Joints shall be pointed if so desired. The setting and fixing shall be according to the manufacturer's specification approved by the Engineer.

2.02.04 **Rubber, Vinyl Tiles Finish**

This shall include various types of tiles manufactured from rubber, vinyl, etc. set with an adhesive on concrete or masonry base. An under bed may be required to secure desirable surface and grade.

a) **Thickness**

The thickness of the tiles shall be mentioned in the specification elsewhere or in drawing.

b) **Tiles**

Unless otherwise desired the tiles shall be squares of approved dimensions. The tolerance in dimensions shall be $\pm$ 1.5 mm.

The face of the tiles shall be free from porosity, blisters, cracks, embedded foreign matters or either physical defects which affect appearance or serviceability. All edges shall be cut true and square. The colour shall be non-fading and uniform in appearance, insoluble in water and resistant to alkalise, cleaning agents and usual floor polishes.

Each tile shall be marked on the back legibly and indelibly with manufacturer's trademark, the thickness, sizes, batch number and date of manufacture.

Tiles shall be delivered securely packed and stored in clean, dry well ventilated place at a temperature near about to that the tiles shall be called upon to stand ultimately.

Adhesive to be used for sticking the tiles shall be approved by the tile manufacturer. The adhesive shall have a short drying time and long life in addition to toughness.

c) **Mix: Under bed**

The under bed where required to make up the specified thickness or to give the required grade or to get the right type of surface shall be composed of 1 part like putty: 1 part cement: 4 parts coarse sand mixed with just sufficient water to make it workable.

d) **Laying**

The tiles shall be kept in the room to be tiled for at least 24 hours to bring them to the same temperature as the room. For air-conditioned space, the air-conditioning shall be completed before tiling is taken up. The surface to receive this finish shall be firm even textured but not too smooth, without undulations and other deficiencies. If an under bed is laid the same shall be cured for at least 7 days by keeping it moist and then fully dried.

The surface shall be thoroughly cleaned. All loose dust particles shall be removed. Oil and grease if any shall be completely cleaned by use of detergent.

The adhesive shall be applied to fully dry surface in desired thickness uniformly. The adhesive shall also be applied to the backs and edges of the tiles and allowed to surface dry. The tiles shall be placed neatly on the surface exactly to the approved pattern and set with a suitable tool. If the edges tend to curl, weights are to be used to keep the edges down. Special care shall be taken to avoid formation of air pockets under the tiles. The joints shall be very fine. Any adhesive squeezed out through the joints shall be removed immediately.

e) **Finishing**

If any adhesive mark is there on the surface a soft cloth soaked in solvent shall be used to wipe it off. The surface shall be cleaned with soft soap, dried and polished with an approved type of polish just before handing over.

2.02.05 **Stone Slab Finish:Marble, Granite Stone and KotaStone**

a) **Dressing of slabs**

Every stone shall be cut to the required size and shape, fine chisel dressed on all sides to the full depth so that a straight edge laid along the side of the stone shall be fully in contact with it. The top surface shall also be fine chisel dressed to remove all waive ness. In case machine cut slabs are used, fine chisel dressing of machine cut surface need not be done provided a straight edge laid anywhere along the machine cut surface is in contact with every point on it. The sides and top surface of slabs shall be machined rubbed or table rubbed with coarse sand before paving. All angles and edges of the stone slabs shall be true, square and free from chippings and the surface shall be true and plane.

b) **Thickness**

The under bed shall be average 20 mm thick. The thickness of the slabs shall be 18 to 20 mm or as specified. Tolerance of ± 3% shall be allowed for the thickness. In respect of length and breadth of slabs a tolerance of ± 2% shall be allowed. The overall thickness of the Floor Finish shall be 50mm.

c) **Stone Slab**

The stone slabs shall come from specific regions and in specified quality with top surface fine chisel dressed. All sides shall also be fine chisel dressed to the full depth to allow finest possible joints.

The slabs shall be delivered to the site well protected against damages and stored in dry place under cover.

d) **Laying**

Base concrete or the RCC slab on which the slabs are to be laid shall be cleaned, wetted and mopped. The bedding for the slabs shall be with cement mortar 1:4 (1 cement: 4 coarse sand)

The average thickness of the bedding mortar under the slab shall be 20mm and the thickness at any place under the slab shall be not less than 12mm.

The slabs shall be laid in the following manner:

Mortar of the specified mix shall be spread under the area of each slab, roughly to the average thickness specified. The slab shall be washed clean before laying. It shall be laid on top, pressed, tapped with wooden mallet and brought to level with the adjoining slabs. It shall be lifted and laid aside. The top surface of the mortar shall then be corrected by adding fresh mortar at hollows. The mortar is allowed to harden a bit and cement slurry of honey like consistency shall be spread over the same at the rate of 4.4 kg of cement per sqm. The edges of the slab already paved shall be buttered with grey or white cement with or without admixture of pigment to match the shade of the stone slabs as given in the specification.

The slab to be paved shall then be lowered gently back in position and tapped with wooden mallet till it is properly bedded in level with and close to the adjoining slabs with as fine a joint as possible. Subsequent slabs shall be laid in the same manner. After each slab has been laid, surplus cement on the surface of the slabs shall be cleaned off. The flooring shall be cured for a minimum period of seven days. The surface of the flooring as laid shall be true to levels and slopes as instructed by the Engineer-in-Charge. Joint thickness shall not be more than 1 mm.

Due care shall be taken to match the grains of slabs which shall be selected judiciously having uniform pattern of veins/streaks or as directed by the Engineer-in-Charge.

The slabs shall be matched as shown in drawings or as instructed by the Engineer-in-Charge.

Slabs which are fixed in the floor adjoining the wall shall enter not less than 12mm under the plaster skirting or dado. The junction between wall plaster and floor shall be finished neatly and without waviness.

Slabs flooring shall also be laid in combination with other stones and/or in simple regular pattern/design as desired by the engineer-in-charge or drawing.

e) **Polishing, Finishing**

Fine chiselling shall be done to remove the slight undulations that usually exist at the joints. The polishing and finishing shall be done as specified However; the joints shall be so fine in the case of stone slabs that grouting shall not be called for. Cement slurry with or without pigment shall not be applied on the surface before each polishing. In case of granite only Shop Polished slabs shall be laid.

2.02.06 **Marble Stone In Risers Of Steps And Skirting**

Marble Stone Slabs and Dressing of slabs shall be as specified in Clause no. 2.02.05except that the thickness of the slabs shall be 18mm. A tolerance of ± 3% shall be allowed, unless otherwise specified

Preparation of Surface

It shall be as explained earlier. The wall surface shall be cut uniformly to the requisite depth so that the skirting face shall have the projection from the finished face of wall as shown in drawings or as required by the Engineer-in-Charge. In no case the skirting shall project by more than thickness of stone.

Laying

The riser of steps and skirting shall be in grey or white cement admixed with or without pigment to match the shade of the stone, as specified, with the line of the slab at such a distance from the wall that the average width of the gap shall be 12mm and at no place the width shall be less than 10mm, if necessary, the slabs shall be held in position by temporary M.S. hooks fixed in to the wall at suitable intervals. The skirting or riser face shall be checked for plane and plumb and corrected. The joints shall thus be left to harden then the rear of the skirting or riser slab shall be packed with cement mortar 1:3 (1cement: 3 coarse sand) or other mix as specified. The fixing hooks shall be removed after the mortar filling the gap has acquired sufficient strength.

The joints shall be as fine as possible but nor more than 1 mm. The top line of skirting and risers shall be truly horizontal and joints truly vertical, except where otherwise indicated.

The risers and skirting slab shall be matched as shown in drawings or as instructed by the Engineer-in-Charge.

Curing, Polishing and Finishing

It shall be as specified and as far as possible, except that cement slurry with or without pigment shall not be applied on the surface and polishing shall be done only with hand. The face and top of skirting shall be polished.

2.02.07 NOT USED

2.02.08 NOT USED

2.02.09 **Kota Stone In Risers of Steps, Skirting and Dado**

Kota Stone Slabs and Dressing shall be as specified in 2.02.05 except that the thickness of the slabs shall be 20mm or as specified. The slabs may be of uniform size if required.

Preparation of surface shall be as specified in 2.02.06.

Laying shall be as specified in 2.02.06 except that the joints of the slabs shall be set in grey cement mixed with pigment to match the shade of the slabs.

Curing, Polishing and Finishing shall be as specified in 2.02.06.

2.02.10 **Anti-Static PVC Flooring**

PVC flooring of 2mm thick shall be of approved make & brand with scratch proof, flexible & impregnated polyurethane reinforced (PUR) permanently static conductive Vinyl sheet, consists of impregnated polyurethane homogeneous mixture of PVC, plasticizers, urethane, colour pigments and filler calendared of approved colours and pattern detail. The material shall be fixed with synthetic acrylic adhesive after preparing the floor, leveling & smoothening when necessary with suitable putty, as per the design & instruction of the Engineer-in-charge. Electrical resistance shall be min $R10^8$ ohm as per ESD approval, SP-method 2472. Anti-static sheets shall be confirming clean Room Test Class A as per ASTMF 51/100.

3.00.00 ACCEPTANCE CRITERIA

The finish shall be checked specially for :

a) Level, Slope, Plumb as the case may be

b) Pattern and Symmetry

c) Alignment of joints, dividing strip etc.

d) Colour, texture

e) Surface finish

f) Thickness of joints

g) Details at edges, junctions etc.

h) Performance

i) Precautions specified for durability

4.00.00 I.S. CODES

Important relevant codes for this section:

IS: 777	:	Glazed earthenware tiles
IS: 1196	:	Code of practice for laying bitumen mastic flooring.
IS: 1197	:	Code of practice for laying of rubber floors
IS: 1237	:	Cement concrete flooring tiles
IS: 1443	:	Code of practice for laying and finishing of cement concrete flooring tiles.

IS: 2114	:	Code of practice for laying in situ terrazzo floor.
IS: 3461	:	PVC asbestos floor tiles
IS: 4860	:	Specification for acid resistant bricks
IS: 5518	:	Code of practice for laying of flexible PVC sheet and tile flooring.
IS: 5491	:	Code of practice for laying in situ granolithic floor topping.
IS: 4457	:	Specification for ceramic unglazed vitreous acid resisting tiles
IS: 4441	:	Code of practice for use of silicate type chemical resistant mortars.
IS: 4443	:	Code of practice for use of resin type chemical resistant mortars.
IS: 4832 (part I)		Specification for chemical resistant mortar: silicon type.
IS: 4832 (part II)		Specification for chemical resistant mortar: resin type.
IS: 4832 (part III)		Specification for chemical resistant mortar: sulphur type.
IS: 13753	:	Specification for dust pressed ceramic tiles with water absorption of E>10%
IS: 13755	:	Specification for dust pressed ceramic tiles with water absorption of 3%, E6% (Group B11a)
SP 27: 1987	:	Handbook of Method of Measurement of Buildings Works

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SECTION-XIII

GUIDELINE
FOR
PAINTING AND POLISHING ETC.

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SECTION-XIII

GUIDELINE
FOR
PAINTING AND POLISHING ETC.

1.00.00 SCOPE

This specification covers painting, polishing etc. of both interior and exterior surfaces on wood work, masonry, masonry surface with white cement putty, concrete plastering, plaster of Paris punning, false ceiling, structural and other miscellaneous steel items, rain water down comer, floor and roof drains, soil, waste and service water pipes, and other ferrous and non-ferrous metal items as shown on drawings, or as directed by the Engineer.

Copper, bronze, chromium plate, nickel, stainless steel, aluminium and monel metal shall generally not be painted or finished except if otherwise specified.

The painting Bidder shall inspect the work of others prior to the application of paint. If surface to be finished cannot be put in suitable condition for painting by customary preparatory methods, the painting Bidder shall notify the Engineer in writing or assume responsibility for and rectify unsatisfactory finishing those results.

Before commencing painting, the painting Bidder shall obtain the approval of the Engineer in writing, regarding the schedule of work to minimize damage, disfiguration or staining by other trades. He shall also undertake normal precautions to prevent damage, disfiguration or staining to work of other trades or other installations. Bidder shall keep record of number of coats of painting. Before applying second coat, the Bidder shall obtain prior approval of Engineer in Charge

2.00.00 INSTALLATION

2.01.00 Materials

Materials shall be Grade-1 quality from well-known approved manufacture and shall be delivered to the site in original sealed containers, bearing brand name, manufacturer's name and colour shade, with labels intact and seals unbroken. All materials shall be subject to inspection, analysis and approved by the Engineer. It is desired that materials of one manufacturer only shall be used as far as possible and paint or one shade is obtained from the same manufacturing batch.

All paint shall be subject to analysis from random samples taken at site from painter's bucket, if so desired by the Engineer.

All prime coats shall be compatible to the material of the surface to be finished as well as to the finishing coats to be applied.

All unspecified materials such as shellac, turpentine or linseed oil shall be of the highest quality available and shall conform to the latest IS standards. All such materials shall be made by reputable recognised manufacturers and shall be approved by the Engineer.

All colours shall be as per painting schedule and tinting and matching shall be done to the satisfaction of the Engineer. In such cases, where samples are required, they shall be executed in advance with the specified materials for the approval of the Engineer.

a) **NOT USED**

b) **NOT USED**

c) NOT USED

d) **Exterior emulsion Painting on Wall**

Material: The paint shall be (Textured exterior paint / Acrylic smooth exterior emulsion paint / premium acrylic smooth exterior emulsion paint) of approved brand and manufacture.

This paint shall be brought to the site of work by the Bidder in its original containers in sealed condition. The material shall be brought in at a time in adequate quantities to suffice for the whole work or at least a fortnight's work. The material shall be kept in the joint custody of the Bidder and the Engineer-in-Charge. The empty containers shall not be removed from the site of work till the relevant item of work has been completed and permission obtained form the Engineer-in-Charge.

Preparation of Surface: For new work, the surface shall be thoroughly cleaned off all mortar dropping, dirt dust, algae, fungus or moth, grease and other foreign matter of brushing and washing, pitting in plaster shall make good, surface imperfections such as cracks, holes etc. shall be repaired using white cement. The prepared surface shall have received the approval of the Engineer-in-Charge after inspection before painting is commenced.

Application:

Base coat of water proofing cement paint – All specifications in respect of base coat of water proofing cement paint shall be as described before.

Primer shall be as per the recommendation of the manufacturer suitable for the type of paint to be applied.

Before pouring into smaller containers for use, the paint shall be stirred thoroughly in its container, when applying also the paint shall be continuously stirred in the smaller containers so that its consistency is kept uniform. Dilution ratio of paint with portable water can be altered taking into consideration the nature of surface climate and as per recommended dilution given by manufacturer. In all cases, the manufacturer's instructions & directions of the Engineer-in-Charge shall be followed meticulously.

The lids of paint drums shall be kept tightly closed when not in use as by exposure to atmosphere the paint may thicken and also be kept safe from dust.

Paint shall be applied with a brush on the cleaned and smooth surface. Horizontal strokes shall be given, First and vertical strokes shall be applied immediately afterwards. This entire operation will constitute one coat. The procedure shall be followed for prime coat and finish coats. The surface shall be finished as uniformly as possible leaving no brush marks.

The specifications in respect of scaffolding and protective measures shall be as describe before.

3.00.00 PAINTING

Materials

Paints, of approved brand and manufacture shall be used. Only ready mixed Paint (Exterior grade) as received from the manufacturer without any admixture shall be used.

If for any reason, thinning is necessary in case of ready mixed paint, the brand of thinner recommended by the manufacturer or as instructed by the Engineer-in-Charge shall be used.

Approved paints, shall be brought to the site of work by the Bidder in their original containers in sealed condition. The material shall be brought in at a time in adequate quantities to suffice for the whole work or at least a fortnight's work. The materials shall be kept in the joint custody of the Bidder and the Engineer-in-Charge. The empties shall not be removed from the site of the work, till the relevant item of work has been completed and permission obtained from the Engineer-in-Charge.

Commencing Work

Painting shall not be started until the Engineer-in-Charge has inspected the items of work to be painted, satisfied himself about their proper quality and given his approval to commence the painting work. Painting of external surface shall not be done in adverse weather condition like hail storm and dust storm.

Painting, except the priming coat, shall generally be taken in hand after practically finishing all other building work.

The rooms shall be thoroughly swept out and the entire building cleaned up, at least one day in advance of the Paint work being started.

Preparation of Surface

The surface shall be thoroughly cleaned and dusted off. All rust, dirt, scales, smoke splashes, mortar droppings and grease shall be thoroughly removed before painting is started. The prepared surface shall have received the approval of the Engineer-in-Charge after inspection, before painting is commenced.

Application

Before pouring into smaller containers for use, the Paint shall be stirred thoroughly in its containers, when applying also, the Paint shall be continuously stirred in the smaller containers so that its consistency is kept uniform.

The painting shall be laid on evenly and smoothly by means of crossing and laying off, the latter in the direction of the grains of wood. The crossing and laying off consists of covering the area over the Paint, brushing the surface hard for the first time over and then brushing alternately in opposite direction, to or three times and then finally brushing lightly in a direction at right angles to the same. In this process, no brush marks shall be left after the laying off is finished. The full process of crossing and laying off will constitute one coat.

Where so stipulated, the painting shall be done by spraying. Spray machine used may be (a) high pressure (small air aperture) type, or (b) a low pressure (large air gap) type, depending on the nature and location of work to be carried out. Skilled and experienced workmen shall be employed for this class of work. Paints used shall be brought to the requisite consistency by adding a suitable thinner.

Spraying shall be done only when dry condition prevails. Each coat shall be allowed to dry out thoroughly and rubbed smooth before the next coat is applied. This shall be facilitated by through ventilation. Each coat except the last coat, shall be lightly rubbed down with sand paper or fine pumice stone and cleaned off dust before the next coat is laid.

No left over Paint shall be put back into the stock tins. When not in use, the containers shall be kept properly closed.

No hair marks from the brush or clogging of Paint puddles in the corners of panels, angles of moulding etc. shall be left on the work.

In painting doors and windows, the putty round the glass panes must also be painted but care must be taken to see that no Paint stains etc. are left on the glass. Tops of shutters and surfaces in similar hidden locations shall not be

left out in painting. However, bottom edge of the shutters where the painting is not practically possible, need to be done nor any deduction on this account will be done but two coats of primer of approved make shall be done on the bottom edge before fixing the shutters.

On painting steel work, special care shall be taken while painting over bolts, nuts, rivets overlaps etc.

The additional specifications for primer and other coats of Paints shall be as according to the detailed specifications under the respective headings.

Brushes and Containers

After work, the brushes shall be completely cleaned of Paint and linseed oil by rinsing with turpentine. A brush in which Paint has dried up is ruined and shall on no account be used for painting work. The containers when not in use, shall be kept closed and free from air so that Paint dose not thicken and also shall be kept safe from dust. When the paint has been used, the containers shall be washed with turpentine and wiped dry with soft clean cloth, so that they are clean, and can be used again.

Precautions

All furniture, fixtures, glazing, floors etc. shall be protected by covering and stains, smears, splashing, if any shall be removed and any damages done shall be made good by the Bidder.

4.00.00 PAINTING PRIMING COAT ON WOOD, IRON OR PLASTERED SURFACES

Primer

The primer for wood work, iron work or plastered surface shall be as specified

Primer for plaster / wood work / Iron & Steel / Aluminium surfaces shall be as specified below.

Table-1

Sl. No	Surfaces	Primer to be used
1.	Wood work (hard and soft wood)	Pink conforming to IS 3536
2.	Resinour wood and plywood	Aluminium primer confirming to IS 3585
3.	(A) Aluminium and light alloys	Zinc ethyl silicate primer
	(B) Iron, Steel and Galvanized steel	zinc ethyl silicate primer.
4.	Cement/Concrete/RCC/brickwork, Plastered surfaces, non-asbestos surfaces	As recommended by the paint manufacturer.

The primer shall be ready mixed primer of approved brand and manufacture.

Where primer for wood work is specified to be mixed at site, it shall be prepared from a mixture of red lead, white lead and double boiled linseed oil in the ratio of 0.7 kg : 0.7 kg : 1 litre.

Where primer for steel work is specified to be mixed at site, it shall be prepared from a mixture of red lead, raw linseed oil and turpentine in the ratio of 2.8 kg :1 litre : 1 litre.

The specifications for the base vehicle and thinner for mixed on site primer shall be as follows:

i) **White Lead:**The white lead shall be pure and free from adulterants like barium sulphate and whiting. It shall confirm to IS 103.

ii) **Red Lead:**This shall be in powder form and shall be pure and free from adulterants like brick dust etc. It shall confirm to IS 102.

iii) **Raw Linseed Oil:**Raw linseed oil shall be lightly viscous bit clear and of yellowish colour with light brown tinge. Its specific gravity at a temperature of 30 degree C shall be between 0.923 and 0.928.

Note: The oil shall be mellow and sweet to the taste with very little small. The oil shall be of sufficiently matured quality. Oil turbid or thick, with acid and bitter taste and rancid odour and which remains sticky for a considerable time shall be rejected. The oil shall confirm in all respects to IS 75. The oil shall be of approved brand and manufacture.

iv) **Double Boiled Linseed Oil:** This shall be more viscous than the raw oil, have a deeper colour and specific gravity between 0.931 and 0.945 at a temperature of 30 degree C. It shall dry with a glossy surface. It shall confirm in all respects to IS 77. The oil shall be of approved brand and manufacture.

Turpentine: Mineral turpentine i.e. petroleum distillate which has the same rate of evaporation as vegetable turpentine (distillate product of oleoresin of conifers) shall be used. It shall have no grease or other residue when allowed to evaporate. It shall confirm to IS 533.

All the above materials shall be approved manufacture and brought to site in their original packing in sealed condition.

4.01.00 **Preparation of Surface**

4.01.01. **Wooden Surface:** The wood work to be painted shall be dry and free from moisture. The surface shall be thoroughly cleaned. All unevenness shall be rubbed down smooth with sand paper and shall be well dusted. Knots, if any shall be covered with preparation of red lead made by grinding red lead in

water and mixing with strong glue sized and used hot. Appropriate filler material confirming to IS 345 with same shade as Paint shall be used where specified. The surface treated for knotting shall be dry before paint is applied. After obtaining approval of Engineer-in-Charge for wood work, the priming coat shall be applied before the woo work is fixed in position. After the priming coat is applied, the holes and indentation on the surface shall be stopped with glazier's putty or wood putty. Stopping shall not be done before the priming coat is applied as the wood will absorb the oil in stopping and the latter is therefore liable to crack.

4.01.02. **Iron and Steel Surface:** All rust and scales shall be removed by scrapping or by brushing with wire brushes. Hard skin of oxide formed on the surface of wrought iron during rolling which becomes loose by rusting, shall be removed.

All dust and dirt shall be thoroughly wiped away from the surface.

If the surface is wet, it shall be dried before priming coat is undertaken.

4.01.03. **Plastered Surface:** The surface shall ordinarily not be painted until it has dried completely. Trial patches of primer shall be laid at intervals and where drying is satisfactory, painting shall then be taken in hand. Before primer is applied, holes and undulations shall be filled up with plaster of paris and rubbed smooth.

Application

The primer shall be applied with brushes, worked well into the surface and spread even and smooth. The painting shall be done by crossing and laying off as described before.

Treatment on Steel for Aggressive Environment

A second coat of ready mixed zincethyl silicate primer may be applied where considered necessary in aggressive environment such as near Industrial Establishment and Coastal regions where the steel members are prone to corrosion. The second coat is to be applied after placing the member in position and just before applying Paint. Unless otherwise specified the second coat of primer is not necessary in case of painting with synthetic enamel Paint.

5.00.00 PAINTING RAIN WATER, SOIL, WASTE AND VENT PIPES AND FITTINGS

The primer shall be prepared on site or shall be of approved brand and manufacture as specified in the item.

Paint shall be anti-corrosive bitumastic Paint /exterior paint of the building or other type of Paint as specified

Painting New Surface

Preparation of Surface: The surface shall be prepared for priming coat as described earlier.

Application: The number of coat of painting over the priming coat shall be as stipulate in the specification. The application of Paint over priming coat shall be carried out as specified above.

Painting on Old Surface

Preparation of Surface: If the old Paint is firm and sound, it shall be cleaned and grease, smoke etc. The surface shall then be rubbed down with sand paper and dusted. Rusty patches shall be cleaned up and touched with synthetic enamel paint.

If the old Paint is blistered and flaked, it shall be completely removed as described before. Such removal shall be paid for separately and painting shall be treated as on new work.

Application: The specifications for application shall be as described earlier.

6.00.00 PAINTING WITH WOOD PRESERVATIVE

Oil type wood preservative of specified quality and approved make, confirming to IS 218 shall be used. Generally, it shall be creosote oil type-I or anthracene oil.

Painting on New Surface

Preparation of Surface: Painting shall be done only when the surface is perfectly dry to permit of good absorption. All dirt, dust or other foreign matter shall be removed from the surface to be painted. All roughness shall be sand papered and cleaned.

Application: The preservative shall be applied liberally with a stout brush and not daubed with rags or cotton waste. It shall be applied with a pencil brush at the joints of the wood work. The first coat shall be allowed at least 24 hours to soak in before the second (the final) coat is applied. The second

coat shall be applied in the same manner as the first coat. The excess of preservative which does not soak into the wood shall be wiped off with a clean dry piece of cloth.

Painting on Old Surface

The work shall be done in the same manner as on new surface except that only one coat shall be done.

7.00.00 COAL TARRING

Coal tar of approved manufacture confirming to IS 290 shall be used. The tar, to every litre of which 200 gm of unslaked lime has been added, shall be heated till it begins to boil. It must then be taken off the fire and kerosene oil added to it slowly at the rate of one part of kerosene oil to six or more parts by volume and stirred thoroughly. The addition of lime is for preventing the tar from running.

Coal Tarring on New Surface

Preparation of Surface: This shall be done as specified in 4.01.00 except that sand papering is not necessary. Where iron work is to be painted it shall be free from scales and rust before painting.

Application: The mixture shall be applied as hot as possible with a brush. The second coat shall be applied only after the first coat has thoroughly dried up. Where possible, the article to be tarred, shall be dipped in the hot mixture for better results. The quantity of tar to be used for the first or second coat shall be not less than 0.16 and 0.12 litre per sqm respectively. Thinning with kerosene oil shall be suitable done to ensure this.

Coal Tarring on Old Surface

The work shall be done in the same manner as specified above (Coal Tarring on New Surface) except that only one coat using 0.12 litre per sqm. area shall be done.

8.00.00 Not used

9.00.00 Not used

10.00.00 INTERNALWALL PAINTING WITH ACRYLIC EMULSION PAINT

The acrylic emulsion Paint is not suitable for application on external, wood and iron surface and surfaces which are liable to heavy condensation. These Paints are to be used on internal surfaces except wooden and steel.

Acrylic emulsion Paint of approved brand and manufacture and of the required shade shall be used.

Painting on New Surface

The surface shall be thoroughly cleaned and dusted off. All rust, dirt, scales, smoke splashes, morter droppings and grease shall be thoroughly removed before painting is started. The prepared surface shall have received the approval of the Engineer-in-Charge after inspection, before painting is commended.

Application: The number of coats shall be as stipulated in the specification. The Paint will be applied in the usual manner with brush, spray or roller. The Paint dries by evaporation of the water content and as soon as the water has evaporated the film gets hard and the next coat can be applied. The time of drying varies from one hour on absorbent surface to 2 to 3 hours on non-absorbent surfaces.

The thinning of emulsion is to be done with water and not with turpentine. Thinning with water will be particularly required for the under coat which is applied on the absorbent surface. The quantity of water to be added shall be as per manufacturer's instructions.

The surface on finishing shall present a flat velvety smooth finish. If necessary more coats will be applied till the surface presents a uniform appearance.

Precautions

a) Old brushes if they are to be used with emulsion Paints, shall be completely dried of turpentine or oil Paints by washing in warm soap water.

Brushes shall be quickly washed in water immediately after use and kept immersed in water during break periods to prevent the Paint from hardening on the brush.

b) In the preparation of wall for acrylicemulsion painting, no oil base putties shall be used in filling cracks, holes etc.

c) Splashes on floors etc. shall be cleaned out without delay as they will be difficult to remove after hardening.

d) Washing of surfaces treated with emulsion Paints shall not be done within 3 to 4 weeks of application.

Painting on Old Surface

Preparation of Surface*:* This shall be done, generally as specified in 4.01.01 except that the surface before application of Paint shall be flattened well to get the proper flat velvety finish after painting.

Application: The number of coats to be applied shall be as specified. The number of coats shall be as stipulated in the specification The Paint will be applied in the usual manner with brush, spray or roller. The Paint dries by evaporation of the water content and as soon as the water has evaporated the film gets hard and the next coat can be applied. The time of drying varies from one hour on absorbent surface to 2 to 3 hours on non-absorbent surfaces.

The thinning of emulsion is to be done with water and not with turpentine. Thinning with water will be particularly required for the under coat which is

applied on the absorbent surface. The quantity of water to be added shall be as per manufacturer's instructions.

The surface on finishing shall present a flat velvety smooth finish. If necessary more coats will be applied till the surface presents a uniform appearance.

Except the above the thinning with water shall not normally be required.

11.00.00 PAINTING WITH SYNTHETIC ENAMEL PAINT

Synthetic Enamel Paint (confirming to IS 2933) of approved brand and manufacture and of the required colour shall be used for the top coat and an under coat of shade to match the top coat as recommended by the same manufacture as far the top coat shall be used.

Painting on New Surface

Preparation of Surface*:* Preparation of surface shall be as specified in 4.01.00 as the case may be.

Application: The number of coats including the undercoat shall be as specified.

a) **Under Coat:**One coat of the specified synthetic enamel Paint of shade suited to the shade of the top coat, shall be applied over the primer coat and allowed to dry overnight. It shall be rubbed next day with the finest grade of wet abrasive paper to ensure a smooth and even surface, free from brush marks and all loose particles dusted off.

b) **Top Coat:** Top coat of synthetic enamel Paint of desired shade shall be applied after the under coat is thoroughly dry. Additional finishing coats shall be applied if found necessary to ensure properly uniform glossy surface.

Other details shall be as specified in 'EXTERIOR PAINTING ON WALL' as far as they applicable.

Painting on Old Surface

Preparation of Surface: Where the existing Paint is firm and sound it shall be cleaned of grease, smoke etc. and rubbed with sand paper to remove all loose particles dusted off. All patches and cracks shall then be treated with stopping and filler prepared with the specified Paint. The surface shall again be rubbed and made smooth and uniform.

If the old Paint is blistered and flaked it will be necessary to completely remove. Such removal shall be paid for separately and the painting shall be treated as on new surface.

Painting: The number of coats as stipulated shall be applied with synthetic enamel Paint. Each coat shall be allowed to dry and rubbed down smooth with very fine wet abrasive paper, to get an even glossy surface. If however, the surface is not satisfactory additional coats as required shall be applied to get correct finish.

12.00.00 Not used.

13.00.00 PAINTING WITH ACID PROOF PAINT

Acid proof Paint of approved brand and manufacture and of the required shade shall be used.

Preparation of surface and application shall be as specified under 11.00.00 for new/old surface as the case may be.

Other details shall be as specified in 3.00.00 as far as they applicable

14.00.00 PAINTING WITH ANTI-CORROSIVE BITUMASTIC PAINT

Ready mixed Paint (confirming to IS 158) shall be of approved brand and manufacture. It shall be black, lead free, acid-alkali-heat-water resistant.

Preparation of surface and application shall be as specified in earlier clauses for Painting on new or old surfaces as the case may be.

The drying time between consecutive coats, however, shall be not less than 3 hours.

Other details shall be specified in 3.00.00 as far as applicable.

15.00.00 FLOOR PAINTING

Floor Paint of approved brand and manufacture and of the required colour shall be used.

Preparation of Surface

All dirt, grease shall be removed from the floor by wiping with rags, soaked in turpentine and scraping where necessary and then washing with warm water, containing caustic soda or washing soda in solution. The floor shall then be rinsed thoroughly with water and dried. Cracks and holes shall then be filled with specified filler as recommended by the manufacture and rubbed smooth.

Application

The number of coats as specified shall be applied. Each coat shall be allowed to dry for not less than 24 hours before the next coat is applied. The flooring shall not be brought into use for a week after final coat so that the painted surface can thoroughly harden.

16.00.00 NOT USED

17.00.00 FRENCH SPIRIT POLISHING

Pure shellac confirming to IS 16 varying from pale orange to lemon yellow colour, free from resin or dirt shall be dissolved in methylated spirit at the rate of 140 gm of shellac to 1 litre of spirit. Suitable pigment shall be added to get the required shade. Ready made polish confirming to IS 348 can also be used.

Polishing New Surface

Preparation of Surface: The surface shall be cleaned. All unevenness shall be rubbed down smooth with sand paper and well dusted. Knots if visible shall be covered with a preparation of red lead and glue size laid on while hot. Holes and indentations on the surface shall be stopped with glazier's putty. The surface shall then be given a coat of wood filler made by mixing whiting (ground chalk) in methylated spirit at the rate of 1.5 Kg of whiting per litre of spirit. The surface shall again be rubbed down perfectly smooth with glass paper and wiped clean.

Application: The number of coats of polish to be applied shall be as specified elsewhere in the specification.

A pad of wooden cloth covered by a fine cloth shall be used to apply the polish. The pad shall be moistened with the polish and rubbed hard on the wood, in a series of overlapping circles applying the mixture sparingly but uniformly over the entire area to given an even level surface. A trace of linseed oil on the face of the pad facilitates this operation. The surface shall be allowed to dry and the remaining coats applied in the same way. To finish off, the pad shall be covered with a fresh piece of clean fine cotton cloth slightly damped with methylated spirit and rubbed lightly and quickly with circular motions. The finished surface shall have a uniform texture and high gloss.

Other details shall be as specified in 3.00.00 as far as they are applicable.

Polishing Old Surface

Preparation of Surface: If the old polished surface is not much solid it shall be cleaned of grease and dirt by rubbing with turpentine and then rubbed with fine sand paper.

If the old polished surface is much soiled then it will be necessary to remove the entire polish and such removal shall be paid for separately outside the rate of polishing. Further the polishing itself will have to do done like new work and will be paid for as such.

Application: The specifications shall be same as described above and as far as applicable.

Other details shall be as specified in 3.00.00 as far as they are applicable.

18.00.00 EPOXY COATING/PAINTING

On the clean surface of concrete after properly drying of the following system is to be adopted as per manufacturer's specification:

One coat of primer of following proportion is to be applied over clean and dried concrete surface by brush application.

ARALDITE GY 250 - 100 Parts by weight

HARDENER HY 840 - 50 Parts by weight

Over the primer, the uneven surface of concrete shall be filled with levelling putty as mentioned above. The cost of putty is included in the item rate without fixing prior limit to consumption of putty. Two top coats of the protective treatment to be applied over the prepared smooth surface in the following proportion.

ARALDITE GY 250 - 100 Parts by weight

HARDENER HY 830 - 45 Parts by weight

HARDENER BY 850 -15 Parts by weight

SILICA FLOUR - 20 Parts by weight

FLOW CONTROL - 2 Parts by weight
AGENT

Pigment may be added if desired by Engineer. The first top coat is applied over the primer and is left to reach a tack free state. At this stage, the final top coat is applied.

18.01.00 Protection

Furniture and other movable objects, equipment's, fittings and accessories shall be moved, protected and replaced upon completion of work. All stationary equipment shall be well covered so that no paint can fall on them. Work finished by other agencies shall be well protected. All protections shall be done as per instructions of the Engineer.

18.02.00 **Cleaning up**

In addition to provisions in general conditions the Bidder shall, upon completion of painting etc. remove all marks and make good surfaces, where paint has been spilled, splashed or splattered, including all equipment, fixtures, glass, furniture, fittings etc. to the satisfaction of the Engineer.

19.00.00 ACCEPTANCE CRITERIA

a) All painted surfaces shall be uniform and pleasing in appearance.

b) All French polished surfaces shall be of uniform texture and high glossy finish.

c) The colour, texture etc. shall match exactly with those of approved samples.

d) All stains, splashes and splatters of paints shall be removed from surrounding surfaces.

20.00.00 I. S. CODE

Important relevant IS Codes for this Sections are listed below :

IS: 348	:	Specification for French polish
IS: 427	:	Specification for Distemper, dry colour as required.
IS: 428	:	Specification for Distemper oil emulsion, colour as required.
IS: 1477 (I & II)	:	Code of Practice for painting of ferrous metal in buildings.
IS: 2338 (I & II)	:	Code of Practice for finishing of wood and wood based materials.
IS: 2339	:	Specification for Aluminium Paints for general purposes in dual containers.
IS: 2395	:	Code of Practice for painting concrete, masonry and plaster surface.
IS: 2932	:	Specification for enamel, synthetic, exterior, type-I.
IS: 5410	:	Specification for cement paint, colour as required.
SP 27: 1987	:	Handbook of Method of Measurement of Buildings Works

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SECTION-XIV

GUIDELINE
FOR
SUSPENDED CEILING

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SECTION-XIV

GUIDELINE
FOR
SUSPENDED CEILING

1.00.00 SCOPE

The work under this Section shall include the supply and insulation of suspended ceiling using insulation / acoustic boards, plaster of paris boards. Perspex etc. together with the suspension system as shown on drawing or as specified with all materials labour and equipment. The work shall also include providing of openings in the ceiling for lighting, air conditioning diffusers etc. as shown on drawings or instructed by the Engineer.

2.00.00 INSTALLATION

2.01.00 Suspension System

2.01.01 General

Suspension system shall consist of the grid supporting the ceiling panels, intermediate runner supports for the grid if any and hangers, wall angles etc. required to suspend the grid or the runners from structural walls, slabs and beams or trusses.

All members of the suspension system shall be of sufficient strength and rigidity to carry the ceiling boards or sheets in a true and level plane without exceeding a deflection of 1/360th of their span. All joints in ceiling panels shall run straight and cross joint shall be securely fixed to walls. All drillings of structural concrete or welding to steel for installation of the suspension system shall be included in the scope. All M S sections used for supports etc. shall be given one coat of synthetic enamel paint over a coat of zinc ethyl silicate primer. All wood supports shall be painted with two coats of “Solignum” or other approved wood preservative before erection.

2.01.02 Metal Grid Suspension System

Aluminium grid ceiling system shall be “Bead lock” as manufactured by W A Beard shell and Co. Pvt. Ltd. or approved equal. Steel grid ceiling system shall be snap grid as manufactured by Anil Hardboards Ltd. or approved equal.

Angle cleats or other suitable fixing device shall be fixed to the structural beam or slab above for fixing of hangers. Main runners shall be hung by M S flats angles or 12 g or heavier galvanized tie wire hangers at maximum 1.2

centres. Extra hangers shall be provided at light fixtures that are supported from the ceiling system. The spacing of main and cross runners shall be as shown on drawings.

The cross tees shall intersect main runners in pattern shown on drawing and positively looked together with intersection clips. All perimeter areas shall have angle mouldings fixed to vertical wall surfaces and end tees shall rest on the moulding, unless otherwise shown on drawings.

2.02.00 Ceiling Panels

2.02.01 Materials

Ceiling panels shall be best quality material in thickness and properties call for in the specification. The Bidder shall submit test certificates to the Engineer for approval before bulk supply. The ceiling panels may be of the following types :

a) Plaster of Paris boards

b) Expanded polystyrene insulation boards

c) Fibre insulation boards

d) Wood particle boards

e) Glass fibre reinforced polystyrene sheets

f) Glass Reinforced Gypsum Board / Gypsum Board or Tiles

g) Mineral Fibre Board

h) Aluminium Panel – Linear / square / plank type false ceiling

i) Calcium silicate Board or tiles

Acrylic plastic sheets translucent or figured glass sheets moulded plastic louvers etc. shall be from approved manufacturers and in thickness as specified.

The type of false ceiling shall be as specified in the relevant clauses

2.02.02 Installation of Ceiling Panels

Installation of ceiling panels shall be strictly as per manufacturer's instruction.

For exposed grid ceiling system, tile hold down clips shall be used at the rate of minimum one per 1.2 meter length of perimeter. These shall however be omitted in access panels which shall be located as per the instruction of the Engineer.

For concealed grid ceiling system, tiles shall be fixed to the supporting grid in manner shown on drawing or as specified by the manufacturer. Where V joints in tiles are called for in drawings, these shall begin true lines. Where flush surface is required, the joints shall be filled with approved filler material and finished to give a neat uniform surface. Where shown on drawings and specification, 6 mm thick cement : lime : sand surface of ceiling boards and finished in a true and even surface without undulations suitable for subsequent painting. Special care shall be taken to neatly finish the ceiling at junctions with walls, light fixtures, diffusers etc.

2.03.00 **False ceiling systems with different materials**

2.03.01 **Glass Reinforced Gypsum (GRG) or Gypsum Moisture Resistant Tiles / Board**

1). Load bearing galvanized light gauge sections shall be used for supporting of (seamless) finished ceiling. G.I. channels of size 0.55 mm thickness having one flange of 300 mm. and a web of 27 mm. shall be fixed along with perimeter of ceiling, screw fixed to brick wall/ partition with the help of nylon sleeves & screws at 610 mm centres. Then suspending G.I. intermediate channels of size 45 mm. 0.9 mm. thick with two flanges of size 15 mm. each from the soffit at 1200 mm centres with ceiling angle of width 25 mm X 25 mm X 0.55 mm thick fixed to soffit with G.I. cleat and steel expansion fastner. Ceiling section of 0.55 mm thickness having knurled web of 51.5 mm and two flanges of 26 mm each with lips of 10.5 mm are then fixed to the intermediate channel with the help of connecting clips and in direction perpendicular to the intermediate channel at 457 mm centres. 12 mm thick GRG/Gyp MR Board is then screw fixed to ceiling sections with 25 mm dry wall screws at 230 mm centres. The board shall be joined and finished to have a flush look.

2). For profiled and curved surface, supporting structure from galvanized steel shall be made in required shape. Board shall be formed in to the curved shape while wet before fixing.

2.03.02 **Mineral Fibre Board**

For laying Mineral Fibre Board in tile of 600 mm X 600 mm the supporting grid system shall be formed by light gauged galvanized steel T- sections. Supporting grid system shall be rolled formed double web galvanized tees and shall meet the requirements of ASTM C-635. Nominal size of T-section shall be 24x38 mm for main runner. Exposed flange surface i.e. 24 mm wide shall be precoated or provided with a matching coloured cap. Main supporting section shall be suspended from RCC soffit / steel member with 4 mm dia galvanized rod & spring steel clip @ 1200 mm c/c. Suspensions from RCC shall be taken using expansion fasteners. The main supporting member shall be placed @ 1200 cross T-sections is inserted into the slots provided in main supporting member at 600 mm c/c so as to give a maximum size of 1200 mm x 600 mm.

Mineral Fibre Board Tiles shall be laid onto the grid 4 nos. of PVC holding clips shall be provided for each panel.

Aluminium Panels – Linear / Square tiles (lay-in or lay-on type) / planks

Aluminium panel ceiling, perforated or un-perforated as per requirement, of approved make, colour consisting of panel 150 mm wide x 15.5 mm deep x 0.5 mm thick with bevel edge, panel length up to 6 mtr, Coil Coated on a Continuous Paint Line, Double baked and roll formed from enamelled corrosion resistance Aluminium alloy AA 5050(Al.mg) for higher strength and good roll forming characteristics. The Panels about each other with a narrow V grove. Panel shall be clipped to a baked enamelled Aluminium Panel carrier of 32 mm wide x 39 mm deep x 0.95 mm thick in standard length of 5 mtr made of double baked enamelled Aluminium alloy AA 5050 (Al.mg) black with cut-outs to hold the panels in a module of 150 mm closed at a distance 1.00 mtr. Panel carrier shall be suspended by means of G.I. suspension rod 4-mm diameter and a Galvanised suspension spring clip at a distance of 1.7 mtr c/c. Paint Finish: Aluminium Panels shall be chromatised for maximum bond between metal and paint enamelled twice under high temperature, one side with a full primer and finish coat the other side (inner side) with a primer coating and Skin Coat on a Continuous Paint Line. Mode of Measurements: Measurements shall be wall to wall without any deductions for lights, diffusers, columns etc.

Or tile of 600mm wide and 600mm long manufactured out of 0.7mm thick Aluminium alloy AA 5050(Al.mg). Tile ends will be raised with pips and stops to ensure positive engagement into the spring to enable for de-mounting of individual panels. The Tile sides will be sufficiently high to ensure a minimum deflection across the length of Tile. All Tiles will be bevel edged. The Tile shall be Polyester based, powder coated in white colour. The Tile shall be clipped into clip in profile of 0.5mm thick G.I. The clip in profile shall be supported from slab by means of rigid suspension of 4mm G.I. Rod, Hold on Clamp with Clip. Mode of Measurements: Measurements shall be wall to wall without any deductions for lights, diffusers, columns etc.

Or Aluminium lineal ceiling system shall be “Luxalon84˚C or approved equal and the installation shall be strictly as per manufacturer’s instruction/ specification subject to approval of the Engineer. Aluminium lineal ceiling shall comprise of plain panels, 84 mm wide and 12.5 mm deep with a 23.9 mm recessed flange, roll formed out of 0.5 mm thick aluminium alloy panels stove enamelled on both sides, fixed on roll-formed carriers made of enamelled 0.95 mm thick aluminium, 32 mm wide and 39 mm deep with prongs to hold panels in the module of 100mm, at maximum spacing 1.2 M centre to centre.

The carriers shall be suspended from roof by 4 mm dia galvanised steel wire hangers with special height adjustment clips made out of spring steel at maximum spacing of 1.2 M c/c. Hangers shall be fixed to roof by 12mm dia 50mm long anchor bolts and nylon inserts. 25 mm thick resin bonded mineral wool (spintex 300 or equivalent) insulation bound in polythene shall be laid on top of panels. Lineal ceiling shall be fixed in pattern as per detailed drawings.

3.00.00 ACCEPTANCE CRITERIA

Finished ceiling shall be at the correct plane and present a pleasing and uniform appearance, free from sags, warps, figures or damaged boards, joints, exposed grids etc. shall be in true lines and symmetrically placed in manner shown on drawings. Cut-outs for light fixtures, diffusers etc. shall be of exact dimensions and in exact locations.

4.00.00 I. S. CODES

IS: 2441 : Code of Practice for fixing ceiling coverings.

SP 27: 1987 : Handbook of Method of Measurement of Buildings Works

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SECTION-XV

GUIDELINE
FOR
ROOF WATER PROOFING, INSULATION
AND ALLIED WORKS

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SECTION-XV

GUIDELINE FOR ROOF WATER PROOFING, INSULATION AND ALLIED WORKS

1.00.00 SCOPE

This specification covers providing, furnishing, installation, repairing, finishing, curing, testing,, protection, maintenance till handing over of roof water-proofing, insulation and allied work for buildings and at locations covered under the scope of the Contract. Roof water proofing shall be followed as per cl 3.02.00/4.00section IV/G1. However the following section gives the methods of waterproofing for general guidance.

2.00.00 INSTALLATION

2.01.00 Before taking up the water proofing work the construction of parapet walls, including finishing shall be completed. Similarly, the ancillary items like haunches, khurras, grooves to take the fiber cloth layer, fixing up of all down take pipes, water pipes and electric conduits etc. shall be completed and no such work shall be allowed on the area to be treated during the progress of water proofing treatment or even later.

2.01.01 There is no necessity of hacking the surface to be treated shall be cleaned including removing the mortar dropping from the surface.

2.01.02 **Grading Under bed**

The surface to receive the under bed shall be roughened and thoroughly cleaned with wire brush and water. Oil patches if any shall be removed with detergent. The surface shall be soaked with water and all excess water removed just before laying of the under bed.

The under bed shall not be laid under direct hot sun and shall be kept in shade immediately after laying so as to avoid quick loss of water from the mix and separation from the roof surface. The under bed shall be cured under water for at least 7 days.

The under bed shall be laid to provide an ultimate run off gradient not less than 1 in 120 and as directed by the Engineer. Upto an average thickness of 25 mm the underbed shall usually be composed of cement and sand plaster.

For higher thickness the under bed shall be made with cement concrete.

The underbed shall be finished to receive the waterproofing treatment direct or insulation as the case may be.

2.01.03 The grading plaster shall be average 25mm thick maximum. It shall consist of cement and coarse sand in the ratio 1:4 nominal by volume. The same and cement shall be thoroughly mixed dry and them water added. Each batch of mix shall be consumed before the initial set starts.

The plaster shall be fully compacted to the desired grade in continuous operation. The surface shall be even and reasonably smooth.

2.02.00 **Concrete**

The concrete shall be used where the sub-grade is more than average 25mm thick. It shall consist of cement concrete 1:2:4 nominal mix by volume with 12 mm down stone chips and coarse sand. The aggregate shall be mixed dry and minimum quantity of water shall be added to make the mix workable.
The mix shall be laid to proper grade, fully consolidated and surface shall be smooth and even.

2.03.00 **Insulation**

The successful bidder shall furnish the specification of insulating materials he proposes to use and the proposed method of laying. Before bulk supply, the Bidder shall send samples of insulating material to the Engineer, and after approval of the samples, the Bidder shall procure and transport the bulk material to the site. Whenever asked by the Engineer, The Bidder shall furnish test certificates from testing laboratory on the insulating and other properties of the materials.

After laying the insulation the surface shall be made ready as required to receive the waterproofing treatment. If any plastering is used it shall be not leaner than 1:4 cement sand by volume and not thinner than 12mm and it shall be cured for seven days.

2.03.01 **Expanded Polystyrene Blocks**

The expanded polystyrene block insulation shall be fire retardant quality and shall have a maximum thermal conductivity of 0.026 KCl m/m degree C. It must be strong enough to withstand without deformation the workload and standard loads expected on the roof.

The Bidder shall lay the expanded polystyrene block as per manufacturer's approved specification. Only specifically experienced workers shall be used for this work.

If the Engineer is not satisfied about the efficiency of the workers the Bidder shall have to secure manufacturer's supervision.

Material: Expanded polystyrene shall conform to IS 4671. It is of two types given below :

Type N-Normal

Type SE – It shall be of self extinguishing type when tested in accordance with IS 4671.

Dimensions: The size of the finished boards shall be 1.0 x 0.5 m or as specified and having a thickness of 15, 20, 25, 40, 50, 60, 75 or 100mm.

Tolerance: The tolerances on the length, width and thickness of the finished board shall be ± mm.

Requirements for Expanded Polystyrene for General Use:

Sl. No.	Characteristics	Requirements at various nominal apparent densities in kg/cum					Test Reference
		15	20	25	30	35	
1.	Thermal conductivity (k. value) (a) at 0ºC (b) at 10ºC	 0.34 0.37	 0.32 0.35	 0.30 0.33	 0.29 0.32	 0.28 0.30	IS 3346
2.	Compressive strength at 10% deformation in kg/sq.cm Minimum.	0.7	0.9	1.1	1.4	1.7	IS 4671
3.	Cross breaking strength in kg/sq.cm Minimum.	1.4	1.6	1.8	2.2		IS 4671
4.	Water vapour permeance in g/sqm 24 hrs. Max.	50	40	30	20		IS 4671
5.	Thermal stability Percent Max.	1	1	1	1		IS 4671
6.	Water absorption	Less than 0.5% by volume (after 24 hrs. immersion)					IS 4671

Sampling: In a single consignment all the items of the same type, shape and dimensions belonging to the same batch of manufacture shall be grouped together to constitute a lot. For the purpose of judgment conformity to the requirements each lot shall be considered separately. The number of sample items for this purpose shall depend on the size of the lot and shall be in accordance with col. 1 & 2 of Table given below. The sample shall be taken at random from the lot.

No. of items in the lot	No. of sample items	Permissible number of defective sample items
1	2	3
Up to 25	3	0

26 to 100	5	0
101 to 300	8	0
301 to 1000	13	0
1001 to 3000	20	1
3001 and above	32	2

All the sample items selected from the lot shall be tested for all requirements of the specifications. Any item failing in one or more of the requirements shall be regarded as defective.

General: Expanded polystyrene can either be fixed with suitable adhesive to the false ceiling board or else it can simply be rolled over the suspended false ceiling.

2.03.02 **With Resin Bonded Fiber Glass Wool (Bonded Mineral Wool)**

Material: The material shall be mineral wool made from sock slag or glass processed from a molten state in to fibrous form and shall be bonded with a suitable binder. Bonded mineral wool shall be 25, 40, 50, conform to specifications of group I of IS 8183.

Dimensions: The bonded mineral wool shall be supplied in width of 50, 60, 75 and 100 cm, and length of 100, 120 and 140 cm and the thickness of the bonded material wool shall be 25, 40, 50, 65 or 75 mm.

Tolerance: For width and length, the dimensional tolerance of the bonded material wool shall be -1/2 %. For nominal thickness in the range 25 to 75 mm the tolerance shall be -2 mm. An excess, in all dimensions is permitted.

Requirements for Fiber Glass Wool

Sl. No.	Characteristics	Group I	Test Reference
1.	Bulk density	12 to 15 kg/cum	IS 3144
2.	Recovery after compression	Not less than 90% of original thickness	Annexure. A of IS 3144
3.	Shot content max	500 micron-5% 250micron-15%	IS 8183
4.	Moisture content and absorption	Not more than 2%	IS 3144
5.	In combustibility	Incombustible	IS 3144
6.	Thermal conductivity deg. C at mean temperature 50 deg. C	0.49 mw/ cm°C	IS 3346
7.	Sulphur content	Not more than 0.6%	IS 3144

General: Bonded mineral wool insulation can be either laid over false ceiling or alternatively it can be fixed to the ceiling when the space above false ceiling is being used for carrying return air. In the first case the bonded mineral wool

can either be fixed with suitable adhesive to the false ceiling board or else it can simply be rolled over the suspended false ceiling.

2.04.00 **Fillets**

Fillets at junction of roofs and vertical walls shall be provided with the same insulating material as provided for the main roof insulation. The fillets shall be 150 mm x 150 mm in size unless otherwise shown on drawings or instructed by the Engineer.

Where there is no insulation over roof slab, fillets shall be cast-in-situ cement concrete (1:2:4) nominal mix by volume.

2.05.00 **Water proofing by epoxy resin based application**

Exposed surfaces of cement concrete, lime concrete or brickwork to be treated for waterproofing by the resin based application shall be thoroughly cleaned and the epoxy resin based material to be applied as directed by the manufacturer. The material shall not have any adverse effect on the surface on which it is applied and must stick to it uniformly to make a strong durable bond. It shall not be affected by short duration from fire, sun, and light traffic. The application shall be resistant to growth of fungus and proof against saltpeter action. If desired by the Engineer, a sample shall be prepared in advance and tested for waterproofness for 48 hours under 300 mm depth of standing water. The Bidder shall arrange the demonstration by providing free the materials and labours for the application.

2.06.00 **Flashing**

Unless otherwise stated flashing shall be done in the same way as the waterproofing except that the last layer, instead of being finished with pea-sized gravel, shall be finished with two coats of bituminous primer. The flashing shall be extended up the vertical surfaces as shown on drawing. The flashing shall end in grooves in vertical walls. The grooves shall be at least 65 mm deep and caulked with waterproof mastic cement. The minimum overlap with horizontal roofing felt shall be 100 mm.

Where specified on drawings or directed by the Engineer, metal flashing shall be provided. The metal flashing shall be done as shown on the drawings. The materials shall be 18g or 22g G.I. sheets, as specified on the drawings and/or as directed by the Engineer.

2.07.00 **Elastomeric Membrane**

2.07.01 **Primer Coat**

It shall consist of polyurethane (P.U.) or any other equivalent material. Primer coat shall be a special blend of moisture curing urethane pre-polymers in solvent. A single coat of this primer shall be applied by brush /spray with

airless spray equipment over the prepared bed as an adhesion coat with an application rate of 6-8 sq.m per liter depending on the surface porosity.

The primer shall be allowed to dry for a minimum period of 2 to 4 hours time before the successive finishing coats of P.U. liquid membrane are applied. In any case successive finishing coat shall be applied within 24 hours.

The substrate shall be properly prepared by removing all loose materials by vigorous brushings, fungal growth with proprietary fungicide as recommended. Priming coat shall not be applied to damp substrate.

2.07.02 **Finishing Coats**

The finishing coats shall consist of two successive liquid coatings of high solid content urethane pre-polymers material to form an elastomeric membrane. Application shall be with brush or spray to form an uniform joint less elastomeric membrane. The overall dry film thickness shall be 1.5 mm subject to minimum 750 gm per sq.m per coat application rate.

Each coat shall be allowed to dry for minimum 12 hours before applying the next coat. The surface shall be dry and smooth before application.

The coating shall be continued up the parapets/walls for minimum of 150 mm over the finished roof surface or fillet with suitable tucking into the vertical wall surface. It shall be continued into rain water pipes by at least 100 mm.

The final coat of PU liquid when tacky shall be sprinkled with the sand.

For edges, expansion joints and any vulnerable points a layer of polyscrim cloth/fabric are to be embedded between 2 finishing coats.

The entire work shall be carried out under the supervision of approved authorized agency.

2.08.00 **Under Deck Insulation**

2.08.01 Insulation material shall be Closed Cell Elastomeric Nitrile Rubber

2.08.02 Density of Material shall be between 40 to 60 Kg/m3

2.08.03 Thermal conductivity of elastomeric nitrile rubber shall not exceed 0.035 W/m°K at an average temperature of 0°C

2.08.04 The insulation shall have fire performance such that it passes Class 1 as per BS476 Part 7 for surface spread of flame as per BS 476 and also pass Fire Propagation requirement as per BS476 Part 6 to meet the Class 'O' Fire category as per 1991 Building Regulations (England & Wales) and the Building Standards (Scotland) Regulations 1990

2.08.05 Material shall be FM (Factory Mutual), USA approved.

2.08.06 Water vapour permeability shall not exceed 0.017 Perm inch (2.48 x 10-14 Kg/m.s.Pa), i.e. Moisture Diffusion Resistance Factor 'μ' value shall be minimum 7000.

2.08.07 Under-deck insulation thickness shall be as per HVAC requirement and calculation.

2.08.08 Under-deck insulation shall be provided for all AC areas having roof/floor exposed to sun/hot environment.

2.09.00 **For vertical surfaces (Parapet)**

Surface preparation, minor cleaning works, removal of loose concrete, laitance, dust particles, etc. and filling cracks with polymer modified mortar using latex based bonding agent. Removal of algae if present is to be done. Providing and applying a water based acrylic primer over the entire surface of the parapet walls(2 part primer : 1 part water). Providing and applying 2 coats of a high performance elastomeric coating, composed of acrylic emulsion polymers having anti-carbonation properties, UV resistant and DFT of 110 microns, conforming to ASTM-D412-02, D1202-97, D 4587, D 4645, BS-EN 12390 over the exterior wall surface.

Note: Waterproofing materials shall be applied by the manufacturer in-house application wing or authorised applicators only under supervision of manufacturer's authorised person.

3.00.00 ACCEPTANCE CRITERIA

The surface level shall be such as to allow quick draining of rains without leaving any pool anywhere. The finishing course shall be fully secured and shall have an even density. There shall not be any bubble formation or crushed or squeezed insulation or under bed.

4.00.00 I.S. CODES AND STANDARDS

a)	IS:73	:	Paving Bitumen
b)	IS:702	:	Industrial Bitumen
c)	IS:1203	:	Methods of testing tar and bitumen
d)	IS:1322	:	Bitumen felts for waterproofing and damp proofing
e)	IS:1346	:	Code of Practice for waterproofing of roofs with bitumen felts

f)	IS:3384	:	Bitumen primer for use in waterproofing and damp proofing.
g)	IS:2645	:	Specification for integral water proofing compounds for cement mortar and concrete.
h)	IS:3144	:	Methods of test for mineral wool thermal insulation materials.
i)	IS:4641	:	Expanded polystyrene for thermal insulation purpose.
j)	SP 27: 1987	:	Handbook of Method of Measurement of Buildings Works

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SECTION-XVI

GUIDELINE
FOR
SHEET WORK IN ROOF AND SIDE WALL

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SECTION-XVI

GUIDELINE
FOR
SHEET WORK IN ROOF AND SIDE WALL

1.00.00 SCOPE

This specification covers the erection of Zincalume sheet plain /corrugated/trough covering to roof and side walls at various elevations and the fabrication and/or installation of gutters, flashings etc., as shown on drawings

2.00.00 INSTALLATION

2.01.00 Storage of Materials

All materials shall be stored by the Bidder in proper way to prevent all damage. If the materials are issued at site by the Owner, the Bidder shall at the time of issue, satisfy himself about the condition of issued sheets, gutters, etc. and no complaints shall be entertained later.

2.02.00 Workmanship

The workmanship shall be according to best construction practice to give a water tight finish to the satisfaction of the Engineer fixing of gutters and down pipes shall be according to IS:2527.

2.02.01 Zincalume Sheeting

The wall cladding for buildings shall be of double skin sandwiched(wherever specified) prefabricated factory made Rockwool/PUF TR panels comprising of outer metal colour coated profile steel sheet of minimum depth 34.5 mm at 333 mm pitch & inner slightly ribbed or plain permanently colour coated steel sheet made out of 0.6 mm TCT high tensile zincalume steel (150 gsm. Zinc – aluminium coating total of both sides as per AS:1397) & min. 550 MPa yield strength for top sheet and 0.5 mm TCT zincalume steel (150 gsm zinc – aluminium coating total of both sides as per AS:1397) & min. 550 MPa yield strength for inner sheet The sheets shall have colour coating with silicon modified polyester finish of thickness 20 microns over 5 microns (DFT) back coat on outer surface and 5microns over 5microns back coat for inner surface of the sheet. The permanently colour coated sheet shall meet the general requirements of IS:513, IS:277 & IS:14246. In between the metal sheet, there will be lamellar mineral wool insulation having density 100 kg/m3 and average thickness 50 mm conforming to IS:8183 having a thermal

conductivity value of 0.040 W/m2K at 50oC mean temp. Alternatively insulation shall be PUF having density of 40- 42Kg/m3 and a thermal conductivity value shall be as per IS:12436. The prefabricated Rockwool/PUF panels shall be supplied up to max. length of 12 m and finished with profile sheet overlap jointing arrangement. The panels shall be directly bolted on to the horizontal runners..

Note: For single skin wall cladding/ roofing, specification for outer sheet as mentioned above is to be followed and the thickness of the sheet shall be 0.8mm minimum. Flashings shall be of same material that of sheeting.

The work is to be executed by the in-house/authorised applicator of the manufacturer, under the supervision of the authorised representative of the manufacturer

Purlins: Purlins of the specified material or M.S. rolled sections of requisite size shall be fixed over the principal rafters and the spacing will be as specified in the drawing.

Slope: Roof shall not be pitched at a flatter slope than 1 vertical to 5 horizontal or as specified in the drawing. The normal pitch adopted shall usually be 1 vertical to 3 horizontal.

Laying and Fixing: The sheets shall be laid and fixed in the manner described below, unless otherwise shown in the working drawings or directed by the Engineer-in-Charge.

The sheets shall be laid with a minimum lap of 15 cm at the ends and 2 ridges of corrugations at each side. The above minimum end lap of 15 cm shall apply to slopes of 1 vertical to 2 horizontal and steeper slopes. For flatter slopes the minimum permissible end lap shall be 20 cm. The minimum lap of sheets with ridge, hip and valley shall be 20 cm measured at right angles to the line of the ridges, hip and valley respectively. These sheets shall be cut to suit the dimensions or shapes of the roof, either along their length or their width or in a slant across their lines of corrugations at hips and valleys. They shall be cut carefully with a straight edge chisel to give a smooth and straight finish.

Sheet shall not generally be fixed in to gables and parapets. They shall be bent up along their side edges close to the wall and junction shall be protected by suitable flashing or by a projecting drip course, the later to cover the junction by at least 7.5 cm.

The laying operation shall include all scaffolding work involved.

Sheets shall be fixed to the Purlins or other roof members such as hip or valley rafters etc. with galvanized J or L hook bolts and nuts, 8 mm diameter, with bitumen and G.I. limpet washers or with a limpet washers filled with white

lead as directed by the Engineer-in-Charge. While J hooks are used for fixing sheets on angle iron Purlins, and L hooks are used for fixing the sheet to R.S. joists, precast concrete Purlins. The length of the hook bolt shall be varied to suit the particular requirements. Alternatively Sheets may be fixed to Purlin with self-driven screws with neoprene washers as recommended by the Sheet manufacturer. Sheeting to sheeting fixing may also be done with self-driven screws with neoprene washers.

The bolts shall be sufficiently long so that after fixing they project above the top of the nuts by not less than 10mm. The grip of J or L hook bolt on the side of the purlin shall not be less than 25 mm. There shall be a minimum of three hook bolts placed at the ridges of corrugations in each sheet on every purlin and their spacing shall not exceed 30 cm. Coach screws shall not be used for fixing sheets to purlins.

The galvanized coating on J or L hooks, and bolts shall be continuous and free from defects such as blisters, flux stains, drops, excessive projections or other imperfections which would impair serviceability.

The galvanized coating shall conform to IS 1367 9pt. XIII). The mass of coating per square meter of the surface shall be as under:

Mass and Equivalent Thickness of coating

Minimum Mass (g/m²)	Average Thickness(µm)	Minimum Mass (g/m²)	Individual Thickness(µm)
375	54	300	43

Where slopes of roofs are less than 21.5 degrees (1 vertical to 2.5 horizontal) sheets shall be joined together at the side laps by galvanized iron bolts and nuts 25 x 6 mm size, each bolt provided with bitumen and a G.I. limpet washers or a G.I. limpet washers filled with white lead. As the overlap at the sides extends to two corrugations, these bolts shall be placed zigzag over the two overlapping corrugations, so that the ends of the overlapping sheets shall be drawn tightly to each other. The spacing of these seam bolts shall not exceed 60 cm along each of the staggered rows. Holes for all bolts shall be drilled and not punched in the ridges of the corrugations from the underside, while the sheets are on the ground.

Finish: The roof when completed shall be true to lines, and slopes and shall be leak proof.

Ridges and Hips of Plain Zincalume Sheets

Ridges and Hips: Ridges and hips of Zincalume roof shall be covered with ridge and hip sections of plain Zincalume sheet with a minimum lap of 20 cm on either side over the sheets. The end laps of the ridges and hips and between ridges and hips shall also be not less than 20 cm. The ridges and hips shall be of 60 cm overall width plain sheet, 0.6mm or 0.8 mm thick as given in the specification and shall be properly bent in shape.`

Fixing: Ridges shall be fixed to the purlins below with the same 8 mm dia G.I. hook bolts and nuts and bitumen and G.I. limpet washers which fix the sheets to the purlins.

Similarly, hips shall be fixed to the roof members below such as purlins, hip and valley rafters with the same 8 mm dia G.I. hook bolts and nuts and bitumen and G.I. limpet washers which fix the sheets to those roof members. At least one of the fixing bolts shall pass through the end laps of ridges and hips on either side. If this is not possible extra hook bolts shall be provided.

The end laps of ridges and hips shall be joined together with Zincalume sheet by galvanized iron seam bolts 25 x 6 mm size each with a bitumen and G.I. washer or white lead as directed by the Engineer-in-Charge. There shall be at least two such bolts in each end lap.

Finish: The edges of the ridges and hips shall be straight from end to end and their surfaces shall be plane and parallel to the general plane of the roof. The ridges and hips shall fit in squarely on the sheets.

Valley and Flashing of Plain Zincalume Sheets

Valley and Flashing: Valley shall be 90 cm wide overall plain sheet or other size as specified in the specification bent to shape and fixed. They shall lap with the sheets not less than 25 cm width on other side. The end laps of valley shall also be not less than 25 cm.

Valley sheets shall be laid over 25 mm thick wooden boarding if so required.

Flashing shall be of plain Zincalume sheet of 40 cm overall width as specified in the specification bend to shape and fixed. They shall lap not less than 15 cm over the roofing sheets. The end laps between flashing pieces shall not less than 25 cm.

Laying and Fixing: Flashing and valley sheets shall be fixed to the roof members below, such as purlins and valley rafters with the same 8 mm dia G.I. hook bolts and nuts and bitumen and G.I. limpet washers which fix the sheets to those roof members.

At least one of the fixing bolts shall pass through the end laps of the valley pieces on other side. If this is not possible extra hook bolts shall be provided. The free end of flashing shall be fixed at least 5 cm inside masonry with the mortar of mix 1:3 (1cement: 3 coarse sand).

Finish: The edges of valley and flushing shall be straight from end to end. The surface shall be true and without bulges and depressions.

Gutters Made of Plain Zincalume Sheets

Gutters: Gutter shall be fabricated from plain Zincalume sheets of thickness as specified

Eaves gutters shall be of the shape and section specified in the specification. The overall width of the sheet referred to their in shall mean the peripheral width of the gutter including the rounded edges. The longitudinal edges shall be turned back to the extent of 12 mm and beaten to form rounded edges. The ends of the sheets at junction of pieces shall be hooked in to each other and beaten flush to avoid leakage.

Slope: Gutters shall be laid with a minimum slope of 1 in 120.

Laying and fixing: Gutters shall be supported on and fixed to GI flat iron brackets bent to shape and fixed to the requisite slope. The maximum spacing of brackets shall be 1.20 metres.

Where these brackets are to be fixed to the sides of rafters, they shall be of 40 x 3 mm section bend to shape and fixed rigidly to the sides of rafters with 3 nos. 10 mm dia bolts, nuts and washers. The brackets shall overlap rafter not less than 30 cm and the connecting bolts shall be at 12 cm centers.

Where the brackets are to be fixed to the purlins, the bracket shall consist of 50 x 3 mm GI flat iron bent to shape with one end turned at right angle and fixed to the purlin face with 2 nos. of 10 mm diameter bolts, nuts and washers. The bracket will be stiffened by provision of 50 x 3 mm flat whose over hung portion bent to right angle shape with its longer leg connected to the bracket with 2 nos. 6 mm dia bolts, nuts and washers and its shorter leg fixed to face of purlin with 1 no. 10 mm dia bolt, nut and washer. The overhang of the vertical portion of the bracket from the face of the purlin shall not exceed 22.5 cm with this arrangement. The spacing of the brackets shall not exceed 1.20 metres.

The gutter shall be fixed to the brackets with 2 nos. G.I. bolts and nuts 6 mm dia, each fitted with a pair of G.I. and bitumen washers. The connecting bolts shall be above the water line of the gutters.

For connection to down take pipes, a proper drop end or funnel shaped connecting piece shall be made out of sheet of the same thickness as the gutter and reverted to the gutter, the other end tailing in to the socket of the rain-water pipe. Wherever stop ends, angles etc., shall be provided.

Finish: The gutters when fixed shall be true to line and slope and shall be leak proof.

2.02.02 **Polycarbonate Sheeting Work**

Solid Polycarbonate sheet of minimum 4mm thick shall be of UV resistant and high temperature resistant. Sheet shall be of approved brand and quality, colour and transparency for ceiling/ roofing on plain, sloped, curved surfaces to any pitch or height including fixing purlins with polymer quoted galvanized self drilling, self tampering metal screws and fasteners and EPDM washers, rubber gasket with closing caps, adequate adhesive and sealants as per manufacturer's specification etc. complete but excluding the cost of purlins, rafters, trusses etc.(if any). Polycarbonate sheets shall be uniform

pigmentation and thickness without air pockets and shall conform to IS: 14443: 1997 and including cutting to required length and size including profile machine bending of sheets to achieve the desired profile by conforming minimum joints and laps as per drawing.

3.00.00 ACCEPTANCE CRITERIA

The installations shall present a neat appearance and shall be checked for water tightness. The following shall be checked:

a) Side and end laps
b) Absence of cracks, holes or damages in sheet
c) Spacing of bolts
d) Provision of double washers (G.I. and asbestos or bituminous washers)
e) Proper installation of flashing

4.00.00 IS CODES

The following are some of the important IS Codes relevant to these sections:

IS: 3007	:	Code of practice for laying of asbestos cement sheets
IS: 2527	:	Code of practice for fixing rain water gutters and down pipes for roof drainage
IS: 1626	:	Specification for asbestos cement building pipes gutters and fittings
IS: 277	:	Specification for galvanised steel sheets (plain and corrugated)
IS: 1200 (PT.IX)	:	Method of measurements of building and civil engineering works: Part – 9 Roof covering (including cladding)
IS: 2633	:	Method of testing uniformity of coating on zinc coated articles.
IS: 3144	:	Method of test for mineral wool thermal insulation materials.
IS: 3346	:	Method of the determination of thermal conductivity of thermal insulation materials.
IS: 8183	:	Bonded mineral wool
SP 27: 1987	:	Handbook of Method of Measurement of Buildings Works

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SECTION-XVII

GUIDELINE
FOR
WATER SUPPLY

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SECTION-XVII

GUIDELINE
FOR
WATER SUPPLY

1.00.00 SCOPE

This section includes supply of all materials, labour and incidentals for water supply for industrial and other types of buildings. The water supply system of a building or premises covers service pipes and the necessary connecting pipes, fittings, control valves and all appurtenances in or adjacent to the building or premises.

General Requirements

Any damage caused to the building, or to electric, sanitary water supply or other installations etc. therein either due to negligence on the part of the Bidder, or due to actual requirements of the work, shall be made good and the building or the installations shall be restored to its original condition by the Bidder. All water supply installation work shall be carried out through licensed plumber.

It is most important to ensure that wholesome water supply provided for drinking and culinary purpose is in no way liable to contamination from any less satisfactory water. There shall, therefore, be no cross connection whatsoever between a pipe or fitting for conveying or containing wholesome water and a pipe or fitting for conveying or containing impure water or water liable to contamination or of uncertain quality of water which has been used for any purpose. The provision of reflux or non-return valves or closed and sealed valves shall not be constructed a permissible substitute for complete absence of cross-connection.

Where a supply of wholesome water is required as an alternative or standby to supply of less satisfactory water or is required to be mixed with the latter, it shall be delivered only in to a cistern, and by a pipe or fitting discharging in to the air gap at a height above the top edge of the cistern equal to twice its normal bore, and in no case less than 15 cm.

No piping shall be laid or fixed so as to pass into, through or adjoining any sewer, scour outlet or drain or any manhole connected therewith nor through any ash pit or manure-pit or any material of such that can cause undue deterioration of the pipe.

Where the laying of any pipe through fouled soil or previous material is unavailable, the piping shall be properly protected from contact with such soil

or material by being carried through an exterior cast iron tube or by some other suitable means. Any piping or fitting laid or fixed which does not comply with the above requirements, shall be removed and re-laid in conformity with the above requirements.

The design of the pipe work shall be such that there is no possibility of backflow towards the source of supply from any cistern or appliance whether by siphonage or otherwise, and reflux or non-return valves shall not be relied upon to prevent such back flow.

All pipe work shall be so designed, laid or fixed, and maintained so that it remains completely watertight, thereby avoiding wastage of water damage to property and the risk of contamination of the water conveyed.

In designing and planning the layout of the pipe work, due attention shall be given to the maximum rate of discharge, required economy in labour and materials, protection against damage and corrosion, protection from frost, if required, and to avoidance or airlocks, noise transmission and unsightly arrangement.

To reduce frictional losses, piping shall be as smooth as possible inside. Methods of jointing shall be such as to avoid internal roughness and projection at the joints, whether of the jointing materials or otherwise.

Change in diameter and direction shall preferably be gradual rather than abrupt to avoid undue loss of head. No bend or curve in piping shall be made so as to materially reduce or alter the cross-section.

Underground piping shall be laid at such a depth that it is unlikely to be damaged by frost or traffic loads and vibrations. It shall not be laid in ground liable to subsidence, but where such ground cannot be avoided; special precautions shall be taken to avoid damage to the piping. Where piping has to be laid across recently disturbed ground, the ground shall be thoroughly consolidated so as to provide a continuous and even support.

Where the service pipe is of diameter less than 50mm the stop valves shall be of the screw-down type and shall have loose washer plates to act as non-return valves. Other stop valves in the service line may be of the gate type.

In flats and tenements supplied by a common service pipe a stop valve shall be fixed to control the each branch separately. In large buildings a sufficient number of stop valves shall be fixed on branch pipes, and to control groups of ball valves and draw off taps so as to minimize interruption of the supply during repairs, all such stop valves shall be fixed in accessible positions and properly protected from being tampered with, they may be of the gate type to minimize loss of head by friction.

Water for drinking or for culinary purposes as far as possible shall be on branch pipes connected directly to the service pipe.

Pumps shall not be allowed on the service pipe as they cause a drop of pressure on the suction side thereby affecting the supply to the adjoining properties. In cases where pumping is required, a properly protected storage tank of adequate capacity shall be provided to feed the pump.

Service pipes shall be so designed and constructed as to avoid air-locks, so that all piping and fittings above ground can be completely emptied of water to facilitate repairs. There shall be draining taps or draw-off taps (not underground) at the lowest points, from which the piping shall rise continuously to draw-off taps, ball valves, cisterns, or vents (where provided at the high points).

Service pipes shall be designed so as to reduce the production and transmission of noise as much as possible. Appliances which create noise shall be installed as far distant as possible from the living rooms of the house. High velocity of water in piping and fittings shall be avoided. Piping shall be confined, as far as possible, to rooms where appliances are fixed, it shall have easy bends, and where quietness is particularly desired, holder bats or claps shall be insulated from the piping by suitable pads.

The rising pipe to the storage cistern, if any, or to any feed cistern shall be taken as directly as possible to the cistern and shall be fixed away from windows or ventilators.

All pipe work shall be planned so that the piping is accessible for inspection, replacement and repair. To avoid its being unsightly, it is usually possible to arrange it in or adjacent to cupboards, recesses, etc. provided there is sufficient space to work on the piping with the usual tools. Piping shall not be buried in walls or solid floors. Where unavoidable, piping may be buried for short distances provided that adequate protection is given against damage and that no joints are buried. If piping is laid in ducts or chases, these shall be roomy enough to facilitate repairs and shall be so constructed as to prevent the entry of vermin. To facilitate removal of pipe casing, floor boards covering piping shall be fixed with screws or bolts.

When it is necessary for a pipe to pass through a wall or floor, a sleeve shall be fixed therein for insertion of the pipe and to allow freedom for expansion, contraction and other movement. Piping laid in wood floors shall, where possible, be parallel with the joints.

Where storage tanks are provided to meet overall requirements of water connection of service pipe with any distributing pipe shall not be permitted except one direct connection for culinary or drinking requirements.

No service pipe shall be connected to any water closet or urinal. All such supplies shall be from flushing cistern which shall have supply from storage tank.

No service or supply pipe shall be connected directly to any hot water system or to any apparatus used for heating other than through a feed cistern thereof.

1.01.00 **Materials**

All materials, fittings, fixtures and appliances shall be of the best quality conforming to relevant Indian Standard and shall be procured from approved manufacturers. Unless specifically allowed by the Engineer, the Bidder shall submit samples of fittings and fixtures which will be retained by him for comparison when bulk supplies are received at the site. Ultimate choice of type, model and manufacturer lies completely with the Engineer.

It shall be the responsibility of the Bidder to procure the materials selected by the Engineer. Hence order is to be placed with the manufacturers in time, so that the materials are available at the site well ahead of their requirement.

The materials brought to the site, shall be stored in a separate secured enclosure away from the building materials. Pipe threads, sockets and similar items shall be specially protected till final installation. Brass and other expensive items shall be kept under lock and key. Fragile items shall be checked thoroughly when received at the site and items found damaged shall not be retained at the site.

1.02.00 **Pipes and Pipe Fittings**

Under scope of this specification, pipes and pipe fittings may be any or a combination of the following types:

a) NOT USED

b) MS/DI
c) Reinforced Concrete

d) U.P. V. C.

e) Galvanized Iron- heavy & medium duty pipes- is 1239 & is 4736

However for water supply in buildings only GI pipes of Medium class as per IS 1239 shall be used. And all the pipes shall be laid inside the buildings in concealed type wherever possible.

1.03.00 **Water Tanks**

Water tanks shall be made of HDPE(White colour), shall be factory made and from reputed brand with proper test certificates. The capacity of tanks shall be as per drawing design or as per instruction of Engineer-in-Charge.

1.04.00 **Related Works**

All works, like earthwork, masonry, concrete, steelwork, cutting holes, chases, repairs and rectification associated directly with installation of water supply systems shall come under scope of the Bidder unless specifically excluded. These works are not detailed out in this Specification.

1.05.00 **Regulation**

The work which is required to be carried out under the scope of this section, shall be executed by a licensed plumber only (engaged by the Bidder)

2.00.00 INSTALLATION

While basic layouts may be available in the drawings provided by the Owner, the details might have to be supplemented by the Bidder for approval of the Engineer.

Special attention shall be given by the Bidder to economy. Symmetry of layout is very important. Fittings meant for operation shall be located and oriented to allow easy reach and operation. Maintenance, repairs and replacements of pipes, fittings and fixtures must be conveniently possible.

2.01.00 **Pipe Lines (Plumbing and sanitary water lines)**

2.01.01 **Laying**

In addition to fulfilling the functional requirements all pipelines shall be laid true to line, plumb and level. Any deviation shall need approval of the Engineer. Meticulous care shall be taken to avoid chances of airlock and water hammer.

Pipes shall be laid on continuous unyielding surface or on reliable supports at least one near each joint and spacing as directed by the Engineer. The support must be strong, neat and shall have provisions for securing the pipes in every direction and easy maintenance. Pipes shall be encased or concealed in masonry or concrete if shown on drawing or directed by the Engineer.

2.01.02 **Back Flow**

The layout of pipe work shall be such that there is no possibility of back flow towards the source of supply from any cistern or appliances, whether by siphonage or otherwise. All pipe works shall be so laid or fixed and maintained as to be and to remain completely water-tight, thereby avoiding waste of water, damage of property and the risk of contamination of the water conveyed.

2.01.03 **Contamination**

There shall be no cross connection whatsoever between a pipe or fitting for conveying or containing wholesome water and a pipe or fitting for containing impure water or water liable to contamination or of uncertain quality of water which has been used for any purpose.

No piping shall be laid or fixed so as to pass into or through any sewer, scour outlet or drain or any manhole connected therewith.

2.01.04 **Underground Piping**

Underground piping shall be laid at such a depth that it is not likely to be damaged by traffic and other loads and frost, where applicable.

The size and depth of the trench shall be as approved by the Engineer. Back-filling shall be done with selected fine earth, unless otherwise permitted in 150 mm layers and carefully consolidated. Special care shall be taken while filling in the vicinity of the pipe to avoid damage. Before backfilling the laid pipe shall be fully tested and approved.

Where the pipe rests on rock it may be bedded on a layer of fine selected material or concrete to avoid local point support.

The trench shall be so treated by gradient and filling in the area that it does not act as a drainage channel.

2.01.05 **Concealed Piping**

Where desired by the Engineer or shown on the drawings the pipes shall be concealed in masonry or concrete of the structure. The Bidder may co-ordinate with the building Bidder for leaving the chases, openings, conduits as necessary. However, the Bidder will rectify if required the chases, openings and conduits, supplement and make good after laying and testing of the concealed pipelines.

2.01.06 **Jointing of Pipes**

Jointing of pipes shall be completely leak proof and durable. Instruction of the manufacturer shall be followed unless desired otherwise by the Engineer. However, usually recommended practices are stated below for guidance:

a) **Steel**

Plain ended steel pipes may be jointed by welding. Screwed and socketed joints shall be carefully tightened. Care shall be taken to remove any burr from the ends of the pipes. Jointing compound, if used, shall be lead free and approved by the Engineer. Once a joint has been screwed up it shall not be backed off unless threads are recleaned and new compound applied.

b) **G I Pipes**

Threads shall be cut with sharp tools, and before jointing all scales shall be removed from pipes by suitable means. The screw / threads of the pipe shall be cleaned out and the joint made by screwing the fittings after treating the threads with approved pipe jointing compound. Once a joint has been screwed up it shall not be backed off unless threads are recleaned and new compound applied.

c) **Concrete**

Concrete pipes may be socket and spigot ended collar or band jointed. Joints shall be effected by caulking with 1:3 cement sand mortar.

d) **UPVC/**

Manufacturer's instruction shall be followed. For heating approved equipment with adequate control shall be used.

e) **Tyton Joint**

The manufacturer's instruction shall be strictly followed in making such joints. Tyton joints shall be made by push-on type specification stipulated by the pipe manufacturer. The tools specified by the pipe manufacturer shall be used to secure the joint fully.

2.01.07 **Painting**

Where mentioned, underground steel and cast iron pipes shall be given 2 coats of bituminous paint on the outside after laying, when painting is to be done above ground G.I. pipes shall be given a coat of zinc ethyl silicate primer, M.S. pipes shall be given one coat of zinc ethyl silicate primer. Top coats shall be minimum 2 coats of best quality paint as specified.

2.02.00 **Polythene Water Storage Tanks**

Material

Polythene used for manufacture of tanks and manhole lids may be high density (HDPE),) and shall conform to IS 10146. Polyethylene shall be compounded with carbon black so as to make the tank resistant to ultra violet rays from the sun. The percentage of carbon black content in polyethylene shall be 2.5 ± 0.5 percent and it shall be uniformly distributed. The materials used for the manufacture of tank, manhole lid and fittings shall be such that they neither contaminated the water nor impart any test, colour, odour or toxity to water.

Manufacture and Finish

The tanks shall be manufactured by rotational moulding process. Each tank and the manhole lid shall be single piece having arrangement for fixing and locking the manhole lid with the tanks. Excess material at the mould parting line and near the top rim shall be neatly cut and finished. The internal and external surface of the tanks shall be smooth, clean and free from hidden internal defects like air bubbles, pit and metallic or other foreign material inclusion. Capacity of the tank, minimum weight of the empty tank (without manhole lid) and the manufacture brand name shall be embossed on the top surface of the tank near manhole.

Shape, Size and Capacity

The tank shall be cylindrical vertical with closed top having a manhole. Diameter and height of the tank of various capacities shall be as per manufacturer's specifications and a clearance of ± 3 percent shall be permitted on these dimensions. Capacity of the tank or up to the bottom of the inlet location whichever is less. Capacity of the tank shall be specified. Extra capacity if any shall be ignored.

Weight and Wall Thickness

The flat base of the tank shall be fully supported over its whole bottom area on a durable rigid flat and level platform sufficiently strong to stand without deflection the weight of the tank when fully filled with water. Depending upon the capacity and the location tanks may be suitably anchored as per the directions of the Engineer-in-Charge. For inlet, outlet and other connections fully threaded GI, HDPE or PVC connections with hexagonal check nuts and washers on either side of the tank wall shall be provided. Holes for threaded connections shall be drilled and not punched. Pipes entering of leaving the tank shall be provided with unions and suitably supported on a firm base to avoid damage to the tank walls.

Manhole Lid

The lid shall rest evenly and fit over the rim of the manhole so as to prevent the ingress of any foreign matter in to the tank. The lid shall be provided with suitable arrangement for locking it with the tank.

The tank and its components shall conform to the local bye-laws for preventions of mosquito menace.

Sl. No.	Capacity (litres)	Minimum Wall Thickness (mm)	Minimum Weight of Empty Tank (kg)
1	2	3	4
1.	200	4.4	7.8
2.	300	4.4	9.0
3.	400	5.5	15.0
4.	500	6.0	18.0
5.	700	7.0	23.5
6.	1000	6.6	33.0
7.	1250	7.0	40.0
8.	1500	7.0	47.0
9.	1700	7.0	54.0
10.	2000	7.0	64.0
11.	2500	8.2	81.0
12.	3000	8.2	96.0
13.	4000	8.8	138.0
14.	5000	10.4	191.0
15.	6000	10.7	209.0

Sl. No.	Capacity (litres)	Minimum Wall Thickness (mm)	Minimum Weight of Empty Tank (kg)
16.	7500	10.7	250.0
17.	10000	11.5	363.0
18.	15000	11.5	550.0
19.	20000	13.2	814.0

2.03.00 **Valve, Cocks, Taps**

All valves, stop cocks, taps etc. shall conform to relevant Indian Standard Specification and shall be of best quality from approved manufacturers. These shall be suitable for working pressures as specified. Nominal size and material shall be as specified.

2.04.00 **Protection**

Open end of each pipe shall be protected during installation by suitable covers or plugs so that the ends, threads, sockets or spigot are not damaged and no foreign material can find its way into the pipe line.

Fittings and fixtures liable to be misused or stolen during the construction phase shall be fitted only before testing and handing over.

3.00.00 TESTING AND ACCEPTANCE

3.01.00 **Inspection Before Installation**

All pipes, fittings and appliance shall be inspected, before delivery at the site to see whether they conform to accepted standards. The pipes and fittings shall be inspected on site before laying and shall be sounded to disclose cracks. Any defective items shall be clearly marked as rejected and forthwith removed from the site.

3.02.00 **Testing of Mains after laying**

After laying and jointing, the main shall be slowly and carefully charged with water, so that all air is expelled from the main by providing a 25 mm inlet with a stop cock, allowed to stand full of water for a few days if time permits, and then tested under pressure. The test pressure shall be 5 Kg/CM^2 or double the maximum working pressure, whichever is greater. The pressure shall be applied by means of a manually operated test pump, or in the case of long mains or mains of a large diameter, by a power driven test pump, provided that the pump is not left unattached. In either case due precaution shall be taken to ensure that the required test pressure is not exceeded. Pressure gauges shall be accurate and shall preferably have been recalibrated before the test. The pump having been stopped, the test pressure shall maintain itself without measurable less for at least five minutes. The end of the main

shall be closed by fitting a water-tight expanding plug and the plug shall be secured by struts to resist the end thrust of the water pressure in the mains.

3.03.00 **Testing of Service Pipes and Fittings**

The service pipes shall be slowly and carefully charged with water allowing all air to escape avoiding all shock or water hammer. The service pipe shall then be inspected under working conditions of pressure and flow. When all draw-off taps are closed, the service pipes shall be absolutely water-tight. All piping, fittings and appliances shall be checked for satisfactory support and protection from damage, corrosion and frost.

4.00.00 I.S.CODES

Important relevant IS Codes for this Specification are listed below :

Latest editions shall always be consulted.

IS:2065	:	Code for Practice for water supply in buildings
IS:1172	:	Code of basic requirements for water supply, drainage and sanitation
IS:1200	:	Laying of water and sewer lines including (Pt.XVI) appcurtnant items.
IS:1239 (Pt. I & II)	:	Specification for Mild Steel Tubes and Mild Steel Tubulars and other wrought steel pipe fittings (10 mm to 15 mm nominal diameter)
IS:1536	:	Specification for Centrifugally cast (Spun) iron pressure pipes for water gas and sewage
IS:1537	:	Specification for vertically cast iron pressure pipes for water, gas and sewage.
IS:3486	:	Specification for Cast iron spigot and socket drain pipes (80 mm to 250 mm nominal diameter)
IS:3589	:	Specification for Electrically welded steel pipe for water, gas and sewage (200 mm to 2000 mm nominal diameter)
IS:784	:	Pre-stressed concrete pipes
IS:458	:	Concrete pipes (with or without reinforcement)
IS:783	:	Code of Practice for laying of concrete pipes
IS:1592	:	Asbestos cement pressure pipes

IS:1626	:	Asbestos cement pressure pipes, gutters and fittings (Spigot and Socket types)
IS:404	:	Lead pipes
IS:3076	:	Low density polyethylene pipes for potable water supplies
IS:4984	:	High density polythylene pipes for potable water supplies
IS:2501	:	Copper tubes for general engineering purposes
IS:407	:	Brass tubes for general purposes
IS:1230	:	Cast iron rain water pipes and fittings
IS:804	:	Rectangular pressed steel tanks
IS:4736-1986	:	Hot-dip zinc coatings on steel tubes. (Reaffirmed – 2001)
SP 27	:	Handbook of Method of Measurement of Buildings Works

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SECTION-XVIII

GUIDELINE
FOR
DRAINAGE AND SANITATION

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SECTION-XVIII

GUIDELINE
FOR
DRAINAGE AND SANITATION

1.00.00 SCOPE

1.01.00 This section covers the layout and construction of drains for roof water, surface water and sewage together with all fittings and fixtures and inclusive of ancillary works, such as connections, manholes and inspection chambers used within the building and from the building to the connection to a plant sewer or to treatment work.

2.00.00 INSTALLATION

2.00.01 General

All pipe lines, locations of fittings and fixtures, etc. shall be as per drawings or as directed by the Engineer. Correctness of lines, plumb, orientation, symmetry and levels shall be strictly ensured. All items shall be fully secured against movement in any direction and so located as to allow easy maintenance.

All pipe lines, fittings and fixtures shall be installed leak proof. When the works under scope of this specification linked up with works executed by others, the connections shall be such as to prevent any splashing or spilling or emission of foul odourand gases.

2.01.00 Rainwater Down comers & Soil and Drainage Pipes

Rainwater down-comers shall be standard, UPVC Pipes for Non Plant buildings and DI pipes for Plant buildings. .

Rainwater downcomers shall run along and be secured to walls, columns etc. Where desired by the Engineer these may have to be installed in chases cut in the structure.

All pipes shall be well secured and supported by adequately strong brackets. The brackets may be wrought iron clevis type, split ring type or perforated strap iron type as approved by the Engineer. For vertical runs each pipe shall hang freely on its brackets fixed just below the socket. Suitable spacer blocks shall be provided against the vertical surface to which the pipe is fixed.

All bends and junctions shall be supplied with watertight cleanouts.

Roof and floor drains and yard gullies shall be installed, if required, by cutting into the structure and grouted with 1:2:4 cement concrete. All gutters shall be provided with removable gratings.

All horizontal pipes shall have a minimum fall of 1 in 100.

2.01.01 **Unplasticized Polyvinyl Chloride (UPVC) Pipes**

This specification covers requirements for plain and socket end un-plasticised polyvinyl chloride (UPVC) pipes with nominal outside diameters 40 mm to 160 mm for use for soil and waste discharge system inside buildings including ventilating and rain water applications. In this specification nominal outside diameter DN of pipes are 40, 50, 63, 75, 90,110,125,140 and 160 mm. For the rain water pipes 160mm OD shall be used.

Surface colour of the pipes shall be dark shade of grey. For other details and specifications refer code IS: 13592-1992 (amended to 1995)

Above quality of pipes are divided into two types. Type –A (IS 13592) meant for rain water pipes & Type- B meant for soil pipes.

Colour of Pipe

Surface colour of the pipes shall be dark shade of grey or as specified.

Marking

Each pipe shall be clearly and indelibly marked with the following information at intervals not more than 3 meters.

a) Manufacturer's name or trade mark.

b) Nominal outside dia of pipe.

c) Type 'A'

d) Batch number.

Dimensions

Diameter and Wall Thickness: Mean outside diameter, outside diameter at any point and wall thickness for type-A or type-B manufactured plain or with socket shall be as given in Table-1 of IS 13592.

UPVC rain water/ soil pipe shall of the dia, specified in the description of the item and shall be in nominal lengths of 2, 3, 4 or 6 metres either plain or with sliding/grooved socket unless shorter lengths are required at junctions with fittings. Tolerance on specified length shall be + 10mm and – 0 mm.

Fixing and Jointing

Pipes shall be secured to the walls at all joints with PVC Pipes clips by means of 50 x50x50 mm hard wood plugs, screwed with M.S. screws of required length i/e cutting brick work and fixing in cement mortar 1:4 (1 cement : 4 coarse sand). The clips shall be kept about 25 mm clear off finished face of wall, so as to facilitate cleaning of pipes. Pipes shall be fixed perfectly vertical or to the lines as directed. The pipes shall be fitted to fittings with seal ring conforming to IS 5382 allowing 10 mm gap for thermal expansion.

Installation in Wall/ Concrete

The walls/concrete slots shall allow for a stress free installation. Pipes and fittings to be inserted in to the slots without a cement base have to be applied first with a thin coat of PVC solvent cement followed by sprinkling of dry sand (medium size). Allow it to dry. The process gives a sound base for cement fixation.

Fittings

Fittings used shall be of the same make as that of the PVC pipes injection mouldedor fabricated by the manufacturer and shall have a minimum wall thickness of 302 mm. The fittings shall be supplied with grooved socketted ends with square grooves and provided with Rubber Gasket conforming to IS 5382. The plain ends of the fittings shall be chamfered. The fittings shall be joined with the help of Rubber lubricant. The details of fittings refer IS 13592.

2.01.02 **Pipes-Galvanised Iron**

The pipes (tubes) shall be galvanized mild steel hot finished seamless (HFS) or welded (ERW) HIRW or HFW screwed and socketed conforming to the requirements to IS 1239 Part – I for medium grade. They shall be of the diameter (nominal bore) specified in the specification, the sockets shall be designated by the respective nominal bores of the pipes for which they are intended.

Galvanising shall conform to IS 4736: The zinc coating shall be uniform adherent, reasonably smooth and free from such imperfections as flux, ash and dross inclusions, bare batches, black spots, pimples, lumping runs, rust stains, bulky white deposits and blisters. The pipes and sockets shall be clearly finished, well galvanized in and out and free from cracks, surface flaws laminations and other defects. All screw threads shall be cleaned and well cut. The ends shall be cut clearly and square with the axis of the tube.

All screwed tubes and sockets shall have pipe threads conforming to the requirements of IS 554. Screwed tubes shall have taper threads while the sockets shall have parallel threads.

All tubes shall withstand a test pressure of 50 kg/sq.cm without showing defects of any kind.

Fittings: The fittings shall be of mild steel tubular or wrought steel fittings conforming to IS 1239 (Part-2) or as specified. The fittings shall be designated by the respective nominal bores of the pipes for which they are intended.

2.02.00 **Gutters**

The gutters shall be made of G.I. or as specified elsewhere in the contract. All gutters shall be supplied by reputable specialized firms. Each section shall be sufficiently rigid, edges and corners straight and the slopes perfectly uniform. G.I. gutters shall have the edges strengthened by suitable means.

Unless noted otherwise the gutters shall have a minimum fall of 1 in 120. Adequate number of string supports shall be provided so that there is no reflection even when the gutter is full. Each joint must have a support. Unless otherwise specified the supports shall be fabricated M.S. brackets. All junctions shall be thoroughly watertight. The joints may be made by riveting, bolting or soldering. All joints between successive lengths of gutters shall have on overlap of at least 5 cm. The drop in the overlap shall always be in the direction of the fall of the gutter. Ends of gutters shall be closed watertight. Junction with rainwater down comers shall be made fully watertight and secured.

2.03.01 **Gradients**

If not specified the minimum gradients of soil and drainage pipe line shall be as follows:

100 mm nominal dia	:	1 in 57
150 mm nominal dia	:	1 in 100
200 mm nominal dia	:	1 in 145
230 mm nominal dia	:	1 in 175
250 mm nominal dia	:	1 in 195
300 mm nominal dia	:	1 in 200

2.03.02 **Relation with water supply pipe lines**

Unless specifically cleared by the Engineer, under no circumstances shall special drainage and soil pipes be allowed to come close to water supply pipelines.

2.03.03 **Laying**

Each separate pipe shall be individually set for line and for level. Where lengths of sewer or drain pipes are laid in trench, properly painted sight rails shall be fixed across the trench at a height, equal to length of the boning rod

to be used, above the required invert level of the drain or sewer at the point where the sight is fixed. More sight rails shall be required at manholes, change of gradient and intermediate positions if the distance for sighting is more than 50 ft. apart. The excavation shall be boned in at least once in every 6 ft. The foot of the boning rod shall be set on a block of wood of the exact, thickness of the wall of the pipe. Each pipe shall be separately and accurately boned between sight rails.

2.03.04 **Support and Protection on Pipelines**

All pipes shall be laid with sockets leading uphill. For on/above ground level, Preferably the pipe shall rest on solid and even foundations for the full length of the barrel. However, the pipe manufacturer's instruction as approved by the Engineer shall be followed in the matter of support and jointing.

To achieve full and continuous support, concrete for bedding and packing is the best. Where pipes are not bedded on concrete, the floor shall be left slightly high and carefully placed so that the pipe barrels rest on undisturbed ground. If anywhere the excavation has been carried too low packing shall be done in concrete. Where laid on rock or very hard ground which cannot be easily excavated to a smooth surface, the pipes shall be laid on a cradle of fine concrete floor of gravel and crushed stone over laid with concrete or on a well consolidated gravel and crushed stone bed as desired by the Engineer. For underground, PVC or similar pipes shall be laid directly on stable soil and packed with selected soil.

For above ground level the pipes may be supported on suitable concrete support, where specified. The supports shall be unyielding and strong enough. At least one support shall be located close to ends. Spacing of intermediate supports shall be as decided by the Engineer. Pipes shall be secured to the supports by approved means.

Anchoring of pipes where necessary shall be achieved by suitable concrete encasing designed for the expected thrust at the bends/turnings.

2.03.05 **Entry into structures**

For entry of the pipe lines into any building of structure suitable conduits under the structure or sleeves shall be used. The conduits and sleeves shall be such as to allow easy repairs and replacement of the pipes. When openings or chases are required to be made in the structure for entry of pipe lines, locations and sizes shall be marked and checked by the Engineer. After laying of the pipeline the openings and chases shall be mended.

2.03.06 **Ducts**

Where solid, waste and ventilating pipes are accommodated in ducts, access to cleaning areas shall be provided. Connection to drain shall be through a gully with sealed cover to guard against ingress of sewer gas, vermin or backflow.

2.03.07 **Traps and Ventilating Pipes**

Pipes are carrying off the waste from water closets and waste water and overflow water from baths, wash basins, sinks to drains shall be trapped immediately beneath such fixtures. Traps shall have minimum water seal of 50 mm and shall be ventilated whenever such ventilation is necessary to maintain water seal of the trap.

Ventilating pipes shall be carried up vertically from the drain to a height of at least 600 mm above the outer covering of the roof of the building or as shown on drawings. All vertical ventilating, anti-siphonage and similar pipe shall be covered on top with a cowl. The cowl shall be made of C.I. unless desired otherwise by the Engineer.

2.03.08 **Manhole and Inspection Chambers**

All manholes and inspection chambers shall be of RCC of Grade M30. The maximum distance between manholes shall be 30 meter unless specially permitted otherwise. In addition, at every change of alignment gradient or diameter there shall be a manhole or inspection chamber. The distance between manhole or inspection chamber and gully chamber shall not exceed 6 metres unless desired otherwise.

Manhole shall be constructed so as to be watertight under test. The bending at the sides shall be carried out in such a manner as to provide no lodgment for any splashing in case of accidental flashing of the chamber. The channel or drain at the bottom of chamber shall be plasteredwith1:2 cement, sand mortar and finished smooth to the grade. The channels and drains shall be shaped and laid to provide smooth flow connecting to existing sewer lines shall be through a manhole.

Manholes shall be provided with standard C.I. covers. The covers shall be close fittings so as to prevent gases from coming out. Suitable heavy duty covers shall be used where necessary as decided by the Engineer.

2.03.09 **Cutting of Pipes**

Manufacturer's instructions shall be followed for cutting of pipes where necessary. Suitable and approved tools shall be used for the cutting so as to leave surface clean and square to the axis of the pipe.

2.03.10 **Jointing**

Jointing of laid pipes shall be so planned as to avoid completely any movement or strain to the joints already made. If any joint is suspected to be damaged it shall be opened out and redone.

All joints between pipes, pipes and fittings and manholes shall be gas-tight when above ground and water-tight when underground. Method of jointing shall be asper instructions of the pipe and fittings manufacturer and as approved by the Engineer. However, in the absence of any instruction

available from the manufacturer the methods as detailed hereunder shall be used.

a) **Concrete Pipes**

RCC NP3 pipes shall be used for underground sewer system. Minimum diameter of pipe shall be 200mm. The concrete pipes shall be of socket / spigot ends. Jointing of pipes shall be as per IS 783 – 1985. Care shall be taken at the time of jointing of pipe that cement mortar shall be smooth without any undulations / projections inside the pipes..

b) **Polyethylene Pipes**

The joints shall be thermo-welded or bolted as per manufacturer's instructions.

2.04.00 **Trenches and other excavations**

Width of the trench at the bottom shall be such as to provide 300mm clearance on either side of the pipe for facility of laying and jointing. IS code for excavation shall be followed.

Excavated material shall be stacked sufficiently away from the edge of the trench and the side of the spoil bank shall not be allowed to endanger the stability of the excavation. Spoil may be carted away and used for filling the trench behind the work.

Turf, top soil or other surface material shall be set aside, turf being carefully rolled and stacked for use in reinstatement.

All excavation shall be properly timbered, where necessary.

Efficient arrangements for dewatering during excavation and keeping it dry till backfilling shall be made to the satisfaction of the Engineer. Sumps for dewatering shall be located away from the pipe layout.

Where the excavation proceeds through roads, necessary permissions shall be secured by the Bidders from the appropriate authorities.

Special care shall be taken not to damage underground services, cables etc. These when exposed shall be kept adequately supported till the trench is backfilled.

The backfilling shall be done only after the pipeline has been tested and approved by the Engineer. Special care shall be taken under and sides of the pipe during hand packing with selected material. At least 300 mm over the pipe shall also be filled with soft earth or sand. Consolidation shall be done in 150 mm layers. The surface water shall be prevented from getting into the filled up trench. Traffic shall not be inconvenienced by heaping up unduly

the backfilling material to compensate future settlement. All future settlements shall be made good regularly to minimise inconvenience of traffic where applicable.

2.05.00 **Fixtures**

The successful bidder shall furnish the type and make of the fixtures he intends to use enclosing manufacturer's current catalogues. In the absence of any such agreement, the Engineer shall be at liberty to choose any type and make.

All fixtures and fittings shall be of approved quality and type manufactured by well known manufacturers. All items brought to the site must bear identification marks of the type of the manufacturer. Procurements shall be made well in advance and inspected and approved immediately by the Engineer. All fixtures shall be adequately protected, covered and plugged till handed over.

All fittings, gratings, fasteners, unless specified otherwise, shall be chromium plated. Where PVC or similar pipes are allowed the Bidder shall produce the test reports and convince the Engineer about their durability.

Unless specified in the contract the fixtures shall be as specified hereinafter.

2.05.01 **Water closet**

a) **Raised type**

It shall include glazed vitreous china basin with siphon, open front solid plastic seat and plastic cover, low level PVC flushing cistern with valve less fittings, supply connections and necessary fittings. All fittings shall be chromium plated. Colour of basin, cistern, seat and cover shall be as desired by the Engineer.

b) **Squatting type**

It shall include glazed vitreous china pan with attached foot rests (Odisha Pan)and high level PVC flushing cistern with valve less fittings, supply connections and necessary fittings. All fittings shall be chromium plated. .

2.05.02 **Urinals**

It shall consist of wall type glazed vitreous china urinals , PVC/ Porcelain automatic flushing cistern complete with supply connections, flush pipe, lead pipes, gratings, traps and all other necessary fittings. Automatic flushing shall be approximately once in every five minutes. For a number of urinals located together may be served by one cistern of adequate capacity. All fittings shall be chrome plated. Sensor based urinals shall be provided at all important areas as decided by the engineer in charge.

2.05.03 **Wash basin**

It shall be made of glazed vitreous china. The basin shall be flat back, wall hung by painted cast iron brackets and complete with pattern with hot and cold brass faucets with nylon washers, waste chain, waste washers, lead waste pipes with traps, perforated waste complete with necessary fittings. All fittings including faucets shall be chromium plated. The washbasins shall preferably be of oval shaped fitted on Granite Top.

2.05.04 **Sink**

It shall be made of stainless steel. It shall be wall hung by painted cast iron brackets and complete with one brass faucet with nylon washers, waste chain, waste washers, PVC waste pipes with traps, perforated waste with necessary fittings. All fittings including faucets shall be chromium plated.

2.05.05 **Bathroom mirror**

It shall be made of the best quality 6 mm thick glass and produced by a reputed mirror manufacturer of minimum size 60cmx45cm. It shall be wall mounted with adjustable revolving brackets. The brackets, screws and other fittings shall be chromium plated.

2.05.06 **Glass shelves**

Glass shelves shall consist of 6 mm thick clear glass with guard rails and shall be wall mounted with brackets. All brackets, guard rails and screws shall be chromium plated.

2.05.07 **Towel rail**

Towel rails shall be 20 mm dia. and 600mm length minimum, chromium plated MS pipes wall mounted with steel brackets. The brackets, screws etc. shall also be chromium plated.

2.05.08 **Soap holder**

It shall be made of chromium plated strong members. The holders shall be wall mounted with chromium plated screws.

2.05.09 **Liquid soap dispenser**

It shall be round and easily revolving with removable threaded nozzle. The body, bracket for wall mounting and screws shall be chromium plated.

2.05.10 **Toilet roll holder**

It shall be made of chromium plated hooks with suitable cover cum cutter. Wall mounting screws shall be chromium plated.

2.05.11 **Installation**

All plumbing fittings and fixtures shall be installed in most workmanlike manner by skilled workers. These shall be perfect in level, plumb, plane, location and symmetry. All items shall be securely anchored to walls and floors. All cuttings in walls and floors shall be made good by the Bidder.

3.00.00 TESTING AND ACCEPTANCE

3.01.00 **Inspection before installation**

All pipes, fittings and fixtures shall be inspected, before delivery at the site to see whether they conform to accepted standards. The pipes shall again be inspected on site before laying by sounding to disclose cracks. All defective items shall be clearly marked and forthwith removed from the site.

3.02.00 **Testing of Pipelines**

Comprehensive tests of all pipe lines shall be made by simulating conditions of use. The method of actual tests shall be decided by the Engineer. All test data shall be recorded and submitted to the Engineer for review and instruction. The Engineer's discretion regarding tolerance shall be final.

General guidance for the tests are given below:

a) **Smoke test**

All soil pipes, waste pipes and vent pipes and all other pipes when above ground shall be approved gastight by a smoke test conducted under a pressure of 25 mm of water and maintained for 15 minutes after all trap seals have been filled with water. The smoke is produced by burning oily waste or tar paper or similar material in the combustion chamber of a smoke machine. Chemical smokes are not satisfactory.

b) **Water test**

For pipes other than Cast Iron

Glazed ware and concrete pipes shall be subjected to a test pressure of at least 1.5 m head of water at the highest point of the section under tests. The tolerance figure of two liters per centimeter of diameter per kilometer may be allowed during a period of 10 (ten) minutes. The test shall be carried out by suitably plugging the low end of the drain and the ends of connections, if any, and filling the system with water. A knuckle bend shall be temporarily jointed in at the top end and a sufficient length of the vertical pipe jointed to it so as to provide the required test head or the top end may be plugged with a connection to a hose ending in a funnel which could be raised or lowered till the required head is obtained and fixed suitably for observation.

Subsidence of test water may due to one or more of the following cases:

a) Absorption by pipes and joints

b) Sweating of pipes or joints
c) Leakage at joints or from defective pipes

d) Trapped air.

Allowance shall be made for (a) by adding water until absorption has ceased and after which the test proper shall commence. Any leakage and the defective part of the work shall be cut out and made good.

c) **For straightness**

i) By inserting at the high end of the sewer ordra in a smooth ball of a diameter 13 mm less than the pipe bore. In the absence of obstruction, such as yarn or mortar projecting through the joints, the ball with roll down the invert of the pipe end emerge at the lower end; and

ii) By means of a mirror at one end of the line and lamp at the other. If the pipe line is straight, the full circle of light may be observed. The mirror will also indicate obstruction in the barrel if the pipe line is not straight.

3.04.00 **Fixtures etc.**

All fixtures and fittings shall be connected by watertight joints. No dripping shall be accepted.

4.00.00 CODES AND STANDARDS

Some of the important Codes and Standards relevant to this specification shall be followed: Latest editions shall always be consulted.

IS: 1172 - Code of basic requirements for water supply drainage and sanitation.

IS: 1200 - Laying of water and sewer lines including appurtenant (Pt. XVI) items.

IS: 1239 - Mild Steel Tubes and Mild Steel Tubular and other (Pt. I& II) wrought steel pipe fittings.

IS: 1536 - Centrifugally cast (Spun) iron pressure pipes for water gas and sewage.

IS: 1537 - Vertically cast iron pressure pipe for water, gas & sewage.

IS: 3486 - Cast Iron spigot & socket drain pipes.

IS: 1742 - Code of Practice for building drainage.

IS: 5329 - Code of Practice for sanitary pipe work above ground for buildings.

IS: 2470 - Code of Practice for designs and construction of septic tank for small and large installations.

IS: 3076 - Low density polythelene pipes for potable water supplies.

IS: 4984 - High density polythelene pipes for potable water supplies.

IS: 1537 - Vertically cast iron pressure pipes for water, gas and sewage.

IS: 1538 - Cast Iron fittings for pressure pipes for water, gas & sewage.

IS: 1230 - Cast Iron rain water pipes and fittings.

IS: 3889 - Centrifugally cast (spun) iron spigot & socket soil waste and ventilating pipes, fittings and accessories.

IS: 1729 - Sand cast iron spigot& socket soil, waste and ventilating pipes and accessories.

IS: 1626 - Asbestos cement building pipes, gutters and fittings (spigot & socket types).

IS: 458 - Concrete pipes (with and without reinforcement)

IS: 783 - Code of Practice for laying of concrete pipes.

IS: 784 - Pre-stressed concrete pipes.

IS: 651 - Salt glazed stoneware pipes & fittings.

IS: 4127 - Code of practice for laying of glazed stoneware pipes.

IS: 1726 - Cast Iron manhole covers and frames intended for use in drainage works.

IS: 5961 - Cast Iron gratings for drainage purposes.

IS: 5219 (Part 1) - 'P' & 'S' traps.

IS: 771 - Glazed earthen-ware sanitary appliance.

IS: 772 - General requirements of enamelled cast iron sanitary appliances.

IS: 774 - Flushing cistern for water closets & urinals (valve less siphonic type).

IS: 775 - Cast Iron brackets &supports for wash basins and sinks.
IS: 2548 - Plastic water closet seats & covers.

IS: 2527 - Code of Practice for fixing rain water gutters and down-pipes for roof drainage.

IS: 1703 - Water fittings- copper alloy float valves (horizontal plunger type)Specification.

IS: 1795 - Specification for pillar taps for water supply purpose.

IS: 2556 (Part-1, Part-2, Part-3, Part-4, Part-5, Part-6, Part-7, Part-14, and Part-15)

- Part-1: General requirements
- Part-2: Specific requirements of wash-down water closets.
- Part-3: Specific squatting pans.
- Part-4: Specific requirements of wash basins.
- Part-5: Specific requirements of laboratory sinks.
- Part-6: Specific requirements of Urinal & Partition plates.
- Part-7: Specific requirements of accessories for sanitary
- Part-14: Specific requirements of integrated squatting pans.
- Part-15: Specific requirements of universal water closets.

IS: 3989 - Specification for centrifugally cast 9spun) iron spigot and Socket soil, waste and ventilating pipes fittings and accessories.

IS: 4827 - Specification for electroplated coating of nickel and chromium on copper and copper alloys.

IS: 4985 - Unplasticised P.V.C pipes for potable water supply-Specifications.

IS: 4127 - Code of Practice for Laying of Glazed Stone Ware Pipes.

IS: 4885 - Specifications for Sewer Bricks.

IS: 12592 - Pre-cast Concrete Manhole Covers and Frames – Specifications.

SP 27: 1987 - Handbook of Method of Measurement of Buildings Works

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SECTION-XIX

GUIDELINE
FOR
SAFETY REQUIREMENTS FOR CONSTRUCTION WORKS

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SECTION-XIX

GUIDELINE
FOR
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1.00.00 GENERAL

This specification deals with the subject matter of safety and protection to be observed in the Civil Construction. This shall be followed along with all related statutory requirements/obligation including Governmental byelaws, codes, ordinance of local or central authorities related to the construction work.

In case of complicated work like deep excavation, intricate shuttering and formwork, excavation in loose soil and below water table, stacking of excavated earth etc., work plan with necessary drawings and documents have to be prepared by the Bidder and got approved by the Engineer.

Necessary reference shall be made to the following Indian Standard Codes on safety requirements for various type of work :

Indian Standard

5916	Construction with Hot Bituminous Materials.
4130	Demolition of Buildings.
3764	Excavation Work
5121	Piling & Other Deep Foundations.
4014 - (P-II)	Scaffolding, Steel Tubular.
3696 – (P-I & P-II)	Scaffolds and Ladders.
6922	Structures Subject to Underground Blasts.
4756	Tunneling Work.
5499	Underground Air-raid Shelters in Natural Soil.
4138	Working in Compressed Air.
7293	Working with Construction Machinery
8989	Erection of Concrete Framed Structures.

2.00.00 EXCAVATIONS

2.01.00 Sides of all excavations must be sloped to a safe angle, not steeper than the angle of repose of the particular soil. If it is not possible to give a proper slope, the sides of the excavation where there is a danger of fall or dislodgement of earth or any material, shall be securely supported by timber or other type of shoring.

2.02.00 No excavation or earth work below the foundation level of an adjoining building shall be taken up unless adequate steps are taken to prevent damage to the existing structure or fall of any part.

2.03.00 Every accessible part of an excavation, pit or opening in the ground into which there is a danger of persons falling shall be suitably fenced with a barrier upto a height of one metre suitably placed from the edge of the excavation as far as practicable.

2.04.00 No material or load shall be placed or stacked near the edge of the excavation or opening in the ground. The excavated material shall not be placed within 1.5 m of the trench or half of the depth of the trench whichever is more.

2.05.00 Cutting shall be done from top to bottom. No undercutting of sides of excavation shall be allowed.

2.06.00 All narrow trenches 1.2 m or more depth, shall at all times be supplied with atleast one ladder for each 30m in length or fraction thereof. Ladder shall be extended from bottom of the trench to atleast one metre above the surface of the ground. The side of the trenches which are 1.5 m or more in depth shall be stepped back to give suitable slope, or securely held by planking, strutting and bracing so as to avoid the danger of side collapse.

2.07.00 Materials shall not be dumped against existing walls or partition to a height that may endanger the stability of the walls.

2.08.00 While withdrawing piled materials like loose earth, crushed stone, sand, etc., from the stock piles, no over hanging shall be allowed to be formed in the existing dump.

2.09.00 No material on any of the sites of work shall be so stacked or placed as to cause danger or inconvenience to any person or public or any other agency at work.

3.00.00 DEMOLITION

3.01.00 On every demolition job, danger signs shall be conspicuously posted all round the structure and all doors, openings giving access to the structure shall be kept barricaded or marked except during the actual passage of workmen or equipment. However, provision shall be made for at least two independent exits for escape of workmen during any emergency.

3.02.00 During night, red lights shall be placed on or about all the barricades.

3.03.00 Where in any work of demolition it is imperative, because of danger existing to ensure that no unauthorised person shall enter the site of demolition out-side working hours, a watchman shall be employed. In addition to watching

the site he shall also be responsible for maintaining all notices, lights and barricades.

3.04.00 All the necessary safety appliances as per IS ;4130 shall be issued to the workers and their use explained. It shall be ensured that the workers are using all the safety appliances while at work.

3.05.00 The removal of a member may weaken the side wall of an adjoining structure and to prevent possible damage, these walls shall be supported until such time as permanent protection is provided. In case any danger is anticipated to the adjoining structure the same shall be got vacated to avoid any danger to human life.

3.06.00 The power on all electrical service lines shall be shut off and all such lines cut or disconnected at or outside the property line, before the demolition work is started. Prior to cutting of such lines the necessary approval shall be obtained from the electrical authorities concerned. The only exception shall be any power line required for demolition work itself.

3.07.00 All gas, water, steam and other service lines shall be shut off and capped or otherwise controlled at or outside the building line, before demolition work is started.

3.08.00 All the mains and meters of the building shall be removed or protected from damage.

3.09.00 If a structure to be demolished has been partially wrecked by fire, explosion or other catastrophe, the walls and damaged roofs shall be shored or braced suitably.

3.10.00 Walkways and passage ways shall be provided for the use of the workman who shall be instructed to use them and all such walkways and passageways shall be kept adequately lighted, free from debris and other materials.

3.11.00 All nails in any kind of lumber shall be withdrawn, hammered or bent over as soon as such lumber is removed from the structure being demolished, and placed in piles for future cleaning or burning.

3.12.00 All the roads and open area adjacent to the work site shall either be closed or suitably protected.

3.13.00 No electric cable or apparatus which is liable to be a source of danger or a cable or apparatus used by the operator shall remain electricity charged.

3.14.00 All practical steps shall be taken to prevent danger to persons employed from risk of fire or explosion or flooding. No floor, roof or other part of the building shall be so overloaded with debris or materials as to render it unsafe.

4.00.00 VEHICLE

4.01.00 No person shall board any vehicle or equipment when it is in motion.

4.02.00 Suitable blocks shall be placed against the wheels of a vehicle when it is used for tipping materials into excavation or a pit or over the edge of any embankment or earthwork to avoid the danger of its running over the edge.

4.03.00 All workers shall stand clear of the vehicle while it is dumping. If the material being dumped is very heavy or sticky, dump hooks shall be used or dumper shall be clamped to prevent any danger of its tripping.

4.04.00 Materials shall not be allowed to be loaded in a vehicle so as to project horizontally beyond the sides of the body of the vehicle. All materials projecting beyond the front or rear shall be indicated by a red flag in the day and with red light in the night.

4.05.00 Driver of the truck or any heavy vehicle shall not reverse it unless assisted by a signal man who shall have a clear view of the driver and the area beyond the truck during reversing operation.

4.06.00 Maximum speed of a heavy vehicle must not exceed 15 km. per hour.

5.00.00 SCAFFOLDING, GANGWAYS, LADDERS & SHUTTERING

5.01.00 For all work that cannot be done from the ground level or from part of any permanent structure or from other available means of support, soundly constructed scaffoldings of adequate strength shall be used as a safe means of access to places of work.

5.02.00 All scaffolding shall be securely supported or suspended and wherever necessary be properly braced to ensure stability.

5.03.00 Chains, ropes or other lifting materials used for the suspension of scaffoldings must be of adequate strength and shall be of tested quality.

5.04.00 All such chains and ropes used for the suspension of scaffoldings shall be properly fastened to safe anchorage points.

5.05.00 The platform of a suspended scaffolding shall be sufficiently wide. Suspended scaffolding shall have hand rail on 3 sides of about 1.0 m height.

5.06.00 All working platform and stages from which workers are liable to fall shall be of adequate width depending on the type of work done and closely boarded and planked.

5.07.00 Scaffolding or staging more than 3.5 m above the ground or floor, suspended from an overhead support or erected with stationary support shall have a guard rail properly attached, bolted, braced and otherwise secured atleast 1

m high above the floor or platform of such scaffolding or staging and extending along the entire length of the outside ends thereof with only such opening as may be necessary for the delivery of materials. Such scaffolding or staging shall be so fastened as to prevent it from swaying from the building or structure. The platform shall also be provided with toe boards of atleast 150 mm high so placed as to prevent the fall of materials and tools from there.

5.08.00 All platforms or gangways, runways and the stairs shall be kept free from unnecessary obstructions, materials or junk.

5.09.00 Working platforms, gangways & stairways shall be so constructed that they shall not sag unduly or unequally, and if the height of the platform or the gangway or the stairway is more than 3.5 m above ground level or floor level they shall be closely boarded, shall be of adequate width and shall be suitably fenced.

5.10.00 Every opening in the floor of a building or in a working platform shall be provided with suitable fencing or railing whose minimum height shall be 1 m to prevent the fall of persons or materials.

5.11.00 Every ladder shall be securely fixed at top and bottom. A ladder more than 5 m long shall have a prop.

5.12.00 All ladders used shall be of good construction, sound materials and adequate strength. Ladders with defective or missing rungs shall not be brought into use. The spacing of rungs shall not exceed 30 cm and these shall be recessed atleast 12 mm into rails.

5.13.00 All ladders or rungs used for vertical height of more than 10 m shall have an intermediate landing. All such intermediate landings shall be provided with guard rails to a height of atleast 1 m.

5.14.00 Every ladder shall be securely placed so that it cannot move either at the top or at the bottom and it shall rise to a height of atleast 1.2 m above the place of landing.

5.15.00 No portable single ladder shall be over 8 m in length.

5.16.00 Spacing between the side rails of the ladder shall not be less than 300 mm for ladders upto 3 m in length. For longer lengths, this shall be increased at 6 mm for each additional 0.3 m of length.

5.17.00 Metal ladders must not be used for electrical work or near electric circuit of equipment.

5.18.00 All scaffolds, ladders and other safety devices mentioned or described herein shall be maintained in safe condition and no scaffold, ladder or equipment shall be altered or removed while it is in use.

5.19.00 Unfinished scaffolding which is under construction shall be prominently marked as unsafe and any access points shall be closed.

5.20.00 All Planking and Decking on walkways and scaffolds shall be adequately supported at each end of the plank and intermediately if necessary. Planks shall not be allowed to cantilever beyond the last support but shall be overlapped if necessary on to the next plant.

5.21.00 Shuttering

The above remarks shall be applicable for this also. Shuttering, particularly for slabs, shall be treated as a scaffold. Unfinished shuttering shall be marked as dangerous similarly the finished formwork shall be adequately supported, care being taken to avoid trap door effects.

6.00.00 MOBILE LIFTING APPLIANCES

6.01.00 No mobile lifting appliances shall used on a sloping surface unless adequate precautions are taken to ensure stability.

6.02.00 Adequate precautions shall be taken to see that jib of the mobile crane does not come in contact with overhead electric transmission line.

6.03.00 Only one person shall give signals to the operator of mobile lifting appliances.

6.04.00 Maximum load to be lifted by lifting appliances shall be marked in a position where it can be clearly seen by the crane driver and the operator.

6.05.00 No load shall be raised, lowered or suspended from a chain or rope having a knot in any of the part.

6.06.00 No chain which is joined to another chain by means of bolt and nut shall be used for raising, lowering or suspending any load.

6.07.00 All chains, ropes and lifting gears shall be carefully examined and tested by a competent Maintenance Engineer at least once in every quarter.

6.08.00 When the work is stopped or when the mobile lifting equipment is not in operation, the boom must be lowered to the horizontal position and tied securely in place to prevent accidental drop.

6.09.00 No person shall walk under a load which is swinging by a lifting equipment.

Guide rope must be attached to the load to prevent its swinging.

6.10.00 The foot blocks of the crane before starting work shall be securely supported and firmly anchored to prevent its movement in any direction.

6.11.00 Use of Hoisting machines and tackle including their attachments, anchorage and supports shall conform to the following standards of condition.

6.11.01 These shall be of good mechanical construction, sound material and adequate strength and free from defect and shall be kept in good working order.

6.11.02 Every rope used in hoisting or lowering materials or as a means of suspension shall be of durable quality and adequate strength and free from patent defects.

6.11.03 Every crane driver or hoisting appliance operator shall be properly qualified and no person under the age of 21 years shall be in charge of any hoisting machine or give signals to the operator.

6.11.04 In case of every hoisting machine and every chain ring hook shackle swivel and pulley block used in hoisting or lowering or as means of suspension the safe working load shall be ascertained by adequate means, every hoisting machine and all gears referred to above shall be plainly marked with the safe working load. In case of hoisting machine having a variable safe working loading, each safe working load of the conditions under which it is applicable shall be clearly indicated. No part of any machine or of any gear referred to above in this paragraph shall be loaded beyond the safe working load except for the purpose of testing. Mobile cranes shall have the working load and the radius of jib for the load marked on it.

6.11.05 The top pulley for hoisting a load shall be opened monthly and the spindle inspected to see if any undue wear has taken place and for greasing.

6.11.06 In case of departmental machine, the safe working load shall be notified by the Engineer concerned. As regards bidder's machines the Bidder shall notify the safe working load of the machine to the Engineer whenever he brings any machinery to site of work and get it verified by the Engineer concerned.

6.12.00 Motors, gearing, transmission, electric wiring and other dangerous part of hoisting appliances shall be provided with efficient safeguards. Hoisting appliances shall be provided with such means as shall reduce to the minimum, the risk of accidental descent of the load. Adequate precautions shall be taken to reduce to the minimum, risk of any part of a suspended load becoming accidentally displaced.

7.00.00 RIVETTING, WELDING & GAS CUTTING & STEEL ERECTION

7.01.00 Rivetting

7.01.01 Bolts covered with wet or slippery compounds shall not be used in fabricating structural work.

7.01.02 The rivet heater must keep the rivet heating equipment as near as possible to the place of work.

7.01.03 A pail of water shall always be kept ready for quenching fire when stopping rivetting work.

7.01.04 Hot rivet shall not be thrown across aisles and shaftways.

7.01.05 Metal buckets for catching hot rivets must have false wooden bottoms to prevent rivets from rebounding.

7.01.06 All rivets, bolts, nuts, and other tools must be kept in boxes and not let loose, (For any further safety measures relevant Indian Standards and safety specifications of structural section shall be referred to).

7.02.00 Welding & Gas Cutting

7.02.01 All cylinders must be used and stored in upright position only.

7.02.02 Cylinders must be stored away from open flames and other source of heat.

7.02.03 Oxygen cylinders must not be stored near other cylinders containing gas or oil, grease or other combustible materials.

7.02.04 While the cylinder is in use, the cylinder valve key or wrench must be placed on the valve spindle.

7.02.05 Before a cylinder is moved, the cylinder valve must be closed.

7.02.06 Gas cutting torches must be lighted by means of friction flames or similar other methods and not with matches.

7.02.07 When torches are being changed or welding stopped for some time valves for all cylinders must be closed.

7.02.08 Thecoloured lenses used for welding or gas cutting must be of proper shade for the work being done.

7.02.09 Suitable eye protection equipment such as goggles, hand shields etc., must be used by persons engaged in welding or gas cutting operations.

7.02.10 Before any heavy structural member is gas cut, make sure that it is cleared and supported by ropes, cables, chains or any other means to prevent its dropping or swinging.

7.02.11 Cylinder valves and connections are not to be lubricated. All oily or greasy substances must be kept away from cylinders.

7.02.12 Substantial and incombustible screen must be used below or near the welding operations, if there is a possibility of a spark falling on other workmen engaged in work closely.

7.02.13 All air pipe lines and air hoses must be frequently inspected. Air hoses shall not be used for dusting or for cooling purposes.

7.03.00 Steel Erection

7.03.01 All persons shall stand clear when a crane is sorting or shifting steel girders or other structural materials.

7.03.02 No person shall stand, walk or work beneath any suspended load.

7.03.03 Guide rope must be used for guiding lifting loads.

7.03.04 When guiding a beam or fabricated structure or erection it shall be so held that the employees hands do not get jammed against other objects.

7.03.05 Safety belts equipped with suitable life lines must be used by persons working at heights and standing on structural members. Life line must be tied to an independent support. For any further safety measures, for Structural Steel Works, IS : 7205 shall be referred to.

8.00.00 SAFETY APPLIANCES

8.01.00 Workers employed on mixing asphaltic materials, cement and lime mortars, shall be provided with protective footwear and protective goggles.

8.02.00 Those engaged in white washing and mixing or stacking of cement bags or any materials which is injurious to the eyes, shall be provided with protective goggles.

8.03.00 Those engaged in welding works shall be provided with welder's protective eye-shields.

8.04.00 Stone breakers shall be provided with protective goggles and protective clothing and seated at sufficiently safe intervals.

8.05.00 When workers are employed in sewers and manholes which are in use, the Bidder shall ensure that the manhole covers are opened and chambers are ventilated atleast for an hour before the workers are allowed to get into the manholes, and the manholes so opened shall be cordoned off with suitable railing and provided with warning signals or boards to prevent accident to the public.

8.06.00 The Bidder shall not employ men below the age of 18 and women on the work of painting with products containing lead in any form. Whenever men above the age of 18 are employed on the work of lead painting the following precautions shall be taken :

8.06.01 No paint containing lead or lead products shall be used except in the form of paste or ready made paint.

8.06.02 Suitable face mask shall be supplied for use by them when paint is applied in the form of spray on a surface having lead paint dry rubbed and scraped.

8.06.03 Overalls shall be supplied by the Bidders to the workmen and adequate facilities shall be provided to enable the working painters to wash during the cessation of work.

8.07.00 The workers going into inspection chamber shall have gas masks, gum boots and rubber gloves while working inside. After coming out they shall have some disinfectant from the first aid box for proper washing

8.08.00 All necessary personnel safety equipment such as safety helmets, safety boots, safety belts, leather gloves for welders, clear glass safety goggles etc., as considered adequate by the engineer have to be kept available for the use of persons employed at the site of work and maintained in condition suitable for immediate use and Bidder shall take steps to ensure proper use of equipment by the workers.

8.09.00 All the persons entering the tunnel shall be provided with protective wear, such as helmets, steel toe safety shoe, gum boots or other suitable type of protective foot wear. In the case of steeply inclined tunnels and inshafts, safety belts shall also be provided.

8.10.00 Sign boards 1 x 1.5 m in size with the following wording shall be erected at the access to these areas. "CONSTRUCTION AREA, HELMET REQUIRED BEYOND THIS POINT"

8.11.00 No loose garments or ragged clothing shall be worn by the personnel engaged in tunneling operation.

8.12.00 A telephone system shall provided to ensure a positive and quick method of communication between all control location inside tunnel and portal of the tunnels when longer than 500 m and for shafts when longer than 50 m

8.13.00 Irrespective of length and bends in the tunnel, arrangements shall be made for transmitting of warning signals by any one of the following means.

8.13.01 By electrically operated bells, operated by battery/dry cells with the bell placed outside the tunnel and the position of the switch shifting with the progress of the tunneling work. The position of the operating switch although temporary shall be so chosen as to ensure proper accessibility and easy identification.

8.13.02 By the use of two field (magnet type) telephone.

8.13.03 Any other suitable arrangement like walkie-talkie.

8.14.00 Arrangement for rendering prompt and adequate first aid to the injured persons shall be maintained at every work site under the guidance of a medical officer-in-charge of the project. Depending upon the magnitude of the work the availability of an ambulance at a very short notice (at telephone call) shall be ensured.

8.15.00 First-aid arrangements commensurate with the degree of hazard and with the number of workers employed shall be maintained in a readily accessible place throughout the working hours. At least one experienced first-aid attendant with his distinguishing badge shall be available on each shift to take care of injured persons. Arrangements shall be made for calling the medical officer, when such a need may arise. It is recommended that foreman/assistant foreman/supervisor/ permanent workmen who are normally present at each working phase in each shift are given adequate training on first-aid methods to avoid employment of a separate attendant.

8.16.00 Stretchers and other equipment necessary to remove injured persons shall be provided at every shift.

8.17.00 Where there are more than 50 persons working in a shift, effective artificial respiration arrangements shall be provided, with trained men capable of providing artificial respiration.

9.00.00 ELECTRICAL

9.01.00 Onlyauthorised persons shall handle or otherwise interfere with electrical equipment. Any person detecting electrical apparatus being handled by an unauthorised person or equipment in unsafe condition must report the matter to the Engineer concerned.

9.02.00 No person shall work on any live electric conductor or apparatus and no person shall assist such person on such work, unless he is authorised in that behalf.

9.03.01 After isolating the equipment from the source of supply before the work begins, a sign 'DONT'T SWITCH ON' must be hung on or near the switch to avoid its being accidentally or inadvertently switched on when persons are working.

9.03.02 Take out the fuses and keep in safe custody.

9.03.03 The switch may be locked if locking arrangement exists.

9.03.04 Earth the equipment, before work, to discharge it and short the terminals as a precautionary measure against accidental switching ON.

9.03.05 After the work is finished take out Earthing and shorting link.

9.03.06 Remove all tools and materials from the site of work. Replace the fuses and unlock the switch.

9.03.07 The switch shall only be put 'ON' by the person who switched it 'OFF' or by the person authorised by him in writing.

9.04.00 When working on live equipment use one hand only whenever possible, it is advisable to keep the other hand behind the back. Shocks from hand to hand are most dangerous.

9.05.00 All persons handling electrical gear in elevated position must use safety belts. Even a slight shock may cause loss of balance and fall.

9.06.00 No one shall attempt to extinguish a fire on or near a live electrical apparatus with water. Water is a good conductor of electricity. Use extinguishers wherever provided. Use sand and blankets etc., if available.

9.07.00 No person shall use any part of electrical equipment for storing or hanging clothes, umbrellas or other articles. Serious accidents occur from this practice.

9.08.00 For attending the work on O.H. lines or equipment use wooden ladders. Metallic ladders shall not be used.

9.09.00 Use insulated tools and ensure the insulation is in proper condition periodically at least once in three months. Use rubber gloves wherever possible.

9.10.00 As far as possible verbal instructions shall be avoided in case of pre-arranged shut-down of electrical apparatus.

9.11.00 When workers are employed for electrical installations which are already energised, insulating mats, wearing apparel such as gloves, sleeves and boots as may be necessary shall be provided. The workers shall not wear any rings, watches and carry keys or other materials which are good conductors of electricity.

10.00.00 MISCELLANEOUS

10.01.00 The Bidder shall provide necessary fencing and lights to protect the public from accident.

10.02.00 Fire extinguishers adequate in number shall be kept by the Bidder at the site of works where there is risk of fire hazard.

10.03.00 Adequate washing facilities shall be provided near the place of work.

10.04.00 When the work is done near any place where there is risk of drowning, all necessary equipment shall be provided and kept ready for use and all necessary steps taken for prompt rescue of any person in danger and adequate provisions shall be made for prompt first aid treatment of all injuries likely to be sustained during the course of the work.

10.05.00 These safety provisions shall be brought to the notice of all concerned by displaying on a Notice Board at a prominent place at the work spot. The

persons responsible for compliance of the code shall be named therein by theBidder.

10.06.00 To ensure effective enforcement of the rules and regulations relating to safety precautions, the arrangements made by the Bidder shall be open to inspection by the Engineer and Owner.

10.07.00 Not withstanding the above clauses there is nothing in those to exempt the Bidder from the operations of any other Act or Rule in force in the Republic of India.

10.08.00 All storage, handling and use of flammable liquids shall be under the supervision of qualified persons. Flammable liquid shall not be stored inside the tunnel

10.09.00 All sources of ignition shall be prohibited in areas where flammable liquids are stored, handled and processed. Suitable warning and 'NO SMOKING' signs shall be posted in all such places. Receptacles containing flammable liquids shall be stacked in such a manner as to permit free passage of air between them.

10.10.00 All combustible materials shall be continuously removed from such areas where flammable liquids are stored, handled and processed. All spills of flammable liquids shall be cleared up immediately. Containers of flammable liquids shall be tightly capped.

11.00.00 REPORTING OF ACCIDENT

All accidents, major or minor must be reported immediately. The Bidder, shall provide first aid to the injured person immediately and the injured person shall report to the first aid station along with the 'INJURED ON WORK' form duly filled in quintuplicate and submit to the Medical Officer of the First Aid Station".

Serious Injury

In case of serious injury, the following procedure shall be adopted by the Bidder :

1). Provide First Aid at his own First Aid Station.

2). Take the injured person to the Hospital along with the "INJURED ON WORK" form duly filled in.

3). Reporting the accident to the Owner/Engineer by the Bidder.

Fatal Accident

Fatal accident must be reported immediately to the Engineer/Owner as well as to the Police.

Penalty

Failure to observe the Safety Rules shall make the Bidder liable to penalty by way of suspension of work, fine and termination of bid.

12.00.00 GENERAL SAFETY PROVISIONS FOR COOLING TOWER AND CHIMNEY:

There are numerous safety aspects to consider in construction; they are affected not only by the structural and environmental aspects of the form and scaffold system in use, but also by the strength and stability of the partially completed structure.

The early age of the concrete is a critical item and can control the rate of progress. Similarly, the design, manufacture, and installation of anchorages in the young concrete are important items. Jump form systems rely heavily on strengths of previous lifts to resist construction loads and moments; vertical slip forms do not typically apply eccentric loads to lifts below but are dependent on the strength of concrete at very early ages.

Training of personnel is important to the safe operation of any construction system. It is a critical item in the use of jump form and slip form systems. The sequencing and execution of the many procedures involved can affect the overall safety of the system, including the partially completed structure. The bidder shall implement safety inspection procedures which shall be part of the field records. Personnel shall be made aware of the interrelationships of the various system components and be cautioned as to the critical elements.

Access ways shall be available for use at all times, without restrictions caused by debris or other items. Alternate routes must be made available in the event normal access is interrupted. Ladders between work levels shall be secured and available at all times; access hatches shall be clearly marked and available at any time.

CONSTRUCTION REVIEWS

Preconstruction reviews can be useful in acquainting jobsite personnel and other associated personnel with planned construction methods, form and scaffold systems, materials delivery systems, schedules, and overall operating procedures. Compliance officers can be informed of safety procedures to be in effect and notified of persons responsible for reporting. Preliminary discussions shall include basic construction procedures and schedules, as well as design loading criteria for the form and scaffold system. More specific procedures, schedules, and loads can be provided with design drawing submittals at a later time, but prior to starting construction.

Critical conditions or loads shall be clearly noted; key operations shall be denoted and appropriate safety measures put into effect.

Regular or periodic construction meetings can be effectively used to review progress of construction and to discuss changes to operating procedures, equipment, and/or personnel.

Specific bench marks shall be established for all key operations; these shall include, but not necessarily be confined to, minimum concrete strength for form removal, minimum concrete maturity, minimum size and number of anchor bolts, and their proper placement, sequence of operation, maximum deck loads, minimum size and number of scaffold connections, maximum concrete casting rates and size and spacing of form ties.

Inspections shall be adequate to assure the bench marks are being met. Job site records can be satisfactorily used to review many items. Some items will require detailed inspections to be performed.

There are a number of key factors influencing the overall structural integrity of moving formworks used in the construction of cooling towers and chimneys. The principal forming systems, which have been addressed in the respective sections, cannot be treated independently of the partially completed structure. The forms, scaffolds, moving mechanisms and the structure combine to form an interactive construction system in which the safety of individual components is affected by the design and operation of other components.

A working knowledge of the operational aspects of the systems will ensure meaningful field evaluation of system safety by compliance officers. Among critical safety items, the capacity of partially matured concrete to resist imposed construction loads with an adequate margin of safety shall receive foremost priority.

The minimum factor of safety shall be maintained at a level consistent with the design of concrete structures for occupancy loads for two important reasons.

First, service loads and fully developed concrete strength are more predictable than construction loads and the strength of concrete at early ages. Second, the consequences of a construction failure in terms of human casualties would be quite severe owing to the fact that moving form systems are generally well-populated and inherently limited in providing the exit ways for emergency evacuation of personnel in the event of structural distress.

In addition, where the partially cured concrete supports loads transmitted by scaffolds and other work platforms, its strength requirements shall be consistent with the safety factors prescribed by the construction safety regulations.

The compliance officer shall expect to find field records which will show, above all else, that the construction system is well-conceived and structurally sound with regard to the maintenance of a minimum factor of safety on component strengths. The engineer's records shall be sufficiently comprehensive to indicate, through a detailed set of specifications, critical

benchmarks for the movement of forms and imposition of loads on partially cured concrete.

The field logs shall show these bench marks are being met. The proper implementation of these items is the key requirement contained in regulations. Many of the safety hazards found in cooling tower and chimney construction are universal in application.

Access ways must be available at all times, without blockage by debris or other items. All structural connections of the scaffolding and forming systems must be sound and adequate for the intended loads. Any signs of distress in the system, such as cracking, peeling, bending, etc., shall be noted and remedial measures taken immediately. Structural engineering consultants may be needed in the evaluation of certain moving form systems which incorporate relatively complex mechanisms (such as catheads used in conjunction with flexible cables to transport concrete to the top of the tower) capable of producing extraordinary loads on the partially matured concrete structure.

13.00.00 CHECK LIST FOR INSPECTION OF JUMP FORM SYSTEM

REFERENCE DOCUMENTS

REVIEWED

Tower drawings
Formwork drawings
Formwork calculations
Sequence of moving cycle
Criteria for form movement
Concrete records
Material test records
Maintenance records

GENERAL	YES	NO
Overall formwork condition adequate	----------	----------
Routine maintenance performed	----------	----------
Regular inspections performed:		
Concrete ---------- ----------		
Anchorages	----------	----------
Access ways	----------	----------
Forms	----------	----------
Training provided for personnel	----------	
Form movement criteria observed	----------	----------
Signs of overload or structural distress	----------	----------
If answer is yes, explain further.		

CONCRETE	DESIGN	OBSERVED
28-day compressive strength	----------	----------
Max. slump, in.	----------	----------
Max. water/cement ratio	----------	----------
Min. compr.str. for form movement	----------	----------
Min. comp. str. for placing concrete in succeeding lift	----------	----------

General Comments:

ANCHORAGES	DESIGN	OBSERVED
Design working load (in concrete, with safety factor)	----------	----------
-		
Shear	----------	----------
Tension	----------	----------
Nominal size of embedment	----------	----------
Nominal size of anchor bolt	----------	----------
Min. anch.bolts per strongback	----------	----------

General Comments:

ACCESS/EGRESS	DESIGN	OBSERVED

Level 1 (Top) scaffold (…….. simple…….. braced……. Cantilevered)

Live load	----------	----------
Spacing of scaffold brackets	----------	----------
Nom.bolt sizes	----------	----------

Level 2 Scaffold (……. Simple…….. braced…… cantilevered)

Live load	----------	----------
Spacing of scaffold brackets	----------	----------
Nom. bolt sizes	----------	----------

Level 3 Scaffold (…….. simple…….. braced…… cantilevered)

Live load	----------	----------
Spacing of scaffold brackets	----------	----------
Nom. bolt sizes	----------	----------

Level 4 Scaffold {…… simple…… ….braced…….. cantilevered)

Live load ---------- ----------
Spacing of scaffold brackets ---------- ----------
Nom. bolt sizes ---------- ----------
Miscellaneous Comments:
Ladders: _____
Stairs: _____
Elevators: _____
Guardrails: _____
Toe boards: _____
Maintenance: _____
General Comments: _____

HOISTING SYSTEM	DESIGN	OBSERVED
Main hoist line		
Min. sheave size	----------	----------
Min. line size	----------	----------
Static line		
Min. sheave size	----------	----------
Min. line size	----------	----------
Max. tension	----------	----------
Max. hoist load	----------	----------

General Comments:

_____

RAISERS	YES	NO
Mechanical components checked regularly	----------	----------
Safety mechanism operating properly	----------	----------
Regular maintenance performed	----------	----------

General Comments:

_____

CHECK LIST FOR INSPECTION OF SLIP FORM SYSTEM

REFERENCE DOCUMENTS	REVIEWED
Chimney / silo drawings	----------
Formwork drawings	----------
Formwork calculations	----------
Criteria for slipping rate	----------
Concrete records	----------
Material test records	----------
Maintenance records	----------

GENERAL	YES	NO
Overall formwork condition adequate	----------	----------
Routine maintenance performed	----------	----------
Regular inspections performed	----------	----------
Concrete	----------	----------
Climbing rods	----------	----------
Anchorages	----------	----------
Access ways	----------	----------
Forms	----------	----------
Training provided for personnel	----------	
Form slipping criteria observed	----------	----------
Signs of overload or structural distress	----------	----------

If answer is yes, explain further_____

CONCRETE	DESIGN	OBSERVED
28-day compressive strength----------	----------	
Max. slump in.	----------	----------
Max. water/cement ratio	----------	----------

CLIMBING RODS	DESIGN	OBSERVED
Diameter of rods	----------	----------
Unbraced length	----------	----------
Dist between climbing rods	----------	----------

General Comments: _____

ANCHORAGE (climbing mast system)	DESIGN	OBSERVED
Design working load (in concrete, with safety factor) --------		----------
Shear	----------	----------
Tension	----------	----------
Nominal size of embedment	----------	----------
Nominal size of anchor bolt	----------	----------

General Comments:

_____

ACCESS/EGRESS	DESIGN	OBSERVED
Main work deck Live load, psf	----------	----------
Level I (TOP) scaffold (…….. ..simple……braced……cantilevered)		
Live load	----------	----------
Spacing of scaffold brackets	----------	----------
Nom. bolt sizes	----------	----------
Level 2 scaffold (… simple……. Braced……cantilevered)		
Live load	----------	----------
Spacing of scaffolds brackets	----------	----------

Nom. bolt sizes ---------- ----------

Level 3 scaffold […….. simple……Braced……cantilevered)
Live load ---------- ----------
Spacing of scaffold brackets ---------- ----------
Nom. bolt sizes ---------- ----------
Miscellaneous Comments:
Ladders: ---------- ----------
Stairs: ---------- ----------
Elevators: ----------
Guardrails: ---------- ----------
Toe boards: ----------
Maintenance: ---------- ----------
General Comments:

YOKES/HYDRAULIC JACKS YES NO

Level controls ---------- ----------
adequate Safety mechanisms ---------- ----------
operating properly ---------- ----------
Regular maintenance performed ---------- ----------
General Comments:_____

VOLUME: II-G/2
PART-B

SECTION-XX

GUIDELINEFOR
FENCING WORK WITH BARBED WIRE,CHAIN LINK
AND
CONCERTINA COIL etc.

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PART-B

SECTION-XX

GUIDELINE
FOR
FENCING WORK WITH BARBED WIRE, CHAIN LINK AND CONCERTINA COIL etc.

1.00.00 SCOPE

This section covers supply, fabrication and erection of chain link fencing, barbed wire fencing, concertina coil etc. as specified or shown on drawing or as instructed by the Engineer.

2.00.00 INSTALLATION

2.01.00 Fabrication/casting

2.01.01 General

All work shall be done according to approved shop drawings. All workmanship shall be equal to the best practice in modern structural or foundry shop.

2.01.02 Shop Connections

a) All shop connections shall be riveted or welded except when noted otherwise on drawings.

b) Welding of steel shall be done in accordance with IS: 816.

c) Welding of aluminium shall be done accordance with IS: 2812, “Arc welding of Aluminium and Alloys.”Special care shall be taken to grind smooth all welded surface that shall remain exposed to view. Welds shall be electrically continuous if so required by the Engineer.

2.01.03 Shop Coat

Before leaving the shop, all metal work shall be thoroughly cleaned by effective means of all loose mill seals, rust and foreign matter. Except where encased in concrete, all steelwork shall be given one coat of approved metal protective paint, applied be brush thoroughly and evenly, well worked into joints and other open spaces. All paint shall be applied to dry surfaces. When specified steel work shall be galvanised or painted with a coat of zinc

chromate primer. Aluminium surfaces, which shall come in contact with masonry, shall be given one coat of bituminous paint.

2.02.00 Posts and Struts

2.02.01 M.S. Posts and Struts

All the M.S. posts/struts shall be free from rust, scale, cracks, twists and other defects and shall be fabricated to the required shape and size out of the specified sections. The posts and struts shall be conforming to relevant specifications stipulated here-in-before under relevant sections. All the posts and struts shall be of sizes and lengths as specified in the tender schedule and drawing. The posts and struts shall have split ends for proper fixing and shall be embedded in the cement concrete of mix.1:2:4 or as specified in the schedule. The exposed surfaces of the posts and struts shall be painted with two coats of synthetic enamel paint of approved make and shade over a coat of approved primer.

2.02.02 R.C.C. Posts and Struts

All the posts and struts shall be of standard size as specified in schedule. These shall be casted on suitable places/platforms in cement concrete 1:1.5:3 (1 cement : 1.5 coarse sand : 3 graded stone aggregate 12.5 mm. nominal size) as per relevant specifications stipulated here-in-before. The reinforcement shall be provided as shown in the drawings, as directed by Engineer-in-Charge and specified here-in-before under relevant sections. The posts and struts shall be free from honeycombing, cracks and other defects.

After casting, the posts/struts shall be left at the same place and cured for a minimum period of 7 days. After 7 days curing the same shall be shifted to a leveled ground and stacked for further curing for 14 days. After 21 days of curing only, the posts/struts shall be transported to work site without any damage, for fixing in position.

2.02.03 Spacing of the Posts and Struts

The spacing of posts shall be 3 m. centre to centre unless otherwise specified or as directed by the Engineer-in Charge, to suit the dimensions of the area to be fenced. Every 10th posts, last but one end posts, corner posts, and posts where the level of fencing changes in steps and end post when the fencing changes its direction shall be strutted on both sides, or as directed by the Engineer-in-Charge. End posts where barbed wire fencing is discontinued shall be strutted on one side only.

2.02.04 **Fixing of M.S./R.C.C. Posts and Struts**

Pits of size 45 x 45 x 45 cm. deep or of sizes mentioned in the drawings, shall first be excavated centrally in the direction of proposed fencing work, true to line and level to receive the posts. In case of struts, the pits shall be so excavated, as to receive minimum 15 cm. concrete cover at any point of the struts to suit its inclination or as shown in the drawing.

The pits shall be filled with a layer of 15 cm. thick cement concrete of specified mix. The posts and struts shall then be placed in the pits, the posts projecting to the specified height above ground level, true to line, plumb and position, by providing adequate supports temporarily, and cement concrete of specified mix. shall then be filled-in so that the posts are embedded in cement concrete blocks of specified sizes. The concrete in foundation shall be watered for at least 7 days to ensure proper curing.

3.00.00 G.I. Barbed Wire

The barbed wire shall be of G.I. as specified and it shall generally conform to I.S. 278-2009.

The base metal of the line and point wire shall be of good commercial quality mild steel conforming to IS: 280-2006. The line and point wire shall be circular in section, free from scales and other defects and shall be uniformly galvanized, if specified.

The line wire shall be in continuous lengths and shall generally be free from signs of welds. It shall be able to withstand Wrapping and unwrapping 8 turns round its diameter.

The barbed wire shall consist of two splices per reel. The barbed wire shall be formed by twisting two lines wires one containing the barbs.

The barbed wire and its weight

Type	Nominal diameter of wire		Nominal distance between two barbs(in mm.)	Mass of complete barbed wire(in gm./m.)
	Line wire (in mm.)	Point wire (in mm.)		
1.	2.50(12G)	2.50(12G)	75	146 (136-155)
2.	2.50	2.50	150	114(108-120)
3.	2.50	2.00(14G)	75	117(108-125)
4.	2.50	2.00	150	96(89-103)
5.	2.24(13G)	2.00	75	102(97-106)
6.	2.24	2.00	150	82(78-85)

The barbs shall carry four points and shall be formed by twisting two point wires, each two turns, tightly round one line wire, making altogether 4 (four) complete turns. The barbs shall be so finished that the four points are set and locked at right angles to each other.

The barbs shall have a length of not less than 13 mm. and not more than 18 mm. The points shall be sharp and well pointed. Barbs spacing shall be as given in the above table. Wherever required for every 50 reels or part thereof, samples of the barbed wire and the individual line wires shall be put to tensile test and in case of failure to conform to tensile properties given below, two additional tests of each kind shall be made on the samples cut from other reels.

Tensile Properties

Size of line wire Nominal dia. (in mm)	**Breaking load of line wire**		**Min. breaking load of complete barbed wire (in Kg.)**
	Min. (in Kg.)	**Max. (inKg.)**	
2.50(12G)	216	302	444
2.24(13G)	128	179	263

On the results of these additional tests, the whole or portion of the barbed wire shall be accepted or discarded as the case may be.

3.00.01 **Fixing of Barbed Wire:**

The barbed wire shall be stretched and fixed in number of rows and two diagonals as specified. The bottom row shall be 140 mm. above ground and the rest at 125 mm or at given spacing as per drawing. The diagonals shall be stretched between adjacent posts from top wire of one post to the bottom wire of the 2nd post. The diagonal wires will be interwoven with horizontal wires by fixing the odd rows of wires, then the diagonal cross wires and lastly the even rows of wires. The jointing of the barbed wire in between the posts shall not be permitted.

Necessary holes shall be tapped in the post and the barbed wire shall be fixed in position by means of 'U' clamps or bolts and nuts as specified in drawings. In case of fixing with 'U' clamps, the legs of the 'U' clamps passing through the 10 mm. dia. hole in the R.C.C. post to hold barbed wire shall be turned up and down to get an over-lap of 25 mm. on the face of RCC post. Turn buckles and straining bolts shall be used at the end posts if specified.

3.00.02 **Mode of Measurement:**

The work shall be measured in running metre length of fencing correct to a centimetre for the finished work, from centre to centre of the posts.

The rate shall include the cost of labour and materials involved in all the operations described above including the cost of barbed wire, turn buckle, straining bolts, bolts and the nuts/U clamps including excavation and foundation concrete or as specified in item description for the work.

4.00.00 Chain Link

The chain link shall be of approved manufacture and of correct size, gauge etc. It shall be of M.S. or G.I. as specified of approved manufacture and of required size, gauge etc. The base materials of the wire shall be of good commercial quality mild steel conforming to IS:280-2006. The wire shall be circular in section, free from rust, scale, cuts, welds and other defects and shall be uniformly galvanized, if specified.

4.00.01 **Fixing of the Chain Link Fencing to M.S. or R.C.C post**

The chain link of specified height of fencing shall be fixed first to the end post with necessary G.I. approved type U clamps threaded at the ends and G.I. nut, bolts, washers etc. and with 6 mm. dia. full height M.S./G.I. anchor bar. After fixing the chain link at the end post, it shall be stretched tightly and fixed to next post one after the other by the above mentioned clamps and bars etc. leaving 50 mm. clearance from the ground and 20 mm. clearance in the case of concrete coping at bottom to avoid rusting. The point at the change in level of the fencing top/bottom, necessary links shall be adjusted suitably as per the manufacturer's specification or as directed by the Engineer-in-Charge. The chain link fence post shall be painted with two coats of synthetic enamel paint of approved make and shade over a coat of approved primer or as specified in the item/drawing.

4.00.02 **Measurement:**

The work shall be measured in running metre length of fencing correct to a centimetre for the finished work from centre to centre of the posts.

The rate shall include the cost of labour and material involved in all the operation described above including the cost of barbed wire, turn buckle, straining bolts and bolts and the nuts/U clamps, 6 mm. dia. M.S./G.I. anchor bar etc. including excavation and foundation concrete or as specified in item description for the work.

5.00.00 Concertina Coil Fencing

5.00.01 **Materials**

i) Angle iron post & strut shall be as specified in item no. 2.02.00

ii) Punched tape Concertina coils shall be manufactured using central core of High Tensile G.I. Spring steel core wire of 2.60 mm dia. around which a tape of razor sharp blades(Low carbon G.I strip)of thickness 0.52mm, is machine crimped. Concertina coil fencing shall be of specified diameter such as 450mm,600mm,750mm,900mm, having 10 to 8 turns(loops) per running metre length of coil and shall be of approved manufacturer.

5.00.02 **Spacing of Posts & Struts:**

The spacing of posts shall be 2.4 m or 3.00 m apart centre to centre, unless otherwise specified or as per Engineer-in-Charge to suit the dimension of the area to be fenced. Every 15th last but one end posts and corner posts shall be strutted on both sides and end posts on one side only.

5.00.03 **Fixing of Posts and Struts:**

As per drawing and as specified in item no. 2.02.00 in this specification..

5.00.04 **Fixing concertina coil fencing:**

Concertina coil fencing shall be fixed on angle iron y-shaped with 9 horizontal reinforced barbed tape (RBT) stud tied with GI staples and GI clips to retain horizontal including necessary bolts or GI barbed wire tied to angle iron all complete as per directions of Engineer-in- Charge with reinforced barbed tape.

5.00.05 **Measurements:**

The length of Concertina coil fencing shall be measured correct to a cm for finished work. Angle iron post & strut shall be paid separately under relevant item.

6.00.00 Acceptance Criteria

a) All items shall be correct shape, size, weight etc. shown on drawing sand schedule of items.

b) For installed items, the tolerances shall be as follows

i) Permissible deviation from straightness–1 in 1000.

ii) Seats, stiffener connections etc. shall be as per approved drawings and shall not interfere with architectural clearances.

c) All castings shall be free from blow holes, cracks, and other blemishes.

d) All MS wire fencing shall be in true vertical plain and shall not bulge.

7.00.00 CODES AND STANDARDS

Some of the important Codes and Standards relevant to this specification shall be followed: Latest editions shall always be consulted.

ISCODES

IS:278	Specification for Galvanised Steel Barbed wire for fencing.
IS:816	Code of practice for use of Metal Arc welding for general construction in mild steel.
IS:1367	Industrial Fasteners–Threaded steel fasteners- Technical supply condition.
IS:2721	Specification for Galvanised Steel Chain Link fence fabric.

NLC INDIA LIMITED
NLC TALABIRA THERMAL POWER PROJECT- 3x800 MW
JHARSUGUDA, ODISHA

BIDDING DOCUMENT
FOR
SINGLE PACKAGE ENGINEERING, PROCUREMENT & CONSTRUCTION

SPECIFICATION NO : 18A03-SPC-G-001

SECTION-B

VOLUME: II-H1

TECHNICAL SPECIFICATIONS
FOR
ASH HANDLING SYSTEM

DEVELOPMENT CONSULTANTS PRIVATE LIMITED
CONSULTING ENGINEERS
BLOCK DG-4, SECTOR-II, SALT LAKE CITY
KOLKATA- 700 091, INDIA

November, 2020

DWG. 18A03-DWG-M-002A REV 0

WIND SPEED (Knots)
- >=22
- 17-21
- 11-17
- 7-11
- 4-7
- 1-4

SMC POWER GENERATION LIMITED

JAL BANDHARAN LAND

FOREST LAND

MALDA VILLAGE

TOWNSHIP / CISF BARRACKS

SAMBALPUR JHARSHUGUDA

BHEDAN RIVER

TO SAMBALPUR JHA

RAW WATER RESERVOIR AREA (88 ACRES)

DYKE AREA: 175 ACRES.
SLURRY COLLECTION: 150 ACRES

ITEM No.	DESCRIPTION	ZONE
1	765kV GIS ROOM	
2	400kV GIS ROOM	
3	765kV,400kV & 33kV GIS COMMON CONTROL ROOM	
4	C.W. DUCT CORRIDOR	
5	TRANSFORMER YARD	
6	DG SET	
7	POWER HOUSE BUILDING	
8	SERVICE BUILDING	
9	BOILER UNITS	
10	MILL BAY	
11	ELECTROSTATIC PRECIPITATOR	
12	CHIMNEY	
13	E.S.P. CONTROL ROOM	
14	CPU REGENERATION FACILITY	
15	DEWATERING BIN	
16	AUX. BOILER	
17	STP AREA NEAR WATER POND	
18	STP AREA NEAR LIMESTONE UNLOADING HOUSE	
19	C.W. PUMP HOUSE	
20	C.W. CHLORINATION CUM CHEMICAL TREATMENT BLDG.	
21	COOLING TOWER	
22	TOILET BLOCK FOR BOILER AREA	
23	AHP COMPRESSOR BUILDING	
24	WTP & ETP AREA	
25	FIRE WATER TANK & F.W. PUMP HOUSE	
26	F.O. TANKS	
27	FUEL OIL PUMP HOUSE	
28	PERMANENT STORE	
29	STRUCTURAL STEEL STORAGE YARD	
30	CONSTRUCTION OFFICE COMPLEX FOR CONTRACTOR	
31	33kV GIS ROOM	
32	CONSTRUCTION STORE	
33	WORKSHOP	
34	FIRE STATION	
35	LAYDOWN / PREASSEMBLY AREA	
36	HYDROGEN GENERATION PLANT	
37	MAIN GATE COMPLEX	
38	THERMAL PROJECT BUILDING	
39	WATCH TOWER	
40	RAW WATER RESERVOIR	
41	DRY FLY ASH SILO	
42	SILO UTILITY BUILDING CUM HCSD PUMP HOUSE	
43	CRUSHER HOUSE	
44	CRUSHED COAL STOCK PILE	
45	STACKER RECLAIMER	
46	FIRST-AID CENTER	
47	RAINWATER HARVESTING POND	
48	(DELETED)	
49	ASH WATER PUMP HOUSE	
50	AHS SWITCH GEAR ROOM	
51	CANTEEN BUILDING	
52	COMPRESSOR HOUSE	
53	WEIGH BRIDGE	
54	CST & PUMP HOUSE	
55	FGD ABSORBER FOR UNIT#1,2,&3	
56	FGD ABSORBER RECIRCULATION PUMP FOR UNIT#1,2&3	
57	COMMON FGD AUXILIARY ABSORBER TANK	
58	FGD MAKE-UP WATER TANK	
59	COMMON LIMESTONE UNLOADING HOUSE	
60	COMMON LIMESTONE CRUSHER HOUSE	
61	LIMESTONE SILO	
62	LIMESTONE PREPARATION BUILDING	
63	LIMESTONE SLURRY STORAGE TANK & AGITATOR	
64	GYPSUM DEWATERING BUILDING	
65	GYPSUM SHED	
66	COMMON FGD ELECTRICAL BUILDING	
67	COMMON FGD WASTE WATER TREATMENT BUILDING	
68	FGD PROCESS TANK & AGITATOR	
69	DM PLANT AREA	
70	AMMONIA STORAGE AND HANDLING SYSTEM	
71	33/11KV CONSTRUCTION POWER SUBSTATION	
72	NOT USED	
73	BOILER MAINTENANCE BUILDING	
74	AIR WASHER BUILDING	
75	CHP CONTROL ROOM CUM SWITCHGEAR ROOM	
76	PUMP CUM COMPRESSOR HOUSE FOR DSS/DFDS	
77	COAL PILE RUN-OFF POND	
78	DOZER SHED	
79	CHP MAINTENANCE SHOP	
80	TOILET BLOCK FOR CHP AREA	
81	FGD DG SHED	
82	IDCT SWITCHGEAR ROOM	
83	FIRE WATER BOOSTER PUMP HOUSE	
84	CENTRAL MONITORING BASIN	

DETAILS OF ROAD

Sl. No.	LEGEND	WIDTH	TYPE
1	R1	4	BITUMEN
2	R2	10	RCC
3	R3	10	RCC
4	NOT USED	----	----
5	R5	10	RCC
6	R6	7.5	RCC
7	R7	7.5	RCC
8	R8	7.5	RCC
9	R9	7.5	RCC
10	R10	7.5	RCC
11	R11	7.5	RCC
12	R12	7.5	RCC
13	R13	7.5	RCC
14	R14	7.5	RCC
15	R15	7.5	RCC
16	R16	7.5	RCC
17	R17	10	RCC
18	R18	10	RCC
19	R19	7.5	RCC
20	R20	10	RCC
21	R21	7.5	RCC
22	R22	10	RCC
23	R23	7.5	RCC
24	R24	7.5	RCC
25	NOT USED	----	----
26	R26	10	RCC
27	R27	7.5	RCC
28	R28	10	RCC
29	R29	10	RCC
30	R30	10	RCC
31	R31	7.5	RCC
32	R32	7.5	RCC
33	R33	7.5	RCC
34	R34	7.5	RCC
35	R35	7.5	RCC
36	R36	7.5	RCC
37	R37	7.5	RCC
38	R38	10	RCC
39	R39	10	RCC
40	R40	10	RCC
41	R41	10	RCC
42	R42	10	RCC
43	R43	10	RCC
44	R44	4	BITUMEN

NOTES:–

1. INITIAL SITE LEVELING, AREA GRADING (SECTIONAL) AND THE FINAL MICRO LEVELING SHALL BE UNDER THE SCOPE OF EPC CONTRACTOR (SECTION-B).
2. PLANT (S.GN/S, S.GE/W) REFERS TO UNMORSAL COORDINATE.
3. UNLESS STATED ELSEWHERE SPECIFICALLY, THE FINISHED FLOOR LEVEL OF ANY BUILDING SHALL BE AT LEAST 500 MM FROM ABOVE THE HIGHEST FLOOD LEVEL OF THE RESPECTIVE BUILDING AREA. A POWER HOUSE AREA IS RL 202.5 M. ALL ELEVATIONS ARE WITH RESPECT TO POWER HOUSE BUILDING GROUND FINISHED FLOOR (GROUND FLOOR) AS ELEVATION WHICH CORRESPONDS TO R.L. 202.5M.
4. THE FINISHED PAVING LEVEL (FPL) OF THE TURBINE HOUSE BUILDING SHALL BE 1000 MM BELOW THE FFL OF THE POWER HOUSE BUILDING. (E. FL. OF TPL IS 202.5 M).
5. THE FINISHED PAVING LEVEL (FPL) OF THE BOILER AREA SHALL BE 225 MM BELOW THE FFL OF THE POWER HOUSE BUILDING. (E. FL. OF TPL IS 202.5 M).
6. LOCATION OF PLANT BUILDINGS AND FACILITIES ARE INDICATIVE AND ANY CHANGES IN THE LOCATION DURING ENGINEERING PHASE SHALL BE SUBJECT TO PURCHASER'S APPROVAL.
7. BRIDGE ON BHEDAN RIVER SHALL BE USED FOR ASH PIPES TO MAKE VOID AND ASH DYKE, ETP REJECT SWRO PIPE TO ASH DYKE, MAKE UP WATER PIPES, DRINKING WATER PIPE TO TOWNSHIP AND A LANE APPROACH ROAD BETWEEN MAIN PLAN AREA & TOWNSHIP AREA.
8. ADDITIONAL 220 ACRES OF LAND FOR MAKEUP WATER PIPE LINE AND TRANSMISSION LINES TO JHARSUGUDA POOLING STATION TO BE TAKEN ON RIGHT OF WAY (ROW) BASIS.
9. POWER HOUSE BUILDING LENGTH AND A-B/C-D POINT WIDTH ARE MINIMUM REQUIRED DIMENSIONS. EPC CONTRACTOR TO ACCOMODATE ALL EQUIPMENT WITHIN THIS AREA.
10. BOILER PITCH IS ESTIMATED AS AROUND 151.0M & DISTANCE BETWEEN D-ROW & CHIMNEY AS 322.0M.
11. R.W. & ACW SUPPLY & RETURN PIPES ARE LAID BURIED.
12. FIRE WATER PIPING WITH RING MAINS, WHICH SHALL BE LAID ABOVE GROUND ON PEDESTALS IN ALL AREA EXCEPT IN THE TG, BOILER, ESP AREA PIPE SHALL BE LAID IN RCC TRENCHES WITH REMOVABLE RCC PRECAST COVER SLABS. FOR ALL ROADS/RAIL CROSSING, FIRE WATER PIPE WILL BE THROUGH RCC BOX CULVERTS.
13. IF THE BIDDER FEELS THE EXCAVATED AREA FOR LAY DOWN WITHIN THE PLANT IS NOT SUFFICIENT, THEN THE AREA OUTSIDE THE COMPOUND BUT IN THE MARKED GREEN BELT AREA SHALL ALSO BE UTILIZED AS IS WHERE IS BASIS.
14. THE BIDDER IS CONNECTION OF PIPE RACK AND CABLE RACK TO EACH BUILDING/ SYSTEM FROM THE MAIN ROUTING IS TO BE INCLUDED IN HIS SCOPE.
15. RCC APPROACH ROADS WITH DRAINS SHALL BE PROVIDED FOR AND WITHIN COAL STOCK YARD AS PER CIVIL SPECIFICATION AND REQUIREMENT.
16. BUNKER ARRANGEMENT PLAN SHOWN HERE IS SIDE BUNKER ARRANGEMENT. IN CASE OF FRONT BUNKER ARRANGEMENT,BIDDER SHALL DO NECESSARY LAYOUT MODIFICATIONS.
17. LOCATION OF AMMONIA HANDLING SYSTEM SHOWN HERE IS TENTATIVE. BIDDER SHALL RELOCATE THE SAME IF REQUIRED BASED ON CODE/SAFETY REQUIREMENTS AS ACCEPTABLE TO THE OWNER/CONSULTANT.
18. APPROACH ROAD OF 7.5M WIDTH FROM THE MAIN ROAD TO ALL THE FACILITIES/STRUCTURES/BUILDINGS SHALL BE PROVIDED BY THE EPC CONTRACTOR.
19. RAIL ARRANGEMENT OF BUS REACTOR SHALL BE MADE TO INTERCONNECT WITH THE RAIL ROAD IN TRANSFORMER YARD AREA. DESIGN SHALL BE MADE ACCORDINGLY.
20. LOCATION OF OUTGOING GANTRIES SHALL BE FIRMED UP DURING ENGINEERING PHASE.
21. ALL PLANT ROADS SHALL BE PROVIDED AS SPECIFIED IN THE RELEVANT SPECIFICATION.
22. THE SITE GRADING IN RAW WATER RESERVOIR AREA SHALL UNDER THE SUCCESSFUL EPC CONTRACTOR AND HE WILL DECIDE THE BED (BOTTOM) LEVEL & TOP LEVEL OF THE RAW WATER RESERVOIR BUND DURING DETAIL ENGINEERING MEETING THE EFFECTIVE STORAGE CAPACITY OF RAW WATER RESERVOIR. (NOT- 18A03-DWG-C-0001)
23. RAW WATER INTAKE PUMP HOUSE IS LOCATED IN THE DOWNSTREAM OF RAMELLA BRIDGE AT JOGIPALLI VILLAGE.
24. ONLY MAJOR FACILITIES ARE ONLY SHOWN IN THIS DRAWING. FOR MORE DETAILS SPECIFIC LAYOUT DRAWINGS SHALL BE REFERRED.
25. SITE GROUND FOR ASH DYKE AREA UPTO INSPECTION ROAD, DRAINS AND APPROACH ROAD TO ASH DYKE AREA IN THE SCOPE OF EPC CONTRACTOR AS COVERED IN SECTIONS.
26. A 400kV GIS BUS DUCT CONNECTION FOR ST–1 SHALL BE SUITABLY ROUTED BETWEEN 400kV GANTRY AND 400kV GIS BY THE DESIGN AND MEETING THE LAYOUT CONSTRAINTS. THE LOCATION OF ROAD, SPACING BETWEEN SWYD AND TRANSFORMER YARD SHALL BE ACCORDINGLY MODIFIED.
27. 33kV OUTGOING FEEDERS ARE BY 33kV CABLES UPTO PLANT BOUNDARY.
28. RING BARRIER OF MINIMUM HEIGHT 4.0M SHALL BE PROVIDED ALL 4 SIDES OF THE CRUSHED COAL STOCK PILE.
29. 2M PLANT FEED PUMPS PIPING FROM PRE-TREATMENT PLANT AREA TO DM PLANT AREA HAS TO BE SUITABLY PLANNED EITHER BY PEDESTALS/PIPE RACK/BURIED.

DRAWN NOT TO SCALE

D.DE	K.M										
D.DE	K.M										
APPROV.	MECH.	INST.	ELEC.	STRL.	ARCH.						
	REVIEWED										

DRAWING ISSUED FOR TENDER PURPOSE	S.M	S.K.D	0	23/11/2020	
PRELIMINARY ISSUED FOR NLC's REVIEW/OBSERVATIONS	S.M	S.K.D	A	21/06/2019	
NATURE OF REVISION & DESCRIPTION	CHECKED	DRAWN	REV.	DATE	

REVIEWED	RELEASE STATUS	DATE	SIGNATURE
	PRELIMINARY		
	FOR TENDER ONLY		
	FOR CONSTRUCTION		
	ARCHITECTURAL		
	CIVIL & STRUCTURAL		
	ELECTRICAL		
	INSTRUMENTATION		
	MECHANICAL		
	*		

PRELIMINARY PURPOSE

OWNER: NLC INDIA LIMITED, NEYVELI, TAMILNADU

PROJECT: NLC TALABIRA THERMAL POWER PROJECT (NTTPP) (3x800 MW PHASE-I)

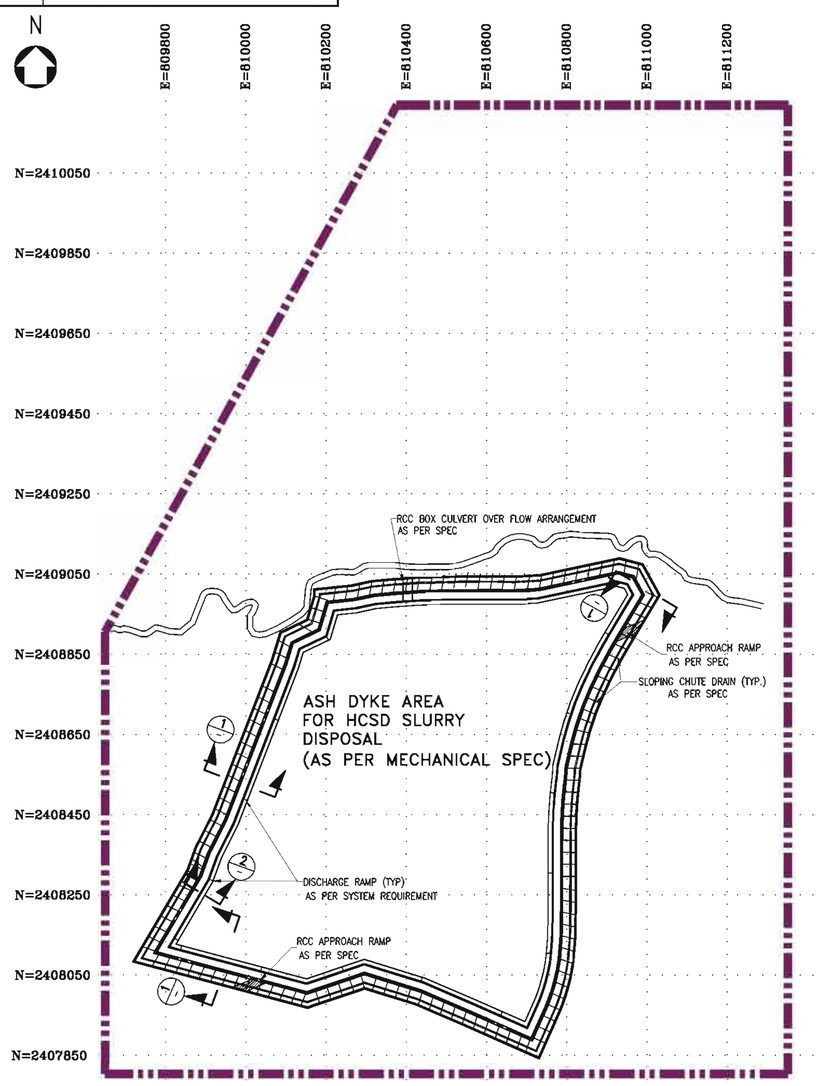
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DEVELOPMENT CONSULTANTS PVT LTD.
CONSULTING ENGINEERS
KOLKATA • MUMBAI • CHENNAI • NEW DELHI

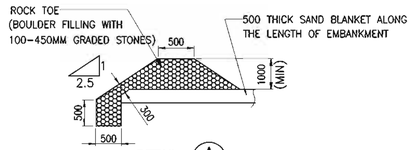
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CHECKED	K.Mukherjee	SCALE	1:4000
APPROVED	B.Lahiri	DATE	21/06/19
DWG. NO.	18A03-DWG-M-002A		REV 0
			SHEET 1 OF 1

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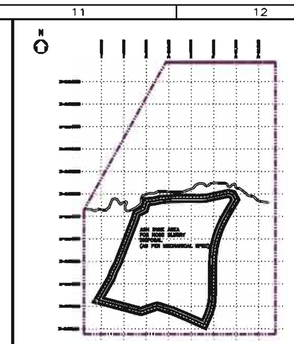
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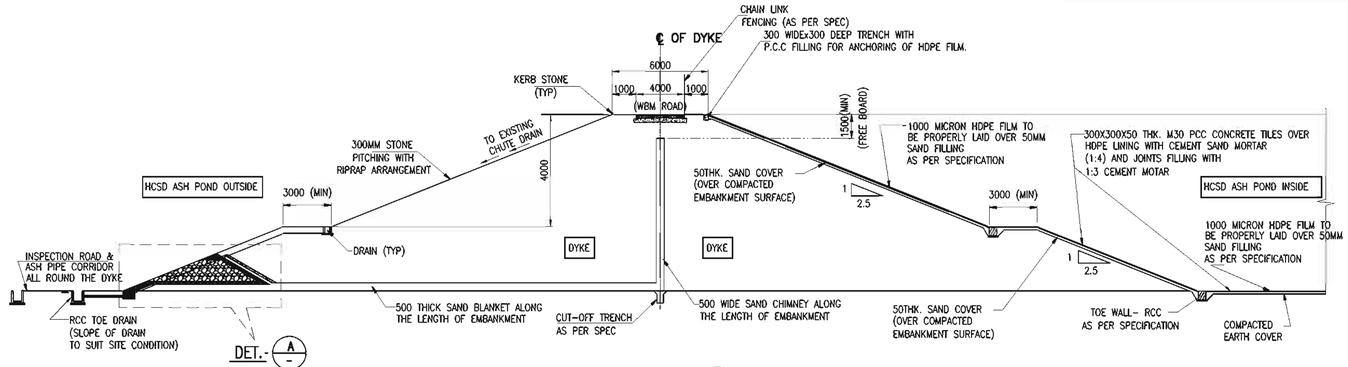
GENERAL ARRANGEMENT OF ASH DYKE
(SCALE-NTS)



DETAIL - A
(DETAIL OF ROCK TOE)
(SCALE-1:25)



KEY PLAN
(SCALE-NTS)

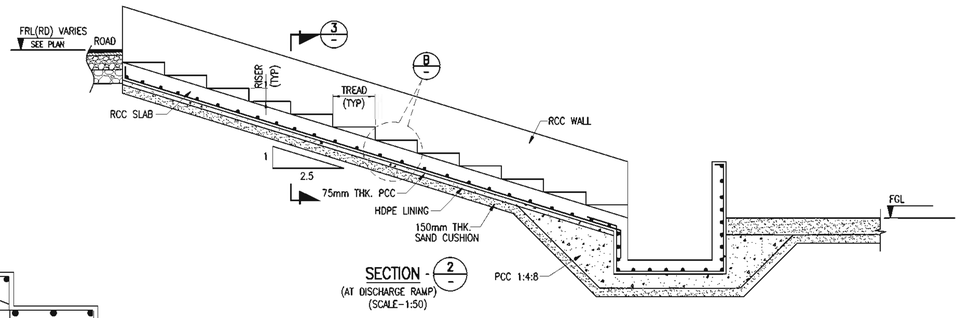


SECTION - 1
(TYPICAL ELEVATION OF ASH DYKE)
(SCALE-1:175)

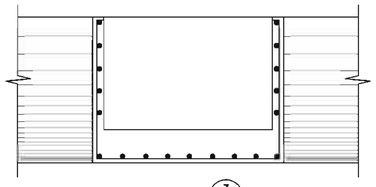
THE TENDER DRAWING PROVIDED IS PRIMARILY INTENDED TO PROVIDE A GENERAL IDEA OF THE EXTENT AND TYPE OF WORK TO BE CARRIED OUT UNDER THE SCOPE OF CONTRACT. IT IS A PRELIMINARY DRAWING AND DOES NOT SHOW FULL SCOPE OF WORK. ALL DETAILS, LEVELS AND DIMENSIONS SHOWN IN THE TENDER DRAWING ARE INDICATIVE ONLY.

NOTES:-

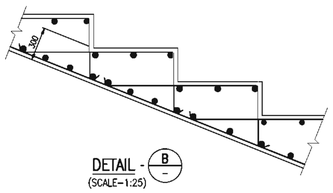
1. ALL DIMENSIONS ARE IN MM AND LEVELS ARE IN METER UNLESS OTHERWISE NOTED.
2. ALL DIMENSIONS ARE INDICATIVE AND WILL BE FINALISED AT THE TIME OF DETAILED ENGINEERING.
3. BOTTOM OF EACH ASH PIPE AT BUND SLOPE SHALL BE PROVIDED WITH 100MM THK 1.0M WIDTH M20 RCC SLAB.
4. 4.0M WIDE BT INSPECTION ROAD WITH 1.5M SHOULDER AND ASH PIPE LINE CORRIDOR SHALL BE PROVIDED AS PER SPECIFICATION.
5. THIS DRAWING SHALL BE READ IN CONJUNCTION WITH THE SPECIFICATIONS.



SECTION - 2
(AT DISCHARGE RAMP)
(SCALE-1:50)



SECTION - 3
(SCALE-1:25)



DETAIL - B
(SCALE-1:25)

REFERENCE DRAWING :-

1. 18A03-DWG-M-002A - PLOT PLAN

FOR TENDER PURPOSE ONLY

APPROV.	MECH.	INST.	ELEC.	STRL.	ARCH.	NATURE OF REVISION & DESCRIPTION	CHECKED	DRAWN	REV.	DATE
	REVIEWED					ISSUED FOR TENDER PURPOSE	RM	RG	0	01.12.2020
						ISSUED FOR TENDER PURPOSE	RM	RG	A	29.11.2020

RELEASE STATUS	DATE	SIGNATURE
PRELIMINARY		
JPDR TENDER ONLY	29.11.2020	BC
FOR CONSTRUCTION		

REVIEWED: ARCHITECTURAL; CIVIL & STRUCTURAL; ELECTRICAL; INSTRUMENTATION; MECHANICAL; *

OWNER: NLC INDIA LIMITED
NEYVELI, TAMILNADU

PROJECT: NLC TALABIRA THERMAL POWER PROJECT (NTTPP) (3x800 MW PHASE-I)

TITLE: GA OF ASH DYKE

DEVELOPMENT CONSULTANTS PVT LTD.
CONSULTING ENGINEERS
KOLKATA • MUMBAI • CHENNAI • NEW DELHI

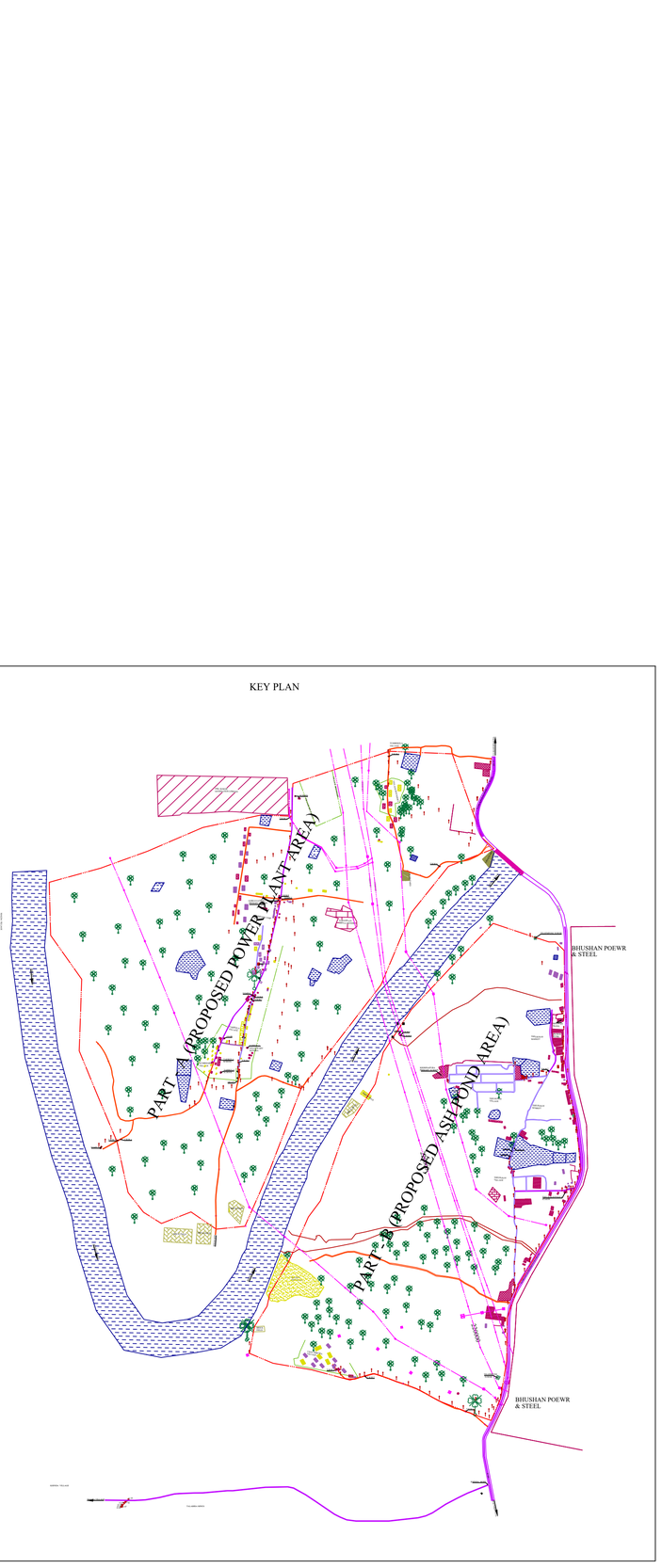
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CHECKED	RM	SCALE	AS NOTED
APPROVED	BC	DATE	29.11.2020

DWG. NO. 18A03-DWG-C-0008 REV 0 SHEET 1 OF

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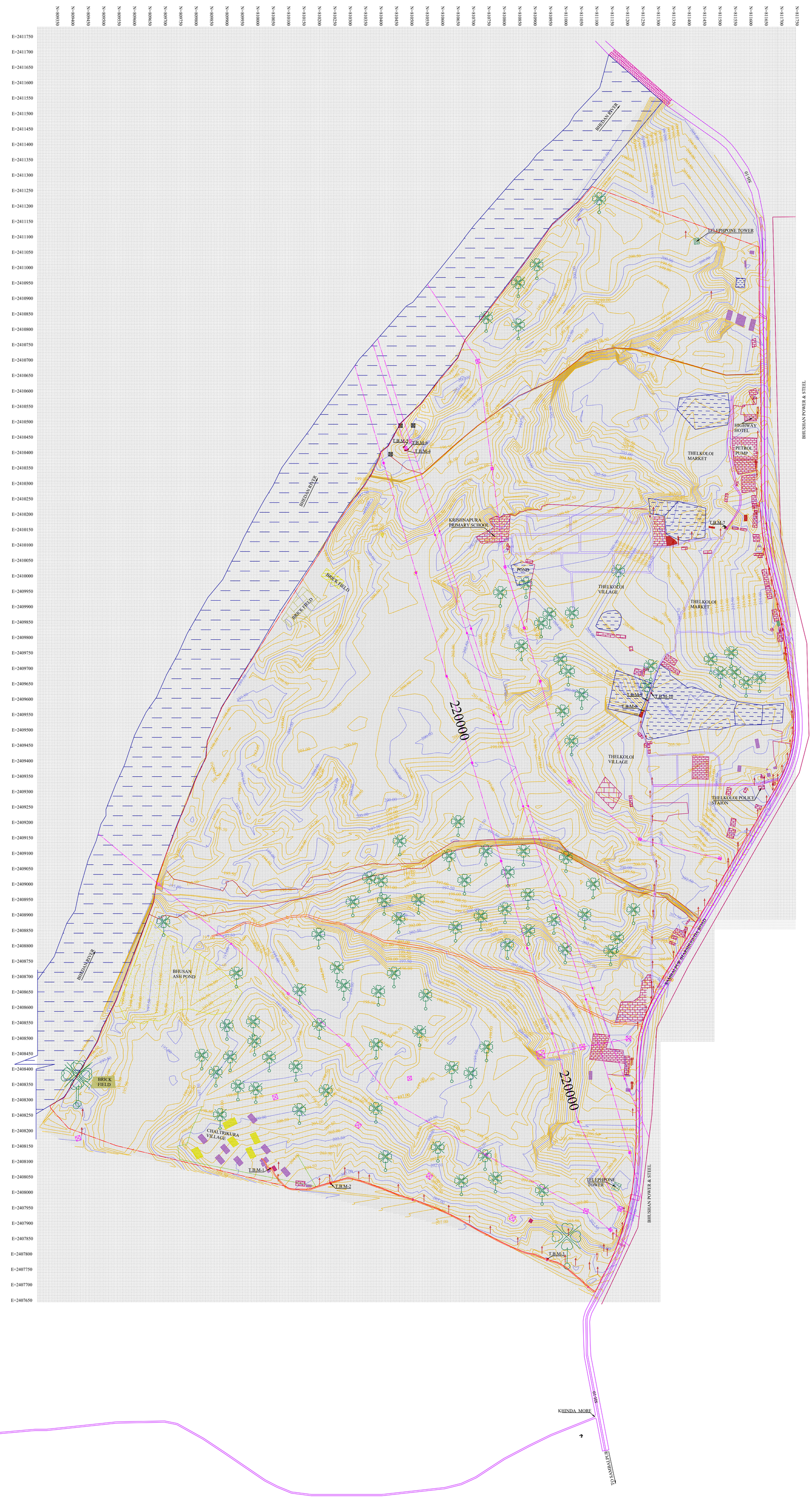
NORTH

KEY PLAN



-:LEGENDS:-

DESCRIPTION	SYMBOL
(1) Canal/River Shown As	
(2) H.T Line Shown As	
(3) Morum Road Shown As	
(4) Bituminous Road Shown As	
(5) Concrete Road Shown As	
(6) Building Shown As	
(7) T.B.M. Shown As	
(8) Village Boundry Shown As	
(9) Bridge Shown As	
(10) Hutment Shown As	
(11) Pond Shown As	
(12) Drain Shown As	
(13) Tubwell Shown As	
(14) Under construction H.T Line Shown As	
(15) Electric Post Shown As	
(16) Tree Shown As	
(17) Temple Shown As	
(18) Boundary Shown As	
(19) Brick Field Shown As	BRICK FIELD
(20) Existing Pilar Shown As	
(21) Major Contour Shown As	
(22) Minor Contour Shown As	


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BRICK FIELD
POND
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HIGHWAY HOTEL
PETROL PUMP
THELKOLOI VILLAGE
THELKOLOI MARKET
THELKOLOI VILLAGE
THELKOLOI POLICE STATION
TELEPHPONE TOWER
BHUSHAN ASH POND
CHALTRIKURA VILLAGE
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T.B.M-2
T.B.M-3
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